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MARCH, 1902, TO FEBRUARY, 1903, INCLUSIVE.

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Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, MARCH, 1902. No. 1.

COMPRESSED AIR FOG SIGNAL PLANT AT RACE ROCK LIGHT HOUSE, LONG ISLAND SOUND.

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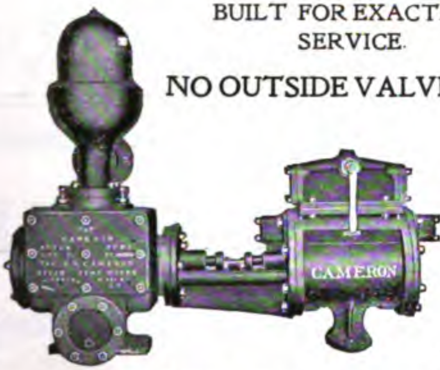
CAMERON

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN,

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 114a Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

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VOL. VII. MARCH, 1902. NO. 1.

This little paper was established in the month of March, 1896, so that with this issue we enter our seventh year. We began as papers usually begin, by producing a rather amateurish sheet of 16 pages, and have learned something by the experience of the past six years; at least our increased circulation and advertising patronage would so indicate. It is not uncommon now for us to issue from 56 to 64 pages each month. The most gratifying feature of this experience is our increased circulation, extending to many foreign countries. It appeared to us six years ago that compressed air had a field of usefulness that was capable of much industrial growth, and as there were few books on the subject, and no journals devoted to its interest, we started this little paper to give vent to an old-time hobby. We have never presumed to pose as experts, or as professors on this important subject, but we have thought that our every-day contact with compressed air machinery and men might give us a certain amount of practical information on the subject, and that this would be of interest to the public. Papers are published from time to time in the various engineering journals illustrating certain uses of compressed air, and as these papers are always in our files, we are able to select those of interest and embody them in this publication, together with a little occasional original matter. It would not be practical to publish even this little paper and fill its columns each month with original matter, that is, with papers written for us. If we attempted to do this, it is very likely that what we would produce would be of less value than when we avail ourselves of the large number of contributors to other journals. We have always attempted to give credit where credit is due, and as our readers are not likely to have either the time or the opportunity to look into all papers to see what is said about compressed air, we have undertaken to do this work for them. In the early issues of this paper we published a complete list of all pneumatic patents taken out in the United States, and have continued each month to select from the *Patent Office Gazette* everything that belongs to compressed air. That this paper is impartial goes without saying, for its record of six years is open for criticism. It is devoted to the interests and the development of an important industrial science, and not to any class or kind of machinery. Our advertising pages prove this, and with a continuation of the patronage which we have enjoyed, we hope and expect to go on towards increased prosperity and usefulness.

Protection.

It is just as important now to protect our manufacturers by securing and maintaining open markets for their surplus products as it was ten years ago to protect them in the home market against foreign competition. Europe then wanted us, we now want Europe.

All commerce to be permanent should be reciprocative. We cannot always sell unless we also buy.

We would follow the advice of President McKinley by using such of our tariffs as are no longer needed for protection or revenue for the purpose of increasing our trade abroad. This means tariff revision of a kind and in a way that could not produce a business collapse but which would pave the way for greater and continued prosperity. It was a serious matter to tinker with the tariff when Europe wanted us for a market and was held back only by the bars of protection. Even five years ago there was a scramble for American trade by foreign merchants, and a desire to get in here, while now conditions have changed and we are standing at the gates of foreign nations with products better and cheaper than theirs seeking their markets. The men who once wanted to sell us their goods are now ready to buy ours. In such a condition of things as this, why should we apprehend any danger from tariff tinkering on the McKinley basis? Does anyone believe that a reduction of 50 per cent. on iron and steel products would produce even a ripple of disturbance to our business? The alarm about the tariff is an inheritance which became rooted at a time when conditions were almost directly the reverse of what they are to-day. Professional politicians and professional protectionists are the alarmists who control the situation to-day at Washington.

The people will not long sustain a condition which cannot logically and fairly be justified. If trusts and combinations are to remain permanently as a part of our industrial system, they must be conducted in the interests of the whole people. The most vulnerable thing about a trust is where it can be shown that legislation has been called to the support of the trust to aid it in stifling competition. We cannot reasonably justify a protective tariff on a trust-made product. At the time the Dingley tariff bill was passed were few of our industries control trusts. To-day there are but few large manufacturing industries the not controlled by trusts. Where th internal competition the people are tected against monopoly profits, but trust-made product the importing alone limits the price. At present in some trust-made products are clo the importing point, it follows tha tariff is a means by which monopoly its are secured. Such a tariff is upon one class of people for the b of another, and as such it violate Constitution of the United States.

What we want is markets, not tection. We build by machinery, and productive capacity is so great that world's market is needed to maintai stability. It is better to provide ma for our surplus than to curtail our p uct and discharge our workmen. more we build of the same thing greater profit do we make, and at a l cost of production. This is one of reasons for our present prosperity. chanical appliances that lower cost made possible only by a large output. productive capacity per man employe made greater by machines, and in o to employ all of our labor and at g wages we must enlarge our markets. one time in the Carnegie works 800 were employed in a department that duced 1,200 tons of steel. By the use improved machinery 1,500 tons were p duced by 65 men. According to La Commissioner Wright, an American fa hand raises as much grain as three England, four in France, and five in G many.

A protective tariff does not benefit mining-machinery trade. Few in business know what the duties are on products, and if they were taken off tirely no harm could result, beca American-made mining machinery is b ter and cheaper than any other. T tariff acts only to increase the cost our product by increasing the cost of r materials. It puts an obstacle in our w when we go out to develop foreign bu ess, as we are met by retaliatory duti by criticism of our prices, which we a told are upheld by high tariff laws, a by the stigma of unpopularity which f lows the product of a country which mai tains the bars of protection against its neighbors, and at the same time seeks business abroad.

Protection is not a shibboleth—not a religion. It is a practical means to an end; a temporary policy to be followed until its object has been attained. It is based on grounds of expediency, and a lower tariff is advocated on similar grounds. Protection means exclusiveness at home at a sacrifice of foreign trade. It is a course of training for that industrial and financial battle for the world's supremacy which it is our determination to win.

To argue that we should "let well enough alone" begs the question. What is well enough to-day may not be well enough to-morrow if conditions change. That conditions governing trade and commerce in the United States have changed in the past five years, who will deny? We are dealing with a great business question, and the business man who does not shape his policy to meet situations will fall behind in the race. A wiser motto than "let well enough alone" is one which has been handed down to us as a truth from Holy Writ: "Let him that thinketh he standeth take heed lest he fall."

Air Haulage.

In our last issue we published in full a paper by Mr. Richard Hirsch presented before the Society of Western Engineers, at a recent meeting, in which the subject of pneumatic mine haulage is summarized in a brief and satisfactory manner. At the same time we also printed a paper by Mr. W. B. Clarke, entitled "Electricity vs. Compressed Air, a comparison of the efficiencies and relative cost of installation of the two systems." This latter is a discussion of a single instance where compressed air is at present used. Both of these papers bring out a number of features of the Air Haulage System, and as they are antagonistic in character both should be read. Mr. Clarke is well known in the electrical industry and is an enthusiast on the subject of Electric Mine Haulage. His paper is readable and apparently would be convincing except for several serious errors in his premises.

In the first place he takes up the mines of the Susquehanna Coal Co. of Glen Lyons, Pa., where a compressed air installation has been in successful operation for some time, and outlines an electrical equipment. In so doing he takes small electric locomotives which he states are capable of hauling larger trains than the air locomotives at present are hauling. On this basis he figures out a power plant which is naturally smaller than the air plant. He then assumes that his engine for operating the electric plant will have a steam economy of 28 pounds, and says that the steam consumption of the compressor will be 34 pounds, ignoring entirely the fact that if the air plant were being installed anew with an idea of steam economy, a compressor requiring even less than 28 pounds could have been used as easily. He then charges up a boiler capacity of 300 H. P. to the compressor and explains that a 100 H. P. electric plant would hardly require any additional capacity other than that which is already used for pumps, etc. These points makes a very creditable showing for the electrical installation, but the items which actually determine the efficiency and economy of a haulage plant are ignored.

Fuel in the case of the coal mine is one of the smallest items in the total expenses, as material which would otherwise be almost refuse is used. Operating expenses, repairs, general maintenance, permanency of the equipment and flexibility of the motive power are the factors on which the success of the Air Haulage System has been built up. A compressed air equipment and air locomotives can be installed in a mine by the regular mine mechanics and can be operated and maintained without employing expert operators or repair men. As Mr. Clarke ignores the question of danger to miners and operators, and the greater danger of gas explosions we will not dwell on it, because on this basis the advantage of air haulage is so obvious that a mere mention is sufficient.

A single explosion in a gaseous mine will as a rule more than off-set the expense of two or three air haulage installations, and the chance of such explosions where electricity is used is by no means uncertain, a fact easily substantiated by an examination of the various State Mine Inspectors' reports. The presence and necessity of bare overhead wire in every gallery where the locomotive is expected to work is a menace to miners who must pass back and forth, and the expense to install and maintain will in the long run more than over-balance the cost of any piping required by a compressed air haulage system.

The letter printed at the conclusion of Mr. Clarke's paper is a complete answer to the arguments which he presents, and is well worth the attention of any one inclined to question the economy of an aid haulage system.

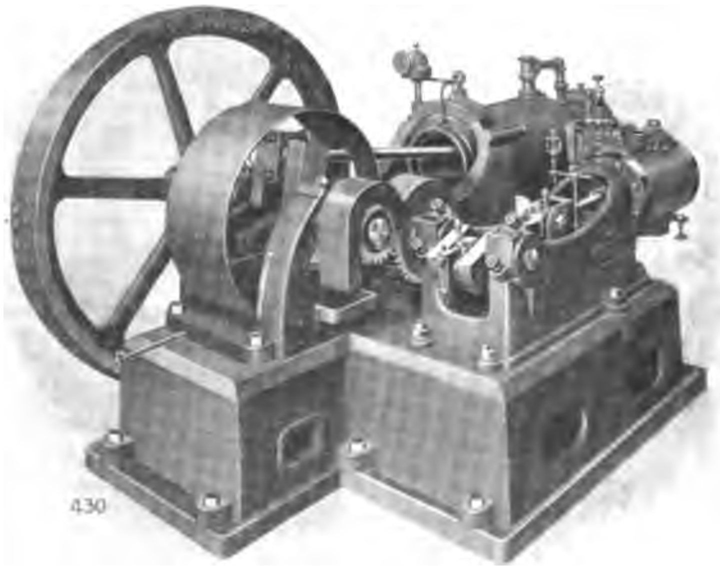
A Compressed Air Fog Signal Plant.

At first glance our frontispiece does not suggest anything to do with compressed air. In reality it is a very satisfactory example of a compact, self-contained, isolated compressed air plant.

The Race Rock light house here shown is built on a small island by that name and resembles in a general way other light stations and is more or less conventional in design. Inside, however, is quite an engine room.

As heavy fogs prevail at times in this vicinity, which make the light of practically no service, a fog signalling apparatus is of the greatest importance. To avoid the possibility of accidental shut down at times when the signal is most needed a duplicate plant is installed. Each outfit consists of a 7 H. P. Hornsby-Akroyd oil engine directly connected by gearing to an Ingersoll-Sergeant class "E" air compressor similar to the picture here shown. The compressor cylinder is 8 inches in diameter with a 6-inch stroke and runs at 150 revolutions, giving 51 cubic feet of free air per minute at 40 lbs. pressure. The engine runs at 235 revolutions per minute, and uses petroleum or crude oil, which is stored in the base of the engine and is automatically raised to the vaporizer by a small pump.

The jacket water necessary for cooling the cylinders of the engine and compressor is kept circulating by a small reciprocating pump actuated from the engine cam shaft.



OIL ENGINE DRIVEN AIR COMPRESSOR. INGERSOLL-SERGEANT COMPRESSOR. HORNSBY-AKROYD OIL ENGINE.

Both engine and compressor are mounted on a substantial cast box base, and thus make a completely self-contained apparatus. The air as compressed passes over into a large air receiver or tank

From this it passes to the reducing valve of the fog horn.

An automatic time trigger or valve allows the air to blow through the horn at specified intervals producing the proper signal whereby the station can be idenfied by passing vessels.

It frequently happens that in time of fog a plant of this sort must continue in operation for as much as one hundred hours without interruption. Add to this the fact that these signal stations are often miles from any means of repairing breakdowns and the necessity of unfailing machinery becomes apparent. The Race Rock station is only one of many compressed air fog signal stations along our extensive coast, but is typical.

We are indebted to the De La Vergne Refrigerating Co. for the use of the photograph from which our frontispiece was prepared.

Moisture in Compressed Air.

D. W. Hering.

Mistaken notions arise occasionally concerning the moisture in compressed air, especially when air has been compressed hydraulically. In the abstract of Professor Kinealy's paper in Compressed Air not long ago, speaking of the method of compressing at Magog by a descending column of water, he says "compression by such an apparatus must, of course, be quite isothermal, but the air must be saturated with moisture, and would, therefore, be objectionable in many cases." Another article in the same number, referring to the same method, says: "Tests have shown that air compressed in this manner contains only one-sixth of the moisture originally in the surrounding atmosphere from which it is compressed."

These statements appear to be contradictory and are somewhat confusing, but both may be correct.

It would seem as if there could be no more effectual way to moisten air than to mix it thoroughly with water, and that is done in hydraulic compression, but paradoxical as it sounds, this may actually be a drying process; air may emerge from it charged with less moisture than it had before entering the water, as we may presently see.

In the effort to make this plain we would better state first a few elementary principles.

In a mixture of air and water-vapor, such as the atmosphere always is, the total pressure is the sum of the pressures due to the constituents separately. At all ordinary temperatures, and through a wide range from very low to any higher temperatures the air will be a gas and will follow Boyle's law of pressures for a given temperature, or Charles' law for varying temperatures. It is not so with the vapor of water, which follows these laws only when its temperature is above what is known as the dew point.

If a small quantity of vapor be enclosed in a large space it will exert a definite pressure at a given temperature. The space being unchanged the pressure will be higher with a higher temperature indefinitely, and lower with a lower temperature, but not indefinitely.

If the temperature be kept constant and the volume diminished, the vapor present will be crowded into a smaller space and its pressure will rise in proportion up to a certain point, above which water vapor will not exist at that temperature. Any further diminution of the volume will not give any greater pressure, but will result in a precipitation of the moisture as liquid. At that pressure, called the *maximum pressure* for that temperature, the vapor is *saturated*, and this would be true whether air be present with the moisture or not.

The maximum pressure, or the pressure of saturated vapor, has been accurately determined for a wide range of temperature, and also the actual weight of the vapor per cubic foot, under these conditions:

If air is at a high temperature and is saturated with moisture the pressure of the vapor will be higher, and the quantity of water in a given volume will be larger than in air saturated at a lower temperature, but the air will be no drier in one case than in the other. In each case the humidity is 100 per cent., and in either case the slightest lowering of the temperature or the slightest diminution of the volume would be attended by the precipitation of moisture, called dew. If, however, in a given volume of air there is only half enough water vapor to saturate it, the pressure due to the vapor will be only half as great as at saturation for that temperature.

Now supppose air at an atmosphere pressure is drawn in with the column of water and carried down the shaft to a depth where it is under a pressure of four atmospheres. Suppose the air to begin with is half saturated with moisture. If the temperature is unaltered, when the air has been compressed to two atmospheres, or half its bulk, there is twice as much moisture per cubic foot as there was at first, and the tension or pressure of the vapor is now double what it was to begin with. It is at its maximum. No further compression will increase this. So long as the temperature is unaltered, there will be just so much pressure exerted by the vapor of water, and just so much water in the air per cubic foot. Further crowding of moist air into the same space will give a higher pressure of air, but so far as moisture is concerned, it will be changed from vapor into liquid and will be mixed with the flowing water. When the outside air has been reduced in volume to one-fourth its original bulk, it will be saturated with moisture, it is true, but that only means that it will contain enough moisture to exert the maximum vapor pressure for that temperature. This compressing operation will extract and carry away much of the moisture from the air. If the latter is driven into a receiving tank, from which it is drawn for power or other purposes, not only will it on expanding to its original volume and temperature, have less moisture per cubic foot than before compression, but on expanding to one atmosphere pressure it may fall much lower in temperature than before without precipitation of moisture. We began in this case with air half saturated or with a humidity of 50 per cent., and supposing the temperature to be not changed, we reached saturation by doubling the pressure.

The same thing might have occurred in another way. Beginning with air at a high temperature, even if it is only half saturated, the pressure due to the vapor of water will be considerable, and with no diminution of volume this pressure is proportional to the absolute temperature, and if the vapor (and air) be cooled down, it will presently reach a temperature for which the actual pressure of the vapor is a maximum or saturation pressure. Thus the air may be brought to saturation either by raising the pressure or by lowering the temperature.

Suppose that the air entrained by the water is warm while the latter is cold. Then as the air is cooled it approaches the temperature of saturation for the quantity of moisture in it, and when it is finally so cool that the pressure actually exerted by the vapor present in the air is equal to the maximum pressure of water vapor for that temperature it will sustain no further lowering of temperature without giving up some moisture, and if the water is cooler than this dew point, it will take moisture out of the air, even without compressing it.

In fact both of these processes are likely to occur simultaneously, and a larger drying will be accomplished than by either alone.

Perhaps one or two numerical examples will illustrate this more clearly.

If the outside air is at a temperature of say 86 degrees F., it would require .00189 pounds of vapor per cu. ft. to saturate it, and this would have a pressure of .61 pounds per square inch. If the humidity is 60 per cent., then these quantities are only 60 per cent. as much; i. e., the vapor present is .001134 pounds per cu. ft. and its pressure 0.366 pounds per sq. inch.

Suppose the water cooling it has a temperature of 59 degrees F. For this temperature the pressure that water vapor can exert is only 0.241 lbs. per sq. inch, and there will be 0.000791 pounds per cubic foot.

The original vapor in cooling to this temperature exerts less pressure in proportion to the fall of temperature, so that on this account its pressure would be 0.95 of the original. This differs so little from the original that the original figure is usually taken instead of the true one. Taking the correct value, however, the pressure of the moisture in the cooled air should be 0.95 of 0.366, or 0.348 lbs. sq. inch. But it cannot have at that temperature a higher pressure than 0.241 lbs. sq. inch, and for that purpose the air can have in it only that proportion of its original moisture that 0.241 is of 0.348; that is, $\frac{241}{348}$ or .69 per cent. It, therefore, gives up 31 per cent. or nearly one-third of its moisture by cooling, and without taking any account as yet of the effect of compression. There will be in the now cooled, but not compressed air, only .00079 pounds of vapor to the cu. ft.; exerting a pressure of 0.241 lbs. per sq. inch, and the air containing it will be saturated with the moisture. Compression now will result in further precipitation, and the higher the compression is carried the more moisture will be condensed. If the air be compressed to four atmospheres, i. e., 44.1 pounds gauge pressure, four cubic feet of air containing .00079 pounds of vapor to the cubic foot will be compressed into one cubic foot. containing just the same quantity of water vapor. Three-fourths of the moisture will be given up, or the actual amount of water now in any quantity of air will be one-fourth of 69 per cent., or a little over 17 per cent. of what was in the same quantity of outside air before it was entrained with the water.

There may be many variations of this on account of various degrees of humidity of the air. of its temperature, the temperature of the water, and the ratio of compression. Whenever the water is colder than the dew point of the air, the latter will lose some of its moisture by cooling in the water. but there may be instances in which the air will take up moisture from the water. As an extreme case of that kind. suppose the air to be at a temperature of zero Fahrenheit and very dry, say with a humidity of only 20 per cent., and the water at 32 degrees F.

The vapor needed to saturate the air at zero temperature is .0000786 pounds per cubic foot, and has a pressure of .0215 pounds per square inch. With only 20 per cent. of saturation the quantity of moisture would be .0000157 lbs. per cu. ft. and the pressure .0043 pounds per sq. inch. The water now would warm the air and increase its capacity for moisture. At 32 degrees F. the saturation pressure is .085 pounds per sq. in., and the quantity of vapor .000295 lbs. per cu. ft. The pressure of vapor by rise of temperature to 32 degrees would become .0046 pounds per sq. inch. and the air would take up more moisture until it was saturated at this temperature, or the vapor pressure was .085 pounds per sq. in. This would be in the proportion of .085 to .0046, or 18.5 times its original quantity, making .000295 lbs. per cu. ft.

Here, by the change of temperature alone, there has been a great addition of moisture, with no compression. It would now be necessary to compress the air more than eighteen-fold to deliver it at the original temperature and pressure with the original quantity of water vapor to the cubic foot.

If the pressure were only double the air would lose half its moisture and a given mass (not bulk) of it at 32 degrees F., and zero gauge pressure would have 9.25 times as much moisture per cubic foot as at first. If it were then to cool to the temperature of 0 degree F., it would give up all its moisture except .0000786 lbs. per cu. ft. by which it would be saturated instead of nearly dry.

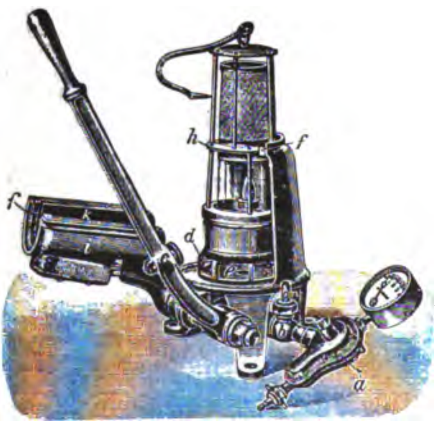
If it had been compressed fourfold, as in the former example, it would retain one-fourth of 18.5 times, or 4.6 times the original quantity of moisture, and that would still be almost enough to saturate it. The humidity would be 92 per cent. as against 20 per cent. to begin with.

In compressing hydraulically, no moisture condensed by compression reappears in the air, as it is carried off by the flowing water, but in compressing with dry metal compressors, in which very little cooling of the air is accomplished in the compressor cylinder, practically all the moisture is driven with the air into the receiving tank, or the cooler, or the mains. Whatever may be the vessel into which the air is driven, if the air in it is cooled to the temperature it had before compression the moisture will be precipitated in it, and if the humidity and compression were both high, the quantity of water so precipitated will be considerable. For example. if the outside air have a temperature of 68 degrees F. and is half saturated it will contain .000535 pound of water vapor to the cubic foot. If this be compressed to 8 atmospheres (102.9 lbs. gauge pressure). three-fourths of the water vapor will be condensed into liquid when the compressed air is cooled to 68 degrees F. This will be .0004 pounds per cubic foot of free air, that is condensed, or four pounds in ten thousand cubic feet, which would be deposited in the tank or mains, or in the first intercooler if this were the first stage of compound compression.

If this precipitated moisture is drawn off by means of a cock suitably placed for the purpose, the air to be utilized will be drier than it was in the beginning, on reaching its original temperature and pressure, by the amount of moisture it has given up. A plain discussion of this condition with some pungent remarks is contained in the sixteenth chapter of Frank Richards' book, "Compressed Air."

An Apparatus for Testing Miners' Lamps.

We illustrate a pneumatic device for testing the tightness of safety lamps. Briefly described, it consists of casing flame chamber of the lamp large enough to hold the reservoir, and is made in two halves, one of which forms part of the base of the device. The other half is hinged and provided with a lever to swing it open to admit the lamp, or closed when the lamp is in place and ready to be tested. Suitable rubber packing is provided to seal the two halves and the flange of the lamp. The closing lever also opens the valve, which admits compressed air. To observe the condition of the



flame, which flickers or goes out, according to the amount of leakage in the lamp, a glass window is provided in the front of the movable half.

A reducing valve and small pressure gauge also form a part of the apparatus, so that the pressure to which the lamp is submitted can be accurately gauged. Generally these range from 0.12 to 0.28 atmosphere, depending upon the oil being used. Different sizes of packing rings are provided so that any lamp can be tested.

The device is manufactured by the Westfalia Armaturen Manufaktur Co., of Gelsenkirchen.

A Portable Pneumatic Riveting Plant.

A recent and novel application of compressed air to the work of riveting is afforded by the roadbed reconstruction of the Scranton Railway Co., Scranton, Pa. under the direction of Mr. Frank Silliman, the general manager of the company.

The plan adopted consisted in riveting a four-foot section of old rail under each joint and involved the putting in 18¾-inch rivets at each of these places. Instead of the usual wooden ties old sections of rails were used, placed 5 feet between centres, and these also were riveted to the bottom flange of the rails, requiring four rivets each. All riveting was done with a portable pneumatic riveter of the jaw or "squeeze" type, made by Chester B. Albree, of Allegheny, Pa. This was suspended from a derrick mounted on a four wheel flat-car, which runs on the rails of the track to be riveted. This car also carried an electrically driven air compressor made by the U. Baird Machinery Co. of Pittsburg, Pa., and driven by a 500 volt motor of the Lundell type. The air was compressed to 80 lbs. pressure in a receiver on the car. The plant is shown in the figure, which also shows one of the steel ties in place.

Power for operating the motor and propelling the car on which the outfit is mounted is taken from the regular overhead trolley wire. We are indebted to "*Engineering News*" for the illustration given herewith.

Some Pneumatic Locomotive Attachments

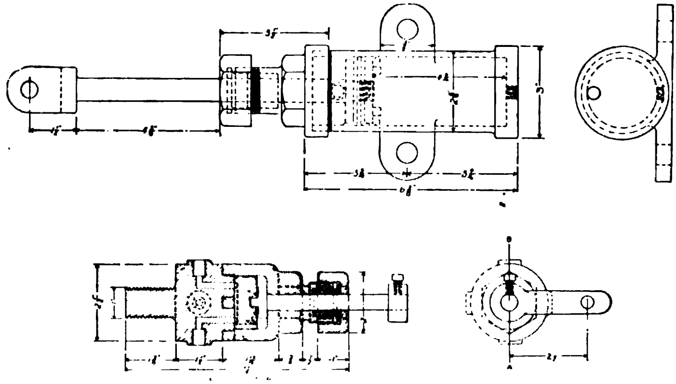
The *Railway Age* for Nov. 1 describes several novel uses of compressed air as employed by Mr. D. S. Cook, general foreman of the Evansville & Terre Haute R. R. Co.

Two of these are of more than passing interest, and we reproduce them for our readers.

The first of these, a device for opening and closing the firebox door, shown i

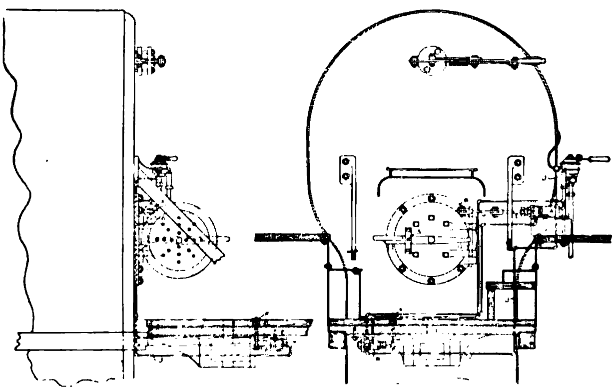
RIVETING PLANT FOR RAIL JOINTS, SCRANTON RAILWAY CO.
(Showing reinforcing rail under the joint, and also one of the steel cross ties at the right.)

Figs. 1 and 2, consists of an air cylinder, Fig. 1, connected to the firebox door by a rod and crank lever. Two one-eighth inch gas pipes run, one from the front end



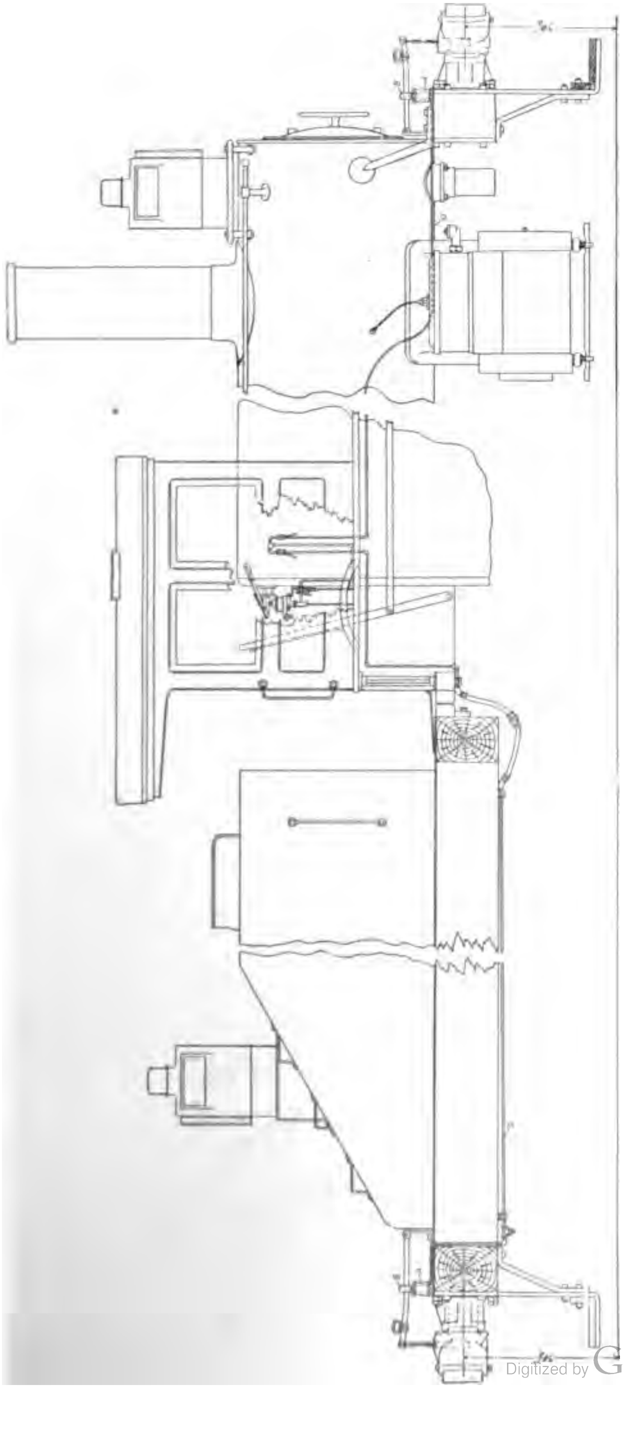
PNEUMATIC ATTACHMENT FOR FIREBOX DOORS.

and one from the back end of the cylinder, down under the deck of the engine, where they are connected with an oscillating valve. This valve is fed by an eighth of an inch pipe from the main reservoir of the air brake system. The valve is operated by the pressure of the foot on a button projecting through the



PNEUMATIC ATTACHMENT FOR FIREBOX DOORS.

floor of the cab. The operation of this button pushes down a lever which rotates the valve upon its seat and admits air through the openings in the valve, which passes into the pipe leading to the front end of the cylinder. The operation of forcing the piston to the back part of the cylinder, which is thus effected, opens the firebox door. When the button is released a coil spring raises it to its original position. This allows the valve to rotate in the opposite direction, and thus admits air to the back end of the cylinder, forcing the piston out. This operation closes the fire door. The rod which is connected with the button in the cab floor has a shoulder under the deck casting which prevents the button from raising beyond a given height. The crank lever, by means of which the door is operated, is fastened to the fire door by means of two setscrews.



PNEUMATIC ATTACHMENT FOR OPERATING LOCOMOTIVE AND TENDER COUPLERS.

A second device is used to raise the locking pins of the couplers at the rear end of the tender and upon the pilot. Referring to Fig. 3, the chain leading from the locking pin is connected to the end of a lever which is connected midway between this connection and its pivoted extremity to a bearing upon the stem of an air cylinder. The raising of the piston by the admission of air lifts the lever and consequently raises the locking pin from its seat. Connections are made by means of an ⅛-inch pipe and the admission of air is controlled by valves in the cab within easy reach of the engineman.

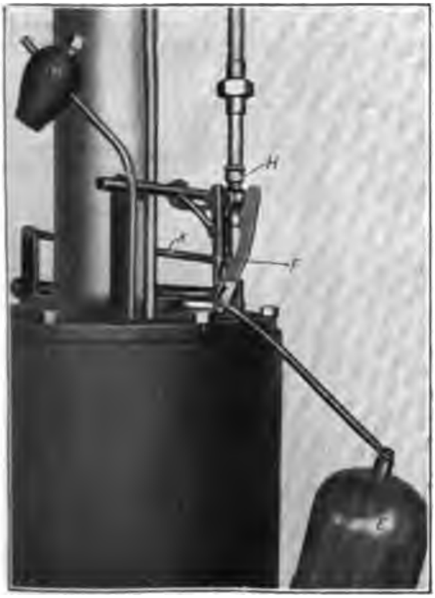
Compressed Air for Pumping Oil Wells.

One of the latest uses to which compressed air has been put is the pumping of oil wells. California has oil fields throughout its entire length, but of these what is known as the Bakersfield or Kern River District, situate about the middle of the State, is head and shoulders above all the others, both as to present production and possible developments. In this district the formation lies almost horizontal and, with the exception of a sticky clay and heaving sand, is just hard enough to drill rapidly, but the heaving sand has been so difficult to overcome that in many cases wells that, from their surroundings were absolutely sure of oil, have, after months of constant effort, been abandoned on account of the heaving sand. It certainly requires courage and persistence in the drillers, after working for days and perhaps only gaining ten or fifteen feet, or possibly nothing at all, to run his tools into the hole and find that they will not go down within one, two or possibly three hundred feet of what they had gone but a few minutes before; and to have this experience day after day and week after week will test every virtue a man may possess, including his pocketbook. Every expedient known in other fields has been tried here, but with only moderate success. The formation being loose and open allows the water to run away so fast that the rotary hydraulic rig is a failure, though where the sand heaves inside the casing a column of water is used with good effect to aid in holding it back. Even after the oil sand has been reached and the pump put in, the troubles have only begun, as the pressure outside of the casing forces the sand through the perforations and the well has to be shut down at short intervals to remove the accumulated sand and clear the working barrel, necessitating an engine and rig at each well, and also the retaining of a "pulling crew" of at least three men. To overcome these conditions a great deal of expensive experimental work has been done by various companies, and at this time compressed air gives promise of solving the problem. The air is piped from the air compressor (too well known to need any description) to the well, a 1-inch pipe run down into the well and connected with a 3-inch tubing near the bottom by a U-joint, though in some cases two or three pipes are connected one at the bottom of the tubing, one at about three-quarters distance down and one about one-half the distance. In starting the well pumping they are all turned on together until the column of oil is started, when the intermediate connections are shut off and the lower one will do all the work, usually requiring about 120 pounds pressure in an 850-foot well, 14 gravity oil. By this method everything above the connections is carried out of the tubing and the deeper they are submerged the better the results. In this way the sand, which has been the source of so much trouble, is not allowed to accumulate, but is carried out with the oil, and by gradually lowering the tubing the well is cleared of whatever sand may have accumulated in it. In one instance which has come under our observation the well, after being completed, had filled up 180 feet with sand which, working day and night for nearly six weeks with the tools, failed to lower. As an experiment and last resource compressed air was introduced with the result that in four days, besides getting a benefit of the entire production of the well, the sand had been removed and the tubing lowered to the bottom of the hole and the well has since produced steadily. Briefly, the advantages of the new method are as follows: One man to attend to the compressor plant and one man to attend to all of the wells being pumped, instead of one man to every well and a pulling crew in addition. The compressor plant being the only machinery required, instead of an engine and rig to every well, wells can be operated at a long distance from the compressing plant with practically no loss of power. Last, but possibly most important, the wells produce for thirty days in the month instead of about fifteen days, as heretofore.—*Scientific American.*

Compressed Air Oil Service.

Not all rotary oil pumps supplied with machines for lubricating their cutting tools are entirely satisfactory. There is usually trouble with leaky joints, or the belts get oilsoaked and throw oil over everything within reach. It often happens that the oil supply is not needed, but still the pumps keep running, wasting work.

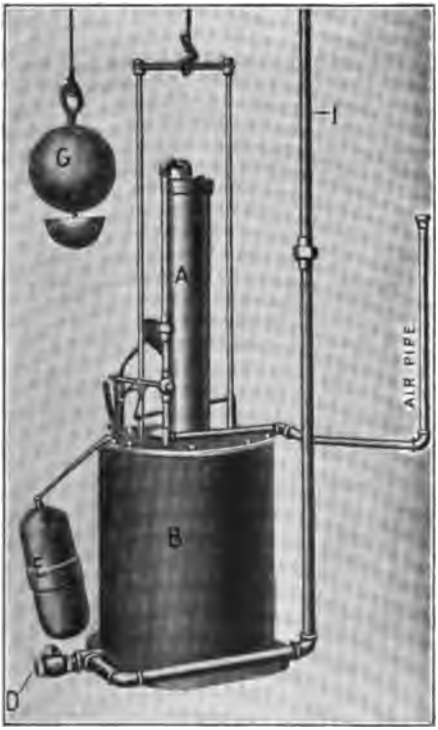
All these conditions existed in the case



DETAILS OF OIL ELEVATOR.

I am about to speak of. The pump, getting intolerable, was taken out and a tank set on brackets above the machine was substituted. From a tank below the attendant would fill the upper tank as often as needed, but as he had to do some climbing this arrangement was not satisfying.

There was in the shop a constant supply of compresser air at 70 or 80 pounds pressure, which I concluded to use, and the photographs show the result. *A* is a 3-inch brass tube serving as an air cylinder, *B* is a cast-iron cylinder about 14 inches inside diameter. Pistons connected by a rod are fitted to each cylinder, and cup leathers are used for packing; the rod has no packing. The apparatus is single acting, and the pistons are returned to the upper position by the counterweight *C*, through the rope and rods shown. The



COMPRESSED AIR OIL ELEVATOR.

whole thing is set into a tank, not shown, into which is led the used oil. The oil rises on the inside of cylinder *B* as well as on the outside, passing in through the check valve *D*. A small hole through the side of cylinder *B*, near the top and close under the lower piston when it is up as far as it will go, allows the air to escape, and it is closed as soon as the piston descends a distance equal to the diameter of hole. When the oil is high enough the float *E* trips the hook *F*, the weight *G* falls and opens the air valve *H*, admitting air on top of the small piston. The pistons descend and the larger one forces the oil in cylinder *B* to the upper tank. When the piston is near to the lower limit of its travel, it strikes the rod *K*, which passes through the cylinder *A*, and this lifts weight *G* in position for another "cycle." It should be noted that the trigger on the float remains in a position to interfere with the hooking up of weight *G* until the pistons return, and must be constructed accordingly.

The releasing mechanism was first made very cheap and too flimsy, otherwise the operation seemed to be good; so it was replaced by better, and after that it worked entirely satisfactorily for several years, and so far as I know it is working still. The time of making it complete and installing was thirty-five to thirty-eight hours, and afterwards eight to ten hours for a new tripping mechanism. It required no attention except cleaning out; but if I had to make another I think I should dispense with the pistons and admit the air on top of the oil, and, so to say, "blow it up."

The advantages as I see them are: cleanliness, no belts, no bearings, noiselessness and no motion except when wanted.—*American Machinist.*

Some Special Applications of Compressed Air.

Through the courtesy of the Westinghouse Air Brake Company of Pittsburg, Pa., we are enabled to present several illustrations showing some special applica-

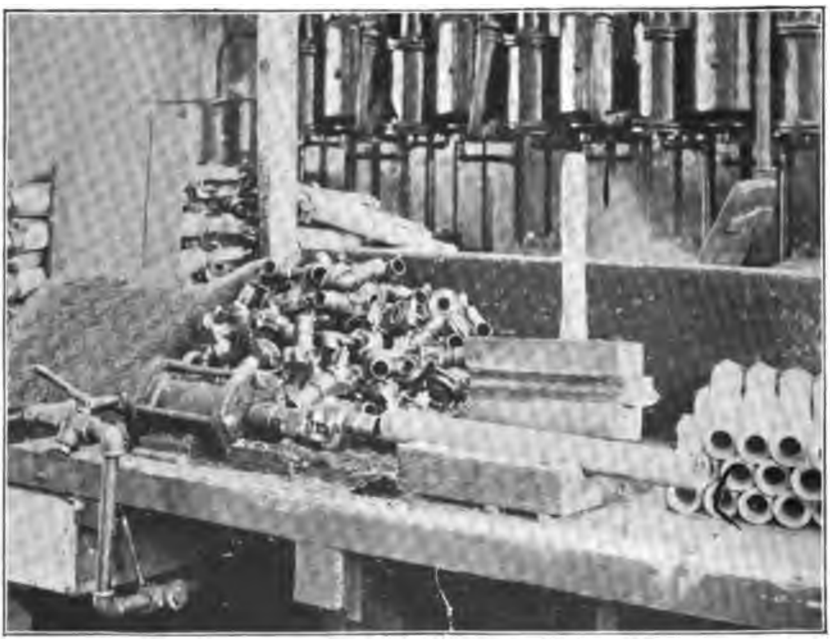


FIG. I—INSERTING COUPLING SHELLS.

tions of compressed air at their Wilmerding works.

Besides further illustrating the flexibility of a compressed air system the pictures may serve to suggest new uses to some of our readers already employing air to some extent.

Figure 1 shows a simple device for inserting coupling shells in the short lengths of hose used to couple up cars. The coupling shells are slipped on the end of a piston rod working in a small cylinder. Directly in front the hose is held between two blocks grooved to fit snugly about it. Air forces the shell into the end of the hose, while a spring returns the piston ready for a second operation.

Figure 2 is somewhat similar to Fig. 1, but has a taper mandrel on the end of the piston on which is slipped the malleable iron clamp rings used to surround and clamp the hose to the shell piece. A use of the air hoist is well shown in Fig. 3. In this, rough cylinder castings are lifted from the floor, swung over a boring machine and slid into place without effort or delay on the part of the operator, who is thus permitted to devote his strength and attention to setting and operating his machine.

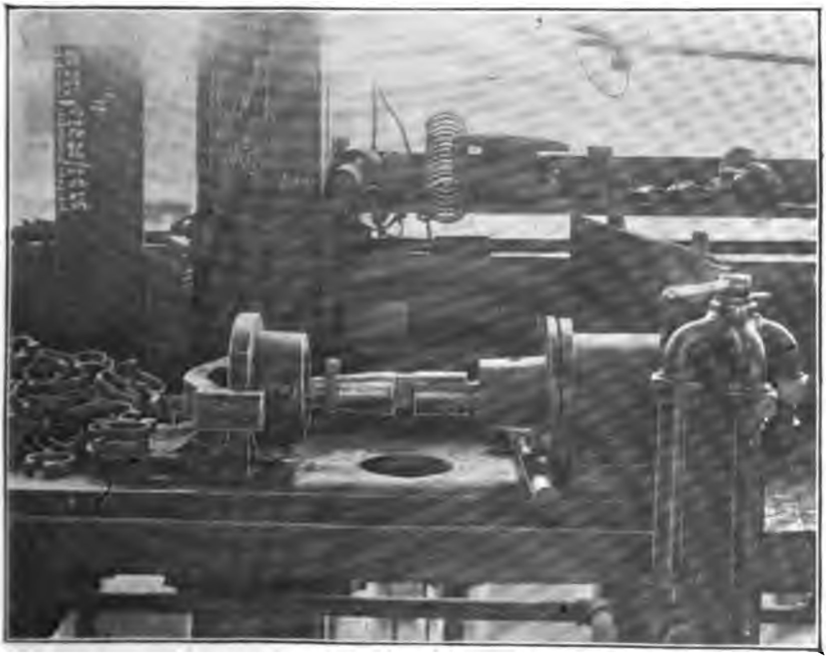


FIG. 2—ENLARGING MALLEABLE IRON HOSE CLAMP RINGS.

Figure 4 is of especial interest, and suggests many uses in shops where a large quantity of small duplicate pieces are turned out. The drill press shown is fitted with a small cylinder placed under and in the centre of the plate. A piston rod extends up through the usual central

siderable reduction in the time requir to machine a given piece.

Figure 5 is simply an application of t straight air hoist suspended from a tru running on an overhead rail.

Compressed air for operating these ai many other appliances in and about tl

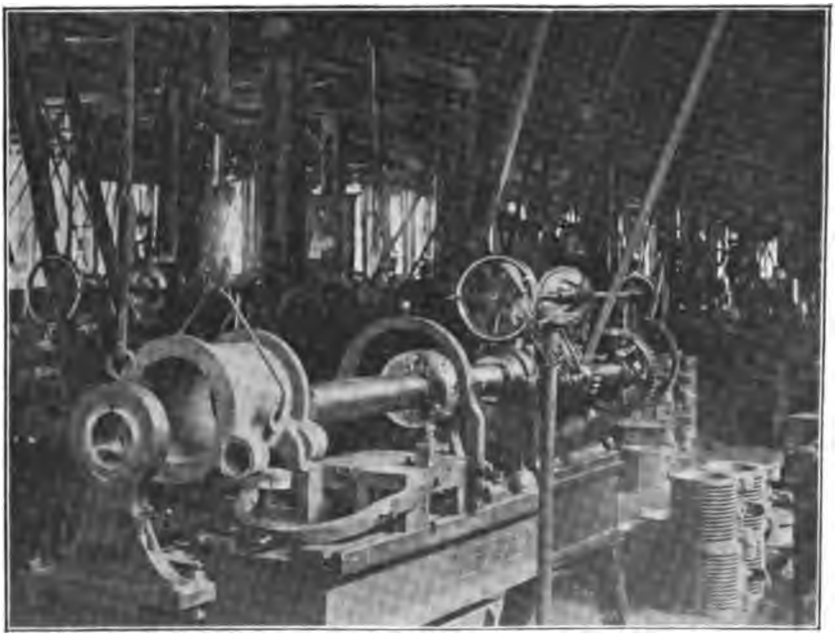


FIG. 3—PLACING CYLINDER CASTINGS IN BORING MACHINE WITH AIR HOIST.

hole and is used to clamp the work up against the face of the jig. A turn of the valve releases the pressure when the piece is free, and can be removed without slacking any bolts.

There are many places where a device of this sort could be employed with a con-

Westinghouse works is obtained from the airbrakes undergoing a test, an uneconomical method of producing air for shop purposes generally, but not so here, because the airbrake pumps must be tested, and if the air were not utilized this way it would have to be wasted.

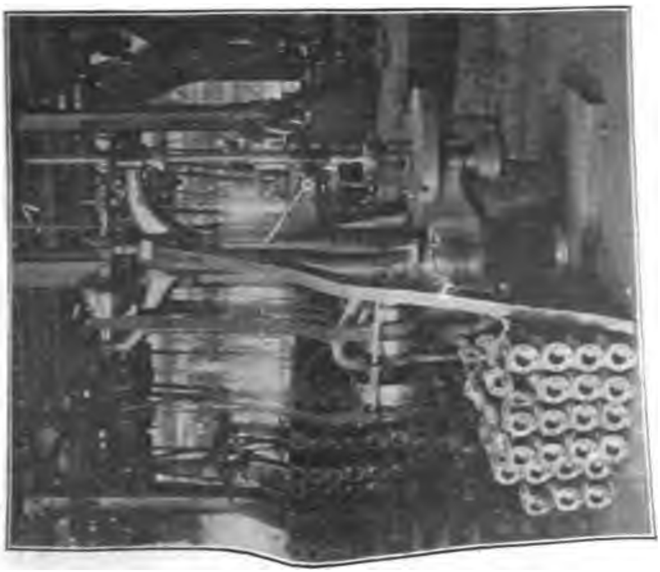


FIG. 4—COMPRESSED AIR CLAMP TO HOLD PIECE BEING OPERATED UPON.

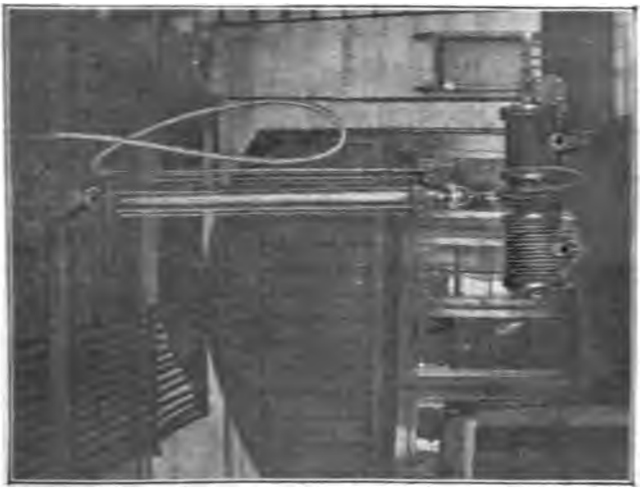
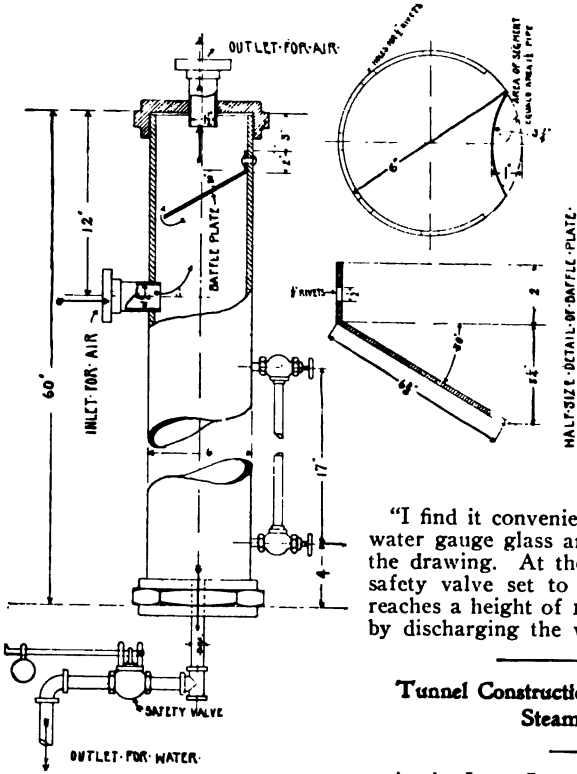


FIG. 5 AIR HOIST HUNG FROM TRUCK, FORMING A TRAVELLING HOIST.

Water Trap for Compressed Air Mains.

Sometimes in connection with the use of compressed air for operating pneumatic apparatus in machine shops or elsewhere, difficulty is experienced due to the moisture, which is present in the air in an amount, depending upon the method of compression, from where the air is obtained and also the humidity of the atmosphere.

We illustrate herewith a water trap for the removal of this moisture, which was designed and constructed by Mr. H. N.



TRAP FOR COMPRESSED AIR MAINS.

Covell, Superintendent of the Lidgerwood Mfg. Co., of Brooklyn, N. Y. We understand that this trap works with marked success and we present it for the benefit of our readers, many of whom may find it of service. Referring to this Mr. Covell says:

"The sketch needs but little explanation. The trap in question was constructed from a piece of ordinary 6-inch wrought iron pipe, and is 5 feet long. The top end was tapped for a 1½-inch outlet for the air, and at a distance of 12 inches from the top the pipe was tapped for a 1½-inch inlet.

"The baffle plate shown in the drawing is set at an angle of 30 degrees from the horizontal. This baffle plate extends clear across the 6-inch pipe, leaving only a small opening, equaling the area of a 1½-inch pipe.

"I find it convenient to have a common water gauge glass arranged, as shown on the drawing. At the bottom is a ¾-inch safety valve set to trip when the water reaches a height of 15 or 20 inches, thereby discharging the water."

Tunnel Construction for Underground Steam Pipes.

At the Iowa State College at Ames, Ia., a tunnel has recently been constructed for the steam, compressed air and electric mains leading from a central power station to a new engineering building; ultimately the system will extend to the other large college buildings and be utilized for the distributing mains of a central heating plant. The tunnel has been constructed from the plans and under the direction of Prof. G. W. Bissell. From a paper read by Prof. Bissell before the Iowa Engineering Society, the following additional details have been taken:

The total length of the tunnel is 460 feet, consisting of a single stretch 360 feet in length, with right angle offsets at the power station and at the new engineering hall of 60 feet and 40 feet, respectively. The grade of the tunnel is about 0.6 foot to the 100 feet from each end toward an assigned low point designated as station D, where a connection is made from the floor of the tunnel to a sewer, and also from a 4-inch drain tile under the floor to the same sewer, thus securing internal and external drainage. The internal drainage connection is properly tapped.

The walls and roof of the tunnel are hard-burned brick, laid up for a 9-inch wall in cement mortar, plastered outside to a thickness of one-half inch with cement mortar. The floor of the tunnel is 4 inches thick, constructed according to the usual specifications for a cement sidewalk. The extreme height of the tunnel on the outside is 6 feet, and the width on the inside is 5 feet.

At intervals of 10 feet in the length of the tunnel a 1½-inch iron steam pipe is placed to serve as a column for carrying supports for the heavy pipes. This column is supported by a flange casting at the bottom, resting on a 12x12-inch pier of concrete, and is built into the roof of the tunnel.

At the same intervals, 10 feet, and opposite the columns, are placed two wooden bricks on each side of the tunnel. These will serve on one side to support a 2x4-inch cleat, which will hold one end of the pipe carrier and serve for ring pipe hangers to carry compressed aid and vacuum pipes required for operating the thermostatic heat regulating system of the new engineering hall. On the opposite side of the tunnel will be placed a similar cleat, on which the electric lighting and power wires will be suitably hung.

The pipe-carrier consists of one-inch round iron rod, supported by a flange bolted to the cleat on the wall of the tunnel, and by a clamp casting secured to the column in the center. The carrier may be adjusted to any height desired to give the pipes thereon the required grade or fall. The pipes rest on rollers which are free to turn upon the rod, thus permitting expansion to whatever extent may be necessary.

The steam pipe will be anchored securely at two points, and the expansion between the anchorages will be provided for by the use of an expansion joint of standard design. The amount of expansion thus to be provided for will amount to about 5 inches in the extreme cases. The expansion occurring on the outside of the anchorage, and toward the ends of the tunnel, will be provided for by the spring in the offset.

The steam and return pipes will both be thoroughly protected from wasteful radiation of heat by covering them with the best grade of sectional pipe covering. The pressure to be maintained in the steam pipes may be anywhere from atmospheric to 80 pounds to the square inch, but it is not expected that more than 40 pounds to the square inch will be required at any one time.

The lighting of the tunnel itself has been provided for by placing overhead a half-inch iron pipe conduit with receptacles and lamps at intervals of 30 feet. The conduit is supported on brackets on the central column.

The cost of the tunnel, including excavation, brick work, cement work, drain tile, iron columns, wooden brick and backfilling, was $3,300, approximately $7 per foot. The installing of the pipe, including steam, return, compressed air and vacuum pipes and the hangers therefor, and including the lighting of the tunnel itself, is now in progress and will cost $1,800, or about $3.90 per foot complete. The total cost, therefore, for the whole construction will probably be about $11 per foot. In comparing the cost of this construction with others frequently used it will be noticed that it is quite high, but, on the other hand, it is expected that the construction, at least of the tunnel part, will last for all time, and it is reasonable to assume that on account of the accessibility of all of the pipe and electric circuits, that they will be kept in better condition than if buried under the ground, and, on account of these features, that the running expenses due to the radiation of heat occasioned by the deterioration of the insulation will be reduced to the very lowest figures.

Another advantage is in the use of the tunnel for electric light and power circuits. This exists in the fact that the same will be under ground, thereby doing away with the unsightly overhead poles and wiring system, and doing away with the liability of such overhead wires becoming entangled or being blown or broken down.—*Engineering Record.*

A Portable Pneumatic Riveting Machine.

The riveting machine illustrated in the accompanying half-tones is designed for work on beams and girders in bridge building. The levers, turning on a fulcrum, contain at one end the dies for forming the head of the rivet and at the other end are connected to a toggle joint; the center of the linkage being attached to the piston rod of a pressure cylinder. The arms are interchangeable, so that one set will straddle the edge of girders, while the other will serve to drive rivets in plates where several rows of rivets have to be driven and a protruding nose is required to reach them—a condition existing in the rivet work on some car trucks for which the present design has been found well adapted. Three machines

FIG. 1.—ALLEN PORTABLE PNEUMATIC RIVETER.

have been built for the Sterlingworth Railway Supply Co., to be used in close work on plates in their cars.

The pressure used on the machine is from 60 to 75 pounds to the square inch, and the arms are of sufficient strength to drive one-inch rivets. In consequence of the peculiar construction of the toggle joint, a small ten-inch cylinder will produce at the end of the stroke, or when the dies are nearly closed, a pressure upon the rivets of about fifty tons. The means employed for the suspension of the machine are conveniently arranged. The tool is attached to a suspension arm by a knuckle joint at the center of gravity and the whole apparatus may be turned to any desired position with great freedom. The advantage of this construction can be seen in the ready application of the tool to almost any position in which a rivet may be placed provided the gap of

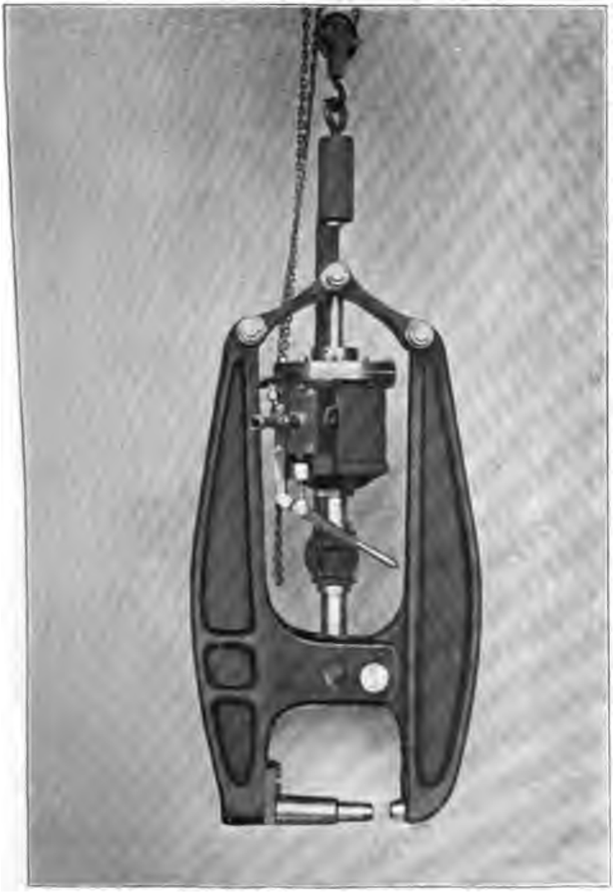


FIG. 2.—ALLEN RIVETER ARRANGED FOR VERTICAL WORK.

the machine will allow the dies to reach the ends of the rivet. The general adaptability of the device is thoroughly shown in the engravings where the one machine may be seen in various positions.

The weight of the tool under consideration is 1,250 pounds, and it is manufactured by John F. Allen, 370-375 Gerard avenue, New York.—*The Iron Trade Review.*

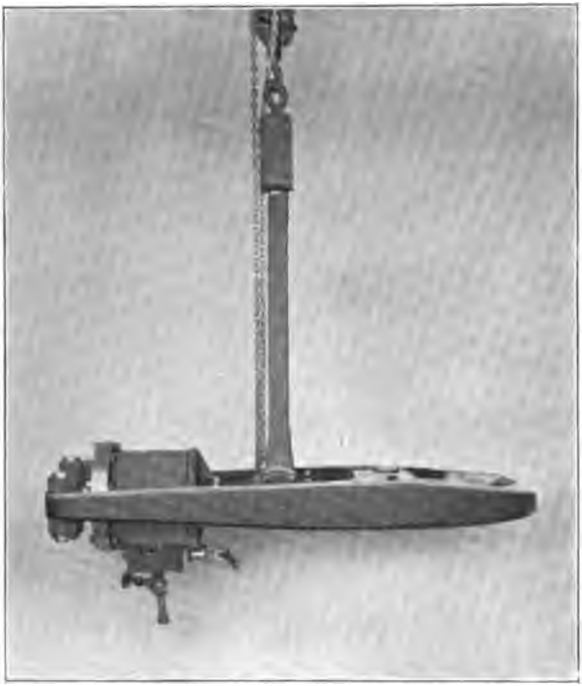


FIG. 3.—ANOTHER ARRANGEMENT OF THE ALLEN RIVETER.

Boiler Works Compressor Plant.

We give an illustration below of a compressor plant installed at the boiler works of S. Freeman & Sons, Racine, Wis., by A. J. Fisher, of 50 South Clinton street, Chicago. It has a capacity of 300 cubic feet of free air per minute and is of 10-inch bore and 42-inch stroke. The compressor is attached to an E. P. Allis Corliss engine 26x42 inches and operates tandem fashion, furnishing air for operating pneumatic tools and a thr ton pneumatic elevator. No changes w made on the engine except the rec struction of a new back cylinder he suitable to receive the compressor. T back cylinder head was fitted with a st fing box to receive the piston rod of t compressor and the head was drilled a tapped to attach the two tie rods wh hold it firmly in position. No foundation was necessary except enough to carry the weight of the compressor.

The piston rod of the compressor is screwed into the piston of the engine operating in unison and in a direct line. The compressor is supplied with an automatic unloading and regulating device that regulates the air compression accordingly as the air is consumed. This feature makes it a very economical and effective machine, as no air is compressed unless the receiver pressure falls below

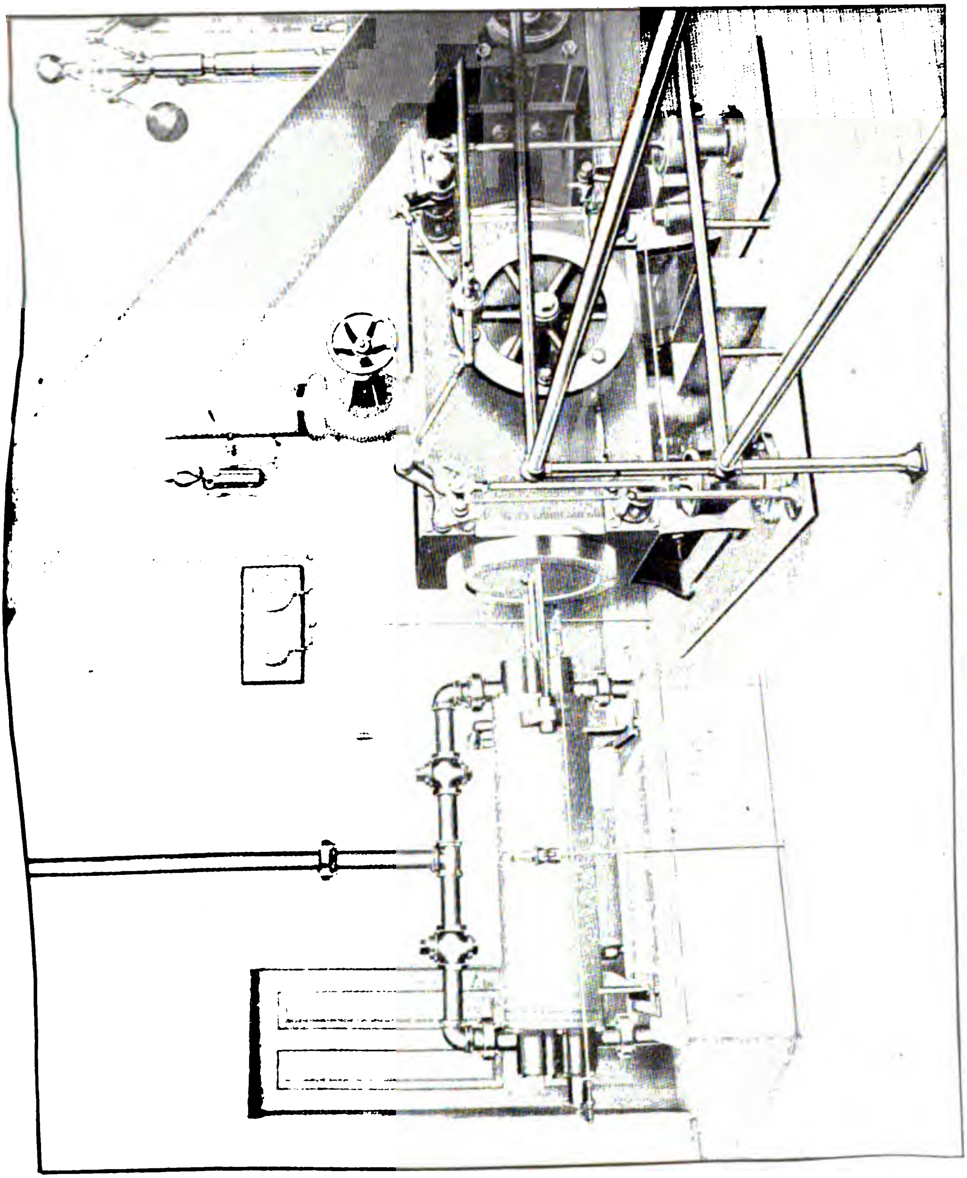
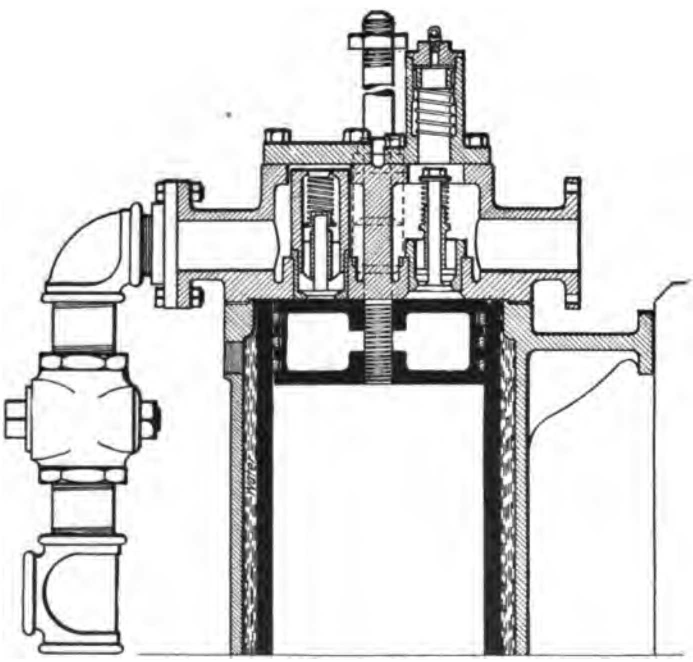


FIG. 1.—FISHER COMPRESSOR ATTACHED TO CORLISS ENGINE.

the point set on the regulator, the result being a saving of fuel. The air cylinder is thoroughly cooled by a water jacket and the compressor is so arranged that a free air supply can be piped from the outside of the engine room.

The capacity of the compressor can be increased or decreased by a simple change in the diameter of the inner cylinder and piston. For instance, if the bore is five inches in diameter and the stroke inches, the capacity may be increased removing the five-inch cylinder and s stituting one that is 10 inches. No chai is required in either of the valves, c inder heads or water jacket. This chai can be quickly made and at a nomi cost. Their construction will be und stood from the section elevation, Fig. 2 *The Iron Trade Review.*



SECTIONAL VIEW, FIG. 2—AIR COMPRESSOR CYLINDER, SHOWING VALVES IN DETAIL.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

One of our correspondents writes us as follows:

Editor COMPRESSED AIR:

"Do users of air compressors encounter any difficulty from deposits of scale, etc., in the water jackets, and what means are resorted to for removing such deposits, if they occur?"

In answer to this we may say that the question is purely one of the character of water used for jacket cooling. Any water which will cause a scale or deposit in a boiler will certainly cause a deposit in the jacket of a compressor, but, of course, to a less degree, as the formation of scale is dependent to a considerable extent upon the degree to which the water is heated.

If it is possible, use the water you employ in your boilers. In cases where this cannot be done and ordinary well water or water rich in lime must be used, it is well to wash out the jackets at frequent intervals, using for this purpose a jet of hot water.

In extreme cases, and especially where the formation of deposit is rapid, the cover plates can be taken off and the inside of the jackets scraped while being washed down with a jet of hot water. In some instances the formation of scale or deposit cannot be prevented, and when this is found to be the case the only remedy is to scrape the jackets as far as possible and continue running until the jacket becomes clogged and the flow of water prevented, when the cylinder can be removed and sent to the factory for overhauling. Or, if means are at hand the cylinder liner can be taken out, cleaned and put back. In this, as in other matters, "An ounce of prevention is generally worth a pound of cure," and in extremely bad cases filtration or some such means can be employed to advantage.

Notes.

H. H. Stoek, editor of *Mines and Minerals*, has been elected president of the Engineers' Club of Scranton, Pa.

It is reported that the Chicago Pneumatic Tool Company has absorbed the Standard Pneumatic Tool Company of Aurora, Ills.

The Pneumatic Crane Co., Pittsburg, Pa., has sent us a copy of an attractive little pamphlet describing its self-traveling trolleys. Size, 6⅜x3½ inches.

So far there is no determined limit to the distance that compressed air can be carried. Air has been utilized at a distance of five miles from the compressor.

The C. H. Shaw Pneumatic Tool Company, C. H. Shaw, proprietor, Denver, Col., who for the past three years have been engaged in the manufacture of pneumatic hammers, have been incorporated under the same name with a capital stock of $50,000.

At a depth of 20,000 feet the air would have such compression because of its own weight that a temperature of 60 degrees F. at the mouth of the shaft would be near 300 degrees at the bottom. A depth of 10,000 feet is probably the limit of deep mining.

We have received an illustrated circular from M. H. Treadwell & Co., 95-97 Liberty street, devoted to descriptions of the various types of wooden freight cars manufactured by this concern, who succeed the Lebanon Mfg. Co., of Lebanon, Pa. They will gladly send this upon request.

It is quite an uncommon occurrence when a well equipped railroad yard can not boast of an air compressing plant for cleaning and other purposes, and we find that the New York Central & Hudson R. R. R. Company's power plant at Albany, N. Y., which they have recently equipped, is no exception to the rule, they using this power for the cleaning of cars and for air brake testing.

According to *Popular Science Notes,* the Montreal Board of Trade has lately had on exhibition a model for a contrivance to brake ships, so that they can be stopped almost instantly in case of threatened collision, or when a person falls overboard. The device consists of two or more doors on each side of the ship beneath the water line, attached outside to the sheathing and opening outward. The doors can be operated by electricity, steam or compressed air.

A site is being surveyed by the American Car & Foundry Company at Berwick, Pa., for the new plant to be erected at that place for the manufacture of steel cars. The main building will be 200 by 700 feet, which, with annexes, will cover about 200,000 square feet of ground. The building will be of steel and brick construction, and will be equipped throughout with electricity and compressed air. The new plant will be located north of the rolling mill and wheel foundry.

The Blanchard Machine Company, 16 Harcourt street, Boston, sends a little pamphlet devoted to the Blanchard air compressor. The principal feature of this compressor is that all the working parts are enclosed and are oiled by the splash method of lubrication, the same as in various new types of high-speed engines. The machines are also provided with valves of a new design, which do not pound on the seats, being air cushioned at the ends of the stroke. The catalogue is 6x3½ inches, standard size.

The Stehn Manufacturing Co., Sheboygan, Wis., builder of engines, air compressors and machinery, is crowded to the limit with orders from foundries for air compressors and for its automatic sand blast apparatus which it recently placed on the market. The latest plant equipped with this sand blast apparatus was that of the Rundle Mfg. Co., Layton Park, Milwaukee, Wis., who report they have been able to clean, in some cases, four times the amount of castings that could be cleaned by hand.

The Sullivan Machinery Co., of Claremont, N. H., and Chicago, Ill., have established a branch office at 306 St. Louis street, El Paso, Texas. This extension was rendered necessary by the increased business of this firm in the southwest and Mexico. It will be recalled that the already extended business of the Sullivan Machine Co., has recently been augmented by the purchase of the entire plant and equipment of the M. C. Bullock Mfg. Co., of Chicago, and the capacity of this latter plant is now being doubled by the addition of large erecting and machine shops.

The new Chamber of Commerce building stands on the corner of Liberty street and Liberty place, New York, and is conspicuous in the district of the 22-story office buildings for being only four stories high. The contractors for the structural steel work were Messrs. J. B. & J. M. Cornell.

Pneumatic hammers were used in this work, the compressed air being furnished by an Ingersoll-Sergeant compressor with a capacity of 210 cubic feet per minute. The receiver had a 2½-inch pipe with two 1¼-inch rising lines; these were each fitted with four ¾-inch valved outlets for hose connections which supplied three Chicago Pneumatic Tool Company's hammers and one Little Giant reamer.

The Philadelphia Pneumatic Tool Co. have let the contract for their new plant (previously mentioned in these columns) to J. E. and A. L. Pennock; ground has been broken and active building operations started. This company report a very favorable condition of business, the shipments for export to England and the Continent having been particularly large, and a decided increase has been noted from this market as well as from the domestic field. Numerous shipments of pneumatic tools are also to be noted for various shipyards and large steel works. The Philadelphia Pneumatic Tool Company have recently established an agency for the Pacific Coast, Berger, Carter & Co. 320 Market street, San Francisco, Cal., being their representatives.

The Pneumatic Railway Signal Company, Beckley Building, Rochester, N. Y., recently organized, will take over the Pneumatic Railway Signal Company and the International Pneumatic Railway Signal Company, two corporations organized under the laws of West Virginia, and the Standard Signal Company of Troy, N. Y. The Standard Company have been for several years manufacturing railway signal devices, and for the past three years have been the installing agent of the system of low pressure pneumatic interlocking signals, covered by patents owned by the Pneumatic and International Pneumatic Railway Signal companies. The new company will continue the operation of the Standard Company's plant at Troy. J. N. Beckley is president.

The Standard Pneumatic Tool Co. have appointed Mr. J. B. Wilson, formerly connected with the mechanical department of the Grand Trunk Railway, manager of their new Canadian offices, which have just been opened at 103 Union Station Arcade, Toronto, Ontario, at which place they will carry a full line of their "Little Giant" Pneumatic Tools and Appliances, repair parts and accessories.

In the future all machines for Canadian customers will be shipped direct from their Toronto office, thereby saving purchasers the inconvenience of making out manifests and paying duty.

Their business in Canada has greatly increased during the past few months, and the outlook is very encouraging.

At the construction of the Aspen-Wyoming tunnel on the Union Pacific R. R.. air drills were used for both headings and the shaft, and, rather amusing to say, for the "steam" shovels also. The plant was located about 3,000 feet outside of the east entrance to the tunnel, and consisted of three piston inlet air compressors, one of size 24 ins. and 24¼ ins. by 30 ins. stroke, and one of 22 ins. and 22¼ ins. by 24 ins. stroke, all with a combined horse power of nearly 600. The air is conveyed as far as the mouth of the shaft in a 6-in. main, and from here to the west end in two 3-in. mains. At points where the pipe is tapped to draw off a portion of its supply, a small reservoir is placed to equalize the pressure whenever there is any sudden draft.

The Cambria Steel Co.'s new works are situated near Franklin, on the left bank of the Conemaugh River, a short distance from Johnstown, Pa. The power plant, furnishing electric power and compressed air to all portions of the new works, is located in its own group of buildings near the structural plant. It contains four 400-kw. Westinghouse 200-volt generators, each being directly connected with a compound condensing Southwark engine. The engine room further contains four air compressors capable of delivering 1500 cubic feet of air per minute; also an expansion pump of 500 pounds pressure for operating the shears in the beam yard. The boiler house contains four Babcock & Wilcox 300 horse-power boilers fitted with Murphy automatic stokers.

The Ripley Hardware Co., Grafton, Ill., are offering an improved compressed air glass jar hand sprayer. The operation of the sprayer is described as follows: The air is forced into the reservoir by pumping, in the same way as with any sprayer. The reservoir has a brass discharge tube, extending to the bottom and an air tube at the top, which allows the air to blow the solution out in the form of a continuous fog mist on all parts of the foliage. It is stated that it will spray in any position, including overhead. One filling of a 1 quart jar, it is explained, will spray 500 hills of potatoes, thus saving half of the usual time and labor. A 1 or 2 quart Mason glass jar will fit the sprayer. It is pointed out that nothing but the best material is used in the construction of the sprayer, and that leather washers are used on the jar, which are the best for use when spraying oily solutions.

A pneumatic tube system for delivering parcels is in successful operation in Boston. From the main station at Essex street and Harrison avenue, in the retail store district, parcels are sent 1½ miles to the "Back Bay" station and one mile to the "South End." There are two lines of common cast-iron pipe 10-in. in diameter. These are not bored out, but the joints are carefully smoothed and laid like water pipe. The carriers run on five small wheels at each end which have stood service tests of more than 8,000 miles. With this construction no packing is required, and this is the greatest improvement embodied in this application. Very simple transmitters and receivers are used and a pressure of 2 lbs. per square inch is sufficient to give a speed of 30 miles per hour. Air power is supplied by a motor-driven 24 by 12 in. Rand compressor. From descriptions already published, this appears to be a distinct advance over previous pneumatic transmission methods.

In our February number there was illustrated and described in detail a powerful pneumatic forging machine in use at the Burnside shops of the Illinois Central R. R., which has attracted considerable attention and comment. In connection therewith it is interesting to note a very powerful bull-dozer, operated by compressed air, which is in use at the McKees Rocks shops of the Pittsburg & Lake Erie Railway. This forging machine is fitted with tandem cylinders, each 30 inches in diameter, placed on a horizontal frame made up of two 16-inch beams. The piston rod or plunger arm is 5 inches in diameter, and with 100 lbs. air pressure in the reservoir, the cylinders being placed in tandem, a working or effective pressure of about 70 tons can be exerted. The arrangement is such that either cylinder can be cut out so as to use the pressure from a single cylinder for light work, in order to economize in the use of air, or both cylinders can be operated when greater pressure is desired for heavy work. The forms and tools which have been devised for use with the machine permit of performing a great number of the jobs required in locomotive, passenger or freight car forgings. The machine will upset 5-inch square iron when the latter is properly heated.

The water supply for the Central Heating & Lighting plant for the county buildings, Indianapolis, Ind., is obtained from an 8-inch well by means of an air lift. For this purpose there are two double-acting Rielly air compressors 14x14-inch steam cylinders and 12x14 air cylinders, arranged to maintain a working pressure of air of 75 pounds per square inch and operated under the control of a governor to maintain a constant water level in the receiving tank for the water. The air from the compressors is discharged into a receiver 36 inches in diameter and 5 feet long. This is constructed of flange steel having a tensile strength of 60,000 pounds, shell ¼ inch thick and dished heads ⅜ inch thick, and is tapped for a 2-inch connection to the air-pipe in the air-lift. The water receiver, which takes the discharge from the air lift, is 60 inches square and 6 feet high, and constructed of ¼-inch steel. The well is about 500 feet deep and the water level when pumped at the required rate is at the greatest about 50 feet below the level of the basement floor. The capacity of the air life system is about 500 gallons per minute under these conditions. The suction to the water pumps is taken from the bottom of the water receiving tank, both for the water supply and the boiler-feed pumps. The water supply pumps are equipped with the Fisher Pump governor, selected large enough for both pumps.

At the main shops of the Cincinnati & Southern Ry. at Ludlow, Ky., the principal feature of interest is the extent to which compressed air is used in connection with the various shop tools, etc. It is used for air hoists over the machine tools, etc., for air riveters (by pressure, not hammering), for painting cars and for operating the transverse table in the yard. It is also applied to a yard-testing plant for testing the brakes after trains have been made up. A large Ingersoll-Sergeant compressor is used, and the air pipe line carries a pressure of 100 lbs.

The Cincinnati Southern Ry. is of peculiar interest historically in that it is a municipally owned line, having been promoted and built by the city of Cincinnati, Ohio, for the purpose of connecting that city with Chattanooga, to connect with the Southern systems of railways. There were originally 27 tunnels in the road, varying from 189 feet to 3,984 feet in length, but the last one of the line, near Emory Gap, has given so much trouble, the disintegrated shale rock having slipped at one time and crowded in the timber lining (although the lining was exceptionally heavy) that it was found necessary to build a new line. This new line swerves off to the southeast, skirting the ridge pierced by the tunnel. The contract was let to M. J. Condon & Co. of Knoxville, Tenn., and was completed in 1901. When rock was reached compressed air drills were used with steam derricks for loading the dump cars.

The Delaware, Lackawanna & Western R. R. have recently designed a snow plow capable of turning around directly on the track, and plowing back again over the same ground. This is done by means of a turntable arrangement self-contained with the car for turning the plow end at any point on the main track, without having to use a stationary turntable or one such as is in ordinary service for turning engines. This plow was completed during the early part of the winter.

The manner of turning the plow is simple. There is a turntable track about three feet in diameter attached to the front truck of the car, and at or near the centre of the car there is a bolster with a centre bearing to fit the truck and six 8½ inch wheels arranged in a circle to bear upon the turntable track. In order to turn the plow the front end of the car is raised by means of compressed air cylinders, to clear the forward truck, which is then rolled back under the centre bolster or bearing. The weight of the car is then supported by the truck under the centre, the rear truck hanging to the car body. The turntable device being then located at such a point that the car body is balanced over the centre truck, the plow is turned by pushing it around with a couple of men.

The arrangement for hoisting the front of the plow clear of the truck at that end is a 12-inch air cylinder on each side of the car, opposite the centre of the truck. It is a downwardly acting piston, which takes a bearing on blocking placed on the ends of the ties. We are informed that this arrangement for lifting the cars by air was worked out in the company's shops at Scranton, Pa.

Various systems of independent motor cars, operated by steam, compressed air or oil engines, have been experimented with at different times. In 1899 a motor car of generally similar type was built by the Vimotum Car Co., of Chicago, and tried on the Pennsylvania lines, at Indianapolis, but this never got beyond the experimental stage. The car resembled those used on interurban electric railways, and was 41 ft. 6 ins. long, and 8 ft. 6 ins. wide, mounted on a pair of four-wheel trucks with 33-in. wheels. The front end of the car was supported by a steel bolster supported by the outside frame of the truck. On the forward truck (and within the car) was mounted a 45-H. P. Wolverine vertical three-cylinder gas engine, belted to a countershaft, while a second countershaft carried a pinion which engaged with a spur wheel on the front axle. Each countershaft had a pulley of variable diameter, connected by a stiff belt, this arrangement forming the Reeves variable-speed transmission system. The machinery was supported on an inside frame of the driving truck. The car carried a water tank for the circulating system of the cylinder jackets, and was fitted with the Christensen air brake. It weighed about 22 tons, and was designed for a speed of 25 miles per hour, although it attained a speed of 40 miles an hour on a trial trip. Nothing came of this, but the company has since been working on a steam car, having a triple-expansion marine engine to drive a similar transmission system. The Compressed Air Co. of New York was at one time working on plans for a large car to operate on suburban service as a main line of railway, but no such car has been put in service.

A correspondent of the *Engineering and Mining Journal* writes: The success which has attended the application of the chlorination process to the extraction of gold from the Cripple Creek ores has stimulated the efforts of the friends of cyanide as a solvent. Among the several new ideas or applications of well known principles in order to simplify and perfect the cyanide process, is that of the agitation of the solution, and the oxidation of the contents of the leaching tank. Among these methods is that patented and applied by the Pneumatic Cyanide Process Company, with headquarters in Denver, Col.

That all solutions are expedited by agitation is an axiom in all chemical and industrial processes. Accepting this fact, this company also claims that agitation by means of air currents not only hastens the action, but that the oxygen of the air is an important factor in supplementing the simple agitation or stirring of the mass.

To accomplish this latter result, currents of air are injected into ordinary tanks through perforated pipes that rest on the burlap or canvas filters at the bottom. The injection of the air current is continuous with the introduction of the solution and pulp. By this means it is claimed that a gentle agitation causes the heavier and coarser grains to seek the bottom, and thus the slimes, which are the bane of all these percolation processes, are kept in suspension until the latest moment. When the discharge valves are open the air currents are still operated, though under a decreased pressure, and by the gentle stirring of the lower layers of sand it is claimed that the solution can be drawn off in a much quicker time and in equally good shape as by the simple filtration. A new mill employing this method has lately been installed on the Gold Standard Mine at Idaho Springs.

The St. Louis, Iron Mountain & Southern Railway Company's bridge across the Arkansas River at Little Rock, has several fixed through spans and one swing span, built in 1884-85. The piers are of stone masonry on timber caissons sunk to rock, about 45 feet below the low-water line. After the pier was built the sand commenced to wash out under the caisson, especially at high water, so that the pivot pier and one other pier soon began to lean upstream, and in 1898 this became so much exaggerated that it was determined to try to stop farther displacement of the pivot pier by building a new caisson around the old one and work was immediately started with this object in view.

The caisson was lowered at the rate of about 1 foot per hour by about eighty men, three being stationed at each screw to slack off the nut with a wrench 5 feet long, moving a quarter turn at once, by signal. The walls of the cofferdam were built up and the caisson lowered until the cutting edge rested on the sand at the highest point of the river bottom. The surface of the sand was so irregular that the water was 4 or 5 feet deep under the cutting edge at some points, and was filled in at these places by abo[ut] 12,000 bags of sand, carefully dumpe[d] close to the caisson to build up a sup[-] port for the cutting edge. The bags wer[e] made of burlap and contained about o. cubic feet of sand each, as much as a ma[n] could conveniently carry. By this mean[s] all but about 40 feet of the 460 linea[r] feet of cutting edge was supported at [a] distance of 35 feet below the surface o[f] the water.

Sand was filled in the cofferdam to [a] depth of about 4 feet above the roof o[f] the working chamber, and air at a pressure of 15 pounds was pumped throug[h] 1,200 feet of 4-inch pipe from two com[-] pressors on shore. The sand was excavated and was discharged through 4-inch pipes by both the wet and the dry blow-off. Many old piles were encountered and were removed piecemeal by dynamite. The air pressure was blown out to reduce it 10 or 15 pounds at intervals, when the caisson was sunk. The caisson was sunk into the solid rock at all points and concreted and filled in the usual way. The surface of the rocks was very irregular, varied from very soft to very hard, and was blasted with dynamite. It was removed in buckets of 20 cubic feet capacity, which were operated by a derrick on a barge alongside and could make a round trip about once in five minutes. The space between the old and new caissons was filled with concrete to a height of 30 feet above the cutting edge, and all farther scouring, settling or tipping of the pier has thus been prevented.

U. S. PATENTS GRANTED JAN. 1902

Specially prepared for COMPRESSED AIR.

690,468. AIR-BRAKE VALVE MECHANISM. Edward G. Shortt, Carthage, N. Y., assignor to International Air Brake Company, Jersey City, N. J., a corporation of New Jersey. Filed March 11, 1901. Renewed Oct. 18, 1901. Serial No. 79, 111.

690,630. ROCK-DRILL. Arthur C. Bates, San Francisco, Cal. Filed April 6, 1901. Serial No. 54,759.

A rock-drill a machine-casing having a forward and rear chamber, said forward chamber inclosing parts of its mechanism and said rear chamber being provided with vents for admitting air therein, a plunger provided with a recess for inclosing a spring to drive it forward and having a flange or head at the mouth of said recess adapted to fit closely against the walls of said rear chamber so as to permit of the formation of a cushion of compressed air between said flange or head and the forward inclosed part of said rear chamber surrounding the recessed portion of said plunger slidable therein, in combination with a cam-wheel having two parts for successively forcing back said plunger and compressing said spring and suddenly releasing the same, and having spurs on the rim thereof to act in conjunction with pockets in said plunger opposite thereto for twisting the same, a cam adapted consecutively to act upon and release a feed attachment provided with a pawl arranged to engage the teeth of a ratchet wheel attached to a feed-screw for the forward movement of the machine.

690,675. DESPATCH-TUBE. Fred R. Taisey, Indianapolis, Ind., assignor to The Taisey Pneumatic Service Company, Indianapolis, Ind., a corporation of Indiana. Filed May 9, 1901. Serial No. 59,520.

690,681. APPARATUS FOR CARBURETING AIR. Paul R. Van der Made, Breukelen, Netherlands. Filed July 16, 1901. Serial No. 68,488.

690,687. ROCK-DRILL. Alvin M. Ballou, Denver, Colo. Filed May 6, 1901. Serial No. 58,916.

An electro-mechanical rock-drill, the combination of a driving-wheel 6, having holes, a disk provided with loose tapered keys and with springs holding said keys in said holes, and a shaft, upon which said wheel is loose and upon which said disk is mounted with friction-rolls for permitting rotation in one direction and not in the other, a motor for driving said wheel, a crank on said shaft, and a plunger for holding a bit connected up with said crank against the resistance of the spring.

690,706. PNEUMATIC-TIRE PROTECTOR. Clarence G. Dinsmore, Staatsburg, N. Y. Filed April 18, 1901. Serial No. 56,389.

690,744. AIR-CONDUCTING TUBE. Francis Line, Cleveland, Ohio. Filed June 27, 1899. Renewed Nov. 4, 1901. Serial No. 81,054.

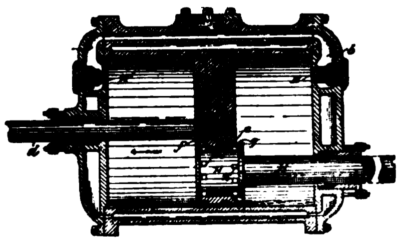
690,894. PNEUMATIC-DESPATCH-TUBE CARRIER. Albert W. Pearsall, Mount Vernon, N. Y. Filed April 3, 1901. Serial No. 54,208.

A carrier or receptacle comprising inner and outer sections pivoted eccentrically with respect to one another.

690,935. PNEUMATIC TIRE. Alfred Ducasble, Paris, France. Filed Feb. 28, 1901. Serial No. 49,199.

691,034. PNEUMATIC FEED-CONVEYER FOR FEED-CUTTERS. Edwin C. Wilharms and Adolph J. Wilharms, Greenleaf, Wis. Filed May 6, 1901. Serial No. 59,017.

691,042. PISTON-VALVE FOR AIR-COMPRESSORS. Burtwin L. Brinton and William P. Brinton, Bradford, Pa. Filed April 23, 1901. Serial No. 57,073.



An air-compressor or analogous apparatus, a cylinder, a piston working in said cylinder, a piston-rod rigidly connected to the piston for operating the same, a valve traveling with and moved by the piston but having a limited movement in an opening therein whereby the position of the valve is changed at each reversal of the direction of travel of the piston, and a hollow stem on and movable with the valve working through an opening in one end of the cylinder and adapted to communicate with the interior of the cylinder on one side or the other of the piston according to the position of the valve relative to the piston.

691,069. AIR-LOCK FOR CAISSONS. John F. O'Rourke, New York, N. Y. Filed Dec. 30, 1896. Serial No. 617,437.

An air-lock for caissons, comprising a shell convex at top and bottom and provided with end openings, a single gate for closing the bottom opening, the gate corresponding in shape to the shape of the shell, a pair of oppositely-arranged swinging gates to close the top opening, said gates being geared together so as to move in unison, counterbalances for the upper and lower gates, mechanism for working the gates, and means for admitting air to and exhausting it from the shell.

691,082. APPARATUS FOR MEASURING AIR CURRENTS. Joseph Thompson, Manchester, England. Filed Jan. 5, 1901. Serial No. 42,261.

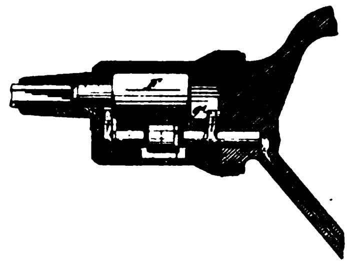
691,091. APPARATUS FOR PURIFYING PAPER-PULP. Albert Aberg, Hermagor, Austria-Hungary. Filed March 23, 1901. Serial No. 52,564.

691,278. COMPRESSED-AIR WATER-ELEVATOR. John L. Latta and James A. Martin, Hickory, N. C. Filed Oct. 20, 1898. Renewed May 25, 1901. Serial No. 61,951.

A liquid-elevating apparatus, the combination with liquid-chambers provided with valved inlet-ports, and a communicating liquid-conveyor, of valve mechanism including separate pressure-chambers, in communication, respectively, with the liquid-chambers, a rocking valve having inlet and exhaust ports in communication with said pressure-chambers, means controlled by the level of liquid in the liquid-chambers, for causing an initial movement of the valve, when the contents of the liquid-chamber have been partially discharged, and a counterbalancing device connected to and movable with the valve, and having a plurality of independently-movable weights for successive movement as the valve advances to different positions to continue the movement of the same.

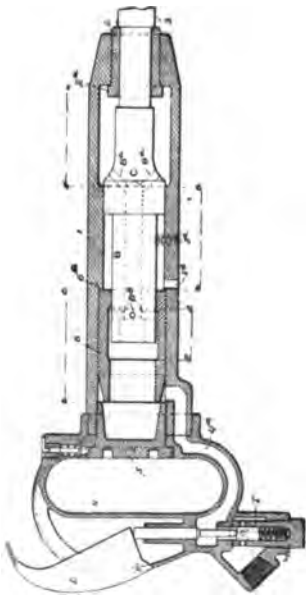
691,334. PNEUMATIC CUTTING-TOOL. John W. Birkenstock, New York, N. Y., assignor, by direct and mesne assignments, to the Empire Pneumatic Tool Company of the State of New York, N. Y. Filed May 7, 1901. Serial No. 59,140.

A pneumatic cutting-tool, consisting of a cylinder, a recessed handle suitably attached to said cylinder, a valve for admitting air under pressure, a lever for operating said valve and located in the recess of said handle, a piston in the cylinder, provided with a hammer for actuating the tool, a tubular slide-valve provided with lugs projecting into the path of the piston, ports for supplying com-



pressed air alternately to each end of the cylinder, and suitable outlet-ports.

691,420. MOTOR-FLUID-OPERATED TOOL. Henry H. Vaughan, Chicago, Ill., assignor to Ridgeley and Johnson Tool Company, a corporation of Illinois. Filed March 19, 1901. Serial No. 51,828.



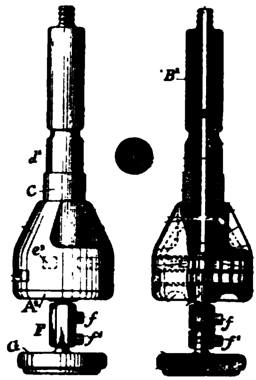
A constant-pressure motive-fluid-operated tool, the combination with a suitable cylinder having an exhaust-port for that end of the cylinder which contains the greater head of the piston, of a differential piston having through-ports which are radially disposed at or adjacent to its lesser head, and means for maintaining constant pressure of the motive fluid on the lesser head of the piston in the direction of the tool.

691,556. ROCK-DRILL. Herman Leineweber, Chicago, Ill., assignor to L and L Pneumatic Tool Company, a corporation of Illinois. Filed May 27, 1901. Serial No. 62,120.

A rock-drill, the combination with a support of a drill-holding shaft, a fluid-pressure-actuated drill-hammering device on the forward end of the shaft, a casing on the opposite end portion of the shaft slidingly mounted on said support, a fluid-pressure-actuated shaft-turning rotary motor in said casing, a feed-screw upon the shaft, a friction-clutch between said shaft and feed-screw, and an adjustable feed-screw engaging and releasing sectional nut on the support for advancing the rotating feed-screw and shaft.

691,726. PNEUMATIC PICKER FOR LOOMS. Josef von Miniszewski, Petrikau, Russia, assignor of one-half to Theofil von Mohl, Wyszki, Russia. Filed Oct. 21, 1899. Serial No. 734,394.

691,740. PNEUMATIC POLISHING-TOOL. John W. Birkenstock, New York, N. Y., assignor, by direct and mesne assignments, to the Empire Pneumatic Tool Company, New York, N. Y. Filed Feb. 25, 1901. Serial No. 48,777.

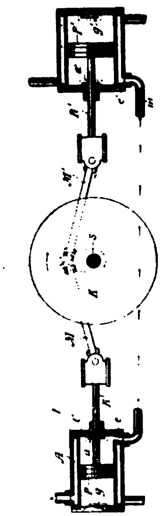


A pneumatic grinding and polishing tool, consisting of a tubular spindle for the compressed air, a casing attached to the lower end of said spindle, a paddle-wheel in said casing, having a shaft journaled at the lower end of said spindle, air-supply channels in the spindle and casing for supplying air to diametrically opposite sides of the paddle-wheel, outlet-ports in the casing adjacent to the supply-channels, reversing means for supplying air to one or the other of said supply-channels, and a polishing or grinding tool attached to the lower end of the shaft of the paddle-wheel, so that the spindle-shaft and tool are aligned.

691,862. PNEUMATIC CAR-SPRING. Paul Herpolsheimer, Seward, Neb. Filed March 28, 1901. Serial No. 53,279.

A car-truck, the combination with spaced bolster-plates of sustaining-springs disposed between the plates and lying flat thereon, each spring consisting of an endless hermetically-sealed tube, brace-plates secured to the front and rear edges of the upper bolster-plate and having slots in their lower ends, and bolts passing through the slots and into the front and rear edges of the under bolster-plate.

691,788. COMBINED AIR AND EXPLOSIVE ENGINE. Robert Lundell, New York, N. Y.; assignor of one-half to Charles J. Kintner, New York, N. Y. Filed March 29, 1900. Serial No. 10,634.



A compound engine having a high-pressure and a low-pressure cylinder and pistons located therein, said cylinders being provided with gas-ports for admitting an explosive gas against the full free faces of the pistons and additional ports for admitting a gas under pressure against the other faces thereof, the cylinders being so interconnected that the gas under pressure as it leaves one of them is admitted at lower pressure as it enters the other.

691,936. PNEUMATIC - DESPATCH - TUBE SYSTEM. Edmond A. Fordyce, Chicago, Ill., assignor to Arthur S. Temple, trustee, Boston, Mass. Filed Sept. 20, 1901. Serial No. 75,942.

692,015. PNEUMATIC SWITCH AND SIGNAL. John W. Keeney, Coalburg, W. Va. Filed Dec. 31, 1900. Serial No. 41,651.

The combination with a compressor; of a bellows, a pipe connection between said compressor and bellows, a strip connected to the bellows, and formed with a double inclined lug, a forked bar adapted to receive the strip and formed with notches, said strip being movable a short distance independently of the bar, a switch connected to the bar, and a pivotally-supported locking-bar adapted to engage the notches in said bar and the lug of the strip.

692,184. PNEUMATIC BARKER. Charles R. Kline, Beechwood, and Julius Keller, Philadelphia, Pa.; said Keller assignor, by mesne assignments, to said Kline. Filed April 29, 1901. Serial No. 57,882.

A pneumatic barker, a casing, a pneumatic motor in the upper portion of said casing, a cutter in the lower part of said casing, the latter being open at its lower portion, and shaped so as to form a hood for said cutter, and power-transmission devices intermediate said motor and cutter.

692,194. PNEUMATIC MOTOR. Charles L. Davis, Chicago, Ill., assignor, by direct and mesne assignments, of one-half to August Heuer, Jr., Charles A. Brown, George L. Craig, and A. Miller Belfield, Chicago, Ill. Filed Dec. 17, 1900. Serial No. 40,141.

A pneumatic motor, the combination with a bellows, of a passage communicating therewith, an exhaust-passage, a passage connecting the bellows-passage and exhaust-passage and communicating with the latter by way of a port formed at the end thereof, the said connecting-passage having an air-port, and valve mechanism controlling the port of the exhaust-passage and the air-port of the connecting-passage.

692,202. PNEUMATIC MOTOR. Charles R. Kline, Beechwood, and Julius Keller, Philadelphia, Pa. Original application filed April 29, 1901, Serial No. 57,882. Divided and this application filed July 6, 1901. Serial No. 67,281.

A rotary engine, a casing, a piston-chamber therein, a rotary piston therein, said piston consisting of a cylinder, having diametrical plates at the opposite ends thereof, journals projecting from said plates and having their bearings in said casing, a sliding blade having its ends seated in said plates and its sides provided with packing devices, and a plurality of rollers arranged in pairs within said piston between which rollers said blade passes, in combination with a plurality of chambers located in said casing in opposite portions thereof, said chambers having ports leading therefrom to said piston-chamber, and said chambers and ports being adapted to be utilized as inlet or exhaust for the motive fluid according to requirements.

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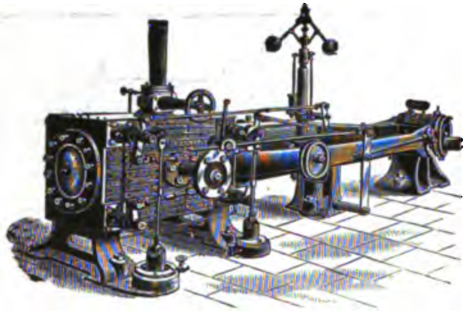

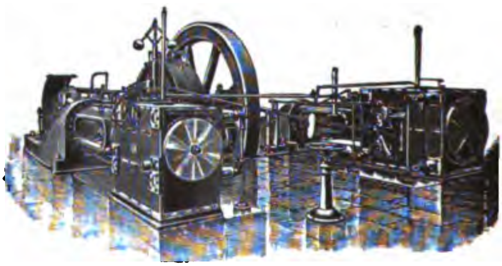

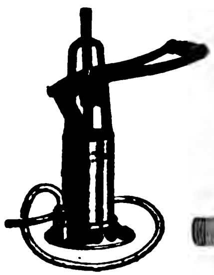

GLEASON-PETERS
No 216

Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, APRIL, 1902. No. 2.

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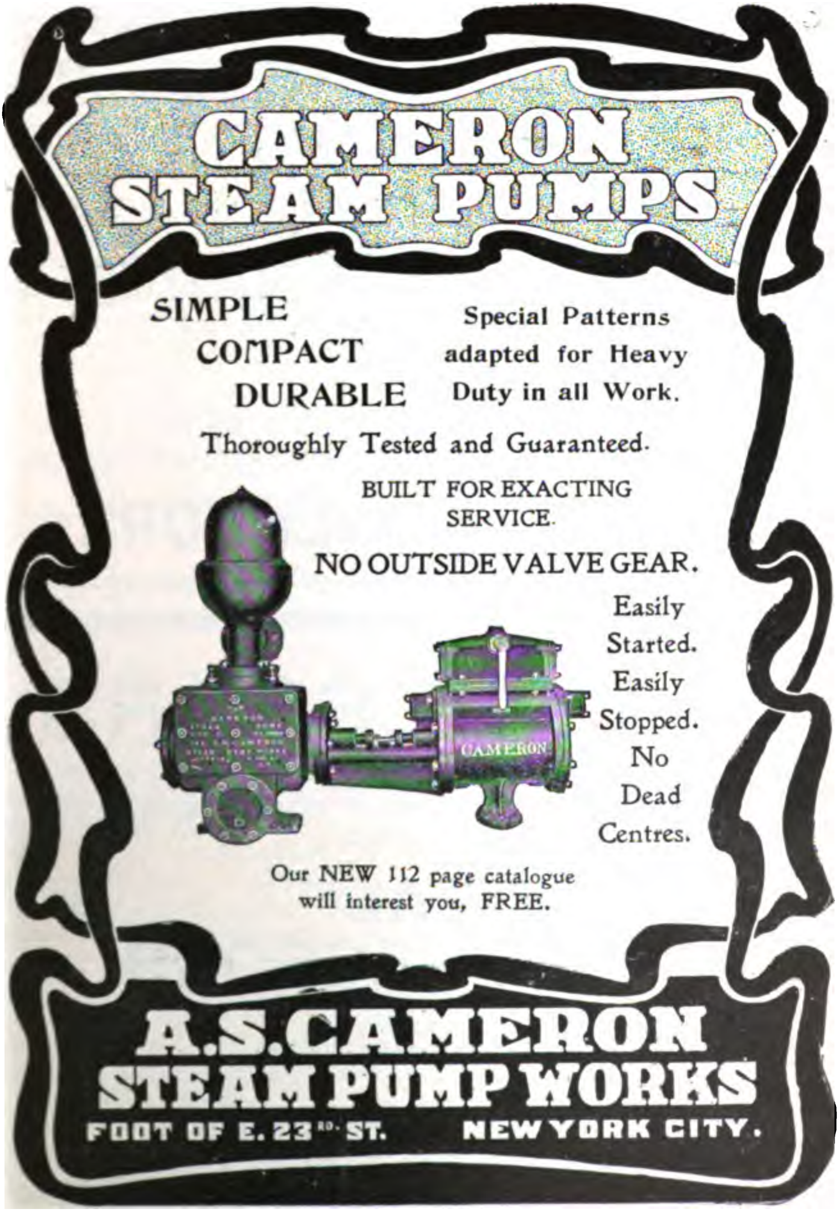
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VOL. VII. APRIL, 1902. NO. 2.

Elsewhere in our present issue we publish a table and some descriptive matter on the yield of air compressors which is largely an abstract of a treatise of mine working recently published in Paris. We publish this table since it is practically the first general comparison of several of the prominent makes of compressors, especially foreign compressors, which has come to our attention. At the same time we must caution our readers against placing too much dependence in the figures, as the conditions of operation are not specified and these have a great deal to do with the showing which any one of the machines would make.

The figures are of interest, however, in that they show to a large degree how nearly alike jet cooled and jacketed cooled compressor cylinders are. Early American practice was identical with foreign made compressors in that this water injector for cooling the air during compression was employed. It is unquestionably true that air compressor practice has developed more rapidly in the United States than elsewhere, certainly if we accept a few isolated cases, such as the compressed air plant in Paris and the air system of one of two of the large mines.

It is also interesting to know that American manufacturers have without exception abandoned the water injector for cooling the air and have adopted the water jacketed cylinder and two or three stage compression with efficient intercoolers between the cylinders. The reasons for this change are not sentimental, but rest on the firm foundation of extensive practical experience.

If a large volume of air is required either a large slow speed engine can be employed or a small high speed compressor. As a general rule, consideration of space has demanded compactness and it has been found easier to obtain a quantity of air by increasing the speed of the compressor. Another limitation in the case of injector cooling is the fact that the compressor to all intents and purposes becomes a species of pump and its operating speed is, therefore, closer to that obtained in pump practice.

Referring to the table this point is nicely brought out. It will be noticed that the foreign compressors, with a few exceptions, have a limiting speed of something less than 75, whereas the American machines operate at from 80 to 150.

We regret that the compiler of this table did not add another column giving the weight of the machine per cu. ft. delivered. In America we can speak with regard to the construction of air compressors with a complete knowledge, because of our experience with both types. Abroad we are inclined to believe that their knowledge is somewhat bias, as so far as we know, they have never done anything with jacket cooled air compressors and have adhered almost universally to the injector type.

The descriptive matter accompanying this table is, however, of interest since it explains this, we are tempted to say, one side view.

Compressed Air.

An Introduction of the Subject at the Annual General Meeting of the Canadian Mining Institute, by W. L. Saunders, of New York.

In introducing the subject of compressed air before the members of this Institute, I feel that I am addressing those who are not only interested in the subject, but through the discussion which will follow I hope to gain a good deal of practical information. To me compressed air has been a close study and a pleasant pastime for more than twenty years, and yet every time I attempt to climb up on a pedestal and pose as an expert, I see all around me things that I did not know. Though one of the oldest of the sciences, there is really less known about compressed air than about steam, hydraulics, or electricity, and however deeply we may dig into the theories of thermodynamics, we find every now and then a practical mining engineer who shows us by a little experience that the formula which has been guiding us is nothing but a cobweb without substance or strength.

I remember very well my first researches on the subject of compression. After learning what was meant by isothermal compression, it appeared very plain that a serious loss was suffered to take place in the cylinder of an air compressor by attempting to compress without injecting a spray of cold water into the cylinder during the process. All theories and most authorities taught me to advocate the "wet" type of compressor as distinguished from the "dry," and yet it is a fact that at the present time I do not know of a single builder who follows the wet process. It must not be inferred, however, that the importance of cooling during compression was overestimated. We have learned to cool by compressing in stages and have abandoned water injection because of its complications of apparatus, the inevitable destruction of wearing parts, and because it is not advisable to bring air and water together while the air is at a high temperature. The reason for this is that the capacity of air to take up moisture is in direct proportion to its temperature, and even with the most efficient system of spray injection it is difficult to start the compressed air on its journey to the mine at a temperature low enough to produce dryness. During the building of the Washington Aqueduct Tunnel a central air compressing plant was located at the foot of a hill. The transmission pipe leading up the hill to the shafts would at times become practically filled with water, which would be taken up and sent forward like a piston into the workings. It is interesting here to note that this difficulty was overcome by pumping fresh, cold water into the air receivers at the foot of the hill, thus condensing the moisture of compression. Dry stage compression actually gives as a pressure line more nearly the isothermal than was obtained by the injection process. In stage compression there are two or more air cylinders, each surrounded by water jackets. Intercoolers are placed between the cylinders, and in this way the air is alternately compressed and cooled until it is discharged into the receiver. By this process the air is maintained in a dry condition, and as it at no time reaches adiabatic, or the heat maximum of temperature, it is not "burned," but is delivered into the mine in a fresh and healthy condition. Too little importance is sometimes given by engineers to the intercooler. The common or cheap form of intercooler only partially serves the purpose, but the intercooler, which is composed of nests of tubes around which the air circulates, splits up the air into thin layers and as cold water passes through the tube these thin layers are rapidly reduced in temperature; so that with cold water, which I judge is not difficult to obtain in Canada, it is quite possible to obtain air temperatures in the intercoolers considerably lower than was the temperature of the air before it entered the compressor. This is an important point as affecting both the actual and the volumetric efficiencies of the air compressor. The theoretically perfect compressor is one which draws in air at a temperature of zero or lower and discharges it compressed at normal or outside temperatures. We must always bear in mind that during compression the temperature of the air at any stage depends upon its initial temperature, and that the higher the initial temperature is the higher will be the temperature throughout the process of compression. This is not a theoretical but a practical question, which concerns those who are engaged in the every day practice of air compression. Engine rooms are usually warm and dirty places from which to draw a supply of air for the compressor. Hot air means thin air, and thin air drawn into a compressor means a low volumetric efficiency. The mine owner who pays for an air compressor of a certain size naturally wants to get out of it all the compressed air he can. He should, therefore, see that the compressor draws air from outside the engine room and from the coldest spot on the property. He should also see that his compressor is provided with a thorough system of cooling, because no matter how cold the air may be, when it goes into the compressor, it is sure to warm up by the action of the piston. This warming up process causes the air to expand and to resist the act of compression in degree directly in proportion to the increased temperature, that is, the hotter it is the harder it is to compress the air and the more power is consumed for a given volume. To express this in figures we find that when air is compressed in a single stage machine from atmospheric pressure and 60° Fahrenheit temperature to 80 pounds gauge pressure, the maximum theoretical loss due to increased resistance through heat is about 33 per cent. when represented in foot pounds of work. As a matter of fact no such loss is ever suffered because maximum temperatures are never reached even in single stage compressors; cool metallic parts brought in contact with the air absorb some of this heat, so that we may safely say that a well-designed water-jacketed single-stage compressor suffers a loss of 20 per cent. in foot pounds of work when compared with isothermal or perfect compression, and under the conditions of temperature and pressure stated above. We may therefore say that in compressing air to 80 pounds pressure without compounding, it is possible to lose one-third in power, though we usually lose one-fifth. To illustrate with these figures the importance of compounding, I would state that under the conditions stated a two-stage compound compressor when properly designed would suffer a loss of a fraction over 15 per cent., and in a four-stage machine we are able to get this down to nearly 5 per cent. As some of you may be using air at 100 pounds pressure, you may be interested to know the figures under these conditions. The maximum loss in a one-stage compressor is 38 per cent; this in a two-stage machine may be brought down to a fraction over 17 per cent and in four stages to 8 per cent. Even at 1,000 pounds pressure the heat loss in a four-stage compressor is brought down to 17 per cent. All representing foot pound of work.

The subject of cooling is not complete without a brief statement about after cooling. It is easier to get our ideas about intercooling carried out than it is to get any hearing when we talk about after-cooling. Assuming that you agree with me that air should be cooled before it enters a compressor and that this process of cooling should go on *during* compression, I would also like you to agree that even after we have bottled up the air in the receiver, something might be gained by inflicting it with a further and final cold bath. This is really the last time that the cooling process should be applied, and from this time on we are to turn square about, reverse our treatment and begin to warm up. An aftercooler between the compressor and the receiver or just outside the receiver in the main line, is a good thing because it will serve as a condenser to abstract moisture from the air by bringing its temperature below the dew point. Air at all times contains moisture, the average moisture being about 50 per cent of what is required to produce saturation, and it is safe to say that during our cooling process in the compressor we are not likely to abstract any of this moisture. The only mechanical way as distinguished from the chemical process by which we may get moisture out of air is to lower its temperature, but we must lower it below its initial temperature to produce any results. Notwithstanding the best systems of jacketing, compounding and intercooling, the compressed air is usually discharged into the receiver at a temperature about double the initial temperature, and as this air cools on its journey to the mine, it is likely to condense moisture on the interior walls of the pipe. In cold weather this freezes and accumulates, sometimes restricting and even stopping the passage of the air. In other cases it condenses its moisture in the ports and passages of the drills and pumps. These troubles can be reduced to a minimum and even overcome entirely by a thorough system of after-cooling, which means nothing more than reducing temperature and abstracting moisture just outside of the engine room.

Before leaving the subject of compression, I would say a word about oil. Air cylinders do not require oil either in quality or quantity like steam cylinders. What is good for the one is bad for the other. A steam cylinder needs an oil of low flashing point, and plenty of it, because the tendency of the wet steam is to wash the oil out of the cylinder. Not so with air, there is no washing tendency and very little oil will last for a long time. This oil should be of the best quality obtainable and of a high flashing point. It should not be a coking oil; that is, when evaporated on a piece of hot metal, it should not leave a carbon deposit. This is a subject which has been very much neglected, and this neglect is responsible for much waste of money and, worse than this, for explosions which destroy property and threaten lives. The actual amount of oil that should be used in an air cylinder is one-quarter that which should be used in a steam cylinder of the same size. I would call this a maximum, for very much less will often suffice, especially where the oil is of the best quality. Too much oil where there is a coking tendency results in choking the valves and ports. A discharge valve might stick through coking, and when stuck it will admit some of the hot compressed air into the cylinder against the receding piston, which on the return stroke is compressed and carried to a temperature beyond the flashing point. Sometimes when discharge valves give trouble, they are cleaned by injecting kerosene. This is a fatal error. Kerosene should never be used in the air cylinder, but, instead of this, fill the oil cup with soap suds, made preferably out of soft soap, and feed this into the cylinder; let the compressor work with soap suds instead of oil for a day each week and no harm is done, care being taken to feed with oil a half hour before stopping, so that the parts may not be subject to rust, which is the only danger from soap suds.

Compressed air has always been, and still is, supreme in mining. As a means of transmission and for surface work it must in many cases give place to electricity and hydraulics, but as an underground power its supremacy is admitted. No power is so safe, none so free from objections in mining work. It aids ventilation and cools the heading. If the conduit pipe is large enough, you will suffer no loss by friction and may convey compressed air several miles from the generating station. In recent years compressed air economies in production, transmission and use have opened up a large field in directions other than mining. All of our large railway systems are now provided with pneumatic appliances in the shops, and many of them use the system for switching. Machine work of all kinds, such as drilling, chipping, riveting, moulding and hoisting, is done by compressed air. The air lift pump for lifting water, salt water and oil from wells occupies a field of much usefulness. The compressed air locomotive has an established place in and about mines, nine of them being in constant operation in the Anaconda Copper Mines in Montana, and several are now at work for the Cambria Steel Company in Pennsylvania. The use of compressed air in bridge and tunnel work has made possible many of these large undertakings. The Blackwall Tunnel under the Thames, in England, is one of the most recent evidences of the utility of compressed air for such work. The stupendous scheme, which has been inaugurated by the Pennsylvania Railroad, to bring its terminal into the heart of New York City is made possible only by the use of compressed air.

In conclusion, it may be interesting to call your attention to a column of "don'ts," which I found in an engineering paper published in far-off New Zealand, and from which we may all, I think, carry home with us some useful lessons.

Don't install a compressor just about equal in capacity to your present requirements, for when once you have compressed air available its number of uses become legion. Good practice is to provide a compressor at least 50 per cent. greater in capacity than your immediate necessities demand. Duplex compressors are made divisible, permitting the installation and operation of one-half at first and the other half later when the additional capacity is needed.

Don't accept the theoretical capacity of an air compressor stated in the list of the maker, as the equivalent of the actual volume of air needed for your service. Remembering the difference between theory and practice, allow a small deduction for friction, heat, clearance, etc., being unavoidable losses in air compression, before calculating what your actual delivery in compressed air will be.

Don't buy an air compressor because it is cheap. It will prove the most expensive proposition of its size that you have ever encountered. If a water pump fails in its work, you will know it at once; if a steam engine is deficient, its shortcomings are self-evident, but if an air compressor is poorly designed or badly constructed, it may continue in the evil of its ways until the scrap heap claims it for its own, unless, as is more than likely, an absolute breakdown calls attention to its deficiencies, and you learn all too late that the hole it had made in your coal pile, added to the loss of keeping it in repair, would have paid a handsome interest on the additional first cost of a properly designed and properly constructed compressor.

Don't buy a second-hand compressor unless you know it has given satisfaction in work similar to your own, and that its working parts retain their full measure of usefulness without deterioration. An air compressor with valves, pistons, etc., worn out or in bad repair can waste more good power than anything of its size known.

Don't buy a compressor that your neighbor used for operating oil burners because you intend putting in pneumatic tools. For, even if all compressors look alike to you, experience teaches that oil burners operate under 12 pounds pressure, whilst pneumatic tools require 100 pounds, and the oil burner compressor, with unevenly proportioned cylinders, devoid of water jackets, will equal your service as well as a low pressure boiler for heating will run a high-speed engine.

Don't use air brake pumps or direct-acting compressors. Statistics show that their steam consumption is about five times that of a crank and fly-wheel compressor for the same volume and pressure of air delivered.

Don't install a steam-driven compressor if your steam supply is short and plenty of belt power available.

Don't put in a belt-driven compressor if you have plenty of steam and are short of belt power.

Don't draw your intake air to the compressor from a hot engine-room, or from any point where dust is abundant. The volume of air delivered by the compressor increases proportionately as the temperature of the intake air is lowered, and dust or grit entering the compressor clogs the valves, cuts the cylinders, and generally impairs the efficiency.

Don't use any old thing for an air receiver. Compressed air under 100 pounds pressure will leak a horse power through a 1-10 diameter hole in five minutes, and a well-made, strong and tight air receiver is the second essentially important factor if you would realize to the utmost all the advantages which compressed air provides.

Don't connect your air admission and discharge pipes improperly at the receiver. To secure the best results and eliminate moisture from the compressed air, connect your pipe leading from the compressor at the top of the receiver and lead your air pipe to points of consumption from the bottom of the receiver.

Don't have leaky air pipes. Test your piping when it is installed, and at regular intervals thereafter, allowing the full pressure to remain an adequate length of time, and if the gauge indicates leakage locate and remedy it.

Don't install your piping without properly providing for drainage of condensed moisture at regular intervals in the system. The simplest method is to slightly incline the branches leading from the main line and insert drain cocks just before the hose connection is reached.

Yield of Air Compressors.

The comparative table given below (reproduced, with equivalents, added, from the treatise on Mine Working, by M. Kuss and M. L. Fevre, Paris, Fanchon,) sums up the characteristic particulars as to the working and yield of several types of compressor. The figures were obtained under very different conditions of experimentation, so that they are not always intercomparable; but they have, nevertheless, the advantage of stating the question precisely with sufficiently near approximation.

Two perfectly opposite tendencies are now manifesting themselves as to the use of air-compressors in connection with mine working. The first, which is special to Continental Europe and chiefly France, consists in carrying water injection to its utmost extreme by realizing a maximum of isothermic compression and thus obtaining a good yield of the compressor itself, but at the expense of complication, additional expenditure of power for the injection (which may attain from 4 to 5 per cent. the power indicated in the steam cylinder), more difficult maintenance and

	Type of Compressor.		Number of Revolutions per Minute.	Piston Speed per Second.		Absolute Pressure.	
				Metres per second.	Feet per second.	kg. per sq. cm.	lb. per sq. in.
One Stage.	Sommeiller		13 to 15	0·55 =	1 ft. 9 in.	6 =	85
	Hanarte		27 to 28	0·95 =	3 ft. 1 in.	6 =	85
			35 to 40	....	....	6 =	85
	Dubois-François	old	30 to 50	1 to 1·20=	3 ft. 3 in. to 3 ft. 11 in.	5 to 6=	71 to 85
		present	50 to 60	1·00 =	3 ft. 3 in.	6 =	85
	Sautter-Lemonnier		50	1·25 =	4 ft.	9 =	128
	Dujardin	old	34	1·30 =	4 ft. 3 in.	4·75=	66
		new	37	1·42 =	4 ft. 7 in.	5 =	71
		present	40	1·53 =	5 ft.	6 =	85
	Mailliet		40	1·47 =	4 ft. 9 in.	6 =	85
			48	2·24 =	7 ft. 3 in.	6 =	85
	Biétrix		64	1·92 =	6 ft. 3 in.	8 =	113
	Burckhardt & Weiss.		85	....	....	6 =	85
			70	1·40 =	4 ft. 7 in.	6 =	85
			104	....	....	4 =	56
	Ingersoll-Sergeant.	A. No. 21	80	2·03 =	6 ft. 7 in.	6·6 =	93
		G. No. 23 A	120	1·83 =	6 ft.	5·2 =	74
		H. No. 313	150	....	....	5·2 =	74
Two Stage.	Dubois (Anzin)		52	2·08 =	6 ft. 9 in.	6 =	85
	Le Creusot		56	2·33 =	7 ft. 6 in.	6 =	85
	Ingersoll-Sergeant.	C-2 No. 229	85	2·59 =	8 ft. 5 in.	8 =	113
		AC. No. 13 C.	110	....	....	6·6 =	93
		H. No. 324	150	....	....	6·6 =	93

more frequent repairs. This method generally dispenses with compression in stages, even for pressures attaining 7 to 8 kilogrammes per square centimetre (mean 106 lbs. per square inch), unless indeed it be desired to produce very large volumes of compressed air.

In America, on the contrary, all introduction of water into the cylinders has been entirely abandoned; and makers content themselves with cooling down the cylinders by external water circulation. Loss is incurred on the yield of the compression proper; but all the complication and loss of mechanical work inherent in water injection are avoided. There is accordingly every advantage, for pressures at all considerable, to resort to compression in stages, which is obtained in as simple a manner as possible.

To judge by the figures given in the above table, it would appear that the two methods do not, generally speaking, afford a very different final result. It is true that injection compressors provided with the most recent improvements yield very remarkable results, which place them far above non-injection compressors as re-

Effective Pressure. kg. per sq. cm.	Effective Pressure. lb. per sq. in.	Volume Delivered per Minute. cu. m.	Volume Delivered per Minute. cu. ft.	Volumetric Yield.	Capacity of Production.*	Yield of Motor.	Yield of Compressor.	Total Mechanical Yield.	Lost by Heating and Throttling.	Loss Through Accessory Resistances.	Volume (Reduced to Atmospheric Pressure) Delivered per H.P. per Hour. cu. m.	Volume (Reduced to Atmospheric Pressure) Delivered per H.P. per Hour. cu. ft.	Actual Useful Effect.
5 =	71	....	...	0 80	25	0·80	0·81	0·65	0·28	0·25	8·0 =	282	....
5 =	71	....	....	0·90	50	0·87	0·85	0·74	0·17	0·14	....	....	....
5 =	71	4·0 =	141	0·90	60	0·81	0·83	0·67	0·21	0·24	9·75=	343	0·31
4 to 5=	56 to 71	....	....	0·87	130	0·83	0·80	0·66	0·25	0·20	8·50=	299	.. .
5 =	71	....	....	0·95	115	....	....	0·79	...	....	9·60=	338	....
8 =	113	2·8 =	98	0·88	87	....	....	0·67	....	....	7·9 =	279	0·27
3·75=	52	4·3 =	151	0·91	62	0·80	0·74	0·59	0·35	0·26	9·9 =	349	0·30
4 =	56	4·60=	162	0·95	70	0·82	0·94	0·77	0·06	0·22	12·6 =	444	0·38
5 =	71	8·60=	303	0·98	78	0·81	0·93	0·75	0·08	0·24	10·9 =	385	0·35
5 =	71	6·8 =	239	0·93	74	0·80	0·91	0·73	0·09	0·26	10·7 =	377	0·34
5 =	71	12·4 =	437	0·93	89	0·91	0·81	0·74	0·23	0·09	10·8 =	381	0·35
7 =	99	2·4 =	84	0·97	124	0·88	0·91	0·80	0·11	0·13	10·3 =	363	0·35
5 =	71	3 =	105	....	....	0·84	0·65	0·55	0·51	0·20	8·8 =	310	0·26
5 =	71	2·4 =	84	0.65	132	0·78	0·67	0·52	0·50	0·28	7·86=	276	0·25
3 =	42	11·5 =	405	0·95	198	0·78	0·84	0·65	0.19	0·29	....	....	....
5·6 =	79	4·7 =	165	0·90	144	....	....	0·62	....	....	8·6 =	303	0·28
4·2 =	59	6·2 =	218	0·90	224	....	....	0·60	....	....	9·5 =	334	0·30
4·2 =	59	3·2 =	112	0·90	267	....	....	0·65	....	. ..	10·0 =	353	0·32
5 =	71	21·8 =	769	0·96	73	0·79	0·85	0·68	0·17	0·26	9.87=	347	0·32
5 =	71	13·6 =	480	0.93	74	0·84	0·91	0·76	0·10	0·19	11·2 =	395	0·38
7 =	99	4·2 =	148	0·90	112	...	....	0·70	....	....	8·8 =	310	0·29
5·6 =	79	3·6 =	126	0·90	146	....	....	0·78	....	....	11·00=	388	0·35
5·6 =	79	2·0 =	70	0·90	186	....	....	0·72	....	....	10·0 =	353	0·33

* Volume delivered per minute at effective pressure divided by cylinder volume.

gards the useful effect; but this is not the only matter to be considered when a new plant has to be put down. More or less account must be taken of the dimensions, the weight and the cost of the compressor, as also of the difficulties connected with driving maintenance and repairs. The latter may vary greatly and exert great influence on the cost of compressed air, so that a comparative examination should be made of the first cost and current expense incurred in air-compression. Now, American compressors have in their favor a faster running, and consequently a greater power of production, so that the first cost must be less considerable for a given volume of compressed air. On the other hand the current expense of producing a given volume must be higher in their case, although the difference is diminished by simplicity of parts and facility of driving and maintenance.

To only consider the question of yield, or useful effect, it may be said that the most improved types of European compressors currently attain 70 per cent. the same figure as that realized by multi-stage American types; but that of simple compressors rarely attains 62 per cent., corresponding with actual yields of about 32 and 28 per cent., respectively.

In fine (conclude the authors) for large plants intended to last a long time, and in which economy should be sought on the current expense of production rather than on the first cost, injection compressors must decidedly be preferred, while non-injection types are on the other hand to be recommended for small plants not intended for any considerable duration.

J. Walter Pearse.

A New Air and Gas Compressor.

Since the line pressure of all air compressor plants varies continually on account of the variation in work done by the different motors using the air, the discharge of air from the compressor takes place at a correspondingly varying point of the stroke, and unless the discharge valve mechanism is properly designed, power is lost by early or late opening of the valves. Up to the present time no valve other than the poppet discharge valve has met these peculiar requirements in a satisfactory manner. In proof of this it may be stated that nearly all compressors of standard types are fitted with poppet discharge valves, while intake valves are of innumerable designs, automatic, or positively operated.

While, however, the poppet discharge valve adjusts itself perfectly to variation in load, the available space in the cylinder when using this type of valve is not sufficient to insure ample discharge area for high piston speeds without perceptibly increasing the pressure at the point of discharge, causing a loss of power. Its construction also prevents proper water jacketing, which tends to diminish the efficiency of compression.

In the compressor illustrated in Figs. 1, 2 and 3, the chief object of the designer has been a discharge valve that would be automatic in operation, open and close quickly at any part of the stroke and permit of ample discharge area for high piston speeds with minimum clearance loss. By means of the wrist plate mechanism this valve performs the function of an intake valve as well. The same valve opening is used for admission and discharge, thus further reducing the clearance loss and providing maximum cooling surface in the water jacket at the cylinder heads.

Fig. 1 is an elevation of air cylinder and wrist plate mechanism. Fig. 2 is an elevation of air cylinder from the side opposite to Fig. 1. Fig. 3 is a sectional elevation along the axis of the compression cylinder. A and B are small cylinders shown here fitted with plunger pistons connected to the valve stem.

Briefly described, the method of operation is as follows: At the beginning of the compression stroke the valve is positively closed by means of the wrist plate, and remains closed until the cylinder pressure slightly exceeds the receiver pressure, when it is opened wide by the slight excess of air pressure. The valve remains open to discharge until the piston has traveled to the end of its stroke or expelled all the air from the cylinder. At this point the difference in pressure between receiver and atmosphere, acting on the two smaller cylinders A and B, closes the valve to discharge and rotates it further to its intake position, where it remains until the end of the intake stroke. It is then quickly closed again by the wrist plate before compression begins. A communicates with the air receiver; B communicates with the inside of the compression cylinder by means of the opening C

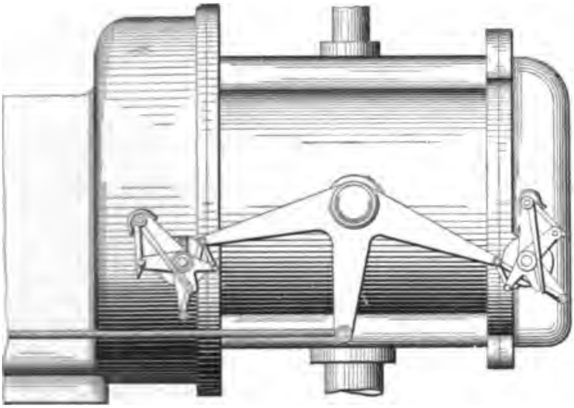


FIG. 1—ELEVATION OF AIR CYLINDER AND WRIST-PLATE MECHANISM.

in Fig. 3. During the intake stroke the plunger pistons of A and B are in the position shown at the right in Fig. 2 (receiver pressure in A and atmospheric or

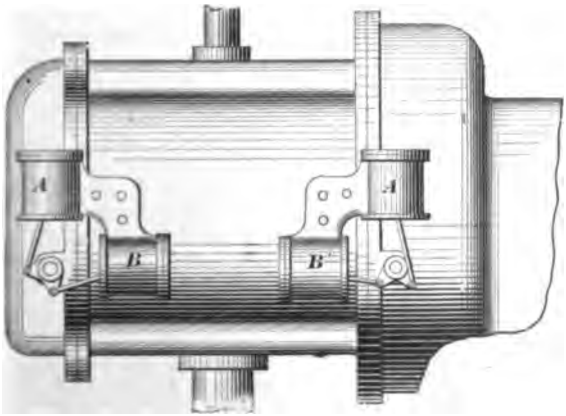


FIG. 2.—ELEVATION OF AIR CYLINDER AND VALVE-OPERATING DEVICE.

intercooler pressure in B). The valve is shown open at the left side in Fig. 3 for corresponding position.

At the beginning of compression stroke the plunger pistons of A and B are moved just enough to close the valve. The corresponding position of the valve is seen on the right hand side of Fig. 3. As soon as the pressure in the compression cylinder (communicating through to the small cylinder B) is slightly in excess of the receiver pressure, it acts on piston of B so that the pistons of A and B balance each other as shown on the left side of Fig. 2. This instantly opens the valve to discharge, and it remains wide open until the piston has passed completely over the opening C. At this instant the air in the small cylinder B expands to atmospheric pressure through the opening C, causing the plunger of A to drive back the plunger of B very rapidly and noiselessly, B acting as a dash pot. The valve now remains open for the entire intake stroke and is again closed positively at the beginning of the next stroke. The compressor is the invention of F. C. Weber, Park Building, Pittsburg.—*The Iron Trade Review.*

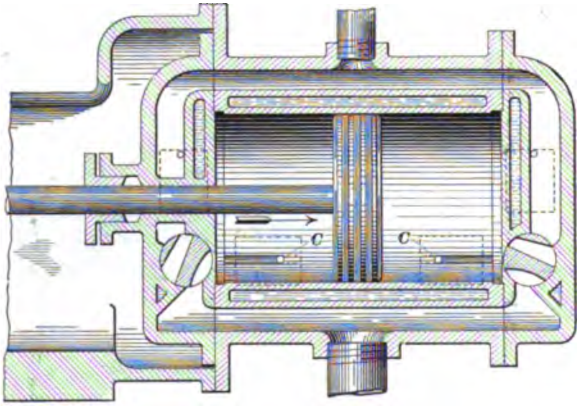


FIG. 3.—LONGITUDINAL SECTION THROUGH CENTER OF COMPRESSION CYLINDER.

The Distribution of Power in Mines.

THE PRINCIPLES RELATING TO THE LOSSES AND ECONOMIES IN ITS TRANSMISSION AND USE.

The writer proposes to discuss the whole question of the distribution of power in and about mines, and also to discuss the question which is closely allied to that of power distribution, viz., the distribution of air in mines for ventilating purposes.

There are several methods by means of which the power that is required for performing the different operations about a mine may be delivered at the points where it is used. There is the oldest method of all, except that of manual labor, that of the horse. There are the methods by which the energy of falling water is made use of, and again the method by which the incompressibility of water is made use of, both of these having a limited application. There are the methods by which the friction of ropes, and their resistance to rupture are used. There is the method still employed in many mines, and in nearly all for a certain portion of the work, that on the surface, the direct delivery of steam at the point where the work has to be done. And there are the two great rivals for the favor of mining engineers at present, the energy delivered to atmospheric air at the surface by compression, and used by expansion where the work is done; and that of electricity generated by the application of steam power to a dynamo, the electricity being caused to drive electric motors at the points required.

All of these have their advocates. Necessarily the maker of ropes is a keen advocate of the utility of rope transmission; he could not live if he were not; and the makers of compressed air apparatus, as well as those of electrical apparatus, have each an unbounded appreciation of the method of distribution in which their own apparatus figures, and each and all are prepared to give any number of reasons why the others are of very little use in every case, except those which the particular apparatus of the particular advocate cannot deal with. Perhaps the makers who are the least enthusiastic about their apparatus, so far as mines are concerned. in the United Kingdom, are electrical engineers. The advance of electricity has been so rapid during the last ten years, and they have got so to look upon electricity as far and away superior to anything else, that it is looked upon as a foregone conclusion with them that electrical will be *the* apparatus, and that there is an end of the matter. Possibly these gentlemen may have a rude awakening in the near future. It will not do them any harm. Swelled head, which many of them are suffering from, is a troublesome complaint, but the medicine, though unpleasant, is otherwise harmless, and there are signs that they are in for a dose of the medicine right now. The rival methods of doing things, gas, oil, compressed air, water, etc., have completely aroused themselves, and the result, in several portions of the field, is somewhat startling.

There is one very striking fact in connection with the different methods of distributing energy about a mine, or anywhere else, viz., that the same principles underlie the whole of them, the same losses, when reduced to their common denominator, are present with all of them, viz., the loss of heat, which has to be made up in the furnace of the boiler, or in other ways; and the same rules apply, with the exception of here and there, for efficient distribution, for distribution with small loss, or at small charge. The above statement may appear startling at first sight, and it may appear to be stretching matters to say that the losses are all in heat, yet this is the actual fact, and it will be seen that though the form of the loss may be disguised in different ways, the loss comes back to heat, usually to the furnace of the boiler, and in the majority of cases it is not difficult to trace the connection between the loss as it appears and the heat loss it actually represents. In nearly every case it will be found that it is necessary to generate heat in the initial process required for the particular method of transmission, and that while it is to the distinct advantage of the efficiency of the transmission that this heat shall be dissipated, such dissipation, and even the generation of the required heat, represent losses that have to be made up by the initial generator, the steam boiler, in some form or other. Also it will be found that the methods of reducing the initial losses by the generation and dissipation of heat are the same in nearly all the methods that have been employed about mines. It will also be found that it is necessary, in many instances, to generate heat, in the process of converting the power delivered at the point of consumption into the form in which it is required to be used, that this conversion could not take place, nor the apparatus be worked, unless this heat was generated, that again it is best, for the efficiency of the distribution, and often for the working of the machine to which the power is delivered, that this heat shall be dissipated, and that again the dissipation of the heat means loss of energy, which has to be made up in the initial generator, the boiler furnace.

In all systems of power distribution there are two important matters to be considered which are nearly always in antagonism. The cost of the installation, and its efficiency. The cost of the apparatus rules the charge that has to appear in the books for interest and depreciation. The efficiency means really the cost of running, and the mine manager often has considerable difficulty in judging to which side he shall lean, in laying down his plant for power distribution. In nearly every case, for instance, with the initial generator, size means efficiency in the double sense that the repairs bill is less and that there are smaller losses by heat, or the equivalent, losses in other forms which are convertible into heat; but size also means high cost, large interest, and it is quite possible to have an apparatus too efficient, in the sense that it costs too much money, and that the increased efficiency over that of an apparatus slightly lower in the scale of efficiency, may be more than counterbalanced by the increased interest on capital; and it may be absolutely necessary to add a substantial amount for renewal, as some apparatus are moving on at such a rapid rate that the best of to-day is out of date, and will place the user at considerable disadvantage seven or eight years hence. And this contest between first cost and working cost runs all through every part of every installation that is designed for the distribution of power about mines. In all cases there must be some method of conducting the power to the apparatus it is to work. This conductor in all cases uses heat. it has a life that is more or less limited, but the life and the heat wasted are in nearly all cases less as the size is increased: again size means first cost, with interest and depreciation. And the same remarks apply to the method of conversion of the power at the point of consumption. With certain exceptions, size spells economy in one sense, though it brings increased charges in the other. Again in all cases of transmission, or distribution of power, the higher the pressure, or as it might be written for certain cases, the higher the speed (higher pressure gives higher speed under given conditions), the more economical does the system of distribution become. Gas engineers have discovered this, and have devised high-pressure Welsbach burners which give a light that compares, for outdoor lighting, not unfavorably with the arc light itself. Compressed air engineers have also discovered this a good many years ago, though the discovery has practically laid dormant in the United Kingdom. Engine builders have discovered the same thing, and where we used to look upon 300 feet a minute as a good standard speed for engines, now 600 feet is a very common speed, and with the small engines used for motor cars, in which the fuel is consumed in the cylinder of the engine itself, the piston speed is often as much as 1,550 feet a minute, and the engines work well. Again, steam pressures have increased from the 30 lb. that was so common at collieries 20 years since, and that may be seen now in some collieries, or shall we say, from the first steamer with a boiler pressure of 5 lb. per square inch up to, in the modern "Ocean Tramp," 250 lb. At collieries in the United Kingdom there are few cases where more than 80 lb. is used even yet, though some have ventured as far as 150 lb. Air compression still stands at 50 lb. or thereabouts, and electricity remains at the figure at which it was originally started, 500 to 550 volts, and is in many cases much less in this country. For economy in all the methods of distribution employed, and if British collieries are to hold their own with American and Continental, higher pressure must be used all along the line, and it is not too much to say that the system of distribution which can arrange to make use of the higher pressures will be the most economical, other things being the same.

But high pressures and high speeds have a good deal against them. In nearly all cases, increased pressure means increased waste of heat, merely on account of the increased pressure, or the increased speed. A rope traveling at a high speed creates more friction than one at a lower speed, and so does a piston running at a high speed. Yet high speeds are used in steam engines, and particularly with motor car engines, with success and economy, the heat generated being carried away by the lubrication, and the economy resulting from the fact that the heat wasted costs less to produce under the present conditions than it would have under the old conditions, and to such an extent that an actual saving has resulted. The economy of the high speed or pressure more than balances the waste arising from its use. High pressures in steam bring awkward problems in their train, owing to the increased pressure being accompanied by increased temperature: also high pressures tend to force themselves through joints and openings much more readily than low pressures, and this applies equally to compressed air and to electricity, while the latter has the disadvantage that high pressures are dangerous to life. Yet it appears that high pressures must be used if economy is to result, and the only question must be, how is it to be done.

The advantage of using steam at high pressure is very strikingly seen, when it is remembered that one-tenth of a cylinder full of steam at 200 lb. initial pressure will do the same work in a given engine as three-quarters of a cylinder full with 70 lb. boiler pressure, while a tenth of a cylinder full of steam at 80 lb. will do more work than nine-tenths of the same cylinder full at 25 lb. The heat absorbed in producing the steam at 25 lb. pressure is 1,186 British thermal heat units per pound of steam generated, while that absorbed in producing the steam at 70 lb. pressure is 1,205 British thermal heat units per pound of steam, and that absorbed in producing the steam at 200 lb. pressure is only 1,230 British thermal heat units per pound of steam. Or, in other words, the steam at 25 lb. pressure costs 47 units per pound of pressure per pound of steam: the steam at 70 lb., 15 units per pound of pressure and steam; and the steam at 200 lb. costs only 6 units per pound of pressure and steam. So that where the steam has cost so much less to produce, it may happen to be economy to waste a larger portion of the energy delivered to a given apparatus than where the steam costs more to produce. It will be remembered that the British thermal unit is that quantity of heat that will raise 1 lb. of water 1 degree, Fahrenheit. This may be connected directly with the boiler furnace by taking the number of pounds of water that any particular fuel will evaporate. If we take the figure that is usually adopted as a standard, viz., 8 lb. of water per pound of fuel, at and from 212 degrees, Fahrenheit, this means that for every pound of coal used to raise steam to 200 lb. pressure, 7.3 lb. of steam approximately are produced, and for the 70 lb. steam, 7.4 lb., and the 25 lb. steam, 7.55 lb., while the 200 lb. steam has over seven times the value for power purposes of that at 70 lb. and more than 60 times the value of that at 25 lb. pressure.—SYDNEY F. WALKER, in *Mines and Minerals.*

Underground Compressed Air.

MINE PLANT—THE APPLICATION OF COMPRESSED AIR TO ROCK DRILLS, PUMPS, HOISTING ENGINES AND COAL CUTTERS.

For mining and tunnel operations the transmission of power by compressed air as compared with steam, is especially valuable and convenient for three reasons: *First,* its loss in transmission through pipes is small; *second,* the troublesome question of the disposal of exhaust steam underground is avoided; *third,* the exhaust air is of direct assistance in ventilating the working places of the mine. In large mines, where it may be necessary to carry steam thousands of feet, down shafts and through lateral workings, the disadvantages attending its use become very apparent; the amount of condensation is serious, even when the piping is provided with good non-conducting covering, and the working efficiency falls to an abnormally small figure.

Without reviewing here the relative merits of electricity, as a competitor of compressed air, a salient point may be noted. For work of an intermittent character, such as the driving of rock-drills, underground hoists and haulage motors, compressed air is in some respects superior to all other forms of power transmission; because, aside from leakage in piping—which is largely preventable—there is but little expenditure of power, or loss of work, when the motors are not in actual operation. When no air is being used, though the compressor may continue running for a time, the power is stored up by the increase of pressure in the receiver and air mains.

While recognizing these advantages, it should be borne in mind that, although the loss attending the conveyance of compressed air in properly proportioned pipes may be made very small, still, owing to the faulty design and operation of plant as ordinarily installed, the net efficiency of the system—including compressor and motor—is often far from satisfactory. Besides the mechanical losses inherent in every conversion of energy from one form to another, a series of unavoidable thermodynamic losses take place, both in the compression and utilization of the air. In the present article, however, it is not the intention to discuss this phase of the subject, but to consider some of the features of compressed air machines as commonly employed for underground service.

Compressed Air Drills.—Though it is a well-known fact that compressed air drills are uneconomical machines in their consumption of power, it appears to be practically impossible to put the matter in the shape of figures. The actual useful work —employing this term in its ordinary mechanical sense—done by any machine drill in making a hole of given depth and diameter in a rock of given hardness, toughness, and general physical character, can not be determined absolutely. All that is really known is that the drill requires a certain volume of air per minute, which has been furnished by the expenditure of a certain average horsepower at the compressor.

Mechanical efficiency, pure and simple, is the basis upon which machines in general are compared, but in the case of compressed air drills, mechanical efficiency is not the only question at issue, nor is it the most important. Efficiency of operation is subordinate to the attainment of strength and simplicity of construction, portability, durability, ease and readiness with which repairs may be made, and capacity for work in terms of number of feet of hole drilled. The strong point of compressed air drills is their convenience of application in the special field of work for which they are adapted. In possessing a cylinder, piston and valves, the drill resembles a steam engine, but there the likeness ceases. There can be no flywheel, or other means of storing up and equalizing the power, and the whole service demanded from the drill is peculiar and totally different from that performed by the steam engine.

The low theoretical efficiency of the air drill is due mainly to the fact that the air is admitted to the cylinder practically throughout the full stroke. As a consequence the valve motion bears a strong resemblance to that of many of the simple pumps. Expansive working to any extent is not practicable for rock drills, both because of the undesirability of introducing complexity of mechanism in machines subjected necessarily to rough usage, and because of the difficulty of adapting a cut-off gear to the variable length of stroke required. Owing to the nature of its work, the drill cannot be kept always at full stroke. While in operation it is often necessary to feed the machine so far forward that the actual length of stroke may not be much greater than one inch, and the valve motion must still be capable of reversing promptly. A sharp, quick reversal of the stroke is absolutely essential. Nearly all the useful work is done on the forward stroke, in striking the blow. If the valve be thrown too soon, the stroke of the piston will be shortened, and the effect of the blow reduced; if too late, the piston may strike the cylinder head. The speed of the drill must be great—say 350 to 400 strokes per minute—and, as a nearly uncushioned blow should be delivered, the exhaust on the forward stroke must be free. On the back stroke, on the contrary, the exhaust must be so adjusted that the piston will be cushioned to avoid unnecessary shock and injury, only enough power being developed on this stroke to overcome the resistance due to the weight of the moving parts, and the frequent tendency of the bit to stick fast in the hole.

For these reasons, it is impracticable with machine drills to attain the economy resulting in other air motors from using the air expansively. Incidentally, the use of air at full stroke is of some advantage, because, in exhausting at high pressure, the exhaust air issues from the port at a high velocity, and its force, combined with the development of some heat from friction, in a measure prevents any troublesome accumulation of ice. The ice is confined, at least, to the exterior portion of the port, whence it is easily removed.

The volume of free air (that is, air at atmospheric pressure) required to operate a machine drill depends upon the gauge pressure, and the size of the cylinder. For drills of different sizes, the volume of air used varies approximately with the squares of the diameters of their cylinders. In making estimates of the quantity of air consumed by a number of drills of different sizes, all can be reduced to terms of one particular size. The 3-inch drill is commonly taken as the standard. At a pressure of 75 pounds a single 3-inch drill will use from, say, 110 to 125 cubic feet of free air per minute, according to the type and condition of the machine, provided it is not materially worn, or otherwise out of repair. But, when several drills are operated from the same main, the average consumption is taken at a lower figure; for the reason that the larger the number of drills the greater is the probability that all will not be running at the same time. Thus, for five 3-inch drills, the total average consumption of free air, at 75 pounds gauge pressure, would be about 450 cubic feet, or 90 cubic feet each, and for ten drills, say, 800 cubic feet, or only 80 cubic feet each.

In 1898, an elaborate test was made at the Rose Deep Mine, South Africa, by Mr. L. I. Seymour. The average number of drills (Ingersoll-Sergeant), of several different sizes, in operation during a six-hour run, was calculated to be equivalent to thirty and nine-tenths 3¼-inch drills. Average air pressure, 69.83 pounds. Average volume of free air used per drill per minute, 81.08 cubic feet. Horsepower developed per drill in the steam cylinders of the compressor, 12.72. It was estimated, however, that the work done during the six-hour test was about equal to that usually accomplished in eight hours of regular work, the time lost in delays due to shifting and setting up the machines being reduced, so that the actual average horsepower per drill, under normal conditions, would probably be $12.72 \times 6/8 = 9.54$. The air piping in this case was known to be remarkably free from leaks. It may be added that the average duty per drill was 4 feet 5 11/16 inches of hole per hour (diameter of the hole not stated). Reducing the above figures from terms of the thirty 3¼-inch to the standard 3-inch size of drill, the consumption of air would be $\frac{9}{10.56}$ of 81.08 cubic feet, or about 70 cubic feet per minute. This agrees quite closely with the rate of air consumption usually assigned in estimates for the number of drills in question.

The average consumption of air per drill is less for work in soft rock than in hard, because the holes are drilled faster, and more time proportionately is occupied in shifting the machines from hole to hole. In very hard rock the drills are kept running with but few intermissions, and it is advisable to provide a greater compressor capacity than is usually given in the tables of the makers. As a partial offset, however, more time is lost in changing bits when drilling in hard rock, because they are dulled more quickly and must be replaced at shorter intervals. In general, the time actually occupied in drilling may vary between four hours and six hours out of a shift of eight hours. The compressor, in any case, should be of ample size, so as to be able to run at a moderate speed and avoid excessive heating in the cylinder and receiver. When old drills are used, whose valves, cylinders and pistons are worn and permit leakage, the consumption of air is greater than for new machines. Leaky valves may be detected by the character of the exhaust. When the valve is in good order the exhaust takes place in sharp, distinct puffs; when leaky the exhaust is practically continuous.

In operating a compressed air plant at an elevation above sea level, allowance must be made for the decreased capacity of the compressor. It will, of course, be understood, for the same pressure, the volume of compressed air used per drill is constant for all altitudes; but to furnish this air, when working at an altitude above the sea, a larger compressor capacity is required, because a greater number of cubic feet of the more rarified air must be compressed. A series of experiments, made not long ago by Messrs. J. E. Bell and L. L. Summers, shows that the volume of free air used per shift of eight hours for a 3-inch drill is as follows, the gauge pressure being 100 pounds:

At sea level..........25,000 to 42,000 cu. ft
At 5,000 ft. elevation...30,000 to 49,000 cu. ft
At 10,000 ft. elevation.35,000 to 60,000 cu. ft

Aside from questions of the size and type of machine drills, the speed of advance, measured in linear feet of hole, varies greatly in rocks of different characters. Under favorable conditions, in underground work, average duties of 60 to 70 feet of hole per ten hours may be attained, occasionally even higher; in harder rock, from 40 to 50 feet. For short runs considerably better records than these have been made.

Operating Pumps by Compressed Air.—The advantages attainable, under some circumstances, by using compressed air instead of steam for driving underground pumps, are often nullified by an improper choice of the pump itself. The pumps commonly employed in mines are ordinary simple steam pumps (often old ones), and little or no attention is given to the important matters of the relative dimensions of the steam and water cylinders and the proportioning of the air pressure to the cylinders and to the head under which the pump is to work. Unless the air be previously reheated the results obtained from using compressed air in such pumps are no better, and may be even worse, than those obtained from steam. As with steam, the air is usually admitted nearly throughout full stroke, and a cylinder full of air, approximately at gauge pressure, is exhausted at each stroke. The very small cut-off given to these pumps is intended mainly to allow the constant pressure in the water end to overcome the inertia of the moving parts, as the piston reaches the end of its stroke. Again, when several pumps are operated from the same pipe line, as is generally the case in mines, it is customary to work all under the same air pressure, even though the conditions be dissimilar. Where there are a number of levels the pumps are distributed in the mine according to various requirements, as to height of lift and quantity of water. The lowest pump may be working under a head of 1,000 feet or more, others under a head of only 100 or 200 feet. Each is supposed to be proportioned properly for the volume of water to be raised, so far as the water end of the pump is concerned, but the power end is often badly designed and out of proportion. The tendency is, of course, to err on the side of furnishing too much power. The steam (or air) cylinder may be of such a size as to require a pressure of only 30 or 40 pounds per square inch, while the pipe-line pressure may be 70 or 80 pounds, as is usual with mine compressor plants. So it often happens that the deepest pump in the mine is the only one operating under a proper pressure. The cylinders of the others, though required to do less work, are filled with air nearly at full pressure when the exhaust takes place, even if running under partial throttle. If the pump be of the duplex pattern, with inter-dependent valve motion, the conditions at times are even worse, because one cylinder may be overfilled with air, while waiting for the piston of the other to finish its stroke and reverse the valve.

It is apparent that, with the common direct-acting simple pumps, uneconomical working is inevitable. The trouble is twofold; the air is used without expansion, and often at a much higher initial pressure than is necessary.

The second point will be dealt with briefly in another article, where it will be shown that the air pressure can be diminished by inserting a reducing valve in the pipe line near the pump. By this device such a volume of air is allowed to pass as will maintain a certain difference in pressure between the air in the main and that at the pump. Not only does this cause a deposition of part of the moisture, which may be drawn off, and so prevent serious freezing at the exhaust ports, but in adjusting the pressure to the requirements of the pump, a reasonable degree of economy in the consumption of air is brought about. After passing the reducing valve the air is led into an auxiliary receiver before reaching the pump.

Pumps Using Compressed Air Expansively.—Reference may now be made to the first point mentioned above. The considerations as to initial cost and the scale of work, which so largely govern the selection of steam pumps, are operative also in the case of those driven by compressed air. For small plants, ordinary simple or duplex pumps, working non-expansively, are the rule, because of the greater cost and complication of the mechanism of those possessing expansion gear. This type of pump, however, whether operated by steam or air, is far from being satisfactory, and the subject—at least as regards mining practice—merits the careful attention of mechanical engineers. With pumps of any considerable size, expansive working in some form should be introduced. It seems probable that where compressed air is used the non-compound flywheel pump, with air and water cylinders set tandem, may be most easily and cheaply installed. This arrangement permits a ratio of cut-off which adds materially to the efficiency, and makes possible a simple and strong construction, well adapted for the somewhat rough usage often received by underground machinery.

In aiming to attain the greater economy resulting from expansive working, means to prevent freezing of the moisture in the air must be adopted. A large part of the loss of heat takes place inside of the cylinder, instead of outside at the mouth of the exhaust port, as in working at full pressure. The same total fall of temperature occurs in either case, whether working at full stroke or with cut-off; but, when the air expands within the cylinder, the force of the exhaust is diminished because of the reduction of pressure at the end of the stroke, and the inner portions of the ports are the more liable to be choked with ice. Hence it follows that the ordinary methods for preventing freezing in the cylinders of pumps which take air throughout full stroke are ineffectual for pumps or other air engines working expansively. To accomplish this, as well as to use the air with a greater degree of economy, the air should be reheated before it enters the cylinder, or heat applied externally at least to the cylinder itself. Without detailing here the various kinds of reheaters, it may be stated that they consist in general of a system or coil of piping, forming in effect a part of the air main, and which is inclosed in a small furnace, or heated by other convenient means. Heat applied in this way produces an additional volume of air at a much lower cost than if it were produced in the compressor.

In connection with reheating an advantage may be obtained by injecting into the reheater coils a small quantity of water.

The water is converted into steam, and on giving up its latent heat in the water cylinder prevents the production of very low temperatures, even when a high ratio of expansion is employed. If it be impractical to use a reheater, underground heat may be applied to the outside of the cylinder; for example, by enveloping it with spiral hot water or hot air pipes, or by injecting into it a spray of warm water. Better results are obtainable by injecting steam instead of water into the air cylinder. Not only is a more intimate mixture produced between the moisture and the air, but in condensing, the latent heat of the steam is given up. Each pound of water ejected at 212° F. will give up 180 thermal units, in cooling down to 32 degrees. But, with the steam at the same initial temperature, each pound in condensing gives up 966 thermal units, besides the 180 units produced by cooling subsequently to 32 degrees.

Sometimes the air cylinders of small compressed air pumps are warmed by lamps or torches, but this is objectionable, as the machines become extremely dirty. Some benefit may be derived by leading a jet of water from the pump-column pipe into the air pipe before it reaches the cylinder. Only a small quantity is required to prevent an excessive drop in the temperature of the exhaust. Merely to prevent freezing, the plan of carrying a very small steam jet over the exhaust port has been adopted; but it is obvious that this could be done only when steam is used nearby for some other purpose. Moreover, the heat of the steam so applied is utilized much less perfectly than if used in a jacket around the cylinder.

If compressed air be used in a compound pump reheating is essential, both as a matter of economy, and because of the ratio of expansion (and consequent production of cold) is much greater than that due to the employment of a cut-off in a single cylinder. It would be practically out of the question to allow the cold, partially expanded air, as exhausted from the high-pressure cylinder to pass directly into the low-pressure cylinder. A second reheating, therefore, should be applied to the air after it has done its work in the high-pressure cylinder, and before it enters the low-pressure cylinder. The temperature of the air, after expansion in the first cylinder, is thus raised sufficiently to prevent the temperature of exhaust from the second cylinder from falling too far below the freezing point. Under circumstances where the use of a reheater requiring the burning of fuel is not convenient, an ordinary boiler feedwater heater has been successfully employed.

Following is the description of a plant in the Gwin Mine, Calaveras County, Cal., as installed by Edward A. Rix, of San Francisco. A Worthington compound pump, having a capacity of 200 gallons per minute, was installed on the 600-foot level of the mine. In connection with the suction pipe was placed a 300 horsepower Wainright heater, containing a number of corrugated copper tubes. The water in the sump, at a temperature of 60° to 70° F., passes through the heater tubes on its way to the pump suction valves. The air, after being exhausted from the high-pressure cylinder, at a pressure of 35 pounds, passes into the shell of the heater and through the spaces between the tubes. In this way the temperature of the air is raised practically to that of the water, and, after expanding again in the low-pressure cylinder, is exhausted without freezing. It is interesting to note that as the sump water was at first foul the inside of the heater tubes frequently became coated, and their conductivity was so much reduced that the pump would freeze up. After clearing the tubes the pump operated as freely as before. Still better results would be obtained from such an installation by water-jacketing both high and low-pressure cylinders, the jackets being connected with the pump column by a small pipe.

Compressed Air Hoisting Engines.—Hoists for underground work are almost always of small size. Occasionally it may be required to erect a hoisting plant at a shaft sunk from a tunnel, where, on account of the distance from the boilers and the injurious effect upon the ventilation of the mine, steam could not well be employed. Such a hoist could be operated by electricity, gasoline or compressed air, and might be of considerable size and power. Compressed air is also applied sometimes in collieries for operating stationary haulage engines for underground systems of transportation. It may be necessary to place these engines a long distance from the bottom of the shaft, where the presence of explosive gas makes it expedient to avoid all possible risk from sparks, either originating at the commutators of electric motors, or caused by the rupture of conductors. Such service for compressed air is more common in Europe than in this country. Up to the present time, however, the principal application of compressed air hoists is for more or less temporary work, such as the deepening of shafts, sinking winzes from one level to another, and the handling of heavy timber for stopes, raises, etc. For work of this character small, portable, self-contained air hoists are employed on account of their convenience, the question of economy being entirely subordinate. As their operation is intermittent, these hoists are usually designed to take air throughout nearly the full stroke; or at least with no more expansion than that due to the lap and lead of the slide valves. At best only a very limited cut-off could be applied, because hoisting engines are denied the equalizing effect of flywheels. Except for small portable hoists reheaters would be of advantage, although, on account of the intermittent work the cylinders in some degree tend to recover normal temperature between hoists.

Coal Cutters Operated by Compressed Air.—Coal-mining machines, or coal cutters, are employed in the actual mining of the coal. They were first introduced about 45 years ago, but were not successful for some years. The great difficulty with which the early inventors had to contend was the lack of a suitable form of power for driving the machines. The transmission of power by compressed air or electricity had not yet come into general use, and steam power is, of course, out of the question for portable machines employed in the working places of mines. Compressed air was probably first applied successfully to coal cutters in 1877; electricity not until 1889.

For the present brief description coal cutters operated by compressed air may be divided into two classes:

First, those in which the driving engine consists of a pair of small horizontal cylinders, coupled at 90 degrees to a crankshaft. The power is transmitted by gearing to a rotary horizontal disk, or bar, or chain, carrying a series of cutting bits, by which a groove or undercut is made in the coal. For the bar and chain cutters, the cylinders are usually from 5 in. × 5½ in. to 6½ in. × 5 in., running at, say, 200 revolutions per minute; for disk cutters, cylinders as large as 9 in. × 8 in., 7¾ in. × 10 in., and 9 in. × 10 in. are used, running at 150 revolutions and geared down to 20 or 30 revolutions for the cutter disk.

Second, machines of the percussion or reciprocating type. These are often called "pick machines," and are similar in general construction to percussion rock drills, the cutting bit being attached to the piston rod of the cylinder.

Standing in a class by itself is the Stanley heading machine, intended specially for driving colliery gangways. It cuts a cylindrical heading. This useful machine is driven by a pair of vertical compressed air cylinders, the exhaust of which assists in ventilating the heading, and carries out the dust. The central horizontal shaft carries a pair of arms (sometimes a flat cone), upon which are mounted a series of cutting bits.

For operating machines of the first mentioned forms, it may hardly be doubted that electric power is preferable to compressed air, both in point of economy and convenience. Compressed air cannot well be used expansively in such portable engines, for reasons already given, and as the machines are moved from place to place, the air piping cannot be as readily shifted and extended as electric wires. As a result, most of the mining machines of this type in the United States are driven by electricity. In Great Britain, compressed air has long been in general use for disk and bar cutters, though electric machines are now coming into favor. When driven by compressed air these cutters are designed for a low air pressure, say 40 pounds.

Up to the present time all of the successful reciprocating or pick machines have been operated by compressed air. Several different makes are widely used in this country, and have found their way also to Europe. The best known pick machines are the Harrison, Sullivan and Ingersoll-Sergeant. The Yoch and the H. & H. picks have also been used to some extent. These machines are mounted on a pair of wheels, by which they are easily moved from place to place and set in position for work. They are intended not only for horizontal undercutting in breast or room work, but also for "shearing;" that is, making vertical cut on one or both sides, for driving gangways.

In constructive details pick machines differ greatly. In the latest form of the Harrison pick a pair of short slide valves are operated by a small rotary engine, mounted on the main cylinder. At a speed of 200 strokes, and an air pressure of 70 pounds, about 14 cu. ft. of compressed air, or, say, 80 cu. ft. of free air, per minute are consumed, not including preventable leakage from pipes. The construction of the Ingersoll-Sergeant and Sullivan pick machines resembles that of the ordinary rock drill, though the cylinders are larger and heavier. They are provided with a common spool or piston valve, which operates a slide valve controlling the main ports. The valve motion is so arranged that, if the piston overruns its stroke air is compressed in the forward end of the cylinder and forms a cushion. At 200 strokes and an air pressure of 75 pounds they use about 90 cu. ft. of free air per minute. Their rate of work is approximately the same as that of the Harrison pick, under the same air pressure.

The chief point of difference between these machines and the rock drill is that the bit of the pick machine need not rotate, because it is not intended to make a round hole. The rifle bar and nut are, therefore, omitted in the Harrison, as well as in the earlier and latest forms of the Ingersoll pick. This feature renders them stronger and more durable than the rock drill. On the other hand, while they are generally subjected to very rough usage, their work in the relatively soft coal is not so trying as that of a drill operating in hard rock. Under ordinary circumstances with a pick machine a skilful man can cut from 250 to 500 square feet per shift (including the usual delays), at the following approximate cost:

Wages—Machine runner........	$2.25
Wages—Helper	1.50
Power, repairs and oil..........	1.50
	$5.25

or, say, from 1 cent to 2 cents per sq. ft. The number of tons undercut depends obviously upon the thickness of the seam of coal.

The compressed air pick machines are not economical in their consumption of power, and in fact, the same considerations in this respect apply to them as to rock drills. It may be that in the future they will be rivaled by electric reciprocating machines, one or two of which have lately been brought out (such as that of the Morgan-Gardner Electric Co.), but in their actual work the compressed air machines are found to be decidedly satisfactory, and, as compared with those operated by electricity, are perfectly safe for use in gassy mines.

Underground Compressed Air Locomotives.—Many compressed air locomotives are in successful operation in both collieries and metal mines, but, as they merit a more extended notice than can be given here, they will be dealt with in a future article.—ROBERT PEELE, in *Mines and Minerals.*

Compressed Air Not Likely to Cause Disastrous Explosions.

The *American Engineer and Railroad Journal* calls attention to the fact that while many have the impression that compressed air carried at high pressures is not a safe power, on the contrary, it is less likely to result in disastrous explosions than either steam or gas. When we consider the great number and variety of uses to which compressed air is put it is not strange that accidents do occasionally occur, but they are generally due to carelessness or ignorance.

"Compressed air installations are used with pressures up to 3,000 pounds to the square inch, not only in every mine of any magnitude, in all tunnel work, quarries, shipbuilding, submarine work and for refrigerating purposes, but it has a very wide range of usefulness in all railroad and manufacturing lines. Nearly every railroad, machine, erecting and boiler shop and foundry of any size has its own compressor plant, and from all of these varied sources comparatively few accidents have been reported. As a means of safety many of the powder magazines throughout the country are using compressed air as a motive power, to the exclusion of steam and electricity. Railroad trains, both freight and passenger, are equipped with air compressors and storage tanks, and on the latter the power is used for as many as eight different purposes, such as the braking of trains, ringing bells, opening fire doors, shaking grates, sanding the rails, lifting tender water scoops, raising water in passenger coaches and operating fans for ventilation.

"The reason why compressed air is a safe power is the fact that it has no reserve force, as in the case of steam boiler explosions, where the destructive effect is caused chiefly from this force; that is, the sudden conversion of large volumes of superheated water into steam, by the reduction of pressure above the water space in the boiler. In the case of air, when a vent occurs, it serves to reduce the strains. This is due not only to the expansion of the air from a smaller space into a large one, but a rapid reduction in volume, due to the fall of temperature in expanding. The failures that have occurred in the use of compressed air can, in nearly every instance, be traced back to the ignition of oil or some inflammable substance which is used with the air. Low-test lubricating oil, for example, fed to the air cylinders, may meet with a temperature greater than that of its flashing point. In putting oil into the cylinders any surplus that may reach the cylinders is forced out through the delivery valves into the air pipes and receivers. The products of decomposition of a large quantity of oil in the receiver would, with the air, form an explosive mixture.

"Air in itself is a perfectly safe fluid, and only requires a vessel strong enough to hold it. In this respect the problem is not a serious one, as the factor of safety in the case of air may be less than for steam, water or gas, as it does not corrode the vessel, its temperature is not changed, and it causes no internal destruction."

A Convenient Air Jack.

A device known as an air jack which will be recognized as an aid to roundhouse repair work in handling the heavy driving boxes now in use has recently been put in operation. The jack consists of a pipe cylinder attached to a strong plank, through which the piston rod extends, an "L" head being attached to the upper end. The required bore of the cylinder depends upon *the air pressure* carried in the shop, and the maximum weight of the driving boxes in use, enough piston area being provided to insure the raising of the heaviest box. The cylinder should be made as long as the depth of the pits will allow in order to obtain as long a stroke as possible, and the cross plank should be made of the proper length to go between the rails. To operate, a thin metal plate is laid on the "L" head, the driving box placed in position and the air turned on, when the box will be raised to the desired position in the jaws. If the engine is so high that the length of the stroke is insufficient to raise the box to the proper height, it may be blocked up, the piston lowered and additional blocking placed on top of the "L" head, which will be sufficient to gain the distance. The jack has shown its practical utility in the Chicago, Burlington & Quincy shops at Aurora, Ill., where it has been in use for some time. —*Railway Age*.

Equipment for a Small Brass Foundry.

I recently had occasion to estimate the equipment for a small brass foundry, and I send you the sketches of the plant which I designed, showing the arrangement. The building can be built of wood or brick, as desired.

Fig 1 is a plan of the foundry, and Fig. 2 shows a sectional elevation. As will be seen in Fig. 1, the building is divided into two sections, the small one being used for an office and the larger for the foundry. In this foundry on the right are three furnaces, with a core oven built over the flue, arranged with a sliding damper which takes part of the waste heat through it to dry the cores. On the left are the benches. Tubs are not much used; they are considered unhandy, as with them the sand cannot be as easily handled. The sand is tempered on the floor and then thrown back against the wall for further use.

One of the features introduced was a crane, with air hoist, so arranged that it could be turned around and cover nearly the entire floor, lifting the pots of melted metal from the furnace and removing the ashes from the pit.

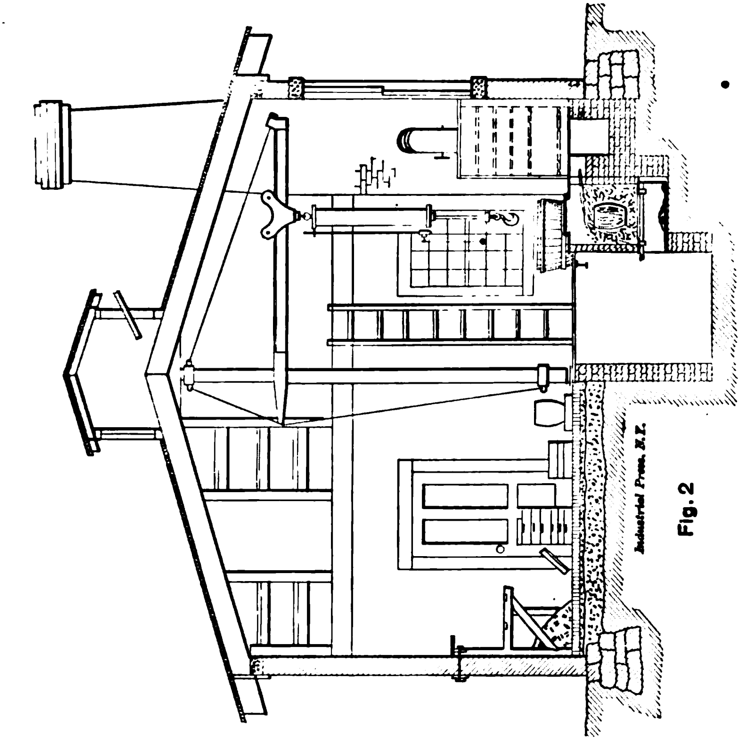


Fig. 2

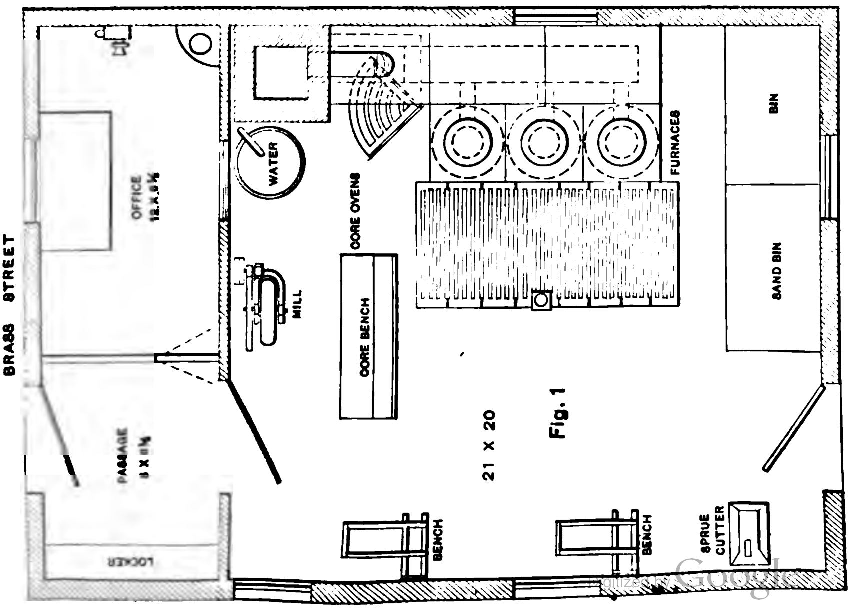


Fig. 1

PLAN VIEW AND CROSS SECTION.

Over the office is a loft with shelves on one side and a space for an electrically-driven air compressor with receiver to supply air for hoisting, dusting, rapping and chipping. The electric motor when not driving the air compressor is used to run the mill for grinding the cinders.

The sketch is of a small-sized foundry, but where more room and benches are needed the foundry can be enlarged in proportion.—WM. F. TORREY, in *Railway Machinery*.

Tools for Repairing the Boyer Long-Stroke Pneumatic Hammer.

"PNEUMATIC."

Having had considerable experience within the past two years in repairing pneumatic tools of various kinds and makes, I submit sketches and descriptions of a number of shop tools and devices which may be of interest to other machinists doing similar work. This article will deal with the Boyer long-stroke riveting hammer, but I do not wish to be understood as inferring that this pneumatic tool requires more attention than other makes. I think that it is a marvelous tool in its work and endurance, but it pays to use all pneumatic tools properly and always watch for any defects that may develop from continued use. The best made tools of any kind must wear when used and eventually require renewal of worn parts. Again, the presence of dirt or other foreign substance in any tool may seriously interfere with its action, and such is particularly the case with pneumatic hammers. Tools are required to take them apart quickly, and some special ones are quite necessary for doing it without damage to the internal mechanism.

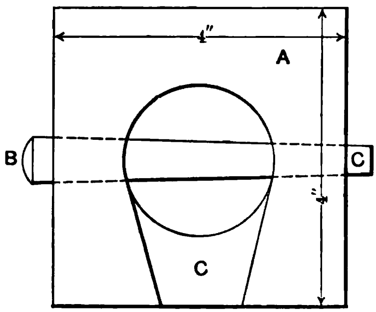


FIG. 1.

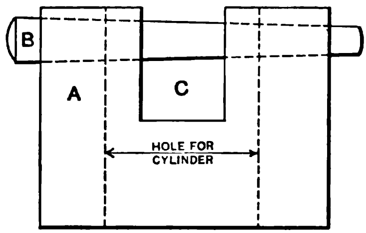


FIG. 2.

In the first place, it is necessary to hold a pneumatic hammer in the vise when taking it apart. It is not advisable to grasp either the cylinder or the handle in the vise, as the pressure required to hold it firmly may squeeze it out of shape and ruin it for future use. Figs. 1 and 2 show a wrought-iron block A for holding a hammer in the vise. It is four inches square and two inches thick and is drilled and cut out for the handle as shown so as to slip over the cylinder of the hammer and onto the handle. The handle drops into the recess C far enough to allow

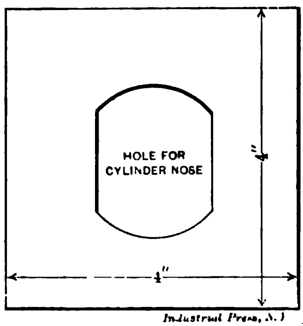


FIG. 3.

the taper pin B to pass and thereby lock the handle in the block. The block can be firmly held in the vise without danger of injuring the hammer while separating the cylinder from the handle. A long spanner is then used to unscrew the cylinder.

Fig. 3 shows another wrought-iron block of the same dimensions as that shown in Figs. 1 and 2. It is used for taking off the cylinder nose. A hole the size of the nose across the flats is first bored through the block and then slotted out so as to fit the circular part. It forms a lock block and has no tendency to squeeze the nose together as would be the case if it were held in the jaws of the vise.

I find the steel claw, Fig. 4, most useful for pressing down the spring lock, which must be done before either handle or the cylinder nose can be screwed off. It is made of ¼-inch round steel flattened at the end and filed out as shown to fit the teeth of the lock, and then hardened.

It very often occurs that the automatic stopping valve has to be ground to its seat. For this purpose the brass mandrel shown in Fig. 5 is used. It is turned to fit the valve and the end is split into three divisions by three saw cuts. A taper head screw is provided for expanding the

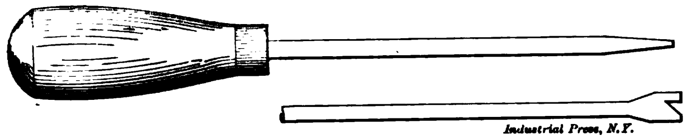


FIG. 4.

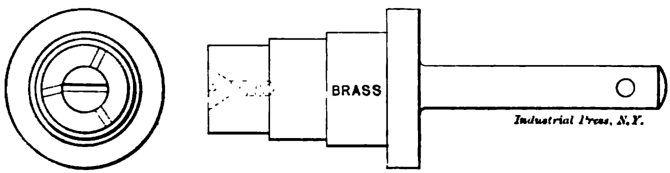


FIG. 5.

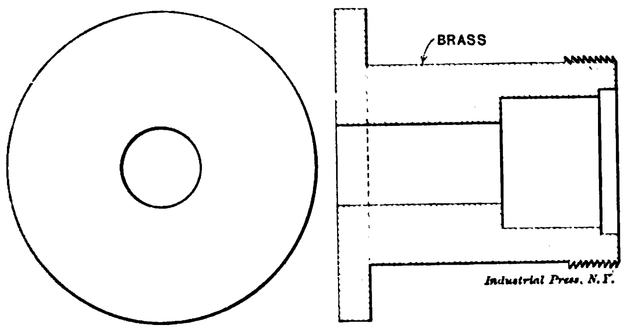
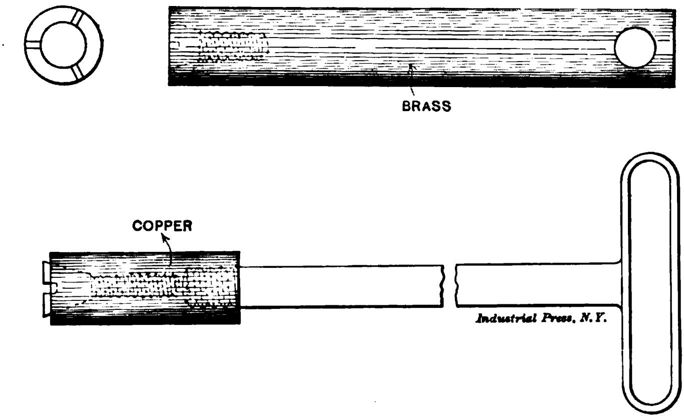


FIG. 6.

end of the mandrel and tightening it into the valve. The valve should not be driven onto the mandrel, but should slip on easily. The remainder of the mandrel is turned to fit the end of the cylinder. The mandrel shown has three sizes turned for reasons that anyone making one will readily see. A hole is drilled through the handle at right angles for the insertion of a rod to turn the mandrel by while grinding. A few minutes' grinding will generally suffice to make the seat and valve tight.



FIGS. 7 AND 8.

I have frequently been troubled by air breaking through the face of the "rear valve lid" and getting behind the piston, causing it to work slowly when not in actual use. It may be thought that the automatic valve, if tight, should prevent this, but air leaking by the inner face of the valve lid, enters the cylinder inside the automatic valve. Of course, the principal reason for the leakage and slow working of the piston is the throttle valve not being tight, but this being a piston valve it cannot be made tight except by making a new one and grinding it in place. A much quicker and simpler way then is to grind the face of the valve lid to the seat in the handle. For doing this I use the device shown in Fig. 6. It is made of brass with ratchet teeth and screws into the handle in place of the cylinder. Before putting it into place. the valve lid is mounted on the mandrel shown in Fig. 7, which has a split end like that shown in Fig. 5. The spring belonging to the valve is also put on the

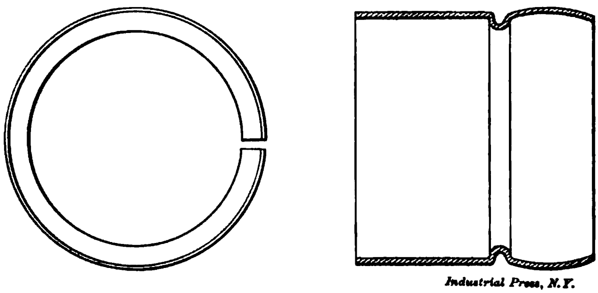


FIG. 9.

mandrel and then the mandrel is slipped through the hole in the piece, Fig. 6. The latter is then screwed into place and the spring gives the proper pressure on the valve while grinding. A hole is put through the outer end of the mandrel for a piece to turn it while grinding. Flour emery is used for grinding all valves and other parts.

It frequently occurs that a piece of dirt or scale gets into the cylinder and cuts a rough spot or groove in one or two places. Should this occur I use an adjustable copper lap, Fig. 8, to grind down the roughness. It is made adjustable the same as the mandrels already described and has a handle somewhat longer than the cylinder, screwed into it. The lap is worked to and fro carefully, using a very little flour emery and oil in the operation. This is only done as a last resort.

A great convenience for the men using these hammers, is the shield shown in Fig. 9. I noticed that they were continually wet by the moisture in the exhaust and often their clothing was soaked. The shield was made to deflect the exhaust. It is made of Russia iron to the shape shown, and is sprung over the largest diameter of the handle, leaving sufficient space for the exhaust to pass out freely but away from the operator. A very few minutes after the first one was made and applied, I received orders to make similar shields for all the hammers in use, and the men think they are the best thing that ever happened for their comfort.—*Railway Machinery.*

The Morrison Automatic Air Safety Valve.

Everyone who is connected in any manner with the handling of air-brake trains has realized the serious consequences generally attendant upon the accidental release of the train line pressure by the train parting or the rupture of a hose, the air thus suddenly escaping from the train pipe, the brakes are applied instantaneously, seriously endangering life and property in passenger trains and causing much damage by the shifting of the loads in merchandise trains. The consequent damage to car bodies and draft appliances is well known. Moreover, many collisions occur between the rear sections and forward sections of parted trains, due to the fact that the stoppage is automatically accomplished on both sections (with the present system), as the train in parting passes entirely out of the control of the engineman. The braking power in each car varies, due to many changeable elements entering into the brake construction, such as the relative brake leverage, the friction, piston travel and the matter of developed friction throughout the entire brake mechanism. As a result one car may have greater holding power than others. The proportionate number of air-brake cars ahead of the brake, and the number at the rear, also has a bearing upon the length of time in which both sections of the train may be brought to rest, and should this difference be such that the forward section of a parted train would have all brakes serviceable and the rear section have but one-half serviceable, a collision would be the inevitable result.

The Morrison automatic air safety valve is designed to obviate such casualties and damage by causing the rear section of the train to be brought to a gradual stop and at the same time allow the front section to be in perfect control of the engineman, which will permit him to advance far enough so that a collision will not take place between the two sections.

The accompanying engravings illustrate a longitudinal section view of this device, the dotted lines showing the movable piston and stem in their normal position with stops on inner wall of cylinder, which limit the downward movement.

When the engineman admits the air into the train pipe it will flow to the enclosed chamber above the piston, and as the piston has no packing the air will pass between it and the wall of the cylinder and fill the lower chamber, producing equal pressures above and below the piston.

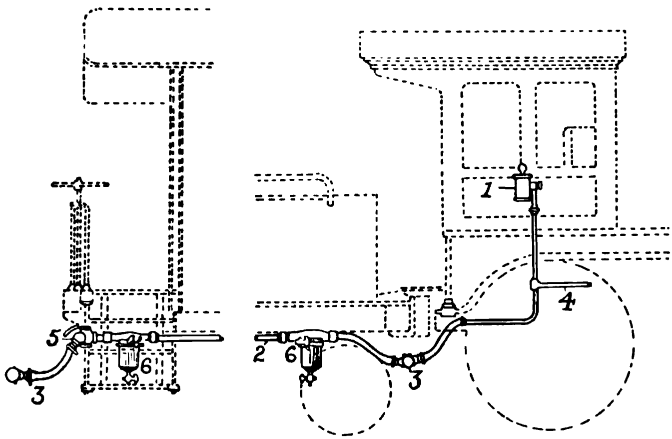
When the train breaks apart and the hose becomes disconnected the sudden discharge of air from the train pipe relieves the pressure on top of the piston, forcing the piston upward, in its travel passing the port in the cylinder, allowing the compressed air from the train pipe to pass below the piston, completing its stroke and holding it in position, the stem closing the main pipe line.

The air in the train pipe slowly discharges through the small hole in the top of the cylinder to the atmosphere, allowing the brakes to be applied throughout the rear section of the train gradually and without shock.

The action of the safety valve at the rear of the front section of the train acts in a similar manner, but as the train pipe of the front section is in communication with the main reservoir upon the locomotive, the discharge of the air through the small holes in the top of the cylinder will be replaced, the pressure will be retained and the brakes will not be applied until the engineman releases the pressure in the pipe in the regular way.

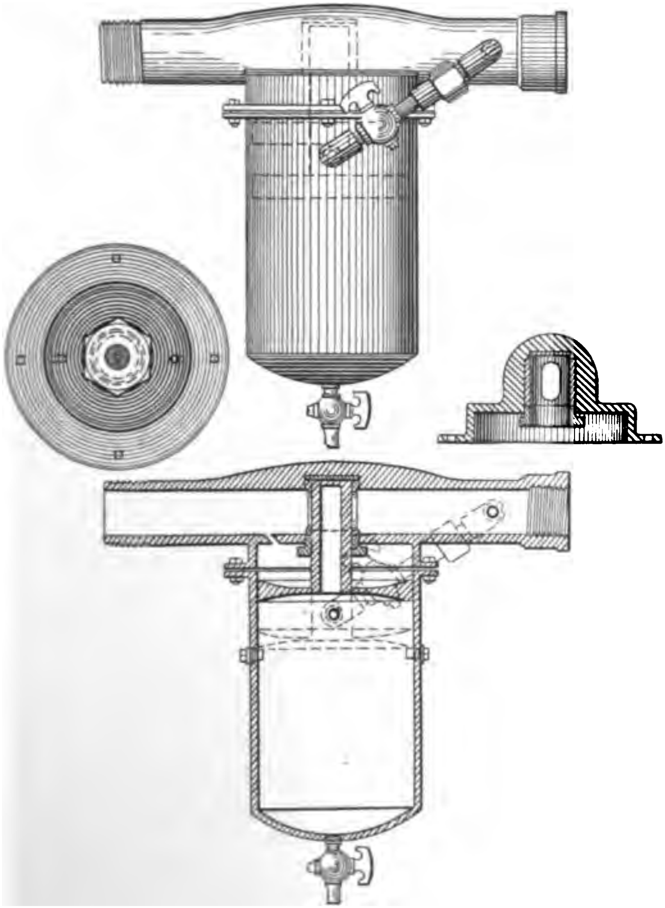
In coupling the two sections of the train when brought together the stop cock is turned, shutting off communication between the train pipe and below the piston; then the stop-cock on the bottom of the cylinder is opened, allowing the air to escape to the atmosphere, whereupon the piston and stem drop to their normal position.

In a service test, made in the Pennsylvania's Company's yards at Toledo, O., on February 10, 1902, with a train of heavily loaded cars running at a speed of 15 miles per hour, the train being broken, the rear section came to a stop without shock at 200 feet from where the train hose parted, and the front section was under perfect control of the engineman, the same as though a "break-in-two" had not occurred. The attachment of these valves on the train pipe did not in any way interfere with or obstruct the free passage of air through the train pipe and subsequent recharging of the train pipe system, nor with the proper making of the service or emergency application of the brakes.



ARRANGEMENT OF MORRISON AIR SAFETY VALVE ON TRAIN AND ENGINE.

The test was witnessed by a number of representative railroad officials from prominent roads, who expressed the opinion that the tests had proved successful in every way. A company has been organized at Toledo to manufacture this valve, and the following officers have been selected: President, O. P. Bowman; vice-president, Eli A. Stark; treasurer, T. F. Whittlesey; secretary, Walter H. Bowman; manager, Frank B. Morrison. The company has been capitalized at $150,000.—*The Railway Age.*



MORRISON AIR SAFETY VALVE.

Notes.

At the great Louisville Cement Mills, Louisville, O., compressed air is used extensively for power purposes, the rock drills in the stone quarries being driven by air.

The Garry Iron & Steel Co., are now engaging more extensively than ever in the production of structure material. Among other large orders they are building a pneumatic portable crane for the Atlas Works of the Standard Oil Co., at Buffalo.

Mr. J. D. Hurley, formerly vice-president and general manager of the Standard Pneumatic Tool Comnany, which company is now owned and controlled by the Chicago Pneumatic Tool Company, has been appointed manager of the Chicago Pneumatic Tool Company, with headquarters at Chicago.

We were rather taken back at reading in a Paris daily paper that the price of a *carde-lettre pneumatique* had been reduced from 50 to 30 centimes (10 to 6 cents); but a frequent visitor to the gay city explains the mystery by informing us that *pneumatique* is the current expression for a message sent through the pneumatic tube to distinguish it from the ordinary telegram.

The amount of air required by a rock drill is usually estimated at fifteen cubic feet at sixty pounds pressure per minute for a three-inch drill and twenty cubic feet for a 3½-inch drill. It is false economy to use too small a compressor for a given number of drills. In estimating the size of a compressor to drive six drills figure that three drills will be working at any one time.

The Stilwell-Bierce & Smith-Vaile Company of Dayton, O., states that O. G. Smith is now manager of its branch office at 612 Arch street, Philadelphia. A. L. McClurg, who has been with the Harrison Safety Boiler Works for six years, has become a salesman of the Stilwell-Bierce & Smith-Vaile Company's pumps, feed-water heaters, etc., making his headquarters at Pittsburg, Pa.

The manufacture of pneumatic tools at the Havana Bridge Works, Montour Falls, N. Y., will be carried on under the management of J. A. Shepard, vice-president. This company recently sold that portion of their plant devoted to the manufacture of bridge and structural work, to the Rochester Bridge and Construction Co., Rochester, N. Y., and will confine their interest hereafter entirely to the manufacture of pneumatic tools.

From the annual report of the board of directors of the Pennsylvania Railroad Co., to the stockholders, March 4th, 1902, we learn that the pneumatic automatic signals were completed to Paoli, the revision of the line and the construction of the four-track system completed at Rheems, on the Philadelphia Division, and the under-grade crossing at Market street partially constructed under the agreement with the municipal authorities of Harrisburg.

The pneumatic caisson for the Brooklyn tower of the Third East River bridge was towed from the construction yard at 151st street and the Harlem River to its location at the foot of Washington street, Brooklyn, on March 17, and the work is now in progress preparatory to the sinking. This caisson is of wood, 144x78 ft. in plan and 56.29 ft. deep. It will be surmounted by masonry tower foundations 58.21 ft. high, which will carry a steel tower 325 ft. high.

Here is where you get rid of that tiresome valve. The Illinois Pneumatic Hammer does the deed, and withal is so simple, strong, quick, that at the end of the thirty days' trial you wonder how you ever got along without it. Th trigger is protected and in a natural position. There it no jarring of the handle, making it perfectly safe, while it strikes a heavy decided blow, or a light one, which ever is suited to your work. These pneumatic hammers are manufactured by the Illinois Pneumatic Hammer Co., 918 N. Sawyer avenue, Chicago, Ill.

A locomotive type of air compressor will be used in connection with the power installation at the new storage and cleaning yard of the Harlem R. R., which is built at North White Plains. This air compressor will be used in the boiler room and will deliver air into a receiver tank located outside of the building, which connects to a 2-inch air pipe placed on the same rack as the steam and water pipes around the inside of the rear wall of the engine-house, with a 1-inch globe valve connection between alternate engine pits. A locomotive-type air compressor will be used.

The ninth annual convention of the Air Brake Association will be held in Pittsburg, Pa., on April 29. The Monongahela House has been selected as headquarters, and members are requested to stop there while in the city attending the meeting. It is hoped that members of the association will be able to obtain exchange passes, in order to attend this meeting, and if such is the case an excellent attendance is anticipated at the convention. Further particulars desired by those wishing to join the association may be had by application to the secretary, F. M. Nellis, Havemeyer Building, New York City.

One would as soon think of committing railroad suicide as to thoroughly equip a train of passenger cars without the regulation air brakes, whether they be of the Westinghouse make. or that of any other of the well known manufacturers. We notice a smart, up-to-date little railroad of twenty-six miles. which extends from Grand Rapids to Holland, called the Grand Rapids, Holland & Lake Michigan R. R. The passenger equipment consists of ten closed cars with seating capacity in each car for over fifty people, each car being supplied with the Magann Storage Air Brake, the air compressor for the charging of the reservoirs being installed at the power house and the Macatawa sub-station.

At the annual meeting of the Compressed Air Company, operating the Rome Locomotive Works at Rome, N. Y., the following directors were elected: Henry D. Cooke, New York; A. C. Soper, Washington; H. Monkhouse, Rome, N. Y.; C. S. Truax, New York; Thomas B. Kent, New York; D. C. Morehead, New York; C. H. Buell, New York; A. B. Proall, New York; Newell C. Knight, Chicago. Officers were elected by the directors as follows: President, Henry D. Cooke; vice-president, H. Monkhouse; secretary and treasurer, H. A. Hinely. It is stated that the financial difficulties of the company have been overcome by funding the floating debt. Of the company's authorized issue of $500,000 bonds, $300,000 are outstanding. About $50,000 is to be expended upon the Rome plant for improvements and additions. There is at present about $100,000 worth of material on hand.

The University of Chicago has recently installed a new heating, lighting and power plant in which compressed air figures largely, as is the natural order of things. It is used for automatic heat regulation, and for use in experimental work and water at high pressure for fire protection and to supply all parts of the various buildings. An air pump in the engine-room operates to maintain an air pressure of 80 lbs. per square inch in a reservoir from which are run receiver lines to the various buildings for use in laboratories for experimental work and in the apparatus for the automatic regulation of heat, after reduction in pressure. In the boiler room, compressed air from this source is employed to clean the boiler tubes and the water and air heating pipes in the smoke ducts. All machinery is lubricated under pressure afforded by the compressed air, and the air is also used in a brazing furnace and in a number of other useful ways.

In order to furnish storage and protection to the southern part of the Metropolitan water district, Boston, Mass., in case of accident to pumps or mains, and to provide for sudden and unusual droughts, a reservoir was built at Forbes Hill, in Quincy, near Boston. When the time came for the calking and riveting, so far as it was possible the people who had the matter in charge desired to have the work done with pneumatic tools, power for which was furnished by a 25 horse power boiler and 12 horse power Clayton Air Compressor, carrying a pressure of 100 to 110 lbs. per sq. inch. A round-nosed calking tool was used and great care taken not to injure the under plate. The use of drift pins was not allowed to force the rivet holes to coincide, any holes more than 1-32-in. out of center being reamed. The side plates were first set up with bolts, and when all were in place the riveting was begun at the top and worked downward, except in the case of the lowest two or three courses, when the riveting kept pace with the erection. The work of erection was finished Nov. 20, and on Dec. 13, 1900, all riveting was done.

Where compressed air is used Quick As Wink Couplers should certainly prove of much value, and as the W. J. Clark Co. themselves quaintly express it, "These couplers won't come apart until you take them apart, and that you can do 'Quick As Wink.'" No twisting and turning will make them let go their hold on the hose—the couplers swiveling freely to unwind the hose, which lasts much longer because thus relieved of twisting strains. Notwithstanding its extreme simplicity of construction, this coupler is not easily damaged, and will stand more abuse than screw couplers. There are no threads to become crossed or battered, and even when slightly flattened are still of use, though in this condition the screw couplers would be almost useless. One piece of hose can be made to serve in the place of many pieces, as only a moment's time is required to detach from one place and attach at another place. If the cost of one section of hose is saved, Quick As Wink Couplers should be a paying investment, and we wish the W. J. Clark Co. the continued success it deserves.

A novel use of compressed air is to be seen in the machine shops of the Hendey Machine Company, at Torrington, Conn. They cut a good many long screws, mostly with square threads, for lathe lead screws and for other transmission screws. The usual trouble was experienced with them from expansion. The temperature of such screws is of course raised considerably during the cutting operation, and much care had to be exercised to prevent this rise in temperature from making trouble and causing too great a departure from accuracy in pitch. Lard oil is used as a lubricant on the screw tool and now in addition to that they have over each lathe a rubber tube through which a blast of air is delivered. The end of this tube is secured to the lathe carriage, and it is so arranged that it moves with the carriage and plays a constant stream of cool air upon the work and the tool. This air carries away the surplus heat as fast as it is developed, keeps the temperature of the work down to about the temperature of the lathe and of the room, does away with the necessity of all waiting or other means of cooling, and enables accurate work to be done much more rapidly than was practicable before the air service was put on.

At the temporary yards of the Eastern Shipbuilding Company, Groton, opposite New London, Conn., a power house has been built exclusively for driving the machinery and compressing the air for the pneumatic tools. Here are the two compound steam and air piston intake compressors built by the Ingersoll-Sargeant Drill Company which have inter-coolers and superheaters and deliver the air at 100 pounds pressure. The capacity of the small machine is about 1,500 cubic feet of free air per minute, and that of the larger machine about 2,000 cubic feet. A Wheeler condenser with 3,000 square feet of tube cooling surface is mounted over a Blake compound air and circulating pump and receives the exhaust steam from the entire plant.

The compressed air from the compressors in the engine room is led to two vertical cylindrical receivers at the after end of the shipbuilding berths through an 8-inch pipe, and from here is distributed through several mains running the length of the berths. From these it is tapped into rubber hose leading to headers and then distributed to the different tools. Pneumatic riveting has been used almost exclusively in all ship construction work at this yard.

The Allis-Chalmers Company, Fraser & Chambers works, Chicago, Ill., issues the fifth edition of its catalogue No. 46 on Riedler compressors and blowing engines. Like all publications of the Allis-Chalmers Company, this pamphlet of 186 pages is well bound, neatly printed and has numerous fine illustrations. It contains some remarks on compressed air and then takes up in detail the construction of the Riedler compressor, showing by numerous diagrams the differences between the Riedler air valve and air valves of ordinary type. The compressors are built either single or duplex, direct acting or two stage, to be driven by water wheels, turbines or steam engines. Some of the notable compressors constructed by the Allis-Chalmers Company are shown as they appear when set up for use. One of these is a King-Riedler compressor recently built for the Rand Mines in South Africa. The capacity of this compressor is 7,000 cu. ft. of free air per minute to a pressure of 80 lbs. per square inch. The Calumet & Hecla Mining Company, of Michigan, is to install two double two-stage Riedler air compressors driven by duplex cross-compound vertical King-Corliss engines, capacity of each being 14,000 cu. ft. of free air per minute to a pressure of 75 lbs. per sq. in.

H. K. Porter Company of Pittsburg, Pa., have recently installed a number of large haulage plants throughout the United States. Among these may be mentioned a complete tramway system for the new reducing works and stamping mills of the Anaconda Copper Mining Company of Anaconda, Mont., air motors to be employed for handling all the concentrates fuel, ore, etc., throughout their entire mill district; also two plants of considerable importance for the Cambria Mining Company of Cambria, Wyo., and a plant for the Homestake Mining Company. The company have further completed and installed for the United States Naval Power Depot at Lake Denmark, Dover, N. J., one 12 by 18 inch pneumatic locomotive, built with compressor, charging stations, receiver, etc., the locomotive being employed in handling cars loaded with amunition and distributing the same to the various magazines. A similar plant was installed a year ago for the United States Naval Magazine at Iona Island, N. Y. Of the other work, a large number of orders have been received for pneumatic locomotives for use in powder works in the far West and for handling lumber in industrial establishments, a plant of the latter sort having just been completed for the McCormick Harvesting Machine Company of Chicago.

There are few railroads to-day which have not tried pneumatic tools for one purpose or another, finding them satisfactory in not only their quick and efficient work, but in the matter of expense as well. No argument should be necessary to demonstrate their earning capacity, but the value of air jacks for cars and locomotives is not so generally known. It formerly required about four hours for eight men with screw jacks to take a ten-wheel engine weighing 132,000 lbs. off its drivers, at a cost of $5.14, and about half that time for four men to do the same work with hydraulic jacks, but using four pneumatic jacks, it is now regularly done by four men in one hour at a cost of 66 cents. However, to be strictly up-to-date an electric crane should be used and the time reduced to ten minutes.

A pneumatic ram was recently made at a cost of $168.55 for breaking staybolts to remove worn-out fireboxes, which earns very large interest on the investment. It formerly cost $45.60 to cut out the crown bolts and staybolts of a ten-wheel locomotive with 9-ft. firebox, using three men, but with the pneumatic ram it is done by two men for $15.20, thereby saving $30.40 on each firebox. If only one firebox was removed each year this tool would earn 18 per cent. on the investment, but as the shop applies 30 new fireboxes a year the saving amounts to $912, or 541 per cent. per annum on the amount invested.

In doing a large class of lathe work much time is used up in starting, stopping and reversing the machine. On brass work especially, such as machining valves, cocks and nuts, where it is necessary to reverse for thread cutting, the lathe is run at a high speed, without back gears, and the time spent in operating an ordinary countershaft may be conservatively estimated as 20 per cent. of the entire time spent on the work.

It was for saving time on this class of work that the pneumatic belt shifter and brake was devised. With this appliance the belts are shifted and the brake is applied by the movement of the hand lever of a pneumatic valve, placed on the lathe apron where its nearness to the other levers of the apron makes it convenient of operation. In it there are five parts, any one of which may be utilized by moving the lever so that the valve covers the desired port. The valve itself is connected, by a flexible tube, to the general air supply pipe of the shop.

The central position of the lever is the "stop" position; when the lever is placed here the driving belts are thrown out of action and a brake is applied to the lathe spindle. The port on the left of this is the "forward" port, while the one to the right is the "back" port. The two outer ports are release ports for the cylinder of the pneumatic brake. When running forward, if it is desired to run back, the lever is thrown directly from left to right, passing over the central port.

Air compression in stages greatly diminishes the influence of the dead space owing to reduction in the ratio of compression for each cylinder, and accordingly it permits of attaining very high pressures, the advantage being greater the more cylinders there are. There are also the additional advantages of less variation in the resistance opposed to the motors, and diminution in the escape of air at the pistons and valves, these parts being subjected to a more favorable regime of pressures. All these effects contribute to increase the mechanical yield; but on the other hand, resistance to the passage of air from one cylinder to another causes additional loss of load, which partly counterbalances the advantages, while the plant is more complicated, and, therefore, costly. Accordingly, simple compression is generally employed when the ratio of compression does not exceed 1 to 7, or 1 to 8; but there is advantage in making an exception for large installations. The necessity of having several motive cylinders for a double or triple expansion of the steam then permits, without increasing the number of parts, a coupling to them tandem-fashion, of the same number of compressing cylinders; and for very high pressures compression in stages imposes itself, for instance, in compressed-air haulage plants when pressures of 30 atmospheres (441 lbs. per square inch) to 50 atmospheres (735 lbs. per square inch) are currently attained.

Have you ever heard of a "Dummy Helper?" *Railway and Engineering Review* says its a small air motor designed for the Aurora shops of the Chicago, Burlington & Quincy R. R. This motor is mounted transversely on a cast iron four-wheeled truck and used for drilling out the vertical holes in cylinders or other jobs that may be easily reached from the floor. The base on which the motor is secured is arranged in such a manner that it may be raised or lowered in two curved guides, and the angle of inclination of the shaft of the air motor thereby altered. A bolt attached to the back of the base passes through the slots in the guides, and it is secured rigidly by setting up nuts on the two ends of this bolt. The drills are set in sockets and operated by small shafts of such lengths as is convenient for the work in hand, these shafts being fitted with unisersal joints to transmit the rotating motion of the air-motor shaft to the drills. This device has proved very useful and is sufficiently rigid as to make the blocking of the wheels unnecessary. It is mounted on cast iron wheels of 5½-in. diameter, the bed plate of the truck being 2 ins. thick, 14¾ ins. wide and 28 ins. long. The base on which the air motor is mounted is ⅝ by 10 by 14 ins. The guides are slotted on a 12-in. radius and the back of the base can be raised through a vertical distance of 7½ ins., being hinged in front. The axles of the truck are 1¼ ins. in diameter, and the distance from the floor to the top of the bed plate is 6¼ ins.

The old Hudson River tunnel was projected by the late D. C. Haskin, who had an original method of pneumatic tunneling. Work was begun in 1874 by sinking a shaft on the New Jersey shore. From the air chamber at the bottom of the shaft the north tunnel was started, the idea being to construct two parallel independent tunnels instead of one large one. Work was carried on from the crown down each side. Iron plates, flanged, were introduced as the excavation progressed and bolted together. When a section of 10 feet had been built it was lined with masonry 2 feet in thickness, this being afterward increased to 2½ feet.

The novelty of the method of building is now to be mentioned. The heading was cut into steps upon which the men worked. The heading was not supported in any way, the tenacity of the silt being depended upon to act as a barrier between the air and water. The air pressure was maintained about equal to the average hydrostatic head. The system appeared to be correct in principle, but in practice it was found to be almost impossible to maintain proper alignment, as the plates had a tendency to settle before the masonry could be finished. The grade of the first 300 or 400 feet is, therefore, extremely irregular.

This led to the introduction of the Anderson pilot, which was a 6-ft. tube located in the center of the tunnel and extending from the completed work some distance beyond the heading into the silt. It was thus supported rigidly at each end, and served as a hub, from which to brace and hold the plates. This method was successful in every respect, and there was no trouble in following the lines. Afterward the shield method was introduced, and flanged cast iron plates were substituted for the masonry.

The Westinghouse Machine Co., East Pittsburg, Pa., has entered the field as a manufacturer of blowing engines, and last week Julian Kennedy, of Pittsburg, awarded this concern the contract for the erection of six engines to be installed at the blast furnaces of the Toledo Furnace Co., of Toledo, O., and the South Chicago Furnace Co., of South Chicago. They will cost $175,000. Three engines will be built for each furnace, and they will be so arranged that they can be run as compound or single engines. Each set will consist of two high-pressure and one low-pressure engine. The low-pressure engine will be used as an auxiliary, and when it is in use the high-pressure engine will receive steam at the boiler pressure and exhaust into the receiver from which the low-pressure engine will be supplied. When the low-pressure engine is in use as a simple engine it will receive steam from the boiler through a reducing valve.

Each high-pressure engine will have a steam cylinder 50 inches in diameter, fitted with the most modern design of Corliss valve gear. The low-pressure steam cylinder will be 96 inches in diameter and will be equipped with the same appliances. The air cylinder in all engines will be 96 inches in diameter and the stroke will be 66 inches. The engines will make 60 revolutions per minute. The air cylinders will be equipped with the Kennedy piston inlet and outlet valve.

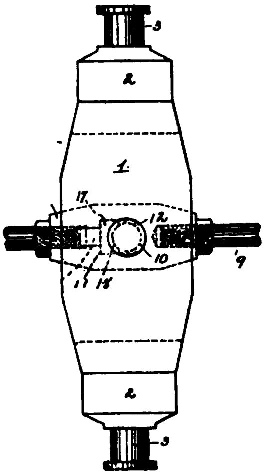
The engines will be of a special type, with the blowing cylinder immediately above a heavy bed plate. On top of the blowing cylinder will be a heavy housing and guide box and on top of the guide box will be the steam cylinder. The advantage is that the engines are very compact. Each will weigh 600,000 pounds, and will have two flywheels 20 feet in diameter, each weighing 65,000 pounds.

The Westinghouse Company has also become a competitor in the horizontal Corliss engine field. It has taken the contract for two such engines of 3,000 horsepower each from the Auburn Interurban Railway Co., of Auburn, N. Y. These engines will cost $70,000. The company has just completed the shipment of eight of the heaviest engines ever built, each having a capacity of 10,000 horsepower. These engines have been sent to the New York Edison Waterside station. The company is also shipping two vertical Corliss engines of 2,000 horsepower each to the new works of the British Westinghouse Co. at Manchester, Eng.

U. S. PATENTS GRANTED FEB. 1902

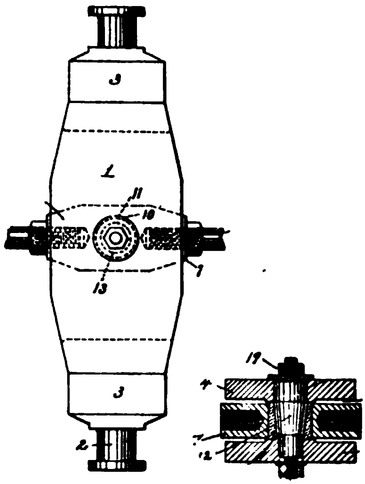
Specially prepared for COMPRESSED AIR.

692,287. ENGINE CROSS-HEAD. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machinery Company, Claremont, N. H., and Chicago, Ill., a corporation of New Hampshire. Filed April 8, 1901. Serial No. 54,979.



An engine cross-head with wrist-pins at the ends for the attachment of connecting-rods thereto, of a block provided with a vertical opening and with a longitudinal opening communicating with the vertical opening, of a piston-rod adjustably secured on said longitudinal opening, a swivel-pin secured to the cross-head to a swing therewith and passing through the vertical opening, and a wear-plate in said vertical opening between the swivel-pin and projecting into the longitudinal opening against the adjustable piston-rod.

692,288. ENGINE CROSS-HEAD. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machinery Company, Claremont, N. H., and Chicago, Ill., a corporation of New Hampshire. Filed April 9, 1901. Serial No. 54,980.



An engine cross-head provided with wrist-pins at the ends for the attachment of connecting-rods thereto, of a block provided with a cylindrical opening, a split sleeve fitting in said opening, and a swivel-pin passing through said sleeve and secured to the cross-head to swing therewith, said block being provided with means for the attachment of a piston-rod thereto.

692,368. PNEUMATIC TIRE. Frederick J. Seddon, Manchester, England. Filed April 15, 1901. Serial No. 55,967.

692,393. COMPRESSED-AIR DRILL. Fred Weimar, Chicago, Ill., assignor of two-thirds to S. A. French, Chicago, Ill., and T. D. Hewitt, Freeport, Ill. Filed Jan. 5, 1901. Serial No. 42,207.

The combination with a portable reciprocating-engine cylinder and its piston, of a flexible pipe for delivering motive fluid to the cylinder, a rigid frame extending from the cylinder alongside the path of the piston-rod, two gears mounted in said frame to rotate upon an axis perpendicular to the axis of the cylinder, two racks connected directly to the piston-rod, to reciprocate therewith, and engaging the two gears, respectively, but upon opposite sides, a tool-chuck mounted in the common axis of the gears, clutch devices arranged to transmit to the chuck like alternate movements of the gears, and a slide-valve operated directly by parts accompanying the piston in its reciprocation.

692,424. AIR-COMPRESSING APPARATUS. Justin H. Burdick, Milton, Wis. Filed May 5, 1900. Serial No. 15,570.

An air-compressing apparatus, comprising an air-cylinder, having an air-inlet and air-outlet; a piston movable within said cylinder; a float, adapted to be raised and depressed by the rise and fall of waves; and means, connected to said piston and said float, for causing the piston to travel inward the full extent of its stroke with each elevation and depression of said float, the outward travel of said piston varying in extent with the height of the waves.

692,685. AIR-PUMP FOR GAS APPARATUS. Ferdinand Logan, Phœnixville, Pa., assignor to Thomas Leiper Hodge, trustee, Philadelphia, Pa. Filed April 17, 1899. Serial No. 713,349.

The combination of an air-pump, having a fixed and a movable section, an air-inlet valve constructed to admit air when the movable section is raised, a cylinder, a piston in said cylinder connected to the movable section of the pump, water inlet and outlet pipes communicating with the cylinder, valves in said pipes, a pivoted lever connected to the movable section of the pump, a weighted lever also pivoted and constructed to be periodically engaged by the first mentioned lever, a pivoted arm operatively connected to the valve in the inlet and outlet pipe, said weighted lever being constructed to move the pivoted arm and thereby operate the valves.

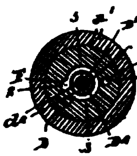
692,741. AIR-EXHAUSTING APPARATUS. Henning F. Wallmann, Chicago, Ill., assignor to the Wallmann Engine Company, a corporation of Illinois. Filed July 24, 1899. Serial No. 724,998.

An apparatus of the character described, the combination with the combustion-cylinder and an igniter therein, of an outwardly-opening discharge-valve closing one end of the cylinder and adapted to be shot open by the force of the explosion, an air-pipe having an annular discharge-opening surrounding the discharge-valve of the cylinder, means for instantly closing the discharge-valve after the exhaust of the products of combustion under the impetus of their own expansion, whereby a vacuum is created in the cylinder, and means for admitting a fresh charge through the agency of the vacuum thus created.

692,796. SHARPENING-MACHINE FOR DRILL-BITS. Theodore H. Proske, Victor, Colo. Filed August 14, 1901. Serial No. 71,996.

A sharpening-machine for drill-bits, comprising a die, and a dolly reciprocating toward and from said die, the die and the dolly having registering bevels to serve as a protection to the shaping part of the dolly and as a guide and bumper for the same.

692,799. PNEUMATIC TOOL. William H. Soley, Philadelphia, Pa., assignor of one-half to George A. Dallett, Philadelphia, Pa., and Thomas H. Dallett, Cheyney, Pa., trading as Thomas H. Dallett & Co. Filed June 15, 1900. Serial No. 20,417.



In a pneumatic tool in combination with a casing, a piston-chamber formed in said casing, a piston of differential area in said chamber, a source of pressure supply, a constant communication between said source of pressure supply and the lesser piston area, a valve-chamber, a valve in said chamber having a closed end, constantly acted on by the pressure-supply, and a chambered portion communicating with the piston-chamber, a piston for said valve, a passage leading from said valve-chamber to the piston chamber and adapted in the reciprocation of the piston to be covered by the piston and open into the chamber below the piston-ports in said valve connecting with the chambered portion of the valve, one port adapted in the movement of the valve in one direction to register with an exhaust-passage and the port in the reciprocation of the valve in the other direction adapted to register with the air-supply, an annular groove b^2 in the piston, a port F extending through the casing to the piston-chamber and a passage H extending from the valve-chamber to the piston chamber opposite port F.

692,948. AIR-BRAKE SYSTEM. Thomas H. Van Dyke, Kansas City, Mo., assignor of one-third to John W. Taylor, Kansas City, Kan. Filed March 11, 1901. Serial No. 50,598.

The combination in an air-brake system, of a lever having a movable fulcrum suitably guided, having a relation with the floating lever whereby its leverage thereon is gradually increased, and pivoted at an intermediate point to the piston-rod.

692,978. GOVERNING DEVICE FOR PNEUMATIC PIANO-PLAYERS. Theodore P. Brown, Worcester, Mass. Filed May 29, 1901. Serial No. 62,344.

A pneumatic governing-device, the combination with a driving-shaft, of a governor-shaft geared thereto, a base-board having a series of air-passages formed therein, said passages each terminating at one end in an elongated port-opening of varying area throughout its length, said series of ports being arranged in parallelism, pneumatic devices attached to said base-board and each having communication with one of the said air-passages, a cranked connection between said governor-shaft and each pneumatic device, and means contacting with said base-board and adapted to control the active area of said port-openings.

693,184. ELECTROPNEUMATIC CONTROL SYSTEM FOR ELEVATORS. August Sundh, Yonkers, N. Y., assignor to Otis Elevator Company, East Orange, N. J., a corporation of New Jersey. Filed Sept. 20, 1901. Serial No. 76,126.

A controlling apparatus for elevators, the combination with a motor, car, and stations, of pneumatic devices and connections for calling and sending the car from one station to another operating in conjunction with the electrical motor-controlling means.

693,195. AIR-SUPPLY TO LIQUID VAPORIZING, COOLING AND AERATING APPARATUS. William H. Weightman, New York, N. Y. Filed July 17, 1900. Serial No. 23,891.

The combination with a cooling-tower open at the top and provided at its upper end with a liquid distributing or spraying apparatus, of a lower compartment open on all sides for the admission of air from without, and through which the liquid passes after treatment; a plurality of radial partitions extending outwardly from the center of said lower compartment; and a liquid drain connecting said partitions, through or along which the treated liquid passes to a receiving-compartment below.

693,198. PNEUMATIC MOTOR. Joseph Weiser, Brooklyn, N. Y., assignor of one-half to Karl Fink, New York, N. Y. Filed Dec. 6, 1900. Renewed Nov. 14, 1901. Serial No. 82,221.

The combination, with a plurality of stationary valve-chests, a suction-chest connected therewith, and an equivalent number of pneumatics also connected with the valve chests, of a crank-shaft connected with the movable members of the pneumatics passing through the valve-chests, and rotary valves fixed at suitable intervals apart on said shaft and working each on one face of each of the valve-chests, said valves and valve-chests being constructed to alternately admit air and shut it off from the pneumatics.

693,366. GENERAL CLASS OF TUBULAR DESPATCH SYSTEMS AND ESPECIALLY TO RECEIVING APPARATUS FOR INTERMEDIATE STATIONS. Bryant H. Blood, New York, N. Y. Filed August 20, 1900. Serial No. 27,455.

A receiving apparatus for tubular transit systems, the combination with a receiving-chamber, pneumatically-operated gates therefor, and a main air-pressure supply for operating said gates, of a governing and controlling system consisting of pneumatically-operated valve mechanisms for said main air-pressure supply, an auxiliary air-supply for operating said valve mechanisms, an excess-pressure valve mechanism, a trip-finger valve mechanism and insurance valve mechanisms, said excess-pressure. trip-finger and insurance valve mechanisms so disposed and constituted as to render each function of the machine absolutely dependent upon the consummation of the preceding function.

693,415. FLUID-PRESSURE SIGNAL-VALVE. Harry R. Mason, Chicago, Ill., assignor to Westinghouse Air Brake Company. Pittsburg, Pa., a corporation of Pennsylvania. Filed June 12, 1900. Serial No. 20,010.

A fluid-pressure signaling system, the combination, with a signal valve device operative by variations of pressure on opposite sides of a movable abutment, of means separate from, but actuated by, the movable abutment, for quickly releasing fluid from one side of the abutment to the other to counteract such variations.

693,431. AIR-RELIEF VALVE. Millard P. Osbourn, Camden, N. J., assignor to Warren Webster and Company, a corporation of New Jersey. Filed Sept. 11, 1901. Serial No. 75,002.

693,434. COMPRESSOR. Frederick W. Parsons, Elmira, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed March 11, 1901. Serial No. 50,589.

The combination in a compressor with a base, two standards uprising therefrom and having bearings at their upper ends, and two vertical cylinders arranged one on the outside of each of the said standards, the said cylinders, standards, and base being in one integral casting, of a shaft mounted in the said standard-bearings, a fly-wheel secured upon the shaft and arranged between the said bearings, crank-pins carried by the shaft and arranged one on the outside of each of the said standards, pistons in the said cylinders, connecting-rods connecting the said crank-pins with the said pistons, and an inlet and outlet for the fluid acted upon in said cylinders.

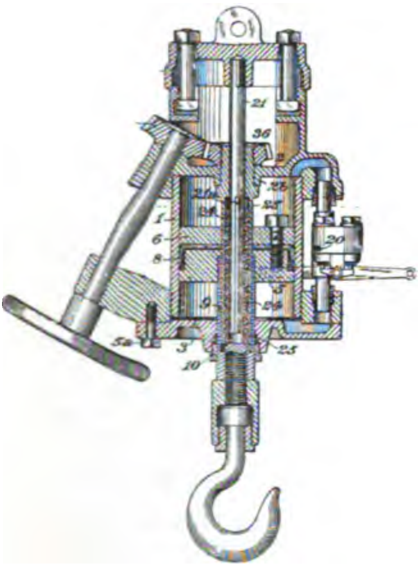
693,484. VALVE-BALANCING DEVICE. Robert L. Ambrose, Tarrytown, N. Y., assignor to Rand Drill Company, New York, N. Y., a corporation of New York. Filed March 11, 1901. Serial No. 50,596.

The combination with a valve-chest having ports therein, and a reciprocating slide-valve controlling said ports, said slide-valve having a lateral-extending boss, and having a lateral orifice extending therethrough and through the said boss, of a non-metallic flexible flanged ring, mounted on said boss, said ring free to move on said boss in a direction transverse of the reciprocating movement of said valve.

693,516. MEANS FOR TRANSFERRING FLUID UNDER PRESSURE. William S. Halsey, Pittsburg, Pa. Filed Aug. 30, 1900. Serial No. 28,508.

The combination of a fluid-pressure reservoir, a receiver surrounding and movable longitudinally thereon, a supply-valve seating over a port in the reservoir, a lever system mounted in the reservoir and coupled to said valve, tappets connected to said lever system, and extending through the shell of the reservoir on the side thereof farther from the supply-valve, and a bearing-surface fixed to the receiver in position to contact with said tappets.

693,517. PNEUMATIC HOIST. William S. Halsey, Pittsburg, Pa. Filed Nov. 13, 1901. Serial No. 82,105.

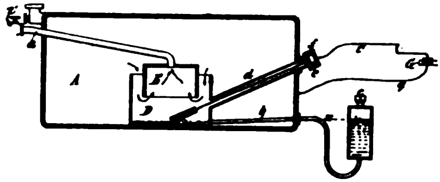


A pneumatic hoist, the combination of a fluid-pressure cylinder, a piston fitting therein, a tubular piston-rod fixed to said piston and projecting through a packed opening in one end of the cylinder, means for admitting and releasing fluid to and from the cylinder, a tubular regulating-screw, fixed to the piston-rod, a rod fixed to the cylinder and extending into the bore of the regulating-screw, a key in said rod engaging a key-way in the regulating-screw, a tubular nut fitting freely in the piston-rod, and surrounding and engaging the thread of the regulating-screw, and means for controlling the speed of rotation of said nut.

693,818. PNEUMATIC TIRE. William F. Stearns, Cambridge, and William L. Haines, Boston, Mass., assignors, by mesne assignments, to Punctnot Tire Company, Camden, N. J., and Philadelphia, Pa., a Corporation of New Jersey. Filed Aug. 17, 1901. Serial No. 72,324.

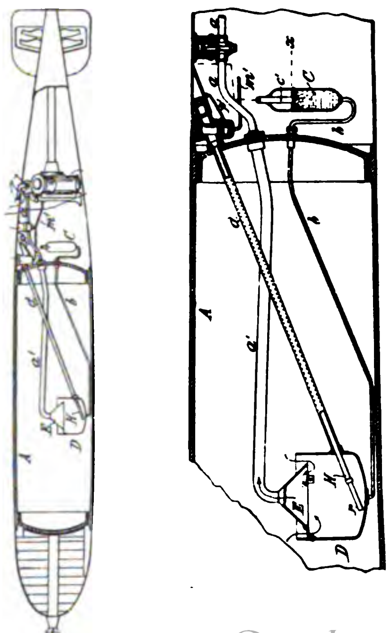
693,823. AIR-GUN. Walter R. Benjamin, St. Louis, Mo. Filed Sept. 11, 1901. Serial No. 75,086.

693,871. GENERATION OF POWER FROM COMPRESSED AIR. Frank M. Leavitt, Brooklyn, N. Y., assignor to E. W. Bliss Company, Brooklyn, N. Y., a Corporation of West Virginia. Filed Dec. 12, 1898. Serial No. 699,006.



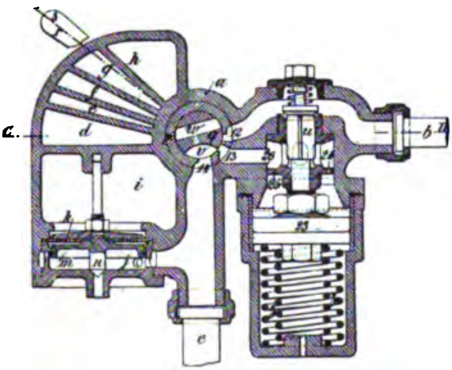
In compressed-air propelling mechanism for automobile torpedoes, the described means for increasing the energy of the stored compressed air which consists in means controlled by the pressure for heating the compressed air.

693,872. PROPULSION OF TORPEDOES, ETC., BY COMPRESSED AIR. Frank M. Leavitt, Brooklyn, N. Y., assignor to E. W. Bliss Company, Brooklyn, N. Y., a Corporation of West Virginia. Filed April 12, 1900. Serial No. 12,545.



An automobile torpedo, the combination with means for storing fluid under pressure, an engine driven by such fluid, and means for starting the engine upon the launching of the torpedo, of means for heating the fluid supply to the engine, and means for starting the action of said heating means adapted to be set in operation by the launching of the torpedo.

693,874. OPERATING MECHANISM FOR COMPRESSED-AIR BRAKES. Joseph Lipkowski, Paris, France, assignor to the Societe Generale des Frenis Lipkowski, Paris, France. Filed Dec. 22, 1900. Serial No. 40,804.



Operating mechanism for compressed-air brakes, comprising a socket, a cock, grooves therein, an opening at the top of the socket to the air and at the bottom to the train-pipe, one of said grooves adapted to connect said top opening and train pipe, a source of pressure-supply opening between them, a casing on the side opposite the source of supply and comprising an auxiliary reservoir and radially-arranged superposed chambers, each having an opening to the socket, a diaphragm in the reservoir, and a valve controlled thereby to open the train-pipe to the atmosphere.

693,939. PNEUMATIC HAMMER. Melvin A. Yeakley, Cleveland, Ohio, assignor to Williams, White & Co., Moline, Ill. Filed Oct. 12, 1900. Serial No. 32,835.

In pneumatic hammers, a hammer-chamber and a valve-chamber and a valve therein, separate vacuum and pressure passages opening into said valve-chamber and a single passage connecting the valve-chamber with the hammer-chamber.

693,991. VALVE FOR PNEUMATIC TIRES. Charles R. Barrett and Elwood C. Phillips, Chicago, Ill. Filed July 12, 1901. Serial No. 67,949.

694,153. MEANS FOR AUTOMATICALLY BALLASTING MARINE BOATS. John P. Holland, Newark, N. J. Filed July, 1901. Serial No. 69,887.

A submarine boat having a tank to contain water ballast, said tank having valve-controlled communication with the water of flotation, means for opening said valve to admit water to the tank, means for admitting an aeriform fluid to said tank for blowing out water therefrom, a hydrometer, electrical means controlled by the rise and fall of said hydrometer for actuating the means for admitting water to and discharging it from said tank, and a float in said tank which breaks the electric circuits established by the hydrometer.

694,154. SUBMARINE BOAT OR VESSEL. John P. Holland, Newark, N. J. Filed July 31, 1901. Serial No. 70,414.

A submarine boat having a tank with capacity, when full, for water ballast sufficient to put the boat in diving condition in fresh water, and an auxiliary tank with capacity when both it and the main tank are full, to put the boat in diving condition in salt water, said tanks being situated with reference to the center of buoyancy of the boat.

694,280. APPARATUS FOR COMPRESSING AIR. Samuel P. Howe and Samuel M. Vauclain, Jr., Ithaca, N. Y. Filed Jan. 15, 1901. Serial No. 43,382.

The herein-described improvement in apparatus for utilizing the operating parts of a steam-engine for compressing air for use in a system of which said engine forms a part, consisting of the combination with a steam-engine and its valve-chest, of a storage-reservoir for compressed air, a liquid-fuel tank, a branch pipe connecting the tank and reservoir for compressed air, a liquid-fuel tank, a communication between said tank and reservoir, a check-valve between said controlling-valve and reservoir, a main pipe connecting the valve-chest of the engine with the branch pipe, a valve for controlling communication between said main pipe and valve-chest, and a check-valve in said main pipe between its controlling-valve and the junction between the main pipe and the branch pipe, whereby when the steam is shut off from the engine, the latter may operate to compress air and discharge the same through the main pipe into the reservoir and tank, or either of them.

694,299. AIR COMPRESSOR AND COOLER. Oscar P. Ostergren, New York, N. Y. Filed May 24, 1901. Serial No. 61,-773.

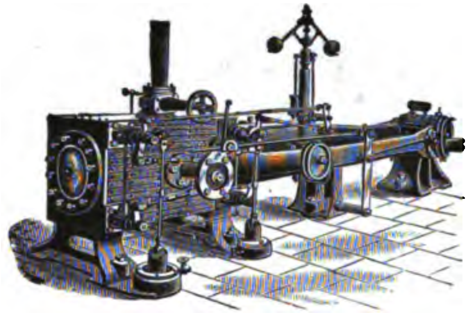
The combination with the air-compressor, of the water-injecting pump, the annular inlet to the compressing-cylinder and the annular valve controlling said inlet.

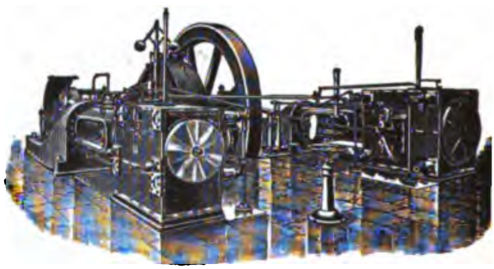
694,324. RECEIVER FOR PNEUMATIC-DESPATCH TUBES. Albert W. Pearsall, New York, N. Y. Filed June 11, 1901. Serial No. 64,167.

A receiving-terminal having a carrier-removal opening made shorter or smaller than the carrier.

694,328. AIR-BRAKE. Charles A. Seley, Roanoke, Va., assignor of one-half to William H. Lewis, Roanoke, Va. Filed Aug. 9, 1901. Serial No. 71,469.

694,339. PNEUMATIC HORSE-COLLAR. Charles S. Boehm, Hopkins, Minn. Filed March 26, 1901. Serial No. 58,014.

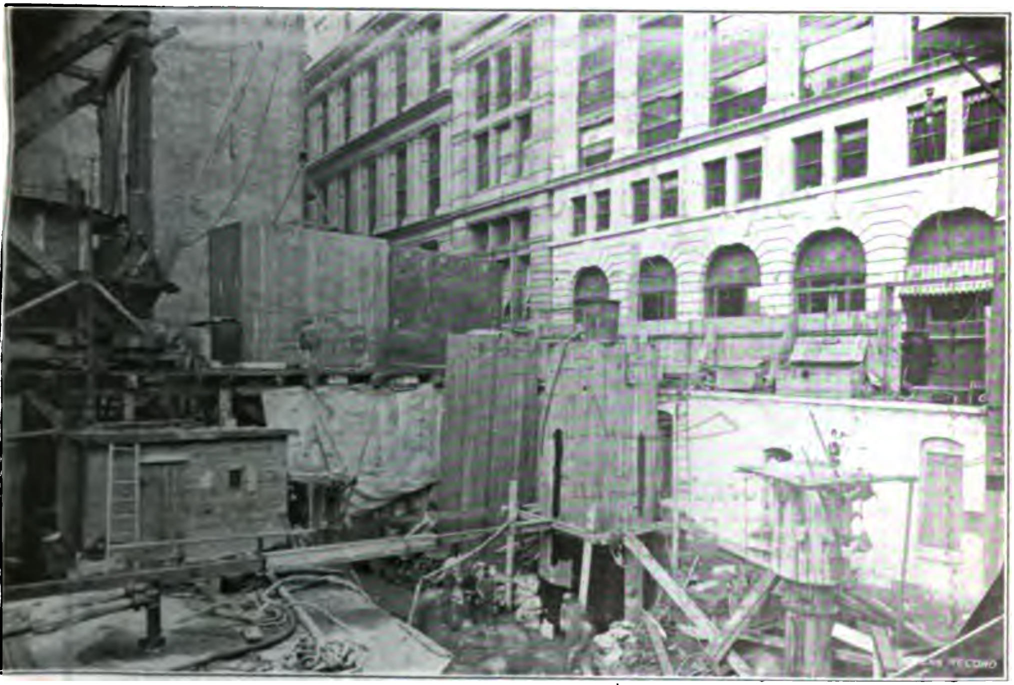




Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, MAY, 1902. No. 3.



SINKING CAISSONS FOR PIER FOUNDATIONS, HANOVER BANK BUILDING.

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, -
M. E. VARIAN, - } Associates

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

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VOL. VII. MAY, 1902. NO. 3.

With this issue we publish in full a paper on "The Use of Compressed Air in Mining," by Mr. T. W. Barber, which appears in our contemporary, *The Iron and Coal Trade Review*, for April 4, 1902.

This paper will be of interest to our readers because in it are offered a number of reasons for the comparatively slow adoption of compressed air, even in cases where a parallel could be found as an example to study.

The first of his reasons, the fact that mining men as a rule are educated in the practical school of experience and are not given to depending much upon theory, was at one time true—and theory is often dangerous when practical work is concerned. Mining methods have not, as a rule, afforded an opportunity for much experimentation of the sort to develop new principles in compressor machinery. Generally such work is conducted in out-of-the-way places where experiments with the power plant are inadmissible. The inherent advantages of compressed air have, however, expanded the use of air beyond the bounds of mining and into factories and other work where opportunity for careful observation, changes and experimental modifications could be made.

As a consequence considerable improvements have been made through scientific logical study the same as has been largely responsible for the importance of electrical industry. Money has been forthcoming and inventive genius has led a growing chance to suggest and improve. The improvement in air compressing machinery resulting from this outside impulse has of necessity reacted toward the improvement of compressors used in mining. With the more extended use of compressed air has also come an improvement in the means for transmitting and the apparatus for using air. Other applications have come up and we now see the use of compressed air on the increase in a very gratifying degree

Certain defects or unfortunate features, formerly believed to be inseparable from compressed air, have been eliminated or so greatly reduced that air in mining has become as essential as hoisting machinery.

The question of cost of production, formerly the bugbear of those contemplating the use of air, and the main stock argument of its opponents is now well down the scale of importance and is surely sliding further down.

With guaranteed volumetric efficiencies in larger sized compressors of from 80 to 95%, and mechanical efficiencies of from 90 to 95%, most favorable comparisons can be made with electrical generators, which have been regarded as at the top notch of efficiency.

Transmission also, owing to great improvements in the methods of pipe manufacture, better methods for coupling and a better understanding of the laws governing the flow of air has resolved itself into a simple matter, permitting the prediction of results with certainty and with efficiencies which can be made anything desired from a fraction of a per cent. to the usual 5 to 10% adopted in electrical transmission. Comparisons of costs of installation no longer stagger 'those contemplating the use of air.

With cheap, satisfactory production and transmission of compressed air its future was insured. Mr. Barber's paper discusses all of these points in an interesting manner. which warrants attention.

Air For Power.

In the past few years there has been an enormous increase in the use of air for power purposes and new applications are being found for it every day which are surprising in their number and variety.

That so common a substance as *air* should be so readily adapted to accomplishing desirable mechanical results makes the subject of interest to the general observer, while to the trained worker the possibilities of its applications are enticing.

Air, of itself, *at rest,* possesses neither power nor energy which we can utilize. It is present in a practically inexhaustible supply, but is an absolutely inert substance, and as useless as any other form of matter unless acted upon from without. In common with other bodies it may serve as a transmitter of energy or power from a source of supply to a place where it may be used, or as a body in which energy may be stored and there kept until recovered at a future time.

When *air* is *in motion* it is capable of doing a certain amount of work. It possesses its energy by virtue of its velocity and is independent of both temperature and pressure. The first use of air for power was the application of the winds to move sailing vessels, windmills, and the like. Air set in motion by mechan means and unconfined has but a relati small use.

It is by working with *confined* port of air that so great advances have l made within recent years. Under s conditions its value for work is cerned with the temperature, pressure volume. These are inter-related acc ing to certain well defined laws.

The *total* energy in a quantity of ai the gaseous condition is determined b temperature alone. Changes in its p sure or volume do not at all affect total energy providing the temperature mains unchanged. The *effective* or av able energy, however, depends upon o conditions, and it is upon *these,* and control we have over them, that the v of air as a power depends.

A given mass of air will occupy a tain space depending upon the pres and the temperature. As either of t are changed the volume of the air cerned will change correspondingly. the pressure be increased the volume decrease, and in an exact ratio, if o influences are not regarded. This may be expressed in the formula, volume varies inversely with the p sure." or "the pressure multiplied by volume equals a constant." By "press is meant here not the pressure as from the pressure gauge, in which is the atmospheric pressure but *a lute pressure* is referred to, i no pressure at all, or, the gauge r ing *plus* the pressure of the air (14.7 per square inch).

The effect of temperature upon vol of air is to increase the volume with of temperature. Temperature and p sure may act together to change the ume of a certain amount of air, or may act separately, the other being constant. Generally both are conce where air is compressed, or a better s ment would be that volume. pressure temperature are interdependent. T relations need to be kept in view in consideration of the value of air power. Conversion formulas and fa may be readily obtained for changes. As we expend work upo either by heating or compressing it thereby endue it with energy which it part with later in doing work. The cally, all that it had received woul given off again in effective energy, b practice there is loss in volume by leakage, in pressure by friction losses and in temperature by radiation of heat. The loss by leakage should be so slight as to be negligible if conduits are properly made and installed. The loss by friction in transmission may be considerable and should be minimized so far as possible by the use of large conduits. It is claimed by some that the heat of friction counteracts the loss of energy, but it is very doubtful if this is of real value inasmuch as this heat with that otherwise imparted to the gas, is liable to loss by radiation. Protective nonconducting coverings lessen heat losses very materially, and many ingenious devices are in use whereby the loss is in a measure counterbalanced.

Air, then, is an inert substance, inexpensive, inexhaustible in supply, upon which we may expend work, then store it or transmit it to such time and place as is desirable to receive from it again the energy given to it, and this without an unreasonable amount of loss of energy. There can be received from it no more energy than has been imparted to it; the great value of air as a power lies in the fact that there is so little loss of energy.

Air is the one substance always present, the supply is inexhaustible, we are living at the bottom of an ocean of air 200 miles in depth; to seize upon and use this substance in our work possesses a fascination of itself. It seems strange that any extensive use of air for storage or transmission of power has come about only in the last few years.

Energy may be imparted to air either by the application of *heat*, or *pressure*. The former is but little used compared with the latter method. It pays to put energy into air by direct heating only when the air is to be applied to do work immediately, as in the case of some hot air engines, and in high pressure air motors. The objection to storing energy in air by giving heat to it is that with the increase of temperature of the air, the loss by radiation and conduction to neighboring bodies is correspondingly increased and it is impossible to prevent consequent dissipation and loss of the heat energy.

The principle of the hot air engine may be briefly stated. The air is heated by contact with a hot iron cylinder or other means, and is thereby caused to expand, acting against a piston which it pushes out against atmospheric pressure. Then by cooling the confined air by water jacket it is caused to contract followed by the piston driven in by the pressure of the outside air.

The application of pressure to air is the common means of imparting energy to it. The effect of the pressure exerted is to compress the air into a smaller volume and to increase its temperature. This volume of compressed air now has energy by virtue of its added pressure and higher temperature, and if allowed to do work will expend both in a return to normal volume, less the losses noted above. If the air is stored the loss of its temperature energy will be considerable, and it is, therefore, desirable that as little energy be stored as heat and as much in pressure as is possible, that is, cooling of the air during compression is desirable. Also the less heat, the less back pressure will be exerted on the piston of the compressor during action. Cooling of the air during compression is attempted either by spraying water into the air or by surrounding it with a cold water jacket. The latter is more efficient where the cylinder is small, thus providing better contact with the air. The spray is objectionable because it renders the air moist and is a detriment in later use. When air is compressed and cooled so that no increase in temperature results during compression it is termed "isothermal compression;" but when all of the heat is retained in the air and both pressure and temperature are increased it is called "adiabatic compression." As a matter of fact neither case is attained in practice because no means are devised whereby all the heat can be either removed or retained under compression. The terms are in general use, however, to express different methods. Because of the expansive action of the heat on the air, in compression, 1 1-3 as much work is needed to compress adiabatically one pound of air from ordinary conditions to a gauge pressure of 90 lbs. per square inch, as would be needed to compress the same isothermically. Therefore, adiabatic compression is uneconomical unless heated air is needed for immediate service in motors.

The cooling of air during compression is largely effected by means of cooling tanks or other devices and the air, after being somewhat compressed, is passed through one of these, thence to a second compression, and so on. In case the air is compressed in one cylinder only, it is termed a single-stage compressor. If the air is first compressed, then cooled, then again compressed, it is a two-stage compressor. If three cylinders, a three-stage, and so on, the apparatus being named from the number of compressing cylinders or stages of compression. The air is usually cooled between each stage by passing it through "inter-coolers," so called, which are vessels variously constructed so as to expose the heated air to as large a cooling surface as possible, thus bringing its temperature down to as near normal as may be before it enters the next compression cylinder. No one form of these mutiple stage compressors is best for all purposes, the comparative economy being a question of the pressure desired, the use to be made of the air, and other factors largely peculiar to each different plant. The efficiency of a compressor depends largely upon its inter-coolers; but every compressor-cylinder and inter-cooler added increases the friction to be overcome by the driving force, and hence increases proportionately the work which the engine must do; hence it is only when the gross saving effected by the addition of another air compression cylinder and an inter-cooler is *greater* than the gross loss due to increased friction and amount of machinery to be driven, that there is any economy in the additional compressor cylinder and cooler.

Air may be compressed by other means, one of which is by the direct action of a waterfall. Wherever possible such means should be employed, but in the vast majority of cases the steam-driven compressor pumps are the best means of air compression. The pressure to which air is subjected varies from one to two ounces per square inch for ventilation purposes, to 2,000 or 3,000 lbs. per square inch for power storage or transmission service. In ventilation large volumes of air are needed under very light pressure, and for this some form of the fan blower is best adapted. For pressures more than a few pounds per square inch, too high for fan blowers but low for piston compressors, the positive rotary blower type is desirable. This form is largely used for blast in forges, forced draught, pneumatic dispatch tubes, and like purposes. In Bessemer steel plants pressures from 15 to 30 lbs. per square inch are generally used and for these and higher pressures up to about 75 lbs. the single stage piston compressor is best adapted. The heating effect on the air at these pressures is quite marked and from above 40 lbs. the question of cooling the cylinder walls becomes an important one with any but very small equipments. For forced draughts the heating of the air is, of course, not objectionable.

From this point on to higher pressures two or three or more compression cylinders are considered more economical. For air drills, mining apparatus, and all the multitudinous applications of compressed air for tools of all descriptions, pressure from 80 lbs. to 90 lbs. per square inch are in general practice, with a tendency developing from experience to increase to 100 lbs. or over, as a working pressure. For all these appliances the air should be as dry as possible and hence it is preferable to avoid the spray of water in cooling at the compressor. The air should also be free from dust and grit to avoid damage from cutting, especially in the drills and motors having a number of small valves and pistons.

For power storage and transmission air from 1,000 to 3,000 lbs. pressure is in demand. Too little is known regarding the most economical handling, transmission and use of the air at these high pressures. For many reasons it is probable that it is more economical to transmit and use air at these rather than at lower pressures.

When the energy stored in the air is finally taken from it, the pressure first communicated to it is given to the various mechanisms provided, and thus it does work. At the same time there is a return to (nearly) original volume and the air now becomes cold. Just as with a decrease of volume heat was developed, so now with the increase in volume, cold is evident. To be more exact, with a diminution of volume or condensation of any gas, heat is liberated, and with the opposite or expansion of the gas, heat is absorbed, evidenced by "cold."

Air being a mixture of gases it may contain varying amounts of its constituents. No trouble is experienced with any of these except the water vapor. When it is chilled sufficiently it changes to solid form and often clogs the exhaust pipes or even the valves of the appliances wherein the air is liberated for use. To avoid this trouble either the moisture must be previously removed or the compressed air heated to a sufficient degree so that in expanding the temperature will not fall below the freezing point of water.

In expansion, as the energy is given up from the air, one cubic foot of air at 60 pounds pressure will expand to 5.10 cubic feet free air; at 80 pounds pressure to 6.46 cubic feet. and at 100 lbs. previous pressure the freed air will occupy 7.82 cubic feet. One pound of air at 60 degrees Fahrenheit when compressed to 1,000 lbs. per square inch would occupy a volume of about one and one-half gallons, and if previously heated can be made to develop in a motor a little over one horse power for three minutes. In this process the air will absorb about 150 calories of heat. Thus a very valuable refrigeration is offered aside from its motive power, and by proper appliances should be, and often is, made use of quite effectively. The cooling effect may be secured and used by water jacket or like device, or the cooled exhaust (and exhausted) air, itself, can be used in many ways. Large advantage is taken of this cooled exhaust air for ventilation purposes and its value is too apparent to need further discussion. Especially is this true in mine work, in submerged caissons, in any enclosed chamber work, and in the hot workshop in summer time it is a boon to the workman. Only in cases where the air is contaminated from the oil used in lubrication in the air machines is it objectionable. One of the most important factors in the use of compressed air for power lies in the fact that the exhaust does not vitiate the air, nor in any way act as a nuisance; on the contrary, it is rather beneficial than otherwise. And at the place where it is used there are no waste products to prove an obstruction, an annoyance or expense for removal. In vehicles of all descriptions, from the heavy compressed air locomotive or surface railroad passenger coach to the lightest running vehicle, compressed air furnishes a power for traction purposes which possesses peculiar advantages. Air motor cars can be compared with accumulator cars for independence and silent running, and have none of their drawbacks except weight. They possess the elasticity of power of steam vehicles with none of their objections on the score of noise, exhaust and fuel handling. Compared with the trolley, air cars are equally powerful and do not necessitate installation of head or surface connections, and are not liable to the trolley limitations and exasperations. While it is unnecessary and not pertinent to disclaim against other motor powers in favor of air, certainly each have advantageous qualities over the others, and air has points in its favor which recommend it. It has an advantage over electricity in that it is safe and harmless, no danger of electric shock or fire through defects or accidents in wiring or use; once compressed, it is ever available whether compressor happens to be running or not, and when not wanted there is no expense and no loss concerned with keeping it constantly and instantly available. Other advantages might be used, but limited space precludes such discussion, as well as any entrance into detail or even mention of the several thousand and one uses which have been found for compressed air. And no matter how complete such a list of uses might be prepared, it would be incomplete and out of date before the printer's ink were dry on the page.

Air supports our life, the life of all animate nature; it is equally ready to be harnessed and thus to do our bidding in countless details of daily duties. It will clean our garments and finest carpets and tapestries in their place, noiselessly and without a whiff of dust; it serves to harden the quicksand and make ready the foundations for great engineering structures; it takes earth's treasures from the mine, opens the way for rapid transit through mountains or under the crowded city streets and blocks of buildings; affords safe transit, or, rather, *safe stoppage* by the automatic air brake; carries our packages, transmits our mail; in short, helps amazingly to make life safe and comfortable, allowing one man to do the work of ten and permitting to each a greater measure of economy in time and in effort.—George Platt Knox, in *The Economist.*

The Imperial Type of Air Compressor.

The accompanying half-tone and line engravings illustrate a new type of air compressor which has been introduced recently by the Rand Drill Company, of 128 Broadway, New York, and which is intended more especially for shop use. The air cylinders are fitted with positive moving Corliss inlet valves and are compounded, the intercooler being in two sections which are placed in the bases.

An interesting and novel feature of the machine is the method of securing flooded lubrication of the various bearings. The splash method of throwing the lubricant from the crank case is not applicable to air compressors on account of the slow speed at which they at times operate. A compressor must of necessity operate at various speeds to meet the constantly varying demand for air. While the higher speeds may be sufficient to throw the oil in the manner employed in enclosed crank case engines, the lowest speed, which is usually set to be the slowest at which the machine will turn over without catching on the center, would be entirely insufficient and at times when but little work is being done, the machine may operate so long at this slow speed as to make it unsafe to depend on the oil thrown at previous higher rates of speed.

This difficulty is met in a very neat way which we believe is new. Each bed is so formed as to provide an oil cellar, the top of which is so located that the crank disks dip into the oil, which oil will obviously be carried around by the disks at any speed. The direction of the motion is "over" and a light scraper *a*, Fig. 2, scrapes the oil from each disk and delivers it into the channel *b*, which is elevated above the highest bearing and from which it is carried by suitable pipes and channels to the various bearings. Such pipes and channels will be seen at *b*, *c* and *d*.

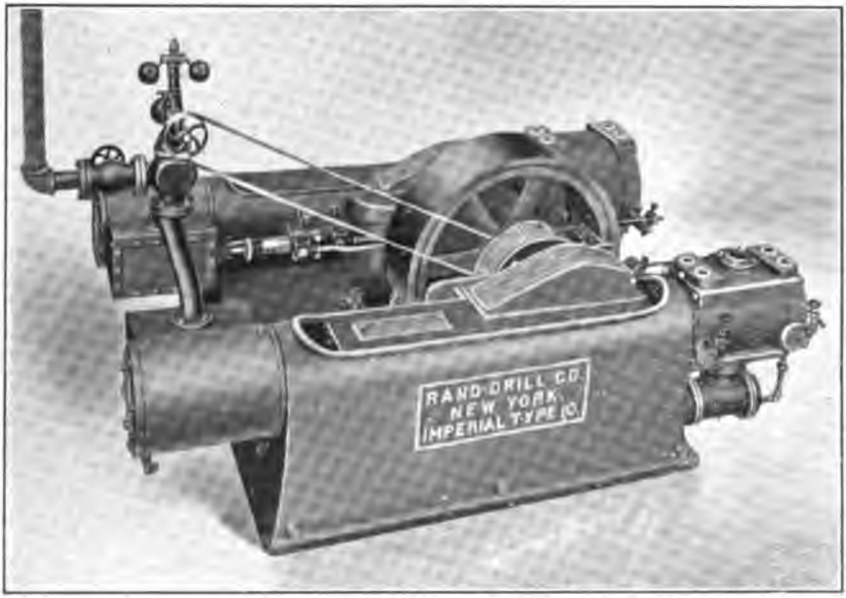


FIG. I. THE IMPERIAL TYPE AIR COMPRESSOR.

The design will be seen to be somewhat bold in that the air piston rod is, in plan, offset from the steam rod. To counteract the effect of this the crosshead is made of unusual length and its sliding surface is formed into a series of V-grooves which fit corresponding grooves in the guide. The downward thrust of the connecting rod forces the crosshead to travel in these grooves in a true straight line and in addition to this the air piston rod will be seen to be, from necessity, of considerable length, giving ample opportunity for spring should it be needed. Large numbers of these machines are running and we are informed that no difficulty has developed from this source. It appears to be a case of "handsome is as handsome does," for certainly the advantages of the arrangement in point of compactness are very apparent.—*American Machinist.*

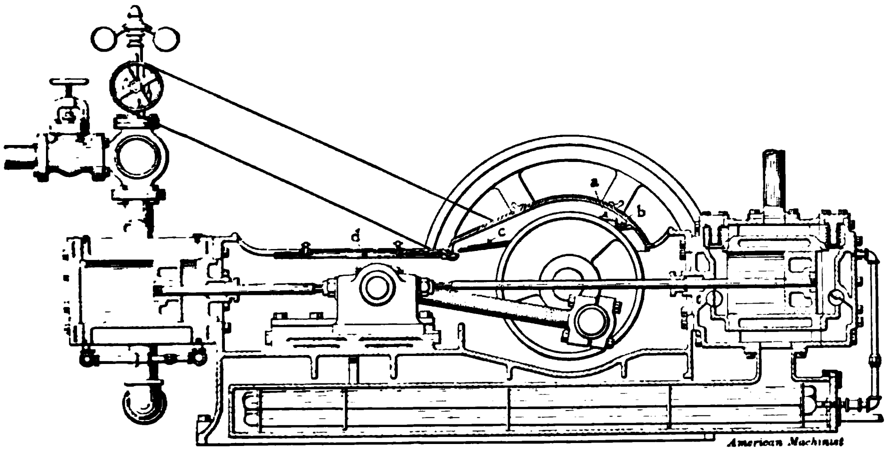


FIG. 2. LONGITUDINAL SECTION OF THE IMPERIAL TYPE AIR COMPRESSOR.

The Freezing of Moisture Deposited from Compressed Air.

The presence of moisture in compressed air must be accepted as an unavoidable condition. Existing in the atmosphere at all times, in greater or less quantity, when air is compressed the moisture is carried with it. In practice, a part of the water is deposited in the air receiver; but a considerable quantity still remains, and will be brought into evidence when the proper conditions occur.

The capacity of air for moisture depends primarily upon its temperature. Under ordinary atmospheric conditions, 1,000 cubic feet of air contain about 1 pound of water. When compressed in the compressor cylinder the increase of heat which takes place augments the moisture-carrying capacity of the air. But the moisture-carrying capacity is reduced by any subsequent decrease in temperature, and if the air be saturated the excess of moisture is deposited. Volume for volume, the capacity of air for moisture is independent of its pressure or density. That is, at the same temperature, a cubic foot of air at atmospheric pressure will hold in suspension the same weight of water as a cubic foot at 100 lbs. pressure. But this must not be misunderstood. If a certain volume of moist atmospheric air be compressed isothermally, that is, at constant temperature, say to one-tenth of its original volume, its water capacity is also reduced to one-tenth, and nine-tenths of the water originally present in the air is deposited. Therefore, while the water capacity of a given volume of air varies with the temperature, it must change also with any increase or decrease of the pressure which changes its volume.

Certain conditions are required to cause freezing: deposited moisture must be present, and it must be subjected to a temperature below the freezing point. So long as the temperature does not fall low enough the presence of moisture can do no harm. Although one of the recognized functions of the air receiver is to permit the deposition of water before the air passes into the pipes, still, unless the receiver be extremely large, the air leaves it warm—usually even quite hot—and therefore carries with it considerable moisture.

Unless liberal sprays are used to attain effective cooling, the air from wet compressors is apt to contain more moisture than that from dry compressors. A well-designed injection compressor, however, not too small for its work, and therefore running at a moderate speed, will deliver cool air which will not give trouble from freezing. Being thus well cooled on entering the pipe line, even though it be nearly if not quite saturated, the moisture-carrying capacity of the air is not greatly reduced by passing through the pipe, and but little further deposition of water takes place. With dry compression, the percentage of humidity of the intake air, and the temperature at discharge, determine the quantity of water carried out of the cylinder. The humidity, in turn, varies with the weather. Changes in the weather may be quickly followed by variations in the quantity of moisture deposited from compressed air. When the air is finally expanded in doing its work intense cold is produced as the pressure falls and the latent heat of compression is absorbed. It is here that the moisture carried with the air into the pipes makes its appearance as frost and causes trouble.

The difficulty which may arise from this state of things is apt to be exaggerated. That freezing not infrequently occurs is true, but with a properly arranged plant it may be easily avoided. Two things require attention: first the air should be caused to drop its moisture as completely as possible before entering the main; second, provision should be made for draining off what deposited moisture remains in the pipe line before the air passes to the machine in which it is to be used. Although this is a simple matter, the means for accomplishing it are often neglected. Considerable quantities of water may collect in low places in the pipe line, and, if not blown out at intervals, will be carried into the ports, cylinder and exhaust passages of the air machine, and there freeze.

Granting that the air leaves the receiver near the compressor practically saturated and still warm, it is evident that a great improvement in working may be realized by introducing a second receiver as near as possible to the machines using the air. In mining, the second receiver is, of course, placed underground. Before reaching it the temperature of the air will have become normal, and the entrained moisture from the pipe line may be conveniently trapped and drawn off. Automatic water traps are preferable to valves or cocks for getting rid of the water.

The statements made above suggest an important consideration, viz., in transmitting power by air at a high pressure there is less liability to trouble from freezing than when low pressures are employed; provided, that the length of pipe line is sufficient to allow the air to be completely cooled and drained of its water while still under high pressure. At a low pressure a greater volume of air is required to furnish a given amount of power than when at a high pressure. More moisture must therefore be dealt with, and at the low pressure it cannot be so thoroughly separated before the air is used. Suppose, now, the transmission is at a high pressure, and through a pipe long enough to allow the air to reach normal temperature. If the deposited moisture be drained away while the air is at its maximum pressure, then, if the air be subsequently expanded down to a lower pressure suitable for working (with a corresponding increase of volume), and allowed to regain its normal temperature, the percentage of moisture in the larger volume is reduced, so that the air may be relatively very dry. When finally used in the air engine, there will not be enough moisture present to cause troublesome freezing.

At the Drummond Colliery, Nova Scotia, for running an underground pump by compressed air two receivers are used, one near the pump and another 300 feet farther back on the pipe line. The air pressure in the main from the surface is 85 pounds, and as the proportions of the cylinders of this particular pump are such that so high a pressure is unnecessary, a reducing valve was put in the pipe just before reaching the first receiver. By this valve the air is wire drawn to reduce the pressure to 45 pounds, which results in a deposition of nearly one-half the entrained water, in addition to that already deposited in the pipe. It is found that more moisture collects in the first than in the second receiver (as might be expected), and by this device the serious difficulty previously encountered from freezing at the pump has been entirely overcome. The temperature lost by the reduction of pressure to 45 pounds is regained before the air reaches the pump.

What precedes refers to the freezing produced by internal reduction of temperature, acting upon the moisture carried in the air. In using compressed air, even for mining purposes, it often becomes necessary to carry lines of air pipe considerable distances on the surface. To prevent condensation and freezing of the moisture in winter by external cold all surface piping must be protected. If exposed to temperatures below the freezing point the inner surface of the pipe will become coated with ice, and its effective cross section reduced. A serious diminution of area may thus be caused at low points in the pipe line, where water tends to collect; or the pipe may even be frozen solid in such places by the gradual accumulation of ice. Underground the temperature is rarely, if ever, low enough to render any protection necessary, except in winter, in cold down-cast shafts.

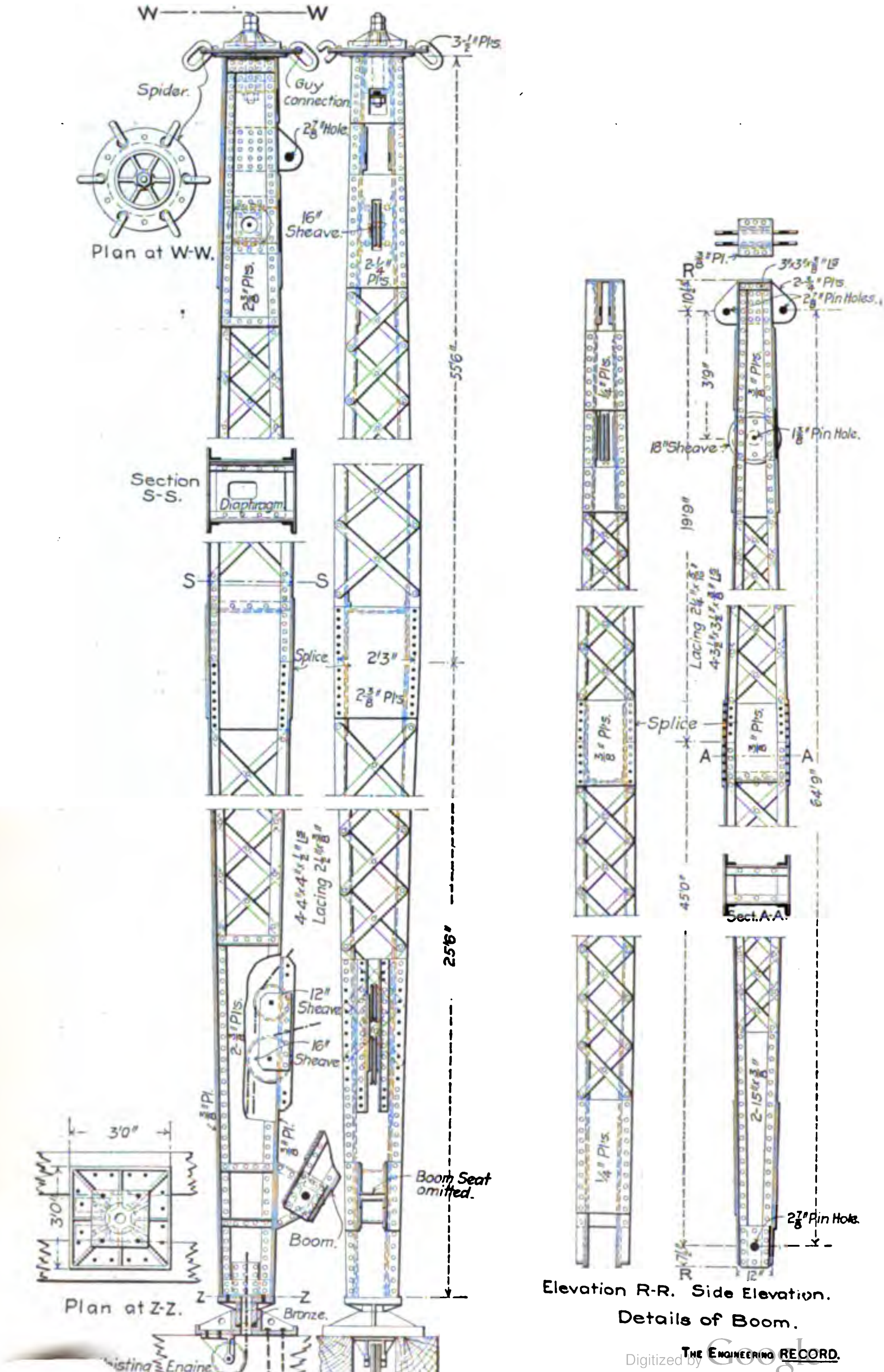
Some time ago, at the Anaconda copper mines, Butte, Mont., (as stated in COMPRESSED AIR), a simple and inexpensive device was installed to prevent the freezing of the moisture in a long line of surface piping. From one of the large compressor plants the air main was carried on the surface a long distance before reaching the shaft. During the winter months it was at times difficult to get sufficient air pressure in the mine, because of the partial choking up of the pipe. As the volume of air was too large to be dealt with by the ordinary receiver, a series of old boilers was put in close to the compressor house. The hot air, at 80 pounds pressure, in passing through these boilers, from one to another, was cooled down practically to the temperature of the atmosphere, and as a consequence a large part of its moisture was deposited. It was found that old tubular boilers, when strong enough, are well suited to this purpose, because of the large surface presented to the cold outside air, especially when they are set horizontally, so that there is a free circulation of air through the tubes. A blower might be used for the same purpose or the boilers submerged in cold water. This effectual remedy is well worthy of imitation where the conditions are similar—Robert Peele, in *Mines and Minerals.*

The Construction of the Hanover Bank Building, New York.

The new Hanover bank building at Pine and Nassau streets, New York, is a twenty-two story steel-cage structure. Before the old buildings were removed from its site preparations for its construction were commenced by sinking half a dozen test holes in their cellars without disturbing the tenants. These holes were jetted down about fifty feet to the hardpan and indicated that the latter had an approximately horizontal surface and was overlaid with quicksand. It was determined to support the building on concrete foundations carried down through the hardpan to solid rock by the pneumatic caisson process, and the contract for the substructure was let to Mr. John F. O'Rourke, M. Am. Soc. C. E., who commenced operations in November, 1901.

The old building was removed and the site excavated to a depth of about 23 feet below the curb or 1 foot above water level. The walls of the adjacent buildings on Nassau and Pine streets were underpinned by 19 vertical cylinders sunk by the Breuchaud process to hardpan, filled with concrete, and wedged up under the wall. These cylinders were made of sections of 16-inch steel pipe joined together with outside screwed sleeves, and were sunk under the centre line of the wall by a powerful hydraulic jet and a hydraulic jack reacting against horizontal beams recessed into the outer face of the wall a few feet above the footing. The pipes encountered no boulders. When they arrived at the hardpan they were pumped dry and a quantity of dry concrete was placed in the bottom; then the pipes were filled with ordinary 1:2:4 Portland cement concrete dumped from the top and rammed in the upper part.

Operations were not fairly under way on the main foundations until the middle of December, when they were prosecuted with great vigor and all were sunk within a remarkably short time. The 40 main columns are supported on 6 rectangular and



Side Elevation. Front Elevation.
Details of Mast.

THE ENGINEERING RECORD.

SPECIAL 15-TON STEEL GUYED DERRICK.

27 circular piers, each of which is built inside a pneumatic caisson and cofferdam. The arrangement and relative sizes of the caissons are shown on the foundation plan published with the previous description of this building. The cylindrical caissons vary from 6 feet 8 inches to 11 feet 8 inches in diameter, and the rectangular ones are, with one exception, 6 feet wide and from 16 to 31½ feet long. All of them were built with 4 x 12-inch vertical wooden sheathing planks on steel angle frames. The cylindrical caissons were made continuous with their cofferdams, and were received at the site in lengths up to 32 feet. The rectangular caissons were received in sections 18 feet high, which were bolted together through inside flanges.

The rectangular caissons are set so as make a continuous wall across the sides of the lot opposite the street fronts, and not only serve to support the wall columns but form a solid concrete dam from bedrock to above water level, which is watertight and resists any external pressure from the quicksand or ground water. These caissons were of special pattern, similar to those used in the new Stock Exchange foundations. Semi-cylindrical shafts were left open in the adjacent ends of the cofferdams on top of the rectangular caissons until after they were concreted, when the end walls of the cofferdams at the shafts were removed to form oval wells which were filled solid with rammed concrete making vertical keys, 4 feet in diameter; these keys reached from the top of the pier to the roof of the working chamber and bonded the sections of the wall or dam together with water-tight joints. These keys penetrated several feet into the hardpan and were considered ample without making connections between the ends of the working chambers as was done in the Stock Exchange work, where the cellar excavation was practicallly to the bottom of the caisson.

At the commencement of operations a raised movable platform 40 feet long, reaching from the edge of the excavations to the opposite curb, was built of heavy timber and supported two 20-ton stiff-leg derricks, hoisting engines and some supplies and machinery above Nassau street without obstructing the traffic there.

Near the middle of the Pine street front a platform was built at street level half way across the excavation, parallel to Nassau street. It had a 4-inch timber deck about 28 feet wide and was supported on frame bents of 12 x 12-inch timber about 24 feet high. On it was a longitudinal track for a traveling tower which had four vertical corner posts and was braced in the six vertical and horizontal faces with pairs of diagonal screw-ended rods. The vertical posts were braced at the tops by diagonal posts in the four sides and served as masts for four derrick booms about 50 feet long. After setting four cylindrical caissons beyond the end of the platform, the falsework was extended above them across the full width of the lot and the derrick tower traveling back and forth on it, was able to command all the site execpt what was served by the Nassau street derricks. Holes were cut through the platform to set the caissons under the place where the derrick tower was at first placed, and shelters for the air compressors, workshops and other sheds were built at convenient places where they would clear the caissons. Each derrick boom was operated by a separate Lidgerwood hoisting engine, which swung it horizontally by a bull-wheel attached to the foot of the mast.

Including those which were being concreted, as many as five or six caissons were under air pressure at once and as many as four were usually being sunk simultaneously. They were sunk to a total depth of 75 to 81 feet below the curb. The first 40 feet was in quicksand through which the cylindrical caissons were sunk in about 24 hours and then an average of 48 hours more was required to sink them through 12 to 24 feet of hardpan to the solid rock. The last caisson was concreted on February 5, and the erection of the steel superstructure was commenced soon afterwards, while the excavation of the cellar was continued to about 4 feet below the water level.

Our frontispiece progress view is made from a photograph looking towards Pine street and showing the foundation work in full operation on January 8, 1902. In the foreground, on the right, is shown the air lock and shaft rising from a cylindrical caisson which is sunk out of sight; beyond it two more cylindrical caissons are being sunk and have cofferdams on top which reach above the curb level. In the background is the falsework platform with the tower derrick at the left, ready to hoist one section of the cofferdam of a rectangular caisson. A working platform for the calkers is suspended from the upper edge of the cofferdam, and at the right there is the caisson or lower section of a wall-pier shell. These foundations included more than 6,000 cubic yards of caisson work, which was executed within two months during the winter. Mr. O'Rourke has made very rapid progress with similar work, which has been described from time to time in these columns, but this is believed to establish a record for speed in caisson sinking; he attributes it to thorough preparation and organization, together with the special caissons and equipment employed. —*Engineering Record.*

Hot Air Engines.

People are so used to steam and gas engines that the old, reliable and economical user of coal for pumping purposes is forgotten, and in many cases where it should be best known, it is altogether unknown. I refer to the hot air engine, sometimes, though erroneously, called a caloric or heat engine. Strictly speaking it should be called an external combustion engine to distinguish it from that class of engines in which the combustion which supplies heat occurs within a closed chamber containing the working substance. The ordinary coal gas explosive engine is the most common type of internal-combustion engine.

Compared with an engine using saturated steam, air and gas engines have the important advantage that the temperature and pressure of the working substance are independent of one another. Therefore, it is possible to use an upper limit of temperature greatly higher than in the ordinary steam engine, and if the lower limit is not correspondingly raised, an increase of thermodynamic efficiency results. It is true that the same advantage might be obtained in the case of steam, by excessive superheating, but this would mean, substantially, the conversion of the steam engine into the type we are now considering, the working substance being then steam gas. The action of the air engines, like that of all other heat engines, consists in admitting the air at a high temperature and pressure, worked expansively, and then it is either exhausted into the atmosphere and a fresh supply introduced, or it is again heated and compressed for a repetition of the former process. In the cycle just described, air has some advantages over steam as a working fluid. The efficiency of an engine depends upon the limit of temperature to which the working fluid is subjected, and it is practicable to use a higher working temperature with air than with steam, because there is no fixed relation between the temperature and pressure of air, as exists in the case of steam.

In the actual forms in which Stirling's engine was used, the most important feature was that the air was compressed (by means of a pump) to a pressure greatly above that of the atmosphere. Stirling's cycle is theoretically perfect, whatever the density ot the working air, and compression in this case did not increase what may be called theoretical thermodynamic efficiency. It did, however, greatly increase the mechanical efficiency, and what is of importance, it increased the amount of power for a given size engine. To see this it is sufficient to consider that with compressed air a greater amount of heat is dealt with in each stroke of the engine.

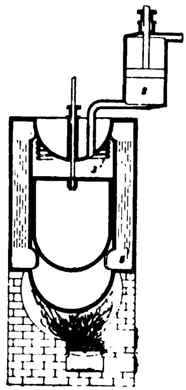


Fig. 1.

The Stirling engine is diagramatically shown in Fig. 1. The several parts are: 1 is a closed vessel containing air externally heated by a furnace beneath it. A pipe from the top of one leads to the working cylinder 2. At the top of 1 is a refrigerator 3, consisting of pipes through which cold water circulates. In 1 there is a displacer plunger 4 (or transfer piston), which is driven by the engine; when this is raised the air in 1 is heated, whereas when 4 is lowered the air in 1 is brought in contact with the refrigerator and cooled. On its way from the bottom or top. also on its way from top to bottom, the air must pass through an annular lining of wire-gauge 5. This is the regenerator. At the beginning of the cycle 4 is up. The air is then receiving heat and is expanding isothermally; this is the first stage. Then the plunger or transfer piston 4 descends. The air is driven through the regenerator 5, where it deposits heat, next the working piston makes its down stroke (in the actual engine the working cylinder was double acting, another heating vessel, precisely like 1, being connected with the upper end of the working cylinder). This compresses the air isothermally, the heat produced by compression being taken up by 3. Finally the plunger 4 is raised, and the working air again passes through the regenerator, taking up the heat it left there.—A. Edward Rhodes, in *Practical Engineer.*

Lubrication of Air-Pump Air Cylinders.

Air-brake men for some time have realized that air cylinders of air pumps have not been lubricated in the proper manner. The common way of oiling the pumps, through the cock on the air cylinder, proved itself to be inefficient and did not produce as good a result as could be desired. When oiling this way, too much oil was generally put in at one application, and before receiving the next dose the cylinder would become dry, causing excessive wear and requiring frequent boring of the cylinder and renewal of piston packing rings, and all the other numerous evils attending badly worn cylinders and leaky piston packing.

There can be no doubt that the air cylinders of our air pumps, which nowadays are generally worked to their utmost capacity, need constant lubrication in proper quantity. This evil has been successfully overcome by Master Mechanic W. S. Clarkson, of Livingston, Mont., who has applied a lubricator to the air cylinder of the air pump. This lubricator consists of a plunger-feed rod cup, which is applied to the air cylinder, by tapping a hole in the wall of the air cylinder, midway between the top and bottom heads. Into this hole an elbow is screwed, so as to hold the cup in a vertical position. The hole in the wall of the air cylinder, just before reaching the inner surface, is reduced to 1-16 inch.

The feed of the cup is regulated by reducing or increasing the lift of the plunger, which is done by a set-screw in the top of the cup. These cups may be so regulated as to feed any quantity of oil desired. They have been in use on the Montana division of the Northern Pacific Railroal for five months, and have been used on pumps engaged in the most severe kind of service. Examination of the air cylinders has shown that the wear has been reduced to a minimum by a small quantity of oil fed continuously to the air cylinder of the air pump. It is found to be a great improvement over the old way of oiling the air cylinder. This device is simple and inexpensive and results in a great saving to the air pump as well as economy in oil. This may be a device used before, but it has never been brought to my notice.—C. E. Allen, in *Railway and Locomotive Engineer.*

Compressed Air for Pumping Plants.

For convenience in figuring on large pumping plants to be operated by compressed air, there is given herewith a table by which the pressure and volume of air required for any size pump can be readily ascertained. Reasonable allowances have been made for loss due to clearances in pump and friction in pipe.

To find the amount of air and pressure required to pump a given quantity of water a given height, find the ratio of diameters between water and air cylinders and multiply the number of gallons of water by the figure found in the column for the required lift. The result is the number of cubic feet of free air. The pressure required on the pump will be found directly above in the same column.

For example: The ratio between cylinders being 2 to 1. Required to pump 100 gallons, height of lift 250 feet. We find under 250 feet at ratio 2 to 1 the figures 2.11; 2.11 x 100 = 211 cubic feet of free air. The pressure required is 34.38 pounds.

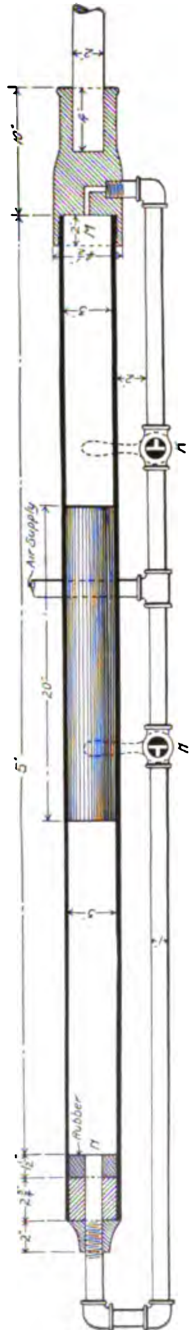
Ratio of Diameters.		25	50	75	100	125	150	175	200	225	250	300	350	400	450	500	
		PERPENDICULAR HEIGHT, IN FEET, TO WHICH THE WATER IS TO BE PUMPED.															
1 to 1		13.75	27.5	41.25	55.0	68.25	82.5	96.25	110.0	.....	.....	.....	.....	.....	.....	.....	Air pressure at pump.
		0.21	0.45	0.60	0.75	0.89	1.04	1.20	1.34	.....	.....	.....	.....	.....	.....	.....	Cubic feet of free air per gal. of water.
1½ to 1		.....	12.22	18.33	24.44	30.33	36.66	42.76	48.88	55.0	61.11	73.32	85.4	97.66	.....	.....	Air pressure at pump.
		.....	0.65	0.80	0.95	1.09	1.24	1.39	1.53	1.68	1.83	2.12	4.41	2.70	.....	.....	Cubic feet of free air per gal. of water.
1¾ to 1		.....	.....	13.75	19.8	22.8	27.5	32.1	36.66	41.25	45.83	55.0	64.16	73.33	82.5	.....	Air pressure at pump.
		.....	.....	0.94	1.14	1.24	1.30	1.54	1.69	1.84	1.99	2.39	2.59	2.83	3.19	.....	Cubic feet of free air per gal. of water.
2 to 1		.....	.....	.....	13.75	17.19	20.63	24.06	27.5	30.94	34.38	41.25	48.13	55.0	61.88	68.75	Air pressure at pump.
		.....	.....	.....	1.23	1.37	1.52	1.66	1.81	1.96	2.11	2.40	2.69	2.98	3.28	3.57	Cubic feet of free air per gal. of water.
2¼ to 1		.....	.....	.....	.....	13.75	16.5	19.25	22.0	24.75	27.5	33.0	38.5	44.0	49.5	55.0	Air pressure at pump.
		.....	.....	.....	.....	1.533	1.68	1.83	1.97	2.12	2.26	2.56	2.85	3.15	3.44	3.73	Cubic feet of free air per gal. of water.
2½ to 1		.....	.....	.....	.....	.....	13.2	15.4	17.6	19.8	22.0	26.4	30.8	35.2	39.6	44.0	Air pressure at pump.
		.....	.....	.....	.....	.....	1.79	1.96	2.06	2.104	2.34	2.62	2.88	3.18	3.36	3.23	Cubic feet of free air per gal. of water.

COMPRESSED AIR FOR PUMPING PLANTS. (See page 1810.)

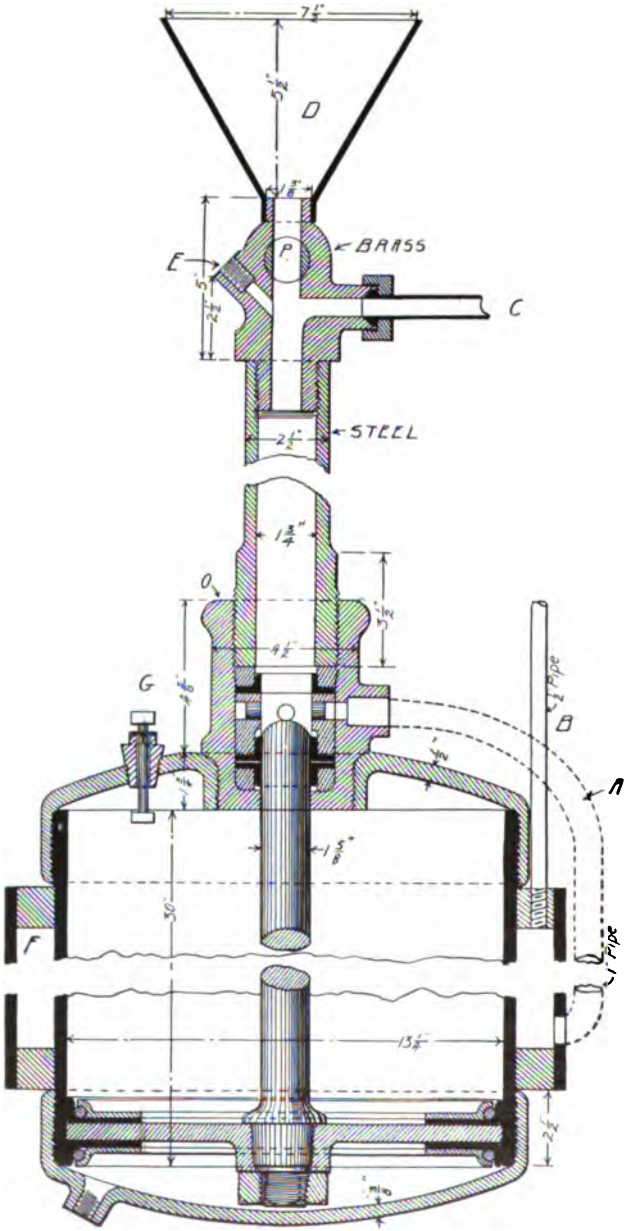
Two Useful Pneumatic Tools.

Compressed air tools have accomplished much in the way of expediting work in many lines of industry. This is especially noticeable in the application of pneumatic tools for repair work such as must be encountered in railroad shops. The character of the work in the boiler and smith shops naturally affording a greater field to test the utility of such tools, it is here that they are found to be the most useful.

The accompanying illustrations show a pneumatic-hydrostatic pressure accumulator and a pneumatic hammer invented by Alfred Parfitt, foreman boilermaker in the Topeka shops of the Atchison, Topeka and Santa Fe. The hydrostatic machine is patented, the latter is not. The pneumatic hammer is a particularly convenient all-round tool. The device may be made any size to suit the work in hand. It can be cheaply constructed and a laborer can, with a little practice, become expert in handling the operating valves. The main cylinder in this case is made of 3-inch wrought iron pipe, 5 feet long. A plug is welded in the one end, as shown. Originally this plug was screwed in, but the knock of the hammer, due to the return stroke, soon resulted in injury to the thread, although the impact was on the rubber cushion. The plug in the opposite end or tool holder is screwed on, as the full force of the blow is transmitted directly to the work through the medium of the tool resting in the socket at its outer end. The hammer, which is 20 inches long and weighs about 40 pounds, is operated by two plug valves, H and K, with the arrangement of piping, as shown. These valves are drilled to operate as a three-way cock, and by turning the handle K so that the port stands lengthwise to the pipe, air is admitted through the contracted port opening M, and the hammer is driven to the opposite end of the cylinder. The valve is then returned to the position shown in the cut and the valve H opened. The opening, N, being large, offers little resistance to the flow of air, and the hammer is driven to the other end of the cylinder with great force. The cylinder is supported by block and tackle and preferably held to the work with a slightly



A PNEUMATIC SLEDGE HAMMER.



PNEUMATIC-HYDROSTATIC PRESSURE ACCUMULATOR.

downward inclination of its forward end. This tool has been found particularly useful in breaking stay-bolts in fire-box legs that are inaccessible with the ordinary stay-bolt breaker. It is also used for cutting off rivet-heads in fire-box sheets and one blow is sufficient to cut off crown-bar nuts and heads. A shorter arrangement of this same tool is used for heading crown-bar bolts, by means of a concave tool placed in the socket. In fact, the tool may be put to many uses in and around the boiler shop and three men will perform as much work as six men with ordinary appliances, where the character of the work demands heavy sledging.

The pneumatic-hydrostatic pressure accumulator here shown was made primarily to be used for punching sheets in repairs to fire-boxes and boilers where operation is necesary without removing the sheets. The device is mounted on a truck and may be moved near the work in hand. The main cylinder is 13¼ inches in diameter and is made of cast-steel having flanged heads on either end. Around the outside of the cylinder is a water space F. A stuffing box O is screwed into the top head, which is flanged inwardly to provide for the thread. A steel cylinder is again screwed into this, which is surmounted by a brass cap containing an ordinary plug valve P. C is a ⅝-inch copper pipe which leads to the punch, which is not shown, being the ordinary form of small jaw punch having a 4-inch plunger and capable of being easily handled by the workman. To place the machine in condition for operating the valve P is opened and the upper cylinder or steel pipe is filled with water through the funnel D, the pipe A furnishing means to fill the space F surrounding the main cylinder. The valve P is then closed. A slight auxiliary pressure is necessary to bring the punch to the plate each time before punching, and this is accomplished by turning the air pressure into the ½-inch pipe B by means of a small plug valve connected with the main pressure pipe. This places a pressure on the water in the receiver F and brings the punch to place on the work. Air is then turned in at the bottom of the large piston which forces the 1⅝-inch ram above the openings leading to pipe A, as shown, thereby relieving the auxiliary cylinder of excessive pressure. The ram is then forced through the pipe C, the pressure, of course, depending on the amount of air pressure used. The valve G is used as an indicator in order that the operator may know that he is receiving the full pressure at all times, and that the piston is not in contact with the head. A pressure gauge may be connected at E, which would also serve the same purpose. With 100 pounds pressure on the large piston, using a 4-inch diameter plunger in the punch, a pressure of about 40 tons is available.

This machine will readily punch 1-inch holes in ½-inch and 9-16-inch steel plate, and is very convenient from the fact that it may be used in any portion of the shops and is not a very expensive tool to construct in view of the results obtainable by its use.—*The Railway Age.*

The Use of Compressed Air in Mining.

Compressed air, as employed in mining, is one of the very few sources of industrial power to which scarcely any exception can be taken. Its advantages—putting aside for a moment questions of comparative cost—are so very obvious that it seems almost loss of time to refer to them, yet it is still in its infancy. It has been in various half-hearted ways partially adopted as a mining motive power for, at least, fifty years past. The slow development of its usefulness is explainable on several grounds. Like every other motive power. it requires time to work out the best results. It is said to be expensive; this we shall deal with presently. A good manv mistakes have been made in installing it which have operated against it, and, lastly, the installers are not wholly free from blame. Mining engineers as a bodv are practical men and not much given to studying theory. Some wholly despise it: others lack the necessary application, and this is scarcelv matter for surprise, for a mine engineer's work is eminently that of a practical man born and bred to it and who has to rely mainly on experience, for with the general working of a mine theory has verv little do and we can hardly blame the engineer for taking little account of it.

But mining, like other industrial enterprises, is fast becoming dependent upon advanced knowledge and ideas, and the rising generation of mining engineers will find it greatlv to their advantage, in fact, absolutely necessary, to study theory and science to keep somewhere near the front, for methods and appliances are fast coming into use which require something more than mere experience, which are, in fact, ahead of experience and therefore demand insight and adaptability of a high order.

In this connection we may mention besides compressed air, electricity and oil gas motors and the employment of machinery in haulage, pumping and getting. ventilating, holing and driving.

We propose to deal here with one only of these modern improvements, compressed air and its applications and advantages.

Its special advantages may be worth repeating here, though every engineer ought to be familiar with them.

1. It can be taken by pipes to any point and used there expansively, just the same as steam and in the same engines.

2. The pipes and the air are cool and the air loses nothing by transmission, except by leakage and a slight drop of pressure from friction in transit.

3. The exhaust is cold, invisible and wholesome, being free air at a low temperature, which may be much below freezing point; a welcome help to ventilation.

4. The engines, being cool, are easy to lubricate and to handle.

5. The air does not corrode the pipes internally.

6. None of the compressing plant need be in the pit—in fact, it is almost always at bank.

7. The cost of it can be kept down easily to that of steam as a motive power if properly installed.

For a moment let us see how this compares with steam, electric, or hydraulic power.

Steam requires boilers, usually below ground. These introduce heat where it is already too hot, the steam pipes and motors are hot, their exhaust is a cloud of hot steam, slow in dispersing and condensing; in fact, impossible to use in detail in the headings and roads for haulage and pumping. Steam engines are, therefore, only usuable near the upcast shaft where the heat and exhaust can be got rid of.

Electricity is many respects a promising rival of compressed air, but only in unfiery mines. It has several very serious disadvantages. These are—apart from its cost, which is high—sparking of dynamo motors, danger of short circuiting from accidental causes very common in mines, high speed of motors, necessitating great reduction by gearing. The motors are too easily injured by unskilled labor and too easily overloaded. There is at present no sign of overcoming these faults, the first two of which are practically prohibitive as far as coal mines are concerned.

Hydraulic power is non-elastic and quite unsuited to general driving of machinery even above ground. It is very wasteful in use, not having the expansive economy of steam or air, and miners do not like any influx of water into a pit, for though it is cheaply pumped to bank by the mine pumping engine, yet the danger from water is such an ever-present one that nothing would induce men to use it as a general source of power.

Oil engines are being proposed for mining purposes and may have some useful, if limited, applications; but petroleum is a dangerous fluid in a mine, and the flame from igniters and vaporizers will entirely prevent their use in coal-pits.

There is, therefore, no effective rival to compressed air for general motor purposes in a pit.

Air is cheap enough as a motor fluid and miners are always ready for any quantity of it, but to use it economically it must be compressed to about the same pressure as steam is ordinarily used. Sixty to 80 lbs. per square inch are ordinary pressures which can be dealt with by the ordinary commercial engines without any special attachment or design. Steam, however, is now used at much higher pressures, 100 to 180 lbs., or more, being common. But such pressures require extra strength in every part and greatly increase loss by leakage and condensation.

In the case of air, the cost of compression and the loss of steam by heating of the air by compression increase very rapidly with the pressure, so that these higher pressures are not at present economical. They require extra strength in the pipes and better joints also; better, in fact, than any now in use, so that until improvements can be effected in the compressor by which the higher pressures can be economically produced and a good pipe joint devised, to prevent leakage, it is not advisable to increase the working pressure much above 60 lbs.

A compressed air plant consists of boilers, air compressing engines, receiver or air vessel, air mains, branch mains, pipes, valves and air engines.

The character and arrangement of the plant will depend much upon the kind of mine and the work to be done below. In many mines there is no rock work, but much hauling, and in many cases driving power is required for coal cutting machines, fans, etc.

In the interests of humanity, hauling ought to be done entirely by engine to save the pony and boy, who are both quite out of their natural element in a pit. The boy ought to be at school or at out-door work, and the pony working on the road.

In designing a compressed air plant the proper course to pursue is first to set out a list of all the motors required, their indicated horse-power, the number of hours each is expected to be at work whether continuously or at intervals. From this list the maximum h. p. demanded at any one time can be deduced.

In estimating this maximum h. p. the character of the motors must be considered. Some engineers think that any kind of a rough made strong engine is good enough in a pit. But this is a serious error. A pit air motor ought to work with the highest possible economy. This is obtainable without any fancy expansion gearing or expensive and complicated valve gear, by using a cut-off slide valve. No engineer should be satisfied with an engine that will not work up to a six to ten-fold expansion. The saving in a good engine from this cause alone may amount to from 10 to 40 per cent.

A high expansion, however, unless the air is heated, produces a very cold exhaust, and unless the air is dry, the exhaust passage may get blocked with ice. This can be avoided by making these passages large, short and direct.

Coal is, of course, cheap at a colliery, and it might be supposed colliery managers would be careless of such minor savings; but coal is coal, and has to be paid for even in a colliery; dividends have to be looked to also. Power is always a dead horse to the mine-owner, and its economical use makes all the difference and bulks very largely on the wrong side of the yearly balance sheet.

But, having estimated the net maximum h. p. required in the pit, a percentage must be added for leakages, which depends on the quality of the pipe joints, as to which any economy in fitting up is a very questionable gain. For a leak leaks twenty-four hours per day and carries off a proportionately large amount of air.

Air mains are frequently of great length—from 1 to 3 miles are common lengths. There must necessarily be some loss by leakage and friction in the mains in such long lengths, and it follows that great care is requisite in laying them. Every pipe should be tested. Settlement of ground is a fruitful cause of broken joints or pipes. A good joint should be flexible and not easily broken by expansion or contraction, due either to temperature or settlement.

If these points are satisfactorily dealt with the loss by leakage should not exceed 1 per cent. per mile and the loss of pressure by friction 1½ per cent. per mile. Such results have been frequently attained, and the engineer should be satisfied with no less.

The diameter of the mains and distributing pipes is important and depends on two factors, the quantity of air passing and the distance from the compressor.

The receiver is in reality part of the air main and in most cases may be dispensed with, the main itself being of ample capacity.

Where the compressing engines are of the wet type a good deal of water is carried over with the air into the mains and should be trapped out at a point not far from the engines. With the dry compressor there is also some amount of condensation which should be drained from the main, as dry air is of advantage in the motors, especially if the air is not reheated. Moist air sometimes produces a good deal of ice at the exhaust.

The diameters of the mains depend upon the maximum quantity of air to be delivered, taking into consideration also the reduction in volume it sustains by cooling after passing the delivery valves. This varies between the isothermal and adiabatic lines of the air diagram and can readily be ascertained by computing the area of the diagram outside the isothermal line as compared with the area of the whole diagram.

It may be assumed that the air will have cooled to atmospheric temperature in about fifteen minutes, more or less, according to its delivery temperature, therefore the point along the main at which it may be reduced to its minimum diameter can easily be found.

Expansion joints should be avoided as far as possible; their place can be taken by bends, or, better still, by a flexible form of packing rings or jointing.

The velocity of the air in the mains and branches should not exceed forty feet per second.

Sluice valves are the best to use for all purposes on air mains.

The compressor is the most important item of the installation. There are wet and dry compressors. The former uses an internal jet of water to cool the cylinder in conjunction with a water jacket, and the latter a water jacket only.

Where a jet is used it should be forced in by a pump during the latter part of the compression stroke, not during the suction stroke, or it will be quite ineffective. Its value in cooling is doubtful, while its destructive action on the cylinder and piston admits of no doubt whatever. By all means use a dry compressor and take the inlet air direct from outside the engine house, that is, as cold as possible. This can be done by using a wood or sheet iron air trunk to the inlet valves.

It must be remembered that every degree gained in low temperature at the inlet means several degrees gained at the delivery, and that the engine-room air is usually about 20 degrees higher than outside.

Another important point is provision for utilizing the air in the clearances. The most simple and advantageous method of doing this is by the bye-pass method; ports or grooves are formed in the cylinder at each end a little longer than the thickness of the piston, so that at the end of the stroke these ports pass the air compressed in the clearances to the other side of the piston, where it adds to the initial pressure of the next compression stroke.

The inlet valve should have a positive movement, so as not to require suction to open it or pressure to close it, as both these cause loss of effective stroke and reduce the capacity of the cylinder.

A positive movement for the delivery valves is not so easy to design, as these valves should open at the moment the pressure in the cylinder reaches that in the mains, whatever it may be. This may be at any point in the stroke, so that it is customary to use spring-loaded valves, lightly sprung and of special design. If too heavy, the diagram will show the delivery line at top to be several pounds above the receiver or main pressure. This excess pressure is not all loss because the air expands to the pressure in the mains, but it increases the temperature which it is important to keep down.

Lubrication and its effectiveness depend upon the temperature, which in badly-designed engines often reaches 300 degrees to 350 degrees, at which point oil scorches and produces dry, burnt surfaces and corrosion. Gas engine oil should be used. But if proper attention has been given to the foregoing points the temperature at 60 lbs. should not exceed 180 degrees.

Good pistons, well fitted to the cylinder, are of more importance than in a steam cylinder; the absence of steam and its moisture causes dryer surfaces, and much leakage may occur which is difficult to locate in the diagram, as it merely causes the compression line to approach the isothermal, giving a false impression of high efficiency.

But the chief loss in every compressor is that due to heating during compression. the air, after passing the delivery valves, cools to atmospheric temperature and loses in bulk proportionately, the loss varying, according to the pressure and other points previously alluded to, from 25 to 60 per cent. and even more.

It is in this direction that the future improvement of air compressors must be aimed.

The latest designs are of the compound or stage-compression type, in which the compound principle of the steam engine is reversed, the air is compressed in two or more stages, passing through cooling coils or chambers between the stages. In this way the temperature can be kept down, but the increase of economy is not in proportion; the mechanical efficiency of the engine is reduced, piston and other leakages and losses are duplicated, and thus the chief actual gain is in the lower temperature and better lubrication.

Stage compression diagrams do not

show these losses and to this extent are misleading. The gain by stage compression is chiefly in working at a lower temperature than in the single compressor.

It is evident that the stage compressor does not cool the air while under compression in the cylinder, but in external coolers after it has passed the delivery valves, whereas the cooling ought to be done in the cylinder during compression.

A new type of compressor has lately been installed at the Murton Colliery of the South Hetton Coal Company. In this compressor the air is cooled before delivery and very high results have been obtained. With air cooling alone, that is, without water-jacket or spray, the air is delivered at 60 lbs. at a temperature of 160 deg., and with water sprayed over the tubes the temperature can be reduced to 110 deg.

With an engine of this type stage-compression is not required, except for pressures of 100 lbs. and over.

We have shown that the efficiency of a compressed air plant depends upon a number of small economies and attention to details, which, in fact, make all the difference between an efficient and a wasteful result.

There is another source of economy which has not yet made much progress, but presents a very promising future, that is, reheating the air before using it in the motors. At first sight one would say that what is thus gained must be lost in cost of coal or other heating medium, but this is by no means the case.

In practice, a very small quantity of coal will heat the air in a tubular heater to 250 deg. or 300 deg. (it is not desirable to heat it beyond 300 deg.), and expand the air to more than double the original quantity and thus similarly augment the useful effect in the motors, besides which the exhaust is discharged at a temperature above the atmosphere, and freezing thus avoided. Actual tests of reheating in this way have shown that the efficiency of the entire plant can be brought up to 100 per cent., that is to say, as much work can be given out at the motors as is supplied to the compressor in steam energy.

Without reheating, a plant should show an efficiency of at least 50 to 55 per cent.

There are several ways of reheating which are more or less applicable to all cases. A furnace and coil or surface heater is the simplest, but is inapplicable in fiery mines. Where steam boilers exist underground steam pipes can be employed to heat the air, the temperature obtained being of course not more than about 180 deg. A furnace or oil burner has been used inside the air main, the products of combustion passing with the air to the motors. Some simple adaptation of this plan as an appliance attachable to any motor seems to be the best form capable of universal application.

This subject is well worth the attention of engineers. To be able to fire a range of boilers with dust or coke gases, producing steam on the most economical scale, and then to be able to obtain the full mechanical energy of this steam in air motors underground a mile or two away from the boilers, without loss, is a most attractive outlook for the mine-engineer and owner, and we do not see how it can be improved upon or rivaled by any other form of power transmission.

Reheating enables the motors to run with a much higher grade of expansion than with cold air. With the latter we get in the motor a reversal of the effects of heating described as going on in the compressing cylinder, that is to say, we get adiabatic cooling instead of isothermal, the effect being to reduce the pressure and volume of the air more rapidly than is due to its expansion only. Keeping the motor cylinder hot will remedy this and induce isothermal expansion.

The next improvement required in air motors is, therefore, means of heating the air before entering the cylinder, and this should be done in such a way as can safely be used in fiery mines.—T. W. Barber, in *The Coal and Iron Trade Review.*

Adiabatic Expansion and Compression of Gases.

In this article we will furnish the means of finding the temperature of adiabatic compression and expansion of gases, and this without the use of anything more than the mere rudiments of ordinary arithmetic. For this purpose the table given below has been computed from the formula:

$$\text{Log. } \frac{P^1}{P} \times \frac{2}{7} = \text{index logarithmic ratio,}$$

where P^1 is the greater pressure. Owing to a slight difference in the specific heat of air at different temperatures and pressures the formula does not at all times give results that are perfectly correct, but the limit of error is well within the requirement of good engineering practice:

Gauge Pressure.	Atmospheres.	Logarithmic Ratio.	Gauge Pressure.	Atmospheres.	Logarithmic Ratio.
10	1.69	1.16	76	6.17	1.68
11	1.74	1.17	77	6.24	1.68
12	1.81	1.18	78	6.31	1.69
13	1.88	1.20	79	6.38	1.69
14	1.95	1.21	80	6.44	1.70
15	2.02	1.22	81	6.51	1.70
16	2.08	1.23	82	6.58	1.71
17	2.15	1.24	83	6.64	1.72
18	2.22	1.25	84	6.71	1.72
19	2.29	1.27	85	6.78	1.72
20	2.35	1.28	86	6.85	1.73
21	2.41	1.29	87	6.92	1.73
22	2.49	1.30	88	6.98	1.74
23	2.56	1.31	89	7.05	1.74
24	2.63	1.32	90	7.12	1.75
25	2.70	1.33	91	7.19	1.75
26	2.76	1.34	92	7.26	1.76
27	2.83	1.35	93	7.33	1.76
28	2.90	1.35	94	7.39	1.77
29	2.97	1.36	95	7.46	1.77
30	3.04	1.37	96	7.53	1.78
31	3.10	1.38	97	7.60	1.78
32	3.17	1.39	98	7.66	1.79
33	3.24	1.40	99	7.73	1.79
34	3.31	1.41	100	7.80	1.80
35	3.38	1.42	105	8.14	1.82
36	3.44	1.42	110	8.48	1.84
37	3.51	1.43	115	8.82	1.86
38	3.58	1.44	120	9.16	1.88
39	3.65	1.45	125	9.50	1.90
40	3.72	1.45	130	9.84	1.92
41	3.78	1.46	135	10.18	1.94
42	3.85	1.47	140	10.52	1.97
43	3.92	1.47	145	10.86	1.98
44	3.99	1.48	150	11.20	1.99
45	4.06	1.49	155	11.54	2.01
46	4.12	1.50	160	11.88	2.02
47	4.19	1.51	165	12.22	2.04
48	4.26	1.51	170	12.56	2.06
49	4.33	1.52	175	12.90	2.08
50	4.40	1.53	180	13.24	2.09
51	4.47	1.53	185	13.58	2.11
52	4.54	1.54	190	13.92	2.13
53	4.61	1.54	195	14.26	2.14
54	4.68	1.55	200	14.60	2.15

Gauge Pressure.	Atmospheres.	Logarithmic Ratio.	Gauge Pressure.	Atmospheres.	Logarithmic Ratio.
55	4.74	1.56	205	14.94	2.17
56	4.82	1.57	210	15.28	2.18
57	4.88	1.57	215	15.62	2.20
58	4.95	1.58	220	15.96	2.21
59	5.02	1.58	225	16.30	2.22
60	5.08	1.59	230	16.64	2.23
61	5.15	1.60	235	16.98	2.25
62	5.21	1.60	240	17.32	2.26
63	5.28	1.61	245	17.66	2.27
64	5.35	1.61	250	18.00	2.28
65	5.42	1.62	255	18.34	2.29
66	5.49	1.63	260	18.68	2.31
67	5.55	1.63	265	19.02	2.32
68	5.62	1.64	270	19.36	2.33
69	5.69	1.64	275	19.70	2.34
70	5.76	1.65	280	20.04	2.35
71	5.83	1.65	285	20.38	2.37
72	5.90	1.66	290	20.72	2.38
73	5.96	1.66	295	21.06	2.39
74	6.03	1.67	300	21.40	2.40
75	6.10	1.67	305	21.74	2.41

Air at 60° F. is compressed adiabatically to 100 pounds gauge pressure, what will be its temperature? Looking in column one under gauge pressure we find the number 100, and opposite it in column three we find the logarithmic ratio to be 1.80; then multiplying the absolute temperature 60 plus 460.66 or 520.66 by 1.80 we get 937; subtracting 460 we have the answer, 477° F.

Air at 75 pounds pressure and 60° F. expanded to the atmospheric pressure, what will be its temperature? Looking in column one we find the number 75 and opposite that in column three we find the ratio to be 1.67. In this case we divide the absolute temperature 520.66 by 1.67. which gives us 311, which subtracted from 460 gives the answer—149° F.

A gas engine with a compression chamber of one-third and a stroke of two-thirds, what will be the temperature and pressure of the compression? In this case the compression isothermal will be three atmospheres absolute. Looking in column two under atmospheres we find the number 3.04, which is near enough for our purpose, and the ratio that corresponds is 1.37; multiplying by the absolute isothermal pressure, 43.1 pounds, we get 59 pounds absolute or 44.3 gauge pressure. The explosive mixture before compression consisted of two-thirds air and gas at 60° F. and one-third the spent gases of the previous explosion of say 1000° F., giving to the charge the temperature of 373° F. or 833 absolute; multiplying by the same ratio as before gives us 1141 absolute or 681° F.

In the same cylinder, the temperature being 2681° F. and the gauge pressure 150 pounds per square inch, what will be the temperature and pressure at end of the working stroke? The expansion being from one to three we use the same ratio, 1.37, the exhaust pressure isothermally would be 50 pounds per square inch; dividing the absolute pressure, 64.7 by 1.37 we get 47.2 absolute or 32.5 gauge. The temperature, 2681° F. or 3141 absolute, divided by 1.37 gives 2292 absolute or 1832° F. at the pressure of the exhaust; when expanded to the atmosphere the heat of the spent gases would be 1083° F. —H. D. Dibble, in *Mining and Scientific Press.*

A New Idea for an Air Compressor.

Our attention has been called to a patent dated March 4. for an air compressor granted to Mr. David O'Connell, of Brooklyn, which embodies features of sufficient novelty to warrant a description of it in our pages.

In principle the machine consists of two reservoirs, an automatic see-saw float which controls the main valve and an ordinary steam pump with the few pipes necessary to connect the tanks, pump and valves.

The principle of the device is the alternate flooding of the tanks with water by means of the pump and the compression of the air contained in the tank above the water. Two tanks are provided, so that the operation is continuous, the air being compressed in one tank while the water is being withdrawn from the other.

The tanks may be made of any size and heavy enough to stand any pressure. The pump may be either steam or electric, motor driven or one of the many belt driven types. The see-saw float is shifted when the water in either of the tanks reaches an overflow pipe and floods either one of the chambers in which the floats work. When this see-saw tips it swings a valve, which starts the water in the other tanks and allows the first tank to empty.

In the discharge pipe connected to the top of the tanks are suitable check valves which open when the air pressure has reached the proper point, thus allowing the compressed air to pass into the mains connected to whatever apparatus the compressor is operating. It will be understood that the action of the pump is continuous, and owing to the use of water there are no pistons, piston rods or working parts in the tanks, and the friction incident to these is eliminated.

There is also an absence of lubricating oils in the tank, so that the air produced is always clean. Also, as the air is in contact with the water at all times, it is claimed that the compression is practically isothermal. It is also claimed that there is no limit to the pressure which can be produced, because it is possible to use a high pressure pump to fill the tanks. We have made no investigation as to the operation of the machine, and therefore cannot say anything as to its economy, but in a general way there would seem to be cases where a machine of this sort could be employed to good advantage. For instance, where there is abundant water power under a fair head when the pump could be done away with entirely and the water used directly, thus making the device the converse of a displacement pump.

Electric and Compressed Air Locomotives.

In America the electric or compressed air locomotive is in frequent use in shops, foundries and manufactories, where in England we should generally employ the ordinary steam engine. More especially is this so on narrow-gauge lines. The whole matter, of course, resolves itself into a question of economy and convenience. We may rest assured that our cousins across the sea would not have adopted the electric or air-driven locomotive in preference to the steam engine simply because it pleased them to do so. We may be very certain that they thought they would save money, either directly or indirectly, by doing so. On the same grounds we may equally say that the steam locomotive is the leading favorite as present in this country. In view of this descrepancy of opinion, however, we think that it may be of interest to our readers if we illustrate and briefly describe some of the types of narrow-gauge electric and compressed air locomotives in use in America, so that they may be able to judge whether or not it would be wise to adopt in this country means of haulage other than steam, all considerations being taken into account.

We will describe four locomotives, the first of which is a storage battery electric locomotive; the second and third are for overhead collection, rail return; while the fourth is a compressed air locomotive. These are, all of them, types in every-day use, and devoted to widely differing objects.

Taking them in the order mentioned above, the first an electric locomotive made by the C. W. Hunt Company. It is constructed to easily run around curves of 12 feet radius, and every wheel of its two bogies is a driving wheel. It obtains its motive power from a storage battery contained in the covered box between the motors. The battery plates are made specially heavy, since it is claimed that, besides insuring durability and efficiency, the great weight adds to the adhesion—and hence the hauling power—of the locomotive. Of course, this great weight precludes the use of such locomotives for long and steep gradients or for high speeds; but, on the other hand, there is the large draw-bar pull, and the speeds attained are said to be ample for any ordinary work. At all events, the advocates of this type of locomotive say that in manufacturing establishments where the ground is level, or where at most short gradients of from 5 to 6 per cent. are met with, it is by far the most convenient, economical and efficient means of taking goods from one place to another. The weight of the locomotive complete is five tons, and the gauge on which it runs 21½ inches. It is 13 feet long over all, and about four feet wide. To the top of the motors it measures some 5 feet, 6 inches, and if a canopy is fitted it is 8 feet, 4 inches to the top of this. Generally speaking, it can haul a load up to its full capacity at a rate of some four miles per hour, while one charge is said to be sufficient for a working day of 10 hours. As to its actual hauling power, it is stated that it can deal with a load of 50 tons on the level. The motors are of the iron-clad type, and the gearing is enclosed in an oil-tight case. Of course, against all the possible advantage of using a locomotive of this type must be placed the fact that storage batteries in unskilled hands are liable to be a great source of trouble. On the other hand, there are no overhead wires to get in the way, and no bonding of rails to keep in order.

The second and third are two types of locomotives which, contrary to the foregoing, take their current from an overhead wire and return it through the rails. The first engine was constructed at the Baldwin Locomotive Works, and is known as the Baldwin-Westinghouse electric locomotive. Its gauge is 2 feet 6 inches, and it is provided with two motors which work at 500 volts. The diameter of the driving wheels is 30 inches, and the wheel base is 4 feet. Its total length is 10 feet, its width 4 feet 11 inches, and its height 9 feet 4 inches, and its weight nearly 8½ tons. It is adapted, therefore, to considerably heavier work than the locomotive just described. The third is a four-wheel mining locomotive made by the Jeffrey Manufacturing Company. Its total weight is four tons, and it is practically entirely iron-clad. Of course, it would be impossible to use this type of locomotive with its overhead collection in coal mines, which are dangerous owing to fire-damp; but in the United States one of the principal applications of these narrow-gauge electric locomotives is in connection with collieries, and the duty required of them is the taking of loaded trucks from the pit mouth or tunnel, as the case may be, to the various sorting and washing buildings or to the standard gauge railway wagons. They are also, so we understand, much used in quarries, sand-pits, blast furnaces, sugar, coffee and other plantations; in fact, in any place where there is a continual transport of raw material, such as ore, charcoal, coke, vegetable produce or earth. It is said that the saving by their employment is considerable, and that in places where there are large fire risks, and where the use of the steam locomotive is impossible, their adoption is almost imperative.

As already intimated, however, in a dangerous coal mine or—to take another instance—in a powder mill, an electric motor may be a source of disastrous explosions. For such places as these comes the opportunity of compressed air locomotives. Indeed, we are informed that they are competing largely in other directions less dangerous than these with the electric locomotive, being used not only in mines, but for coal and mineral work, and also for hauling trains through tunnels and city streets, and for transporting material, lumber, paper, etc., to cotton mills and warehouses. The fourth is a type of such locomotives as are manufactured by the H. K. Porter Co., and employed at the Iowa powder mills. The weight of this engine is 15,000 lbs., and its cylinders are 7 inches by 14 inches, the gauge being 42 inches. The air for locomotives of this class is stored in one or more steel tanks—in the present instance there is but one tank—and the cubic capacity is, of course, regulated by the work required, and by the length and nature of the journeys to be made. The air tanks occupy a similar position to that taken up by the boiler in a steam locomotive. The factor of safety is high. In one case, for example, if the ordinary air pressure to be withstood is 600 lbs., an hydraulic test pressure of 1,000 lbs. is applied. If auxiliary or letting-down tanks are used, the pipes joining the two tanks are of copper. The troubles due to fall in temperature owing to the expansion of the air would appear to have been overcome—perhaps by carefully drying the air before it is compressed. At any rate, the advocates of compressed air claim that locomotives worked by this medium run longer, with less repairs and breakage, and with less leakage than with steam, on account of better lubrication and absence of heat. Further, they claim for the air-driven machine, which is only worked intermittently, that it is more economical than the electric motor used under the same circumstances.—*The Engineer.*

Notes.

Messrs. C. E. Walker and C. Booth, of the Chicago Pneumatic Tool Company, have departed for Europe in the interest of the company.

The Philadelphia Pneumatic Tool Company has appointed Messrs. Berger, Carter & Company, No. 330 Market street, San Francisco, Cal., their representatives on the Pacific coast.

The capacity of air for carrying moisture depends upon its volume and temperature and not upon its pressure. Air compressed to 1,000 pounds pressure will contain but little more moisture than the same air at atmospheric pressure.

The death of Mr. Camille Ferroux, the inventor of the rock-drill bearing his name, has been announced in one of the London papers. Mr. Ferroux was a distinguished engineer who took an active part in drilling the Mont-Cenis, St. Gothard and Arlberg tunnels.

The Jeffrey Mfg. Company's plant at Columbus, Ohio, is not a very large one, but it is worthy of especial note, considering how cleverly and economically it is operated. The air compressor furnishes power for a number of pneumatic tools and hoists throughout the works.

"The More Drills the Merrier," seems to be the motto of the Cosmopolitan Proprietary Cyanide Plant in Kalgoorlie. We note from latest reports that their two six-drill capacity air compressors are being supplemented by a new twenty-drill compressor, which speaks not only well for the prosperous atmosphere of West Australia, but also for their present good business.

The McKiernan Drill Company, of 120 Liberty street, works at Dover, N. J., have just secured an order from the New Jersey Zinc Company, of New York, for two Cross compound condensing Corliss air compressors, with a capacity of 6,534 cubic feet of free air per minute each, involving a transaction of $50,000. These compressors are to be used in their zinc mines at Franklin Junction, N. J.

Mr. Jean F. Webb has sold one-half of his pneumatic cyanide patent to the Colorado Iron Works Company. A new company with $500,000 capital has been formed to build mills and exploit the process. Mr. J. W. Nesmith is president, Mr. J. H. Morcom, vice-president, and Jean F. Webb, Jr., secretary of the new organization. The headquarters of the new company is in the Albany Hotel Building, Denver, Colorado.

Mining in the district of Cornwall, England, does not seem to be booming at the present time, and we notice but one mine, situated at Wheal Kitty, which has seemed to feel especially encouraged with conditions prevailing. Here the conditions are almost unprecedented and the company are congratulating themselves that prosperity has come at a time when they are so well provided and equipped with air compressing machinery and rock drills.

It is said that an enterprising clergyman of St. Louis, the Rev. Chas Stelzle, is giving a series of sermons on parables founded on "The Machine Shop," "Life in the Foundry," etc. Presumably these talks are given to appeal directly to machinists and those people who are interested in that line of thought, and the question arises in our minds what connection, for example, a compressed air hoist or a pneumatic tool could have to do with the salvation of the soul.

In the building of the tunnel beneath the River Thames, London, for the Baker-Street and Waterloo Electric Railway, compressed air was used and this particular power was made absolutely necessary by the conditions arising during the operation. At first the tunnel was built wholly in London clay, but after a bit a bed of clean gravel and sand was encountered, laid in an abrupt depression of the surface, and as you can readily see, this freely water-bearing bed necessitated very delicate handling, and was peculiarly adapted to compressed air methods.

Mr. J. Geo. Leyner, Denver, Colorado, the well-known manufacturer of air compressors and rock drills, has just issued a descriptive catalogue of his make of air compressors. It is one of the most comprehensive and conservative treatises on air compressors and the use of compressed air that we have ever seen issued as a trade publication. Every mining man should possess a copy (whether he has ample air compressor machinery or not) on account of the valuable information it contains.

The American Schools of Correspondence, of Boston, Mass., calls attention to the facilities for home study that it offers industrious and ambitious young men. In its "Handbook," a pamphlet of 100 pages, the advantages of the school are fully set forth and the various courses of study are described. The school offers courses in electrical, mechanical, stationary, marine, locomotive and textile engineering, also in heating, ventilating and plumbing. The school also offers special courses in arithmetic, elementary and advanced algebra, geometry, mechanical drawing, elementary chemistry and metallurgy, chemistry and dyeing, heating and ventilation, electric power and lighting, and other subjects.

Gold mining on the Rand at the present time has a certain fascinating sound whether we are waiting for the "Open Door," and anticipating the end of the Boer war, or merely idle listeners, weaving romances a la Cecil Rhodes. Mr. John Stuart, of the *London Post*, in speaking of this very subject, and talking in a general way of the work on the different mines out there, is inclined to think that the haulage which has been done for some time with electric engines, will have to give way entirely to compressed air, and that nearly all of the rough work on the mines is best accomplished by rock-drills operated by this motive power.

The firm of H. K. Porter & Co. began business in 1866, under the name of Smith & Porter, with a shop of one rented room in Twenty-eighth street, Pittsburg, Pa. There were a man and a boy, besides the "firm." They grew fast, however, and soon built a shop of their own. On March 4, 1867, the first locomotive was contracted for, and shipped on Thanksgiving Day. It was a four-wheel saddle-tank engine, 42-inch gauge. In February, 1871, the shop was burned, and on rebuilding the firm name was changed to Porter, Bell & Co., which lasted until the death of Mr. Arthur W. Bell, in 1878, when the present firm name was adopted. They have built everything from 18 to 72-inch gauge and from 4 to 45 tons, and for all parts of the world.

What power? Why, compressed air. On the Rand, South Africa, before the Boer war, *Mining and Scientific Press* presented a plan in connection with the power to be used for one of the especially deep mines out there, which comprised the installation of a hoist at the surface that would hoist from a depth of 2,700 feet; at that depth another hoist of equal capacity, and at the 5,400-foot level a third, to hoist from the 8,000-foot. This matter is still open and involves among other things a question of what kind of power. To this it would appear that electricity can be relied upon in such a case; so also can compressed air, and the subject presents a favorable field for thought, to say nothing of American enterprise and skill, with the customary attendant profit.

The Pneumatic Signal Company, of Rochester, N. Y., also owns the controlling interest in the British Pneumatic Railway Signal Company, of England, which has installed the first system of automatic block signals as well as the first pneumatic interlocking system in Great Britain. This company has received further the orders for eight large low-pressure pneumatic interlocking plants and 31 block stations in England. It is also forming continental companies for the handling of its various appliances. Mr. Charles Hansel has been elected assistant to the president of the company, with offices in New York and London, England. Mr. Hansel was formerly vice-president and general manager of the National Switch and Signal Company.

The Philadelphia Pneumatic Tool Company has just issued a new catalogue, in which they describe the several types of pneumatic hammers, chippers, drills and other tools which they manufacture. We commend this pamphlet to our readers on account of the very practical information which it gives in tabular form.

In addition to illustrations and brief descriptons of the different types of tools which they manufacture, a number of half-tones are given showing the tools in actual operation. These are new and give very satisfactory evidence of the utility of pneumatic tools in general, and especially of the Keller tools, which are manufactured by the Philadelphia Pneumatic Tool Company, whose main office is at Philadelphia, Pa. The catalogue is handsomely gotten up, well printed on heavy paper and will prove an attractive addition to any collection of catalogues.

On Wednesday last the Benedict & Burnham Mfg. Company, of Waterbury, Conn., purchased through James D. Williams, of New York, and Hugh L. Thompson, engineer, of Waterbury, Conn., the tube-making machinery, licenses, shop right and patents owned by the Mannesmann Cycle Tube Works of Zylonite, town of Adams, Mass. The company was organized sometime in 1896 by the Mannesmann Brothers—Max, Reinhardt and Alfred—the sons of the inventor of the Mannesmann process and machines. Through some misfortune or mismanagement the project failed and the Mannesmanns gave up in August, 1898, without having successfully started the works. The plant was then leased to responsible people, who ran a part of it from November, 1898, to some time in May, 1899, in which time they produced about 450,000 lineal feet of merchantable bicycle tubing. Since that time the works have been idle, and the property was finally sold by order of the District Court of the United States for the Southern District of New York. The tube machinery will be removed and the property used for manufacturing purposes.

We all know the value of compressed air machine tools for railway work; but the value of air jacks for cars and locomotives is not so generally known. It formerly required about four hours for eight men with screw jacks to take a 10-wheel engine weighing 132,000 lbs. off its drivers, at a cost of $5.14, and about one-half that time for four men to do the same work with hydraulic jacks, but using four pneumatic jacks, it is now regularly done by four men in one hour at a cost of 66 cents.

A pneumatic ram was recently made at a cost of $168.55 for breaking stay-bolts to remove worn-out fire-boxes, which earns very large interest on the investment. It formerly cost $45.60 to cut out the crown-bolts and stay-bolts of a 10-

wheel locomotive with 9-foot fire-box, using three men, but with the pneumatic ram it is done by two men for $15.20, thereby saving $30.40 on each fire-box. If only one fire-box was removed each year this tool would earn 18 per cent. on the investment, but as this shop applies 30 new fire-boxes a year the saving amounts to $912, or 541 per cent. per annum on the amount invested.

At the Ronchamp Colliers, France, described with more detail in *The Colliery Guardian*, the great shaft has a depth of 1,010 metres, with a power plant comprising two air compressors capable of furnishing 10 cubic meters of air at 5 kilogs. pressure per minute. Each of them consists of a compound engine and a compressor, the high pressure cylinder of the former having a diameter of 500 mm., low pressure cylinder 850 mm., and stroke 1,100 mm. The steam is distributed by means of slide-valves, the cut-off being a semi-cylindrical slide-valve which can be adjusted by the driver. Each steam cylinder works a corresponding compressor cylinder, in the same horizontal axis and having the following dimensions: Diameter, 560 mm.; stroke, 1,100 mm. The bottoms of these cylinders are fitted with small intake and delivery valves, and the compressed air is cooled by an injected water spray, supplied by pumps actuated by eccentrics keyed on the shaft of the fly-wheel. The normal speed of the engine is 36 revolutions per minute to furnish the amount of air specified above; but this speed can be easily increased to 45 revolutions. The steam pressure in the small cylinder is 8 kilogs, per square centimetre.

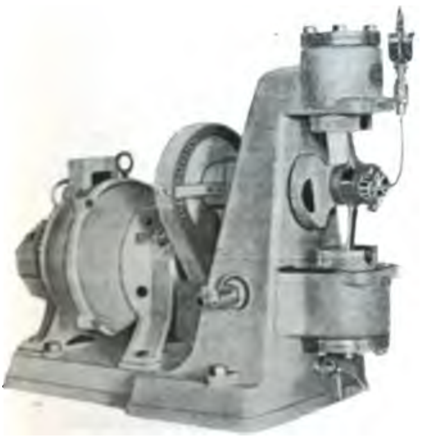
Something new—compressed air as a lifting agent. The old pioneer iron furnaces used two methods of elevating the stock from the yard to the furnace top. At first they tried the water balance and later awakened to the fact that the air balance would answer their purpose better. This consisted of a cylinder *D*, about 36 inches in diameter and long enough to carry the platform to the furnace top. The piston *E* was hollow and filled with pig iron until its weight was slightly less than the combined weight of the two platforms and empty barrows. Starting with the platform in the position shown, air from the blowing engines was admitted on top of the piston. This air was at a pressure of about 2½ pounds per square inch, which was sufficient to force the piston downward and lift the platforms and their load. After the load was discharged and the barrows replaced on the platform, the air was exhausted from the cylinder, thus allowing the weight of the platform and empty barrows to return them to the bottom. This machine worked beautifully and never gave trouble of any kind, except in the coldest weather, when it was necessary to admit steam and heat up the cylinder from bottom to top in order to remove the frost that collected on the surface and prevented the free movement of the piston.

The Yoch improved coal mining machine is described in a 20-page pamphlet published by the Belleville Pump and Skein Works of Belleville, Ill. This machine is of the pick type and uses compressed air. The company states that it has acquired all the patent rights for the United States and foreign countries for the manufacture and sale of the machine, and that it has executed all the Yoch Mining Company's improvements and manufacturing since 1882. The construction and appearance of the machine have been radically changed and the manufacturers now claim for it these merits: Excellence of material and workmanship; interchangeable parts; weigh enough to allow high pressure behind the piston, insuring a vigorous blow; a piston cushioned on air, doing away with metallic or leather buffers; packing easily accessible and an adjustable center, permitting the machine to be balanced for different lengths of picks. The manufacturers also state the machine will undercut 6 feet without too much jarring on the operator and that they will undertake to work the machine in any room or entry where any other machine can be worked. The Belleville Pump and Skein Works also manufacture the Smith double rotary air drill, mine fans, coal mine cars, chilled car wheels, screens, etc.

To think of Athens, Greece, carries us back hundreds of years to scenes which are of so historic an interest and to a city of so romantic an atmosphere, that it seems almost sacrilegious to find that it is a very up-to-date, wide-awake city after all, and that it "Can't help its past and just means to catch up any how." We now hear that within easy walking distance of the Acropolis at Athens, and near by the Temple of Theseus, they have built one of the largest compressed air plants (of its kind) in the Levant. Compared with the seven large plants of Paris it will be noticed that with the exception of one of the Paris plants, the Athens plant exceeds by 3,000 H. P. the largest of these companies. We give you below the table of comparisons:

	H. P.
Usines Municipales	2,450
Usines de la Cie. Edison	5,600
Usines de la Cie. du Secteur Clichy	2,800
Usines de la Société d'éclair et force par d'électricité	5,300
Usines de la Société des Halles Cen., I	1,200
Usines de la Société Secteur des Champs Elysées	4,800
Usines de la Cie. Parisienne d'air compr	12,800
Greek Electric Co.'s plant at New Phaleron	8,620

Messrs. Reavell and Company, Limited, of Ipswich, have issued circulars describing their small compressors. The electrically-driven type is being supplied to electric lighting and power stations. It is of the patented duplex type, and has a capacity of 18 cubic feet of free air per minute. It is driven by a motor of the enclosed type, of 1½ to 2 H. P., depending on the delivery pressure. The frame of the compressor is designed so as to form an air reservoir, and is fitted with relief valve, drain cock and outlet connection screwed 1 in. gas. The base of the compressor is extended to carry the motor, which runs at about 1,200 revolutions per minute, and drives the compressor at 400 revolutions per minute through gear-wheels, the pinion being of raw hide, and the spur-wheel of cast-iron, machined from a solid blank. The gears are protected by a neat planished steel case. The motors are supplied to suit any desired voltage. The machine is designed for delivery pressure up to 30 pounds per square inch, and is usually worked at 15 to 20 pounds pressure.



ELECTRICALLY-DRIVEN COMPRESSOR.

Gas in Los Angeles, Cal., is generated and distributed by the aid of two air compressors and gas engines, which have lately been installed. When the need came for larger mains a six-inch feeder main, about three miles in length, was laid and a compressor and gas engine connected at the end leading from the Seventh street works. The compressor is duplex, 16 x 18, running at 100 revolutions per minute, and is belted to a three-cylinder, vertical, eighty-five horsepower gas engine running at 300 revolutions per minute. The gas at present is compressed to a pressure of thirteen pounds gauge, and a pressure of twenty or thirty pounds is contemplated when required. High pressure meters (No. 1 Equitable Meter Company's dry meters) and regulators (No. 1 Equitable Meter Company's) are used for consumers along the line, and at the end a 6 x 8 Equitable Meter Company's governor is in the line. It has not, however, been found necessary to use this governor as yet. The gas leaves the governor under the present initial pressure of thirteen pounds at the works—at the end of its passage of almost three miles—at from seven to nine inches water pressure, and no house regulators are used at this pressure. The compressor is operated on the peak loads only, and the house regulators operate equally well with normal or with high pressure.

Another and smaller compressor is being operated from the Aliso street works for supplying another district, and the feeder is a two-inch pipe over a distance of 7,000 feet. The initial pressure is thirteen pounds gauge, and the pressure at the first consumer's meter, 7,000 feet distant, is thirty inches water pressure. No regulator whatever is used, and the service is satisfactory. The company is now completing a six-inch line to the city of Pasadena, eight miles distant, and will deliver the gas under pressure of probably fifty pounds to the square inch. These are valuable lessons to the fraternity, and open up a wide vista of profitable engineering for other companies.

On the Wachusett Dam of the Metropolitan Water Works, at Clinton, Mass., all the power needed is furnished from a central power station, which comprises two air compressors, each having a cross-compound condensing Corliss engine with steam cylinders 18 and 34 inches in diameter, air cylinders 24 and 21 inches, and a stroke of 42 inches. The engines were made right and left so as to have the high pressure steam cylinders adjacent to each other, the two compressors being set parallel to each other on well-built rubble and cut stone foundations. At a normal speed of 75 revolutions per minute each has a capacity of 3,310 cubic feet of free air raised to a pressure of 80 to 90 pounds. The engines are controlled by the regular Corliss speed governor which operates on the cut-off mechanism of the steam valves, and also by an automatic air regulator which controls them through the same means. The engines are arranged so as to run either the high or low pressure steam cylinder independently of each other. This provision is made so that in case of necessity four-tenths of the capacity of the whole machine can be made of service with the high-pressure side if the other is injured.

The compressed air is discharged through a 10-inch pipe connection into a horizontal air receiver 6 feet in diameter and 20 feet long. There is a 10-inch outlet pipe from the receiver and the air is distributed from it through wrought-iron air mains, 8, 6 and 4 inches in diameter. Reheaters are used at a number of places on these mains. All the quarrying and hoisting is done by compressed air.

The plant operated last season by compressed air included 10 drills at the quarry and the dam site, 15 hoisting engines, 2 pumps located in the pit, a sand screening engine, blacksmiths' forges, the two cableways and a cubical box mortar mixer. At present about 16 drills, 26 hoisting engines and 10 pumps are ready for use. The air is piped across both ends of the pit and numerous valved branches are inserted in the lines so that connections can be readily made with the hoisting engines and pumps.

An interesting test of safety appliances on elevators was given recently by the inventor of the Ellithorpe Safety Air Cushion in Lit Brothers' department store at Philadelphia. The test proved in every way successful, and clearly demonstrated that riding in an elevator car can be made as safe and secure as walking on solid ground.

Lit Brothers have safeguarded their fourteen elevators with the new safety cushion, and it was to make a practical test of the appliance that the exhibition was given. Two cars, each weighing 3,000 pounds, were dropped from the top floor of the building to the bottom of the shaft, a height of 84 feet, without displacing, jarring or cracking a number of eggs or spilling the water in the several glasses which had been placed in the cars. This proved conclusively that a person within the car at the time of its drop would have hardly felt the fall, and beyond having his breath checked for an instant, would in no wise feel the effects of the sudden descent.

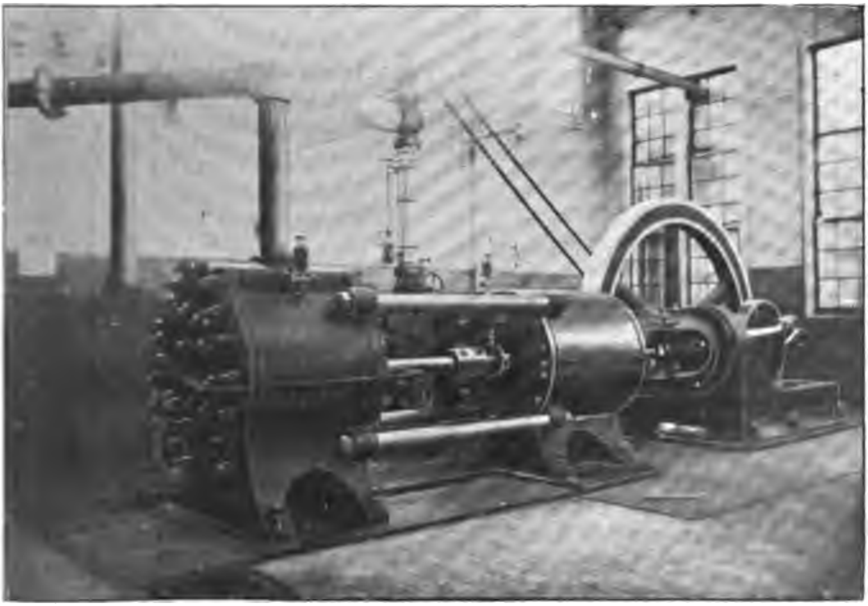
The test was made in the presence of the members of the firm and several mechanical engineers, the elevator constructors and Chief Building Inspector Hill. Mr. Ellithorpe, the inventor of the cushion, was in charge of the exhibition. Two cars in different sections of the store had been run to the top of the building. Here the cables were disconnected and the heavy cars were suspended by new manila ropes.

In the first car to be cut loose a number of eggs and several glasses of water had been placed. There were also two electric bulbs on top of the car. The spectators were gathered about on the first floor. Three men were on the top floor with a knife attached to a long stick of wood. Mr. Ellithorpe was below, and at a given signal announced that all was ready for the test. Another signal told the men on top to cut the rope. A moment later a rumbling sound was heard. The car had been cut loose and was shooting swiftly through the shaft. The spectators held their breath.

The car shot past the first floor like a falling star. It struck the air cushion with a thud, and then slowly settled. The whole thing lasted three seconds. When the car was opened, everything within was just as it had been placed there. The water was not spilled. The eggs were not cracked, and the electric bulbs were intact. The test was as remarkable as it was successful.

A similar test was then made of the second car, with equal success. The eggs, which had been dropped 164 feet, were distributed as souvenirs to those present.—*National Engineer.*

The accompanying illustration represents a Class D S. C. Air Compressor having duplex steam cylinders and two stage air cylinders, with inter-cooler, built by the Franklin Air Compressor Works, of the Chicago Pneumatic Tool Company, with offices in the Fisher block, Chicago, and 95 Liberty street, New York, installed in the Brooks plant of the American Locomotive Company at Dunkirk, N. Y. This compressor has steam cylinders 20 inches diameter by 24 inches stroke, low pressure air cylinder 27 inches diameter by 24 inches stroke, and high pressure air cylinder 16½ inches diameter by 24 inches stroke, representing a piston displacement of 1,580 cubic feet of free air per minute at a working speed of 100 revolutions. The illustration herewith presented is the first of this type of machine that has appeared in the press, it being especially noteworthy that the compressor demonstrated under test one of the most efficient performances ever attained by a compressor of this type and capacity. Similar compressors have recently been installed at the shops of the New York Central & Hudson River R. R. Co., at Depew, N. Y.; Lake Shore & Michigan Southern Ry. Co., at Collinwood, Ohio; New York, New Haven & Hart-



CLASS D. S. C. AIR COMPRESSOR, BUILT AT THE FRANKLIN AIR COMPRESSOR WORKS.

ford R. R. Co, at New Haven, Conn.; Delaware, Lackawanna & Western R. R. Co., at Kingsland, N. J.; Terre Haute & Indianapolis R. R. Co., at Terre Haute, Ind.; Norfolk & Western Ry. Co., at Roanoke, Va.; Erie Basin Dry Dock Co., Brooklyn, N. Y.; United States Navy Yard, Boston, Mass. (three machines). The manufacturers build this type of compressor in a number of sizes and also duplex and single types both steam driven and belt actuated.

U. S. PATENTS GRANTED MAR. 1902

Specially prepared for COMPRESSED AIR.

694,403. ENGINE BRAKE. Edward Y. Moore, Cleveland, Ohio, assignor, by mesne assignments to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed April 19, 1901. Serial No. 56598.

An incased engine, an additional crank-disk therefor within the casing, said crank-disk removably engaging the crank-pin, and means for establishing braking frictional engagement between said disk and a non-rotative member.

694,525. AIR-BRAKE SYSTEM. August Brüggemann, Breslau, Germany, assignor to the Deutsche Waffen-und Munitions-fabriken, Karlsruhe in Baden, Germany, Filed August 7, 1900. Serial No. 26,-178.

A regulating valve for air-brake cylinders and mechanism operated by wind-pressure caused by the velocity of the train to load the same.

694,588. AIR-BLAST APPARATUS. James M. Tyler, Bay St. Louis, Miss. Filed February 18, 1901. Serial No. 47,795.

The combination with a frame, of a blower supported thereon, and having opposite outlets, slide-valves for the respective outlets, a rocking lever fulcrumed intermediate of its ends upon the frame and located between the valves, the latter being pivotally connected to the respective ends of the lever, a transverse rock-shaft, mounted between the valves, a cord or cable having its intermediate portion wrapped or coiled upon the rock shaft, and its ends connected to the respective ends of the lever, and guides located between the rock-shaft and the respective ends of the lever, the opposite portions of the cable being passed through the guides, and means for rocking the shaft.

694,611. AIR AND GAS MIXING AND SUPPLYING APPARATUS. George H. Burrows, Somerville, Mass. Filed Nov. 29, 1901. Serial No. 84,126.

An apparatus of the character specified comprising a mixing chamber having air and gas inlets and an outlet for the air and gas mixture, air and gas supply pipes connected with said inlets, a mixture-delivery pipe connected with said outlet, means controlled by the pressure of the mixture in the chamber and delivery-pipe for regulating the admission of air and gas to the mixing-chamber, and a telescopic air reservoir connected with said air-supply pipe and with a source of air supply.

694,638. VALVE FOR PNEUMATIC TIRES. William D. Hart, Bloomfield, N. J., assignor of one-half to Eugene M. Macdonald, Glenridge, N. J., Filed July 12, 1901. Serial No. 68,042.

694,714. PNEUMATIC DRILL. Thomas Barrow, Cleveland, O., assignor, by mesne assignments, to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Oct. 29, 1900. Serial No. 34.730.

A pneumatic tool, the combination of a casing, an engine within the casing adapted to drive the tool, a cover-plate for the casing having valve-passages leading to the engine, a valve box formed on the outer side of said cover-plate, a hollow valve within said box having an opening from its interior for the admission, and a recess in its exterior, a passage through said cover-plate to said valve-box adapted to be in open communication with the operating fluid, an opening into the interior of the valve in communication with said entrance-opening in both of the operating positions of the valve.

694,885. AIR-COMPRESSOR. David O'Connell, Brooklyn, N. Y. Filed Sept. 13, 1901. Serial No. 75,334.

An air-compressor, the combination with two tanks, each having a valve connection with a pressure-receiver and the outer air respectively, one of said tanks containing water, a pump operatively connected with said tanks, a valve controlling the connections between the pump and said tanks and adapted to be turned to cause the water to be withdrawn by said pump from each of the tanks, in turn, and forced into the other, chambers communicating respectively with the upper end of each tank, a float in each chamber, a rock-shaft on which both of said floats are mounted and means actuating said rock-shaft for alternately shifting the said valve as the water rises in each of said tanks successively.

694,978. AIR-LOCK. Daniel E. Moran, Mendham, N. J. Filed Nov. 26, 1901. Serial No. 83,694.

An air-lock provided with an opening for the passage of a bucket supported by a rope, a single door for said opening, and means to permit lateral movement of said bucket and rope whereby said door may be closed.

694,981. PNEUMATIC DRILL. John T. McGrath, Stratford, Canada. Filed Nov. 24, 1900. Serial No. 37,668.

In combination, the casing, the drill-spindle and driving means therefor, an air-pipe for supplying compressed air to said driving means, a cylinder carried by said casing, a piston working therein carrying a feed-spindle and a branch conduit from said air-pipe to said cylinder.

695,025. AIR-GUN. Walter R. Benjamin, St. Louis, Mo. Filed Sept. 11, 1900. Serial No. 29,674.

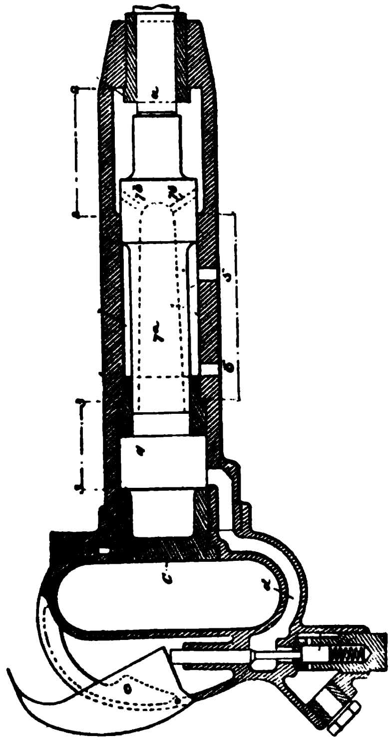
695,162. APPARATUS FOR CLEANING CARPETS. Augustus Lotz, San Francisco, Cal., assignor of one-half to Joseph Haas and Julius Kahn, San Francisco, Cal. Filed Dec. 4, 1900. Serial No. 38,602.

The combination in an apparatus for cleaning carpets or similar material, of a casing or frame, of a receiving-chamber in said casing or frame, an air passage-way extending through the casing, of means for supplying air to said passage-way and forcing the same against the carpet to eject the dirt and dust therefrom and deliver the same into the receiving-chamber, means for automatically removing the dust and air from the receiving-chamber, and a hood E surrounding the casing and communicating with the receiving-chamber.

695,199. AIR-PUMP. George W. Eddy, Waterbury, Conn., assignor to the Scovill Manufacturing Company, Waterbury, Conn., a Corporation of Connecticut. Filed June 1, 1899. Renewed Jan. 27, 1902. Serial No. 91,468.

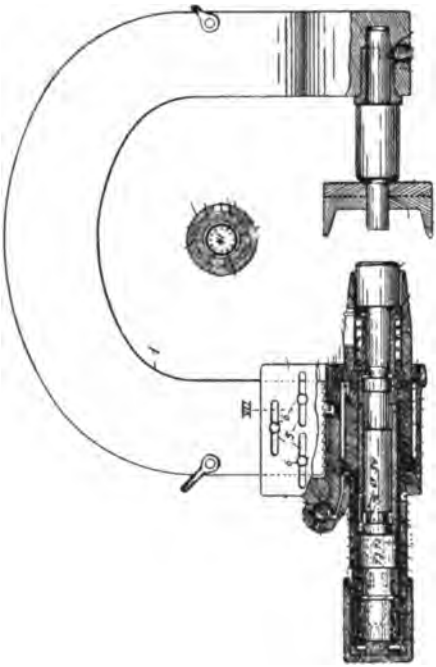
An air-pump, having a discharge-tube of rigid material and provided with a coupling for connecting the same with the inlet of an object to be inflated, and a yielding and detachable joint between the pump and the discharge-tube.

695,396. PNEUMATIC HAMMER. Charles H. Johnson, Chicago Heights, Ill. Filed June 10, 1901. Serial No. 63,957.



A constant-pressure motive-fluid-operated hammer, the combination with a cylinder having an exhaust-port, of a differential piston having a through supply port or passage which is constantly open to the motive-fluid-pressure supply, and means for closing the delivery end of the through-passage before the exhaust-port of the cylinder is opened.

695,415. PENUMATIC RIVETER. Charles B. Richards, Cleveland, Ohio, assignor, by direct and mesne assignments, to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio, and the Philadelphia Pneumatic Tool Company, Philadelphia, Pa., a Corporation of Pennsylvania. Filed December 19, 1900. Serial No. 40,347.



The combination of a suitably-supported cylinder having openings at both ends, a fluid-actuated hammer having a sliding fit in the end openings of said cylinder, and having a piston around it fitted to slide in the cylinder, and means for controlling admission and exhaust of the actuating fluid into and out of said cylinder.

695,437. AIR MIXER AND HEATER FOR GAS BURNERS FOR BLAST-FURNACE STOVES. Charles H. Björckner, Lorain, Ohio. Filed Feb. 9, 1900. Renewed Dec. 30, 1901. Serial No. 87,688.

695,492. AIR-PUMP. John Robertson, Cincinnati, Ohio. Filed Nov. 3, 1899. Serial No. 735,667.

An air pump, a cup-shaped cap to receive and shape a collapsible plunger and hold it in position while it is being inserted into the open end of the cylinder.

695,580. AIR-SHIP. Cassius M. Richmond, New York, N. Y. Filed Oct. 26, 1900. Serial No. 34,453.

695,632. COMPRESSED-AIR WATER-ELEVATOR. Greenlee D. Buchanan, Jacksonville, Fla. Filed May 1, 1901. Serial No. 58,362.

A device of the character specified, comprising two separate water-chambers, each having a valve water-inlet at its bottom and a valved air-vent at its top, an air-supply pipe connected with each of the chambers, a rotary valve carried by each of the said pipes and provided each with a crank-arm, a walking beam, a link carried by each of the ends of the walking-beam and connected to the said crank-arms, a rod connecting with each crank and with the air-vent valve, a shift-rod in each of the chambers, a water-holding cup carried by each of the shift-rods, a connection between each shift-rod and the cranks of the rotary valve, and valved discharge-pipes having their lower ends disposed adjacent to the lower ends of the said chamber.

695,771. AIR-BRAKE. Philip W. Vogt, St. Louis, Mo. Filed Dec. 30, 1901. Serial No. 87,677.

An air-brake, a suitable steam or air cylinder having central inlet and outlet openings; pistons mounted in said steam or air cylinder, one on each side of said openings; piston-rods extending from said pistons outwardly through the heads of said cylinder, and means of connecting said piston-rods to the brakes, said connections being crossed so that the brakes are tightened by admitting steam or air between the pistons, and loosened by exhausting steam or air from between the pistons.

695,948. AIR-VENT. Alfred Roesch, Bridgeport, Conn., assignor to the Davis & Roesch Temperature Controlling Company, a Corporation of New Jersey. Filed May 5, 1899. Serial No. 715,708.

An air-vent for heating systems, the combibination with a tube constituting an air-discharge, of a valve for controlling said discharge, a rod carrying said valve, a thermostat supporting said rod and adapted to raise the rod or permit the rod to lower to correspondingly move the valve under variation in temperature, and a diaphragm adapted to raise and lower said rod independently of said thermostat under variations in pressures.

696,009. AIR CUSHIONS FOR VALVES. Joshua W. Cregar, Philadelphia, Pa. Filed Feb. 4, 1901. Serial No. 45,884.

A cushioned valve, a head and spout, a water chamber having a connection for the water-pipe, secured to the head, a valve-seat at the junction of the head and chamber, an air-tube extending through the head and chamber, a lever connected to the upper end of the air-tube, a valve on the air tube intermediate of its length to engage the valve-seat.

696,059. AIR-CONDUCTING PIPE. Francis Line, Cleveland, Ohio. Filed June 27, 1899. Serial No. 722,050.

As a new article of manufacture, a hot-air pipe formed of a series of plain asbestos tubes and corrugated asbestos filling the space between said tubes, whereby air-cells are formed in the pipe between the tubes, and a joint for connecting the tubes comprising two members each provided with an inner and outer vertical portion, connected by an inclined portion having a shoulder, and inner and outer oppositely-disposed recesses, the inner recess adapted to receive the ends of the tubes, and the outer recess adapted to receive the outer vertical portion of the opposite member of the joint.

696,277. AIR-CHAMBER FOR PUMPS. John E. Sponseller and George Fenno, Hoisington, Kan. Filed June 19, 1901. Serial No. 65,150.

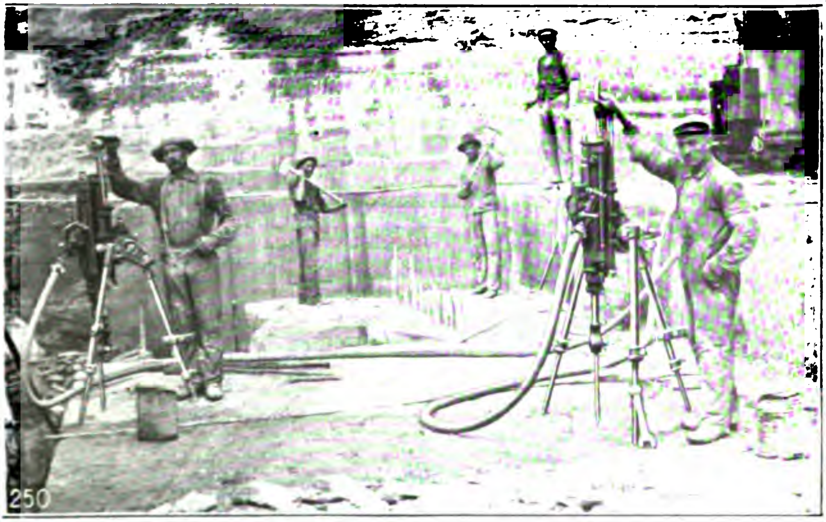
An apparatus, an air-chamber composed of the casing, the reducer threaded on the upper end of the casing and having its reduced portion provided with threads to receive the upper pump-pipe section and also to receive the upper end of the central pipe-section of the air-chamber, the central pipe-section threaded at its upper end in the upper reducer, provided near its lower end with openings for the passage of the water and air and having such lower end tapered externally, and the lower reducer threaded on the lower end of the casing and having its reduced portion provided with threads for the connection of the lower pump-pipe section and having said reduced portion formed interiorly at its inner end to provide a seat for the tapered outer side of the lower end of the central pipe-section.

696,305. PNEUMATIC-DESPATCH-TUBE SYSTEM. Thomas Bemis, Indianapolis, Ind. Filed Sept. 25, 1901. Serial No. 76,453.

A pneumatic-despatch-tube system, a curved tubular section therefor, and a movable wall portion adapted to be moved in the direction of travel of a carrier passing around said curve.

696,387. PNEUMATIC MOTOR. John W. Birkenstock, New York, N. Y., assignor, by direct and mesne assignments to the Empire Pneumatic Tool Company, New York, N. Y. Filed May 7, 1901. Serial No. 59,141.

The combination of a casing provided with an enlargement at one end, a head at the other end of the same provided with channels for supplying compressed air, a head at the enlarged end of the casing, cylinders in said casing, and provided with inlet and outlet ports, pistons in said cylinders, a crank-shaft supported in the enlarged end of the casing, piston-rods connecting the pistons with the cranks of said crank-shaft, cams on said crank-shaft, slide-valves actuated by said cams and guided in the channeled head of the casing, said slide-valves being provided with ports communicating with the supply-channels for compressed air, and means for transmitting the rotary motion of the crank-shaft to the tool to be operated.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Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, JUNE, 1902. NO. 4.

We desire to announce the fact that there will shortly be published by this paper a large volume entitled "Cyclopedia of Compressed Air Information."

This book will contain the editorials and other writings of the editor of this paper, including a full reprint of "Compressed Air Production," and all the leading papers on compressed air subjects that have been published in "Compressed Air" for the past five years including illustrations and other useful data. The book will be unlike anything heretofore published on the subject and is a cyclopedia of practical information on compressed air. Price, $5.00, sent to any address, postage paid.

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OR

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A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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J. E. QUINTERO, - } Associates
M. E. VARIAN,

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The volumetric efficiency of air compression cylinders is a subject that has for some time past been the basis for much discussion, especially among those closely connected with this branch of engineering. Claims of relatively high efficiencies for different makes of compressors have been made and as often disputed, until the purchaser, who is not generally endowed with a knowledge of the thermodynamics of air compressors and often simply looks upon the installation of such machines as an economical means to an end, is unreasonably biased in favor of one style, or, if he has used good judgment, and, as it were, taken some salt with what he hears, is at best more or less at sea and unable to decide as to the relative merits of the different makes.

The question that becomes of real importance is, what effect has the volumetric efficiency upon the first cost, and also upon the cost of operation, and this must be viewed from a point of the total economy extending over the life of the machine. The first of these questions almost answers itself. Of two compressors operating at the same speed and having equal piston displacement capacities, the one having the higher volumetric efficiency will deliver the most compressed air, or, in other words, the one having the lower volumetric efficiency must, to deliver an equal amount of air, be a larger machine at a corresponding advance in cost, all other conditions being equal.

The second of these questions, as to the effect on cost of operation, involves a complete study of the several changes in temperature, pressure and volume that the air undergoes during compression, discharge and admission before one should pass judgment. No attempt will be made here to go over the ground in full detail, but a few reminders may not be amiss to illustrate the importance of what are sometimes considered small points.

In a cylinder sufficiently jacketed, both in the heads and around the bore, it cannot be assumed that the air left in the clearance space upon re-expanding will regain all the heat delivered during compression, and the loss here would argue for a small per cent. of clearance, yet to prepare the cylinder for the new charge of air to be taken in, which we will assume is practically at the surrounding atmospheric temperature, the cylinder should be brought as near that temperature as possible, and the larger the amount of air re-expanding and absorbing heat, the lower the cylinder temperature during the intake period. On account of the practical difficulties to be met in attempting to observe the varying temperatures occurring inside such a cylinder, no actual data on this point having come under the writer's notice, a concensus of general opinions must be taken, and this seems to be that in compressors running at the rated speeds in vogue at present there will be but a comparatively slight variation in the temperature of the air cylinder where the ratios of compression are not excessive. If such is really the case, the clearance space should be kept small, as no advantage is to be gained from its being made greater.

The results of a careful test to determine the volumetric efficiency of a compressor of standard make are given in this issue and will be read with interest.

Volumetric Efficiency of an Air Compressor Cylinder.

In regard to the volumetric efficiency of the piston inlet valve tyne of air cylinders used on the Ingersoll-Sergeant Drill Co.'s Straight Line Class "A" Compressors.

The general construction of this of air cylinder is shown in the acc panying cut, Fig. 1, from which it be seen that the clearance space is red to the least possible amount, the fol ing conditions favoring this form any other.

The piston valve being part of the ton, has, as is shown, a circular of metal about 5-32 inch thick protru from the ends of the piston and a cc sponding groove cut in the heads of cylinder to receive this ring, allowing tne same clearance distance that is lowed the piston itself. The degre which this clearance can be reduce limited by the following conditions, w necessarily exist in all air-compression inders. This cylinder of compression v just starting up is comparatively col being at the temperature of the at phere, upon running up to pres for some little time, it becomes he up to somewhere near the tempera of compression, which, in a cylinder pressing from atmospheric pressur

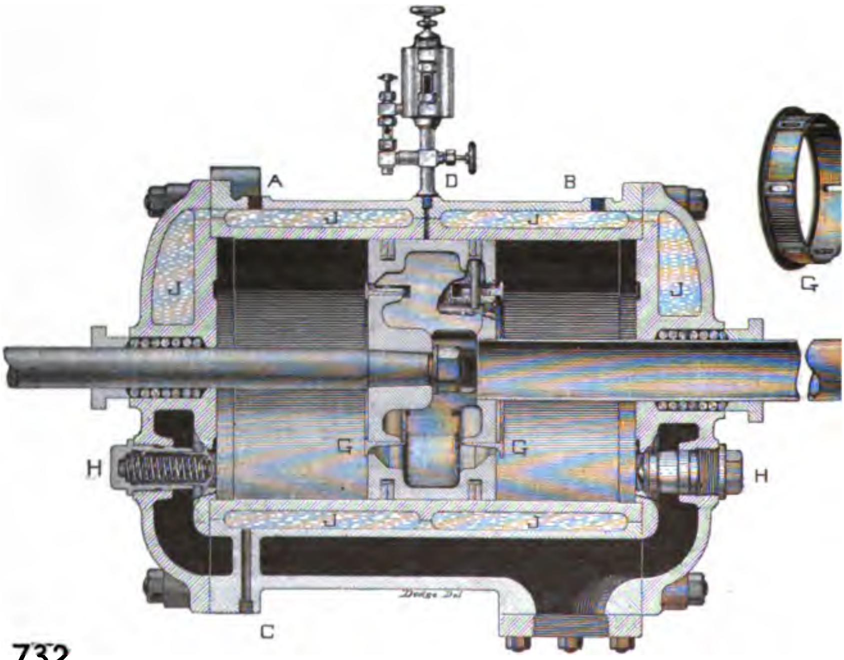

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FIG. 1.—DETAILS OF AIR CYLINDER, SHOWING PISTON INLET VALVE.

100 pounds, is approximately 400 degrees F. This change in temperature is accompanied by a corresponding expansion of the several parts coming in contact with the heated air, of which the piston rod and piston probably show the greatest effect, this expansion of the rod being so great in some cases that a piston set to just hit the front head of the compressor when cold will hit the back head when running up to pressure and the exact amount of clearance to just avoid hitting the heads has been determined for the above make of compressors and approximates 1-16 in. on each end of the cylinder.

Confining the discussion to one size of cylinder, namely, the 24¼ in. diameter x 30 in. stroke air cylinder on the Class "A" Straight Line Compressor No. 4371. Inspected and tested Nov. 29, 1901, so that the results can be attested to as being taken under actual running conditions, and not as general results, which though they are such, and indicate what can be looked for in this type of air cylinder, it has been thought best to found this statement on facts and not generalities.

Expressing the clearance in per cent. of the total cylinder volume displaced by the piston during one stroke, we have for the above cylinder 47-100 of 1 per cent. and from simply figuring this as re-expanding a volumetric efficiency of 96.4 per cent. is obtained.

Without due consideration one might think this figure higher than that actually obtained in practice, but by taking up the several effects as they occur in the cylinder, it seems to be a close approximation. See results of volumetric tests.

The volumetric efficiency of an air cylinder depends entirely upon the conditions affecting the intake stroke, during which air is admitted to the cylinder. Any air which remains in the clearance space at the pressure and temperature of discharge must re-expand until the pressure drops below that of the atmosphere, before a flow of air into the cylinder can be obtained. This re-expansion is accompanied by a drop in temperature and a consequent contraction in volume over that figured from simple re-expansion. After the line of re-expansion crosses the atmospheric line the flow of new air into the cylinder takes place, and during this period one of the most important features of the piston inlet type of valve is brought into play. That of allowing the air to enter the cylinder with the least resistance, the frictional surfaces presented being less than in any other form of inlet valve up to date. A peculiarity noticeable on these cards is the rise in pressure at the end of the intake stroke caused by the velocity of the inrush air during the intake period, continuing while the piston slows down and passes over the dead center. This is caused by the air entering in one large column, it being broken up into several smaller columns in other types of valves. This peculiarity insures a full cylinder of air at approximately atmospheric pressure (see cards).

A set of indicator cards for this compressor taken at random from the files of record cards which are taken during the regular course of inspection of the air compressors of this make, show the following results. See Fig. 2 for exact reproduction of these cards taken at ½ cut-off on steam end.

Now marking off where the re-expansion line crosses the atmospheric line and finding the length, A, dividing it by B and correcting it for the difference from the atmospheric pressure existing at the end of the inlet stroke, we have the volumetric

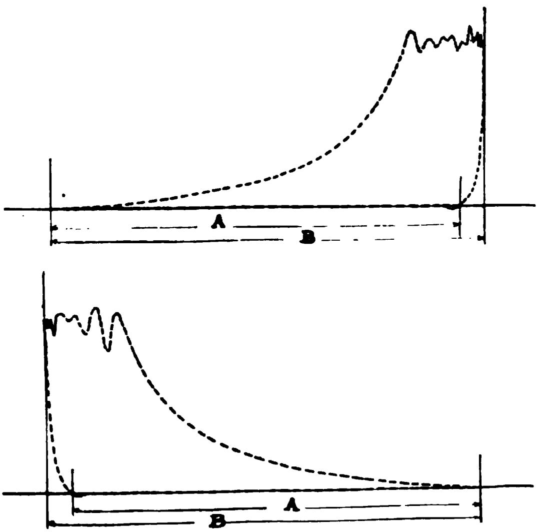


Fig. 2.

STEAM PRESSURE—103 LBS.
AIR PRESSURE—100 LBS.
REV. PER MIN.—82.

efficiency as exactly as it can be figured, and several volumetric tests with a meter attached have checked this method of figuring, giving the proper allowance to be made when using this method.

Volumetric efficiency figured thus = 94.4 for the 24 and 24¼x30 in. Class "A" Compressor in question.

To illustrate the gain in volumetric efficiency realized at lower discharge pressures with cylinders having this type of inlet valves, cards taken from the low pressure cylinder of the 22" and 24¼" and 16" x 24" stroke Class A. C. Ingersoll-Sergeant Compound Compressor or No. 2959 are shown in Figs. 3 and 4.

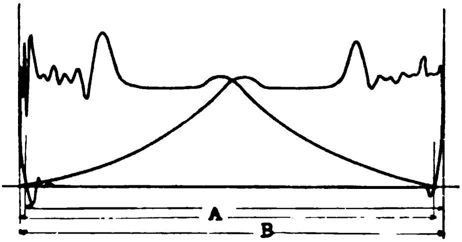


Fig. 3

HIGH PRESSURE—100 LBS.
INTERMEDIATE PRESSURE—22 LBS.
SPEED—96 REV. PER MIN.

This Compressor is designed for a final discharge pressure from 80 lbs. to 100 lbs., the intermediate or low pressure cylinder discharge pressure being 22 lbs. The cards in Fig. 3 were taken at a speed of 96 R. P. M., and figuring the volumetric efficiency as above we get for this cylinder 98.1%. Those in Fig. 4 were taken at a speed of 60 R. P. M., and give a volumetric efficiency of 98.3%, a slight increase due to the lower speed.

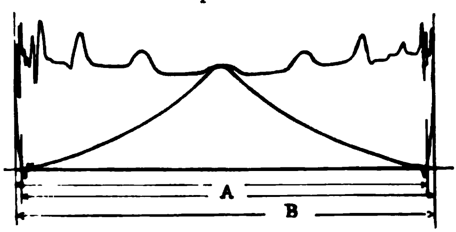


Fig. 4.

HIGH PRESSURE—100 LBS.
INTERMEDIATE PRESSURE—22 LBS.
SPEED—60 REV. PER MIN.

The meter tests for volumetric efficiency referred to were of several weeks' duration, different arrangements of the compressor, coolers, receivers, meter, etc., being tried until the arrangement described below was adopted as that giving the most accurate results.

The compressor, the same size and style as the one already discussed, was connected up for testing in the usual way, the air being taken from the room and not from some outside source. The discharge was first run through an aftercooler where its temperature was reduced to about the same as that of the room itself. From this cooler it passed into a large receiver, thence through a 4" gate valve No. 1 to a second smaller receiver, and from there to the meter, after which it passed through another 4" valve No. 2, to the discharge line, being then discharged into the atmosphere.

Gauges were placed on the large receiver and both immediately before and after the meter. Thermometers were placed before and after the after-cooler and also before and after the meter. A continuous counter was attached to the compressor to accurately record the exact number of revolutions. Indicator cards were also taken at intervals of 5 minutes with the other readings of the meter gauges, thermometers, etc.

The exact procedure during the tests was as follows:

The compressor was started up and valve No. 1 throttled down until the pressure ahead of this valve was 100 lbs., and the speed 80 R. P. M., then valve No. 2 was throttled down to a convenient pressure below 100 lbs., it being varied through several different tests but always kept at a constant pressure during each test; this second pressure was alternately made 60 lbs., 70 lbs. and 80 lbs., to determine if any variation would occur in the results on account of the pressure variation. The results, however, when corrected for the difference in pressure were approximately the same. It may not be clear to the reader just why the above arrangement of the apparatus was adopted, but a consideration of one fact will clear this up. The meter used was one of the Equitable Meter Company's make, having a capacity of 20,000 cu. ft. of air per hour, and was found to only give accurate results when the flow and pressure of air passing through it remained constant, any variation in these causing the diaphragm governing arrangement to oscillate and thus cause an erroneous reading to be recorded.

A short summary of the results of tests taken with compressor at 80 R. P. M., and compressing air to 100 pounds are as follows:

Average speed.............79.8 R. P. M.
Average temperature of room.. 72° F.
Average tem. of air before cooling .... 412° F.
Average tem. of cooling water... 55° F.
Average tem. of air before meter at 60 lbs..................... 69° F.
Average tem. of air after meter at 60 lbs..................... 69° F.
Average pressure, high.......... 100 lbs.
Average pressure, low, varied as given in the several tests, 60, 70 and 80 pounds.
Average volumetric efficiency as recorded by meter.............. 90.2%
Correcting for meter which upon calibration was found to read 8% low, the volumetric efficiency becomes .... 98. %
Allowance to be made when using the card method................ 3.6%

This only refers to this type and size of cylinder at 100 pounds pressure, and the allowance for different pressures and other types must be determined by separate tests.

FRED'K V. D. LONGACRE, M. E.

Compressed Air in Mines.

The transmission of power has in certain directions serious competitors, in favor of which there has frequently been urged greater economy in first cost, in working cost, in efficiency, and in applicability. These claims are, however, keenly contested by advocates of compressed air, who, on the other hand, contend that it supplies a means of power transmission at once safe, economical, and efficient for general mining work. The force of this contention has been much increased recently by reason of the notable improvements effected in the methods of generating and transmitting air. In this connection I cannot do better than draw your attention to some remarks by Mr. J. H. Ronaldson, who points out that it is necessary to an intelligent appreciation of the subject to consider the laws relating to air as a gas.

"*Laws Affecting the Compression of Air.*—Air is an elastic fluid, which, when free from vapor, behaves as a perfect gas. 13.09 cubic feet at ordinary atmospheric pressure, and at 60 degrees Fah., weigh 1 lb. According to Boyle's law, the volume of a gas varies inversely as the pressure affecting it, so long as the temperature remains constant: consequently, in doubling or trebling the pressure, the volume becomes one-half or one-third respectively. According to Charles' law, if the volume of a gas be kept constant, the pressure varies as the absolute temperature, and if the pressure be kept constant, the volume varies as the absolute temperature. By the law of the transmutation of energy, work performed on a body, whether solid, liquid, or gaseous, is evidenced by a definite decrease of temperature in that body, and we are familiar with that fact as shown in the simple laboratory experiment of exploding a small charge of guncotton in a strong glass cylinder, through the rapid heating of the air contained in it by a sudden jerk of a tightly-fitting piston. Consequently, when air is compressed, it is heated; when heated it expands, and the volume of air to be compressed is proportionately increased with a corresponding expenditure of the power required to compress it. Could the temperature of the air undergoing compression be kept constant (isothermal) during the process, and the heat taken up from it returned to the air during its expansion in the motor while doing work, all loss from this source would be avoided. This, however, is impossible, and the aim of modern compressors is to prevent an increase in the volume of the air by keeping down the temperature during the period of compression—that is, by approximating to what is termed isothermal process. It is clear that the least efficient compressor is the one in which no provision is made for cooling the air during the actual period of compression—that is, one working on what is termed the adiabatic process.

"*Air-compressors.*—Two forms of compressors are in use, in each of which a reduction of the temperature of the air is aimed at—in one case by the use of a liquid piston in the cylinder, and in the other way by a water-jacket around the cylinder, or by an internal spray of water. The former is termed a 'wet' and the latter a 'dry' compressor.

"*Wet Compressors.*—Of these there are

two types: (*a*) Where the water-piston owes its energy to the fall of water from a height; (*b*) where the water is actuated by a steam-driven piston. At Mount Cenis, Mons. Sommeiller made use of water, with a fall of 86 ft., and, by utilizing the momentum of the falling water, he was able to obtain an air-pressure of 75 lbs. per square inch. Though extremely low in efficiency (not more than 6 per cent.), and necessitating clumsy plant, the arrangement gave results sufficiently good. This principle has been applied in other cases, and one arranged by Hathorn, Davey & Company, Leeds, was successfully used for many years in Mexico. The application of the principle is simple, and, where an abundant water-supply exists, excellent results are obtained. The second form of wet compressor has attained a wide application on the continent of Europe, where, particularly among the highly-educated Belgian and French engineers, the principles of air-compression are thoroughly understood. It is, however, a question if their adherence to this method is not an instance of the length to which a desire to reach an ideal perfection may lead one from the best practical solution of a problem. As will be shown later on, the dead space at the end of the air-piston stroke is undesirable, and it was largely to eliminate this defect and to keep the air cool that liquid pistons had such a vogue on the Continent. The water forced back and forward in the cylinder and up the pipe at each end, carrying the necessary valves, filled the dead space. But, unfortunately for this ideal, there are a number of inconveniences attendant on the system. The cooling of the air is insufficient, because it is only on the surface of the water. The speed of the piston is extremely limited, and cannot exceed 40 ft. to 50 ft. per minute, on account of the mass of water to be moved; consequently, the number of compressors required for a given work is large. The water agitated by the motion is frothed, and causes an excessive moisture in the air. Various devices, more or less successful, have been used to lessen these defects; but, in spite of all, the fact remains that in other countries these compressors have not found favor.

"*Dry Compressors.*—This type of compressor has a cylinder and piston similar to those of a steam-engine, with suitable outlet and inlet valves at the cylinder ends. The temperature of the air is kept within reasonable limits by the constant flow of cold water through the water-jacket of the cylinder from the bottom upwards. It is, however, doubtful if the process of cooling, even under the most favorable conditions, does more than keep the cylinder from becoming excessively heated, and so imparting heat to the incoming air. A more thorough method of cooling is obtained by injecting a fine spray of cold water into the cylinder near the outlet valves. To this the objection has been strongly urged that the presence of water, with its non-lubricating properties, causes an undue wear and tear in the cylinder, and loss in power.

"*Causes of Low Efficiency in Air Compressors.*—These causes, briefly stated, are the heating of the air during compression, mechanical defects in the inlet and outlet valves, and leakage past the piston. It has been already shown that air, when subjected to compression, is heated, and that, as the volume is thereby increased, much power is uselessly expended in dealing with the heated air. The most efficient compressor, therefore, in this regard, must be the one presenting the best cooling arrangement for the air as it is being compressed. That form of compressor in which the piston is represented by the falling water supplying the power, such as Sommeiller's, permits of a very thorough cooling, as the water piston is renewed each stroke, and the cylinder is kept perfectly cool. But in the second form of wet compressor, such as Dubois', of Belgium, in which the water, only slightly renewed per stroke, becomes considerably heated, the cooling is not more perfectly effected than in the dry compressor. As the pressures to which the air is raised become greater, the losses from this source become serious, and as the efficiency of the motors increases with the pressure, and the sizes of the conduits can be correspondingly small, it is desirable, perticularly in large installations, to use high-pressure air. The most satisfactory results in this direction have been obtained by stage compression—that is, by pressing the air to a certain pressure in one cylinder, and further compressing it in a second, and, if desired, in a third, or even a fourth. By this system the air is cooled between each stage, and the losses from this source are minimized. For low pressure it is doubtful if any practical economy would result from stage compression, but it is now fully demonstrated that for pressures above 60 lbs., the advantages of stage compression are very marked. To diminish the losses caused by resistance to the passage of the air through the inlet and outlet valves, many devices have been resorted to. In the ordinary valves held closed by springs, the valves rattle or chatter if the springs are weak. On the other hand, if the springs are made very strong, a resistance to the passage of the air is set up, resulting in a loss of power, which, in some cases, becomes serious. To obviate this defect, the valves are occasionally devised to open mechanically. In a short letter such as this it is impossible to enter into the details of the various valves used. It is not uncommon to hear much stress laid on the losses caused by the unavoidable dead space occupied by compressed air at the end of each stroke, and it may be pointed out at once that the loss is not in power, but solely in the volumetric capacity of the compressor. To diminish this inconvenience, the air-piston is usually run as close to the cylinder ends as practical, and care is requisite to avoid sailing too close to the wind in this direction, and damaging the mechanism. The best plan is to arrange trick passages, or grooves, on the inside of the cylinder, for a short distance back from each end, to allow the air in the dead space to pass the piston to the end in which compression is about to begin. The inside pressure against the suction valves is thereby relieved, and compression on the other side of the piston begins at once. To prevent knocking through the sudden relief caused thereby at the end of the stroke, a certain amount of cushioning in the steam cylinder is required. The low efficiency due to leakage in the pistons can only be effectually reduced by carefuly attending to their condition. Naturally, the higher the compression the greater the leakage, but stage compression greatly lessens this evil.

"*Air Conduits.*—Two considerations are of importance in determining the pipes to be employed; these are the size of the pipes, and the character of the joints. The frictional loss in the passage of the air through the pipes increases very rapidly as the diameter decreases, as shown by the following example:—If a volume of air at 60 lns. pressure, equivalent to 18,000 cubic feet per hour, at atmospheric pressure be passed through 1,000 ft. of pipes, the loss of pressure of air for 2½ in., 3 in., 3½ in., and 4 in. pipes would be 5¾ lbs., 2 lbs., 1½ lbs. respectively. Leakage at the joints through the expansion and contraction of the pipes is a fruitful and, at times, a serious loss of power. A receiver of suitable size should always be placed alongside the compressor, and where a considerable length of pipes is used, it is an advantage to have a receiver as near the motor as practicable.

"*Method of Using Compressed Air.*—When air is compressed it is heated, and when it expands it is cooled. The latter fact gives rise to the inconvenience so frequently met with in air motors of ice being formed in the ports through the freezing of the moisture in the air. Where the air is admitted to the motor practically during the whole stroke, there is little danger of ice being formed, but there is a terrific waste of power, for it is as important for economy to use air expansively as it is to use steam expansively. While a little moisture in air used expansively results in the formation of ice in the ports, it may be pointed out that aqueous vapor has a specific heat nearly double that of air, and consequently cools less rapidly under expansion than dry air, and the tendency of an excess of moisture is to reduce the cooling. The specific heat of water being still greater, a spray of water may be effectively used in the motor cylinder to prevent cooling to the freezing point. The writer was familiar many years ago with an instance where, in the case of large haulage engines placed underground, the inconvenience caused by freezing was so serious that compressed air was abandoned, and steam, though inconvenient, was substituted. Reheating the air is, however, the most effective method of allowing air to be used expansively without the formation of ice in the ports, and this can best be done by passing the air near the motor through a coil of pipes heated by a small furnace; and a further elaboration, permitting the highest degree of expansion, is effected by introducing a small quantity of water into the heater, where it is converted into steam. A move in the latter direction was made years ago, by the use of a jet of steam in the air-pipe near the motor. In practice, it is found that reheating the air not only prevents freezing, but results in a very great economy in the use of compressed air, at a small cost both for plant and fuel.

"*The Dangers Attending the Use of Compressed Air.*—These are so slight as to be scarcely worth considering, but their existence is worthy of passing notice. A few cases are known where an explosion, more or less marked, has occurred in the receiver placed near the compressor. In these instances combustion has been set up, apparently, in the carbonaceous matter deposited from the lubricants used in the compressor. The readiness with which a piece of old oily waste takes fire at comparatively low temperature is well known, and it is possible that a similar action may take place in the deposited carbon, if subjected accidentally to abnormal heating, by a failure in the cooling apparatus of the compressor."—W. A. PHILLIPS, *in Iron and Coal Trade Review.*

Some Observations on the Deep Pneumatic Work of the New East River Bridge Foundations.

An article entitled "The Occurrence and Treatment of Caisson Disease in Engineering Works," has just come to the attention of the writer. As a statement is made in relation to the greatest air pressure used at the New East River Bridge which differs greatly from the fact and as some conclusions are based on this statement, it seems well that the real facts should be explained. The work in question was done under the immediate direction of the writer as Resident Engineer, and he is therefore very familiar with all the facts and conditions. An explanation was begun in the form of a "letter to the editor," but so many interesting points developed that it was thought better to put it in the form of a short general description of some special features of the work. The compressed air conditions met in the two Brooklyn piers were quite unusual and of sufficient interest to merit description, especially as these conditions may be assumed to apply in a greater or less degree to the numerous compressed air tunnels now projected under the East and North rivers. The north pier only will be described, as the conditions met at the south pier were very similar, though it was of somewhat less depth.

The article states "the work of excavation and of placing the concrete (at north Brooklyn pier, New East River Bridge) was performed at a depth of 108 ft. below water level, requiring an air pressure of 46½ lbs. per sq. in." This pressure seems obvious from the depth, except that it should be 48 lbs., because of sea water. As a matter of fact, however, the highest pressure ever used in this caisson was 38 lbs. per sq. in., and this only when the cutting edge first reached the depth of 90 ft. below mean high water. The pressure was then at once reduced to about 31 lbs. per sq. in. for a couple of days; then carried for the remainder of the pneumatic work (a period of over six weeks) at pressures of 33 lbs. to 37 lbs. per sq. in., the variations being irregular and the pressures not increasing with the depth.

The preliminary diamond drill borings showed above the clay about 50 ft. of water and about 20 ft. of sand with some boulders. The clay began at about 70 ft. below mean high water and extended without change to the rock, the highest point of which was found at a depth of 86 ft. and the lowest at a depth of 105 ft. The depths found by the diamond drill were in general corroborated by the more exact information secured during the sinking. This latter information showed that unless borings are taken very close to each other no inference is warranted as to the shape of the bed rock at intermediate points, at least with the gneiss rock of this neighborhood. The diamond drill borings and the sinking also showed that no reliance could be placed on wash borings to distinguish between boulders and bed rock. Seven wash borings had been made on and close to the tower site, each boring terminating on stone. A charge of dynamite was exploded in most of these borings, resting directly on the stone, in the hope that if the stone were merely a boulder some shattering or change of position would occur. Subsequent examination showed no such effects, though the diamond drill borings and the sinking revealed the fact that in only one case (and that very doubtful) could the stone located by the wash borings have been anything more than boulders, usually of moderate size, lying on the clay. The possibility of the stone located by the diamond drill borings being merely large boulders was guarded against by carrying each boring about 10 ft. into the rock and securing cores of the same for examination.

With the diamond drill borings as data, the caisson, masonry and coffer-dam of the north pier were designed of such heights as corresponded to a final depth of the cutting edge of 100 ft. below mean high water, or 5 ft. above the deepest known rock. The clay was of such hardness and of so great a depth that entirely suitable foundations for any bridge, except perhaps a suspension bridge, would have been secured by sinking the cutting edge only a few feet into it and not trying to reach the rock. The slightest settlement would affect the verticality of the high tower, however, and as in this case the rock could be reached by the pneumatic process at what was proportionally only a very small addition to the cost of the bridge, the only wise and conservative treatment was to carry the foundations to the rock. In case the rock had been much deeper, it is very probable the clay would have been used as a foundation. It was fully equal for this purpose to the clays on which are founded the truss bridges over the Missouri River at Rulo and Bismarck and the long span cantiliver bridge over the Mississippi River at Memphis.

When the caisson of the north pier was landed on the river bottom its cutting edge was about 49 ft. below mean high water. The ordinary fall of the tide was nearly 5 ft. The river bottom was covered by about a foot of very offensive sewer mud, and below this to a depth of 63 ft. to 72 ft. (average about 68½ ft.), extended a bed of sand, gravel and cobbles, with some boulders. Below this lay a bed of hard, dry stratified clay extending to the rock, the highest point of which was found at a depth of about 84½ feet, and the lowest at 107.5 ft. The average depth of the original rock surface within the whole area of the caisson was 96.5 ft. The maximum depth of 110 ft. which has been published several times is incorrect.

The cutting edge was stopped at a depth of 95 ft. (5 ft. higher than originally intended), 46 per cent. of it being then within a few inches of the excavated rock surface and the remainder an average of 7 ft. and an extreme height of 11 ft. above the original rock. The excavated rock surface covered 42 per cent. of the area of the caisson. The mean depth of the final rock surface over the whole area of the caisson is 98.3 ft. below mean high water.

The comparatively small amount of work done at the greatest depths is shown by the amount of excavation being only about 2 cu. yds. below the depth of 106 ft., 21 cu. yds. below 104 ft., 77 cu. yds. below 102 ft. and 183 cu. yds. below 100 ft. The size of the caisson was 63 ft. x 79 ft., giving a volume per foot depth for its whole area of 184 cu. yds. The deeper parts were left uncovered as short a time as possible, about 40 cu. yds. of the excavation being done after the concreting was begun. The extreme depth of 107.5 ft. existed for less than an hour, concrete being placed on the rock within a few minutes after it was satisfactorily cleaned.

The indicated air pressure exceeded that corresponding to the depth of cutting edge by several pounds (generally from 3 to 6 lbs.) from the beginning down to a depth of about 75 ft., or until all parts of the edge were well within the clay. From this depth to about 90 ft. the two pressures corresponded quite closely, sometimes one and sometimes the other being slightly larger. Below 90 ft., as already mentioned, the indicated pressure was much smaller than that corresponding to the depth of water.

Almost from the beginning the excavation in the middle of the caisson was carried to depths of 6 ft. to 8 ft. below the edge, and this accounts for the excessive pressures carried in the permeable materials above the clay. The advantage of doing the work in this way was that all the excavation could be done below the horizontal struts in the working chamber without interference from them and that the material could be excavated to a large degree from a face. This method could be used only in a broad caisson, as in a narrow one the slopes needed next the edge would leave very little space available for deepening the excavation in the middle.

The sinkages were made intermittently, usually from 3 ft. to 6 ft. in one or two days, after many days spent in preparatory excavation. The maxima were 4 ft. in one day, and at another time 5.9 ft. in two days. Slopes were carried around the edge as long as possible until just before the sinkage.

The question of danger of course arises in carrying excavations below the cutting edge. So long as the pressure maintained is as great as that corresponding to the edge no possible danger can arise from this cause, as the water, even in case of an inburst, will not rise above the level of the edge. Even a somewhat less pressure implies no danger, as it is a common occurrence to allow the water to rise 3 ft. in caisson chambers during a sinkage, the men taking refuge on the beams.

When the excavation is carried 11 ft. vertically below the cutting edge, however, to a depth of 106 ft. below mean high water, and the pressure maintained is not more than 36 lbs. per sq. in., some degree of danger may be thought to have been incurred. The depth corresponding to a pressure of 36 lbs. is 81 ft., or 14 ft. less than the depth of the edge and 25 ft. less than the extreme depth of the vertical clay face. The pressure corresponding to the depth of cutting edge is 42.2 lbs., and that corresponding to the extreme depth of 106 ft. is 47 lbs.

From the information furnished by the borings it was decided that it would be conservative to take advantage of the bed of clay to stop the cutting edge at a height of at least 5 ft. above the deepest rock. This allowed a saving of 5 ft. in both masonry and coffer-dam and a large saving in rock excavation, these savings largely outbalancing the extra cost of the concrete needed to refill the excavation below the cutting edge. As actually built, the edge was stopped 5 ft. higher than intended, or at 95 ft. instead of 100 ft. depth. This resulted in a great saving of time, and also, as the work below a depth of 96 ft. was paid for by the cubic yard, in a further saving of cost to both the city and the contractor. The only change in the construction required by the less depth was the omission of 5 ft. from the coffer-dam and from the masonry below low water, and a considerable addition to the clay excavation and concrete refilling between the elevation of the cutting edge and the rock.

For the south half of the caisson the cutting edge has between it and the rock only a few inches of concrete, while for the north half it has an average intervening depth of 7 ft. and a maximum of 11 ft. This concrete will have an excess pressure from the completed bridge of only about 5 tons per sq. ft., while it might safely, in this location, bear 15 tons. The size of the pier was governed by the lateral dimensions of the tower leg instead of by unit working pressures. The compression which may occur in the extra depth of concrete under the north edge is inappreciable and entirely negligible. The concrete is receiving its load very gradually, as it was placed in 1898, and its full load will not have been reached for at least a year or two to come.

The clay was so impervious that the pressure in the working chamber could easily have been raised to the 47 lbs. per sq. in., corresponding to the maximum depth of 106 ft., or even much higher. The pay and the length of shift of the pressure men were fixed by the depth, and not by the pressure, so carrying a lower pressure than that corresponding to the full depth was of no direct advantage to the contractor, except, perhaps, an inappreciable saving in the cost of air compression. The only reason for using an air pressure less than the depth was a desire to lessen the chances of caisson disease among the men. Experience has shown that the disease is not very prevalent at depths less than 80 ft., corresponding (in fresh water) to pressures less than about 35 lbs. Advantage was therefore taken of the imperviousness of the clay to lower the pressure to about this point. There is no reason to suppose that it could not have been safely lowered much more, but with the unusually short hours of the men there was no object in doing so—besides, a limit must always be placed on such experiments. The height of the water inside the coffer-dam was also an element in determining the minimum air pressure. The constant and certain danger to the men from high pressures was prevented and a risk taken in exchange which was less, everything considered, than those usually taken in open excavations.

The only risk possible was in a sudden caving of the vertical bank and an inrush of water. As a matter of fact, the methods and care used obviated practically all risks. As before remarked, slopes were carried around the edge as long as possible and the clay dressed to a vertical face only a comparatively short time before sinking or before concreting. Planks and braces were kept on hand and used in a few places where it seemed advisable. A close watch was kept, and the air pressure could have been increased quickly if necessary. The characteristics of the clay were well known from work at higher levels and in the south pier. In that pier the edge was also 11 ft. above the lowest rock, but the average distance was much less than in the north pier. The maximum pressure carried was 31 lbs., about 5 lbs. less than that corresponding to the depth of cutting edge and 10 lbs. less than that corresponding to the deepest rock.

The clay was very peculiar in its appearance, and quite unusual. It was very uniform and markedly stratified, resembling at a few feet distance a strongly laminated gneiss. It was, in fact, supposed to be a decomposed gneiss rock, until some small boulders were encountered in it. Its junction with the bed rock was plainly marked, only an inch or two of harder material separating them. The clay was free from sand, quite dry, and would absorb very little water, though by continued working it would become greasy and putty-like. It was so hard that it was found economical to excavate a great deal of it by blasting with dynamite, though it was not impracticable to excavate it by pick and bar. Vertical faces were soon affected by exposure to the air, pieces varying in size from a pail to a barrel detaching themselves slowly. This was easily prevented, where necessary, by planks.

The quality of the clay, its soundness—the stratification showing that it had not been disturbed since its original deposition—and its great thickness would have justified risks much greater than any taken. The minimum thickness of clay above the edge was 23 ft., and this was overlaid by a minimum thickness of 36 ft. of sand and excavated materials. No water was ever found leaking down from between the outside surface of the caisson and the clay.

In sand it is impracticable to do any work cheaply at a lower depth than the cutting edge, as the water is very sensitive to changes of pressure, and while in sand it is not possible the raise the pressure very much above that corresponding to the edge. When concreting on a sand foundation, it is often necessary to raise the pressure as high as may be in order to drive the water down in the sand and secure a dry bottom for the concrete. This was necessary in most of the sand foundations of the Cairo Bridge, the excess pressure being there usually 2 or 3 and in one case 5 lbs.

In clay, on the other hand, some work always has to be done below the edge. No sinkage can be made until the clay has been excavated vertically for the full depth of the proposed settlement, and this is done without increasing the air pressure. In one of the piers of the Rulo Bridge a test well was sunk through clay 17 ft. below the edge without any increase in the pressure. A 4-ft. vein of gravel was then struck, when the pressure had to be at once increased 8 to 10 lbs. When the well was refilled the pressure was lowered to its former amount. At the Memphis Bridge tests wells were sunk in each of the five pneumatic piers from 2 to 15 ft. below the edge in clay without any corresponding increases in pressure.

While working with pressures less than the depth is unusual in bridge piers, it is quite common in tunnels built with compressed air, where much reliance is often placed on the imperviousness and strength of the overlying materials and the compressed air is used largely as a safeguard and aid. The distinction between tunnels and bridge piers in this respect is that in the former no intentional connection exists between the tunnel and the water of river, while in the case of the latter the process of sinking necessarily makes a connection, more or less closed by shifting materials, between the working chamber and the river.

It is seen from the facts given that while work was done at a great depth in the New East River Bridge piers, they cannot be classed among structures where high pressures were used.

The most familiar example of high pressures is the St. Louis Bridge, where the sinking was through sand to rock. The east pier, when landed on rock, had its cutting edge immersed 93.2 ft., corresponding to over 40 lbs. per sq. in. The last 34 ft. was sunk in 27 days, or at an average rate of 15 ins. per day. Filling of the chamber with concrete was begun seven days later and discontinued after 38 days, when the immersion had reached a depth of 111.75 ft. The concreting was resumed after an intermission of 28 days, the river having fallen to an immersion of 107½ ft., and was completed 16 days later. The concreting of chamber lasted 53 working days (in two disconnected periods), and was done in pressures of 45 lbs. to 50 lbs., corresponding to theoretical immersions of about 104 ft. to 115 ft.

The only other deep sinking at the St. Louis Bridge was the sinking of the east abutment. When its cutting edge was 14.9 ft. above rock, with an immersion of 97.3 ft., the pressure carried was 43 lbs. Nine days later, with its edge 10.1 ft. above rock, an immersion of 101.1 ft. and a pressure of 46 lbs., the work was stopped by a tornado. After an interval of eight days, the sinking was resumed and rock was reached twelve days later. When landed on the rock the edge was immersed 109.7 ft. and the pressure was 49 lbs. Two days later tne placing of concrete under the edge and girders was begun and completed in 17 days. The remainder of the chamber was then pumped full of sand and water.

The most notable and successful instance among bridge foundations of long protracted continuous work under heavy pressures is the sinking of the two river piers of the Memphis Bridge, though but little attention seems to have been drawn to it. This work was done by day's labor under the direction of Mr. Alfred Noble as Resident Engineer. The piers are on clay foundations, and were sunk through sand and a few feet into the clay. In Pier II. the immersion of edge was for 11 days from 100 ft. to 104 ft., with indicated pressures of 41 lbs. to 43 lbs. and calculated pressures of 43 lbs. to 45 lbs. At a later period the immersion was from 93 ft. to 104 ft. for 50 days, the indicated pressures being 40½ lbs. to 41½ lbs. and the calculated 40½ lbs. to 45 lbs. In Pier III. the immersion was for 21 days from 90 ft. to 105 ft., with indicated pressures of 37 lbs. to 44½ lbs. and calculated pressures of 39 lbs. to 45½ lbs. For 75 days at a later time the immersion was 94 ft. to 106.4 ft., with the indicated and calculated pressures respectively 40 lbs. to 47 lbs. and 41 lbs. to 46 lbs.

An interesting observation of temperatures was made at the south Brooklyn pier of the New East River Bridge. This was done in the middle of June, while concreting the working chamber, with the air pressure 31 lbs per sq. in. The air lock was located about 20 ft. above the cutting edge at the foot of a deep damp 6-ft. shaft, and communicated alternately with this shaft and with the working chamber. The temperature of the lock just after "bringing it in" was + 95° F., and just after "taking it out" + 67°; the general temperature of the working chamber was by observation + 81°. Air was being delivered to the chamber at this time through two pipes, the regular pipe carrying cooled air and a smaller pipe carrying air which had not been cooled. The temperature at the exit of the cold air pipe was + 77° and at the hot air pipe + 90°. The time of bringing in the lock was probably about 3 mins. and of taking it out about 5 mins. The observation is unfortunately incomplete in not including these times and the general temperatures at the foot of the shaft and in the external air.

The air was cooled by passing it through a collection of 1-in. gas pipes (aggregating about 500 ft. in length) immersed in the river, and not by spraying. The same method had been used at Cairo, Memphis and elsewhere. The question of cooling the air for the north pier was unimportant, as the chamber of this pier was concreted in November.

The great immunity from caisson disease of the pressure men employed at great depths on the Brooklyn piers was due to three causes—to the pressure used being much less than that corresponding to the depth; to the length of shift being unusually short even for the full depth and still more so for the actual pressure, and to the use of an elevator in raising the men to the surface.

The deepest work was done with the edge at a depth of 95 feet. below mean high water and with the lowest rock under the edge at a depth of 106 ft. The pressure actually used, however, corresponded to a depth of only about 83 ft. (of fresh water). The corresponding hours worked were 1½ hours per 24 hours, divided into two shifts of ¾ hours each, with an interval of 4½ hours to 6 hours between shifts. This schedule applied to all work below 90 ft. depth, the hours for depths of 80 ft. to 90 ft. being two shifts of 1 hour each, with 4 hours rest between.

The schedules at the Memphis and Bellefontaine bridges were usually as follows:

80 ft. to 90 ft. depth, two shifts of 2 hours each; below 90 ft. depth, three shifts of 1 hour each. At the Kulo Bridge two shifts of 1½ hours each, were used between 80 ft. and 90 ft. The schedule at the Cairo Bridge was generally two shifts of 2 hours each for depths below 80 ft. (80-95), with 10 hours rest between; the shifts were in some cases reduced to 1½ hours each. The inspectors of concreting in the chamber of the north Brooklyn pier (all young engineers) worked two shifts of 1 hour each, or longer than the pressure men; and the writer and some others at times spent an aggregate of three or four hours per day in the pressure, taking extra shifts. The solicitude of the pressure men

for our health was touching but unconvincing, as most of them had worked on the Western bridges mentioned.

The use of an elevator for the men has been spoken of as a great safeguard against caisson disease. It is probably one of the most important in deep work, personal experience having shown that a climb up a ladder in a damp 3-ft. shaft, sometimes a hundred feet or more in depth, just after leaving the pressure, is a more exhausting task than the work in the air chamber. The climb is probably less enervating when made in compressed air, with the lock at the top of shaft, but for many reasons the bottom lock seems usually preferable. The use of elevators is not important when the depths are less than about 80 ft. Their use in connection with deep work should not be regarded as an extra expense, as the more effective work of the men when no long climb is anticipated will probably more than counterbalance their cost. Cooling of the air is very important in summer and in hot climates.

The habits of pressure men have a great deal to do with the prevalence of caisson disease. The high pay, short hours of work and period of idleness between shifts (generally not long enough to allow of going far from the work) all conduce toward the spending of much of the idle time in saloons, and to too much drinking and too little sleep. A "sand-hog" ball is generally followed by a greater prevalence of "bends" among the men.

An elevator was used at the east abutment of the St. Louis Bridge, and one was also used at both the Memphis and Bellefontaine bridges. At the Brooklyn piers of the New East River Bridge the elevator shaft was 6 ft. in diameter and the inside diameter of the elevator itself was 5.4 ft. The elevator would hold 18 large men, estimated at the time to average 170 lbs. each, making an average load per sq. ft. of its floor of about 134 lbs. The 6-ft. diameter lock would hold 20 men and allow the door to open inward. The men were in both cases very tightly packed.

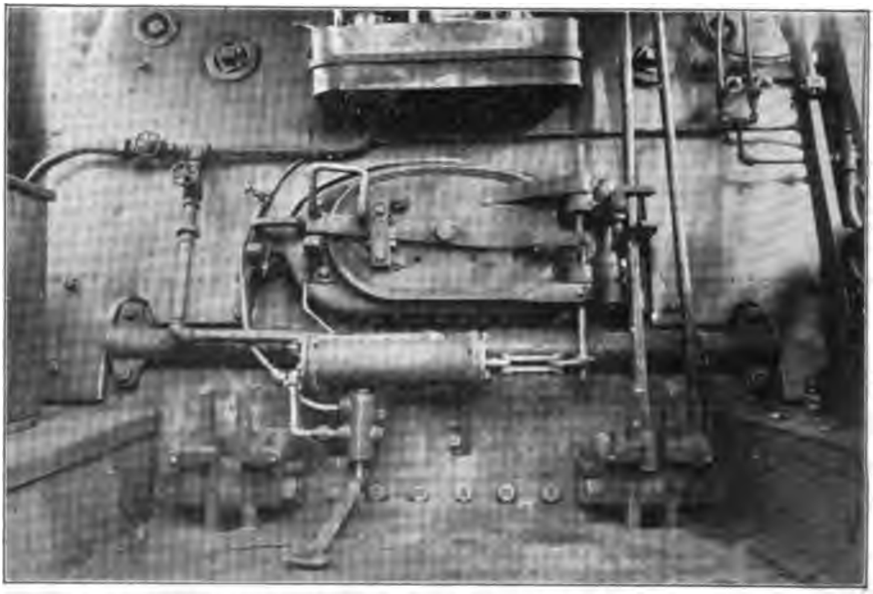
Much more might be written about the Brooklyn piers, but this is intended as a description of some special points only. The piers were built by the Degnon-McLean Construction Co., and the success attending the difficult pneumatic work was due principally to the good judgment and untiring watchfulness of J. E. Taber, their foreman in general charge of the sinking. —Edwin Duryea, Jr., in *Engineering News.*

A Pneumatic Fire-Door Opener.

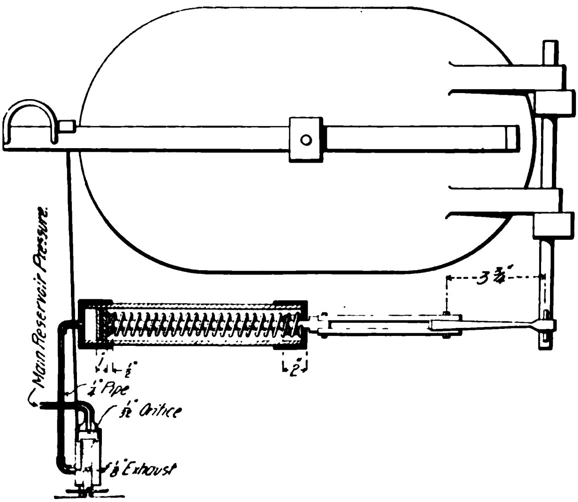
Mr. F. L. Brewer, an engineman on the Rock Island, has invented a device for opening and closing the fire-door of a locomotive. The only action required by the fireman is to press his foot on a pedal when he wishes the door to open and remove the pressure to allow it to close.

As will be seen by the illustrations the apparatus is simple and of few parts. A cast-iron cylinder 2½ in. inside diameter and 14 in. long is bolted to the boiler horizontally just beneath the fire-door by two brackets which are an integral part of the casting. The drawing shows the original design, having the two heads threaded on the cylinder; this has been modified as shown in the engraving from the photograph, flanges being provided and heads bolted on. The piston is of steel, having two ¼-in cast-iron packing rings. The rod, which is ¾ in. in diameter, is enlarged at its outer end and shouldered into a crosshead, to which is attached a toggle-joint, connecting with a 3¾-in. crank, keyed to the door-hinge shaft. The shaft is keyed to the door-half of the upper hinge and has a set-screw through the lower one, insuring a rigid attachment.

The valve is simple in form and seats by gravity. Above the valve is a small chamber which is in pipe connection with the main reservoir; the air enters this chamber through an orifice 1-32 in. in diameter. The stem of the valve extends down through the casing, projecting ¼ in. or more below. The inner end of the operating pedal is directly beneath this stem and a depression of ½ in. at the outer end raises the valve clear of the seat, permitting the air to pass down through the small hole parallel to the valve stem and just to the left of it, and out through the pipe connection to the cylinder, which it enters through a ⅛-in. orifice. The piston has a 6-in. stroke which is sufficient to throw the door wide open. The air pressure acts against a flat-steel helical spring which operates to close the door the moment the air is released. The exhaust is through the same orifice in the cylinder that admits the air and the throttling ac-



BREWER'S PNEUMATIC FIRE-DOOR OPENER.



PNEUMATIC FIRE-DOOR OPENER—SECTIONAL VIEW.

tion of this opening provides a cushion for the spring pressure to act against, preventing the door from slamming. The exhaust reaches the atmosphere by passing around the valve stem through a ⅛-in. groove turned in the stem and thence through a ⅛-in. hole drilled in the casing.

Just back of the valve casing, with its lower end resting on the pedal, is a small steel rod held against the boiler head by suitable guides. Its upper end is in contact with a small latch which holds the door closed. This latch is raised simultaneously with the admission of the air. It is hinged to the boiler head and is cut under at its outer end so that when the door swings shut this small latch is raised and drops into place over the door latch.

With a 1-32-in. admission port the minimum pressure under which the device will work rapidly and easily is 60 lbs. With a lower pressure than this the action is too slow to be satisfactory. This can, of course, be regulated by varying the size of the admission orifice.

The device is in use on two Rock Island passenger engines, Nos. 1,301 and 1,303, in the fastest service on the road, and on No. 1,454, a wide fire-box, 10-wheel freight which is the largest engine on the road. The mechanical department of the Rock Island has been very carefully watching the results from the use of the door opener and recently asked the firemen on the engines equipped with the device for an expression of opinion as to its working, and whether or not it would effect a saving of fuel, lengthen the life of the firebox, and cause a reduction of leaky flues. The replies were without exception very favorable. It was stated in every case that besides working perfectly, the fireman is able to put in a fire in about one-half the time required by the old method. These opinions have been substantiated by the traveling engineer and by Master Mechanic Stocks. The reports were also unanimous in the opinion that there was a saving in fuel, although no tests have been conducted to determine to what extent this is true. Other points mentioned were, that the engines steamed more freely, the black smoke is reduced, and the use of a second fireman on large engines would be rendered unnecessary. Mr. Brewer has applied for a patent on the device.—*Railroad Gazette.*

Compressed Air for Mining from Electric Power.

This paper records some actual results obtained using a 10x18-inch duplex, single stage, belt driven compressor, the area of the outlet ports being 9 square inches on each end of each cylinder, the port area being reduced to 6¼ square inches where it enters the main pipe, a disadvantage, but in this particular compressor, unavoidable. The water jacket covered only three-fourths of the surface of cylinder, one-quarter being taken up by the air ports, another defect in construction. The working pressure varies from seventy-five pounds to eighty-five pounds, blowing off at eighty-five pounds. The compressor runs fifty-nine revolutions per minute, the valves being the ordinary poppet type.

In driving this machine a 30 H. P. General Electric induction motor is used, speed 900 R. P. M., voltage 550, the current being transformed from 10,000 volts in a separate building about 250 feet from compressor house, and measured on the low tension side by an integrating Schallenberger watt meter, 746 watts being considered the equivalent of a mechanical horse power. The current is transmitted from the Standard Electric Co.'s plant, near Jackson, Amador Co., Cal., a distance of 8 miles. The price per H. P. meter measure is $6.50 per month, which is the maximum rate, and which is reduced somewhat according to the amount of H. P. contracted for above a certain amount.

The compressor pumps directly to a small receiver—in this case too small by 500 cubic feet—the total storage being only about 100 cubic feet, allowing altogether too sudden flutuations in air pressure and not enough to carry all the air compressed during the small periods of idleness, of power drills and hoisting engine, without blowing off air.

This brings up an important point in compressor practice, that blowing off air is a large item of expense, is wasteful, and an apparent negligence of proper installation, but for some unaccountable reason is generally considered unavoidable in a compressor plant. Have plenty of storage and the right size compressor, and compressed air will be economical and not expensive, as is the opinion of most users of air compressors.

In this case the blow-off of the receiver is so arranged that it empties into the steam boiler, where it is reheated and used in hoisting engine, passing in just above the water line, through front end of boiler, as shown in the illustration herewith. When the power drills are not operating the lever is raised and all the air passes to the boiler for hoisting purposes. Attention is called to the sketch showing the general arrangement of plant; where possible to do so elbows are avoided and long sweeps are used, by bending the pipe—these bends being made very carefully to avoid any crushing of side of pipe.

Where pressure in receiver rises above seventy-five pounds it overcomes the weight and escapes through the 3-inch check valve; it passes out the side opening of 2½ inch tee, through which passes the stem shown in dotted lines and passes to steam boiler. A check valve shown in the photograph prevents the steam from backing out of boiler when air is below steam pressure—this arrangement makes the blow-off on steam boiler the blow-off of compressor.

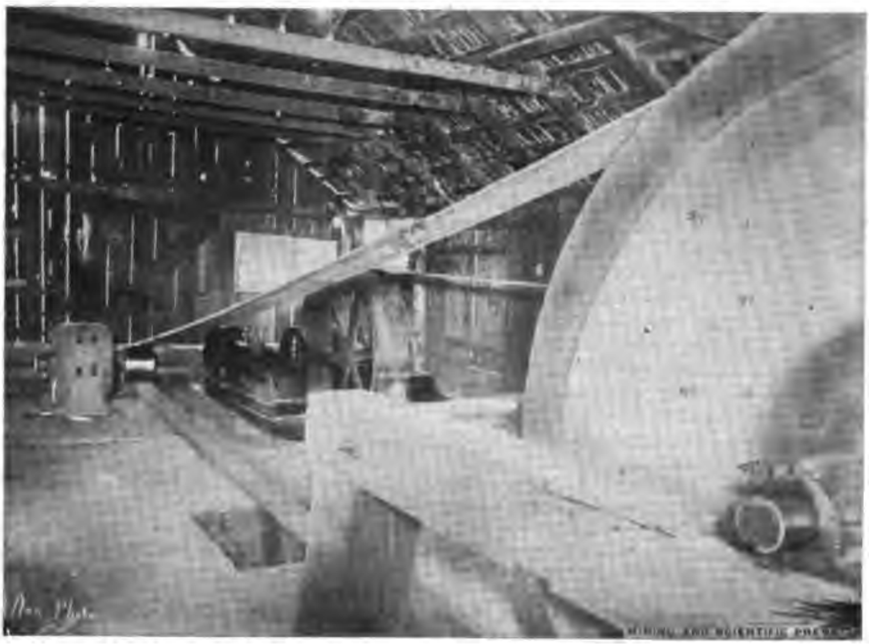
Air is used cold in the power drills, but in the engine it is reheated to about the temperature of steam at forty pounds pressure.

The average consumption of fuel used in combination with electricity for sixty days was:

Twenty H. P. per day at a cost of	$270.00
Wood burned in mean time, 37½ cords at $6	225.00
Total cost for power	$495.00

Under former conditions it required:

Two cords of pine wood per day 120 cords, at $6	$720.00
Water power for compressor (very favorable conditions) two months	350.00
Total by wood and water	$1,070.00
Tons of rock broken by power drills and hoisted 550 feet	2,667
Tons of water hoisted 600 feet	3,600



30 H. P. MOTOR AND 10X18-INCH DUPLEX COMPRESSOR, SPRING HILL MINE, AMADOR, CAL.

Under the present conditions should the power drills and hoisting engine be idle all at once for more than one minute the air blows off, due to lack of storage, which as soon as rectified should make a difference of at least ten cords of wood. Electricity at $6.50 per H. P. month is about 21 cents per horse power for twenty-four hours, consuming, as this plant does, about 20 H. P. per day, means $4.50 per day to produce enough air at eighty pounds pressure to operate two power drills (3¼-inch cylinders) and leave a surplus for hoisting engine sufficient to save the use of over one and one-quarter cord of wood per day. Had all the air pumped to eighty pounds been conserved by ample storage the use of less than one-half cord of wood would have been sufficient for all reheating purposes and supplying steam at times when air pressure was low.

Below is given the fuel cost of power by oil, where it will be noted that the cost per horse power for twenty-four hours is 38 cents; by electricity for twenty-four hours, 21 cents, at $6.50 per H. P. month: by wood, at $6 per cord, 53½ cents, as near as can be estimated. Very few mining

AIR PIPE FROM COMPRESSOR ENTERING BOILER, SPRING HILL MINE.

plants are equipped with as perfect a boiler plant as was the boiler plant used in gaining these results by oil:

FUEL COST OF POWER BY OIL.

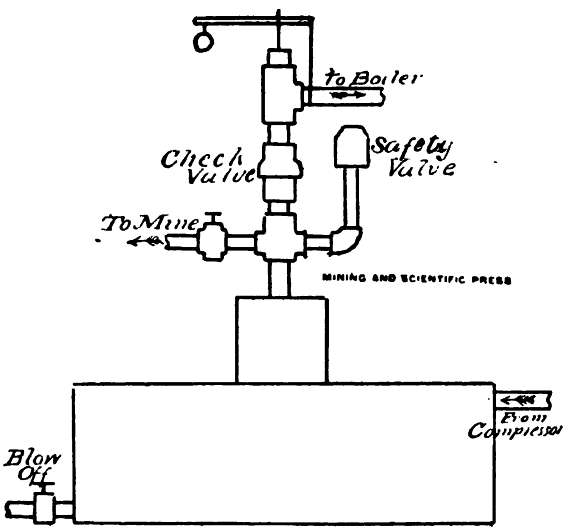
One barrel 16° oil=..........330 pounds
At $1.50 per barrel delivered=....$0.00455 per pound.
Heat units per pound=...........18,000
Heat units per pound of steam at 100 pounds, with feed water at 50° F. =........................1,167
Theoretical evaporation pounds of water per pound of oil =........ 15.4
Actual evaporation, assuming 65% efficiency for boilers, including steam required for vaporization, pumps, etc. =.................. 10.00
Allowing 35 pounds of steam per H. P. hour on engine, including feed pumps, etc., pounds of oil per H. P. hour, will =................. 3.5
Fuel cost per H. P. hour=$0.00455 ×3.5 pounds =................$0.0159
Fuel cost per H. P. hour for 24 hours =...................... .$0.38
Fuel cost per H. P. hour per month =..................... $11.40
Fuel cost per H. P. hour per year =.......................$136.80

The cost of reheating air in a steam boiler is very trivial; for every twenty-four pounds of good coal used in reheating compressed air at about eighty pounds pressure an additional horse power for twenty-four hours can be secured, whereas it requires under good conditions from 96 to 120 pounds of good coal to get one horse power for twenty-four hours from steam.

Two cords of good pine wood is generally taken as the equivalent of one ton of good coal, and fuel oil at $1.12½ per barrel is about the equivalent in heat production under a steam boiler to good coal at $5 per ton. The efficiency of an electric motor is from 85% to something above 90%, whereas from use of wood, coal or oil there is a tremendous loss of heat, in radiation and in heat going up the stack, so that probably 15% would represent about the efficiency of a steam plant.

For the guidance of those who may contemplate the use of air the following general directions will prove most satisfactory from a power standpoint as well as maintenance:

Get a compressor that does not require to be run above 200 feet of piston speed per minute.



Use a two-stage tandem straight-line machine when possible.

Have heavy flywheels.

Avoid countershafting, by using large flywheel.

Have the stroke at least double the diameter of cylinder.

Have long stroke machines rather than short ones.

Have storage that will require the compressor at least one-half hour to fill.

Have the compressor equipped with an unloader.

And above all, have a compressor as nearly equal to the work to be done as possible. The larger the compressor the more dead work, in friction. These may seem commonplace suggestions to a great many, but are the elements that, either considered or neglected, go to make a successful and satisfactory plant or a very unsuccessful and unsatisfactory one. As much intelligence and experience is required in the installation of a compressed air plant as in electrical or other power plant installations.—John B. Tregloan in *Mining and Scientific Press.*

Electrically Operated Air Compressors.

One of the remarkable developments in the recent history of engineering progress is the constantly increasing use of compressed air as a medium of performing many and varied industrial operations.

Pneumatic tools and other appliances for the utilization of compressed air have been introduced into one field after another with gratifying results and the advantage of using compressed air for a wide variety of other purposes is now fully recognized.

The present general use of electricity renders it advantageous in many instances to operate air compressors with electric motors. The convenience and economy of this method is apparent when it is remembered that an electrically driven compressor can be operated from any lighting, power or railway circuit that may be available.

To meet the constantly increasing demand for an electrically-driven, simple, compact air compressing unit, the Christensen Engineering Company, Milwaukee, are manufacturing a complete line of motor-driven compressors. The smaller sizes are made for portable as well as stationary service.

The type "M" motor-driven air compressor, illustrated herewith, is for stationary continuous service and is built in capacities from 50 to 1,000 cubic feet of free air per minute.

The electric motor and the compressor have been designed to form a compact, self-contained unit. The air is compressed in the cylinder, shown on the left, by a double-acting piston, which is operated by means of a connecting rod and steel crank shaft. The latter is mounted in bearings located within the frame of the machine. This shaft carries on the motor end a helical gear, which is driven by a pinion on the armature shaft of the motor. The entire machine is mounted on a substantial cast iron base.

Both the cylinder and the valve heads are water jacketed throughout. The clearance spaces have been reduced to the lowest practicable limit, thereby correspondingly increasing the economy.

The suction and discharge valves are arranged in cast iron heads bolted directly to the cylinder. They consist of seamless, cold-drawn steel cups, so arranged that each is removable independent of the other. No springs are used with these valves. They are operated by the compressed air itself and are reseated by gravity. The peculiar construction of these valves renders a small lift possible, hence the noise from their operation is reduced to a minimum. The suction and discharge valves are identical and interchangeable. Only one connection is necessary when piping from the compressing cylinder to the reservoir.

The piston is provided with an improved form of packing rings. The piston rod is of steel, carefully ground true on dead centres. The rod passes through a self-adjusting metallic packing box.

The connecting rod is composed of steel and is arranged to receive oil for lubricating the crank pin, wrist pin and piston. The crosshead is provided with adjustable shoes of extra large area and with an accurately ground hardened tool steel wrist pin which fits into a phosphor bronze bearing in the rod.

The crank shaft is composed of a high grade steel, and is provided with extra large bearings, thus avoiding the frequent adjustment of the bearing boxes which is usually necessary with bearings of ordinary size. The shaft is carefully balanced and accurately turned true to receive the connecting rod.

The crank shaft is extended at the motor end to carry the gear, which is driven by a pinion on the armature shaft of the motor. The gear and pinion are of the helical herring-bone type, with teeth cut by special machinery in the most perfect manner, thereby reducing the noise.

The gear case and the crank chamber are connected and form an enclosure which is partly filled with oil, with which all the working parts are automatically and continuously lubricated, including the air cylinder. The latter is connected with the oil chamber, so that the proper quantity of oil for lubricating the surface between the cylinder and the piston is automatically supplied and no sight feed lubricator is required. The motion of the crank shaft in the oil causes continuous lubrication of the main bearings, the crank pin bearing of the connecting rod, the cross-head guide, the piston rod, the wrist pin in the cross-head and the piston. Oil is also supplied automatically to the bearings at the pinion end of the motor. The gear and pinion operate continuously in the oil bath. The machine will remain lubricated as long as the oil is kept up to a level determined by a filling plug on the side of the crank chamber. Experience has shown that, after being supplied with oil, the compressor runs for several weeks before replenishing is necessary.

Either an alternating or a continuous current motor may be used. The illustrations herewith show the continuous current multipolar type. The lower frame of the motor is of cast iron and the field is composed of low carbon cast steel with detachable steel pole pieces. The motors are series wound and are started and stopped without using resistance of any kind. The armature is of the latest ventilated type, built up of discs of soft steel and slotted to receive the winding. Machine formed armature coils are used; the insulation and other materials are of the highest grade obtainable. The commutator is built up of hard-drawn bars of the best lake copper, insulated from each other by segments of mica. The armature shaft revolves in extra long bronze bearings with ring oiling arrangement. The bearings are so designed that it is impossible for oil to get into the armature.

TYPE "M" CHRISTENSEN MOTOR-DRIVEN COMPRESSOR.

The brush holder is of the simplest possible construction. It is provided with an instantaneous tension adjuster, arranged so that the tension can be increased while the motor is running.

The design of the motor and compressor is such that every part is easily and quickly accessible.

By unscrewing a few bolts the armature

and the field coils can be removed or exchanged. The gear, pinion, valves or cylinder heads may also be removed without disturbing any other parts.

Access to the cross-head and wrist pin is obtained by doors conveniently arranged on the side of the slide frame. The crank chamber is constructed so that it is completely closed, but the upper part may be quickly removed, giving free access to all the working parts, while a smaller hand-hole covering is provided and may be easily removed for inspection of the interior.

An automatic governor starts and stops the motor at the desired minimum and maximum air pressures. This is a very simple piece of apparatus, consisting of an ordinary pressure gauge mechanism with a special hand which, upon coming in contact with a conducting stud at the position of minimum pressure, allows current to flow through a magnet coil. This coil operates a plunger, to which the contact pieces for the motor circuit are attached, thereby closing the circuit and starting the motor.

As soon as the pressure reaches the desired maximum the hand strikes another stud and current passes through a second solenoid magnet, thereby pulling the plunger in the opposite direction and opening the motor circuit. By this mechanism it is possible to get a close margin between maximum and minimum pressures. This margin is readily adjusted by moving the contact studs.

A smaller compressor for stationary continuous service is built in capacities from 4 to 35 cubic feet of free air per minute.

These are known as type "L" and they are similar in design and construction to type "M," described above. The motor is mounted directly over the compressor instead of on the side. The compressor has two cylinders, which are water jacketed throughout. Each cylinder is provided with a single-acting plunger piston, which is operated by a connecting rod from a well-balanced steel crank shaft. The shaft is extended at one end to carry a helical gear, which is driven by a pinion on the armature shaft of the motor directly above. The base of the motor forms a cover for the compressor frame and the gears are also enclosed in a suitable casing. The interior of the compressor is, therefore, completely enclosed and protected from injury. This compressor is a modification of the type "H"; the water jacketing feature being added to make it suitable for continuous service.

GOVERNOR FOR TYPE "M" COMPRESSOR.

The suction and discharge valves are of seamless, cold-drawn steel. They are conveniently arranged in the cylinder back cover so that each is independent of the other and separately accessible.

The illustration of the type "L" herewith show the current type for use with air-brake equipments on electric cars. They are four-pole, series-wound motors, with two field coils, with cast steel frames.

For portable service the type "H" compressor, with the automatic governor and air reservoir, is mounted on a suitable hand truck, which can be easily and quickly moved wherever necessary. This portable outfit, known as type "I", finds a field of usefulness wherever pneumatic tools or other compressed air appliances are used and an expensive system of piping is not desirable. The compressor is taken to the work instead of transmitting the compressed air from a stationary compressor at a distance.

TYPE "I" PORTABLE COMPRESSOR.

These compressors are frequently mounted on a wagon instead of a hand truck and transported by horses for use in drilling and bonding rails, etc., in electric railway or other work where electric power can be obtained. It is only necessary to make a connection to the trolley wire by a hook or pole for the purpose of obtaining power for the motor.

TYPE "L" CHRISTENSEN COMPRESSOR.

For this information and the illustrations shown we are indebted to the Christensen Engineering Co., Milwaukee.

Types of Foreign Air Compressors.

AIR-COMPRESSING PLANT BY SCHNEIDER & CIE., LE CREUSOT, FRANCE.

In fixing upon a type of compressor the Creusot engineers decided to adopt a form admitting of the immediate and fullest possible contact of the air with cooling water by direct injection of the latter into the compressing cylinder. Although they consider this method of cooling the most simple and the most economical for large productions, it has not (observed M. Burdy, head draughtsman at the Creusot works, to the Société de l'Industrie) succeeded, as hitherto applied, in preventing an appreciable elevation in temperature of the air during its compression. The useful effect of the injection depends upon the temperature and weight of the water injected during the compression, on the state of subdivision of the water and on the position occupied by the spraying nozzles. The weight of water to be injected per piston stroke, always greater than that theoretically necessary, should not be simply proportioned to the weight of compressed air; but it ought to increase with the speed of the compressors in a proportion which experimental investigations can alone determine. The air and water between which the exchange of heat is to be effected are two bad conductors, and in this particular case of heat exchange sufficient account has not yet been taken of one important factor, viz.: time.

In an ordinary compressor, making only about 60 revolutions per minute, the period of compression does not greatly exceed a quarter of a second, and it is during this very short space of time that the heat exchange between the air and water must be made. The shorter the time the greater must be the weight of water in excess, the degree of subdivision in this water, and consequently the multiplicity of points of contact; and, to avoid, in certain cases, an excessive weight of injection water, it was found well to restrict the duration of this injection to the actual period of compression. A sufficient subdivision of the water escaping from injection nozzles is obtained in several ways. The trials made at the Creusot works, when the new compressing plant for the Blanzy Colliery was being gotten out, showed that the degree of subdivision might vary considerably for slight differences of construction and proportions of the nozzles; and in the arrangement adopted as the result of those trials the subdivision of the water is entirely effected by the shock of the water jets, which meet one another on escaping from a double ring of small orifices.

Fig. 1 of the accompanying illustrations gives a transverse section of the Blanzy Plant, showing the air and steam the steam cylinders, and compressing in stages with intermediate cooling receiver. The compressors are provided with Corliss inlet and delivery valves, with water injection by three nozzles arranged on each cover, with water circulation round the jackets and with air receivers for intake and compression.

The air-pumps of the condensers, the feed-pumps of the boilers, the injection and circulation pumps of the compressors with the drain-pumps for the steam pipes and intermediate reheaters have been separated from the main engines and are driven in a group by a special motor, in order to ensure the uninterrupted working of the engines bv freeing them from what constitutes a frequent cause of stop-

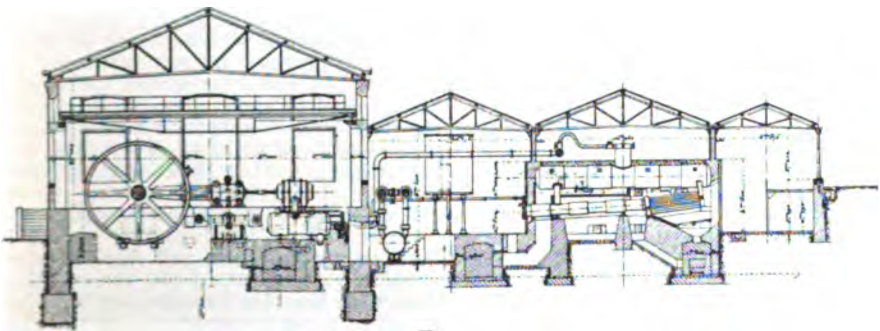


FIG. 1.

SECTION OF BLANZY AIR COMPRESSING PLANT.

cylinders and also the boilers. The feed-pumps for injecting the cooling-down water are driven by a special engine, the speed of which can vary within large limits; but this arrangement, the only one which permits of properly regulating the volume delivered by the nozzles, is only applicable to large plants. The degree of subdivision in the water depends not only on the type of nozzle adopted, but also upon the excess of water pressure over that of the air. This 3,000 H. P. plant is divided into six 500-horse groups, each consisting of a horizontal Corliss steam engine, with high and low pressure cylinders and intermediate reheater, the pistons working on to the same shaft, and driving an air-compressor, with two cylinders arranged tandem-fashion behind page. Every precaution is taken for ensuring that the stoppage of any one pump of the auxiliary group, or even the complete stoppage of that group, shall not interfere with the working of the air-compressing engines; and the various pipes, especially the steam pipes, were designed to avoid a simultaneous stoppage of all the engines, whatever breakdown may occur.

The air drawn in is freed from its dust, moistened and cooled before entering the cylinders, by being made to pass through a special charcoal filter and a decantation chamber. The injection and circulation water for the compressors is freed from suspended impurities by large sponge filters; and these filters, together with the MacNicol boilers, the pipes and receivers—the whole plant, in fact—were made at the Creusot works. The following are the leading dimensions and particulars:

Diameter of small steam cylinders, 65 cm. = 26 in.

Diameter of large steam cylinders, 1m. = 40 in.

Diameter of large air cylinders, 90 cm. = 35 in.

Diameter of small air cylinders, 56 cm. = 22 in.

Common stroke, 1.25 m. = 4 ft.

Normal number of revolutions per minute, 60.

Pressure of compressed air, 6 kg. per sq. cm. = 85 lb. per sq. in.

Initial steam pressure on small pistons, 7 kg. per sq. cm. = 99 lb. per sq. in.

Boiler pressure, 8 kg. per sq. cm. = 113 lb. per sq. in.

The plant was started in August, 1892, and has worked ever since without stoppage and without giving rise to any incident. The obligation of starting the compressors directly they were erected and of avoiding any interruption in their working has prevented the carrying out of intended tests, but observations made during an uninterrupted period of 96 hours about a year after the plant was brought into operation, furnished information which is interesting because it bore upon the current working of the compressors that was then defective. This was due to insufficient vacuum in the condensers, the auxiliary engine working without expansion and one of the intermediate reheaters not having been brought into use; but, notwithstanding these disadvantages, the following satisfactory results were found to have been attained: Ratio between Ind. H. P. on the compressor pistons and the Ind. H. P. on the steam pistons, 0.843; ratio between the power stored up in the compressed-air receivers and the work given out on the steam pistons, 0.79, and volumetric yield of the compressors, 0.92.

CREUSOT 3-STAGE AIR-COMPRESSOR.

An improved type of compressor is that made by MM. Schneider et Cie, for compressing air to 50 atmospheres (735 lbs. per sq. in.) in three double-acting cylinders marked D, E and G on the accompanying plan—Fig. 2. The motor is a

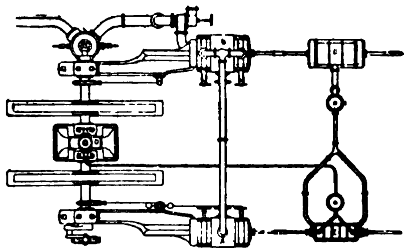


FIG. 2.—THREE STAGE COMPRESSOR FOR 735 LBS. PRESSURE.

horizontal Corliss compound condensing engine with two steam-jacketed cylinders, A and B, and an intermediate receiver. The speed, which is 72 revolutions per minute in normal working, may be made to vary from 54 to 90 revolutions. The low-pressure and intermediate air cylinders, D and E, are arranged in line with tne steam cylinders, but the high-pressure compressing cylinder, G, is vertical, its piston being worked by a crank off the fly-wheel shaft. Between two successive cylinders there is an intermediate receiver I or J, in which the air is cooled by a stream of water, and there is also water circulation round the three cylinders, with injection into the first two, by means of a pump connected with the air-pump of the condenser.

The low-pressure cylinder, of which a vertical section and an end view are shown by Fig. 3, has two jackets, the

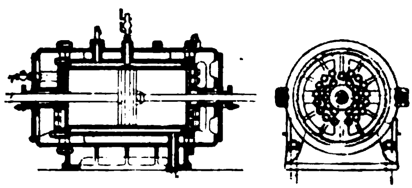


FIG. 3.—SECTION OF LOW PRESSURE CYLINDER OF COMPRESSOR SHOWN IN FIG. 2.

inner one serving for water circulation and the outer (extending also over the covers) constituting the air-receiver, while each cover contains the seats of 13 inlet and 13 delivery Corliss valves. The valves, of which details are also added,

Fig. 4. consist of flat discs of phosphor bronze, 6 cm. ($2\frac{1}{2}$ in.) in diameter and of about 1 mm. (say 1-16th in.) thick. Each disc is kept down upon its seat by a brass

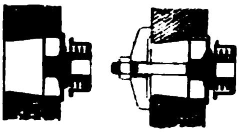


FIG. 4.—SECTION OF VALVES OF CYLINDER SHOWN IN FIG. 3.

spiral spring, made of flat bar, so elastic that it yields to the slightest pressure. By this arrangement the loss of load and re-entrance of air, unavoidable with self-acting valves, are almost entirely suppressed, and the great number of valves affords a large sectional area of opening for the air's passage, being at least 18 per cent. of the piston area both for inlet and delivery.

The two packing rings of the low-pressure piston are made of gun-metal, and the three rings each of the other pistons are of ebonite. The vertical position of the high-pressure air cylinder possesses certain advantages. Water collects in the lower portion of a horizontal cylinder, while the piston also presses on the same place, causing considerable wear and leading to the necessity of reboring; and the leakage of air due to the ovalization of the cylinder is a function of the difference in pressure on the two piston faces. For the low-pressure air-cylinder this difference is only 3.5 atmospheres (51 lbs. per sq. in); but it exceeds 40 atmospheres (588 lbs. per sq. in.) in the high-pressure cylinder. With a vertical position of the latter the water introduced with the air covers the whole surface of the piston and forms a tight joint, which opposes leakage, at any rate in one direction.

HANARTE AIR COMPRESSOR.

After many trials with dry compressors the engineer of the Mont-Cenis Tunnel, M. Sommeiller, adopted the hydraulic piston compressor for carrying out his great work, and devised a form called after him the Sommeiller, this consisting of two cylindrical vessels connected together by a horizontal cylinder, in which moves a piston entirely surrounded by water, this piston raising and lowering in the columns a body of water for drawing in and compressing the air. Tests at Mont-Cenis and at the Saint-Gothard showed that this appliance was capable of giving out as much as 95 per cent. of useful effect, provided the speed did not exceed 14 revolutions per minute, corresponding with a piston speed of about 2 ft. per second; but, if this was exceeded, the means for cooling became insufficient, and the speed communicated to the water by the compressing piston caused shocks, owing to which regular compression was not effected.

By giving a rational form to the compression columns M. Gustave Hanarte, Ingenieur Civil des Mines, of Mons, Belgium, has transformed this hydraulic-piston compressor, making it work at three times the speed, and increasing its useful effect by rendering more complete the means for cooling down the compressed air.

With reference to Fig. 5 of the accompanying illustrations, partly in vertical sec-

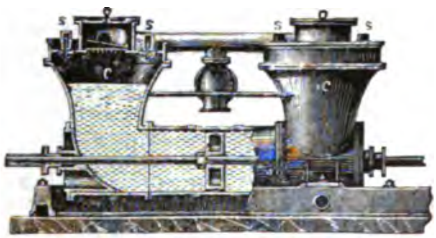


FIG. 5.—SECTIONAL VIEW OF HANARTE WATER COMPRESSOR.

tion and partly in elevation, the air is compressed by water volumes of increasing sectional area in the splayed-out columns, c c, which permit the water impelled by the piston to gradually slacken speed until it reaches the delivery valves. At each stroke a slight quantity of water is expelled with the air, and there enters by the inlet valves, s s, seated in the cover above, a corresponding quantity of cold water led up by a pipe.

The pressure, p, exerted on the piston, of area M, moving at a speed of v per second, produces a mechanical work, p M v, which is transmitted to the area n M, due to the splaying out, while being transformed into $p\ n\ M\ \frac{v}{n}$. Accordingly, the air and water reach the delivery valves at a reduced speed equal to $\frac{v}{n}$, resulting from the ratio (n) which exists between the piston area and the upper sectional area of the splayed-out column. Thanks to this arrangement, shocks and a sudden starting of the water due to acquired speed are entirely avoided; and the compressor can run at a considerable speed, provided that the splaying-out be in accordance with a rigorously parabolic curve, which alone can permit the water to pass without disturbance from the speed v to that of $\frac{v}{n}$. For the same reasons the drawing in of the air is also favored by the descending body of water.

It is well known that, when air is compressed to the effective pressures of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 atmospheres, if there be no cooling down, this air will attain the respective temperatures of 85, 130, 165, 195, 220, 242, 263, 281 and 298 degrees Centigrade; but, if this heat be abstracted as it is given out, the air compression will be effected, according to Mariotte's law, with a minimum of mechanical work and consequently a maximum of useful effect, which is obtained almost in its entirety by the parabolic columns of compression. In fact, the bodies of water which compress the air in rising, become renewed and extended, so as to take off the heat proportionately to the law according to which it is produced.

For large air-compressing plants the Hanarte compressor assumes the form shown by Fig. 6; and such compressors

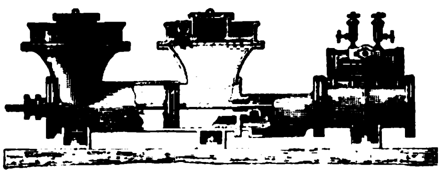


FIG. 6.—IMPROVED HANARTE WATER COMPRESSOR.

have been erected at a great many collieries in France and Belgium, while tests carried out on several of them have shown that this method of cooling the compressed air is so efficacious as to dispense with the use of water-sprayers, which, however, can be added if desired.

Indicator diagrams taken on the steam and air cylinders at the Dourges Colliery, in France, and that of the Bois-du-Luc, in Belgium, with a piston stroke of one metre (3 ft. 3⅜ in.), from 27 to 40 revolutions per minute, boiler pressures of 3 atmospheres (29 lbs. per sq. in.), and the same pressure of the compressed air, have shown that the mechanical yield of the compressor was 96.8 per cent. and the useful effect of the whole plant 87 per cent. Besides its use for mines, this compressor is also employed in public works, for producing a vacuum or for compressing gases; and in its application to the artificial production of ice or cold air with ammonia or carbonic anhydride, oil is substituted for water in the compression columns.

In addition to the advantages due to the splayed-out form given to the compression columns, the Hanarte air-compressor contains several improvements which contribute to its efficient working. The compression water encounters no obstacle in its movement, because all the spring-weighted valves are seated in the cover above, which valves move vertically with great regularity; the valve seats may be taken out without breaking a joint; and, lastly, the cylinder is independent of the columns, so that it can be renewed separately, while the bolt-holes are divided so correctly that a quarter turn may be given to the cylinder from time to time, so as to prevent its wearing oval.

BURCKHARDT & WEISS' AIR-COMPRESSOR.

These constructors, of Bale, Switzerland, have substituted for the automatic suction and delivery valves a slide-valve, worked by eccentric and sheave, as in the usual steam engine; but the air follows, in the ports, a path the reverse that of the steam, and the eccentric is keyed 90 degs. behind the crank.

If an ordinary slide-valve were employed the piston would, directly compression begins, be subjected to the whole pressure of the receiver, which would greatly increase the work of compression at the expense of the useful effect. The difficulty, however, is obviated by using a slide-valve of Meyer type with special passages for the delivery, leading to a single orifice at the back of the slide-valve. This orifice is closed by a retaining valve formed by a large plate, P—, see accompanying section Fig. 7, guided by the pin, Q. and kept down upon its seat by a spiral spring, only rising when the pressure on the compressing face of the piston exceeds that in the receiver.

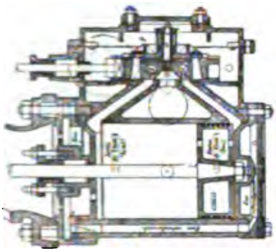


FIG. 7.—SECTION OF AIR-COMPRESSOR WITH MEYER SLIDE VALVE.

The influence of the dead space is largely overcome by the presence of a compensation passage, O O, entirely formed in the body of the slide-valve during the operation of casting, thus putting the two sides of the cylinder in communication when the slide-valve is at its mid position and the crank on the centre point. Consequently, after each stroke, the compressed air contained in the dead space passes behind the piston and is compressed with that which has just been drawn in, while on the opposite side the tension of the air falls to that of atmospheric pressure from the beginning of the stroke, and the air may be drawn in at once.

In order to avoid the escape that would occur if the full parts of the slide-valve had exactly the same width as the ports, slight overlaps are admitted, both upon the inside and outside, of a width slightly greater than that of the compensation passage; and they are also equal, so that the admission and delivery orifices open and close simultaneously and are always uncovered to the same extent. In order to obtain a maximum production of compressed air it is advisable to only close the delivery passage just at the end of the piston stroke, which, moreover, about coincides with the closing of the inlet passage, so that the eccentric should be keyed a little more than 90 degrees behind the crank. This consideration, however, is not imperative; and account must also be taken of balancing the parts in motion and the reactions exerted on the various organs. It is thus that, with the tandem arrangement, it is advisable to diminish the angle of keying between crank and eccentric, to allow the air compensation to begin a little before the end of the stroke.

The annexed diagram represents distribution by a slide-valve of this kind, and above is shown the hypothetical indicator diagram of the progress of the pressures on one face of the piston. If e be the outside overlap equal to i, the inside overlap, a, the width of the ports, m a small quantity, that may be reduced to zero, which the slide-valve travels more than is required by the width of the passage, and p the eccentricity,

$$p = a + e + m.$$

The angle for keying the eccentric (90 degrees + δ) is determined in such a manner that the closing of the passages be effected just at the end of each stroke. The principal positions of the piston are indicated by the Nos. 1, 2, 3 ,4 and 5 in Fig. 8. Between 1 and 2 the compensation of pressure takes place; from 2 to 3 the inlet and outlet passages open; from 3 to 4 they are entirely open, and from 4 to 5 they are again closed. These passages, therefore, remain fully open during the greater portion of the stroke, which considerably reduces throttling both during inlet and delivery.

The lubrication of dry compressors running at great speed requires special care; and it is insured in the Burckhardt com-

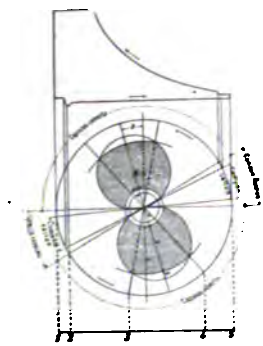


FIG. 8.—DIAGRAM SHOWING POSITIONS OF PISTON.

pressor by automatic lubricators, regulated by a cock terminating in a point and put in communication with the internal atmosphere of the cylinder. The few air-bubbles which penetrate therein during compression drive out the oil during the period of intake.

The mean speed of the air in the distribution passages does not exceed 30 M. (98 ft.). The guaranteed volumetric yield, which amounts to 90 per cent., whatever be the pressure, frequently attains 94 to 95 per cent. The number of revolutions, which varies with the size of the compressor and may attain 200 per minute for those of small size, is generally determined by giving the piston a speed of 1.8 M. (nearly 6 ft.) per second, but not exceeding 2 M. (6 ft. 6¾ in.).

The disadvantage of this compressor (observed M. H. Kuss and M. L. Fevre, in their treatise on mine working) is the heating of the air, which is considerable, while the dynamic yield is not very good. In addition to this the oil is volatilized by the heat; and there is a risk of deficient lubrication of the rubbing parts, so that the slide-valve may set fast. Spontaneous explosions have even occurred, owing to the formation of a detonating mixture by the vapors of the mineral oil employed for lubrication.

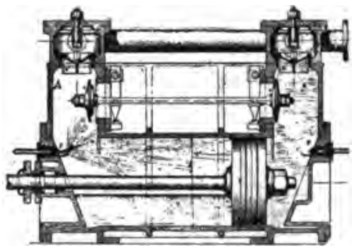


FIG. 9.—WATER COMPRESSOR WITH INJECTION COOLING.

DUBOIS-FRANÇOIS AIR-COMPRESSOR.

In order to obtain an increased speed of running, inventors of wet compressors were led to reduce the quantity of cooling water put in motion by the piston, while at the same time raising to its maximum the cooling effect of the water by injecting it in a finely divided state. The water could, however, still fill the dead space at the end of each stroke and cover the delivery valves, if suitably arranged, so as to prevent the re-entry of air; but it cannot cover the piston nor prevent leakage at the circumference, except at the dead point, unless the cylinder be vertical and single-acting. In any case the dead space must be far smaller than in the water-column arrangement.

In this connection the Dubois-François compressors marked an interesting series of steps in advance. The earliest type, shown by Fig. 9, the columns A and B terminating in the delivery valves S′ S′, are well defined. The inlet valves, S S, are rigidly connected together by a rod resting on knife edges or oscillating sectors, which insure the necessary mobility, with the object of diminishing the time of closing at the dead point. The water, brought up by pipes of 1½ mm. (1 1-16 in.) diameter, is injected by nozzles, P P; and just in front of them are curved projections, C C, against which the jet is converted into spray.

In a later type, a section of which is shown by Fig. 10, the vertical water columns are very much reduced, so as in reality to only constitute valve chambers. The rod connecting the inlet valves is made telescopic, so as the yield under the action of a spiral spring, the tension of which may be regulated so as to insure an instantaneous closing of the valves. The closing of the delivery valves is accelerated by the action of a small piston surmounting them, and the top of which is constantly subjected to the pressure of the compressed air, led up by a small copper pipe communicating with the delivery passages of the compressor. The delivery valves are of gun-metal, and the inlet valves of leather with wrought iron fittings, while the piston packing consists of gun-metal rings, lubricated by soapy water mixed with the water injected.

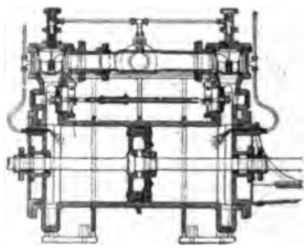


FIG. 10.—A LATER TYPE OF COMPRESSOR SHOWN IN FIG. 9.

In the latest type of François compressor, shown by Fig. 11, the vertical columns are reduced to their simplest expression, and the dead space to what is only just necessary for the play of the valves. Each inlet valve is fitted with a spiral spring, J, worked by a system of very light rods and

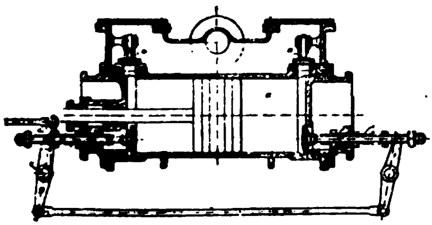


FIG. 11.—A RECENT TYPE OF WATER COMPRESSOR.

levers from a prolongation of the slide-valve rod of the steam cylinder, for hastening and maintaining the closure of the valves; but their action is interrupted during the whole period of intake, so that the valves are free to open completely at the first suction effect of the piston, and in this manner the sharp beat of the valves that occurred during this period of the stroke with the arrangement shown by Fig. 10 has been entirely avoided.

At the same time all injection of water has been suppressed; and a return has been made to its free introduction by the inlet valves, the quantity introduced not exceeding 2 litres per cu. m. (0.1 pint per cu. ft.) of the volume given by the compressing piston, and this abandonment of injection with spraying is due to the relative inefficiency of that system at the high speed of 60 revolutions per second normally, or 80 at the outside.—*J. Walter Pearse.*

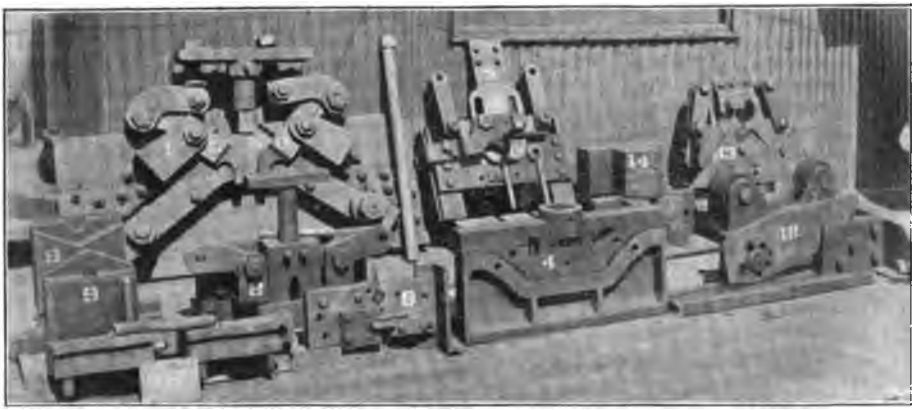
Pneumatic Bulldozer, Pittsburg & Lake Erie Shops.

The subject of the illustrations herewith presented is a 70-ton pneumatic bulldozer in use in the blacksmithing department at the McKees Rocks shops of the Pittsburg and Lake Erie, the machine and tools used in connection therewith having been designed by Mr. A. W. McCaslin, foreman blacksmith. The employment of machines of this order has a marked effect in the reduction of the cost of forgings, as well as in an improvement in the quality of the work produced. Moreover, this machine largely increases the daily output, thereby not only increasing the capacity of the smith shop alone, but facilitating the work passing through the several shops where the amount of work turned out is contingent upon the dispatch with which it is received from the smith shop. The introduction of improved methods in this department and the consequent reduction in the cost of production serves to bring to notice the importance of employing skilled mechanics. The best results are to be obtained from the introduction of bulldozers and like machines, but the utility of these depends entirely upon the design of the tools and formers to be used in connection therewith, and the skill with which they are manipulated. The comparative efficiency of the shop is thus dependent to a large extent upon the mechanical qualifications of the practical smith.

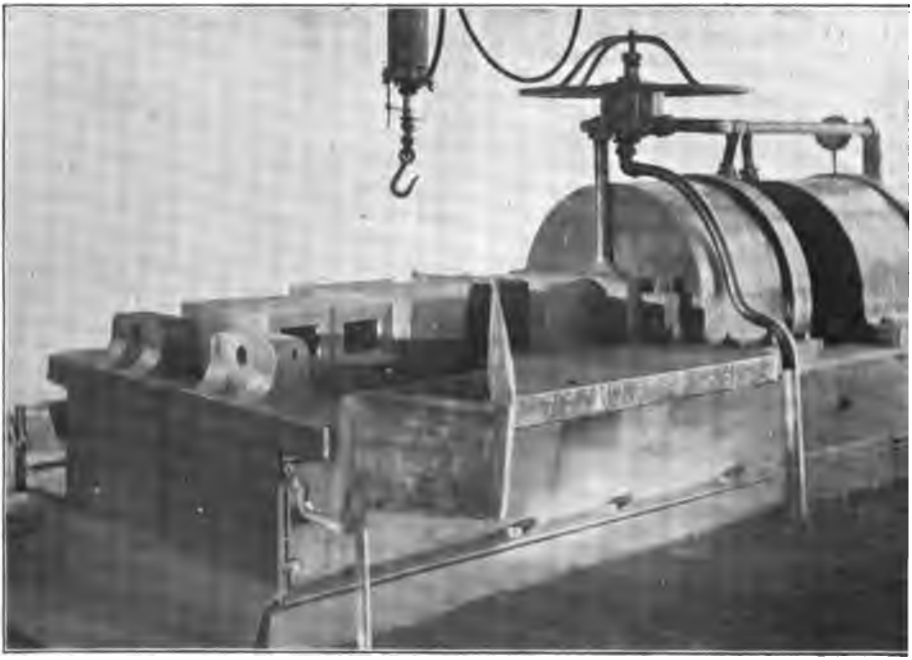
This machine is particularly well adapted to turning out standard shapes of heavy material in large quantities, and it is considered at the shop in question to be preferable to the ordinary bulldozer of the same power for the reason that the stroke can be regulated at the option of the operator and work can be turned out more expeditiously. It is an improved design of a similar machine of much smaller capacity brought out by Mr. McCaslin some two years ago.

The general view of the bulldozer and the formers is shown in the accompanying engravings. The several parts are numbered in the latter engraving for convenient reference. Referring to the general view, the machine consists of two 30-inch cylinders, which are attached to a frame made up of two 16-inch I-beams, the face plate being secured to the top of the beams at the front of the cylinders. The cylinders are placed tandem, and by this arrangement the full power of both cylinders can be concentrated at one point, while the arrangement is such that the pressure from one cylinder can be used independently of the other to economize in the use of air when operating on light work. One hundred pounds pressure in the reservoir will produce a working pressure of 70 tons.

This machine will upset 5-inch square iron when properly heated. No. 1 shows



FORMERS FOR PNEUMATIC BULLDOZER—PITTSBURG AND LAKE ERIE.



PNEUMATIC BULLDOZER—PITTSBURG AND LAKE ERIE.

a tool for heading large bolts, kingpins, collar ends of roller bars, gibs on drawhead pockets, etc.; "OO" are the eccentrics and hooks combined. The eccentrics close the die arms, and when the pressure is released the hooks connect with pins in the arms and open them. The die arms being on an angle, back stops are not necessary, for the greater the pressure the tighter the work is held in place. No. 2 is another style of eccentric tool for heading drawhead rods and bolts of all kinds. The same tool, by changing dies, is used for punching key-ways in kingpins, drawhead bolts, and the like. No. 3 shows a former for bending either the hook or the eye on 1-inch brakebeam hangers. No. 4 is a tool for bending drawhead carriers. No. 9 in the rear and No. 9 in the front show two halves of a tool for forming trainpipe clamps or hangers, one movement making both pieces, the angle and clamp. No. 14, resting on the top, is a "V" tool with two different angles for forming brake carriers from 2-inch and 1-inch iron, one bent edgeways and the other bent flatwise with the iron. No. 12 is a pair of shears for shearing off round iron from 1/2 to 1 1/4 inches diameter. No. 7 is a tool used for bending drawhead pockets, and by changing the rollers, to larger or smaller diameter, this tool can be used for many other purposes, such as bending rod straps, spring saddles, etc. Various other formers are in use for bending archbars 4 1/2 by 1 1/2 inch material; engine truck equalizers 4 1/2 by 1 inch; main and side rod straps, coach truck equalizers, drawhead pockets, guard rails, etc. One movement of the machine is sufficient to produce two bends of 90 degrees in tank frame transoms of 8 by 1 inch.

The list herewith given of some of the work that can be done with the machine will afford some idea of its effectiveness. However, a complete list would cover nearly all the wrought-iron parts of locomotives, coaches, and cars that require upsetting, offsetting or bending.—*The Railway Age.*

Cleaning Steel Structures Before Painting.*

Before any paint or other coating of any kind is permitted to be applied to the iron or steel of a bridge or viaduct, all the scale, rust, dirt, grease and other foreign substances, as well as the dead paint, should be removed from its surface, so that the coating may come into intimate contact with a clean surface of metal, and thus give the best condition for firm adhesion of the coating to the metal. No one who has had any experience with such work will dispute this proposition, and yet all over the country bridges are constantly being painted with very slight attempt to secure a clean surface for the paint. The cost of cleaning, and, in the case of new work, the delay in getting the material into the field for erection, are the cause of much of the poor work done in this matter.

The sand blast has been given sufficient trial to make it reasonable to say that such cleaning as is necessary on new work at the shops—that is, removal of mill scale and some rust and grease—can be done at about 1/2 cent. per square foot of steel surface cleaned, and possibly a little less. This is reported to have been the cost of cleaning such steel plates at the United States Navy Yard at Brooklyn, N. Y., with a moderately perfect permanent plant. Hence it is reasonable to expect that with more experience and an improved permanent plant such work can without doubt be done at this cost or perhaps a little less. On the basis of 1/2-cent per square foot, the cost per ton for cleaning steel plates would be: For plates 1 inch thick, 49 cents.; for plates 1/2 inch thick, 98 cents, and for plates 1/4 inch thick, $1.96. For shapes: For 7-inch I-beams, weighing 17.5 lbs. per foot, the cost would be $1.35 per ton; 12-inch I-beams, weighing 50 lbs. per ft., would cost about 80 cts. per ton, while heavier sections would cost less and lighter sections more. The average cost for cleaning most plate girder bridges would probably be about $1 per ton. The cost for a truss bridge might vary from $1 per ton for heavy bridges to $1.75 per ton for light bridges. These figures are based on what has been done in only a few places, but upon actual work, and it may be reasonably expected that they are not too high.

As soon as cleaning of this sort shall be required of the bridge shops, and when paint of good, lasting, protective qualities shall be properly prepared, and first coat applied to the metal so cleaned immediately after being cleaned, under proper

*Abstract of a paper by George W. Lilly before the Engineers' Club, of Columbus, O., Feb. 1, 1902.

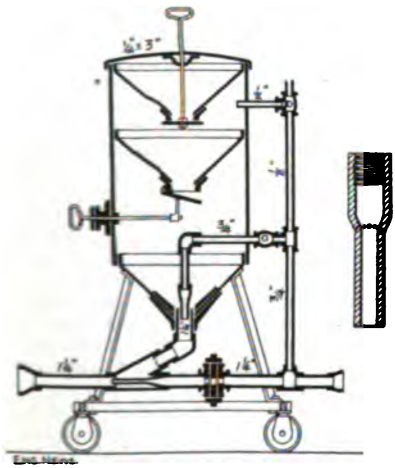
conditions of weather, it will be possible to maintain our bridges without the necessity of again cleaning with the sand blast for a long period of time. It would be necessary to have such bridges inspected occasionally and when they need repainting but before the paint shall be worn off, or so far destroyed as to seriously affect the metal beneath, a new coat of paint should be applied after a thorough cleaning with scrapers, wire brushes and other tools, such as may be required. We may not hope to see this accomplished before the purchasers of bridges shall require it, because the desire to make good profits will prevent the bridge manufacturing companies from adopting it. It is to be hoped that railroad companies, municipalities, counties and others requiring such structures to be erected will at no very distant day adopt such requirement.

Mr. L. L. Buck, Engineer for the New East River Bridge, specified sand blast cleaning for that structure, and the same should be done for all important bridges and viaducts. For such structures as are exposed to gases from the combustion of coal this is especially desirable. Of course when this is done the additional cost must be paid, but it will no doubt be a saving because of the longer life of the paint, less frequent repainting and longer life of the structures.

The more serious question arises as to the structures heretofore erected, a large majority of which are being rapidly destroyed by rust and corrosion. The viaducts over railroad tracks are more affected than bridges in other locations, on account of the severe trial to which they are subjected. The same is true of trusses and all steel work of train sheds and shops, and to a somewhat less degree as to through railroad bridges. Many of such viaducts and other structures, after standing not to exceed eight or ten years, are found to be in a deplorable condition, although in many cases cleaned by hand and repainted from one to three times. Upon such structures scale will often be found as thick as the original metal, with distinct layers of paint and scales and in many cases with the paint still in fair condition upon the scale. The rust has worked under the paint perhaps as much as through it. For such structures the best hand cleaning is of little effect. After using scrapers, chisels and other kinds of edge tools, loosening scales as far as possible by jarring produced by blows of hammers, then thoroughly brushing with steel brushes, followed by whisk brooms or stiff bristle brushes, much rust and scale very closely adhering to the metal still remains, and very often when the first coat of paint is applied over this the scale will be loosened by the oil softening up the cementing rust.

The only way I know of to effectually clean such metal so that it will be in proper condition to receive the paint is by the use of the sand blast. By employing it every trace of rust and scale and old paint, grease and dirt can be removed and the true metallic surface of the metal exposed to receive the paint, which will then closely adhere to it and afford such protection as it is impossible to secure with the very best hand cleaning or in any other way. Trials of this method on such work have been made, but rarely on a large scale, and generally on a sort of experimental basis. The cleaning of about 50,000 sq. ft. of the 155th St. viaduct, in New York city, was very satisfactory, but the cost averaged about 13 cts. per sq. ft., with a minimum of 10 cts. on a portion of it. Old plates have been cleaned in the United States navy yard at a cost of 4 cts. per sq. ft. with a temporary, somewhat experimental plant. Later a more permanent plant was installed and undoubtedly such work is now done at less cost. The United States Government Army Engineers cleaned nearly 50,000 sq. ft. of steel lock gates and aqueduct on the Muscle Shoals Canal during 1898 and 1899. The plant was erected upon a boat, and seems to have been a fairly complete one. The total cost of cleaning and painting was 5.88 cts. per sq. ft. of surface, and probably the cost of cleaning alone was about 3 cts., or a little more or less, but it is not separately stated. The experience of the P., C., C. & St. L. Ry. Co. in cleaning steel under the High St. viaduct buildings and driveway at Columbus, and on a bridge at Akron, O., indicated that such work would cost about 3 cts., although no accurate record of surface cleaned and cost seems to have been kept.

To secure good results it was determined in the summer of 1901 to use the sand blast in cleaning some of the viaducts of Columbus, O., several of which urgently needed cleaning and repainting, some parts of them being so badly rusted as to be covered with thick scales and pitted to a considerable extent. Unavoidable delays prevented the commencement of the work until late in November. It was decided to make a beginning on one of the small viaducts, notwithstanding the unfavorable season of the year, and the Front St. viaduct over the L. M. R. R. was chosen as the one to be first cleaned and painted. This is composed of six quite heavy plate girders, with floor system of 9-in. I-beams and buckle plates, and having an exposed painting surface of a little less than 25,000 sq. ft. A 2-in. steel pipe line, 2,300 ft. long, was laid from the receiver of the air compressor at the east end of the Union Depot, and air was furnished by the Union Depot Co. at a charge of 40 cts. per hour for one sand blast machine and 60 cts. per hour for two machines. More than half of the time one machine was used, and the remainder of the time two machines and nozzles, one sand hose leading from each machine. The 2-in. pipe was somewhat increased in carrying capacity by the aid of a 1,300-ft. length of



THE NEWHOUSE SAND BLAST MACHINE USED IN CLEANING VIADUCTS AT COLUMBUS, O.

1¼-in. pipe formerly laid from the compressor connected into the 2-in. pipe under the High St. viaduct. A small receiver of about 9½ cu. ft. capacity was placed at the viaduct to be cleaned and the pipe connected into it and then out of it to the machines. This dried the air better, and a considerable quantity of water was drawn out of it each day by a cock in the bottom, the amount varying with the moisture in the atmosphere. The sand blast machine used is the one invented by J. M. Newhouse, a general foreman of the P., C., C. & St. L. Ry. Co., at this place. It will be seen from the drawing that this machine has some features not seen in other machines. One of these is the arrangement of the air and sandpipes, with nozzle shaped air-siphon pieces in both the air and sand pipe, to facilitate the working of the machine without clogging. The nozzle leading the air through the opening in the bottom of the machine being surrounded with sand, and having small holes extending down and out, the air escaping through them keeps the sand stirred up and prevents its clogging and also keeps the sand chamber filled with compressed air. Three valves are provided, two of which serve to regulate the relative amount of air and sand so as to do the most effective work, and the upper one, a 3-way cock, regulates the supply of compressed air to the upper section of the machine and permits the filling of the machine with sand without stopping the sand blast. These machines are placed upon truck castors to facilitate moving them about where desired, the air being led from the pipe to the machine by a 1½-in. rubber air hose 50 ft. long. The sand hose may be old rubber hose 2¼ or 2½ ins. in diameter, sufficiently strong to stand the pressure used, with a nozzle of ½-in. extra heavy gas pipe, which was used because it costs less than tool steel and not many more are required. Two to three each day were worn out, the most severe wear being 3 ins. from the reducer connection to the hose. We used 2-ft. lengths of the pipe, because it was found that the blast is more effective than when a short nozzle is used, and it permits the nozzle man to stand farther from the part being cleaned, and not be so much affected by sand and flying dust. The sand rebounds with sufficient force to frost the glass of his helmet and require the glass to be changed about three times each day. With this machine it has been found that the blast is practically as effective with 100 ft. as with 30 ft. of sand hose.

We usually used not more than about 30 to 35 ft. of sand hose, for the reason that it is less expensive. The pressure at the entrance to the machines averaged 33 lbs., ranging from 25 to 38 lbs., as shown by a gauge employed at all times, and a record of the pressure was made each day. The sand was dried in two old locomotive ash-pans, which were placed on brick walls high enough to give fire space, and it required the attendance of one man to dry enough sand to keep two machines running. The sand must be cool again before being used, to prevent steaming in and clogging of the machine, and a sand house was constructed to store a small quantity of dry sand.

This viaduct affords only sufficient clearance for the highest cabooses, and hence no scaffold could be swung from the floor I-beams. Above the clearance (or lower side of the plate girders) it is only 12 ins. to the buckle plates. When working over the main tracks, on account of the curves in the tracks leading to the viaduct, three flagmen were required to watch for the trains and warn the workmen to clear the track. These were furnished by the railway company and paid for by the city. The interruption of work by trains amounted to 1½ hours per day, while working over the main tracks, or one-fifth of the working time during the short days of that time of the year; 12,600 square ft. of the viaduct were cleaned and then the weather became so severe that the work was discontinued on Dec. 13. The cost of the work, including flagmen, drying the sand, compressed air and all other expenses, was 3.04 cts per sq. ft. The best day's work was 1,227 sq. ft. at a cost of 1.23 cts. per sq. ft. This was in a favorable location, accessible and uninterrupted by trains, and on the surface of a plate girder; 3,727 sq. ft. of such surface cost 2.37 cts. per sq. ft.

The red lead priming coat, of the mixture before mentioned, was applied as soon as possible after the cleaning was done, the painters following very closely after the nozzlemen, so that it required only one-half hour after the blast was discontinued for the day for the painters to complete the painting of the surface cleaned. No cleaned surface was left over night unpainted. Upon the surface thus secured the paint, warmed as suggested, seemed to make a good coating, firmly adhering to the metal, notwithstanding the unfavorable temperature at which the work was done.

With added experience, favorable weather and longer days, and such improvements in appliances as may be made, it is not unreasonable to expect that,where uninterrupted by trains, this kind of sand-blast cleaning can be done for less than 2¼ cts. per sq. ft., and it is hoped that we may be able to do that well on our viaducts where there is room for a staging, giving clearance sufficient for the passing trains. After once cleaning a bridge in this thorough manner and properly applying the paint, it is expected that it can afterward be maintained in good condition for a great number of years by proper care in inspecting it at frequent intervals and cleaning by hand and repainting whenever the paint shows sufficient wear to endanger the rusting of the steel. We hope to resume this work when the weather is favorable and continue it during the coming season. It is expected that better figures may then be shown than we have at present.

Mr. Keil (Foreman Painter, L. S. & M. S. R. R., Buffalo) in commenting on this paper, said: I believe I was the first man that took up the sand blast on locomotive work, about 16 years ago. It used to cost from $4 to $6 to prepare a new steel tender tank ready for painting. After I perfected the sand blast the work could be done on a small steel tank for $1.25 and a large one would average from $1.50 to $1.75. I noticed after two or three years' service of these tanks that there was a great saving in the cost of repainting. The after results pay well for the time taken at first, but it is also cheaper in the first place. At to the pneumatic painting machine, in places where it is hard to get in with a brush the machine is certainly a good thing and the places that in my judgment would rust out the quickest are under the sills or places that are generally left untouched when painting is done with a brush. I believe that rust in the steel car is the same as a cancer in a person's body; it must be removed down to the bottom; if not, it will keep on. No matter how well painting is done, the rust must be removed first; otherwise it will rust under the paint. I used to be very careful in doing a steel locomotive tank. As soon as I was through sand blasting I had it painted at once. In one hour's time, with a powerful magnifying glass, the tank would show rust, no matter if it were a dry day. I found that it paid to put the paint on at once.

Notable Ship Riveting by Pneumatic Tools.

It is now not only highly advisable, but, in the case of the huge steamships now common, absolutely imperative, to substitute power in place of hand riveting in shipbuilding. Undoubtedly, a task lying ready to the hands of progressive shipbuilders is to render possible the complete application of power riveting in shipbuilding. Riveting by hydraulic tools is, of course, quite a common practice already, but this system has its limitations, in its application to work to be done *in situ* especially. The quality of portability in the tool is here a regulating condition, and the ratio of weight to power exerted in hydraulic tools is inadmissibly high. Consequently tools of this class are a disadvantage, if not entirely inapplicable, when tools have to be brought to the work as in binding a ship's structure. Powerful appliances in the way of travelling cranes and gantries for transporting and holding the tools to their work certainly minimize the drawback of excessive weight; but the cost involved is such as will scarcely justify the adoption of these appliances, except in very exceptional cases, and even then the field of application is restricted. For the most complete and all-round satisfactory system of power riveting in shipwork, we must look to the pneumatic tools already thoroughly established in American yards and now almost equally well known in England, in spite of the obstacles and restrictions to their use brought into play by the prejudices, jealousies and ignorance of the classes of artisans their introduction affects. The all-round satisfactoriness alluded to is not alone in the fact of the riveting being accomplished with much greater speed, less cost, and with at least equal thoroughness, but largely consists in the applicability of the system to tools and operations closely associated with riveting. Pneumatic power for drilling, seaming, chipping, cutting, and caulking, is even more indubitably established than for riveting operations, hence its cumulative potency as the medium for riveting. In all our shipbuilding centers, notably the Clyde, the Tyne and Wear, pneumatic tools for drilling, caulking, chipping, etc., are already introduced and in constant use. In the case of riveting tools, there is an equal readiness on the part of employers to introduce them, and in the case of most of the large firms, tools for riveting are as liberally ordered as others, but their use is retarded by the economic or labor questions involved. Employers, in return for the installation of expensive tools, naturally desire to secure some reduction in the rates paid to those who use them, but so far the attitude of the ordinary riveting operative has been that of eyeing tne pneumatic riveter askance, and for working it, insisting on the price per 100 as in the case of handwork. In some cases where riveting tools have been put to work, the autocratic riveting squad have had to be paid for simply standing by, all the work meanwhile being done by a mere stripling. The tools now finding their vocation in British and Continental yards are those of the "Boyer" type, supplied by the New Taite Howard Pneumatic Tool Company, Limited, whose striking demonstrations of the capabilities of pneumatic tools for all sorts of shipbuilding, boilermaking and structural iron work generally at Glasgow Exhibition last year, many readers will doubtless remember. The work then accomplished was in every respect closely analogous to the actual work undertaken in large marine and locomotive shops and in shipyards, and the period of exhibition doubtless left its due and potent impressions even on the prejudiced workman. Some doubt has been entertained as to the quality of the riveting work done where large rivets and many thicknesses of plating are concerned.

We are in a position to draw attention to a very notable instance of heavy work done, intended to withstand the test of severe daily ordeal. This was on the large Clyde-built Atlantic steamer "Zeeland," of the International Company's fleet, while in dock for repair at Southampton, having, like previous vessels of the same design, given symptoms of local weaknesses, as evidenced by the loosening of rivets.

At the desire of the owners, who have had a sister ship to the "Zeeland" built in America, the riveting in which has been wholly done by "Boyer" tools, pneumatic riveting was adopted in the repair work on the "Zeeland." The plate was 1½ inch thick, and the plating and angles to which it was attached in some places formed 4 and 5 ply, 4¼ inch and 5¼ inch thick, necessitating rivets 6¼ inch to 8 inch long. The rivets were 1⅛ inch diamater, and altogether between 280 and 290 were driven with the tool. The air pressure was 100 lbs. per square inch. The rivets before being driven projected as much as 2¾ inches through the plate, this being necessary in order that they might provide enough metal to fill the countersinks—which were extra large—and leave metal sufficient to form the heads. Where there was a clear run of work, and with the necessary gear and rigging fixed, these very heavy rivets were driven at the rate of one per minute. The work was done to the entire satisfaction of the surveyors appointed to supervise the repairs, as well as those of the Board of Trade and of Lloyd's. It is of interest to add that the tools and the workmen employed in this case are now engaged on the repair work being done to the Cunard steamer "Etruria," in the Canada Dry Dock, Liverpool, after her recent breakdown in the Atlantic. At present operations are confined to heavy chipping and drilling by the tools, but in the course of a week or so, when the new stern post has been put in place, the tools will be called upon to deal with riveting of the heaviest description, the diameter of the rivets being 1½ inch. The work is being carried out by the New Taite Howard Pneumatic Tool Company, Limited, and no impediment is placed in the way of any one wanting to inspect the notable work being done by their pneumatic tools.—*The Syren and Shipping.*

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of Compressed Air. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

One of our correspondents writes us as follows:

"Will you please inform me about what is the average velocity in ft. per minute allowed in air compressors both for the intake and exhaust valves? Is it the same for single and two-stage compressors?"

It is very difficult to answer these questions in anything like a satisfactory manner, as there is a great variation in the velocities used by the different manufacturers. In a general wav we find that the velocity of the inlet air—that is, the speed with which the air enters the cylinder of an air compressor—varies with different makes and different sizes of the same make, and ranges from 3,000 to 8,000 feet per minute for 100 lb. compressors.

The discharge valves are, naturally, smaller than the inlet, because by the time the air is ready to pass through these its volume is being decreased in almost direct proportion to the final pressure. In round numbers the discharge velocity seems to be from 800 to 1,800 feet per minute. In the case of two-stage compressors there seems to be no uniformity whatsoever, and the velocity at the inlet end may be figured anywhere from 3,000 to 8,000 feet per minute.

Notes.

The Cleveland Pneumatic Tool Company have appointed The Compressed Air Machinery Company, of San Francisco, Cal., to represent them on the Pacific Coast.

In the Kalgoorlie Gold Mine, West Australia, the cumbersome method of mechanical agitation in the large steel vats has been superseded by the process of agitation with compressed air.

His Majesty, King Edward VII., recently paid a visit to Whitehead's Torpedo Works at Portland, England. The arrival of the royal party was greeted with numerous torpedoes discharged in the air and filled with compressed air.

The Pneumatic Ore Concentrating Company, with a capital stock of $500,000, has been incorporated under the laws of the State of New Jersey. It is an Ohio concern, and its charter permits the company to manufacture by-products of iron, steel, etc. The incorporators are Jay J. Snyder, D. M. Stewart, of Xenia, O., and John O. Wilson, of Camden, N. J.

The contract for the pneumatic installation required by the India office for the Bombay Dockyards has been granted to the International Pneumatic Tool Co., Ltd., of London. This company have also received the two large contracts for the pneumatic tool installation for the Bengal Nagpore Railroad Company, to be installed at the Kharpur Workshops, India.

The Chicago Pneumatic Tool Company has recently been awarded contracts for three of their large "Franklin" Air Compressors for the Philadelphia and Reading Railway, and two compound air compressors of 2,000 cubic feet capacity for the new car shops of the N. Y., N. H. & H. Railroad, of Readville, Mass., and one for the Atchison, Topeka and Santa Fe Railroad.

Familiarity with danger leads very often to trouble. Witness the case of the workman at the ship-building yard near Toulon, France, who was killed while handling a diving-bell apparatus. He released the connection at the end of the communicating shaft, and the compressed air blew him with terrible violence against the top of the shaft, crushing his body beyond recognition.

With the Philadelphia Pneumatic Tool Company inquiries, both from foreign and domestic sources, have been numerous and some good orders have been taken, foreign and extreme Western trade being particularly strong. A large number of rammers, clippers and hammers have recently been shipped for export to various European countries, and deliveries to various concerns in all parts of the United States have been made.

To find the amount of air that can be produced by different size air cylinders: Find the area of the cylinder and multiply that by the stroke; then multiply result by 2 if it is a Straight Line Compressor; by 4 if a Duplex Compressor; or by 2 if a compound Duplex Compressor. Divide this result by 1728, which will give the amount of air per stroke, and then multiply by number of strokes per minute.

The compressor for the United States Mining Company, at Bingham, Utah, is from the works of the Allis-Chalmers Company. The size of the machine is as follows: Steam cylinders, 22 and 40 ins. in diameter; air cylinders, 36 and 22 in. in diameter, all 40-in. stroke. The compressor runs condensing and compounds the steam used and air delivered, delivering about 3,400 cu. ft. of free air per minute. The engines for the smelter at Bingham Junction are beginning to arrive from the Allis-Chalmers shops.

The Moundsville Coal Company has received from the Norfolk Iron Works a large compressed air machine, weighing probably 40 tons, to run fourteen compressed air mining machines. This is a very great improvement and will take the place of several men. The coal company contemplates making many more important improvements in this as well as in other lines. The improvments will be so conducted that no men will be thrown out of employment for some time, at least.

Fraser and Chalmers, Limited, Erith, have lately secured an order from the Glyn Colliery Company, Tonyrefail, South Wales, for a large horizontal Riedler Air Compressor, with steam cylinders 23 in. by 35 in. by 54 in. stroke,. and air cylinders 22 in. by 36 in. by 54 in. stroke. The compressor is to be constructed for 120 lbs. initial steam pressure, to deliver air at 80 lbs. pressure. The steam cylinders are to be of the Fraser and Chalmers' standard Corliss gear type, fitted with the Whitmore air-governor.

The repairs on the steamship "Zeeland," at Southampton, which are being executed with pneumatic tools, are being carried out by Messrs. John Brown & Co., Ltd., of Clydebank, assisted by Messrs. Mordey, Carney, Limited, of Southampton, who say that they have used pneumatic tools in their works for some months. The New Taite Howard Pneumatic Tool Company, which owns the European patents of the tools in question, states that for 1⅛ in. rivets the time occupied has been one minute per rivet, and only two men are employed instead of three.

The efficiency of a compressed air power transmission plant varies considerably according to the design of the plant, the conditions under which it works and the uses to which the air is put. The losses are made in the following manner: 1. Engine and compressor friction. 2. Friction in pipe line. 3. Loss in valves and connections. 4. Loss in the motors using the air. With a mine plant as ordinarily designed the following experiences may be obtained: Engine and compressor, 65 per cent.; pipe line, 96 per cent.; motors, 80 per cent. Efficiency of the whole system, about 50 per cent.

There are forty compressed air drills at work on the Sodbury Tunnel of the Great Western R. R. (Wotton Bassett to Patchway), the construction of which is in charge of Messrs. S. Pearson & Son., Ltd., of Westminster, England. A year ago this work was stopped by the inrush of a very large quantity of water, but it has been rapidly progressing since then, and in spite of a flooding of a portion of the works, nearly one and a quarter miles have been excavated. There are about 1,800 men at work on the tunnel and it is expected to be finished in about two months.

Crossing the River Clyde at Glasgow, the river bed is especially poor and considerable difficulty has been found in constructing and maintaining the quay walls along the river bank for bridges, etc. At one point we hear that a wall is being built for the fourth time, the previous ones having failed owing to weak foundations, either due to the river bottom or to bad judgment on the part of the contractor. The wall now under construction is being built on a steel caisson which was sunk by the penumatic process, the wall of brick and concrete being built as the caisson sank into place.

Various schemes for the mutual benefit of the human race are popping up every day and everywhere. Most of them go up in the air like toy balloons and so sail away never to return. In a London paper (note that the news has first travelled across the seas) just read is a description of a patent granted to Professor Thede of Chicago, U. S. A., to utilize wind mills for power accumulation in the shape of compressed air. Professor Thede proposes to compress air until it is liquefied and then to make use of it for innumerable purposes. It is said that he claims to have sufficient financial backing to put his scheme to a practical test. Let us wish him "good luck."

The Mysore Gold Mines of India have the peculiar interest of being (in that country of hand work) among the few who employ up-to-date methods and machinery. The Kolar Fields extend for over ten miles, but the most productive and busy part centres around the Mysore District. Here are 14 shafts, the most important having reached a depth of half a mile. Near by are stationed the air compressors, designed at the present time to drive 24 rock drills (3½ inches). This is the main power house, although in different parts of the mine air compressors have been sprinkled about, between them all supplying air to sixty rock drills, fourteen donkey-pumps and three air hoists.

The postmaster general has appointed the following committee to visit various cities and investigate conditions governing a need of pneumatic tube service, and prepare a report for Congress: John M. Masten, chief clerk of the first assistant postmaster general's office; J. H. Crew, superintendent of railway adjustment, postoffice department, and V. J. Bradley, superintendent of the New York division of the railway mail service. This committee will act in conjunction with the postmasters of the following cities, which heretofore have been recommended by the department as places where pneumatic service should be established: New York, Brooklyn, Philadelphia, Boston, Chicago, St. Louis and Washington.

In many cases compressed air experiences considerable loss of power, but the inevitable deficiencies may be greatly increased by needless defects in the appliances. To get the best possible results we ought to have well-designed and well-constructed air compressors, of sufficient power, and the valves should be controlled mechanically. The compression should be by the compound system, so as to deal effectively with the heat generated. The pipes conveying the compressed air should be such that the linear velocity will not exceed 6,000 feet a minute. In front of each engine using compressed air there should be a receiver to allow the moisture in the air to settle and be drawn off. Careful attention to, and compliance with, these conditions will give us minimum loss; neglect of these conditions will give us maximum loss.

To understand the action of an air vessel we must have well in mind the fact that water is practically incompressible, and the bucket or ram of an ordinary pump reverses its motion for each separate stroke. Unless some precaution is adopted the unyielding pump, acting on an unyielding liquid, would produce a succession of severe shocks. The air vessel is always partly full of air, and is open alike to the delivery column and to the pump. The air in this air vessel is a highly elastic cushion, and successfully avoids what would otherwise be a series of injurious shocks. The air vessel loses its efficiency if the water is allowed to absorb all the air. This should be prevented, and there are methods of keeping the air vessel charged with the needful amount of air.

The Industrial Undertakings Company, Ltd., of London (which is a firm with a name), have put on the market what they style as the "Champion" coal cutter which is worked by compressed air. This machine is simple in construction and can be used for either nicking or cutting the coal. The drill once set to work, the cutting-bit strikes the coal at the prodigious rate of 350 blows per minute. When used in a coal-mine the machine dispenses entirely with the use of explosives for breaking down the coal. It is claimed for this machine that, with skilful handling, it is capable of making a cut in fairly hard coal of from 50 to 60 square feet per hour. The consumption of compressed air amounts to about 12 cubic feet per minute. If an air drill is used, and if an electrical drill is employed, from one to two horse-power.

One-hundred-miles-an-hour trains at Berlin, Germany, called the "Allgemeine Electriciats," have a 14-mile run with steep grades for even an ordinary steam locomotive, yet here is used an electric motor. There are three cars to a train, each car having three compartments. At either end of the car are the electrical apparatus operated by compressed air and used also for controlling the working of the car and in connection with the air brakes. Beneath the car are two duplex pumps with 190 revolutions per minute, which force air into two cylinders having a combined capacity of 14 1-3 cubic ft. at a pressure of 120 lbs. Two air cylinders are utilized for working the controller which cuts into the electric motors. These two cylinders are of different diameter and work in opposite directions and the motors are put in one at a time.

With the exception of a few very restricted applications of "Pneumatic Transport," the use of compressed air for transmitting power was first realized in a practical form for driving the Mont-Cenis Tunnel, when Sommeiller's water-column compressor was invented for driving the rock drills from a distance and greatly contributed to the achievement of that grand undertaking. Owing to the special facilities which this method of transmitting power affords in underground workings, its employment has quickly spread in mines, where it has received numerous and important applications; and although electricity has proved a formidable competitor of late years, and may be destined to supersede it in many cases, the field of action that can be covered to advantage by compressed air remains very vast, and can but still further extend with the development of mechanical plant for mine working. "This method of power transmission, therefore, merits special attention," remarked M. H. Kuss and M. L. Fevre, in their treatise on mine working.

Mr. J. W. Duntley, President of the Chicago Pneumatic Tool Company, has just returned from a trip through Europe. While there he secured orders for an aggregate of 2,700 "Boyer" and "Little Giant" Pneumatic Tools, as well as 25 "Franklin" Air-Compressors, for early delivery. Mr. Duntley states that the Europeans now realize the absolute necessity of using labor-saving tools so as to reduce the cost of manufacture and counteract the influence of the "American Invasion" (which is causing widespread alarm in commercial circles) and enable them to compete for the markets of the world.

The unprecedented increase in the sales of pneumatic tools in foreign countries recently, may be attributed, in a measure, to the cause above mentioned and also to the fact that the opposition to pneumatic tools by workmen, on account of their labor-saving qualities, has been entirely overcome. The various plants of the Chicago Pneumatic Tool Company are taxed to their utmost capacity, and will have to be greatly enlarged in the near future in order to meet the ever-increasing demand for their products.

The University of Wisconsin will open the second summer session of its summer school for apprentices and artisans on June 30th, which session will close August 8, 1902.

This school is intended primarily to give to stationary engineers, superintendents of power stations, machinists, artisans and apprentices in various trades such mathematical, laboratory and shop instruction as would be found of most practical value to persons in these employments, and which would be imparted in the limited time of six weeks.

Any person over sixteen years of age, speaking the English language and having a fair knowledge of arithmetic, will be admitted. The school has a faculty of ten, composed of regular professors and instructors from the faculty of the College of Engineering.

Correspondence school students will find the opportunities for laboratory and shop work here offered particularly helpful.

The tuition fee for the term is fifteen dollars for all courses. In addition to this, there are laboratory fees of five cents per hour for all time spent in such practical work.

At a meeting of students of the Institution of Civil Engineers held on Friday evening, April 4th, in London, Mr. Basil Mott, M. Inst. C.E., in the chair, Mr. L. G. Crawford, Stud. Inst. C.E., read a paper on "Compressed Air and its Applications," of which the following is an abstract: In this paper the author investigates the theories which govern the design of compressed air plant, indicating the advantages which result from the use of multiple stage compressors and the economies effected by re-heating. Detailed descriptions are given of the D'Auria, Taylor and Boreas air compressors, and also of those manufactured by George Wailes and Co. The results of some trials of the latter are given and commented upon. The author then describes the applications of compressed air in connection with riveting, hoisting, despatch and traction, sub-aqueous excavations, etc. In conclusion, the advantages to be derived from the use of compressed air under certain conditions are briefly indicated. The reading of the paper was followed by a discussion, in which Messrs. A. J. Deane, E. A. Davies, F. H. Clough, H. E. Wimperis, and A. M. Arter, Studs. Inst. C.E., took part.

Yankee methods and British workmen are still performing feats that startle the English public, who have hardly had time to close their mouths from wondering at the records made in brick laying at the British Westinghouse Company's works at Manchester, when they are called upon to admire the huge chimney stack of the generating station of the Mersey Railway Company, at Liverpool. Commenced about Christmas time, the stack, which is about 250 feet in height, has been completed already, and stands as a record-breaker as far as expedition in building is concerned. The work has been carried out by the British Westinghouse Company, who have the contract for converting the Mersey Railway tunnel from steam to electric traction, and the work has been done by British labor under the direction of Messrs. J. Stewart & Co., famous for record-breaking time in the construction of the Manchester Works, the Galveston docks and the renowned grain elevator, "Kalumet K." From nearly every part of Liverpool the Mersey chimney, decorated with the American and British national flags, stands out plainly on the sky-line as the highest structure in that part of Cheshire.

The Homestead and Mifflin Street Railway Company, financed by business men of Homestead, Pittsburg and vicinity, has recently begun the construction of a line from Homestead, Pa., to Lincoln Place, in Mifflin township, a distance of three and a quarter miles. It will cost $100,000, and is expected to be in operation by July 1. Later additions will be built to the road. Next spring a branch will be constructed to Whitaker, the residents of which now have no street car facilities. This branch will cost $75,000, $33,000 of which, according to an estimate, will be needed for erecting a bridge across Whitaker Run, in Munhall Hollow. The bridge will be about 70 feet high.

The new road will prove a great convenience to the people of the Third ward of Pittsburg, Homestead, and to the residents of the hill district south of the borough, where there are practically no transportation facilities. The project also includes the improvement of a large amount of land along the route for building lots. A fare of five cents will be charged. The Laclede Car Company of St. Louis has been awarded the contract for the cars. Westinghouse motors will be used and the cars will be equipped with the Westinghouse magnetic brake. The rails will weigh 90 pounds to the yard and will be joined with a recently patented coupling, which insures easy travel.

The Ehrenfeld Plant of the Webster Coal & Coke Co., whose properties, owned and leased, amount to 51,000 acres in all, are situated on the main line and branches of the Pennsylvania Railroad, where the system crosses the summit of the Alleghanies, between Altoona and Johnstown. This whole territory is underlaid by coal beds belonging to the lower productive coal measures or Freeport series, which outcrop at the southern end and permit the coal to be mined bv drift openings. In regard to the kind of mining, whether pick or machinery, to use the words of the superintendent of this division, Mr. J. L. Nicholson, the coal is of a woody nature and requires a machine of the puncher style, delivering hard blows of greater length of stroke than the short, quick stroke used with such telling effect in hard, brittle coal.

Six Sullivan and three Ingersoll punchers are used in No. 6 and No. 8 openings. In No. 3 mine two Sullivan machines drive the main heading, and pick mining is used in the other working places here as well as throughout No. 5 opening.

The compressor plant includes two Ingersoll compressors delivering air at 85 pounds pressure and furnished with steam by three tubular boilers of 100-horse power each, made by the Eagle Iron Works, of Terre Haute, Ind. The compressors have 20-inch stroke and 24-inch air cylinder.

A method for measuring the volume of air delivered by a compressor (checked by Hirn and communicated by Professor Rateau to the authors of Fanchon's *Mine Working*, who describe and illustrate the two-stage compressors of the Ingersol-Sergeant Drill Co..and the Rand Drill Co.) consists in exhausting the air through a small tuyère, or nozzle, the diameter of which has been calculated by means of a preliminary and approximate estimation of the volume delivered, so as to correspond with this volume at the pressure given by the compressor. Inasmuch as such pressure is generally more than double that of the atmosphere, the volume delivered only depends upon this pressure and the final sectional area of the nozzle. This volume is estimated at the initial temperature of the air before entering the nozzle and should be reduced to that of the outer air, so that these two temperatures must be taken. For a converging nozzle the volume delivered is expressed by the formula

$$D = 18.9\, s \sqrt{\frac{To}{278}}$$

in which D is the volume delivered in litres (1 litre = 61 cu. in.) per second at the pressure given by the compressor, s the sectional area of the orifice in square centimetres (1 sq. cm. = 0.155 sq. in.), and To the absolute temperature in centigrade degrees of the air before entering the nozzle.

The new shops of the Philadelphia Pneumatic Tool Company, situated at 21st St. and Alleghany ave., Philadelphia, Pa., are completed, and the company is now doing business at the above address. The power plant is installed and everything is in readiness for the full operation of the new plant. About $10,000 worth of new machine tools, to be delivered early in June, have been ordered, and with these new tools the company hopes to be able to relieve the very much overcrowded condition of their works and be able to make more prompt deliveries than heretofore. About 150 men will be required immediately to do the work, which at present they are trying to do in their crowded quarters with 95 men. The Philadelphia Pneumatic Tool Company has recently placed upon the market two new sizes of Rotary Drills and have perfected an improved Riveting Hammer, which is being made in three sizes, having capacities varying from ¼-inch to 1¼-inch rivets. They report that they have recently received orders aggregating nearly 200 tools from one of the largest shipyards in the country, and this, together with a lot of railroad and other trade makes an unprecedented rush of business. They are making preparations for an elaborate display of their tools in a working exhibit at the Master Mechanics and Master Car Builders' Convention, which is to be held in Saratoga from June 18th to June 25th, and visitors at the convention will do well to visit this display.

We have heard the subject of liquid air discussed with so many "castles in the air" that nowadays we have become skeptical and shrug our shoulders when we hear the wonderful things promised with this motive power. If the subject waxes too warm, we almost feel like following the example of the naughty boy who put his fingers in his ears and fled. Nevertheless, this power has been chained and utilized in many ingenious ways, and among the companies formed to accomplish this is the Air Power and Automobile Company, of Pimlico, London, which has certainly turned liquid air to some account, though how far it is going to revolutionize methods of traction and power we must wait to discover. At the company's works at Pimlico there was recently a very unique demonstration of a little motor car driven by liquid air. Powerful engines were compressing the air of the atmosphere and reducing it in temperature under the pressure till it liquefied at more than 300 degrees below zero. The lid of the back portion of the car was then removed, revealing a felt-covered receptacle, with orifices carefully screwed up. A tin vessel was then filled from a tap beneath a registering gauge on a large, wood-covered tank. A bluish liquid was the result—this was liquid air. It was then emptied into the tank on the car and up rose a cloud of cold steam, chilling the hand if held in the mist. A considerable quantity of this liquid was necessary for the charge, but when the signal was given off sailed the car as daintily and as well behaved as the heart could wish, free from vibrations and other objections, responding to the slightest touch of the lever. The cost of running this car has been estimated to be about a halfpenny per mile. Their great difficulty at present would be the absence of storage stations where the supply of liquid air might be replenished. Perhaps, if we could see into the future, we might see advertised in all country villages: "Liquid air sold here by the gallon." That would certainly help science along and, incidentally, the liquid air companies.

Upon the erecting floor of the J. George Leyner Company are a pair of large compressors, exact duplicates of each other. The history of the order for these compressors has been given to us and, as an illustration of what American manufacturers are doing in foreign markets, the story is worth repeating.

About four years ago a prominent mining and mechanical engineer from Australia was asked, while in Denver, to recommend an air compressor for installation in a mine which had formerly been under his management. After due investigation he recommended one of the largest air compressors then built by Mr. J. G. Leyner. The purchase and installation followed. A year later the twin of this compressor was shipped to the same mine. Extended development of the group of properties owned by the purchasing company created a demand for more air compressors. During all of this time no personal acquaintance has existed between the officials of the mining company and the members of the Leyner firm. Yet with the development of the mines have come frequent cable orders until nine Leyner compressors are now installed there.

When the fact is considered that, except for their correspondence relations, manufacturer and purchaser are strangers to each other; when it is considered also that the mine and factory are some 7,000 miles apart; that American machinery is subject to import duty and is sold in competition with the manufacturers of the world, this unbroken record appears somewhat remarkable.

A neighboring mine required a compressor. The only salesmen the Leyner establishment had in the field were the nine compressors there and the good opinions they had won, yet the order was cabled for a Leyner machine. This was about a year ago. The twin machines now building at the factory are going to the purchasers of this tenth compressor. They are of the new type of the Leyner compressors, for which the manufacturers claim great improvement over former models. There could be no doubt of their being effective salesmen, adding still further to the reputation of machinery of American manufacture abroad and to that of Denver as a source of supply for mining machinery.—*Mining Reporter.*

The building of the second tunnel under the River Thames, that of Greenwich street, has also, like its twin brother, the Baker street tunnel, been operated and worked by the means of compressed air.

During sinking the caissons the opening in each shaft for the tunnel has been closed by a "plug" formed of steel plates fitted between girders in such a way as to be removable singly when the shield was ready to start. This steel plug was removed by gradually substituting, four feet behind it, a timber diaphragm, and filling the space between this diaphragm and the face with plugged clay.

The cast-iron lining was similar to that used in previous works of the same kind, but some improvements had been made in details to obtain better water-tight joints. All bolt-holes were made with a short portion bevelled off, and when the bolts were put in, lead washers were put on them, and, on the bolts being screwed up, the lead completely filled the space round the bolts at each end made by the bevelled edges of the bolt-holes. This arrangement had proved very successful, and comparatively few bolts had been found leaking when the air-pressure was removed. Into the joints between castings soft lead wire was hammered before caulking. The shield, of the "trap" or "box" type, was 14 feet 6 inches in length and had an external diameter of 13 feet. The cutting edge was made in thirteen segments, each segment having two 6-inch teeth cast on it, and immediately behind the cutting edge was a circular built box girder. Certain alterations suggested by experience had been made in the shield. The method of tunneling differed from previous similar work only in the use of face-rams for holding up the timbering of the face. The rate of progress had been exceptionally rapid, an advance of 10 feet per working day having been made over all the tunnel except a short length in open ballast on the Greenwich side. This was attributed mainly to the favorable character of much of the material excavated.

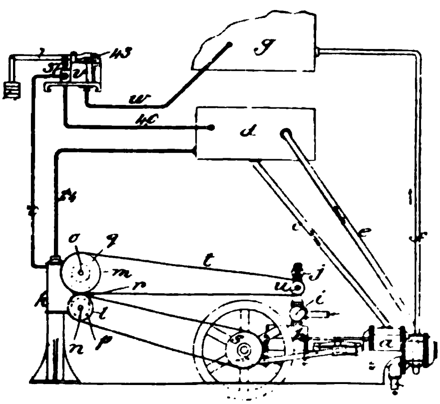
An attempt had been made to eliminate the carbonic acid from the air supplied to the tunnel by means of caustic soda. With this object an apparatus consisting of boxes or rectangular tubes of wood, one above the other, open at one end, and having sliding doors at the other end, had been devised. The ends, fitted with doors, were connected to the air-inlet of the tunnel by a conical box, the connection with the air-pipe being made air tight by a flexible joint. By opening one or other of the sliding doors the air could be made to pass through either the upper or the lower tube as required. These tubes had removable sides, and each contained eight movable wire boxes containing pumice stone broken small, which, before being put into the tubes, were dipped in a saturated solution of caustic soda.

U. S. PATENTS GRANTED APR. 1902

Specially prepared for Compressed Air.

696,461. SPRING AIR-GUN. William F. Markham, Plymouth, Mich. Filed July 9, 1900. Serial No. 22,935.

696,504. REGULATING DEVICE FOR AIR-COMPRESSORS. Henry C. Sergeant, Westfield, N. J., and William Prellwitz, Easton, Pa., assignors to the Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Feb. 28, 1901. Serial No. 49,211.



The combination with an air-compressor and a motor therefor, of a motor-controlling governor, a speed-varying mechanism consisting of two expanding and contracting pulleys and a belt between them, means for driving one of said pulleys from the motor-shaft, means for driving the governor from the other of said pulleys and means for simultaneously expanding one and contracting the other of said pulleys under the control of the pressure of the air delivered by the compressor.

696,531. PNEUMATIC CONVEYOR. James M. Akers, Gays, Ill. Filed June 1, 1901. Serial No. 62,746.

A device of the class described, a fan, a discharge-chute leading from said fan, a feed-hopper, a chute leading from said hopper into the eye or inlet of said fan, a chute leading from said hopper into the discharge from said fan, and means whereby the material fed into said hopper may be conducted into either of said chutes.

696,553. PNEUMATIC STACKER. Daniel Dow, Grand Forks, N. D. Filed Oct. 24, 1901. Serial No. 79,841.

A pneumatic stacker, the combination of a main wind-tube, a fan, a chaff-floor disposed above the fan, a main air-duct, a chaff air-duct having an inlet near the lower part of the fan and a throat located at the bottom of the chaff-floor.

696,730. COMPRESSED-AIR CONTROLLING DEVICE FOR SAND-DISCHARGERS. James Farley, Waukesha, Wis. Filed Sept. 13, 1901. Serial No. 75,258.

The combination with an engineer's brake-valve, and its handle, of a device secured to said handle to move therewith, and provided with an inclined surface; an independent valve-casing, having a channel there-through; a valve intercepting said channel and having a stem projecting beyond said casing; pipe connections between one end of said channel and the main reservoir of the brake-valve; another pipe leading from the other end of said channel; and means connected to the said projecting valve-stem for engagement with the inclined surface of the device secured to the brake-valve handle, and thereby controlling the admission of air to and regulating its passage through said channel.

696,803. ANGLE-COCK ADJUSTER FOR AIR-BRAKES. William S. De Camp, Chillicothe, Ohio. Filed Dec. 31, 1901. Serial No. 87,885.

An angle-cock adjuster comprising pneumatic means for turning the plug of said cock, and a by-pass valve for carrying the air around the angle-cock plug, said by-pass valve being located in the casing of the angle-cock.

696,843. PNEUMATIC-DESPATCH TERMINAL. Erbine C. Phillips, London, England, assignor to the Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed Dec. 13, 1899. Serial No. 740,174.

An upward-discharge terminal for pneumatic-despatch-tube systems, comprising in combination a substantially semicircular tubular member to be secured at one end to the upper end of the receiving-tube and constituting the discharging element of the terminal, a short straight tubular member adapted to be secured to the upper end of the sending-tube directly beneath and within the curve of said semicircular member and constituting the sending element of the terminal, and an air-return-pipe section uniting said curved and straight tubular members laterally near their discharging and receiving ends respectively, the space bounded by and included within said parts being entirely open, whereby the sender is equally accessible from all sides of the terminal.

696,972. SUBMARINE BOAT. John P. Holland, Newark, N. J. Filed Aug. 7, 1901. Serial No. 71,131.

A submarine boat or vessel having in it a closed tank containing a liquid hydrocarbon, means for charging and supplying the liquid from same, a ventilating-pipe extending from the upper part of said tank out through the shell or hull of the boat, a check-valve controlling said pipe and opening outwardly and means for automatically controlling the admission of air to said tank from the interior of the boat to replace the liquid used.

697,003. AIR BRAKE. Joseph E. Normand, Watertown, N. Y. Filed May 4, 1900. Serial No. 15,489.

697,015. AIR-PRESSURE SYSTEM OF LIGHTING. James E. Raff, Garwin, Iowa, assignor of two-thirds to Harry V. Moyer and Edwin Beery, Garwin, Iowa. Filed Mar. 18, 1901. Serial No. 51,749.

An apparatus of the class described. the combination of an air-reservoir, a fuel-tank, a main air-pipe extending directly from the air-reservoir to the fuel-tank, a main supply-pipe extending from the bottom of the fuel-tank, a supplemental pipe extending from the main supply-pipe at a point adjacent to the plane of the bottom of the fuel-tank to the air reservoir and having an upright portion adapted to contain a portion of the fuel and provided with a valve 16 and with a cock 17 located below the valve and adapted to be open to permit the fuel to rise in the upright portion of the supplemental pipe, said supplemental pipe forming a passage or conduit for the air when the tank is cut out for re-filling, and valves for cutting out the tank.

697,055. INNER TUBE FOR PNEUMATIC TIRES. Frank A. Wilcox, Erie, Pa. Filed Feb. 6, 1902. Serial No. 92,803.

697,171. COMPRESSED-AIR WATER-ELEVATOR. James R. Ricketts, Kingfisher, Okla., assignor of one-half to George W. Wilson, Kingfisher, Okla. Filed Dec. 3, 1901. Serial No. 84,561.

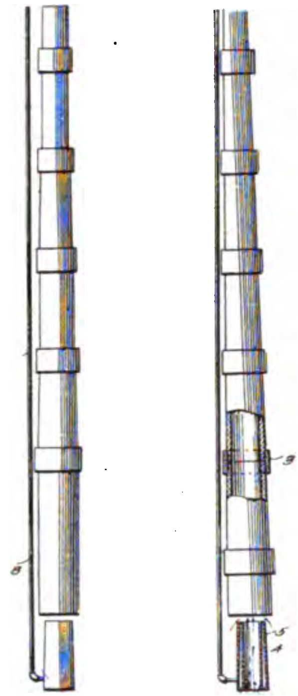
The combination with a water-vessel, of an air-pipe connected therewith, a liquid-discharge extending from the lower portion of the vessel, an escape-pipe extending from the upper portion of the vessel, an inlet-valve having a stem extending upwardly therefrom, and an escape-valve movable simultaneously with said inlet-valve and adapted to reciprocate upon said stem to close said escape-pipe before the seating of the inlet-valve.

697,227. INNER TUBE FOR PNEUMATIC TIRES. Frank A. Wilcox, Erie, Pa., and John R. Gammeter, Akron, Ohio, assignors to Pennsylvania Rubber Company, Erie, Pa., a Corporation of Pennsylvania. Filed Feb. 24, 1902. Serial No. 95,398.

697,403. PROPELLER FOR AIR-SHIPS. Charles Groombridge, London, England, assignor of one-half to William Alfred South, London, England. Filed Feb. 12, 1901. Serial No. 47,034.

697,296. COMPRESSED-AIR WATER ELEVATOR. George R. Tyler, Pomona, Cal. Filed Nov. 25, 1901. Serial No. 83,614.

A compressed-air water-elevator, an eduction-pipe having its bore diminished in diameter from its intake to its discharge end, and means disposed below and spaced from



the lower end of the pipe for discharging a current of air concentrically of the pipe.

697,414. AIR-COMPRESSOR. Frank L. Reeder and Albert B. Freville, Louisville, Ky., assignors to the National Foundry and Machine Company, Louisville, Ky., a Corporation. Filed Feb. 6, 1901. Serial No. 46,203.

An air-compressor, the combination with the taper threaded valve-chamber, having an annular interior groove, and a passage connecting chamber and cylinder, of a taper-threaded double, valve-seat bushing, having a projecting threaded end portion, the valves in said bushing, the perforated jam-nut engaging said projecting portion of the bushing, and the threaded plug engaging a threaded opening in the end wall of the valve-seat chamber.

697,564. PNEUMATIC TIRE. Charles E. Thomas, Tucson, Ariz. Filed Sept. 23, 1901. Serial No. 76,231.

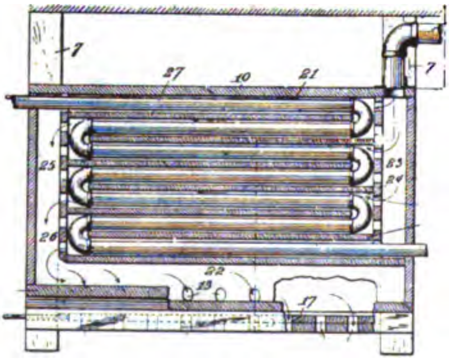
697,567. HYDROPNEUMATIC RENOVATOR. John S. Thurman, St. Louis, Mo. Filed June 22, 1901. Serial No. 65,703.

An apparatus of the character described, the combination with a curtain-wall, of means for projecting liquid against the front face thereof.

697,621. PNEUMATIC VEHICLE-TIRE. Edgeworth Greene, Montclair, N. J., assignor, by mesne assignments, to the American Rubber Works Company, a Corporation of New Jersey. Filed Jan. 4, 1902. Serial No. 88,371.

697,653. PNEUMATIC STACKER. Frederick L. Norton, Racine, Wis. Filed Jan. 6, 1902. Serial No. 88,586.

697,679. AIR-COOLING APPARATUS. Alfred Siebert, St. Louis, Mo. Filed Oct. 4, 1901. Serial No. 77,569.



An air-cooling apparatus, a cooling-box comprising a coil-chamber, having perforated end portions, a cooling-coil arranged within the coil-chamber, partitions arranged between the folds of the coil, a receiving-chamber communicating through one of the perforated partitions with the coil-chamber and a discharge-chamber with which the coil-chamber communicates through the other perforated partition.

697,694. PRESSURE-RETAINING VALVE FOR AIR-BRAKES. John A. Toal, Clancy, Mont., assignor of one-half to Peter Leary, Clancy, Mont. Filed Nov. 29, 1901. Serial No. 83,995.

697,793. PNEUMATIC HAMMER. Joseph Boyer, St. Louis, Mo., assignor to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Nov. 19, 1898. Renewed Jan. 4, 1901. Serial No. 42,121.

A pneumatic hammer comprising a cylinder formed at its front end to receive the shank of the working tool and having a grasping-handle secured to its rear end, a valve-chamber separate from the piston-chamber in said cylinder and located at the rear end thereof, two longitudinal passages in the cylinder-wall communicating at their rear ends with the motive-fluid supply and with the valve-chamber, respectively, a piston-controlling valve located in the valve-chamber, and a hammering-piston located in the piston-chamber and operating at its forward stroke to place the front ends of the two longitudinal passages in communication with each other and thereby admit motive fluid to the valve-chamber to shift the valve in one direction, and operating at its rearward stroke to cut off such communication and open the exhaust from the valve-chamber to permit the valve to be shifted in the opposite direction.

698,012. AIR-ESCAPE VALVE. August Grevel, Cologne, Germany. Filed Sept. 13, 1901. Serial No. 75,349.

An air-escape valve for operating the air-brakes of a car or train from the road-bed, the distinguishing feature of which is that the valve-cap or cylinder-head *h* is fastened to a lever *d* by means of a threaded spindle *f* and through which the cap or cylinder-head *h* is held in place at the end of the cylinder *a* so that the main lever *p* through its roller *o* bears upon the way *m*.

698,170. HOT-AIR FURNACE. William H. Birge, Franklin, Pa. Filed July 5, 1901. Serial No. 67,160.

A hot-air furnace comprising a casing having to one side of the same a fire-pot and on the opposite side an exit for the products of combustion, a plurality of vertically-disposed hot-air tubes carried by top and bottom plates, a dome or top for the reception of the heated air, and a perforated baffle or heat-restraining plate located within the casing and positioned nearer the opening for the exi of the products of combustion than to the fire-pot.

698,236. HYDRAULIC AIR-COMPRESSOR. Joseph Weyand, Guttenberg, N. J. Filed Dec. 18, 1901. Serial No. 86,445.

The combination with a shell having water inlet and outlet openings a lever pivoted within the shell, two valves controlling the said openings and connected with said lever and a vertical rod connected at its lower end with the said lever and provided with vertically-sliding floats the lower float having a limited upward movement on the rod to raise it, of air-delivery and air-vent in the upper end of the shell and a valve covering the air-vent raised by the direct action of the upper float.

698,362. MEANS FOR COMPRESSING OR LIQUEFYING GASES. Bruce Borland, Cambridge, Mass. Filed June 7, 1900. Serial No. 19,392.

Means for compressing and liquefying gas, which consist in a compressing-cylinder open at its bottom, a gas-receiver carried by the upper portion of the cylinder, a communication between the gas-receiver and cylinder, which communication is normally closed by a valve opening inwardly in the receiver, the said receiver being provided with a circumferential chamber between its inner and outer walls in communication with the main chamber, and means for drawing off the compressed gas from the receiver.

698,538. CLUTCH FOR PNEUMATIC HAMMERS. Albert C. Murphy, East St. Louis, Ill., assignor to Standard Railway Equipment Company, a Corporation of Illinois. Filed May 17, 1901. Serial No. 60,694.

A clutch for pneumatic hammers comprising clamping-jaws and a resilient split ring encircling them, said jaws being adapted to be mounted upon a pneumatic hammer.

698,710. AIR-PUMP. George W. Kellogg, Hartford, Conn. Filed Feb. 13, 1901. Serial No. 47,162.

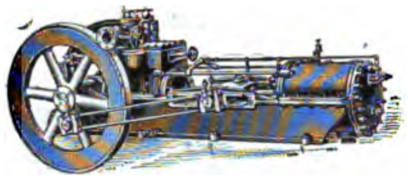
An air-pump, the two cylinders of unequal diameters, the smaller one being mounted end to end upon the other and at one side of its center, a piston in each cylinder having a hollow rigid connection with that in the other whereby the cylinders may communicate, and mechanism for moving the pistons mounted upon the side of the smaller cylinder and connected through the end of the larger cylinder to its piston.

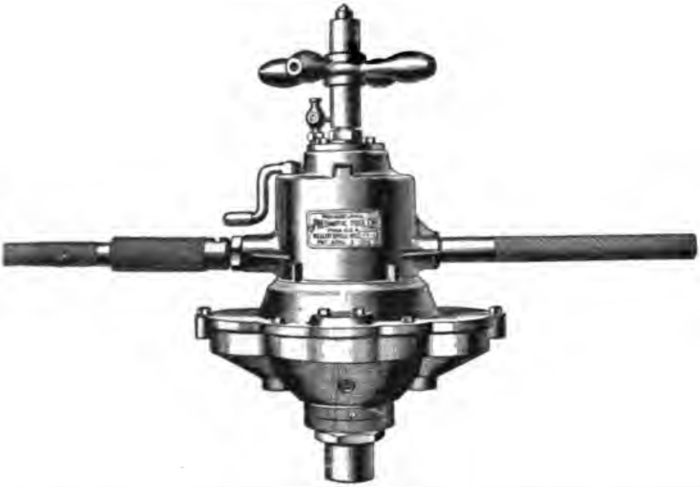
698,830. PNEUMATIC-DESPATCH TUBE. Edmond A. Fordyce, Chicago, Ill. Filed Feb. 14, 1902. Serial No. 94,144.

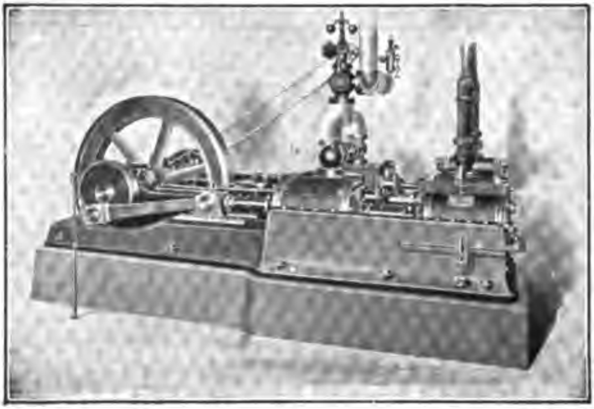
A pneumatic-tube system, the combination with an overhead main-line tube adapted to transmit carriers from an outlying station to the cash-desk, of a looped branch connected with and depending from said main-line tube at a local sending-station, a valve at the junction of said main tube and branch normally deflecting the current through the latter but permitting the uninterrupted travel of through-carriers past the junction, and a sending-terminal located in said looped branch.

698,900. CLAMP FOR ROCK-DRILLS. Frank R. Brown, Unga, Alaska. Filed July 18, 1901. Serial No. 68,794.

698,905. VALVE FOR PNEUMATIC MUSICAL INSTRUMENTS. Melville Clark, Chicago, Ill. Filed July 23, 1901. Serial No. 69,349.







Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, JULY, 1902. No. 5.

We desire to announce the fact that there will shortly be published by this paper a large volume entitled "Cyclopedia of Compressed Air Information."

This book will contain the editorials and other writings of the editor of this paper, including a full reprint of "Compressed Air Production," and all the leading papers on compressed air subjects that have been published in "Compressed Air" for the past five years including illustrations and other useful data. The book will be unlike anything heretofore published on the subject and is a cyclopedia of practical information on compressed air. Price, $5.00, sent to any address, postage paid.

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M. E. VARIAN, }

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Entered as Second-Class Matter at the New York, N. Y., Post Office.

VOL. VII. JULY, 1902. NO. 5.

Elsewhere in this issue we print an interesting description of several new devices to be used in connection with compressed air for pumping water from deep wells.

Within recent years the subject of air lifting of water has attracted considerable attention, and many successful installations can be pointed out where a large quantity of pure water is now obtained for municipal or private water supply where formerly a surface supply of inferior or dangerous character was alone available.

Where conditions are right the air lift seems to have no equal for raising water from underground sources. Unfortunately, there are sharp limits to the range of economical application of the older or Pohlé type of air lift, and the success of this system working under favorable conditions has brought to light many propositions where conditions as to lift and submergence are not at all favorable. Frequent attempts to devise apparatus suitable for such cases have been made. Some of these are claimed to attain the desired result of minimum volume of air and low pressure with no working parts and permanency and certainty of action. So far as we know, however, none of the so-called improvements will stand in the light of impartial investigation.

The methods here shown certainly seem reasonable and we should like to hear how they work in practice. One feature very much in their favor is the lack of mystery which usually shrouds "air lift" pumps. This feature makes some patent air lift pump concerns ridiculous and properly arouses suspicion. We recall one concern which brings the mysterious pump to the well carefully wrapped up and places it at night or when no one is about. In reality this pump is practically the old Pohlé arrangement.

With this issue we reproduce the illustration which appeared as the frontispiece of the June number of COMPRESSED AIR, with an idea of again calling attention to the book "Cyclopedia of Compressed Air Information." The work of classifying and arranging the mass of material which will be included is well under way and we are looking forward to the appearance of the book within a reasonable time.

An effort is being made to include such material and data as will be of the most service as a historical and technical record of the advance in the science of air compression and the practical application of air to the arts and industries.

No attempt is being made to change or re-write and the book, as already explained, will be simply a reprint of the best material which appeared in the first five volumes of COMPRESSED AIR, arranged according to subject under the headings of "Production," "Transmission" and "Use." In this way the information is made available for study or reference, and will, we think, be in the most valuable form. Since our first announcement we have received many favorable letters indicating that the "Cyclopedia of Compressed Air" will fill a gap in the literature on compressed air, and we are encouraged to believe it will meet with an even more friendly reception when it actually appears.

The Harris System of Pumping by Compressed Air, as Applied at the Deloro Mine.

The raising of water from mine workings is often a serious problem, and always a heavy cost on mining, even under favorable conditions; this subject, therefore, is a matter deserving of serious consideration.

At the Deloro Mines, Hastings county, Ontario, a shaft was being sunk which had an inflow of water amounting from 400,000 to 500,000 gallons per 24 hours. To deal with this amount of water by the then existant plant of "direct-acting steam pumps" was both slow and costly.

The greater part of this water flowed into the mine through and along the footwall, at the south end of the ore chute, and from thence to the lower workings, where the shaft was to be sunk.

The writer conceived the idea of impounding most of this water, making a permanent pumping station on the third level, and thus practically leaving the lower workings dry. An old shaft at the south end of the ore chute, being admirably situated to suit this purpose, was selected.

The bottom of this old shaft was 47 feet below the second level and full of water, and 35 feet above the third level, which latter had already been driven under and past this shaft.

The work preparatory to the installation of this pumping system was as follows:

A chamber 30 x 15 x 12 feet was blasted out on the third level immediately under the bottom of the old shaft, and all necessary preparations made for constructing a dam to prevent the water from flowing into the third level. This being done an upraise was made to the bottom of the old shaft, thus unwatering the shaft.

While this work was in progress investigations were made of the several types and varieties of pumping engines. The direct-acting pump was out of the question. Plunger pumps driven by compound-condensing engines seemed the best in this line of pumps, but the situation was such that, should anything happen to the pumps or engine, they would be drowned before repairs could be effected.

The next thing presenting itself as suitable was the "Harris" system of lifting water by direct air pressure.

Not only did this system promise great economy over previous installations, but its construction was such that no machinery was required in the mine, other than two tanks and some pipes connecting them with the machinery on surface; and with this system there could be no drowning, no matter what happened to the surface equipment.

The objections against its adoption were these, viz., its greater first cost compared to other systems, and secondly it was an untried system as applied to a comparativly high lift mining installation. However, against these, its simplicity so appealed to the writer that it was finally adopted.

The two tanks, 4 ft. x 20 ft., were placed in the "sump" or "chamber" on the third level, the pipes connected to surface and the dam built.

The reservoir thus made (that is, the chamber at the bottom of the shaft 30 ft. x 15 ft. x 12 ft., and the shaft itself, being 82 feet below the second level, and 9 ft. x 15 ft. in cross section), altogether gave a storage capacity of 130,000 gallons approximately, thus permitting the engines at surface, if so desired, a period of from 6 to 7 hours' rest, without any fear of the water finding its way to the lower workings.

This arrangement has proved very satisfactory and has been a strong factor in reducing the cost of operations, not only in shaft sinking, but also in stoping; these places now being dry, comparatively speaking.

It had also reduced the cost of raising water from 25 to 30 per cent. on former cost—part of the economy being in fuel, but mainly in labor and repairs.

Formerly it was necessary to have a pump man constantly attending the pumps; now this service is entirely dispensed with. It will be apparent from what has been said, that this system is only applicable as a "stationary pump." but as such it is, in the writer's opinion, very satisfactory.

The "Harris" system of air-lift is composed of two tanks in the mine, which are connected by two air pipes to an automatic switch located in the engine-house at surface, the switch in turn being connected with an air compressor.

The principle of the system is simplicity itself, although not easy of explanation.

A "cross compound" "steam and air"

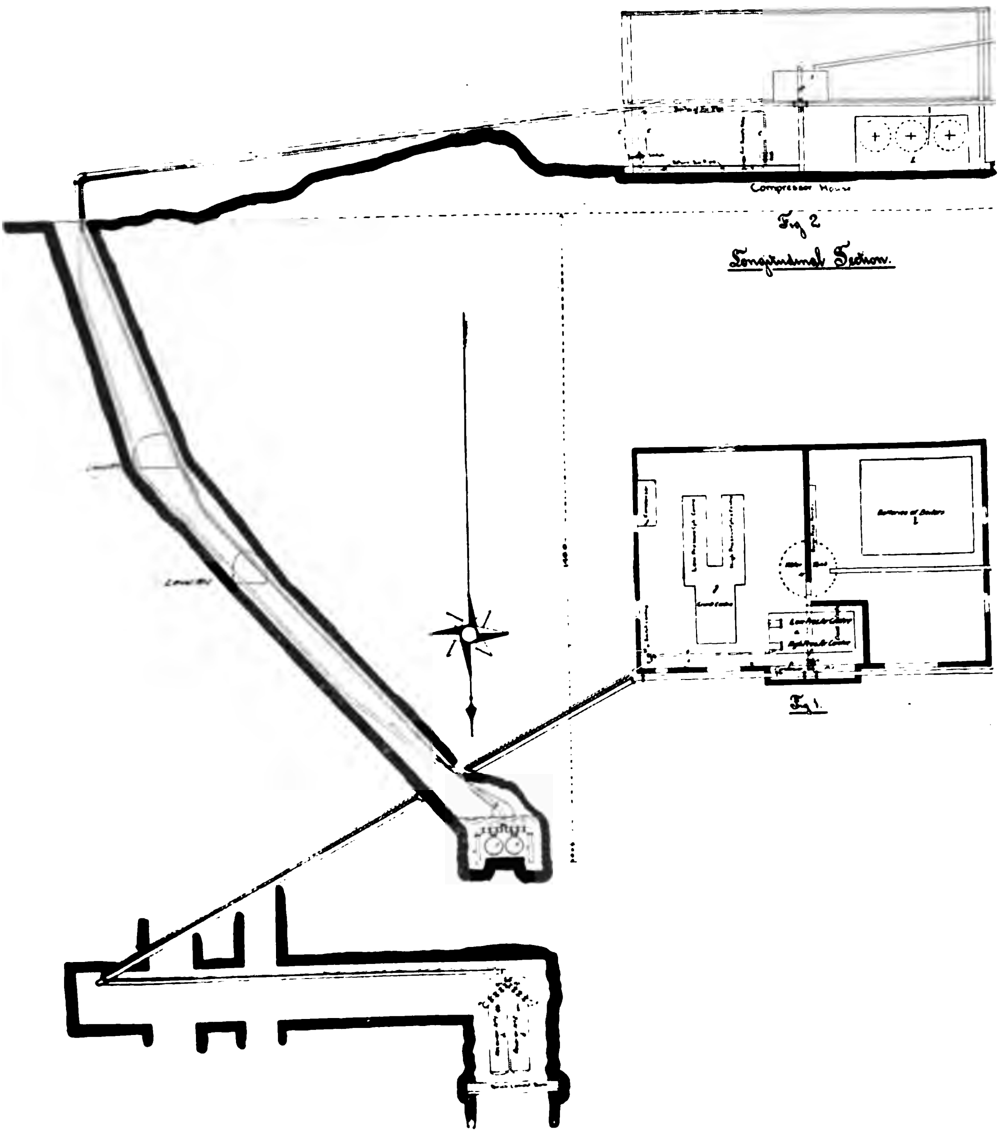


FIG. I. DISPLACEMENT METHOD OF RAISING WATER BY COMPRESSED AIR, DELORO MINE, HASTINGS, ONT.

of the Rand type, class B, compressor is placed at a suitable location at the surface, and two tanks, 4 ft. x 20 ft. each, are placed in the mine—the air compressor and tanks are connected by two air pipes, and between the air compressor and the tanks at a suitable point near the compressor a switch is located.

This switch serves the purposes of changing the inflowing air from one tank to the other at regular intervals; these intervals are termed "cycles."

The duration of the cycle may be varied from 2½ to 6 minutes, to conform to the amount of the water to be raised; these variations are governed through the amount of air forced into the system.

If there is only a limited amount of water to be raised (and there is no object in maintaining a constant supply), provided that the sump or reservoir is of sufficient capacity, the engine may be stopped for a time and again started by simply turning steam on the compressor, the switch at once resuming its functions, no attention being required at the tanks in the mine.

As regards the air, the system is "closed" or return pipe system, i. e., the same air is used over and over again, returning to the compressor at the end of each cycle for compression, ranging in pressure from that required to do the work, to that which equals the pressure due to the head of water around and above the tanks.

The greater the head above the tanks the greater the economy.

In this feature is the chief economy. The tanks are so connected that they receive air and water alternately—when one receives air and delivers water, the other receives water and delivers air.

It will thus be seen that the air is not brought up to working pressure from the atmospheric pressure, as would be the case in the ordinary air compression.

Attention should be drawn to the fact that the only moving parts in the mine are the inlet and outlet valves at the tanks.

These valves only move once for each cycle, and as near as can be ascertained by listening to them, they open quickly but close gradually, hence the wear is slight. In this case they have never caused any trouble.

In the particular plant under review 96 pounds air pressure is required to force the water through an 8-inch pipe to the mill tank, a vertical lift of 208 feet. The "lift" is kept running steadily night and day in order to supply the requisite water for mill purposes, also for condensation purposes in the compressor house for the condenser of the air lift, and also another pertaining to a 20-drill compressor.

As before stated, the air is forced into the system at 96 pounds pressure, and after the completion of the cycle it returns through the switch into the low pressure air cylinder at a pressure of 65 pounds, immediately after switching, and gradually decreases in pressure through the cycle to zero, or the pressure of the

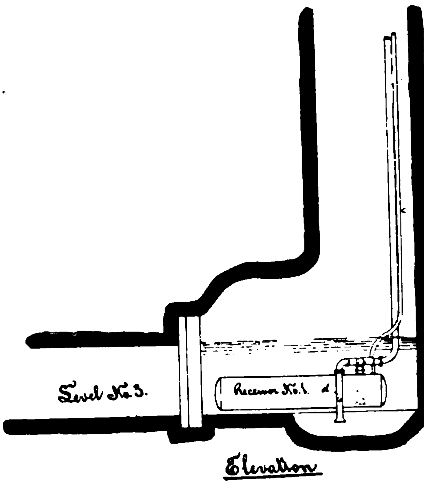


FIG. 2. SECTION OF SUMP SHOWING ARRANGEMENT OF TANKS.

atmosphere; on reaching this point and the compressor still running and having no other source of supply (it should be noted that there is a small loss of air through leakage and the working of the switch, as this latter is exhausted into the atmosphere, this loss is made up by a supply of air through a small check valve on a three-eighths inch pipe, fixed to the low pressure inflow pipe), it follows, therefore, that all the air in the system is extracted, and finally a partial vacuum is created within the tank and pipe line of that side of the system; this vacuum continues to increase until it reaches a point where the atmospheric pressure on the surface of the water overcomes the weight of the inlet valve on the suction pipe connected to the tank, and the water rushes in, filling the tank. The vacuum will vary with the height of the water; if below the tank, switching will take place at about 11 inches; if above the tank, at 4 to 5 inches or less.

The switch in general appearance resembles a direct acting steam pump, having what corresponds to both steam and water ends. At what would be the steam end, there is a vertical cylinder serving the purpose of the valve; in this works a piston. The space above the piston is directly connected with the air inlet of the compressor, but the space under this piston is open to the atmosphere; it therefore follows that as the low pressure cylinder exhausts the air out of the tank and the pipe connecting it with the switch, creating a vacuum, a vacuum is necessarily thus produced above the little piston; when this point is reached, the atmospheric pressure pushes the piston upwards, and this in turn being suitably connected with a rotary valve on a ¼ inch pipe connected with the high pressure air pipe, opens this valve, admitting the air, which acts upon another piston similar to the steam piston in an ordinary pump. This latter piston is directly connected with a plunger, corresponding to the water-end of a pump, but this latter acts as a valve, opening or closing the passages leading to the pipes connecting compressor and tanks with the switch.

The drawings that accompany this brief description give a general view of the arrangement of the "Harris System of Air Lift" as applied to the raising of water at the Deloro Mine.

Figure 1 gives a plan and elevation of the system as installed, while Figure 2 shows the third level retaining wall and sump in section.

Referring to the drawings, *a* is a cross-compound steam and air Rand drill compressor, type B, steam, 10-16-16, air, 14-8-16; *a* is a condenser; *b* is the switch located in the engine-room; *c c'* are 3 in. air pipes leading from the compressor to switch, and from switch to tanks, in the mine; *d d'* are the tanks, each 4' x 20' with an approximate capacity of 1,800 gallons each; *e e'* are the suction pipes; *f f'* the valves on the delivery pipes *f*² the 8 in. delivery pipe; this, as also the air pipes, *c c'*, are securely clamped between timbers, at intervals up through the shaft, and from the collar of the shaft are laid together until they reach the compressor building; here the air pipes are connected with the switch, while the water pipe is secured under the eave of the house, running the full length of the building, 75 feet, and from thence up the hill on trestles, until it reaches the mill at the level of the ore floor, a total vertical height of 65 feet, above the collar of the shaft; here the pipe empties into a tank, *g*, 6 feet in diameter, by 8 feet deep; this tank is in turn connected with another tank, *g'*, at the opposite corner of the mill; these are the supply tanks for the mill; *h* is an 8 inch overflow pipe connected through the bottom of the tank, *g*, and leading back to the circulating tank, *i*, in the compressor building.

This was done to obviate any waste of water, which might otherwise occur if the mill at any time needed less water than the regular supply.

On the delivery pipe, *f'*, at *f*², a 6 inch branch is fixed, leading to the circulating tank, *i*; on this 6 inch pipe is a valve, *f*³, for the purpose of regulating the amount of water needed for the compressor condensers.

For about four to six months in the year all the water raised by the air-lift from the mine is needed at the mill, and during this time, the condensers, as also the boilers at the compressor, are supplied by an auxiliary pump located on the river; (*j* is a 20-drill cross-compound steam, single acting air, Rand compressor, furnishing air for all underground work, *j'* the condenser); *l* a battery of three, 100 h. p. each, return tubular boilers.

Fig. 4 shows the position of the tanks in the mine; it will be noticed that these are located at the bottom of a shaft ending on the third level. As already explained, nearly all the water of the mine is confined to this place, the fourth level is almost dry, as is also a winze lately sunk to the fifth level; it is also pointed out that work is being pushed to pass under the bottom of the water shaft, leaving 50 feet of the ore in place.

When this air-lift was put in, it was thought quite probable that the water would break through to the fourth level, it was therefore specified that the lift should be capable of lifting 500,000 U. S. gallons per 24 hours from the fourth level, this would add about 70 feet more to the vertical lift. The makers of the plant have given a guarantee that the plant will perform the above duty, should it be necessary to move the tanks down.*

The writer would like to give more detailed data covering the efficiency of the plant, but owing to the fact that the steam used for the lift is drawn from the same boilers that are supplying the larger compressor, and this latter running constantly, there has been no opportunity to make a test other than a series of "cards" taken at intervals of 15 seconds, throughout the cycles, both from the steam and air cylinders.

These cards are very interesting, showing the variations throughout the whole cycle—there are no two cards alike, but the very fact of this variation makes them of little value—no information of value can be deducted from them.

A table showing these variations is hereto attached. — J. P. KIRKGAARD, Deloro, Ont., in *Canadian Mining Review.*

*This plant has been in operation continuously for over a year, raising from 300,000 gal., the minimum, to 650,000 gal., the maximum, per 24 hours.

INDICATOR CARDS, TAKEN JUNE 8TH, 1901.

HARRIS AIR-LIFT CROSS-COMPOUND AIR COMPRESSOR ENGINES.

No. Card.	Time in Cycle.	Gauge reading H. P. Steam.	Gauge reading L. P. Steam.	Gauge reading H. P. Air.	Gauge reading L. P. Air.	Revolutions per minute.	End of Cylinder.	Card taken by	Remarks.
1	Start Switch......	90	25	110	20	124	Both.	Swallow	
2	15 seconds........	90	28	105	110	120	"	and	
3	30 "	90	30	110	105	140	"	Donaldson	
4	45 "	90	30	95	95	148	"	"	
5	1 minute.........	89	30	95	80	120	"	"	
6	1 "	90	31	93	80	144	"	"	
7	1¼ "	89	30	93	60	144	"	"	
8	1¼ "	90	30	92	75	120	"	"	
9	1½ "	90	28	91	55	148	"	"	
10	1½ "	90	28	92	45	144	"	"	
11	1½ "	90	27	90	40	148	"	"	
12	1¾ "	90	26	92	45	128	"	"	
13	1¾ "	91	25	91	42	132	"	"	
14	2 "	89	25	91	40	124	"	"	
15	2¼ "	89	22	91	34	148	"	"	
16	2¼ "	90	23	92	35	124	"	"	
17	2½ "	89	23	90	30	148	"	"	
18	2½ "	91	23	91	35	136	"	"	
19	2½ "	90	22	92	33	140	"	"	
20	2¾ "	89	22	92	30	140	"	"	
21	3 "	90	22	91	32	144	"	"	
22	3¼ "	91	22	91	30	136	"	"	
23	End of Cycle.....	90	21	92	30	132	"	"	

COMPOSITE CARDS.

No. Cards.	Time from.	Steam. H. P.	Steam. L. P.	Air. H. P.	Air. L. P.	Rev.	End of Cylinder.	Remarks.
24	0 to	90	20	110	20	140	Crank.	High and low pressure cylinders.
	30 sec.	90	30	90	100	140		
25	1½ min. to	90	28	92	50	131		—
	2 min.	90	23	92	35	131		
26	2½ min. to	90	22	92	30	127		*Composite Card Explained.*—
	3 min.	90	22	92	30	127		Pencil kept in contact with
27	0 to	90	20	110	20	132	Head.	card during the 30 seconds.
	½ min.	90	30	100	100	132		
28	1½ min. to	90	27	93	50	143		
	2 min.	90	23	92	35	143		
29	2½ min. to	90	22	92	34	134		
	3 min.	90	22	92	30	134		

AIR CYLINDERS.

30	Switch..	90	20	60	20	136
31	½ min.	90	30	100	105	136
32	1 "	90	31	90	82	148
33	1½ "	90	29	93	60	140
34	2 "	90	25	92	40	152
35	2½ "	90	22	92	35	144
36	3 "	90	22	92	32	120
37	3½ "	90	21	92	30	142

Electro-Pneumatic Control of the Moon Island Sewage Reservoir.

The term "electro-pneumatic" is a familiar one to railway signal men, and from what is known of the possibilities of pneumatic operation under electrical control in that field, it is not surprising that useful application should be found for the system in other lines of engineering. At the Moon Island sewage reservoir, in Boston, there is an installation of Westinghouse electro-pneumatic apparatus and machinery which controls the flow of sewage into and out of the reservoir, the appliances in some respects being similar to the controlling part of the electro-pneumatic push-button machine for operating railway switches. Before describing the appliances now in use a resume of the sewage systems of the city may be of interest and also may assist those who are unfamiliar with the subject to understand more fully the functions accomplished and the causes which led to the present installation.

Under the old system, all sewers terminated at tide gates at different points in the harbor, these gates opening and allowing discharge as the pressure in the sewers overcame the resistance of the sea at low tide, and closed again as the tide raised and pressure became greater from the sea side.

During flood, high water and part of the ebb tide, sewage was necessarily stored in the sewers themselves, and this, during or after heavy storms, led to a congested condition which caused either a backing up of the sewage and gases into dwellings and stores or a premature discharge, which if taking place just after low water and continuing for a time, would cause sewage to be carried to all parts of the harbor amongst the shipping and around the wharves. Even under normal discharge conditions large quantities of sewage covered much of the surface of the upper harbor.

Obviously it was necessary that some system be adopted which would provide a more sanitary condition along the water front of the city, and the solution of the problem seemed to be in the construction of storage reservoirs (at a point in the lower harbor) of sufficient capacity to care for all sewage during such times as the tide was not favorable for its immediate passage to sea upon discharge; the rearrangement of the existing sewers in order that their flow might be centralized for passage to the reservoirs; and the erection of new sewers from such a point of centralization.

FIG. I—MOON ISLAND SEWAGE RESERVOIR, BOSTON, MASS.

The location for the reservoir was found at Moon Island, where channels from both Dorchester and Quincy bays offer a strong tidal flow and where condictions affecting both erection of reservoirs and sewer to the main land offered least difficulty in the way of engineering. Means of centralizing the flow of all the main sewers to a point convenient for connection to Moon Island were found in a system of intercepting sewers converging at a point on Dorchester Bay (at what is known as the Cow Pasture) and communication with Moon Island, a distance of something over two miles, to be effected by sewer, part of which should pass under Dorchester Bay to Squantam and thence over a partially submerged neck of land to the location of the reservoir.

With a system as outlined above, sewage from all parts of the city would flow by gravity to the terminus of the intercepting sewer at the Cow Pasture, but in accomplishing this a level of 14 ft. below low water was obtained. Conditions effecting a prompt and thorough outflow from the reservoirs (by gravity) required that they be at a level above low water and to obtain this high level desired, a pumping plant was found necessary, its function being to elevate from a depth of 14 ft. to an altitude sufficient to give head for flow and discharge. The most suitable location for such a plant was at the Cow Pasture.

RESERVOIRS.

The reservoir at Moon Island (Fig. 1) is divided into four basins (No. 1 being on the west side) built with bottoms of concrete covered with asphalt and with walls of granite blocks laid in cement, their total capacity being 50,000,000 gallons. At the northeast corner of Basin No. 4 is located the engine house, and from it, extending across the north end of all the basins, is a gallery under which is a chamber, and by way of this chamber communication, from the inflow or "high-level" and outflow or "low-level" sewers, is obtained to the basins.

Sewage from the pumping station enters at the west end through the high-level sewer and by means of a series of gates passes into the different basins at time of storage. Under discharge conditions sewage from the pumping station flows direct

FIG. 2—PNEUMATIC CYLINDER FOR LIFTING FLUSH GATE.

through the chamber, and that in the reservoir (by opening the gates) mingles with it, both flows finding exit through two sewers, at a level of one foot above low water, which lead from the east end of the chamber to the sea.

GATE OPERATION.

Power generated by a turbine operated by the sewage flow is utilized for opening and closing the gates which control the filling or discharging of the basins. This turbine is placed in a well under the engine house and by opening a gate (manually controlled) the flow of sewage is directed against it, causing it to revolve.

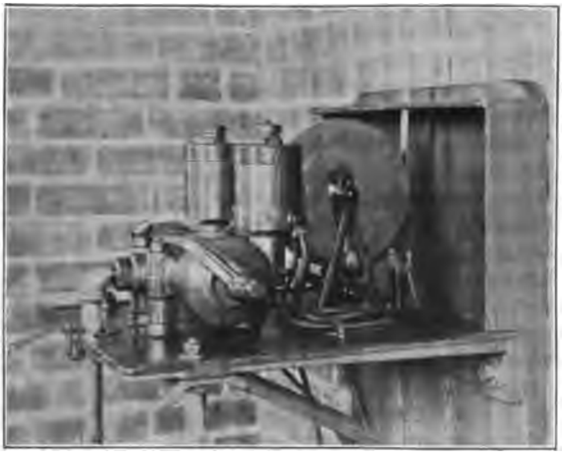


FIG. 3—ELECTRO-PNEUMATIC VALVE MECHANISM.

To the turbine shaft is connected, by means of clutches and bevel gearing, a line of shafting which extends the full length of the gallery and is in turn connected, by gearing, to the different gates. A separate line of shafting runs to a machine shop and furnishes power for the machines used in making repairs. The position of the turbine well is such that either storage or discharge flow is available, and consequently power from this source is constant.

FLUSHING.

Both inflow and outflow in the basins, being from one end and of low velocity, allow a deposit of sediment to be left on the bottoms after each discharge and this in time would necessitate the shutting off of the basins for cleaning purposes. This difficulty is overcome by flushing. Sewage at a high velocity is introduced at the opposite end of the basins from the chamber, the head thus obtained having sufficient force to carry all sediment the full length of the basins and out by the discharge gates. A small sewer for this purpose branches from the high-level sewer and is carried to the rear of the basins, where "flush gates" are installed to control the flow.

Owing to the length of the basins, the operation of these gates by the turbine-driven shafting is impracticable, and if operated by manual power would entail an additional force of men whose services would be required only at such times as flushing was actually in progress. Consequently, a system which would make use of the energy supplied by the turbine and be admissable of carrying the power thus generated to a considerable distance for application is found in the use of compressed air controlled by electricity, as arranged in the Westinghouse electro-pneumatic devices, some slight alteration from the standard form in use on railways being necessary to suit the special application here.

The essential features embodied in this installation are: First, the operation of one to four gates located at a distance of from

950 to 1500 ft. from the center of control; second, a power sufficient to operate under varying heads of flow, causing a variance of power required; third, a means of control for each or all gates, by which any one or all may be opened or closed; fourth, an indication of their position, closed or open or in motion.

erected over the flush gates, it being there connected to the operating mechanism. All pipe is carried under ground in hard pine trunking and auxiliary reservoirs are located in manholes at points of connection to the houses and also at the exit of the main air pipe from the engine house. These collect any moisture or sediment

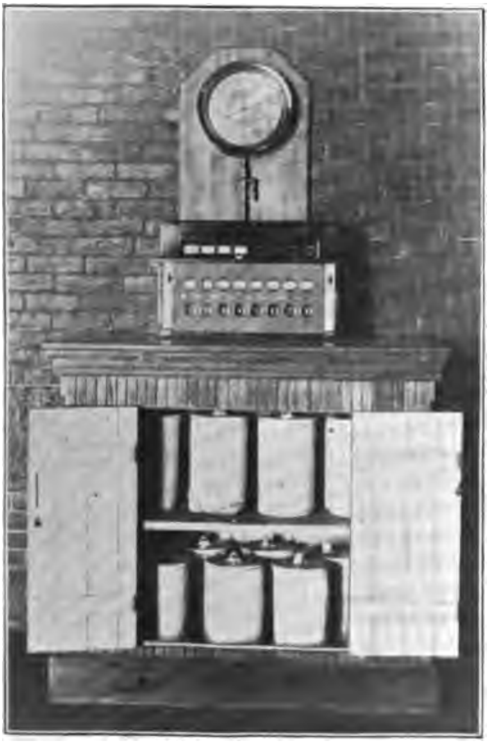


FIG. 4—PUSH-BUTTON CONTROLLING MACHINE.

POWER.

Operating power is supplied by an Ingersoll-Sergeant air compressor belt driven from the shafting connected to the turbine. It has a capacity of 69 cu. ft. per minute, at a speed of 120 revolutions. From the receiving tank, located in the engine house with the compressor, a main $1\frac{1}{2}$-in. air pipe is carried along the east side and south end of the basins, and from it $\frac{3}{4}$-in. pipe branches into the four houses which may be contained in the air pipe and carried along by the air, and by means of blow-off cocks may be emptied at any time, thus insuring a supply of clean, dry air at the point of appliance.

The flush gates are of iron and raise vertically through grooves in a frame fastened against the granite wall, friction being minimized by the use of composition metal plates on the sliding surfaces; and to insure a minimum leakage are forced tight against the frame, when down, by wedges attached to the four corners of the gates, the weight of the gate being sufficient to cause the wedges to perform their function. Connected to the gate is the piston rod of a 4 ft. x 10 in. vertical cylinder or ram (Fig. 2) and by the introduction of air at sufficient pressure above or below the piston head, the piston is forced up or down, thus opening or closing the gate. Pipes of ¼-in. diameter are tapped into the top and bottom of the ram and are carried to an electro-pneumatic switch cylinder valve mechanism, placed on an iron shelf against the side of the building, as shown in Fig. 3.

FIG. 5—INFLOW OF SEWAGE TO BASIN.

CONTROL.

In the engine house a cabinet containing 15 cells of Edison-Leland battery, the only source of electrical energy required, is used as a support for the push-button machine by which the operation of the gates is controlled and in which the indication is shown. No interlocking of the gates being necessary, the circuits required for their control and the indication of their position, is carried on two No. 9 H. D. C. water-proof wires for each gate, the air pipe affording ample means of common return. All wires are run underground in the same trunking with the pipe, but in a separate groove, and as an extra precaution against injury by the action of sewer gas, both are covered with pitch poured over them while hot.

From the machine a 10-wire cable (two wires being spare) is carried to gate house No. 4; from house No. 4 to house No. 3 a six-wire cable is run; from house No. 3 to house No. 2 a four-wire, and from house No. 2 to house No. 1 a two-wire, the cable in each of the houses being brought to a terminal board. This is done to facilitate the tracing and location of any trouble which might occur, all wires being in practically short stretches.

In the gate houses the wires are connected to the magnets controlling the motion of the slide valve, which by assuming either of two positions, admits air into the pipes to the ram for an upward or downward throw, and by the use of a mechanical arrangement of gears, connected by wire run over pulleys to a light rod which projects through the top of the ram, and being a continuation of the piston travels with it, a new circuit is formed, remaining constant while the gate is in operation and ceasing when the gate reaches either extreme position, up or down. By this latter circuit indication is made in the machine in the engine house, where, during the movement of a gate a corresponding marker shows "red," but upon the completion of the stroke and a consequent ceasing of the current, the marker is released and assumes a new position by gravity where it shows "white."

The controlling buttons in the machine are in pairs, one above the other, as in railway switch operation, and as the upper one is pushed in by the one movement setting the indication arm and making contact which forms the circuit for raising the gate, the lower one is forced out and in this way the position of the buttons indicate the position of the gate.

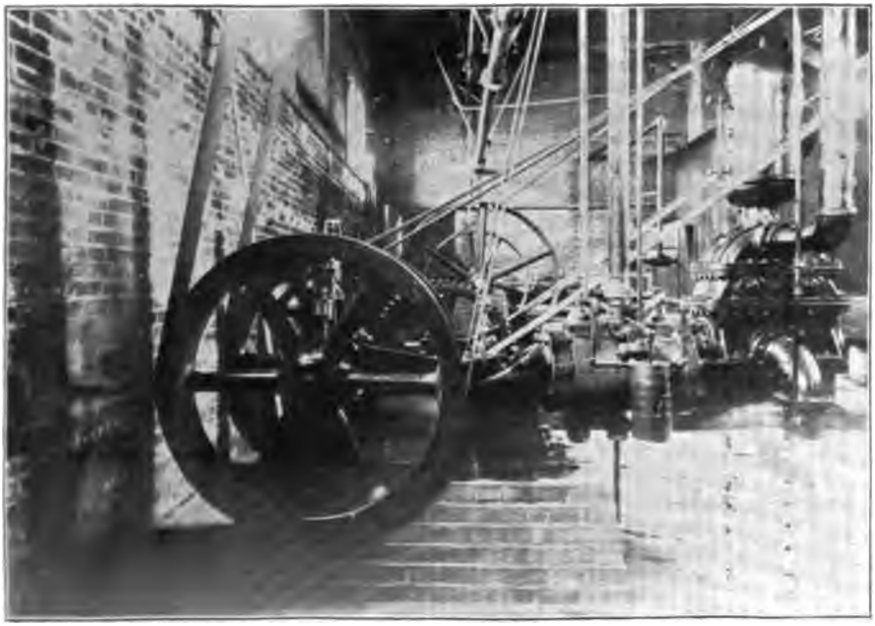


FIG. 6—AIR COMPRESSOR PLANT, MOON ISLAND SEWAGE RESERVOIR.

The two pipes from the slide-valve to the ram are used alternately as a passage for air applied in the ram or exhausted from it, the exhaust reaching the open air through a small chamber which is part of the valve. On the up-stroke, for opening the gate, air is admitted to the bottom of the ram, and as the piston is forced upward the air above is exhausted through the pipe connecting the top of the ram with the valve mechanism. On the downstroke, for closing the gate, the operation is reversed, the top pipe acting as supply and the bottom as exhaust.

The gates weigh 1,500 lbs. and this, when the weight of the piston, the friction in the ram and on the sliding surfaces is added, will be equal to about 2,000 lbs. to be lifted. With no head in the sewer the gates rise at 15 lbs. pressure, and with extreme head at 35 lbs.

On the down stroke, the weight of the gates, etc., would have a tendency to cause a rapid fall if the pressure supporting it was at once discontinued. To obviate this difficulty a swing check valve having a small hole drilled in the seat, is so inserted in the pipe from the bottom of the ram that pressure to the ram causes a full opening, but exhaust causes it to close, the drilled hole allowing but a small escapement of air, which, by its slow passage, forms a cushion in the ram and offers sufficient resistance to prevent any sudden fall. Shortly before the time of flushing, the compressor is thrown into service and in about 15 minutes enough air (a gauge pressure of 35 to 40 lbs.) is stored in the receiving tank and pipe line for the operation of all the gates. The compressor may then be shut down until air is again wanted for another operation.

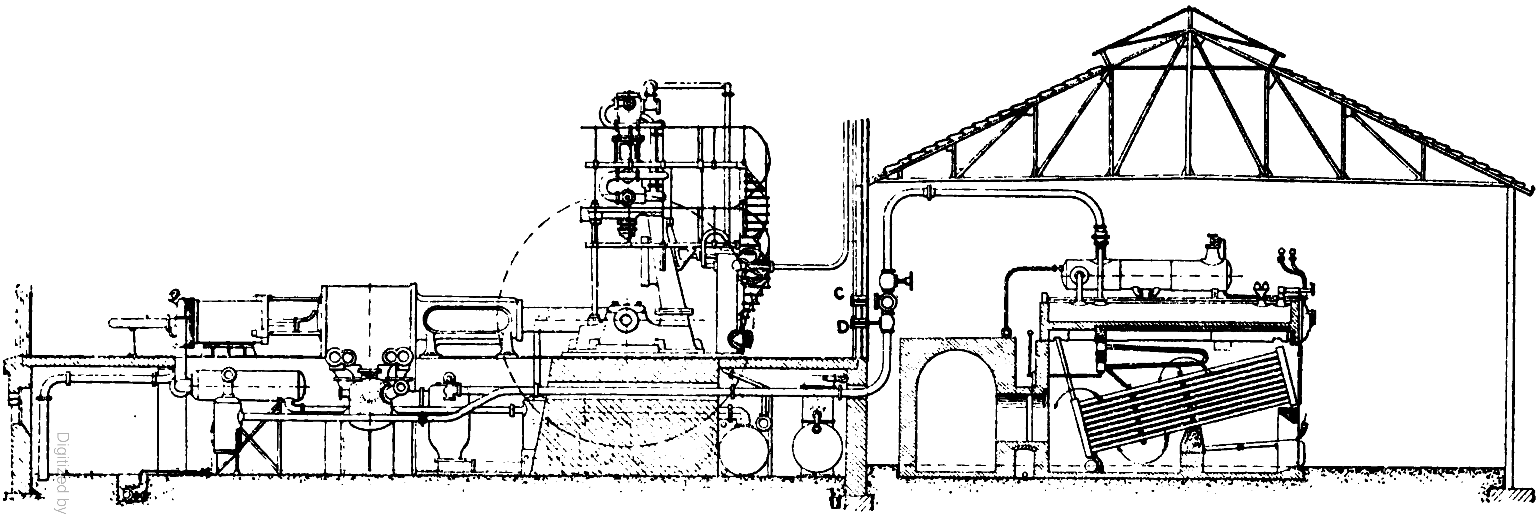
During the almost ten years of the operation of this plant, no changes have been made except the enlarging of the basins to twice their original capacity, this enlargement making necessary the system of flushing which has now been installed for a period of six months. At the pumping station a shaft 140 ft. deep connects with the sewer under Dorchester Bay, this sewer having a diameter of 7½ ft., being constructed through solid rock. The sewer from Squantam is 11 x 12 ft. inside, and the outflow sewers from the chamber are the same size, but two in number. Storage of the basins takes place for 20 hours each day and 4 hours is allowed for discharge, this being ample time, for the sewage passes out at the rate of 1,000,000 gallons per minute, and the basins may be emptied in about 50 minutes. During discharge, sewage is noticeable for about two miles down the harbor, but in a short time after closing down it is so thoroughly mixed with the salt water that it is entirely lost to observation.—*Railway and Engineering Review.*

The Billancourt Compressed Air Plant, Paris.

The General Omnibus Company of Paris, France, has built at Billancourt, a suburb to the southwest of the city, a plant of about 7,000 horse-power capacity for the purpose of compressing air to 1,140 pounds per square inch and distributing it to different charging stations along the routes of its compressed air cars. The works are situated on the right bank of the Seine about 5,000 feet below the fortifications of Paris, and form a group of buildings, the largest containing the steam engines and compressors, a smaller one the steam boilers, and a number of detached buildings, one of which is a storage or accumulator building for compressed air. About a year ago 148 cars were in use, with 100 to 120 in operation simultaneously.

The boiler house is 53.5 feet wide and 249 feet long. There are 16 boilers of the Babcock & Wilcox type, set in eight batteries of two each. Each boiler has 2,260 square feet of heating surface, and, besides two steam drums, has a reservoir above the drums forming a steam collector and separator. This is about 31.5 inches in diameter and 14.75 feet in length. Four economizers, each with a heating surface of 2,690 square feet, are placed in the passage of the gases of combustion, and in running service furnish water to the boilers at about 150 degrees Fahrenheit. The smoke passage is located immediately back of the boilers in a masonry tunnel extending the whole length of the boiler room and communicating at each end with a chimney. One chimney is of brick, 197 feet high and 8.2 feet in inside diameter at the top; the other is of sheet metal, 105 feet high, formed into an inverted truncated cone for operation with mechanical draft. The two chimneys may be rendered independent by means of dampers behind each pair of boilers so that the 16 boilers can be operated in two distinct batteries. The cross-section of the smoke passage is about 67.2 square feet. The normal boiler performance is 2.66 pounds of steam per square foot of heating surface, but it is stated that 13,200 pounds of steam are easily obtained per hour from each pair of boilers.

The steam is taken from the steam collector of each boiler in a pipe 5.9 inches in diameter, curved upward from it and then



SECTIONAL ELEVATION OF THE BILLANCOURT COMPRESSED AIR POWER STATION, PARIS, FRANCE.

downward into the top of a steam header placed back of the boilers along the wall separating the boiler from the engine room. The supply pipes to the various steam engines in the compressor room are taken from the bottom of the steam header and carried overhead in a basement story to a separator from which the pipe passes upward to the engine cylinder. The valves dividing the steam header into various sections and the valves in the supply pipes to the steam engines have long stems and the valve wheels come within the engine room at man's height above the floor so as to be readily controlled. The engine room contains seven three-stage compressors with triple-expansion condensing steam ends, and four simple condensing engines, the latter driving jack shafts and in this way various electric generators. This room is served from a 15-ton traveling crane bridging the entire width. The piping, condensers, etc., are located in the basement. The engine room is 351 feet long, 69 feet wide and 42.7 feet high in the clear above the floor; the rails of the traveling crane are about 27.4 feet above the floor.

The compressor engines are of 740 horse-power capacity at 52 revolutions per minute and of about 985 horse-power at a speed of 70 revolutions per minute. The steam end, which was constructed by Messrs. Dujardin & Company, of Lille, consists of a high and medium pressure steam cylinder on one side of the engine and a low-pressure cylinder in tandem with the low-pressure of first-stage compression cylinder on the other side; the air end, which was constructed by Messrs. Brissonneau & A. Lotz, of Nantes, consists of a low-pressure cylinder in tandem with the low-pressure steam cylinder, as stated, and of medium and high-pressure air cylinders arranged vertically side by side and driven by cranks from the main shaft. Each compressor has two flywheels, one on each side of the upright portion of the machine; they are 21.3 feet in diameter and weigh 33,000 pounds each. Steam cylinders are 51.2, 31.1 and 20.2 inches in diameter, and the common stroke is 55.1 inches. The air is furnished at a pressure of 1,140 pounds per square inch, but this, it is said, can be raised to 1,420 pounds. The compression is carried to about 57 pounds in the first stage, to 355 pounds in the second and to the figures given in the third. There is one cylinder for the first stage, and two each for the second and third; and all are single-acting. The diameter of the low-pressure cylinder is 39.3 inches, and it has the common stroke of the engine, 55.1 inches; the diameters of the medium and high-pressure cylinders are 22.5 and 10 inches, respectively, with a stroke of 22.5 inches. It is said that the arrangement of a single-acting air cylinder in tandem with the steam cylinder, as described, has proved defective, in the sense that the system is thus out of equilibrium, and it is proposed to replace the cylinder with one double-acting.

A peculiarity about the first stage of the compression is that the air is cooled by spraying water into it as it leaves the cylinder. The water is delivered by a pump driven from an eccentric on the main shaft of the compressor unit, and its supply is regulated by a valve to about 0.24 gallon per pound of air compressed. From the low-pressure cylinder the air is taken to an intermediate reservoir, which acts as a regulator, and from this is a smaller pipe, to give the air a sufficiently high velocity, into a second reservoir; in this it crosses a small column of water to free itself of foreign bodies which are liable to become entrained during its compression. The high and medium-pressure cylinders are vertical, as stated, and driven by cranks 180 degrees apart. The cranks of the steam engines are also set 180 degrees apart, but 15 degrees in advance of the compressor cranks to maintain at every instant as constant a relation as possible between the engine effort and the work of resistance.

After leaving the high-pressure cylinders of the compressors, the air is passed successively through two cylindrical reservoirs, or dryers, each with a capacity of about 120 gallons. The compressed air is distributed through three sets of mains, two leading to the different charging points, and the third to the accumulator house. The mains are of welded steel pipes, 3.94 and 2.95 inches in diameter and in lengths of 64 feet. The accumulator house contains 280 reservoirs of 132 gallons capacity, with a total capacity of about 5,000 cubic feet. These reservoirs are divided into seven batteries, each battery consisting of four groups of ten reservoirs. They are built of steel plate, 1.65 inches thick, and are 10.5 feet high. The apparatus was tested to 1,890 pounds per square inch, is stamped for 1,420 pounds, and each group of 10 reservoirs carries a safety valve regulated for 1,280 pounds.

Tests show that 8.05 pounds of air at 1,138 pounds per square inch were obtained per indicated horse-power, and 5.94 pounds per pound of coal. One compressor produces about 7,050 pounds of air per hour. The cost of compressing the air when the plant was first operated was $3.85 per ton of 2,000 pounds, but it has been reduced to $2.45.—*The Engineering Record.*

Notes on Indicator Cards from Air Cylinders.

The principal uses of an indicator on the air cylinder of an air compressor are (1) to determine the amount of vacuum that is in the cylinder during the time the air is passing in; (2) to determine the pressure of the air in the cylinder during the time the air is being discharged in the pipe line; (3) to determine the amount of clearance that there is in the cylinder; (4) to determine the H. P. developed in the cylinder.

In applying the indicator the connection from it to the cylinder should be as short as possible, and to obtain the most accurate results an indicator cock and indicator should be directly connected to each end of the cylinder and cards taken from each end. It is, however, customary to run a pipe from one end to the other and connect the indicator in the centre with the necessary three-way valve or two cocks. For ordinary purposes this is sufficiently close.

In the case of a small compressor, say 6" x 6", the volume of air included in the usual ½" pipe from one end of the cylinder to the three-way cock in the centre would amount to about 2.5 cu. ins., or 1.5 per cent. of the cylinder volume. When compressing to 75 pounds pressure this would cause a loss in volumetric efficiency of 9 per cent., which loss would not occur when the indicator was not in use. In larger machines this loss chargeable to the indicator disappears, amounting in a 16" x 18" cylinder to 0.14 per cent. of cylinder volume, or a loss of 0.9 of one per cent. in volumetric efficiency when compressing to 75 pounds.

For the purpose of following the various parts of the card in Fig. 1 we will letter the several lines thus:

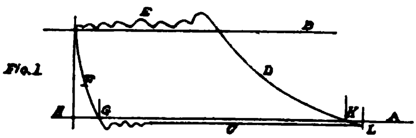


Fig. 1.

A is the atmospheric line and is the line drawn on the card by the indicator pencil when the indicator is cut off from the cylinder and there is no pressure under the indicator piston. This line should be very carefully drawn and care should be taken that the cocks are not leaking so as to allow pressure to accumulate beneath the indicator piston. A slight error in drawing this line will lead to very incorrect results when figuring the volumetric efficiency of the compressor.

B is the line indicating the pressure in the pipe line or receiver. This is not drawn by the indicator, but may be drawn in by hand on the card after the card is removed from the indicator. It should be parallel to line A and a distance above it equal to the observed gauge pressure in the pipe line or receiver.

C is the intake or suction line and is the line drawn when the air is passing into that end of the cylinder.

D is the compression line. This starts at the end of the suction line and rises as the piston compresses the air until it reaches a pressure sufficiently high to open the discharge valves. The air then begins to pass out of the cylinder and the pressure ceases to rise. E, the discharge line, represents this part of the card.

F is the expansion line and represents the drop from the discharge pressure to the suction as the piston at the end of the stroke ceases to discharge and once more begins to take in a new supply.

The following are the characteristics of the various lines:

Beginning with line C, there must always be a slight vacuum during the suction period, as this is necessary to cause the air to flow into the cylinder. The amount of vacuum depends on the size of the inlet ports, and the character of inlet valve; the smaller the ports and passages in proportion to the piston displacement the greater the vacuum, as the air has to travel so much faster while passing through same.

When a compressor is fitted with Poppet inlet valves having springs to close them there must be a vacuum in the cylinder sufficient to overcome the springs and suck the valves open. A wavy appearance in the suction line is caused by the valves fluttering on their seats. No sooner does the vacuum pull them open than the springs pull them shut only for them to be sucked open again. This is the usual action of this kind of valve.

A heavy wave at the beginning of line C is caused largely by the inertia of the indicator parts. The drop from line E to line C is so sudden that the pencil goes past the point it should stop at and then it vibrates a few times before settling down.

The vacuum shown during the suction stroke may vary from nothing to two pounds. With a mechanical or other positively moved inlet valve compressor under the maximum speed it should not exceed one and a half pounds at most. A compressor having spring closed inlet valves might exceed this by one-half pound.

At the end of line C the compression line D commences. This should be a smooth, even curve gradually rising until it reaches the discharge line E. It will cross the line B, as it is necessary for the pressure in the air cylinder to slightly exceed the pressure in the receiver before the discharge valves will open. There is usually a high crest at the end of line D, this being caused by the pressure in the cylinder rising so rapidly due to the high speed of the piston at this point in the stroke that the inertia of the discharge valve cannot be overcome quickly enough to prevent this excess pressure building up. The line E will have a wavy appearance for the same reason as explained in the cast of Poppet inlet valves. These waves are usually magnified by the indicator.

There is another cause for the fluctuations and waves that appear in the discharge line and that is the surge of the air in the pipe line between the compressor and receiver. At the moment that the air in the cylinder reaches discharge pressure the air in the pipe line is not in motion and as the piston forces the air out of the cylinder an excessive pressure is built up before the column of air in the pipe can be started, this in turn being followed by a drop sometimes below receiver pressure, as the air under the influence of the accumulated pressure acquires a momentum which carries it away faster than it is discharged from the cylinder.

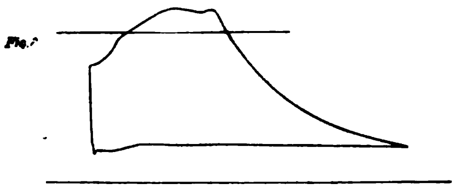


Fig. 2.

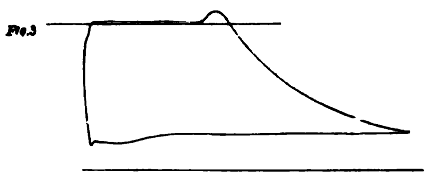


Fig. 3.

The frequency of or time between these surges appears to be constant for any given pipe line, and with different speeds of compression widely different discharge lines will be found. The two cards in Fig. 2 and 3 were taken from a compressor having the discharge valves opened and shut positively and the only difference in the conditions of the two cards were the speeds, being in Fig. 2, 64 R. P. M., and in Fig. 3, 96 R. P. M. In a machine running faster, say 120 R. P. M. or over, the surge would probably not be apparent, but it is evident that with a large compressor running slowly it is a factor to be considered.

In any card, however, there is apt to be a high crest at the end of the compression line even though the after surge is not evident.

In measuring the area of a card an average line should be taken midway between the high and low points. The line F should fall quickly down to line C. It represents the drop in pressure as the piston moves away from the cylinder head and the air in the clearance space expands from discharge pressure to suction pressure. This line should be smooth and even, but it will sometimes at high speeds have a broken or uneven appearance. This is due in part to the indicator and sometimes to the discharge valves not closing quick enough.

The volumetric efficiency of a compressor is the proportion of the amount of air actually delivered into the pipe line to the theoretical piston displacement of the compressor. To measure this from the card we proceed as follows, the total length H L of the card in Fig. 1 representing the stroke of the compressor: The point G, where the line F crosses line A, indicates the position of the piston when the air in the clearance space had expanded down to atmospheric pressure. This indicates that an amount of air at atmospheric pressure equal to G H was left in the cylinder at the end of the stroke and not discharged, it being bottled up in the clearance spaces. When the piston reaches the other end it returns to point K before the pressure in the cylinder reaches atmospheric pressure. We have, therefore, in the cylinder only the volume K H of air at atmospheric pressure to be compressed, and as the amount K H remains in the cylinder we only have the amount K G as the net amount delivered. As H L represents the full stroke of the compressor the proportion of K G to H L represents the volumetric efficiency of the compressor.

Should a discharge valve not be tight, the leaking back would be indicated on the card by line C rising and perhaps passing over line A. This would indicate that there was a greater pressure in the cylinder than outside and that consequently the cylinder must be getting air from somewhere under pressure. A more rapid rise of line D on one card than the other would also indicate a leaky discharge valve in one end or a leaky inlet valve in the other end, provided the point L on each end of the card was the same distance below line A.

When both ends of the cylinder are working properly the intersection of the two lines D should be exactly in the middle of the card. Should this intersection be much out of centre one end is not working properly.

The compression line should lie between the isothermal and adiabatic curves and for the convenience of any one who may wish to draw these curves on a card the following table of pressures is given:

TABLE OF PRESSURES IN AIR COMPRESSOR CYLINDERS.

Per cent. of Stroke.	Adiabatic.		Isothermal.	
	Initial Pressure 14.7 lbs.	Multiplier for any Initial Pres.	Initial Pressure 14.7 lbs.	Multiplier for any Initial Pres.
	Col. 1	Col. 2	Col. 3	Col. 4
10	17.05	1.160	16.33	1.111
20	20.12	1.368	18.38	1.250
30	24.29	1.652	21.00	1.428
40	30.18	2.053	24.50	1.667
50	39.01	2.652	29.40	2.000
55	45.26	3.072	32.67	2.222
60	53.41	3.633	36.75	2.500
65	64.46	4.385	42.00	2.857
70	80.08	5.447	49.00	3.333
75	103.5	7.042	58.80	4.000
80	141.7	9.640	73.50	5.000
85	212.5	14.460	98.00	6.667
90	376.1	25.57	147.0	10.00
95	998.1	67.90	294.0	20.00

To draw either curve divide the card into ten parts and draw vertical lines numbered beginning from point L. Then if the point L is on line A, or in other words, if at the beginning of the stroke the cylinder is full of air at atmospheric pressure the points on the several ordinates may be laid off directly from columns 1 and 3 of the table. If the compression line does not begin on the atmospheric line as when there is a vacuum or in the case of the high pressure cylinder of a compound compressor the absolute pressure at point L must be multiplied by the multipliers in column 2 and 4 of the table. This should be done if the compressor is at an altitude which would cause an intake pressure of less than 14.7 pounds per square inch. The curve may then be drawn through the points

In using the above table it must be

borne in mind that the pressures given are absolute pressures and all measuring should be done from the line of perfect vacuum. In fact the safest way to do any figuring with compressed air is to reduce all pressure to absolute in the first place and after the results are obtained subtract the atmospheric pressure for the given elevation in order to obtain gauge pressures.

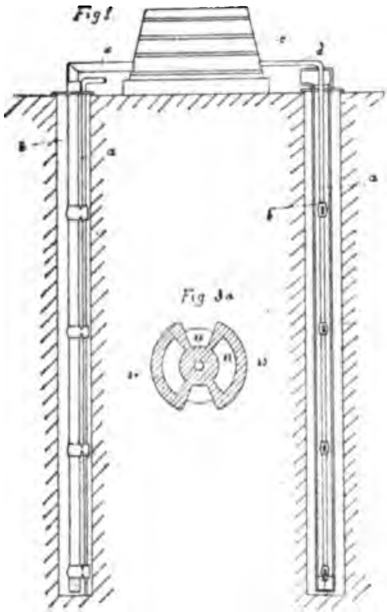
WARD RAYMOND.

Raising Liquids from Shafts, Boreholes, Etc., by Means of Compressed Air.

Under ordinary circumstances the pressure of air requisite for raising a column of water is equal to the height of the column in metres divided by 10.33, *i. e.*, if the column of water is to be raised 300 metres high, the pressure of air will have to be 29 atmos., which would entail the erection of a powerful compressing plant, and would, moreover, overtax the strength of the pipes met with in commerce. The necessity for such a course, however, is obviated by the author's new process, enabling liquids to be raised from any depth by compressed air, the pressure of which does not exceed 5 atmos. This object is accomplished by introducing the compressed air into the column of liquid at various levels or points of the upcast pipe instead of at the bottom, so that each jet of air has merely to lift such part of the column as lies between it and the jet next above. Thus, in the case of a column 300 metres high, if 10 compressed air jets be employed, the pressure of 29 atmos. is divided by 10, so that each jet will only need to have a pressure of 2.9 atmos., and therefore no costly compression plant will be required.

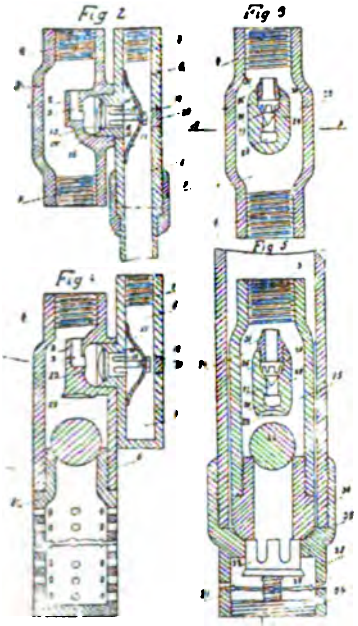
Several modifications in the manner of performing this method are illustrated in the accompanying drawings. Fig. 1, for instance, shows on the right a form of plant in which the upcast is enclosed in the air pipe, while on the left of the Fig. the two are arranged side by side. Fig. 2 represents a longitudinal section of a modification of the jets in the case of the external air pipe, and Fig. 3 is the corresponding application to the internally situated air pipe. Fig 3A is a section along AA of Fig. 3: Fig. 4 is a longitudinal section through the bottom of the apparatus referred to in Fig. 2; and Fig. 5 is the corresponding portion of that relating to Fig. 3. Fig. 6 is a device for regulating the admission of compressed air to the jets.

In Fig. 1, left side, *a* is the air pipe and *b* the wider upcast pipe for the liquid. At certain intervals in the height of these pipes jets are provided for the admission of air to the upcast. These jets consist of short lengths of pipe, *l* (Fig. 2), with screw connections top and bottom for attaching them to the upcast pipe, *b*. In the centre of the short pipe is a small button, 2, which is pierced by a small bore, 3, bent at right angles, for the passage



of air. A second short length of pipe, 6, fitted with a female screw at the top and a male screw at the bottom, forms part of the air pipe, and is provided with a lateral adjutage, 10, screwing into a corresponding recess, 11, of the pipe, 1; and thus connecting the lengths 1 and 6 firmly together. The adjutage, 10, is fitted with a central bore, 12, through which the compressed air passes from the air pipe into a hollow space, 13, and thence, *via* 3, into pipe 1. The central bore, 12, is provided with a valve, 14, which is kept in position on its seat by the pressure of a spring, 15, the tension of this latter being regulated by a nut, 18, accessible through an opening (in pipe 6) which is closed by a screw-plug, 20.

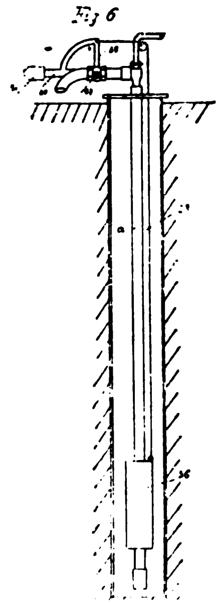
The apparatus for the bottom of the air and upcast pipes is somewhat different from the foregoing. At the bottom of the short length of pipe 1 is screwed a suction head, the upper end of which is so constructed as to form the seat of a suction valve. The stroke of this ball valve is limited by the button, 2, which is hollowed out at 23 to receive the ball at the end of its upstroke. The bottom length, 6, of the air pipe is closed at its lower end.



As the pipe must be quite full of liquid before the different jets can act simultaneously, it is necessary to provide a raised reservoir, *c* (Fig. 1), close to the borehole. This reservoir is filled with liquid, and is connected with the upcast pipe by means of a pipe, *d*, so that the upcast is always kept full.

The valve, 22, prevents the liquid running out of the upcast pipe, while the valves, 14, keep it from flowing back into the compressed air pipe. As soon as the upcast is full of the water or other liquid to be raised, the compressed air is turned on, and directly the air-pressure exceeds that of the liquid, the valves, 14, are forced open, and the air drives the liquid up the pipe. The fractions of the column raised by each jet do not exert any pressure on such portions of the column as are below them; consequently the incoming air is in equilibrium, as regards pressure, with the underlying portions of the column, and raises the supernatant portions, so that all the jets continuously aspirate the liquid, and force it up into the reservoir, *c*.

In order to secure the accurate working of the system it is advisable that the in-



tervals between the air jets should not be equal throughout, but arranged on an increasing scale. Thus in a 300 metre hole, one jet should be placed at the bottom, a second at a depth of 260 metres, the third 219 metres, the fourth at 177 metres, the fifth at 134 metres, the sixth at 90 metres, and the last one at 45 metres from the surface, the intervals thus increasing one metre each time from below upwards. This difference corresponds to a pressure of about one-tenth atmosphere, which compensates for the loss of pressure by friction in the air pipe.

In the right half of Fig. 1 is a modification with the upcast pipe, situated within the air pipe. Apart from the alterations necessitated by the changed posi-

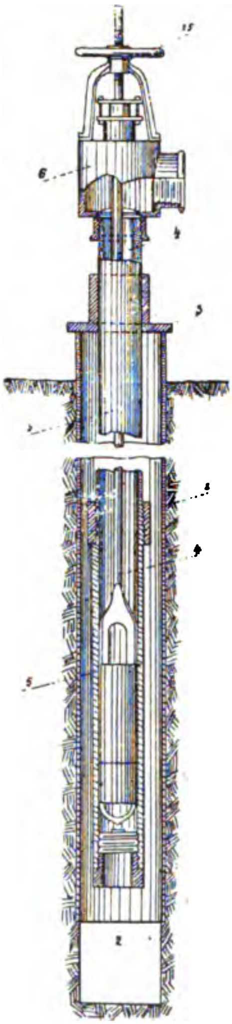


FIG. 7.

tions of the jets, the principle of working remains the same. The jets consist of a cylinder, Fig. 3, provided with two channels, 24, 25, communicating with the screw connections, 4, 5, by which the short length of pipe is attached to the upcast. The solid block, 26, separating the two channels, 24, 25, is pierced by a narrow central bore, 27, communicating with a lateral orifice, 28. The bore, 27, is kept closed by the weight of a triple-winged conical valve, 29, which moves in a chamber, 30, on the other side. A nozzle, 31, pierced by a bore equal in diameter to that of 27, is screwed into the chamber, 30.

The jet for the bottom of the pipes is arranged in a similar manner, except that the lower end is closed by a sleeve, 36, which is fitted with a ball valve, 22, the upstroke of the ball being limited by the hollow, 23, underneath the block, 26. The air pipe is closed by a suction head, 21, the valve of which, 32, is pressed upwards on to its seat by a spring, 33, which is supported by a plug, 34, thus preventing any influx of water into the air pipe so long as the valve is not forced downward from its seat. In this modification the air pipe is first lowered into the borehole, and then the upcast is put into position. The latter forces open the bottom valve, and rests on a ledge, 35, in the suction head, thus cutting off all connection between the valve, 32, and the air pipe, while opening communication between itself and the valve, and thus admitting liquid from the borehole. On now turning on the compressed air, the latter passes through the lateral orifices, 28, Fig. 3, into the upcast pipe, lifts the valve, 29, escapes through the chamber, 30, and nozzle, 31, and forces up the column of water between this jet and the next one above.

In boreholes the compressed air pipe can be dispensed with if the mouth of the borehole be hermetically closed, and the air blown into the hole itself.

Where, as in the case of some oil wells, the inflow of liquid is insufficient for the air blast to be kept continuously at work, the pressure of the compressed air is in the pipe, *a*, regulated by means of a float, 36 (Fig. 6), which works outside the air pipe and is connected by a chain, etc., 38, and lever, 39, with the compressed air tap, 37, the other arm, 40, of the said lever being provided with a counterpoise, 41. This float follows the rise and fall of liquid in the hole and automatically adjusts the air pressure accordingly, entirely closing the air tap (and reopening same) when necessary.

Another method of raising liquids is illustrated in Figs. 7 to 11, the fundamental idea of which is to produce the same effect as that exercised by the pressure of natural gas on petroleum in spouting wells. The apparatus consists of two sectional view of the lower part, and Figs. 10 and 11 are cross-sections along XX and YY of Figs. 8 and 9.

The outer pipe, 1, occupies the whole of the borehole, except for a small drainage pit, 2 (for the oil), at the bottom,

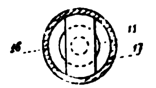


FIG. 11.

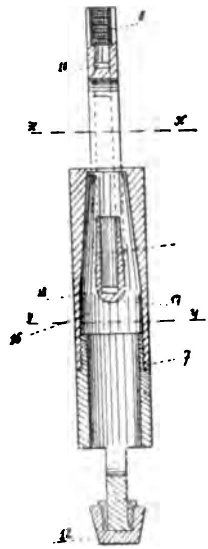


FIG. 9.

FIG. 10.

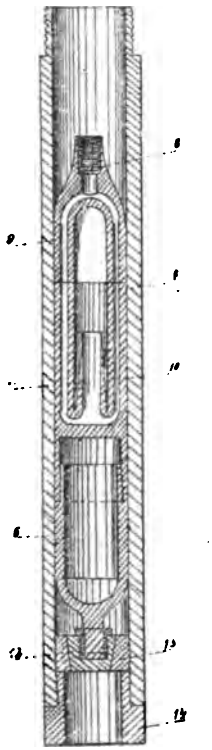


FIG. 8.

concentric pipes, the inner or air pipe being movable in a vertical direction and provided with a number of jets at intervals and a bottom valve, closing the outer or upcast pipe. Of this apparatus, Fig. 7, is a combined elevation and section, while Figs. 8 and 9 give a larger scale while the pumping apparatus, properly so-called, is suspended on this pipe by means of the flanged collar, 3, and consists of two concentric pipes, 4 and 5, the latter serving as upcast and terminating in a pump-head, 6. The compressed air pipe, 4, communicates with an air reservoir, traverses the pumphead, 6, and is screwed at the lower end on to a pump barrel, 7, wherein the air channel, 8, forks into two branches, 9 and 10, which again unite in a protruding nozzle, 11.

The lower end of the pump barrel carries a rotable valve, 12, the seat of which, 13, is screwed into the pipe, 4, and kept fast by a screw, 14. The valve, 12, can be opened or closed by turning the handwheel, 15, screwed on to the top of the air pipe, 4.

To work this apparatus the whole is lowered, with valve 12 closed, into the borehole, and the compressed air is turned on. This latter escapes violently through the nozzles, 11, and drives the air out of the pipe, 5. On then slowly opening the valve, 12, the oil is forced by the external air pressure in the direction shown by the arrow, passes the space 16, 17, and is forced upwards by the air. As soon as the hole is emptied, the air is turned off again until a sufficient quantity of oil has collected to make it worth while starting afresh.

With this apparatus the author has raised oil from a depth of 170 metres with compressed air under a pressure of 3 to 5 atmospheres.—Victor Petit, in *Petroleum Industrial and Technical Review.*

An Experiment in Traction.

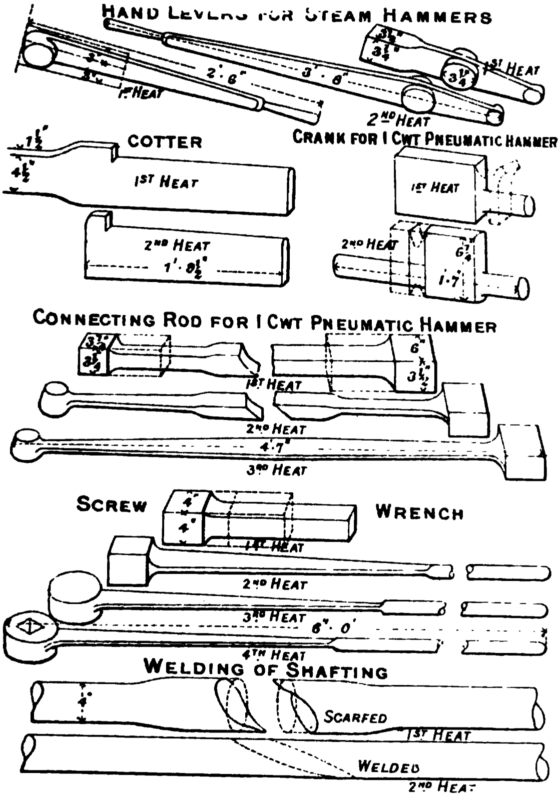
In consequence of the alliance formed between one of the great American houses which equip electric railways and the Budapest engineers, Ganz & Co., *The Tribune* recently remarked that the world was likely to hear a good deal about the use of alternating currents for traction in the future. An additional reason for thinking so has since been afforded. At the Great Barrington meeting of the American Institute of Electrical Engineers last month Bion J. Arnold described an experiment about to be tried in Michigan. He is providing the mechanism for operating an electric road now about twenty miles long, but destined to be extended to sixty. This will be the first line in America on which the alternating current will be employed. On the Lake Como line, equipped by Ganz & Co., the high voltage employed for transmission is reduced at sub-stations before entering the motive machinery under the car. On the Berlin-Zossen line the reduction is effected by a transformer on the car itself. Mr. Arnold will follow the latter plan on his experimental road. Notwithstanding the fall in voltage from 15,000 to 200, though, the current will still be of the alternating type.

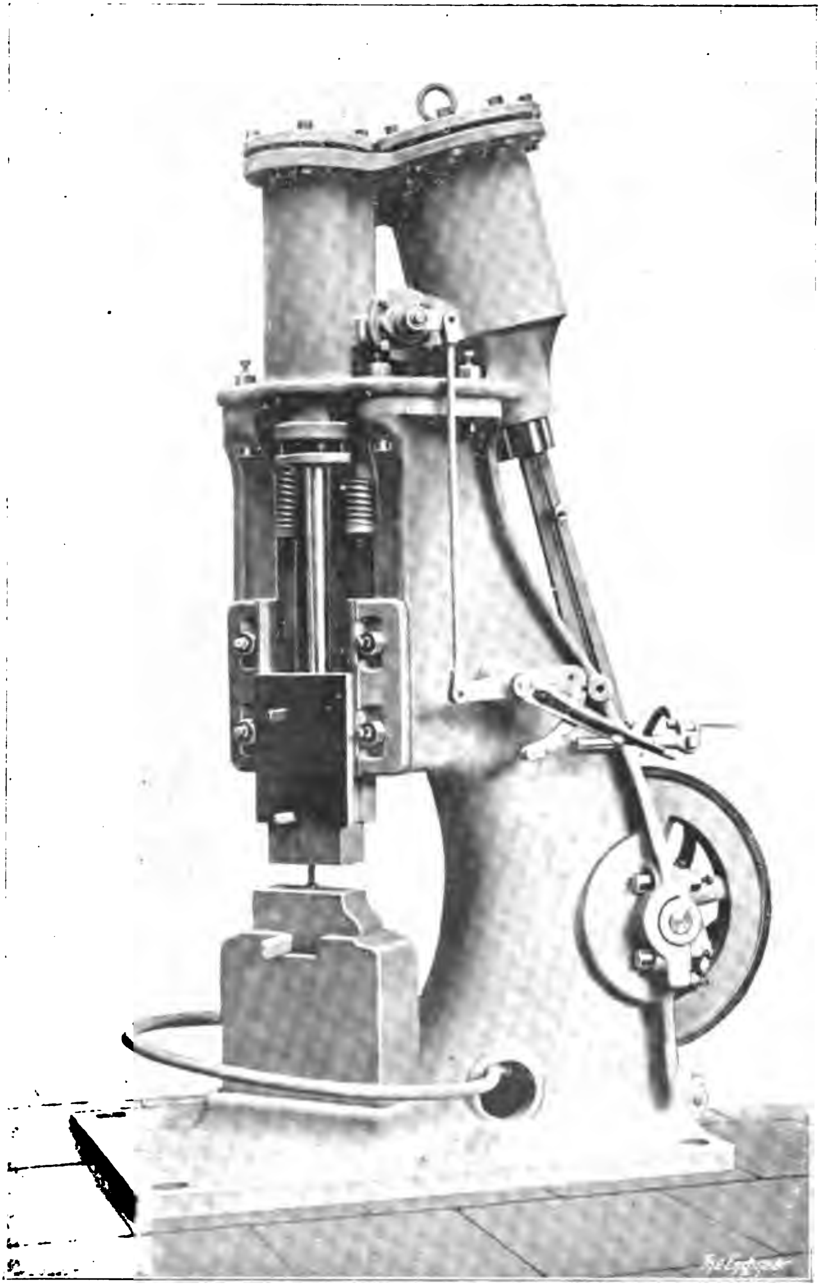
The most remarkable part of the system about to be tried is the motor. It will be unique in two particulars. Ordinarily the revolving portion of an electric motor moves only when the car is under way, and it stops when the latter does. Mr. Arnold has designed a machine resembling the gas engine which propels an automobile. This begins running before the vehicle starts, and keeps going when the carriage stops temporarily. The machinery under the electric cars of the new Michigan road will behave in the same manner, and, the inventor believes, effect a slight economy of power in consequence. The other innovation will be the combination of an air compressor with the electric motor, whereby mechanical energy will be stored when the latter is not run at the limit of its capacity. The reserve thus accumulated may be employed to supplement the motor when there is an extra demand for power, or to propel the car without any electricity at all, on a siding or in a city where the private right of way is abandoned for a short distance. In neither of these respects does Mr. Arnold's plan resemble any mechanism which has yet been tried in Europe, and for that reason the experiment is sure to prove the more instructive.

The author of this ingenious scheme is the expert who was retained a few months ago by the New York Central to formulate plans for equipping the terminal of that road in the metropolis for operation with electricity. He presented to the Great Barrington meeting an outline of his recommendations to that company. These did not call for alternating current motors. Another point of difference between them and the suggestions adopted for the Michigan line is that the latter are being carried out with the utmost expedition. Nobody seems to know when the Central will execute the programme laid out for it. From present appearances there will be ample time for Mr. Arnold to achieve a brilliant success in the West and then to advise the substitution of the new system for the one previously proposed for New York city.—*New York Daily Tribune.*

A Pneumatic Power Hammer.

We illustrate a pneumatic hammer now being constructed by Messrs. B. and S. Massey, of Manchester. In this appliance the object has been to make a hammer that, while driven by belt power, will do actually as much work, both as to size and speed, as a steam hammer of equal weight. In the construction of the hammer itself the makers have followed very closely the design of their usual smithy steam hammers, believing this to be the most satisfactory form. The hammer, instead of being operated by steam, is worked by a double-acting pump placed immediately behind, which supplies air in the place of steam at the top and bottom of the hammer cylinder at each stroke. The pulleys and crank are placed low down, in order to ensure steadiness for the hammer, and are of very compact design, so that they may be arranged within the standard. There are consequently no projecting parts, the hammer occupying scarcely more space than a steam hammer of similar capacity. A diagonal position has been given to the anvil block in order that the pallets on all sides may be accessible, and to allow of long bars being worked in either direction across the anvil. The hammer is controlled by a single valve, which is placed between the cylinders, and by varying the position of this valve by either hand-lever or foot-lever the operation of the hammer is promptly and easily regulated by the attendant. When the levers are in their top position air is forced only under the hammer piston, and the tup is held up at the top of its stroke, and remains stationary there. On either lever being depressed,





MASSEY PNEUMATIC POWER HAMMER

the air passes alternately above and below the hammer piston, and the hammer begins to work. The further the lever is depressed the heavier the blow, until the full blow is given. Thus light or heavy blows, with long or short strokes, can be struck at will, the regulations being easy, accurate, and instantaneous. As soon as the lever is released the tup rises to the top of its stroke, and remains there. Another useful feature is that the tup can be held firmly down on the anvil when it is required to use the hammer as a vice. This is frequently convenient for bending work, and for holding it during various operations. We have had an opportunity of inspecting one of these new pneumatic power hammers in operation at Messrs. Massey's smithy, and also specimens of the work done, which afforded proof of its efficiency. The work comprised all varieties of forgings; and as a test of the largest work that can be produced by a 3-cwt. hammer, as shown in illustration, a steel billet 8 in. square was drawn down at one heat to 2¼ in. square and 28 in. long. We illustrate some examples of the class of work done by this hammer.—*The Engineer,* London.

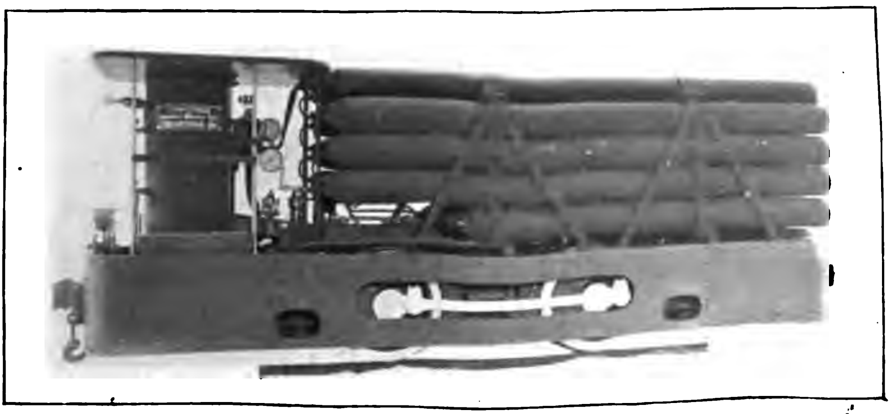
Compressed Air Locomotives Manufactured by Schweizerische Locomotiv & Maschinen Fabrik, Winterthur.

We present herewith two illustrations showing in some detail the appearance and construction of a type of compressed air locomotive which has been adopted and is now being used in connection with the construction of the Simplon Tunnel in Switzerland.

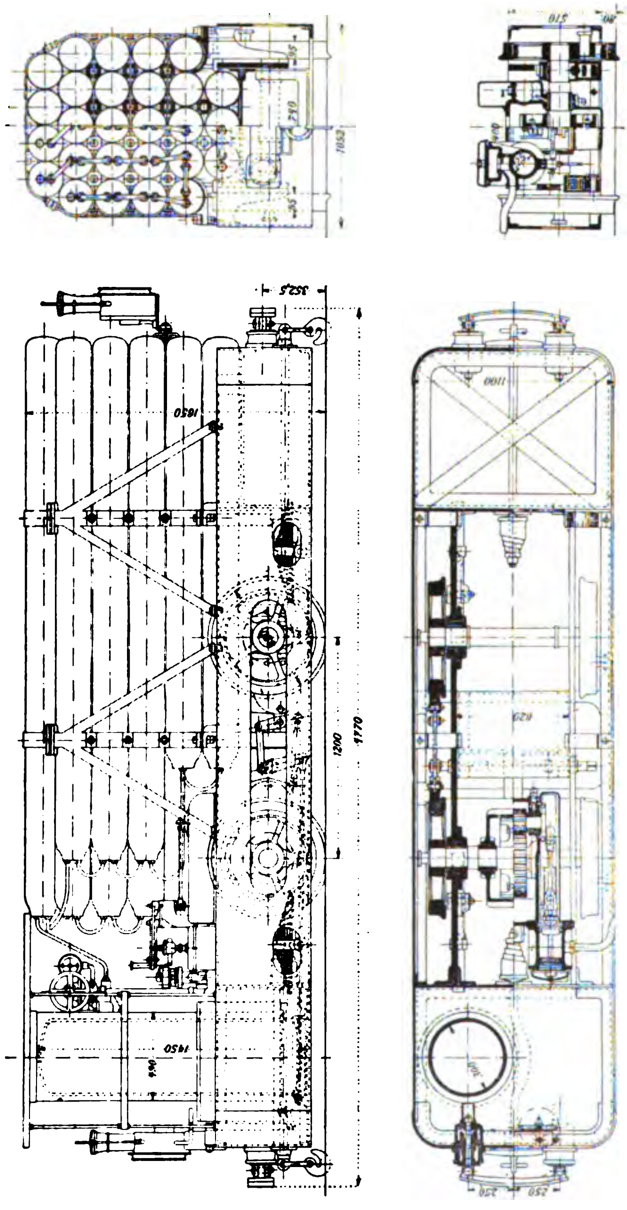
Before going into the details of this machine, it might be well to briefly review the conditions surrounding the Simplon Tunnel. It will be recalled that this is the largest tunnel in the world and is being worked from either end. It runs from Breig, Switzerland, to Isalle on the Italian side, a distance of about 13 miles, through snow-covered mountains of a height which precludes intermediate shafts. The result of this has been that unusual precautions were necessary to insure proper ventilation.

Previous to the introduction of compressed air locomotives material was handled by means of horses and steam locomotives; the steam locomotives running into the tunnel as far as the enlargement and lining had been completed, and the horses handling the cars and trucks beyond this point clear up into the headings. The cars hold about a cubic meter of material and are made up in trains at the headings or wherever enlargements are under way, and are then taken by these compressed air locomotives and hauled back to a terminal of the steam line, where they are made up into longer trains and run out of the tunnel on regular schedules.

The locomotive shaft has a substantial frame mounted on four wheels, the frame and wheels being surrounded by a protecting band, as shown very clearly in



COMPRESSED AIR LOCOMOTIVES USED IN SIMPLON TUNNEL.



DETAILS OF COMPRESSED AIR LOCOMOTIVE USED IN SIMPLON TUNNEL.

the half-tone illustration. Suspended from the frame is a single cylinder driving engine with a pinion on its shaft. The pinion meshes into a large gear keyed to the rear shaft of the truck. Connecting rods on either side connect the rear and front wheels, thus insuring maximum tractive effort. The engines and gears are encased and run in oil insuring perfect lubrication and smooth running. The working air pressure is from 10 to 15 atmospheres and even at the lowest pressures of 10 atmospheres the engine can still develop a pulling power equal to the adhesion to the rails. The gear ratio is 1:3.25. The valve gear is built according to the Joy System and reverses in the ordinary way. Suitable springs and very powerful brakes are provided and the front and rear end are provided with cushions, coupling hooks and buffers. The storage tanks or reservoir consists of a series of Mannesmann tubes mounted in layers above the frame and rigidly held in place by straps and lateral braces. The combined capacity is 70 cubic feet and the storage pressure is from 70 to 80 atmospheres. The reservoirs are connected up in such a way as to form three independent sections, so that should a leak occur in one it is only necessary to cut out this section when the engine will still have capacity enough to take it out of the tunnel or on to a siding so as not to interrupt traffic. The air passes from the reservoirs through a reducing valve whereby its pressure is dropped to from 10 to 15 atmospheres and then through a reheating tank, which is charged with superheated water, where its temperature is raised to such a point that the exhaust temperature occurs at only a few degrees above zero. In this way the efficiency of the outfit is increased and the exhaust air is of service for ventilating the tunnel.

The operator's seat is at the rear to one side of the reheating tank and all operating mechanism is conveniently placed so that he has full control of the locomotive without changing his position. Guard rails, lanterns, a whistle, and other attachments are provided making the locomotive complete in all respects and fully self-contained. The brake mechanism can be operated either by a lever or a hand screw and acts on all four wheels which insures a prompt and positive control. In operation the machine is quiet and very satisfactory and as can be seen from the picture is rather an attractive looking apparatus.

The Darlington Boring Machine.

This machine is claimed to be remarkable for its simplicity in construction, and for its effective working. It is worked by compressed air. The piston, 3½ inches in diameter, and the piston rod, only 1 inch less, are cast in one mass, and form the only working part of the drill proper. The cutting tool is fastened by means of a tightening screw into the end of the piston rod.

During the working of the drill the compressed air, admitted through the inlet port, is continually acting on the front face of the piston, and when there is no pressure on the other side the piston is driven backwards in the cylinder, and the tool is withdrawn from the face of the drill hole.

In making this movement the piston uncovers the equilibrium port, and thus establishes a communication between both ends of the cylinder. The total pressure at once becoming greater upon the back face of the piston by reason of the area for pressure being greater there, the moving mass is first arrested by this superior force, and strikes the blow. In this forward movement the front face of the piston closes the equilibrium port, and cuts off the supply of compressed air from the driving side, and soon afterwards the back face of the piston opens the same end of the cylinder to the exhaust immediately before striking the blow. These movements take place very rapidly, about 500 or 600 blows being struck per minute.

There are no valves or striking parts, and the piston is cushioned on either side of the air, which tends to safe and even working. Rotation is effected, as is usual in all modern drills, by means of a rifled bar let into the middle of the back of the cylinder, on which the piston slides, and is so held by ratchet wheels and pawls that, when the piston is making the instroke the bar is rigid and the piston is forced to turn upon it; but when making the outward stroke, being free to move in the direction that the piston has a tendency to turn it, the bar turns instead of the piston.

The feed is performed by an attendant by hand. When used in drifting or sinking this machine is fixed in the required position upon a cross-bar, which is made rigid by its ends being forced into the sides by means of telescopic pins or screw pins. The best and most expeditious arrangement, however, when used for drifting, is to attach the drill or drills upon a carriage made to run upon rails, and held rigid when working by screw pins in a similar way as described. In drifting, the drills are used in pairs, one on each side of the drift. The machine is connected with the compressed-air supply pipe by means of a few yards of flexible tubing.

The machine above-named is not intended to bore holes more than 6 feet in depth, and from 1 inch to 2½ inches in diameter; the boring is done at a speed of from 2 inches up to 9 or 10 inches per minute in granite. To bore a hole 3 feet deep in 15 minutes, including changing the drill bar, would be very good work for ordinary practice; it would very likely take two hours for three men to bore a similar hole by hand.

Compressed air from 30 to 60 lbs. pressure per square inch is generally used, and is useful after blasting to clear away the smoke, and, if the mine is hot, in cooling the heading.—*Science and Art of Mining.*

Velocity of Air Flowing Under Pressure.

A correspondent writing to *Mines and Minerals* gives this example: At what velocity will air flow from a tank having a gauge pressure of 100 lbs., into a tank having a gauge pressure of 80 lbs., through a short pipe connecting the two tanks? Find the velocity, also when the gauge pressure in the tanks is (*b*) 100 pounds and 60 pounds; (*c*) 100 pounds and 40 pounds; (*d*) 100 pounds and 20 pounds. *Mines and Minerals* publish the following reply:

In the flow of a compressible fluid the *velocity head* is equal to the *pressure head* causing the flow multiplied by a coefficient. The pressure head causing the flow is the difference between the initial and terminal heads. The equation is expressed as follows:

$$\frac{v^2}{2g} = \frac{r}{r-1}\left(\frac{p_1}{d_1} - \frac{p_2}{d_2}\right); \qquad (1)$$

in which v = velocity of flow (ft. per second);
g = force of gravity (32.16 ft. per second);
r = ratio between specific heats of air at constant pressure and constant volume (1.405);
p_1 = initial pressure (lb. per sq ft.);
p_2 = terminal pressure (lb. per sq. ft.);
d_1 = density of air at initial pressure (lb. per cu. ft.);
d_2 = density of air at terminal pressure (lb. per cu. ft.).

By deductions from Gay-Lussac's and Mariotte's laws, we have,

$$\frac{p_1}{d_1} = \frac{p}{d}\,\frac{T_1}{T}; \qquad (2)$$

in which p = any pressure (lb. per sq. ft.);
T = any absolute temperature;
d = weight of 1 cubic foot of air at pressure p and absolute temperature T;
T_1 = absolute temperature of air in first tank.

Combining equations 1 and 2, and performing certain transformations, we have,

$$\frac{v^2}{2g} = \frac{p}{d}\,\frac{T_1}{T}\,\frac{r}{r-1}\left[1-\left(\frac{p_2}{p_1}\right)^{\frac{r-1}{r}}\right]. \qquad (3)$$

But the weight of 1 cubic foot of air at a temperature of 60° F. and a barometric pressure of 30 inches is .0766 lb.; hence, we may assume d = .0766 lb.; p = 30 × .49 × 144 = 2,116.8 lb. per sq. ft.; and T = 459 + 60 = 519° F. Then substituting given values for p, d, T, g, and r, we have, after reducing,

$$v = 109\sqrt{T_1\left[1-\left(\frac{p_2}{p_1}\right)^{.29}\right]} \qquad (4)$$

(*a*) Substituting the given values in equation 4, p_1 = 100 + 15; p_2 = 80 + 15; and assuming the temperature of the air in the first tank T_1 = 459 + 80 = 539° F., we have,

$$v = 109\sqrt{539\left[1-\left(\frac{80+15}{100+15}\right)^{.29}\right]}$$

= 587 + ft. per sec.

Likewise substituting the given values in equation 4, we obtain for the velocities of flow in each of the other cases, (*b*) $v = 864 +$ ft. per sec.; (*c*) $v = 1{,}055 +$ ft. per sec.; (*d*) $v = 1{,}360 +$ ft. per sec.

The free spaces, which are incorrectly called "prejudicial spaces," reduced as they may be in well-designed compressors and for the pressures usually adopted, do not exert any great influence on the industrial yield of air-compressors, their only effect being to cause a very slight increase in the volume delivered. The arrangements of compressors based on the suppression or compensation of dead spaces have not, in fact, owing to this circumstance alone, any superiority over those of other types; and not only so, but even the compensation of dead spaces, as it has been applied in some compressors, consisting in exhausting the spaces at the ends of the stroke by making communication between the two piston faces, leads to a loss of power in consequence of the non-restitution of the compression work stored up in these spaces. The slight reduction in the dimensions of compressors resulting from the compensation of dead spaces is certainly insufficient to compensate, by the insignificant diminution in friction which results from it, the inevitable increase of work on the compressing piston.

The above-named loss of power has been determined by Burckhardt & Weiss, who, in their treatise on the subject, give the following table, showing for a given weight of air drawn in and for different ratios of compression, the theoretical work developed on the compressing piston both with and without compensation of the dead spaces:

RATIO OF COMPRESSION.	THEORETICAL WORK ABSORBED BY THE COMPRESSOR.	
Dead Space: 0.07.	Without Compensation.	With Compensation.
2	1.00	1.04
3	1.00	1.07
4	1.00	1.11
5	1.00	1.16

Ozone for Sterilization of Water.

When the question comes up as to the purification and sterilization of a city's water supply, the cheapest and best plan is to make the ozone yourself and utilize it immediately, at least, this is what Mr. F. Regaud, of *Mining and Scientific Press*, tells us, and we quote his own words:

"The following is a description of the operation and scheme of its organization: It is necessary to use fresh, cold air. In case it should be impossible to obtain air below 60° F., it is necessary to cool the flow of air before its ozonization by passing it through pipes enclosed in ice or by refrigeration by some process.

"The water must be under about one-half atmospheric pressure and the purification must take place under this pressure. The air is deprived of moisture by caustic alkali. In the accompanying diagram A is the air compressor, B the drier, C the cooling chamber.

"The quantity of air to pass into the ozonator D is about one gallon to ten gallons of water to be treated, or 33,000 cubic feet daily, in our type—385 cubic feet per second, under pressure of 20 inches of mercury.

"The ozonator may be constructed on several plans, the principle alone being fixed. It contains a large number of small cells, each of which is formed by two surfaces of glass. The exterior sides of their surfaces (plates or cylindrical) are covered with metal—tin or copper—or are in contact with pieces of iron, and the surfaces respectively are connected by wires with the two poles of an electrical alternator E and transformer F, giving at least 40,000 volts pressure. The electrical engine furnishing electric current for our type is a 30 H. P., producing daily about 14 pounds of pure ozone.

"Between the surfaces of glass runs slowly the air sent by the compressor, and it acquires about ½ % of pure ozone as a result of this indirect electrization. Then the air goes directly to a tower G, or, more exactly, three or four towers (about 15 feet high), whose diameter is calculated to provide 15 seconds for the water to pass through. The aim of this disposition is to assure perfect mixture of ozonized air at ½ % ozone with water during 15 seconds.

"The variables in the operation are the amount of air furnished and the number of turns at the electric engine. Regulation is made by accurate bacteriologic examination of water flowing from the tower. The indications we have given above appear like a maximum, except in extraordinarily impure and dangerous water.

"The result is absolutely perfect and marvelous. Examination of water arriving at the aerator, in the experiment to which I refer, gave about 60,000 bacilli colonies to the cubic inch. After 15 seconds mixture it was not always easy to find any microbes, but the estimation was 20 or 30 all non-noxious.

"On the other hand, when taking water in a pipe 6 feet long, terminated by two glass plates, it was difficult to see light through the water arriving. After treatment the transparence was complete; and, tasting the two kinds of water, I found a big difference. The first one was insipid, the second very agreeable to drink. And this experiment is not the least one, because the taste is a better analyzer than some chemists and scales.

"From the experiments I made, and confirmed by other observations, the plant for this operation will cost about $20,000 for the type treating 2,500,000 gallons of water daily.

"The necessary current expenses are the cost of running an engine of 25 to 30 H. P. and the maintenance of all apparatus in perfect shape. From our experiments the direct expense was 1 cent for 5,000 gallons, or $5 daily for the 2,500,000 gallons. The cost of maintenance for the $20,000 plant may not be far from the same figure; but for general expenses it is difficult to foresee everything without knowing the special indications. If the purification is connected with pumping, the general expenses will be low, the salary of an engineer only; but if the operation is separate the cost may be very high. I think as a provisional figure, under various circumstances, the price may be between 2 and 5 cents to 5,000 gallons; but the above figure, applied with care, allows anyone to make an exact estimate in given circumstances.

"The important point is constantly made that air at ½% ozone, in contact during 15 seconds with impure water, transforms this liquid into a perfect beverage."

Notes.

The man who invents an airship with a safety clutch and something for it to clutch to will solve the problem all right.

The McKiernan Drill Co. has removed their office to 170 Broadway, New York City. They report having secured some contracts from Norway and China.

A water-power hoist, air compressor and other machinery are to be immediately put on the What Cheer Mine, owned by John Landers, of San Francisco, Cal.

The Cleveland Pneumatic Tool Company have appointed the Compressed Air Machinery Company, of San Francisco, Cal., their representatives on the Pacific coast.

Pneumatic drills range in weight from 14 to 35 pounds, and drill from ¼ to 2 inches with from 3 to 4 inches feed, and require pressures from 80 to 100 pounds, with a consumption from 20 to 45 cubic feet of free air per minute.

The Pneumatic Horse Collar Company, of Holland, Mich., is to fit up a factory there for that line of manufacture. The officers include: President and general manager, G. W. Browning; vice-president, J. C. Post; secretary, A. Visscher; treasurer, Charles H. Browning, of Battle Creek.

In the reports from the mines of the Yorkshire and Lincolnshire districts. England, returns showing the amount of coal cut by machinery have been furnished by a number of owners. These returns show that 85 machines were at work, 63 being driven by compressed air and 22 by electricity, and that 956.230 tons of coal in all have been cut within the last year.

The Columbus Pneumatic Tool Co. Columbus, Ohio, have issued a pamphlet on the U. & W. Piston Air Drill upon which this company have based a number of statements showing the peculiar conditions of work for which this air tool is particularly adapted. Eight fine half-tone engravings in the pamphlet illustrate the application of this drill in difficult locomotive and boiler work.

Mention of the first employment of pneumatic tools in Cramps' shipyard inspired one of the Chicago Pneumatic Tool Company's representatives to disclose the fact that Cramps now have an air plant compressing 15,000 cubic feet of free air per minute and use over 1,200 pneumatic hammers, drills and riveters, all furnished by the Chicago Pneumatic Tool Company.

A trial of pneumatic tires for motor cars is being organized by the Automobile Club, and will take place during four weeks in September. The distance to be covered will be 3,000 miles, in sections of 150 miles per day. The cars on which the tires are to be fitted are to weigh not less than 30 cwt., and must be propelled by petrol engines of at least 10 horsepower. Valuable prizes are offered.

Compressed air for pumping oil wells is to be tried in connection with some of the Beaumont wells that have lately ceased to "spout." The Spindle Top Power Co. is reported as having commenced the erection of an enormous compressed air plant, and it proposes to sell the product to those needing it. Compressed air has already been successfully tried on a small scale as a substitute for gas pressure.

The compressor for the United States Mining Company, at Bingham, Utah, is from the works of the Allis-Chalmers Company. The size of the machine is as follows: Steam cylinders, 22 and 40 ins. in diameter; air cylinders, 36 and 22 ins. in diameter, all 40-in. stroke. The compressor runs condensing and compounds the steam and air cylinders, delivering about 3,400 cu. ft. of free air per minute.

The Librarian of Congress, Washington, D. C., writes that they are short of several numbers, which they are very anxious to have in order to complete the file of COMPRESSED AIR for the Congressional Library. If any of our readers can furnish any of these numbers, a list of which we give below, it will be very much appreciated:

Volume 1. Nos. 5, 6, 7, 8, 9, 10, 12.
Volume 2. Nos. 1, 2, 3, 5, 6, 7, 8.
Volume 3. Nos. 2, 3, 4.

The Cleveland Pneumatic Tool Company, Cleveland, Ohio, have purchased a tract of land on Hawthorne and Second avenues, and will at once begin the erection of modern factory buildings. They have outgrown their present shop space, and are unable to keep up with their orders. They will employ about 150 men in their plant, and hope upon its completion to be in a position to serve the trade more promptly than at present. Electrical power will be used in driving the machinery.

It is with pleasure that we note the little red pamphlet, "Circular E," sent us from the Abendroth & Root Mfg. Co., 99 John St., N. Y., manufacturers of spiral riveted pipe and water tube boilers. "He who runs may easily read" (for these few words on the cover tell their own story well). "Brooklyn factory destroyed by fire July 24th, 1901; new works at Newburgh opened December 1st, 1901;" and we find rising up before us an admiration for so much "go-aheadness" and prompt action.

Pedrick & Ayer, Philadelphia, Pa., builders of air compressors, pneumatic riveters, hoisting machinery, railroad tools, etc., have recently received orders for tools from the Canadian Pacific and for a pneumatic riveter, with 16-inch throat and 54-inch reach, for the Central Railroad of New Jersey. The company will remove its works from Philadelphia to Garwood, N. J., the plant at the latter point including two machine shops, 520 by 100 feet and 620 by 100 feet, together with power house, storehouse, etc.

The Lady Engineer Again.—A press note says: "Miss Alverda M. Stout, of Columbus, Ohio, although but 18 years of age, is a mechanical engineer and among the most competent members of that craft." Should the young woman's duties at some time require her to cull a few indicator cards from a locomotive going at a 75-mile clip there might be some difficulty in keeping the hat on straight. But let us hope that Nature would be so startled that it could be said "and all the air a solemn stillness held."

The Paris Compressed Air Company, which several years ago subordinated its compressed air branch to that of the supply of electric light, continues in an unsatisfactory condition. During the past financial year the gross profits amounted to £146,185, of which £5,267 was derived from the compressed air department, and the net profits reached £99,066, as against £81,200 in the preceding year. The net profits have as hitherto been transferred to the special account for the redemption of the capital expenditure, thus increasing this item to £235,334.

In a safety arrangement for winding cages, patented by Theodor Eichhorn, Königshütte, Upper Silesia, brake shoes on the outer ends of piston rods are pressed outwards against the inside faces of the guides, by means of gas or compressed air admitted between two pistons moving in a horizontal cylinder underneath the cage; and there is an arrangement in the cage itself for admitting the gas or compressed air into the cylinder by means of a valve, and also of permitting the cage to be braked down against the guides, independently of the rope in the event of its having given way. This device was suggested in COMPRESSED AIR.

Mr. Frederick Walker, of Oxford, England, is to design a new air yacht for M. Panuzzi. It will be 230 ft. long, with frame similar to that of an inverted ship and with a rigid car. The twin propellers, 11 ft. in diameter, and forward and above the centre of gravity, are driven by electric motors through a dynamo attached to the spindle of a turbo-petrol motor of special design and 55 H. P. Compressed air, used with the petrol, will keep the temperature very low, and it is estimated that the vessel will attain a speed of twenty-five miles an hour. This is the second largest airship laid down in England, and the inventor says it is by no means an aerial toy.

The Corrington Air Brake Company, of New York city, was incorporated in Albany, N. Y., recently with a capital of $5,000,000 to manufacture air, electric and other brakes and appliances for locomotives, cars and vehicles. The directors are John N. Beckley, Frederick Cook and John F. Alden, of Rochester; K. W. Blackwell, of Montreal; Elias Rogers, of Toronto; Henry M. Watson, of Buffalo; John P. O'Donnell, of London, England, and William G. Choate, Coleman Hanford, Nelson Shipman, Joseph Larocque, Jr., Charles F. Gehrmann, Charles Hansel, Clarence A. Hope and Murray Corrington, of New York city.

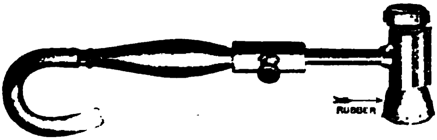
A new air compressor was patented by E. Josse, Charlottenburg, Germany, and accepted April 9, 1902. This air compressor is intended for highly compressing air in one operation, comprises an outer casing partly filled with oil, a cylinder, two pistons, a valve or valves for suction in one or both of the pistons, a delivery valve in the cylinder or in one of the pistons, and connecting gear. The two pistons are within the one cylinder, and are arranged to move in opposite directions with the object of improving the balance of the engine and minimizing the total clearance space in proportion to the total cylinder content. In one apparatus there is a suction valve in one cylinder and a delivery valve in the other.

Where there is already a reservoir and general equipment for compressed air tools around a shop it will be found very convenient sometimes to use the air pressure to run the steam hammer, if it be not too large.

I have seen this means employed on a hammer in the forge shop of a large concern where they employed all sorts of compressed air tools, and they had a long radius elbow on the exhaust pipe which was located so that it could be readily directed on the anvil, keeping it free from dirt and scale at all times. The man who operated the hammer said it was a very convenient scheme and that they used the 80-pound pressure from the regular reservoir.

Baldwin's Vibrator Mallet consists of a pneumatic vibrator at right angles to a handle and is intended for use when very quick blows are required. The one illustrated here is for foundry use, one face being covered with rubber so the pattern itself can be rapped if necessary.

In use the mould is rammed as usual and after draw spike has been inserted in pattern the metal face is placed against the spike and the valve in the handle opened with the thumb. As the piston



makes several hundred strokes a minute a very quick vibration is communicated to the pattern which enables it to be drawn more quickly and with less enlargement of mould than when the old style of hand rapping is used.

Instead of the rubber face any tool desired may be inserted in a proper holding device.

These mallets are manufactured by the Power Specialty Company, 126 Liberty street, New York city.

The Philadelphia Pneumatic Tool Company is now entirely settled in its new shops, at Twenty-first street and Allegheny avenue, Philadelphia. Considerable loss of time naturally resulted from moving and the company reports being somewhat behind in making shipments. The works are being run night and day, however, to catch up, and orders will be filled with usual promptness at no distant date.

A great deal of attention is being attracted to the Keller Pneumatic Hammers, made by the Philadelphia company, by reason of a recently devised improvement in their construction. On account of this improvement the working capacity of the Chipping and Riveting Hammers is increased at least 25 per cent., and the vibration, inseparable from any pneumatic tool, is reduced very materially. This applies to both Chipping and Riveting hammers.

Recent large orders have been received from the Southern Pacific Co., Newport News Shipbuilding and Dry Dock Co., Pennsylvania Railroad Co., Lackawanna Steel Co., and others.

The latest application of compressed air is a vacuum carpet and upholstered furniture cleaner, which has been perfected by the Vacuum Cleaner Company, Ltd., of 25 Victoria street, S. W. A vacuum is established by means of an air pump operated in a portable truck, which carries the entire plant, and the suction of air created by this means is carried to the carpet or furniture being treated, through flexible india-rubber tubes, with the result that by passing the cleaner over the floor, the dust contained in and under the carpet is drawn up by the great suction pressure, and is removed along the tube to a filter attached to the truck, where the dust is collected and deposited. The nap of the carpet is raised by this treatment, and carpets trodden down by much traffic again become soft and bright in color. The operation is quick and quiet, and, most important of all, no dust is driven into the air by the cleaner, which, if disturbed and not collected, would ultimately resettle on the carpet. So thorough is the removal of the dust that not only is the dust on the carpet removed, but also dust from underneath the carpet, so that when the treatment is complete both carpet and underfelt are free from dust. The same process with a different form of cleaner is applied to upholstered furniture.

The Allis-Chalmers Co. write as follows:

"We have been compelled by the large volume of orders on our books, to make additions to our plants and install additional machinery to enable us to take care of the business offered. We are now in shape to give prompt service and the very best results.

"The Allis-Chalmers Co., comprising the Edw. P. Allis Co., Milwaukee, Wis.; Fraser & Chalmers, Chicago; Gates Iron Works, Chicago; Dickson Mfg. Co., Scranton, Pa., is, without doubt, the largest company in the world devoted to the manufacture of mining and metallurgical machinery, and in consequence of this consolidation we are placed in a position to give our customers the benefit of all knowledge, improvements and conditions brought about by the change, which will enable us to specialize our work to a degree that will assure prompt attention to all orders.

It is the aim of the Allis-Chalmers Company to produce the best machinery for the particular purposes intended. When we speak of the "best," we do not necessarily mean the most costly. Even though the best material is used, and the workmanship the most perfect of its kind, it is only when the whole product is appropriate to the purpose intended that it is entitled to be termed the best.

"Our experience enables us to design and execute what will best serve your particular needs at a minimum cost. We shall be pleased to receive advices from you as to your requirements, assuring you of our determination to merit your continuous patronage."

A comparison between Schütz two-stage air-compressors, one with self-acting valves, at the Centrum Colliery, Westphalia, and the other with actuated oscillating valves at the Fröhliche Morgensonne, shows that the volumetric yield is intimately connected with the speed of running. The differences of pressure required to open and keep open the valves increase, on account of the increasing friction of the air volumes passing through them, with the piston speeds; and the closing of the valves is progressively delayed in comparison with the positions of the piston corresponding with the various periods of work. With Köster oscillating valves, on the contrary, the volumetric yield is not affected by the speed, because the valve-gear is arranged for openings and closings of the passages corresponding with suitable positions of the piston. In the course of time the compressor with self-acting valves leaves much to be desired as regards the air volume delivered on account of the many places of contact in the valves which in normal working are not constantly kept tight and this in direct ratio to the speed, whereas with oscillating cylindrical valves it occurs to a far slighter extent; and herein consists the superiority of compressors with positively actuated valves. Inasmuch as there is no material difference in the first cost of the two types, one would not at first be inclined, especially for usual speeds, to give an unqualified preference to one of them over the other; but the case is far different when it is required to decide whether greater importance should be attached to a slightly greater simplicity in the self-acting valves or to the superior efficiency of those positively actuated. With oscillating cylindrical valves, as compared with other types, dead spaces may be reduced to a minimum; and the simple manner in which the Köster valves are actuated ensures for them an advantage similar to that afforded by Corliss valve-gear in steam engines. Thus concludes Engineer Goetze, of Bochum, in a communication to *Gluckauf* on the volumetric yield of air-compressors.—*Colliery Guardian.*

The St. Charles of Milwaukee is the first hotel in the world to install a permanent plant for cleaning house by compressed air. As this method of cleaning possesses many novel features, and the claim is made by the company controlling it that it is superior to all others and that it controls the fundamental patents for cleaning carpets without removal from the floor, the editor of the *Hotel Monthly* was sufficiently interested to make a special trip to Milwaukee to see the new plant in operation. Mr. F. J. Matchette, proprietor of the St. Charles Hotel, showed the plant in detail, explained the workings and gave a practical demonstration in one of the long halls of the hotel.

In the basement of the hotel there is an air compressor of the Christensen type operated by electric motor. Mr. N. A. Christensen, inventor of this motor and one of the foremost authorities on pneumatics in the United States, is president of the American Compressed Air Cleaning Company, who installed this plant. Nearby are two seamless steel air reservoirs, into which air is compressed and maintained to the desired pressure (usually 60 to 85 pounds to the square inch), this being regulated by an automatic governor which starts the motor when the pressure is below, and stops it when it is above, a given point. The compressed air is led from the reservoirs to the floor above by means of a ¾-inch iron stand pipe, which rises in the elevator shaft and which has hose connections on each floor. Hose (one-half inch) is attached to this stand pipe and run to any part of the floor where cleaning is to be done. The patented device for cleaning the carpets is about the size of a Grand Rapids carpet sweeper—a trifle larger perhaps—and weighted so as to keep it close down to the floor. Underneath are two steel rollers, one to the front and the other to the rear. Midway between the rollers is a tiny orifice extending across the machine, the mouth so fine that a knife blade can barely be inserted. Along each side of this orifice are larger openings into the machine, where is kept a removable dustpan.

In operation the air delivered to the machine through the hose is driven through the small mouth with such force that, striking downward into the carpet, it dislodges every particle of dust, even that under the carpet, and the power of the blast is such that the dust must escape. The only avenue of escape is through the larger openings at either side of the small mouth, and here it is imprisoned in the dustpan. The air itself escapes into a dust-proof bag, attached to the top of the machine and which, while the machine is working is inflated like a balloon. The machine is pushed over the carpet backward and forward the same as a carpet sweeper, the blast getting in its work both on the forward and back strokes.

To give an idea of the power of the blast, Mr. Machette tilted the machine and asked the visitors to put their hands over the escaping air. It was a concentrated hurricane. He turned the blast towards the carpet and the air was filled with fine dust, in appearance as a cloud of steam. He took a cupful of flour, sprinkled it over the carpet, trod it in thoroughly, ran the machine over it and the flour disappeared, leaving the carpet clean.

There are devices for dislodging dust from corners and crevices, from curtains and furniture, from billiard cloths and from walls and ceilings, but the collecting of dust is mainly that from the carpet.

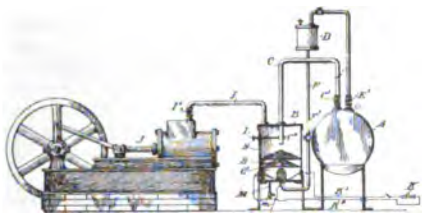
Mr. Matchette explained that it was economy for a large house to install its individual plant, so as to have compressed air always on tap and permit of a continuous housecleaning of so many rooms or halls a day, year in and year out. For a small house, where the expense of installing a private plant might not be warranted, the suggestion is made that what he calls the "wagon or portable plant" can be adopted. In this way a wagon equipped with the necessary compressor, a gasoline engine, a few lengths of hose, and the necessary paraphernalia for cleaning, is made available not only for the hotel, but also for cleaning private residences, public buildings, etc., a wagon with two or three men having an earning capacity sufficient to pay a large income on the amount invested.

Exclusive territorial franchises for operating these wagons are sold to responsible parties. In many cities throughout the country hotel men are becoming interested in this plan for the reason that it affords them a way to have their hotels cleaned by compressed air without the expense of installing a stationary plant, besides an opportunity for a safe and good-paying investment.

U. S. PATENTS GRANTED MAY, 1902

Specially prepared for COMPRESSED AIR.

699,156. COMPRESSED AIR-HEATER. Chas. B. Duncan, New York, N. Y., assignor to John C. Henderson, New York, N. Y. Filed Jan. 12, 1901. Serial No. 43,024.



A compressed-air heater, the combination with a motor adapted to be driven by compressed air, of a compressed-air chamber, an expanding-chamber provided with an air-inlet, a burner within the expanding-chamber for heating the air, and wire screens arranged in the expanding-chamber and interposed between the burner and the air-inlet.

699,166. APPARATUS FOR PURIFYING AIR. David Grove, Berlin, Germany. Filed May 29, 1899. Serial No. 718,736.

699,288. AIR-COMPRESSOR AND INTER-COOLER. William B. Cowles, Cleveland, Ohio. Filed Aug. 16, 1901. Serial No. 72,529.

An apparatus of the character described, the combination of a heating and cooling tank, a reservoir for compressed air, means for supplying compressed air to said reservoir including a cooling-coil in said tank, and means for carrying off air from said reservoir at a reduced pressure, including a heating-coil in said tank.

699,405. SAND-BLAST. Ray C. Newhouse, Columbus, Ohio. Filed Dec. 10, 1901. Serial No. 85,399.

A sand-blast comprising a casing, frusto-conical partitions arranged within the casing at different points and forming upper and lower sand-chambers, a blast-pipe connected with the lowermost partition, valves arranged at the other partitions, an air-supply pipe connected with the blast-pipe and with the individual chambers, and means for connecting the chambers and the air-supply pipe individually or simultaneously.

699,570. AIR-COMPRESSOR. George W. Rhine, Altoona, Pa. Filed Jan. 8, 1902. Serial No. 88,856.

An air-compressor, the combination with a stationary disc, of an annular air-chamber surrounding the disc, an annular casing between the disc and air-chamber, a series of pump-cylinders supported within the casing, a revolvable shaft extending loosely through the disc, wheels fixed upon the shaft on opposite sides of the disc grooved cams secured to the inner sides of the wheels, and pump-pistons provided with rollers adapted to travel within the grooves of the cams.

699,680. PNEUMATIC SHOVEL. Lafayette Hanchett, Idaho Springs, and William C. Davis, Denver, Colo. Filed Dec. 12, 1901. Serial No. 85,715.

A power-shovel, a carrying-truck, a turntable mounted thereon, guides on said turntable, arms slidingly and pivotally supported from said guides, a shovel carried by said arms, means for advancing and retracting said arms, and means connected to said arms for raising and lowering them.

699,838. SAND-BLASTING APPARATUS. Myron E. Evans, New York, N. Y. Filed Sept. 5, 1899. Serial No. 729,480.

A sand-blast apparatus a nozzle-body, consisting of an air-chamber, an inner nozzle, and a detachable outer nozzle, the adjacent surfaces of said air-chamber and said inner nozzle forming an annular opening when said outer nozzle is detached, and the adjacent surfaces of said inner and outer nozzles forming an annular opening when said outer nozzle is attached.

700,239. PNEUMATIC SHEET-CARRYING DEVICE. George F. Read, New York, N. Y., assignor to Robert Hoe, New York, N. Y. Filed July 29, 1901. Serial No. 70,077.

700,519. AIR-HEATER. Arthur H. Lovejoy, Gallia, N. J. Filed Dec. 17, 1901. Serial No. 86,208.

700,607. SENDING APPARATUS FOR PNEUMATIC-DESPATCH SYSTEMS. Birney C. Batcheller, Philadelphia, Pa. Filed July 31, 1901. Serial No. 70,328.

A pneumatic-despatch system, a sender connected to a transmission tube in combination with outer and inner gates adapted to open under the pressure of an inserted carrier, means for closing said gates when the carrier has passed them and means actuated by the insertion of a carrier into the sender for connecting the sender with an air-receptacle having substantially the pressure of the transmission-tube for the purpose of equalizing pressure on the inner gate.

700,628. MINING-MACHINE. Henry B. Dierdorff, Columbus, Ohio, assignor to Joseph A. Jeffrey, Columbus, Ohio. Filed Oct. 14, 1896. Renewed Oct. 29, 1901. Serial No. 80,460.

The combination with the bed, the carriage, resting upon and sliding along the bed and the laterally-acting chain having cutters mounted upon and advanced by the carriage, of the rotating holder mounted at the front of the carriage, and adapted to engage with the horizontal wall of the coal-kerf, and a support for said rotary holder adapted to be adjusted in position vertically.

700,664. HOT-AIR FURNACE. Marion Lee and William W. Bryan, Angola, Ind., assignors to William M. Fanning, Angola, Ind. Filed March 22, 1901. Serial No. 52,362.

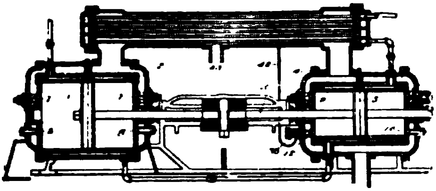
700,840. PNEUMATIC TIRE. Enos Smith, Vernham Dean, near Hungerford, England, assignor to John Smith, Troy, N. Y., and Harry Smith, New York, N. Y. Filed April 12, 1902. Serial No. 102,510.

700,842. PNEUMATIC MALTING-DRUM. Henry Smith, Milwaukee, Wis. Filed Dec. 24, 1900. Serial No. 40,849.

700,858. AIR PURIFYING AND COOLING APPARATUS. Richard H. Thomas, Chicago, Ill. Filed April 18, 1901. Serial No. 56,507.

700,859. AIR PURIFYING AND COOLING APPARATUS. Richard H. Thomas, Chicago, Ill. Filed May 21, 1901. Serial No. 61,280.

700,927. AIR-COMPRESSOR. Ebenezer Hill, South Norwalk, Conn. Filed August 17, 1901. Serial No. 72,349.



A compound air-compressor having cylinders, pistons, inlet and discharge valves and cylinder-interduct, means for opening a valve of the second cylinder, and a passage so connecting said interduct with the valve-opening means that the pressure in the cylinder-interduct controls the operation of the valve-opening means.

700,995. AIR-FORCING DEVICE FOR ATOMIZERS. Charles J. Walz, New York, N. Y., assignor to West Disinfecting Co., New York, N. Y., a corporation of New York. Filed March 20, 1901. Serial No. 51,968.

701,074. AIR-CLEANSING AND COOLING DEVICE. Joseph McCreery, Toledo, Ohio. Filed Feb. 5, 1900. Serial No. 4,001.

701,130. APPARATUS FOR TESTING THE VOLUME OF AIR FROM THE LUNGS. Michael Benedict, New York, N. Y. Filed July 23, 1901. Serial No. 69,347.

701,163. COMBINED AIR AND WATER PUMP. Edward D. Deeter, Milford, Ind. Filed Feb. 23, 1901. Serial No. 48,466.

A pneumatic system for water elevation, a sealed tank, a water-service leading therefrom, a pump comprising a cylinder having an outlet connected with the tank, a water-pumping device consisting of a plunger-rod, and a head thereon having means for the upward passage of water and air, an air-induction device coacting with the water-pumping device and having a valve for controlling the amount of air pumped, and adjustable devices for controlling the movement of said valve.

701,205. AIR-BRAKE FOR RAILWAY CARS. Forest M. Kreitz, South Bethlehem, Pa., assignor to William N. Miller and William J. Rau, South Bethlehem, Pa., Filed Aug. 19, 1901. Serial No. 72,617.

701,228. AIR-DIFFUSER. Stephen G. Smith, Hannibal, Mo. Filed Nov. 25, 1901. Serial No. 83,607.

701,272. AIR-BRAKE CONNECTION. William Neil, Newark, N. J. Filed June 7, 1901. Serial No. 63,601.

11,994. PNEUMATIC STRAW-STACKER. John M. Andrews, Andrews, Tenn., assignor of two-fifths to A. P. Roberts and C. P. Roberts. Filed Feb. 7, 1902. Serial No. 93,092. Original No. 669,500, dated March 12, 1901.

Compressed Air

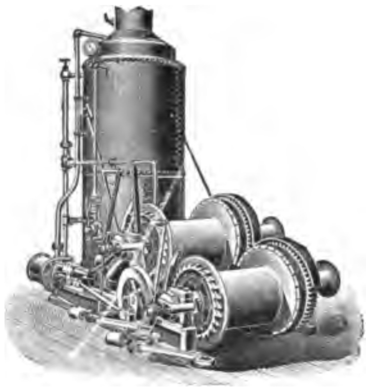
A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, AUGUST, 1902. No. 6.

We desire to announce the fact that there will shortly be published by this paper a large volume entitled "Cyclopedia of Compressed Air Information."

This book will contain the editorials and other writings of the editor of this paper, including a full reprint of "Compressed Air Production," and all the leading papers on compressed air subjects that have been published in "Compressed Air" for the past five years including illustrations and other useful data. The book will be unlike anything heretofore published on the subject and is a cyclopedia of practical information on compressed air. Price, $5.00, sent to any address, postage paid.

NOTE.—As the edition will be limited, orders should be booked at an early date.



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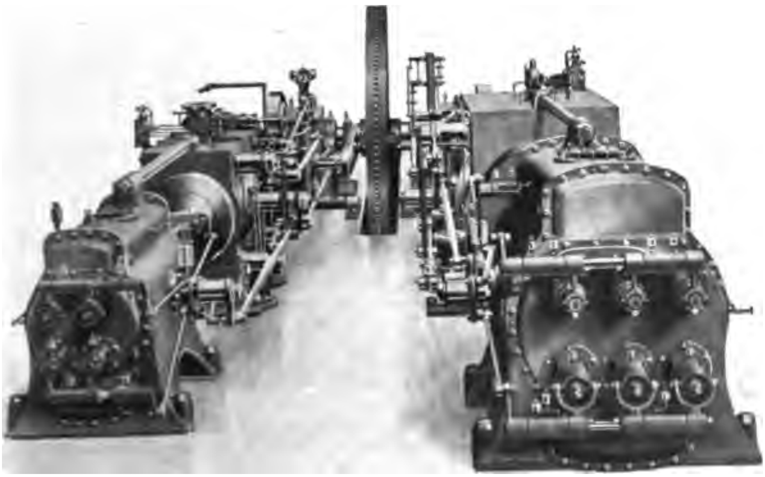

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Compressed Air in a Mine Disaster.

The importance and supremacy of compressed air in mining has again attracted attention in connection with the recent disaster in the mines of the Cambria Steel Company, near Johnstown, Pa. This coal mine, which has been considered comparatively free from gas and a safe mine was in some unaccountable manner involved in a serious explosion, resulting in large loss of life. It is reported that in one section of the mine after the explosion occurred no less than six or eight lives were saved by a happy thought which entered the mind of one of the entombed men. Knowing that an air pipe was used for conveying air into the workings, he groped his way through the darkness until this pipe was reached and with a pick succeeded in breaking one of the coupling joints, thus discharging health-giving compressed air into the foul, confined air of the mine. It is very likely that had more of the men thought of doing this in other sections of the mine, other lives might have been saved. This is not the first time that the air pipe has proved itself to be a life-saver. It so happens that this pipe when led into mines is of normal thickness and each section, as is well known, will stand considerable crushing strength, so that even after a serious explosion or fall in the mine, little if any damage is done to the pipe. Being of wrought iron, it is sometimes crushed out of shape, but even then it retains its capacity to carry air. Here we have the means by which air from the surface may be supplied to the inner workings of a mine after an explosion which has destroyed certain sections of the mine, cutting off chambers where life exists and making it impossible to reach the surface until rescued by a long and tedious process of excavation. This air pipe, it is true, is limited in its air capacity, but it is quite possible to increase the supply of air after an accident by concentrating all the air compressors upon one or more lines of pipe and for a considerable distance around the discharge opening in the mine noxious gases might be driven away and men may live for hours and even days. Another point which this mining disaster brings to our attention is the serious results which might follow the use of electricity in mines. It is impossible to always distinguish the safe mine from one that is unsafe. Gas seams may be perforated at any time, and where electricity is used there is always the liability of sparking which cannot be prevented, so that when considering the equipment of a so-called non-gaseous mine with electric machinery, it should not be forgotten that an accumulation of gas or fine dust might at any time be brought in contact with an electric spark with disastrous results. Too much importance cannot be given this subject, and we would not be surprised to see legislation directed against the introduction of electric power within the mine. Air is exactly what is wanted in a heading and electricity is just what is not wanted. So long as air can do the work of driving machinery in mines and do it with reasonable economy there is no excuse for the introduction of electricity. It has been established by years of experience that air can be used in mines with not only greater safety but with greater economy, and that with the single exception of lighting it serves every purpose for which electricity might be applied.

The McCann Spreader Car.

The report of the committee on roadway, submitted to the annual convention of the American Railway Engineering and Maintenance of Way Association last month, divides spreader cars or bank levelers into two principal classes, as follows: "First, those in wnich the wings open downward and outward, with hinges horizontal, and are handled either by a windlass or air pressure; second, those in which the wings fold against the sides of the cars, with a vertical hinge near the front of the car. In this class the wings may be adjusted for height."

It is a car of the first-class that has been used on the Gulf, Colorado & Sante Fe., and other roads. This car was designed by Mr. E. McCann, now general supervisor of bridges and buildings for the Atchison, Topeka & Santa Fe Ry., and was built for the purpose of spreading material plowed from flat cars to raise embankments in the work of grade reduction. Since that time six additional cars of the same type have been built, making seven now in service, on the following roads: The Gulf, Colorado & Santa Fe Ry. has one, the Atchison, Topeka & Santa Fe Ry. has three, the Southern California Ry. has one, the Chicago, Rock Island & Pacific Ry. has one, and the Colorado & Wyoming Ry. has one. Experience with the original car, built for the G., C. & S. F. Ry., has led to improvements in certain details of construction, although on general lines the cars recently built are similar to the original pattern. The purpose of this article is to describe the improvements that have been made, and to refer more particularly to the character of some of tne heavy work which the car is able to handle.

Briefly described, the operating mechanism of the car consists of a pair of wings hinged at the floor line, on each side of an ordinary flat car. These wings are constructed of 4½-in. oak plank faced with steel boiler plate and are supported at the back by struts bearing against heavy timbers extending across the car, underneath the sills. To stiffen the wings longitudinally they are braced with angle irons between the struts. The front section of the wing is hinged to a heavy bar extending diagonally across the corner of the car, and when the wings are let down for service this section overlaps the rear section. To prevent damage to the wing or dislodgment of the same in case a hinge should break, a chain is attached to the rear section to take the longitudinal stress in case of necessity.

The wings are lifted by means of air cylinders arranged on a beam running lengthwise the car and supported upon A-frames at each end of the car, at a height sufficient to clear the wings in their raised position. On the first car built there were four 8-in. air cylinders for this purpose, but on the improved cars there are two air cylinders, each 14 ins. in diameter and 6½ ft. long, with a piston travel of 6 ft. As the wire cable which hoists each wing is doubled around a pulley at the end of the piston rod, the end of the cable is pulled twice as far as the travel of the piston. The air for operating the wings is taken from the air brake system of the train and stored in a reservoir having a capacity of 57½ cu. ft. In lifting the wings they are raised to a vertical position, from which they swing over to a bearing against the forward A-frame, and a vertical post on the middle line of the car. In putting the wings into service they are pushed outward past the vertical position by two 7-in. air cylinders. In dropping to the service position the fall is cushioned by admitting air to the large cylinders at the top.

This use of the air, which controls all the movements of the wings, is manipulated by one man, who stands on the car floor at the right side of the storage reservoir, located at the rear of the car. The action of the top cylinders in lifting and lowering the wings is similar to that of a steam hammer, air being admited to one end of the cylinder for lifting the wings, or into the other end to cushion their fall, or to stop them at any desired point. The time consumed in dropping the wings to the service position or in lifting them from the service position to fold against the supports on the car, is only four seconds. In passing bridge floors, cattle guards, etc., the wings can be raised and lowered again without stopping the train.

In operation the front section of the wing clears the material from the rail. and out as far as the ends of the ties, and the rear section spreads it from the ends of the ties outward. The rear section is usually arranged to cut to a depth even with the bottom of the ties at their ends, and to form a gentle slope from this point outward. The spread of the wings is 13 ft. 8 ins. on each side of the center of the track. When it is desired to cut the bank down to form a shoulder a steel templet of proper shape to trim the material to the desired cross section is attached to the outer part of the wing.

In the case of the car built for the Colorado & Wyoming Ry. the weight of all the apparatus which is attached to the naked flat car is 22,600 lbs., of which 10,400 lbs. are carried by the forward truck, and 12,200 lbs. on the rear truck. In constructing these cars a ballast box was placed at either end, with the idea that ballast might be needed to hold the car to the track while in service. In practice, however, it has been found that this ballast is not needed, and none is used. These ballast boxes are used as a place for storing chains, templet plates, tools, etc. The construction of the wings, leaning as they do from a vertical position, and sprung at the lower edge, and backed by struts hinged from above, is such as to give them a downward draft when plowing through material, the action being similar to that of a plow point. This draft assists in holding the car down to its work, which is not the case with wings which stand vertically, and explains why ballast loading is not needed.

To prevent the end of the front section of the wing from scraping against the rail, and to carry it safely over rail braces and joint splices, the machine has been improved by placing a wheel at the front end. When the car is in service the side pressure of the earth crowds the wing over, so that the wheel then takes a bearing on the rail.

The air contained in the storage reservoir is sufficient for four applications of both the large and small cylinders. The first application reduces the pressure in the reservoir only four pounds. The pipes which feed the top cylinders are only ½ in. in diameter, so that the flow of air is not sufficiently rapid to do damage to the machinery in case an inexperienced operator should open the cocks too suddenly. As the pistons are of large diameter, the wings when free from dirt are lifted without admitting full reservoir pressure, the cylinders being designed with a capacity sufficient to lift the wings when plowing through dirt the full depth, and then when the train is in motion. There is an automatic valve to prevent the reservoir from being emptied in case the train should pull apart and break the hose connection.

In actual service this car has spread earth at the rate of 17,000 cu. yds. per hour, all the operations of the car being handled by one man. In one instance the car, starting from a standstill, dropped the wings and spread 176 car-loads of earth, carrying from 20 to 30 yds. to the car, in 13 minutes. Either one or both sides of the car may be used as desired. The stability of the car when spreading from one side only is sufficient for heavy work. In numerous instances two engines have been used to pull the car when it was spreading from only one side. So long as there is sufficient tractive force the car will plow its way through heavy gumbo or rock without difficulty. In leveling down rock large stones weighing from one to two tons have been handled without trouble. During the past year one of these machines spread 358,316 cu. yds. of earth and rock.

The construction of the machine is covered by patents, and the entire management of the manufacture and sale of the machine is in the hands of Mr. O. C. Mann, 3032 Monroe St., Chicago.—*The Railway and Engineering Review.*

A New Deep Pumping System in the Far West.

A very successful application of the pneumatic principle has just been made at Cambria, Wyo., by the Cambria Mining Company, in which a column of water is lifted 1,850 feet in one straight lift, an accomplishment that is something new in mechanical operations. The principle is not entirely new, for there are a few instances where it is in successful operation to a depth of 500 or 600 feet, but so far as known to the operators and the writer, this is the only well where it has been operated to such depths. Two months ago the well was completed to a depth of 2,300 feet, at a cost of $25,000. The well starts at the coal horizon, near the openings to the mines, which produce the coal for the B. & M. railroad system, and was put down for the double purpose of increasing the water supply necessary to operate the mines, and also to prospect the underlying strata. After passing through sandstones and shales, prior to the coal producing period, a hard limestone was encountered when a progress of only from one to two feet a day could be made. It is believed that nothing of importance in the way of lower coal seams was discovered, and the oil sands of the New Castle fields, which is seven miles to the south and on a lower level, are known not to enter the foothills but a short distance, so the product of the well is confined to water. No flow was experienced, and the water only rose to within about 200 feet of the surface. It was with a spirit of experimenting that the pumping system was put in, for all of the most experienced compressed air men of Denver were outspoken in their belief that such a feat was beyond the realm of possibility.

The water, on analysis, proved very acceptable for boiler and domestic uses, so 2,000 feet of one-inch pipe was ordered. The larger casing in the well was removed and replaced by a four and five-eighths inch casing, and the inch pipe, after connecting with the high pressure compressor, used in the haulage system underground, enters a T joint at the top of the well and flows down inside the casing for a distance of 1,700 feet from the surface. This air line is reduced near the bottom to three-fourths inch, and the lower end is turned upwards and drawn out to a half-inch opening, forming a nozzle through which the compressed air makes its entrance under a pressure of from 800 to 1,000 pounds from the compressor. When the air is first turned on there is a column of water from the 1,700 up to the 200-foot level, and it requires about

AIR-LIFT WELL OF CAMBRIA MINING COMPANY, WYOMING.

15 minutes for sufficient pressure to accumulate in the empty air line and at the bottom of the well to start this immense column of water in motion. The back pressure at this point on each square inch would be equal to the weight of a column of water one inch in diameter and 1500 ft. in height or 645 pounds per square inch. The air pressure at 800 to 1,000 pounds is nearly twice the back pressure of the weight of the water, so that when once in motion it raises the 1,700 feet in the well and the 150 additional feet to the reservoir on the hillside, at a dreadful velocity, and at a rate of 1.000 gallons per minute,which it is only unable to maintain on account of the well failing to supply more water at the same rate. After this first terrific rush of water and the almost deafening roar that follows it, as the expanding air that follows it is being discharged, the well flows intermittently, first a short column of water and then a discharge of air. Before the discharge pipe was carried up the hill to the reservoir tank, as shown in the illustration, it was allowed to discharge in a horizontal position near the ground. To the eye it looked as though the other end of the pipe must be drawing in one of London's famous fog banks, for the only appearance of anything resembling water was the stream that collected on the ground under the white mist. The rapidity of the flow is regulated by the size of the opening admitting the air. Two orifices are used, one five-eighths of an inch, which gives a flow of 120 gallons per minute, and another seven-eighths, which raises the discharge to 200 gallons. If the well replaced the water with greater rapidity it would be interesting to know the maximum capacity of this method of pumping. It is certain from the first discharge that it would not be less than 1.000 gallons and probably several times that amount. The first test made was done with the five-eighths inch, and the air turned on for 90 minutes, including the first 15, during which nothing was discharged, the flow measured up 109 gallons per minute. It has long been claimed by authorities that liquids could not be raised in this manner unless there was a certain amount of back pressure. In this well, of course, it is impossible to determine the amount of water left above the nozzle when the flow is exhausted, but in other shallow wells the water has been almost if not entirely blown out by the management. With insufficient pressure, of course, such as atmospheric air, the gas would climb through the liquid in bubbles, but when the elasticity is sufficient, which is acquired by increasing the pressure, the air bodies withstand the tendency of the liquid to drop back through them, and then as the diameter of the water column is increased, the volume of the air supply must be raised correspondingly. Of the cost of operating this well, the exact figures have not been determined. It is certainly very little, for the high pressure compressor was already installed for the use of the traction engines. Just how much air is required is not known, only approximately, in comparison with that used by the engines. When one of the latter is charged the pressure is reduced in the pipe line 50 pounds. When the well is started, the pressure only falls 12 pounds, and the steady consumption is known to be much less than that of one of the engines, but how much less has not been determined. These engines are 40 horse power, and consumes 120 cubic feet of air per minute. This method has been tried in the oil fields to a depth of about 400 feet. It raised the oil more rapidly than water, but was not a success for two reasons, the action of the oxidizing power of the air tended to coagulate the oil, and the back pressure of the combined oil in the column and the air interfered with the flow of oil, and in some instances temporarily stopped it altogether. It is, however, an unquestionable success when an artesian well will not flow.—*Western Mining World.*

Compressed Air in Mining.

FOR DRILLING, HAULING, HOISTING AND PUMPING.

Three general classes of air compressors are used for mining purposes—those that are steam driven; those that are water driven; and those driven by electric motors. They all may be either simple or compound. The general arrangement of the cylinders is not of great moment; that is to say, it matters little whether the compressor is duplex, cross-compound, tandem-compound, or of any one of three or four combinations, provided that the cylinders are disposed in such a manner that the work of the motor will be a minimum.

The best known and simplest form of compressor is the so-called straight-line machine in which the air cylinder is directly behind the steam cylinder and one piston rod connects them both. This form of compressor is, as a general rule, not desirable, for economical reasons, for an equipment of more than 50 or 75 horse-power, and, for powers up to 150 horse-power, should be replaced by a compound machine of a similar type. For larger machines it would seem that a Corliss engine would be better calculated for economy, either simple or compound or compound condensing, according to the power and the opportunity for obtaining condensing water.

It naturally must be assumed that at this time, when the conservation of power seems to be an important consideration, a mine which has to convert so large a portion of its power into compressed air will do so with economical machines. It seems useless to discard the more expensive fuel and encourage the water-power companies who offer cheaper power, if, after that power has been obtained, no effort is made on the part of the mine management to take advantage of it for the larger powers, and the writer has this fact in view in placing the various kinds of compressors in the order named.

For compressors driven by water-power the simpler forms are plain air cylinders, operated by belt or gearing from impulse water-wheels. This type should not extend beyond 50 horse-power, at which point the compound machine should take its place, and no improvement upon this form can be suggested, excepting that, where the opportunity offers, it is always preferable to have the water-wheel direct-connected on the compressor shaft. This practice eliminates many objectionable features, principally the cost of separate foundations, saves space, a separate fly-wheel and the maintenance of belt or gears.

It has been generally assumed that this practice has mechanical limits, within ordinary conditions, but the writer has not found this to be the case. The excessive diameters of these wheels, due to the fact that the number of revolutions should be small, has been an apparent barrier to their employment for heads of water above 500 feet, and the first wheel employed for a head of 700 feet and 100 revolutions, which called for 19 feet in diameter, was undertaken with some hesitation. The ease, however, with which it performed its work, justified the construction, later, of one of 22 feet, following which came one of 25 feet, another of 30 feet, and later still one of 33½ feet, the latter operating under a head of 1,400 feet. This wheel has satisfied all expectations.

It can readily be seen that in wheels of this large diameter, where the principal weight is concentrated in the rim, and with a jet under tremendous heads impinging from one or two nozzles upon the buckets, the fly-wheel effect is perfect and a much lighter wheel may be suspended on the shaft to give the same general effect as a heavier fly-wheel. Another advantage in having a direct-connected wheel, where compound compressors are used, lies in the fact that the water-power in the tail race and the spray from it may be used very advantageously for intercooling without using an excessive length of pipes.

In compressors driven by an electric motor new conditions are encountered. Most of the motors used are induction or synchronous motors, which run at practically constant speed. In the other classes a system of governing can be applied to the speed of the machine for the conservation of power, while with the electrically-driven compressors the speed must be constant and there must be some other means of regulating the duty. This is found in what are termed variable volume machines—that is to say, machines which are so governed that they compress more or less air, depending upon the requirements of a mine. This is generally done, and is eminently successful in handling the quantity of air and at the same time relieving the compressor from undue service. Nothing is more objectionable than the continual blowing off of air from the receiver and nothing is more wasteful of power. In addition to the classes above mentioned, compressors are also driven from line shafting in mills, but these are generally of small capacity; otherwise the uniformity of motion demanded by the mill would be seriously disturbed.

The principal uses for compressed air in a mine are for running rock drills, for shaft sinking, drifting, stoping and upraising, and pumping. It has generally been considered good practice, depending upon the hardness of the material encountered, to use for shaft sinking either the 3⅛, the 3¼ or the 3½ inch drill; for drifting, either the 2¾, 3⅛ or 3¼ inch machines; and for stoping, either the 3-inch, 2¾ or 2¼ inch machines. There are mines that use a 3½-inch drill for stoping, but it would appear to the writer that a smaller size would be more economical.

The average shaft drill consumes from 100 to 120 cubic feet of free air per minute, compressed to about 90 pounds; the average drill used in drifting consumes from 70 to 100; and the average drill for stoping consumes from 40 to 70. In general, while holes are drilled very frequently to a depth of 8 feet, they average about 4½ feet, and the size of the hole is such as will permit the use of sticks of powder of from 1 inch to 1½ inches in diameter.

The average work of a rock drill for one shift is from 30 to 40 feet of holes drilled. It is generally assumed that a good rock drill will do the work of from six to ten men. It takes from five to twelve horse-power to furnish a drill with compressed air, and with the exception of what are known as "Baby" drills, it takes two men—a machine man and his helper—to operate a machine.

Air is furnished to the drills through pipes leading from the shaft into the drifts or stopes. In general, these pipes are too small for the work intended. In the average mine, not knowing just how far drifting will be continued, too small a provision is usually made for the diameter of the branch pipes, and often such a pipe, laid in a drift originally for the sole purpose of running rock drills, is tapped to operate a winze hoist, and after that a pump in the winze, and very frequently for operating fan engines, so that often with ninety pounds pressure at the surface, a rock drill will not receive over forty to forty-five pounds in its cylinders. This lessens its proper work to a marked degree and increases the cost of the output of the mine. It always pays, whether operating one drill or more, to put in a pipe of sufficient size to give very nearly full pressure at the drill.

Most of the standard drills are reliable in character and are good enough for performing proper service in a mine. The man behind the drill practically determines how much work the drill will do in a shaft. A poor machine in the hands of a good workman will do more work than if the situation were reversed. For economy in mining a first-class machine man should be given a good drill and one of proper size for its work, and he should be permitted to repair his drill often enough so that the machine will expend its energy upon the rock instead of jumping about on a loose clamp, a worn-out feed-screw or loose guides.

Too often the economy of a rock drill is judged by the amount of repairs it takes, though these may or may not be the fault of the machine; but, in any event, this feature should not be taken into consideration.

From an experience of something like twenty years with drills the writer finds it impossible to make a proper comparison between different kinds of drills operating at different mines, and even in the same mine two different drills should be operated at the same time and in the same drift by equally skilled men in order to permit making a fair comparison. After keeping tabulated lists for a number of years the writer finds that of the standard makes of drills, having the same weight and the same diameters of piston and piston rod, there is practically no difference in cost of repairs per foot of holes drilled during the month. The repairs on a drill are so insignificant with respect to the cost of running the drill that they may be neglected, and one's thoughts and energies should be concentrated on the other features of expense attached to their operation.

One mine that has come under observation and which keeps a very complete record of its operations, pays $3 a day for a machine man and $2 for a helper. These wages average 16 cents per foot of hole drilled; the power averages 5 cents per foot of hole drilled; the breakage and repairs are about 0.06 cent per foot, making a total of 21.06 cents per foot. It will be noted that the cost of breakage and repairs is only one thirty-sixth of the cost of drilling the holes, or less than 3 per cent., which may be neglected and attention given to the more important elements of wages and the capacity of the drill.

In the above record the average is 38 feet of holes per shift per drill. There were two shifts per day, making 76 feet per day, or 2,280 feet per month, for one drill. The cost of breakage and repairs on these drills during the month, at 0.06 cent per foot, would be $13.68, and this is about what it ought to be.

Now, if the repairs and breakages are $13.68 for drilling 2,280 feet of rock, then in order to offset this expense by extra service of the drill it would be necessary to drill during the month only 65 feet additional, at 21 cents per foot. If it is desired to gain 65 feet in a month where 2,280 feet are being drilled, it would mean that there would have to be a gain on each amount of holes drilled of one-third of an inch, or, practically, if another machine man or another drill were substituted and either the man or the drill advanced the record one-third of an inch to the foot, it would entirely cover the cost of keeping the drill in repair.

It will be seen from this what an insignificant item the matter of breakage and repairs is on a rock drill in comparison to the actual cost of drilling the holes. In contrast to this small expenditure it would be well to note that the amount saved to the mine by either a drill or a drill man who could drill, for example, 15 per cent. more than another, is very considerable. Taking the previous figures, where 2,280 feet of holes were drilled, an advance of 15 per cent. would mean a gain of 342 feet of holes, which, at a power and wages cost of 21 cents per foot, would be $71.82, so that at the end of two or three months a mine would save the cost of an extra drill.

From these facts it is naturally deduced that the first cost of a rock drill may be given no great consideration; the amount of repairs necessary to keep a rock drill in operation may also be given no great consideration; but the number of feet of holes it will drill in a month is the real consideration, and in a competition or comparison between different men or different drills the basis should be the cost per foot of holes drilled, this cost to be made up from the power of cost of operating the machine plus the wages and the repairs.

The "Baby" drill, having a cylinder 2¼ inches in diameter, with a 4 or 5 inch stroke, is one which is at present demanding a great deal of attention from mine operators. It has been supposed that this drill had not sufficient power for general mine work on account of the vast difference in weight and strength of its various parts, as compared with the ordinary mine drill; but in certain California mines especially these little drills, made of steel, are drilling in hard metamorphic rock holes 8 feet deep at a less cost than with the larger machines, and one large mine has laid aside the larger drills entirely, excepting for shaft work.

The advantage of the "Baby" drill lies in the fact that it is a one-man drill, which cuts off at once one-half of the principal cost of operation. Its exceedingly light weight, viz., about 100 pounds, permits it being easily carried in stopes and in upraises, and its small size permits it to be used in close quarters. It takes less than one-half the air to run a "Baby" drill than one of the larger machines; consequently the air conduits are less expensive and easier put in place.

There seems to be very good reason why the smaller drills should fulfill many of the requirements of the larger machines, and in many places the selection of the size of the drill has been on a wrong basis. Sticks of powder about 1¼ inches in diameter are an average of the sizes used. It is, therefore, not necessary that the bottom of the drill hole should be any larger than 1¼ inches. Allowing five different lengths of drill to reach the bottom of a 5-foot hole, and allowing ⅛ inch clearance to each successive drill, it is evident that the hole need not be started larger than 1⅞ inches, and there is no need of wasting powder or employing a drill heavy enough to drill a larger hole.

The larger the drilling machine, the larger the steel that has to be used with it to prevent it from buckling; and the larger the steel, the larger must be the diameter of the hole in starting, so that in many instances the ratios of the diameters of the drill cylinders to the diameter of the holes required for starting are such as to offset the advantages of the larger cylinders.

At a mine near Sonora, in California, the owner states that he is operating one "Baby" drill with a compressor driven by a gasoline engine. One man succeeds in drilling ten 4-foot holes in ten hours, at an expense of four gallons of gasoline, costing twelve and one-half cents per gallon. This is a remarkably cheap performance for drilling holes in hard rock.

Compressed Air for Mine Haulage.—When the distances in a mine become great the cost of tramming ore and waste becomes quite an item. The length of time necessary for a round trip makes it difficult to handle the quantity, and man haulage gives way to a train of cars hauled by animals. Steam motors cannot be used, on account of their heat and smoke.

During the last ten years a great many miners have replaced animal haulage with compressed air motors, which lend themselves splendidly to the work desired. There are, in general, two systems—the low-pressure system, in which air is compressed to five or six hundred pounds; and the high-pressure system, with air pressures of 2,000 pounds and over. The former system can be used in large galleries or tunnels or drifts where the width is ample and the track is reasonably straight. This permits a large receiver on the motor, 30 to 40 inches in diameter and from 8 to 16 feet long, to be handled with ease. The high-pressure system is used where the drifts are narrow or the curves on a small radius, permitting only a small wheel-base on the motor. Large receivers are, therefore, impractical, and steel tubes must be used and charged with high-pressure air to get sufficient volume.

Compressed air may be used cold on either of these motors, or the air may be passed to small tanks of hot water supplied to the motor at the charging stations.

The air and hot water combination does almost double the work that cold air will do. These motors can carry sufficient air for any ordinary run desired and haul tremendous loads. Two miles and return, with fifteen or twenty loaded cars, is not an extraordinary effort, and from the general results obtained, the cost of haulage is from one-half to one-third of the cost of the animal power. The air escaping from the exhaust of the motor engines adds to the ventilating effect in the mine and the whole system harmonizes thoroughly with the power outfit in the average mine.

During the year 1900 the writer was given the opportunity at the Morning Mine, at Mullan, Idaho, U. S. A., of installing upon their property a typical modern mining plant and one which contains most of the salient features that are considered important in compressed air engineering. A brief description of the plant, which, aside from being interesting from a compressed air standpoint, employs now the largest tangential water-wheel in the world and shows how three different heads of water can be harmonized on one compressor shaft, may not be inappropriate here.

The considerable cost of fuel to operate the steam-power compressors at the mine determined the management to utilize the water-power in the neighborhood to drive a compressor large enough for future needs. Surveys of possible water-power were made long ago, and eventually a site was determined upon near Mullan which made it possible to utilize three water-powers; first, that of the Cœur d' Alene River, by building a a dam and headgates just below the Morning mill and carrying the water in a flume to Grouse Gulch, giving 140 feet of pressure; second, by taking up the headwaters of Grouse Gulch and conducting them to a favorable point so as to obtain a fall of 1,420 feet; third, by similarly taking up the waters of St. Joe and Rock creeks and obtaining a head of 1,140 feet. The total capacity of these three sources would give a minimum of 1,100 horse-power during the season of the lowest stage of water.

The river flume is built of planed lumber, and battened inside and covered. It is 5 feet wide by 4 feet high in the clear and about 8,000 feet long, delivering into a steel pipe 42 inches in diameter and 400 feet long, reaching to the power-house. The Grouse Gulch pipe line is 7,350 feet long, containing 2,000 feet of 9-inch and 5,350 feet of 8-inch standard pipe. The Rock Creek water-line consists of 2,645 feet of 8-inch standard pipe. All of these lines are well anchored and completely buried.

The compressed air line consists of 9,500 feet of 12½-inch inserted joint pipe, which reaches to what is known as Station No. 6. From there two 9-inch branches are made, one into the No. 6 tunnel, which, when completed, will be 10,200 feet long, and one branch of 9-inch pipe to No. 5, 11,700 feet long and into No. 5 tunnel 1,500 feet, making a transmission of 22,700 feet to the present workings.

The compressor is designed to run 100 drills, and, owing to conditions relative to power, has offered a very interesting problem in compressor construction. On the main shaft of the compressor is mounted, as previously stated, the largest tangential water-wheel in the world, being about 33 feet in diameter. The rim is made very heavy to serve as a fly-wheel, and the diameter is a compromise between the requirements of the two higher heads, taking eighty revolutions of the wheel as the standard number of turns. This wheel will give the tremendous rim speed of more than 8,000 feet per minute, which has required special construction of the highest grade.

Two separate pipe lines convey the water to the nozzles at the periphery of the large wheel, and each nozzle is controlled by a suitable high-pressure gate valve and its by-pass, to prevent shock to the pipe line. The nozzles also have deflectors, so that the water streams may, in an emergency, be thrown from the wheel by the station operator. On the other side of the large wheel are two 11-foot Pelton wheels to receive the water from the Cœur d' Alene River, at a head of 140 feet, the total capacity of these two wheels being about 1,200 horse-power.

The compressors are compound, compressing the air in the first stage to twenty-five pounds and delivering it into the mains at ninety pounds, the heat generated by the first compression being absorbed in a double set of intercoolers placed in the tale-race of the low-pressure wheels. The compressor cylinders are, respectively, 32½ and 18 by 42 inches stroke, so that the piston speed of the compressor is 560 feet a minute, which is practically the limit of compressing speed. While this speed might not be disadvantageous to a single-stage compressor where the delivery occurs at or near the end of the stroke, in a compound compressor for the above pressures the delivery valve must open at about the centre of the stroke where the piston speed is 50 per cent. higher than the average. The delivery valves are thus compelled to open when the piston is moving at somewhat over 800 feet a minute. This presented a unique problem for valve construction, which has been solved in this instance by a very complete and satisfactory valve gear. All of the foundations are elaborate and expensive and are three separate stories in height. They are pierced by tunnels, and will be lighted so that any portion may be inspected at any time.

The intercooler is unique in character, and consists of a large number of 1¼-inch brass tubes, about 18 feet long, in a reservoir of water situated in the middle story of the foundations, flooded by backwater from the low-pressure wheels. Perforated floors under the intercoolers permit continual circulation, and are arranged to take away any sand which may be deposited.

The compressor is also fitted with an aftercooler, and underneath the cylinders and main frames a wide channel in the concrete is made, through which water continually flows to take away the immediate heat from the discharge valves, and to take away the discharge from the water circulations and also the oil and dust refuse. Each cylinder has two independent water circulations and each head has an independent water circulation. No expense has been spared to make this a thoroughly first-class and satisfactory installation.

The plant has realized all expectations. The temperatures in the compressor are remarkably low, indicating efficient working. The pipe line is perfect, and was tested to 160 pounds water pressure before turning in the air. It is seldom that a compressor has an opportunity to pump into so large a reservoir, namely, 12,000 cubic feet at present, but which will be, later, about 17,000 cubic feet. At present the reservoir holds 100,000 cubic feet of free air at ninety pounds pressure, or about 10,000 stored horse-power, calculated on the basis of a reheated economical motor. It will be interesting to those who are contemplating compressed air transmissions to know that the loss in this four-mile transmission may be neglected. The Morning Mine closed down the old compressors and found, upon turning in the new line that it took about 2,000 cubic feet of free air to do their present work. This amount passing through the pipes showed no appreciable loss on the gauges. It was not one pound at the most.

Compressed Air for Hoisting.—Compressed air is used for hoisting, both inside of the mine and on the surface. Either steam or compressed air is preferable to other media for hoisting, and the majority of hoists are built to use either one or the other medium, and the fact that they can be used in the same hoist proves an advantage in many places.

For underground work most of the hoists are small and are operated on winzes. Except in particularly favorable places, these hoists are operated with cold air, and are, therefore, not economical, as far as power is concerned; but they are extremely useful.

A winze hoist should be backed up by a large receiver near by.

Compressed air timber hoists are an extremely useful appurtenance for underground work. They are very light, weighing five or six hundred pounds, have small reels and small geared engines, and are of powers ranging from 5 to 10 horse-power. For hoisting timbers and drills into an uprise, or for hoisting timbers into stopes or around a mine generally, they are very useful. These hoists are also made on trucks so that they may be taken from one part of the mine to another very easily. All these underground hoists consume from 20 to 25 cubic feet of free air per horse-power of actual work done.

Surface hoists operated by compressed air are much in vogue, especially where the power is electrically transmitted to the mine. A portion of the electrical power is converted into compressed air to be used for the hoists. The most economical way to use this air is to so arrange the plant that the electrical power is practically constant and the compressor is just large enough to absorb this power. There must be large storage capacity, so that when the hoist is not in operation the power may be stored.

The hoist itself should be a compound, first-motion hoist to be a thoroughly up-to-date machine. A compound geared hoist is not quite so economical in air. The hoist cylinders should be jacketed. The air, after passing from the receivers, should go through a heater having two compartments, one for high-pressure and one for low-pressure air. In the first compartment the air is heated to about 400 degrees and passes around the jackets of the initial cylinder and finally into the cylinder itself, being exhausted from there back to the second compartment of the heater, where it is heated again to about 400 degrees, passes to the low-pressure cylinder of the hoist, and from there escapes to the atmosphere. A hoist of this character requires from 7 to 8 cubic feet of free air per horse-power, a vast difference as compared with the requirements of a cold air hoist. The cost of reheating is very small. The North Star Mine, at Grass Valley, Cal., using such a hoist, employs crude oil for heating purposes and consumes about a gallon an hour, which is insignificant in comparison to the power that this heating develops.

These compound, first-motion hoists are not expensive, even in first cost, and are extremely economical in operating. Large receiver capacity is an insurance against shut-down of the power plant, for unless the hoist itself gives way there will always be air enough on storage to bring the cage out of the mine, no matter what happens to the power plant.

Compressed Air for Pumping.—One of the most important uses of compressed air in a mine is for pumping, and within the limits of space the writer finds it difficult to properly consider the subject. Compressed air has been handicapped from the very beginning in the matter of pumping, because it has been used with stock pumps which have been designed in general for boiler feeding and tank purposes, and no particular regard has been paid to matters of cylinder proportions and appropriate pressures. Steam and compressed air are not similar enough in their phenomena to be used in the same motor.

The various rules and tables offered for calculating the amount of air required to lift water, without proper explanations, lead to the almost general conclusion that compressed air is a very expensive luxury. The percentage of efficiency credited to compressed air in the ordinary tables ranges from 15 to 30 per cent. No mention is made of possibilities beyond these numbers, and one is left but the one conclusion, that from 4 to 7 horse-power must be furnished to the compressor in order to produce a net yield of 1 horse-power in water pumped.

One hundred gallons per minute, lifted 200 feet, require about 5 theoretical horse-power. Consulting the various tables at hand, it is found that the efficiencies range from 17 to 40 per cent., the pressures from 110 to 20 pounds, the quantities of free air from 225 to 130 cubic feet per minute, and the cylinder ratios from 1 to 5 to 1. It may also be noted that the pressures required for the same cylinder ratios vary 150 per cent. The pressures given are all receiver pressures, or pressures in the main air pipe, which fact is not mentioned, leaving one to draw the conclusion that no matter what the pressure in the main is, it is only necessary to install a pump with large cylinder ratios and use low pressures.

The average pressures carried, in the main, correspond very nearly to the steam pressures formerly used for the same work, and ninety pounds gauge, independent of the altitude, seems to be the standard mining pressure. All tables and pumping data should be calculated from some such standard basis, with proper coefficients for variations for the standard pressure, and a table giving the proper cylinder ratios for the different heads, using standard pressures as a basis, would be more helpful to those who wish to consult tables for guidance.

There appear to be six general forms of compressed air pumps: First, displacement pumps for full pressure only; second, displacement pumps using expansion; third, direct-acting pumps for full pressure only; fourth, direct-acting pumps using expansion; fifth, air-lift pumps, simple and combined with displacement chambers; and sixth, pumps operated by independent motors.

In the first style of pump, the Merrill type, two chambers are employed, submerged in the water, the compressed air being admitted directly to the chambers and displacing the water, the chambers acting alternately. With such a pump an efficiency of about 22 per cent. has been claimed, which is better than most ordinary direct-acting pumps will do with cold air. One can readily see, however, that this style of pump exhausts its chambers into the atmosphere at full pressure and all the expansive work contained in the air is lost. This system compounded, however, can be made very efficient.

In pumps of the second class, exemplified by the Harris system, the air, after displacing and raising the water as above, instead of being at once exhausted into the atmosphere is allowed to do work in expanding against the compressor piston, and thus, practically speaking, all its expansive energy is saved; but the manufacturers admit the losses in leakage and friction to be about 15 per cent. This is a very interesting and efficient system, and may be justly entitled to an efficiency of from 60 to 70 per cent. It should prove a very desirable system for mine station pumping.

In the third system we have a type of direct-acting pumps which are generally given a mechanical efficiency of 65 per cent. and an actual efficiency of from 15 to 22 per cent. They use the air at full pressure only. If a pump uses full pressure only, it is evident that the more full pressure a compressor diagram shows, the greater will be the efficiency of the system; the lower the air pressure, the less the compression work and the greater the proportion of full pressure work; consequently the lower the pressure, the more efficient the system. This really refers to the compressor and not to the pump, for the pump works the same whether it receives air at ten pounds pressure from the compressor, or whether it has been expanded from a receiver having a higher pressure, provided the temperatures are constant. If we look for the best efficiencies from the direct-acting pumps we must put in an independent compressed air system and carry low pressure.

The general conclusions in operating direct-acting pumps are as follows:

First—The lower air pressure in the main, with the cylinders designed properly, the greater the efficiency, reaching as high as 30 per cent.

Second—The efficiency drops immediately if the air is expanded through the throttle into an air cylinder which requires less pressure than the main.

Third—At standard mining pressure of ninety pounds the efficiency is about 17 per cent., with properly designed cylinders, and probably drops as low as 12½ in the pumps where just one turn of the valve is open.

Fourth—Very little loss occurs in using pressures within 10 per cent. of the pressures in the main, which is ample to impart proper dynamic head to the pump. Compound compression will increase these efficiencies 15 per cent., and reheating will also increase the efficiencies in proportion to the ratios of the absolute temperatures.

Fifth—Compound, direct-acting pumps are very little understood. The general idea has been that if the expansion of air produces such low pressures that it frequently freezes the simple pump, it would be an unwise proposition to try full expansion in compound pumps; consequently compressed air users practically avoid multi-cylinder pumps.

To use compound pumps the air must be heated in some manner. This reheating can be done either with the water which is being pumped, or extraneous heating before the initial cylinder, or extraneous heating before the compound cylinder, or extraneous heating before both cylinders. By reversing the idea of the intercooler in compression and passing the air from the initial cylinder of a compound pump through a series of coils around which the water that is being pumped circulates, the air will take on very nearly the temperature of the water, and it will be delivered to the second cylinder at practically the same temperature as the first, thus permitting a number of expansions to be used, and the efficiency of any ordinary compound pump may be made equal to from 37½ to 40 per cent. by this simple method of water reheating. In other words, almost double the water can be pumped for the same amount of air used in a simple pump.

Where extraneous heating is used before the initial cylinder and between the two cylinders, the efficiency in compound pumps may be made to vary from 30 to 72 per cent., a vastly greater efficiency than is generally thought possible.

The combination of displacement and air-lift pump can be obtained in the Wheeler pneumatic pump.

The Cummings, or the two-pipe system, is a very interesting one, consisting of compressing the air to a high pressure—about 200 pounds—and exhausting it back from the pump at 100 pounds. This may be made to give an efficiency of probably 50 per cent., and if reheated, possibly more.

Air-lift pumping, or the Pohlé system, as it is called, is a simple system, which consists in reducing the specific gravity of water in the pipe by admixture of air, so that the head of water on the outside of the pipe will push it out. Extensive experiments have been made with it in America and in Germany, and it may be assumed that the efficiency may reach as high as, say, 50 and 60 per cent.

Motor-operated pumps consist of pumps belted or geared or directly connected to all kinds of engines. There is no doubt that with Corliss engines coupled directly to pumps, and properly reheated and compounded, the efficiency will reach somewhere about 75 per cent.

In conclusion, the efficiencies following are suggested. The percentages given in the table there may be taken as fairly accurate in comparing the various kinds of pumps, and the relations between them will be properly expressed by these figures, even if the actual efficiencies, as determined by other observers, may be somewhat different.

In explanation of the following table, the writer would say that the figures are on the basis of a pressure in the air mains of ninety pounds gauge. By foot-gallons is meant the product of the number of gallons pumped and the feet elevation that the water is pumped. This I find to be the most convenient and reliable way to designate the duty of pumps, and the foot-gallons designated are the work of one cubic foot of free air compressed to ninety pounds gauge pressure.

90 LBS. AIR PRESSURE ON MAIN.

	Kind of Pump.	Foot Gallons	Efficiency Simple Comp.	Efficiency Compound
1.	Direct-acting simple	135	19	20
2.	Direct acting simple 300 reheated	180	24	28
3.	Direct-acting compound, water reheated	232	32	37.5
4.	Direct-acting compound, 1 cyl. heated 300	280	40	46
5.	Direct-acting compound, 2 cyl. heated 300	326	46	53
6.	Direct acting triple cyl. heated 300	338	54	62
7.	Direct-acting triple cylinder heated 400	444	63	72
8.	Plain displacement	175	22	25
9.	Wheeler displacement, 34 per cent. for 34 lbs. pressure	..	..	..
10.	Multiple displacement	320	40	46
11.	Harris displacement	60 to 70 p. c.		
12.	Merrill displacement	175	22	25
13.	Cummings system	35 to 70 p. c.		
14.	Compound motor pumps	50 to 80 p. c.		
15.	Direct-acting triple water-heated	300	42	48
16.	Pohlé air lift. 30 to 60 per cent. heads less than 300 feet	...	..	..

The second column shows the efficiency of the system with ordinary single-stage compressors and the third column with compound compressors.

No. 1 is the plain, direct-acting pump, like a plain boiler-feed pump, and the table shows that one cubic foot of free air, compressed to ninety pounds gauge pressure, will perform 135 foot-gallons of work; that is to say, it will lift one gallon 135 feet, or ten gallons 13.5 feet, and so on.

No. 2 shows that the above pump will perform 180 foot-gallons of work if the air is heated to 300 degrees before entering the pump.

No. 3 shows that an ordinary direct-acting compound pump, using the water that is being pumped to heat the air on its way from the high to the low-pressure cylinder, will perform 232 foot-gallons of work, giving thus almost double the efficiency of No. 1, and requiring no fire heating—simply a little more investment in the installation.

No. 4 is the same kind of pump as No. 3, heated by fire to 300 degrees between high and low-pressure cylinder instead of utilizing the heat of the water. It is more economical, but the utility is not so high.

No. 5 is same pump as Nos. 3 and 4, but is fire-heated to 300 degrees before and after the high-pressure cylinder.

No. 6 is a triple-cylinder pump heated before and after the high pressure and after the intermediate to 300 degrees, giving 383 foot-gallons.

No. 7 is same pump heated to 400 degrees, giving 444 foot-gallons, showing that the same air as in No. 1, giving 19 per cent., can be made to give 63 per cent. properly manipulated.

No. 8 is a plain displacement tank, showing that it is more economical than an ordinary direct-acting pump.

No. 9, the Wheeler displacement pump, which is an ordinary tank displacement and an air lift combined, gives 34 per cent. efficiency.

No. 10 is a multiple displacement proposition where the displacement tanks are arranged above one another at distances corresponding to the ratios of isothermal expansion, giving a calculated efficiency of 40 per cent.

No. 11, the Harris system, where, after displacement in a tank, the air is returned through the compressor to the other tank operating in harmony with the first, is the most economical way of handling water by compressed air that the writer has seen.

No. 12, the Merrill displacement system, is a plain displacement system of two tanks.

No. 13, the Cummings system, which is used in connection with direct-acting pumps, is a two-pipe or closed system, delivering air to the pump at about 200 pounds per square inch and exhausting back to the compressor at 100 pounds, the idea being to utilize, as far as possible, the full pressure part of the air card. The economy is quite high, from 35 to 70 per cent., depending on the pressures carried and the character of the pump.

No. 14, compound motor pumps, refers to pumps driven by a compound air motor where heat is used before and after the high-pressure cylinder, and economies as high as 80 per cent. may be realized.

No. 15. Triple expansion, direct-acting pumps may be made to perform 300 foot-gallons of work, or 2.25 times as much as the same air will do with an ordinary direct-acting pump, by simply heating the air between the high and intermediate cylinders with the water being pumped, which has usually a 60-degree F. temperature.

No. 16 represents the air lift pump, which has an efficiency of from 25 to 60 per cent., depending upon the conditions. —EDWARD A. RIX, in *Cassier's Magazine.*

The Paxson-Warren Sand Blast System.

The sand blast process has been before the public for more than 30 years, but not until the last ten years has it come into use in the foundry. Although not yet universally used, the merits of the sand blast are fast being recognized, and quite a number of plants have been installed during the past two years. The improvements made in air compressors and the more general use of compressed air, have, in a large measure, been responsible for this. It is not until comparatively recently that there has been on the market an efficient American built sand blast machine. The machine itself should be strongly built, to stand rough usage of unskilled labor. As damp sand will clog up any sand blast, hand holes should be so located that the obstruction can be removed at once without much trouble. I have seen with the use of the double shell sand blast fully an hour required to remove some damp sand. The machine had to be disconnected and hung up by a hoist so that the sand could come out through the top.

With the improved sand blast machine all this trouble is obviated. It has a single shell, no inside hopper, all parts are accessible through hand holes and all parts liable to wear can be easily replaced. The valve at the top of the machine controls the air supply, the one at the bottom regulating the supply of sand. The sand is fed in through a valved opening in the top head, which is closed when the machine is in operation. To operate, turn on the air and direct the jet of sand and air against the casting to be cleaned. The air serves to give a high velocity to the sand, which does the work. A specially designed helmet is used to protect the face of the operator. The most wear comes on the hose and nozzle. For hose we use a

THE PAXSON-WARREN SAND BLAST.

grade specially made for us; it is practically pure Para rubber, and will last, with constant use, from six months to one year. Length of hose may be used up to 50 feet, 12-foot lengths being long enough for most requirements. It has been found that hard iron tips and nozzles give the best satisfaction.

POINTS TO BE CONSIDERED.

An important point not to be overlooked is the quality of sand which should be used in these machines. It should be hard and tough and not too fine, and thoroughly dried and cooled before using, so that it will not steam and clog up the machine. Care should be taken not to overheat the sand, for this will cause it to break up, and a good deal of its efficiency is destroyed. To avoid trouble, it is necessary to have a good air compressor. The idea that because only a low pressure is used any old machine will do is a wrong one. As there are a number of first-class machines on the market, it is not necessary to mention any particular make. The compressor selected should have a confined suction, so that cold air can be supplied to it and thus avoid taking in more moisture than necessary. It is a well-known fact that cold air carries less moisture in suspension than hot air. The receiver should be located near the sand blast in order to trap out any moisture that may condense in the pipe. Either a belt or steam driven compressor may be used, as best suits the power conditions of the plant where it is installed. Where there is ample engine power available it is best to use a belt driven compressor, because a large engine uses steam more economically than a small steam driven compressor. The best place to locate the air compressor is in or near the engine room, so that the engineer can take care of it. With the proper size of pipe air can be conducted a long distance with very little loss in pressure. The number of cubic feet of free air required per minute will vary according to the opening in the nozzle and the pressure required to do the work. For brass castings 10 pounds pressure is sufficient; on gray iron castings 15 to 20 pounds is generally used; and for steel castings 25 to 30 pounds is required. Experience has proved that a large amount of air at a low pressure will do more work than a small amount at a high pressure.

The sizes of openings in the nozzles commonly used are 3/8, 1/2, 5/8, 3/4 and 7/8 inch. Many of the compressor catalogues give the amount of air that will be discharged through different sized orifices at certain pressures. As the sand takes up some room, it is obvious that the figures given will be ample for this service.

SPECIAL COMPRESSOR RECOMMENDED.

It quite frequently happens that an establishment having a high pressure air service already installed will consider the advisability of putting in a sand blast plant. One of the first questions arising is whether the high pressure air can be reduced. While this can be done it is not economical. Take, for example, a sand blast for cleaning gray iron castings, using air at 20 pounds pressure, through ½-inch nozzle, the amount of free air required would be about 120 cubic feet per minute. To compress this amount to 20 pounds requires about 9 horse-power. To compress the same quantity to 80 pounds would take about 23 horse-power. As there is no power or advantage gained by reducing, there would be a loss of about 14 horse-power, and the total loss for a year would amount to nearly the cost of a special compressor for this service.

In the preceding part of this paper the sand blast proper and the compressor for furnishing the blast have been described. As the sand blast makes a large amount of dust it is customary in most cases to have it installed in a room by itself, of sufficient size and conveniently arranged to handle the work. In all cases I would strongly advise using an exhaust fan to take away the dust. The size of fan will vary according to the size of the room; size of sand blast and amount of dust to be exhausted. It is better policy to install a large fan and run it a medium speed than to run a smaller fan at a high speed to do the same work. While the first cost may be a little more, the difference will easily be made up by the horse-power saved. Where it is objectionable to exhaust the dust out doors it becomes necessary to install a washer that sprays the dust as it is drawn through, so that the exhausted air is practically clean. The dust settles to the bottom of the washer as mud, and occasionally has to be shoveled out.

USING SAND OVER AND OVER.

Where the sand blast is used on a large scale it is an advantage to have an arrangement for preparing sand so that it can be used over and over. In this case a hopper is located in the center of the room, or to one side, and covered with a grating. The hopper discharges into an elevator boot, from which the sand is elevated and fed into a revolving screen, where the fine sand is screened out into a dust box and the tailings fall into the sand box, which is above the sand blast. From the sand box the sand is fed back into the sand blast as required. With this scheme the fine sand does not get into the washer or fan, consequently the washer does not have to be cleaned out as often. The belt elevator is a positive device, and when it is properly fed gives good satisfaction. As the conditions in any two plants are never exactly alike it requires considerable thought to get the best arrangement and one that will give the best satisfaction.

For cleaning large amounts of small castings a sand blast tumbling barrel is used to advantage. Capacities of these barrels vary from 5 to 10 tons per day. The barrel, mounted on rollers, is filled less than half full and caused to revolve very slowly, say three or four revolutions per minute. The sand blast jets are introduced through the ends of the barrel, and as the barrel revolves each casting comes in contact with the blast. The time required to clean one charge varies from 20 to 30 minutes. The advantage of this method is that the castings are thoroughly cleaned and the sharp corners preserved. The barrel itself is covered with a sheet iron casing, which is connected to an exhaust fan and washer, if necessary.

In comparing the sand blast process with other methods of cleaning it is unfair to make comparisons with methods where the castings are only half cleaned. In the bathtub business the sand blast is almost an absolute necessity on account of the labor saved, and because it is the best way to prepare tubs for enameling. On castings to be machined there is a great saving on the tools in the machine shop. The sand blasted casting takes paint better and has a more finished appearance than a casting cleaned in any other way. In most cases, where the sand blast is properly installed, it should pay for itself in two or three years. The sand blast is not confined to the foundry alone, but is extensively used for removing scale and rust from sheet iron and structural work, for cleaning brazed joints and for cutting and cleaning marble and other stones; for cleaning pieces to be galvanized it is of great service, as it does away with the possibility of the acid eating into the metal and impairing its strength.

Compressed Air Reheating.

The advantages to be gained by the heating of compressed air before delivery to the engines are not sufficiently well understood by mine operators. It is true that there are difficulties to be overcome which, until they are solved, militate against the use of reheaters underground. The chief drawback is due to the fumes and gases given off by the reheater; this problem should, however, be capable of ready solution and in view of the enormous gains to be made it is well worth attacking.

In brief the system consists in passing the air, compressed say to seventy or eighty pounds per square inch, through a coil of pipes heated by means of gas, petroleum or coke. The air is thus raised from a temperature of about 60° to 350° F. Under the best conditions the mechanical efficiency is exceedingly high, as much as seventy per cent. having been obtained under test conditions. This means that one-fifth of one pound of coal has developed in the reheater one horsepower per hour as against from two and one-half to five pounds of coal at the compressor; it converts a notoriously wasteful method of obtaining power into a much more economical force. Finally the machines using the hot air are much more efficient than when using cold air.

The most thorough study of the effect of reheating compressed air for power purposes has been made in the famous compressor plant in Paris, although in the California mines much attention has been given to it. About 1888 a gigantic air compressor plant was erected in Paris for the purpose of delivering cheap power to small factories, private houses and for such general purposes as power is needed in large cities. The city of Paris was dotted with stations for compressing air, one being laid out with a capacity of 24,000 horsepower, although we are not aware that this amount of power was ever generated. The system was designed by M. Popp, the famous French engineer. At first the air was used in the condition in which it left the stations, but with very unsatisfactory commercial results. Indeed it appeared, at one time, as if the system would have to be condemned. In this dilemma Popp commenced experimenting with small and crude reheaters made of coils of pipe and heated by coke or city gas. The result was a saving of nearly forty per cent. in the consumption of compressed air and the enormous outlay of capital was saved, partially at all events.

The results obtained by the reheaters will be of interest to all those who use compressed air, and in view of the very

LEYNER REHEATING STOVE.

great advantages to be gained it is well worth the while of mine operators to experiment along the same lines, especially if their present compressor power is too small for the work to be done in the mine. The effect of reheating is not only to increase the efficiency of the compressor system, but also allows it to do more work.

At Paris, when the Popp system of air compression was first adopted, the consumption of air was enormous. Rotary engines of one horsepower capacity and working expansively, consumed no less than 1,469 cubic feet of cold air per brake horsepower per hour, but when the air was heated to only 122° F. the engine only consumed 960 cubic feet of air. A two-horsepower engine used 1,059 cubic feet of cold air and 847 cubic feet heated air per brake-horsepower. It was found, finally, that the air should be heated to

COILS FOR STOVE.

about 350° F., and the consumption of air was then reduced to about ten cubic feet free air per horsepower per minute as against fifteen to twenty-five cubic feet for cold air. The amount of fuel required was trifling and it was demonstrated that about one-half pound of coal in the reheater gave one horsepower of useful work at the engines. It was further found that a heating surface of one square foot was needed for every 750 cubic feet of free air heated per hour. The size of the heater required is therefore not very large. The cheapness, the efficiency and the simplicity of the reheater stoves is so obvious that it is somewhat surprising that they have not been adapted to mining work. Of course the air, after leaving the stove, should be carried in covered pipes to the pumps, drills or other machinery which is being operated. Ordinary steam pipe covering answers admirably for protecting pipes carrying hot compressed air.

Herewith is shown the heating stove designed by J. G. Leyner, the Denver manufacturer of air compressors and drills. It appears admirably adapted to the purposes for which it is designed.—A. W. Warwick, in the *Mining Reporter*.

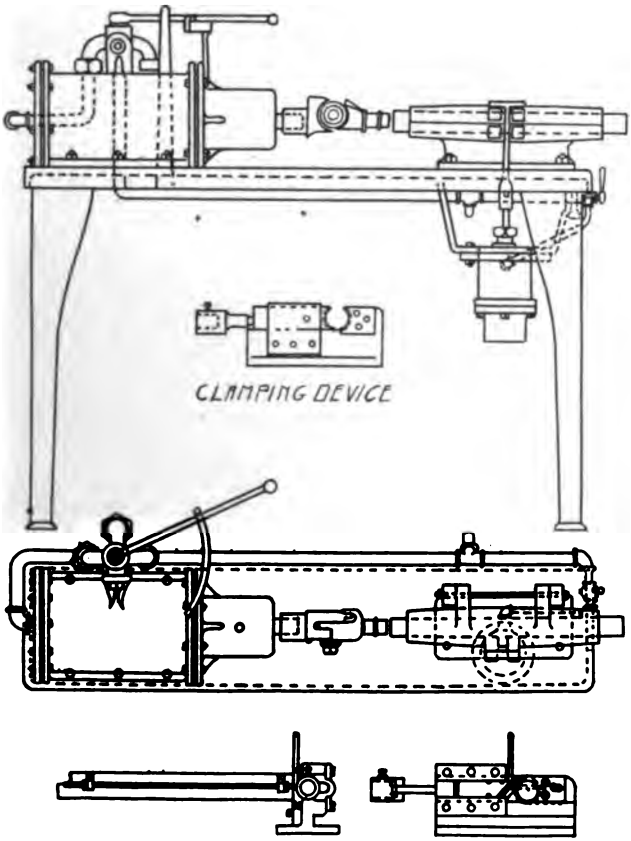
Air Lift Pump on the London Central Railway.

In a recent issue of the *Financier and Bullionist* there is an article describing a new air-lift pump which has been installed at the power stations of the Central London Railway and at Ilford. It is well known that the efficiency of an ordinary deep-well pump is only about 40 or 50 per cent. after it has been working for some time, while the efficiency of an ordinary air pump is 25 per cent. at the best. In the event of any grit getting in the valve of a deep-well pump the result is anything but pleasing. The pump has to be stopped for a period of several days, sometimes weeks, and the slightest breakdown of any detail in connection with the pump occasions a long delay and a consequent waste of a large amount of time and money. The risk of breakdown is almost eliminated in the air-lift pump, and the simplicity of the system is a distinct point in its favor. One power house can supply the necessary power for any number of pumps, and when all expenses entailed by repairs, etc., are taken into account, it is not at all certain that the efficiency of the deep-well is better than that of the air-lift pump—at any rate, from a financial point of view. This only applies to an air-lift pump with an efficiency of about 25 per cent., but by the invention of Mr. Joseph Price, of the firm of Messrs. Le Grand and Sutcliff, it is claimed that this can be increased by 40 per cent. With the ordinary air-lift pump a certain amount of water is forced up a tube of uniform bore by compressed air, which, as it rises, expands and parts with a good deal of its energy in giving momentum to the column of water above it. This, of course, causes the water at the top of the tube to move considerably faster than that at the bottom. Mr. Price has departed from the rule of making the tube of uniform bore, and has made the rising main to taper. As the air rises with the water it still expands, but as the tube is greater in diameter it can expand laterally, thus leaving the actual height of the column the same as when it entered the tube at the bottom. No additional momentum is given to the water, and it leaves the rising main at precisely the same rate as it entered. This pump should be of considerable service to central station engineers and to those engaged in mining work, and in any case where a continuous supply is needed.

Air Hose Repairing.

Many railroad shops have in use some form of machine adapted to assist in the repair of air brake hose, and a great saving is thereby effected on account of the large individual expense item caused by necessary hose renewals. A machine is here illustrated which has been in use on the Southern Pacific for several years, and which performs the operations necessary in making over old hose.

The machine consists of a flat lathe bed, upon which is mounted a horizontal air cylinder, and provision is made for the placing of three attachments upon the bed by the attendant. In repairing, the first operation consists in cutting off the old hose squarely, and this is accomplished by placing in position the cutter, shown detached, into which the hose is placed. The air is turned on and the knife shears off a length, which may be determined by means of a supporting scale extending to the rear. After a number of hose are cut the proper length, the cutter is removed and a clamping device, shown in position,



MACHINE FOR HOSE AND COUPLING REPAIRS.

is applied. The hose is laid in this clamp and held by the use of air pressure in the vertical cylinder underneath the machine bed. A dummy connection on the main air cylinder piston rod holds the hose connection, and upon the application of air pressure it is forced into place in the hose end. This operation completed for the lot, the clamping device shown detached is placed in position and the clamps applied by power.

Although it is apparent that some changing is necessary, yet the alterations, consisting in simply lifting off the attachment in use and setting the desired one upon the form, are accomplished quickly. In running through a large number of hose, the whole may be renewed at a great saving of time over other methods and with a better grade of workmanship. This machine is manufactured by the J. D. Connell Iron Works, New Orleans, La., who hold patents covering the same. —*Railway Age.*

Rand Belt and Motor-Driven Compressors.

The accompanying illustration shows a new type of air compressor designed for machine shops, foundries, and other industrial establishments where little attention can be given to a compressor and where compactness, simplicity and strength in design are appreciated. The compressor requires a small floor space so that it can be set up "out of the way" and is driven by belt direct from a main shaft or countershaft, or, as shown in the illustration, it is conveniently driven by a gas engine or electric motor. As a direct connected gear driven compressor for portable or stationary use, the design permits of the most compact arrangement. Two machines may be operated by the one motor, if circumstances require it.

Each compressor has two single acting vertical cylinders, fitted with extra long trunk pistons, which act as guides for the lower ends of the connecting rods. This does away with stuffing-boxes and crossheads, and reduces the height of the machine as well as the number of bearings. The cranks are set opposite to each other so that one piston and one connecting rod are moving downward while the opposite piston and connecting rod are moving upward. One side thus perfectly counterbalances the other.

The belt wheel is placed between the two main bearings and is made unusually large, with broad face to give ample belt power without straining the belt. Its rim is made very heavy so that it acts as a balance wheel. In the direct motor-driven compressor the belt wheel is replaced by a heavy gear wheel as shown.

For pressures above 25 pounds the cylinders are water-jacketed and are cast in one piece with the frame, insuring rigidity. They are bored on a special machine and finished with a reamer. The main borings are also bored out at the same time. The main bearings are fitted with removable shells made of hard babbitt metal, which when worn out can be easily replaced at slight expense, thus restoring the original correct alignment of the machine.

Both crank pins and crosshead pins are made of special steel and are hardened and ground. The connecting rod is of malleable iron, and there is no strain on it except that of compression, as all work is done on the outward stroke. Both ends of the connecting rod are bored out and fitted with hard bronze bushings, which can be easily and cheaply renewed when they are worn out.

The inlet and outlet valves are of the poppet type, fitted with light springs, and work vertically. On account of their position at the bottom of the cylinder they are well lubricated, and also on account of their vertical position there is no tendency to wear down out of line with their seats. They are made from drop forgings, are light and practically indestructible, do not hammer the seats and are prevented from getting into the air cylinder (in case of breakage) by sheet steel guards.

The inlet valves for both cylinders take air from a common passage, which is tapped to receive a pipe leading out doors or to some place where air at a lower temperature may be obtained. The outlet valves on both cylinders discharge into a common passage, which is tapped to receive a pipe connecting with the air receiver.

The base of the machine is high enough so that the air heads can be readily removed. Any valve can be removed without disturbing the air head, by simply unscrewing the cap over the particular valve. The main bearings, crank pins and crosshead pins are of unusually generous proportions and these bearings will run for long periods without readjustment. The pistons are packed with cast-iron

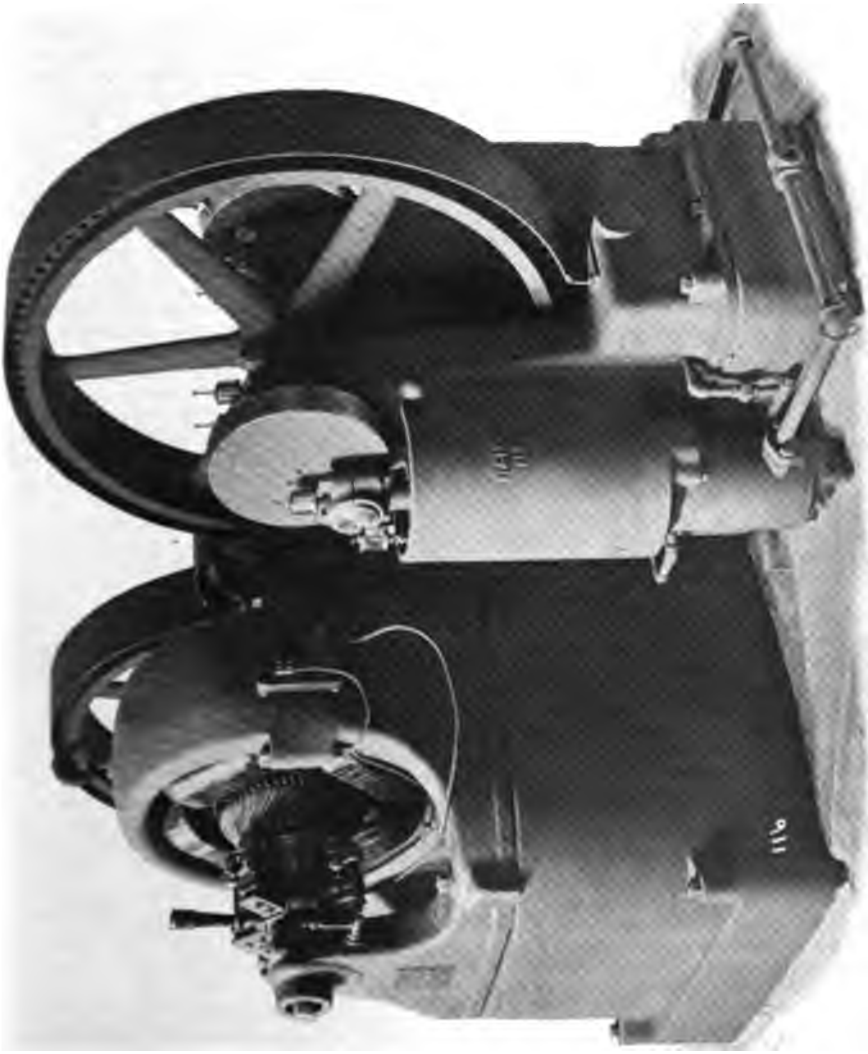


FIG. 1.—DIRECT MOTOR-DRIVEN AIR COMPRESSOR.

snap rings of approved construction. Each compressor is fitted with an automatic regulating valve attached to the common inlet pipe, which throws off the load without stopping the machine, when the pressure reaches a predetermined limit, and again throws on the load as soon as the pressure is lowered.

Efficient means are provided for lubricating the cylinders and all bearings. At the top of the cylinders there is a metal projection which catches the drip from the main bearings and crank pins, and any oil which may work out from the cylinders. These compressors are designed for air pressures up to 150 pounds per square inch, and range in capacity from 16 cubic feet to 500 cubic feet of free air per minute.—*Iron Trade Review.*

Compressed Air versus Gas and Steam.

Compressed air has become such a factor in the manufactures throughout the United States that the scientists and skilled mechanics have been called upon to prove that it is a far safer power than either steam or gas. When it is considered that compressed air is put to an almost limitless number of uses it seems remarkable that so few accidents occur. Every case reported so far in the technical journals is credited to carelessness or ignorance on the part of the workman.

Compressed air installations are used with pressures up to 3,000 pounds to the square inch, not only in every mine of magnitude, but in all tunnel work, quarries, shipbuilding, submarine work, and for refrigerating purposes. Its greatest range really is in all railroad and manufacturing lines.

Nearly every railroad, machine, erecting and boiler shop and foundry of any size has its own compressor plant. From all of these varied sources comparatively few accidents have been reported. As a means of safety many of the powder magazines throughout the country are using compressed air as a motive power, to the exclusion of steam and electricity. Railroad trains, both freight and passenger, are equipped with air compressors and storage tanks, and on the latter the power is used for as many as eight different purposes, such as the braking of trains, ringing bells, opening fire doors, shaking grates, sanding the rails, lifting tender water scoops, raising water in passenger coaches and operating fans for ventilation.

The reason compressed air is a safe power is the fact that it has no reserve force, as in the case of steam boiler explosions. The failures that have occurred in the use of compressed air can, in nearly every instance, be traced back to the ignition of oil or some inflammable substance which is used with the air. Lowtest lubricating oil, for example, fed to the air cylinders, may meet with a temperature greater than that of its flashing point. In putting oil into the cylinders and surplus that may reach the cylinders is forced out through the delivery valves into the air pipes and receivers. The products of decomposition of a large quantity of oil in the receiver would, with the air, form an explosive mixture.

Air in itself is a perfectly safe fluid, and only requires a vessel strong enough to hold it. In this respect the problem is not a serious one, as the factor of safety in the case of air may be less than for steam, water or gas, as it does not corrode the vessel, its temperature is not changed, and it causes no internal destruction. —*Modern Machinery.*

Arnold's Electro-Pneumatic Motor Car.

At the convention of the American Institute of Electrical Engineers, at Great Barrington, June 20, Mr. Bion J. Arnold, after reading his paper on "Electric Power for Heavy Railroad Service," gave a brief description of a system which he has designed for utilizing compressed air, stored on each car, in the propulsion of electric cars. He said that he was constructing 20 miles of road* to be worked by this system; and the necessary trucks and motors are being built. Mr. Arnold believes that it will be necessary ultimately to abandon the direct current motor for heavy and long distance service. The main points of his description are as follows:

*The road to which Mr. Arnold refers is the Lansing, St. Johns & St. Louis. The line begins at Lansing, Mich., and runs northward to St. Johns on the Grand Trunk (D., G. H. & M.), and thence to St. Louis on the Pere Marquette. It was briefly described in the *Railroad Gazette* of Feb. 21 last, page 184. The length of the entire projected line is 60 miles. The part of the line on which the track is finished is that between Lansing and St. Johns. We understand that this portion has been in operation some time, steam locomotives being used.

1. A single phase or multiphase motor, mounted directly upon the car, designed for the average power required by the car, and running continuously at a constant speed and a constant load, and, therefore, at maximum efficiency.

2. Instead of stopping and starting this motor and dissipating the energy through resistances, as is customary with all other systems, I control the speed of the car by retarding or accelerating the motor, by means of compressed air, in such a manner that I save a portion of the energy which is ordinarily dissipated through resistances, and store it to assist in starting the car, helping over grades, for use in switching purposes, and for the operation of the brakes.

3. By this method of control I secure an infinite number of speeds from zero to the maximum speed of the car, which may or may not be at the synchronous speed of the motor, for with the air controlling mechanism at work compressing, the speeds below synchronism are maintained, and by reversing the direction of the air through the controller, speeds above synchronism may be attained for reasonable distances. This feature gives to the alternating current motor the element absolutely essential for practical railway work, for it permits a car or train to ascend a grade at any speed with the motor working at its maximum efficiency, and imparting its full power to the car. When descending the grade the motor may utilize its full power drawn from the line in compressing air, or it may be used to compress air with the stored energy of the train, thereby acting as a brake.

4. By virtue of the air storage feature each car becomes an independent unit and capable, in case of loss of current from the line, of running a reasonable distance without contact with the working conductor, and this without the aid of storage batteries. This feature will be valuable in switching and in crowded cities.

5. Since a single-phase motor can be used the motors can be supplied with current from a single overhead wire or third rail, and with a single rail return circuit, thus permitting the overhead constructions, or third-rail construction, to conform to the standard of to-day, except that a much higher working voltage can be used, provided the insulation is taken care of. In steam railway work the use of only one of the track rails will be required for the return circuit, thus leaving the other rail for the use of the signal system.

6. The current will be taken from the working conductor at any voltage up to the limit of the insulation, and in case this voltage is high (I am building my line for 15,000 volts), a static transformer will be carried upon each car and the pressure reduced from the line voltage to the voltage of the motor, which, in the case under construction, is designed for 200 volts. Where it is unnecessary to utilize so high a line pressure the motor may be designed for the working voltage and the current fed directly from the working conductor into the motor, thus eliminating the static transformer. When a high voltage working conductor and static transformer are used, and it is thought advisable to use a working conductor through cities or towns this working conductor will be supplied with energy through a stationary transformer at each city limit.

7. By virtue of the speed of the motor and its constant load, either when the car is in motion or when it is standing still and motor compressing air, the variable load now customary in electric railway power plants is eliminated, and the power station works at practically a constant load, thereby eliminating a large part of the investment at present requisite in power station and line construction. Furthermore, by virtue of the air storage feature, each car, in the particular apparatus I have designed, is capable at any time when current is on the working conductor of delivering to the car wheels a much greater torque in proportion to the capacity of the motor than is possible with any electrical system known to-day. —*Railway Gazette.*

Removing Sand from Wells by Compressed Air.

When sand is to be removed from wells it has been suggested to blow out the wells by compressed air, the method being to pump up a high pressure in the receiver and to discharge it through a small pipe put down the well. The idea of this was not only to blow the sand out of the well by stirring it up and carrying it off by the large flow of water due to the action of the air lift, but also to make such action sufficiently violent to knock any rust off the perforations. Particularly on this last account it is thought that this would be superior to the system of using the sand pump.

This was tried in three different artesian wells. In none of these instances was any appreciable benefit accomplished. But this was not due to the fault of the system, but simply because the water had fallen in these wells due to dry years and the interference of other artesian wells. In the first well experimented with the water stood about two feet below the ground. This was blown out by compressed air. A pressure of 300 pounds was pumped up in a receiver of about thirty-five cubic feet capacity and discharged through a one-inch pipe, the open end of which was near the bottom of the well, about 550 feet deep. The discharge shot a stream of water about forty feet into the air. It looked for the time being like a young geyser. After the discharge the water in the well went away down and gradually came back again. Then the air compressor was allowed to discharge steadily into the pipe and to pump from the well as an air lift. The result of this was to bring up a steady stream of water containing much sand and large pieces of rust. Several runs of an hour or so were made on this well, but at the end of that time the water stood just where it had before the tests were begun.

The next well on which this was tried was about a mile away on lower ground, giving a flow of 17.9 miners inches. This well was 399 feet deep and of six-inch casing. A one-inch pipe was run within about six feet of the bottom of the well, 300 pounds pressure was pumped up in the receiver and the well blown out three times, after each discharge letting the compressor run into the pipe down the well for about twenty minutes. A measurement of the sand blown out showed that 37,500 cubic inches, equivalent to a volume of 110 feet of six-inch casing had been removed. This lowered the well bottom only about three feet, showing that it was an open bottom well. After these runs the measurement of the flow of the well was 18.9 miners inches, about 5 per cent. increase. Then one-half of the pipe in the well was taken out, leaving the end 200 feet down under the water. The receiver was again pumped up and discharged. The result of this discharge of the receiver was that the water ceased flowing entirely and stood about ten feet down in the well, showing that the bottom had filled up with sand. Keeping the pipe at the same 200-foot level the compressor was run for about half an hour, pumping steadily into the well. At the end of that time the well had resumed the same flow which it had before making this last test. The sand removed in this last blow and run was equivalent to forty-four feet of six-inch casing—the size of the well—the depth of the well at the end being 402 feet. The hydrostatic head of this well was only twenty-eight inches above the level of discharge, so that had the pressure in the ground fallen twenty-eight inches the well would have ceased to flow. The stream of water which shot up from this well on discharging the compressor went far above the derrick, about seventy-five feet in the air. It came out with a loud roar.

The next well tested had only a small flow of about half an inch of water. The well was about 575 feet deep. A ¾-inch air line was run down near the bottom of the well and 450 pounds pressure pumped up in the receiver and discharged. The illustration shows a view of the water shooting out of the well as the discharge was subsiding. After the discharge the water went away down in the well, and seemed to come up spasmodically from the action of the compressed air, every once in a while sinking far down. On taking soundings the well had filled up about 200 feet. By continuous running of the air the sand was lowered about 130 feet, but it was impossible to lower it still further, as it seemed to run in as fast as it was pumped out. The sand was exceedingly fine quicksand. The last seventy feet of sand removed had to be taken out by a sand pump. Subsequent inquiry developed the fact that a string of tools had been lost in the well, and that gunpowder had been used in it and had probably blown a hole in the bottom of the casing. It was either through this or else through the perforations that this fine sand came in as fast as it could be taken out by the air lift, the flow of water into the well when pumped by the air lift being sufficiently great to carry this sand in with it.

The conclusion of these experiments is that for obtaining good results in cleaning wells by the air lift, first, that the well should be capable of furnishing a sufficient supply of water to carry off the sand; second, that it is sometimes better not to use the discharge from the receiver, but to pump the well steadily. A discharge from a receiver will cause a sudden diminution of pressure on the inside of the casing. Should the casing be old and the water supply from the well small this may be sufficiently violent to collapse the casing. Third, it is not always necessary to put the end of the air pipe at the bottom of the well. When the receiver was discharged into this well those looking on were astonished to see a large tin can, a bottle and a few fence posts come sailing out of the well on the top of the water spout. The meanest man in the world is the fellow who puts things down wells.—Abstract from *Power, Electricity and Gas.*

Plate by The Half Tone Co., S. F.

BLOWING OUT A WELL BY COMPRESSED AIR EXPLOSIONS.

Reversible Pneumatic Drill.

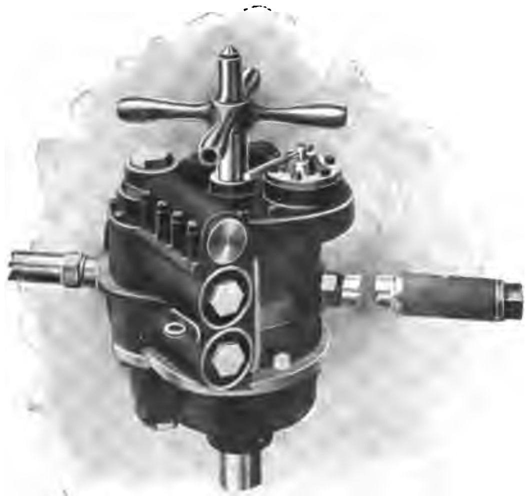
We illustrate herewith a new reversible drill of the "Little Giant" type, recently developed and put on the market by the Chicago Pneumatic Tool Company.

This machine was primarily designed to meet the want of customers who required a drill for general use, but whose work is not sufficiently specialized to warrant the purchase of any one of the "Little Giant" exclusive reaming and tapping machines.

The motor is of the same general construction as all of the now well-known interfere with the feed screw when the machine is used as a simple drilling machine.

The controlling lever may be removed from motor when not required as reversible machine. It can then be controlled with the ordinary throttle, which is situated at side of machine as in the plain drills.

The reverse valve can be used as a throttle-valve, however, when very rapid and accurate reverse motion is required, as would be the case when motor was used in connection with machine for setting locomotive slide-valves, or tapping



REVERSIBLE PNEUMATIC DRILL.

and time-tried "Little Giant" drills, the distinguishing feature of which are four single-acting pistons coupled to one crank-shaft at an angle of 90 degrees. Each piston of each pair traveling in opposite directions at all time insuring a well-balanced and durable engine. All moving parts are in an oil-tight case and each pair of cylinders controlled by one balanced piston slide-valve. These features are fully covered by United States and foreign patents, and are found in no other pneumatic drill. To this has been added a simple reverse valve of same construction as in Nos. 11 and 12 machines, but so situated that it does not to a given point, or to bottom, and various other applications, which will readily suggest themselves to the mechanic requiring a machine of this kind.

The motor is made in the following sizes:

No. 00, same size as plain No. 0 Drill.
No. 10, same size as plain No. 1 Drill.
No. 22, same size as plain No. 2 Drill.

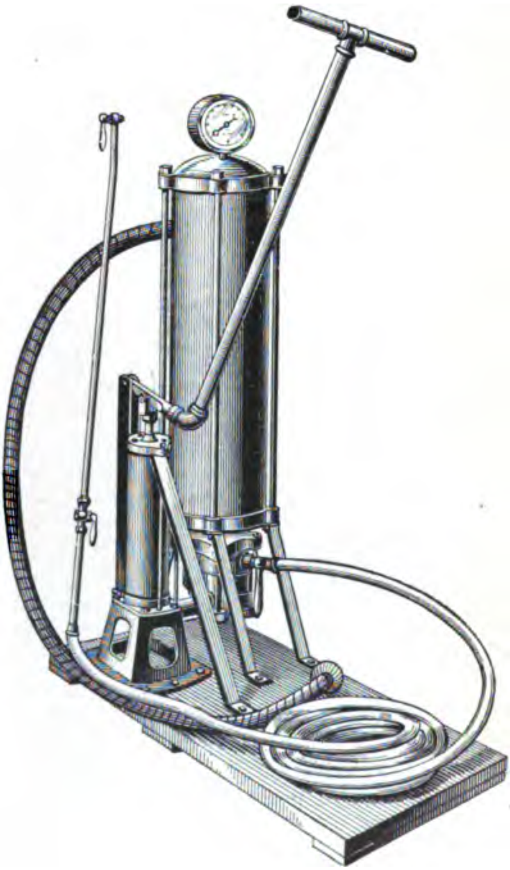
Like parts of these drills are interchangeable with the plain drill of same size, features which will be appreciated by the trade, as it avoids complication of parts.

Some of the improvements that will be appreciated by mechanics who have used these drills are as follows: All bearings are furnished with removable bushings; the crank journals have been increased by 50 per cent.; the crank pinion is now shrowded on both ends (formerly on one end only)—this will prevent teeth from breaking; the upper and lower bearings for crank shafts are bronze; sleeves of ball of ball and socket form easily removed–no screws required to hold them in place, which form of bearing insures perfect alignment always and consequent increase in speed and power; hardened steel eccentric straps connect valves to crank-shaft in place of bronze used formerly; oil plugs have been dispensed with; oil is poured in through handle, and, as it is impossible to use drill without this handle, and nothing but the handle will fit the hole, it will surely be replaced even by the most careless workman, and this insures long life to working parts; a leather-packed stuffing-box is supplied to keep oil from escaping; every moving part is hardened and ground to fit.

Pneumatic Coating Machine.

Mr. F. E. Hook, Hudson, Mich., is the originator of the Pneumatic Coating Machine (which we illustrate herewith), the principle of which is the compressing of the air and the liquid into the receptacle while the compressed air discharges the liquid through the hose and a special nozzle in the form of a misty spray. The machine is arranged with a contained air pump, by means of which one is enabled to obtain 40 pounds of air pressure in the receptacle in less than three minutes. This pressure is increased by the pumping in of the liquid to 150 pounds, and when this pressure is in the machine it will spray out automatically, without anyone operating the handle, for nearly twelve minutes. The valve and valve chamber are so arranged that the compressed air passes through the liquid to the top of the receptacle at all times, so that it not only keeps the liquid thoroughly mixed, but the air, on compressing down on the liquid, forces it out through the discharge hose, as before stated.

Where three men are using the discharge it is necessary to have an extra man at the pump, as the machine would not have capacity enough to supply the liquid fast enough for three men without the working of the pump. The 40 pounds of air which is first put into the receptacle is not discharged out again, but is put



HOOK PAINT SPRAYER.

there simply for the purpose of keeping the liquid agitated, and forms the means of discharging the liquid. In this respect the machine is radically different from the air compressor machines, which use the compressed air to form the spray.

Modern Water Supply Stations for Locomotives.*

Compressed air is used for raising water, and that there is a particular field for this form of pumping does not need proof. The requirements for such a system are an air compressor, and, of course, some means of driving it; frequently the compressor is run by a gasoline engine, and the two may be made very compact.

Compressed air gives a very convenient means of raising water from deep-driven wells, because the operating machinery is all above ground and the pipes, if they are found out of order, are easily and quickly replaced; another condition which justifies the use of compressed air is the necessity of using a number of wells to provide the necessary quantity of water, allowing the water from the various wells to flow either to the place where needed, or to flow to the suction of force pumps. The air-lift will not deliver the water horizontally to any great distance, so that when the lift, or well, is at a greater distance than 40 feet from the place where the water is to be used it is generally necessary to raise the water perpendicularly at the well to such a height that it will be delivered by gravitation to the place desired, or to provide other means for the horizontal delivery. The construction of such wells is probably so thoroughly understood that only a few words are necessary here, that there may be left no possibility of misinterpreting to what reference is made. There is the pipe projecting into the well, through which the water is to be raised, and there is another pipe, or passage, through which compressed air may be delivered to a place near the bottom of the well, where there is connection between the air passage and the water-delivery pipe.

This means of pumping can be used to advantage also when it is desired to locate the pumping machinery at some distance from the well. This condition may arise when it is difficult to get the machinery or the fuel for operating it sufficiently close to the well; or when it is possible, by locating the machinery at some distance from the well, to keep the attendant busy at other work, when his services are not required all the time for pumping water. Also compressed air may be available for other service at the place where required, and in the use of it for raising water a considerable economy may be shown.

For example the details of the water system at the Denver shops of the Colorado & Southern Railway may be taken. In this plant there are two artesian wells, 700 feet deep, in which the water rises to within 160 feet of the top, and twenty surface wells, 27 feet deep, in which the water rises to within 5 feet of the top. The water from the artesian wells is used for boiler purposes, and the surface water is used for washing and for other similar purposes.

Information concerning the proper proportioning of air-lifts has been the result of experience obtained by those who are engaged in making air compressors and in designing air-lifts, and the formulæ which have been deduced from experience are treasured highly and are not available for publication. The general practice is, however, to make the relation of the submersion to the lift from 4 to 3, to 3 to 2. This is the "working" submergence as distinguished from the height at which the water stands in the well before pumping is begun; generally the water level in the well falls as soon as pumping is begun. If a lower percentage of submergence is used the cost of operation is increased. The weight of the column of water above the air inlet is readily calculated, and this will equal the pressure at which the air must be delivered to the point where the air and water are mixed. The starting pressure will be greater than the working pressure. The working gauge pressure in pounds per square inch, divided by the atmospheric pressure at the altitude of the well, will give a quotient to which, if unity is added, will give the number of volumes of free air required. The capacity of the well may be calculated by allowing 15 gallons per square inch of cross section of pipe per minute, or by taking the rate of flow in the discharge pipe at 5 feet per second. For heights of from 15 to 50 feet there will be required 2 to 3 cubic feet of air at atmospheric pressure per cubic foot of

*Abstract of a paper by Mr. F. M. Whyte, Mechanical Engineer, N. Y. C. & H. R. R. R., read before American Master Mechanics' Association.

water delivered; for heights of from 50 to 100 feet it is considered best to provide 3 to 6 cubic feet of free air at atmospheric pressure for each cubic foot of water delivered. The efficiency of this system of pumping is about 50 per cent. maximum, and may be as low as 15 to 20 per cent.

The water is not raised usually by air pressure; the air mixes with water in the delivery pipe, making the weight of the column of water and air in the pipe less than the weight of the column of water outside of the pipe. Sufficient air must be mixed with the water to make the difference in weight of the column inside the delivery pipe and the one outside of it such that they balance each other when the column inside the pipe stands at a height slightly in excess of the height to which it is desired to raise the water. If more than the required amount of air is forced into the delivery pipe the cost of raising the water will be increased. The water may be forced to some height by increasing the air pressure, but the expense in so doing becomes excessive.

Western Air Lift Plant.

We present herewith an illustration of a Western air-lift plant, which affords another instance of the utility of this means of raising water from artesian or deep wells.

This plant lifts about 600,000 gallons of water every twenty-four hours, with a total vertical lift of from 360 to 370 feet. The air pressure is 125 pounds at the receiver, and the compressor is estimated to give about 115 horse power.

AIR LIFT PLANT. CAPACITY 600,000 GALLONS IN TWENTY-FOUR HOURS.

Electrical Engineers' Pocket-Book.

A hand book of useful data for electricians and electrical engineers by Electrician, Horatio A. Foster, M. A. I. E. E.; size containing 987 pages, leather bound; fully illustrated; published by D. Van Nostrand Co., New York. Price $5.00.

We take pleasure in calling the attention of the readers of COMPRESSED AIR to this work on electrical engineering, which is to the practical engineer what Trautwein and Kent are to the civil and mechanical engineer. The book is gotten out in hand-book style and is a cyclopedia of electrical data, which is needed by anyone dealing with the design, construction or use of electrical machinery.

The book has been prepared with the aid of a number of specialists and is unquestionably the most satisfactory collection of useful electrical data which has ever been published. The whole range of applied electricity is covered in a very practical way, and a number of subjects, regarding which it was almost impossible to obtain data without an extended examination of books and technical journals, are clearly and concisely covered. Particular attention has been given to such subjects as transmission of alternating currents, storage batteries, lightning arresters, electric lighting and electric railway. At the same time tables and formula for calculating resistance, length of spans for overhead wiring, proper design for electro-magnets, designing motors and dynamos and transformers, and a large range of other electrical subjects are included. Lengthy and complicated descriptions have been omitted and the book as it stands represents the essence of electrical engineering practice of to-day. We unhesitatingly recommend the book to our readers as a valuable addition to any general engineering library as a book of reference, but more particularly to those of our readers who are using electricity in one form or another.

Compressed Air Machine for Making Glass.

At the old DePauw factory at Alexandria, Indiana, the veil of secrecy has been lifted, the high board fence which inclosed the factory has been pulled down, and the public have been admitted. The final test of the glass-blowing machines just completed promises to do something toward revolutionizing the glass-making industry.

On questioning Mr. DePauw after the test, he said:

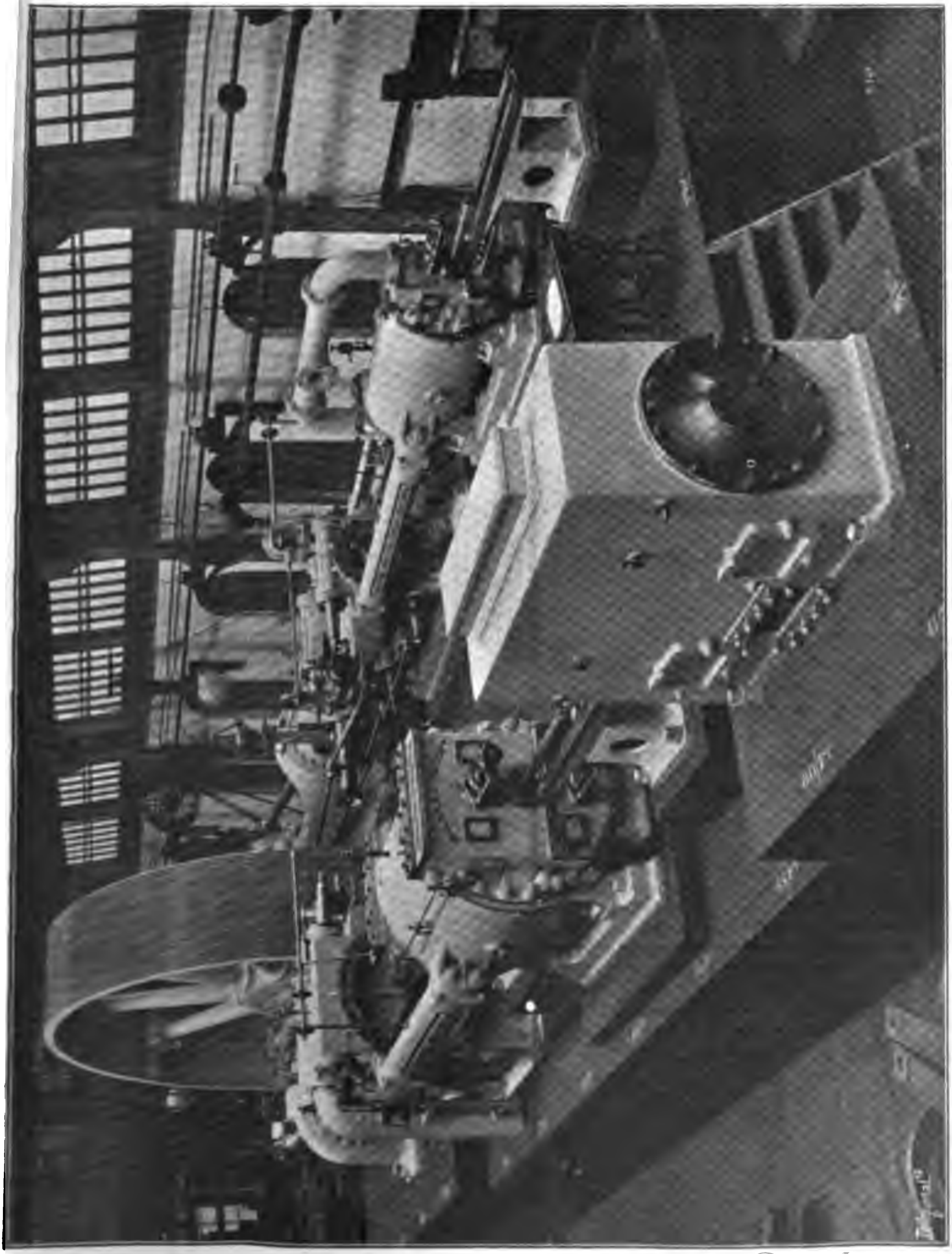
"There has been a general misconception in regard to the matter of secrecy. The company have not been testing the machine itself—that was done long ago, but we have been endeavoring to find the cheapest method of operating the machine. Our main reason for secrecy has been that we have not until recently secured patents on our apparatus. It is very simple and the only thing wonderful about it is the fact that the process was not perfected long ago. This will be to the glass trade what the linotypes have been to the newspaper business.

"The patents provide, in substance, for a tank furnace having a force-hearth extension. A vertically moving frame on which is rigged the blowing pipe is placed over this extension. Compressed air is then admitted to the pipe. When drawn to the required length, the cylinder is withdrawn from the mass of glass by the insertion of heat currents. This accomplished—all automatically—the glass is swung to one side and is drawn from the drawing tool and put through the finishing process exactly as the glass from the blower's pipe heretofore. The apparatus is, in truth, merely a sort of ingenious device for the operation of an automatic condensed air mechanism. It was built, it would appear, to apply the force of compressed air to the molten sand exactly as the blower applies it from his lungs."

It was further stated at the completion of the experiment that the machines can be built cheaply, that enough will be procured and in operation by the time of the renewal of the fires later on to do away with a number of blowers at once.

Compressor at Ooregum Gold Mine.

The air compressor herewith shown has been supplied by Messrs. Walker Bros., of Wigan, and is in operation at the Ooregum Gold Mining Co., of India, Ltd. It is intended to operate rock drills and other machinery. There are about forty drills, mostly Climax pattern, at work in this mine, most of which are under the charge of the natives. Formerly Italian miners were largely employed in working the rock drills, but European operators are now no longer necessary, as the natives have



COMPRESSOR AT THE OOREGUM GOLD MINE.

been trained to handle the machines with efficiency.

The Ooregum Mine started into existence January, 1881, but prior to that date it was owned and worked by a Madras company, with a somewhat similar name. It is situated in the heart of the Kolar mining area, being bounded on the south by the Champion Reef and on the north by Nundydroog.—Supplement of *The Mining World*.

Notes.

The McKiernan Drill Co. announce the removal of their New York office to 170 Broadway. They have also moved their works to Dover, N. J.

Compressed air can be used directly for ventilation, refrigeration, drying or operation of elevators. It is not a rival of electricity, but has its field as one of the great motive powers, the same as the steam or gas engine.

If a volume of air at sixty pounds pressure, equivalent to 18,000 cubic feet per hour at atmospheric pressure, be passed through 1,000 feet of pipes, the loss of pressure of air for 2½-inch, 3-inch and 3½-inch pipes would be 5¾ pounds, 2 pounds and 1½ pounds, respectively.

The Pedrick & Ayer Company is exceedingly busy, and much hampered for want of room. The air compressor department is much taxed, and the orders for pneumatic hoists find the department for such goods entirely inadequate. The company has not yet placed its orders for the power equipment of its new plant at Garwood, N. J.

The plans for the new plant of the Cleveland Pneumatic Tool Company are just about completed, and contracts will be let at an early day for the construction of the buildings. The Company has just opened up an office at No. 411 Park Bldg., Pittsburg, Pa., represented by Chas. L. Nelson, and at No. 34 Lemoine St., Montreal, Canada, represented by N. J. Holden & Company.

A machine cannot give off more power than is put into it in one form or another; the power given off is always represented by a fraction, that put into it being unity. This is due to the losses within the machine itself—that is, it takes some power to run the machine alone so that the power given off will be equal to that put into it minus the amount required to run the machine itself.

The lifting power of any gas is the difference between the weight of the gas and the weight of the same volume of air. One cubic foot air at normal pressure weighs 1.29 ounce avoirdupois; one cubic foot pure hydrogen under the same conditions weighs 0.089 ounce avoirdupois. The difference is 1.2 ounce, which is the weight that one cubic foot of hydrogen will balance in the air. It will lift any weight less than that.

At sea level 1,000 cubic feet of air compressed to 80 pounds in two stages develops 1,000x.137=137 horse-power at an altitude of 10,000 feet above sea level, the volume to be equivalent at this pressure must be 39 per cent. greater, or 1,390 cubic feet. At that altitude the horse-power factor for compression to 80 pounds is .113 per cubic foot; so 1,390x.113=157 horse-power. Hence 20 horse-power more than at sea level is required for the same effect.

The Caskey Portable Pneumatic Punch is described and its advantages set forth in a pamphlet just issued by F. F. Slocomb & Co., Wilmington, Del. The essential features of this punch are: The hollow ball piston and oil intensifier. But one charge of air is required for the backward and forward motion of the piston. Several shop views show the application of the punch to various classes of work. Illustrations of several standard designs, together with descriptive tables, are given.

Steam Hammers.—We have just received from Bement, Miles & Co., Philadelphia, Pa., a catalogue illustrating their various forms of steam hammers. In this no attempt is made to describe the machines in detail and the book is confined to a series of full-page illustrations of the several sizes of hammers which they make and very brief descriptions. We call this to the attention of the readers of Com-

PRESSED AIR, because in many instances hammers of this sort are being operated by compressed air and the subject is one which opens up possibilities which may be of interest to some of our readers.

Westinghouse, Church, Kerr & Co. are pleased to announce the removal of their Pittsburg office from its former location on the first floor of the Westinghouse Building to more commodious quarters on the eighth floor of the same building. This change is the direct outcome of largely increased business in this district, and is accompanied by the organization of two new departments, viz., Engineering and Construction Departments, in addition to the original Sales Department, and the acquirement of a commodious reception-room devoted exclusively to the convenience and entertainment of visitors and patrons.

The Philadelphia Pneumatic Tool Company has established an agency in South Africa, with headquarters at Johannesburg. It will be in charge of Gen. Samuel Pearson, late of the Boer forces. General Pearson has been in the United States for some months in the interest of his government, in the attempt to have the mule shipments from Port Chalmette stopped. Now that peace has been declared he will return to his former business in machinery lines and will handle the accounts of the Philadelphia Pneumatic Tool Company and others. Before coming to America General Pearson saw much active service in the field, and for a time was in charge of railroad traffic.

In producing compressed air a great difficulty is the question of heat, which increases as the pressure increases. Formerly, whatever pressure was required, the whole operation was performed in one cylinder, and for high pressures the amount of heat produced was far too great to be dealt with effectively. The result was that the heat generated expanded the air, and we not only lost the heat, but the expanded air required an increased amount of mechanical work, which was also lost. In the compound system we divide the compression into two stages in two cylinders, thus having a less amount of heat to deal with in one operation, and we can deal with it with better effect. The intermediate cooler between the stages is a vital part of the arrangement.

Air, and compressed air at that, is beginning to supersede towels in the equipment of the well-regulated barber shop. After the shaving process has been concluded the tonsorial artist in an uptown Broadway establishment carefully sponges from the customer's visage all traces of soap. Then he reaches under the shelf and draws forth a piece of rubber hose the end of which is tipped by a metallic contrivance. This is affixed to the atomizing apparatus of a bottle of bay rum. A button is pressed and a fine spray of the cooling liquid is directed at the face of the customer. A sharp click and the pipe is disconnected to be reaffixed to a bottle of the regulation toilet water.

Then the barber massages the face for a few minutes and concludes by reaching for the rubber pipe once more. This time there is no attaching it to a bottle. The current of air is directed at the face, and in less time than it would take with a towel the features are dried. The sensation of the air pouring across the mouth and nostrils is apt to cause a gasp or two from the prostrate victim in the chair, but after he has passed through the ordeal once or twice he is prepared for the emergency and the sensation is rather pleasing than otherwise.—*New York Press.*

U. S. PATENTS GRANTED JUNE, 1902

Specially prepared for COMPRESSED AIR.

701,327. CONTINUOUS AUTOMATIC AIR-BRAKE SYSTEM. Edward L. Gosse, Chanute, Kans., assignor of one-half to Louis A. Laughlin, Kansas City, Mo. Filed Nov. 1, 1901. Serial No. 80,758.

701,359. AIR-SHIP. Carl F. A. Klotz, Indianapolis, Ind. Filed July 8, 1901. Serial No. 67,430.

701,506. METHOD OF TREATING AIR FOR COOLING AND MOISTENING SAME. William P. Rice, Chicago, Ill. Filed Feb. 25, 1901. Serial No. 48,635.

The process which consists in inducing a current of air directly from a source of natural humidity to or through a space to be cooled, placing a gas under compression to materially reduce its volume, removing the heat of compression from said gas, permitt the cooled and compressed gas to expend into said current of air, and delivering into th path of the expanding gas water in such quantity that the expanding gas acts to atomize the water and disseminate the same through the air-current in the form of a mist or fog; the said air-current being supplied from a natural source in such quantity and humidity that the particles of liquid forced or carried thereinto by the expanding gas are at once evaporated and the air-current is thereby cooled and at the same time suitably humidified.

701,510. AIR-SHIP. Peter Samorski, Chicago, Ill. Filed Dec. 9, 1901. Serial No. 85,219.

701,580. PNEUMATIC-SURFACER FRAME. Herman G. Kotten, New York, N. Y. Filed July 17, 1901. Serial No. 68,592.

A post, an arm rotatably mounted thereon, a drum carried by said arm, rollers carried by said post and arm, a connection passing around said rollers and leading from an end of said arm to said drum, and means for rotating the latter, in combination with a carriage mounted on said arm, trolleys on the upper and lower portion of said carriage adapted to contact with tracks on said arm, and a set of rollers mounted in the lower portion of said carriage and adapted to contact with the lower of said tracks.

701,796. AIR-BRAKE APPARATUS. William L. Clark, Oelwein, Iowa. Filed Dec. 30, 1901. Serial No. 87,743.

701,869. PNEUMATIC-DESPATCH SYSTEM. Hugo W. Forslund, Chicago, Ill., assignor to the American Pneumatic Service Company, Boston, Mass., a Corporation of Delaware. Filed Sept. 28, 1899. Serial No. 731,930.

701,981. AUTOMATIC AIR-BRAKE. Granville T. Woods, New York, N. Y., assignor, by mesne assignments, to the Westinghouse Air-Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Feb. 5, 1901. Serial No. 46,080.

702,124. FLUID-PRESSURE BRAKE APPARATUS. Nathan J. Benton, New Decatur, Ala., assignor of one-half to William P. Thomas, Birmingham, Ala. Filed May 8, 1901. Serial No. 59,306.

702,268. APPARATUS FOR APPLYING AND CONTROLLING BRAKING FORCE. Henry H. Westinghouse, Pittsburg, Pa., assignor to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Nov. 14, 1892. Serial No. 451,937.

702,324. AIR-LOCK FOR CAISSONS. William McIlvrid, Jersey City, N. J. Filed Apr. 14, 1902. Serial No. 102,903.

An air-lock for caissons, comprising a casing having exterior lateral extensions, upper and lower gates, and means for actuating said gates located outside of the casing within the vertical planes of said lateral extensions, and connected within the casing of the gates.

702,367. PNEUMATIC-TRANSFER-TUBE SYSTEM. Francis W. Jones, New York, N. Y., assignor to the Transfer Tube Company, New York, N. Y., a Corporation of New York. Filed Apr. 25, 1902. Serial No. 104,605.

702,374. AIR SUPERHEATER OR CARBURETER. Harry M. McCall, Pittsburg, Pa., assignor to Pittsburg Gas Engine Company, Pittsburg, Pa. Filed Mar. 7, 1902. Serial No. 97,079.

702,497. FLUID-PRESSURE COUPLING. William H. Simmons, Alexandria, Va. Filed Nov. 8, 1901. Serial No. 81,593.

702,529. APPARATUS FOR SUPPLYING AIR AND HYDROCARBON. William N. Best, Los Angeles, Cal., assignor of two-thirds to John H. Best and Ezra Best, Quincy, Ill. Filed June 3, 1901. Serial No. 62,907.

702,931. PNEUMATIC RAILWAY SWITCH AND SIGNAL APPARATUS. Frank L. Dodgson, Rochester, and Murray Corrington, New York, N. Y., assignors to International Pneumatic Railway Signal Company, Rochester, N. Y., a Corporation of West Virginia. Filed Oct. 26, 1901. Serial No. 80,107.

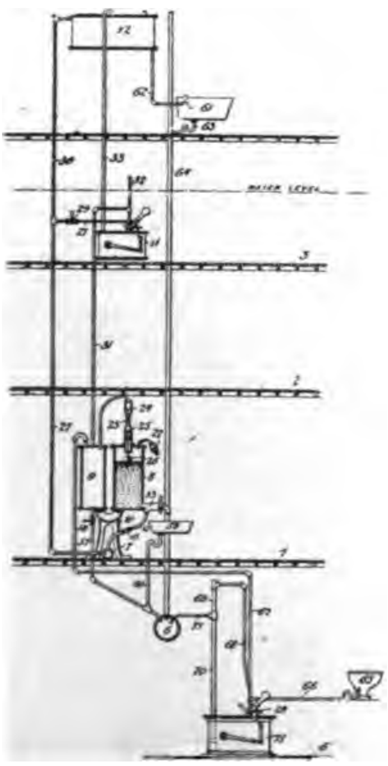
702,979. PNEUMATIC HOIST. George E. Martin, Philadelphia, Pa., assignor to the Pedrick and Ayer Company, Philadelphia, Pa. Filed Aug. 15, 1901. Serial No. 72,-114.

A fluid-pressure hoist comprising a cylinder, piston and piston-rod, a constant fluid-pressure communication to one side of the piston, a communication between both sides of the piston and a double valve device mounted in a single casing for controlling the admission of fluid-pressure to one side of the piston, its exhaust therefrom and automatically regulating the escape of pressure to hold the piston in its moved position.

702,994. APPARATUS FOR COOLING AND AGITATING AIR. Edwin F. Porter, Boston, Mass., assignor to the Bay State Electric Heat & Light Company, Jersey City, N. J., a Corporation of New Jersey. Filed Dec. 20, 1897. Serial No. 662,540.

An apparatus of the class described, a rotatable fan for creating a current of air and having passages leading through the same, a receiver for containing a cooling medium, a chamber leading from said receiver and connected with the passages in said fan, a chamber leading to said receiver and connected with the passages in said fan, and means for forcing the cooling medium through the passages of the fan, the chambers and the receiver.

703,045. APPARATUS FOR RAISING LIQUIDS. Gustavis L. Cudner and John Dyer, New York, N. Y. Filed June 5, 1901. Serial No. 63,203.



An apparatus for raising liquids, a liquid-elevating tank, a liquid-elevating pipe leading therefrom, a liquid-feed pipe, an air-vent pipe, a compressed-air-feed pipe, a controlling-valve for the liquid-feed, air-vent and compressed-air-feed pipes, and means for operating said valve comprising a float, a rocking lever loosely mounted on the valve-stem connected to the float, a two-armed lever fixed to the valve-stem and an intermediate weighted lever loosely mounted on the valve-stem in position to be engaged by the lever connected to the float for causing the weighted lever to engage the lever connected with the valve-stem.

703,078. PNEUMATIC STACKER. Frederick L. Norton, Racine, Wis. Filed Mar. 8, 1902. Serial No. 97,230.

703,120. PNEUMATIC - CARRIER SYSTEM. Willis W. Danley, Chicago, Ill., assignor to American Pneumatic Service Company, Boston, Mass., a Corporation of Delaware. Filed July 30, 1900. Serial No. 25,246.

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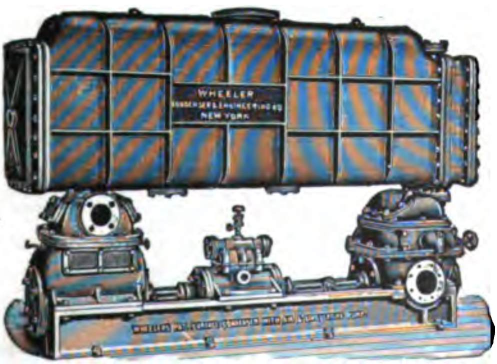

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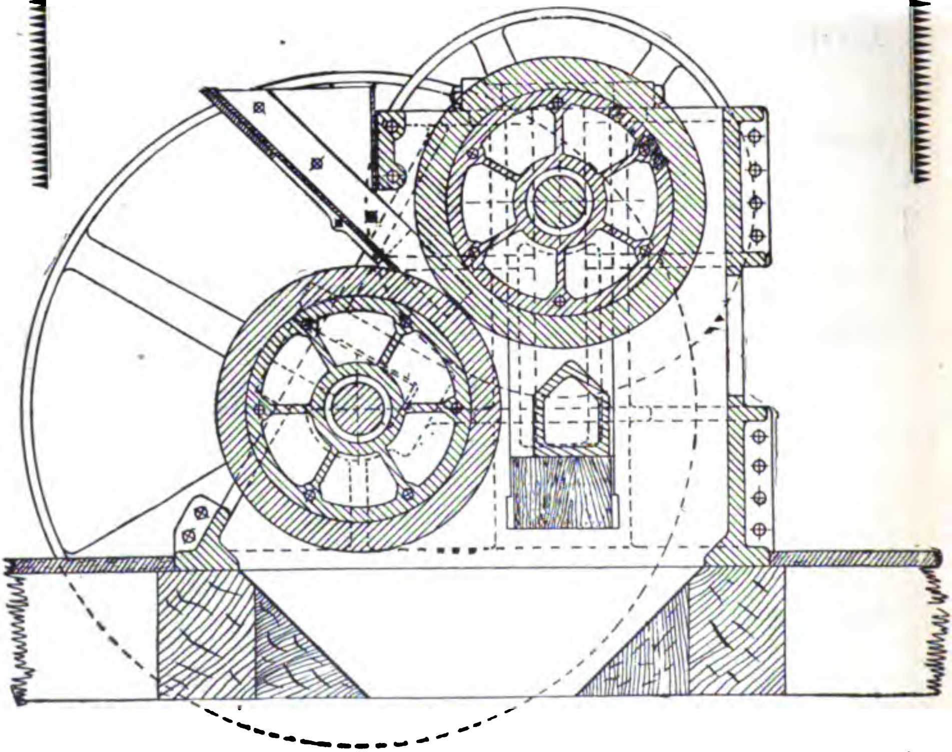

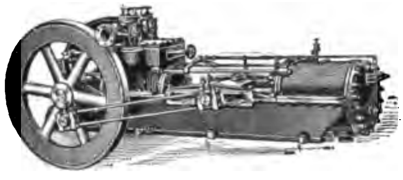


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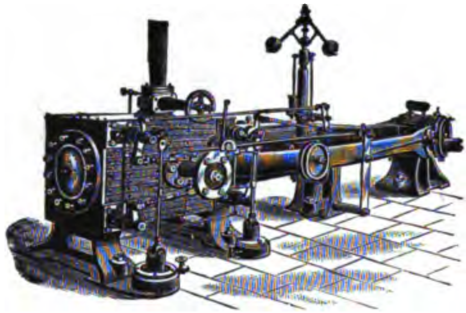

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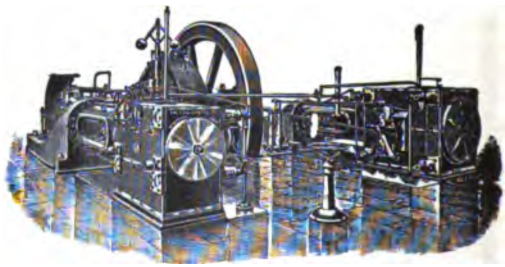

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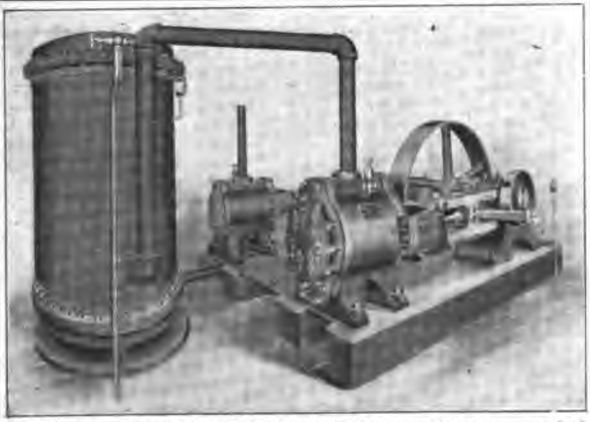
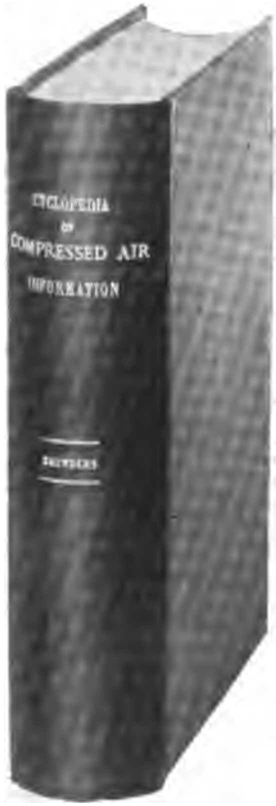


Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, SEPTEMBER, 1902. NO. 7.



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VOL. VII. SEPTEMBER, 1902. NO. 7.

Abuse in the Use of Compressed Air.

It is interesting to note the correspondence and comment which has recently taken place in some of the English mining papers in relation to an alleged disease contracted by men working in the South African mines. It is reported that Cornish drill men went to South Africa to earn higher wages than they could receive at home and that in a short time they were compelled to return home because of a disease of the lungs which proved fatal in some two years' time. The *Royal Cornwall Gazette* asks the question whether or not, under such circumstances, it is not better for men to work in the Cornish mines under healthier conditions and at less wages. It seems very likely that because of the feeling indicated by the remark of the *Gazette* this disease and its effects may have been exaggerated in the popular mind, yet there are reasons for believing that a form of consumption may be contracted in mine and tunnel headings by continuous work under certain circumstances, and a discussion of the subject with suggested precautions may not be out of place. It is reported that a Captain Oates, "well-known in mining circles at home and at the Cape," has been "very forcibly struck" with the belief that it is a serious matter, and he has ordered medical men in the mining district to prepare and tabulate statistics of the deaths among the miners during the past two years. Mr. Nicholas Trestrail, Civil Engineer, of Redruth, has also taken much interest in the matter, and in a recent letter to the press he says:

"Although, no doubt, inhaling fine dust causes most of the mischief that produces phthisis, I am sure there is another thing, too, that does not conduce to the health of the miner. It is generally supposed that exhaust air from rock drills is beneficial to the miner, and probably it is up to a certain point, but these machines are invariably working a long way off from any natural ventilation, and if air was compressed and sent down in a pure state, much better conditions would exist, but there is no doubt that air compressed with lubricants generally used for the compressor cylinders is most objectionable. In all well laid out underground air mains a reservoir is fixed to catch the moisture, and, if properly attended to, would partially prevent some of the mischief, but there is no disguising the fact that air compressed to 80 lbs. per square inch (the pressure mostly used for rock drill work) when mixed with ordinary oils becomes very offensive, indeed. About two years ago I consulted a well-known chemist with a view of experimenting on the purity of air so compressed, but the costs for carrying out such experiments thoroughly was rather more than an individual could be expected to incur, but I am quite satisfied it would repay any company using a number of rock drills, or those using compressed air for ventilating purposes, to test the matter. I am strongly of opinion that much mischief is caused to the health of miners by the use of inferior oils for lubricating compressor cylinders, and I would suggest glycerine as a substitute in all cases."

This is a very striking and important statement because it calls attention to what might be called the abuse of compressed air, and it is well worth sounding an alarm so that by the use of proper remedies these dangers may be avoided. In the first place, as to dust: It is said that the usual water pipe leading in the mine is not a part of the South African installation, hence the miners at work are at all times subject to an atmosphere of fine dust which gets in the lungs and produces consumption. The mines in South Africa are very extensive and use a large number of rock drills. It is also well known that they are dry mines; that is, they bear very little water, hence it is to be inferred that the drilling operations are conducted dry, but in view of our large experience elsewhere in mines of all kinds, many of them quite as dry as the African mines, it is rather strange to note that no such trouble as that referred to has been incurred, at least so far as we know. It is quite possible, however, that ill effects may have been produced in a number of cases and that the cause has not been properly investigated, and, through neglect or otherwise, the matter has never attracted attention. That an atmosphere impregnated with fine grit particles will produce consumption is well known. The disease is commonly called "stone consumption," and its development was at one time quite marked in the Ohio Sandstone Quarries, particularly where grindstones were produced. About twenty-five years ago workmen engaged in turning grindstones contracted a disease of the lungs which usually proved fatal in about seven years' of service. The lungs of the deceased were impregnated with small triangular particles of sand rock and it was only the temptation of high wages which would induce a man to learn the trade in a grindstone mill. Later on improvements were introduced and safety drafts applied, by means of which the dust was carried away and the operator maintained in a clearer atmosphere, so that this disease no longer affects the men. It is quite possible to understand a similar accumulation of stone particle in the lungs of miners produced by working in an atmosphere of dust produced by drilling without water, and the first and most obvious remedy to suggest is to put water in the holes. This not only will prevent a discharge of dry dust, but it assists the drilling operations. If water is not available in large quantities, it should be used in small quantities, especially in places where it is found that the dust is liable to accumulate. The use of compressed air exhausting from a power drill should very materially assist in driving this dust from the working places in a mine. If there is not sufficient air from the exhaust of the machines a separate hose connection should be provided by means of which at intervals a blast of compressed air might be discharged at places where dust is found to accumulate in the atmosphere. Those accustomed to work in headings know very well that the exhaust from machine drills produce a very perceptible cooling effect in the heading ,and that, in addition to this, the atmosphere there is usually clear. This is particularly noticeable shortly after a blast and where smoke and other products of combustion have accumulated. As the power drills are started it is found that a piston of clearer air gradually accumulates in the heading and forces the smoke to the rear.

As to the objectionable nature of the compressed air discharged due to its being impregnated with bad oils, this is a matter which may be easily remedied. The first and most logical remedy is to use compound air compressors: that is, compressors which even at 80 pounds working pressure compress in two or more stages with intercoolers in between. By this process of compound compression greater economy is affected in steam consumption and a purer, cooler and drier air is produced. The oil which is sometimes carried over with the air is an oil vapor produced by high air temperatures and it is deposited along the line all the way from the engine room to the working, just in proportion to the changes in temperatures which the air undergoes; hence we have an air conduit of considerable length with the interior of the pipe oil-coated and not at all conducive to a healthy discharge of compressed air. Even with good oil this condition might exist because it is due more to high temperature than to any other cause, and the best remedy available is to lower the temperature of the air before it starts on its journey to the mine. If this cannot be done during the process of compression, as is the case in plans already installed where the air is compressed in one stage only, considerable advantage may be gained by putting in aftercoolers; that is, air receivers provided with tubular passages for cooled water and thus acting as condensers to bring down the temperature and deposit oil and moisture at a place near the engine room where it can be cared for and kept in proper condition. This moisture and oil can be drawn out periodically as these aftercoolers or receivers are usually provided with proper man-holes.

Air-Compressors at the Düsseldorf Exhibition.*

The great number and variety of compressors exhibited at the Düsseldorf Exhibition bear evidence of the favor in which compressed air continues to be held in Germany as an agent for transmitting power in mine working.

The compressors shown are of very different types, both as regards their general arrangement and the details of their construction; but the fact deserves notice that they all belong to the category of "dry compressors." German makers appear to have quite given up the introduction of water, in greater or less quantity, into the cylinder, for neutralizing the influence of the dead space or clearance on the volumetric efficiency and for counteracting the heating of the air during compression.

In most of the compressors shown the cylinders are only provided with jackets and hollow heads, through which a circulation of cold water is maintained; but it is well known that, owing to the slight calorific conductibility of air, the cooling action of this jacket water extend but little beyond the working or cylinder surfaces.

Single stage-compressors of this type have necessarily a reduced volumetric output, at any rate when the final air pressure is considerable. Too much importance is sometimes attached to the volumetric efficiency or output. What is required of a compressor is the delivery of a large volume at the desired pressure. Now, with no water in the cylinder a much higher piston speed is permitted and such a compressor can be run at a much higher speed than those using water in the cylinder. This latter type rarely attain a speed of more than 50 revolutions per minute. Dry compressors, on the contrary, easily make from 150 to 200 revolutions per minute and sometimes more especially when fitted with suitable valves. It follows that, notwithstanding this low volumetric efficiency, the power of production in the case of dry compressors is far greater so long as the final pressure is moderate.

When, however, the final air pressure

*Abstract of a paper by Henri Dechamps, Ingénieur des Arts et Manufactures, communicated to the Liége Engineers' Association.

is high, dry single stage compressors cease to be efficient or safe. The delay in opening of the inlet valves, due to the presence of compressed air in the clearance space, occasions, in all compressors not provided with an arrangement characteristic of the Burckhardt & Weiss system, a diminution in the volumetric efficiency not compensated for by fast running.

The heating of the air increases the power required to compress it and renders lubrication difficult if not impossible. Also, owing to the great difference in the pressures on the two faces of the piston and valves, leakage may become considerable.

For high pressures German makers resort to multiple stage compression in two, and sometimes even three, cylinders. The exhibition does not contain a three-cylinder compressor; but those with two cylinders are numerous. They all comprise an intermediate receiver, cooled by water circulation, in which the air, after being partially compressed in the large or low-pressure cylinder, remains a sufficient length of time for its temperature to be brought approximately to what it was originally. The air, thus partially compressed, is then further compressed to the degree required in the small or high-pressure cylinder. Calculation shows the great advantage, for high pressures, of staged compression, both as regards diminished influence of the clearance spaces and the decrease of the power required to compress the air owing to its lower temperature.

As regards the character of construction, the compressors exhibited may be classed as those with freely working non-actuated valves or poppet, and those with actuated or mechanical valves.

The former class includes the compound horizontal compressor made by Schuchtermann & Kremer, of Dortmund, for the Harpen Colliery Company, characterized by the adoption of Collmann valves. In this there are two valves at each end of each cylinder, one above for discharge and the other below for inlet; and these valves consist of well-guided annular discs with flat seats of aluminum bronze, having spiral springs for hastening their fall. For deadening the shock when a valve comes down upon its seat, there is an oil cushion, comprising a piston attached to the shank of the valve and a cylinder carried by the frame. The periphery of this cylinder has a ring of circular orifices, which remain open during the greater portion of the valve's travel, and are only covered by the piston at the moment of the valve's closing, thus opposing the exit of the oil and suppressing the shock which is so difficult to avoid in compressors with lifting or poppet valves. The maximum number of revolutions is 70 per minute; and this compressor is designed for a piston displacement capacity of 5,200 cubic meters (183,646 cu. ft.) of air per hour and a final pressure of from 6 to 8 atmospheres (88 to 117 lb. per sq. in.).

All the other compressors exhibited run at a far higher speed, and their valves are designed in accordance. The compressor exhibited by the Humboldt Company is fitted with hinged valves on Professor Gutermuth's system, consisting of thin plates turning on a hinge and coming down on a grating. At each end of the cylinder, and at its lower portion an inlet and a discharge valve are placed in the same chamber, being arranged so as to reduce the clearance to a minimum.

The valves of the compressors shown by Rudolf Meyer, of Mulheim, are made of light steel discs with a very slight lift. These come down on seats cast with feathers. One of these compressors is direct connected to an electric motor and runs at 160 revolutions per minute.

The valves just mentioned realize, in different degrees, the Corliss principle of small valves with slight rise and requiring only the action of light springs to bring them sharply down on their seats, an insufficient cause for any considerable loss of load. This is also the principle carried out in the small compound air-compressor shown by Haniel & Lueg, which compresses the air to 65 or 70 atmospheres (mean 992 lb. per square inch) with a speed of from 150 to 220 revolutions per minute.

The compound compressor of the Gebrüder Meer, of Gladbach, making 125 to 150 revolutions per minute and compressing air to 6 or 7 atmospheres (mean 95 lb. per square inch), has a low and a high pressure cylinder, both single-acting and arranged in line, the space between the two pistons being in constant communication with the atmosphere. The air enters the low-pressure cylinder, while passing through the

Hörbiger inlet valves in the piston, while the delivery valves are arranged in the head—an arrangement which recalls one type of the Ingersoll-Sergeant compressor. In the small cylinder the inlet and delivery valves are grouped in the head, which is enlarged by splaying out the cylinder at its end.

Many makers consider that freely lifting or poppet valves do not afford the best method of closing the inlet and discharge ports in the case of a compressor running at a high speed, but in such a case prefer reciprocating valves, worked by an eccentric keyed on the driving shaft.

The Burckhardt & Weiss compressor, first exhibited at Paris in 1889, affords one of the earliest solutions of this problem; a compressor of this type shown by Fröhlich & Klüpfel, of Unter-Barmen, at the Düsseldorf Exhibition, contains several new examples of this class.

The compressors exhibited differ chiefly through the various methods of distribution adopted; but they all have certain characteristics in common. The distribution of air is effected in the same manner as in a steam engine, except that the air moves in a direction opposite to that of the steam. The air is introduced into the cylinder by the space corresponding with the hollow of an ordinary slide-valve and, after compression, is forced through the ports in the valve chamber, which communicates with the intermediate receiver in the case of a low-pressure cylinder, or with the compressed-air receiver in the case of a high-pressure with only one cylinder. Independently of the distributing valve there is always an additional part consisting of a retaining valve, kept closed by the pressure in the valve chamber and also by a spring. The object of this part is to cut off the inside of the cylinder from the valve chamber during the period of compression, until the moment when the storage (or final) pressure is attained. The retaining valve in the Burckhardt & Weiss compressor consists of a plate bearing against the back of the distributing slide-valve and travelling with it. In several of the compressors exhibited the valve is arranged on a fixed seat so as to take up, between the distributor and the valve chamber, as small a space as possible.

Besides the Fröhlich & Klüpfel, there is only one example of a flat side-valve, and this is in the compressor exhibited by Paul Hoffmann & Co., of Eiserfeld. The slide valve, of wedge form, slides on two faces, one for inlet and the other for delivery; and the rectangular retaining plate of the Burckhardt-Weiss compressor is replaced by several circular lifting valves. This compressor is specially interesting because a single eccentric actuates the slide-valve of the air cylinder and also that of the Meyer valve gear with which the steam engine is provided.

The compressors shown by Pokorny & Wittekind, of Frankfort, are fitted with the Köster valve-gear, in which the distributor valve is a piston with two heads fitted with spring rings, as in the pistons that are often used for distributing steam in modern engines. This firm shows several such compressors, the most important of which is vertical, having a piston displacement of 7,000 cu. m. (247.-216 cu. ft.) of air and compress it to 6 atmospheres (88 lb. per sq. in.) when making 100 revolutions per minute. It consists of two air cylinders, one high and the other low pressure, and also two steam cylinders, all four being arranged side by side, and the pistons connected to the four cranks of a shaft, made in two parts and carrying the fly-wheel in the middle. There are also two horizontal compound compressors with one single-acting cylinder and differential piston, making one 140 revolutions and the other 225 revolutions per minute, and also two single-cylinder compressors of which one, of small size driven by a belt, can make as many as 500 revolutions per minute.

The Köster piston is also used in the horizontal compound compressor exhibited by Neumann & Essert, of Aix-la-Chapelle.

A Strnad compressor, characterized by oscillating cylindrical valves like the Corliss plug valves, is shown by Th. Calow, of Bielefeld; and the Duisburger Maschinenbau Actien Gesellschaft has also adopted the oscillating cylindrical valve for its compressor which makes 120 revolutions per minute. This single valve, arranged in the middle of the cylinder, resembles an ordinary slide-valve; and it travels in a chamber of small size, separated by a retaining or discharge valve from the delivery pipe.

The Stahl und Eisen Company of Hörde shows two compressors fitted with both mechanical and poppet valves, an arrangement designed by Professor Stumpf. The valves are actuated by an eccentric and are cylindrical blocks of the Corliss type, placed on the covers and serving only for inlet, the delivery being effected by spring-weighted valves also arranged on the covers; owing to this arrangement clearance space is very much reduced. The valve seats comprise two concentric portions, the outer being fixed, while the other is movable and sliding in the former. When the compressor piston is near the end of its stroke the spring parts on its face raise the movable seat and bring it towards the valve, so that the passage of air is interrupted just at the end of the stroke; and, directly the next stroke begins, the spring brings back the valve and its movable seat on to the fixed seat. One of the compressors exhibited is compound and makes 135 revolutions per minute, while the other has only one cylinder and makes 250 revolutions per minute.

J. W. P.

Compressed Air and Bore-Wells.

THEIR APPLICATION TO WORKS OF PUBLIC WATER SUPPLY.

The use of compressed air as a means of power transmission has been the subject of considerable difference of opinion amongst engineers, but the convenience it affords as a means of conveying power to long distances is a matter of such immense industrial importance that it has become an efficient and powerful agent in the hands of the present-day engineer.

The subject opens up a wide field for useful and interesting investigation, and demands the careful study of the engineer in its application to the very numerous uses to which it may now be advantageously put. In the course of the present article one of these uses will be more particularly dealt with—viz., the application of compressed air to the raising of water for public supply, from deep bore-wells, a plant of this description having recently been installed under the author's supervision at the Coporation Waterworks of Tunbridge Wells.

Every engineer who has had experience in the use of the various available agents for the transmission of power, such for example, as steam, electricity, air and water, will doubtless have learnt their comparative efficiencies and have proved for himself that compressed air, when compared with the use of steam direct (if consumed on the spot where generated), is low in this respect. Compressed air, however, has its own peculiar advantages, which operate in special cases, thereby making it not only the most economical agent under certain circumstances, but frequently the only possible one. Cases often arise, as in mining, tunnelling, &c., in which compressed air is the only power-agent capable of performing the services required, and where questions of economy are of secondary consideration.

Compressed air is the only general mode of transmitting power to great distances large enough to be measured in miles, and is the only one which is always possible, no matter how the power is to be distributed or applied. Its adaptability, too, to the utilization of distant and otherwise unavailable sources of power render it a medium, the commercial importance of which can scarcely be over-estimated.

Considerations such as these led to the adoption of compressed air in the works above-named. Here it was found convenient to put down compressors at the pumping station, to supply them with steam from the existing boilers and so generate compressed air to be conveyed in a cast-iron main to two bore-wells 250 ft. deep situated about one-third of a mile distant, and to raise water therefrom to gravitate back to the reservoir and pump-wells at the main station.

The system is one which lends itself admirably to almost indefinite extension. Any number of wells may be put down in the surrounding country, within, say, a radius of 20 miles—the whole to be operated either individually or simultaneously from one central base by one staff. Thus, while the actual power cost of the air, or cost of fuel, per 1,000 gallons raised may exceed that of a separate steam-driven plant operating deep well pumps, there are many other items which go to make up the ultimate actual cost of the water obtained; and herein lie the advantages of a system of compressed air under circumstances similar to those described. All machinery may be centralized under one roof, and no work or buildings are required at the site of the well, beyond perhaps a single stand-pipe and rising main. At the outset, then,

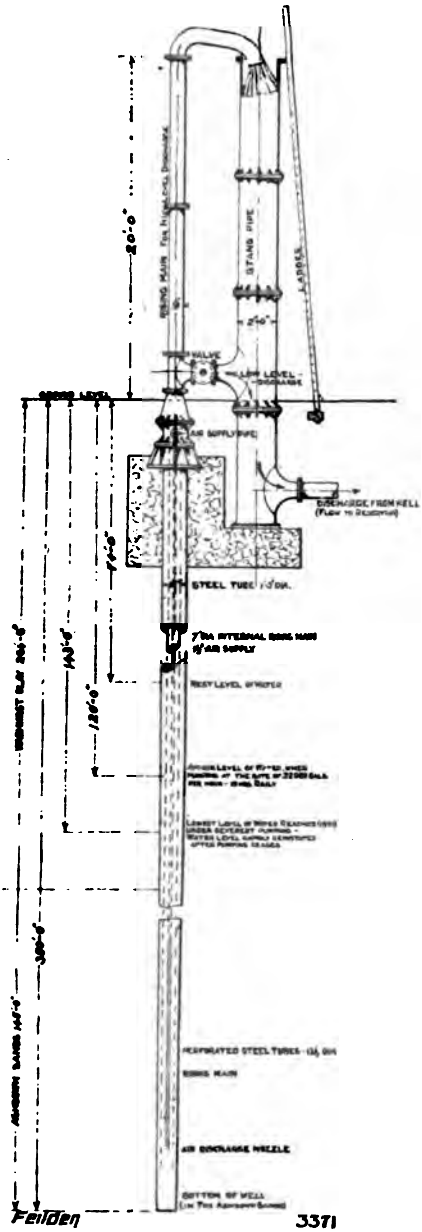


FIG. I.—SECTION OF WELL, STAND-PIPE, COMPRESSED AIR-LIFT, ETC.

there is a saving in capital cost of the works. In working expenses the annual cost of supervision, labor, cartage of fuel to distant sites, repairs, rates and taxes, and numerous other incidental charges inseparable from the running of separate stations, are avoided. Under such conditions it would certainly appear that compressed air is the most economical power agent to employ, and, all things considered, that it is the most efficient means of bringing together for public supply a number of deep well waters.

The compressor plant under description is situated in the engine-house, at a point close to the boiler-house supplying steam to the large forcing engines which deliver the town supply into high-service reservoirs through some two miles of rising main against a head, exclusive of friction, of about 350 ft. These boilers are of sufficient capacity to yield the additional quantity of steam required by the compressor engines, besides other machinery at the works.

The compressors, to which further reference will be made later, compress the air by two-stage compression, first to 25 lbs. per square inch, and then, after cooling, to from about 90 to 100 lbs. to the square inch (but varying according to the depth of water levels in the wells), and deliver it into a reservoir or large steel receiver communicating with the length of 4 in. air main through which the air is conveyed to the wells. The connection and application of the air supply to the same are shown in detail in Figs. 1 and 3.

PLANT AT THE BORE-WELLS.

The plant at the bore-wells consists of a rising-main, air supply pipes, standpipe, and various valves and connections, and is illustrated in Figs. 1 and 3. Fig. 1 is a section of the well showing water-levels, rising-main, etc.

The well is sunk through the Wadhurst clay, which is over 200 ft. in thickness at this point, into the Ashdown sands, from which the supply of water is derived. The well is lined with steel tubes 15 ins. in diameter for its upper portion, and with perforated steel tubes 13½ ins. diameter below.

The method of boring and the various tools and plant used in the processes of sinking the well will be referred to in detail later.

The rest-level of the water, when no pumping is being carried out, is 74 ft.

below the ground surface, and the approximate level, when pumping at the rate of 32,000 gallons per hour for ten hours daily, is reduced to about 120 ft. below the surface. The lowest water-level reached under the severest pumping with the present plant is about 150 ft., and the level is rapidly reinstated after pumping ceases.

Inside the bore-well is hung a 7-in. diameter rising-main as shown in Figs. 1 and 3, through which the flow of the well discharges. The air-supply pipe, which the author has enlarged from 1½ in. to 2½ ins. in diameter, is suspended from

The effect of enlarging the air-pipe as above-named was to reduce the high-pressure gauge from 105 to 91 lbs. per square inch, the latter pressure corresponding exactly with the water level in the wells, thus showing no back pressure losses.

In an air lift it is important to get suitable conditions as regards depth of immersion or head of water over the air nozzle. When the water levels in the wells are well maintained, as when recommencing to pump after a period of rest, the discharge obtained is very large, ranging from 25,000 galls. to 30,000 galls. per hour

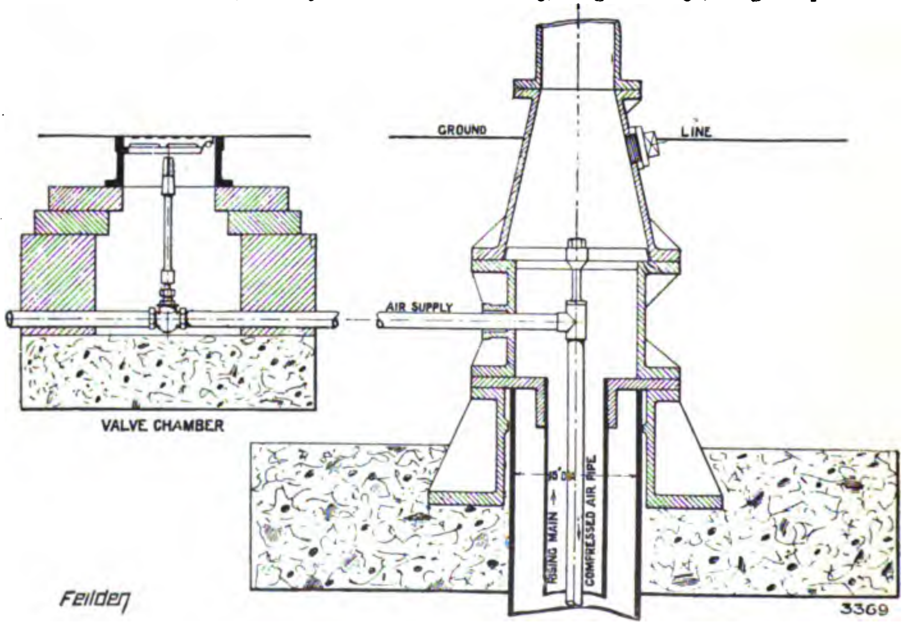


FIG. 3.—DETAIL AT TOP OF BORE-WELLS, SHOWING CONNECTION OF AIR SUPPLY.

the top of the well and hangs centrally in the 7-in. rising main, delivering its air-supply through a distributing nozzle or outlet near the bottom of the well. The action of the highpressure air on issuing through the nozzle is to mix with and lighten the water-column inside the 7-in. tube through which it ascends, driving the water with it. The air is used expansively in the bore-well, continually expanding as it rises nearer to the surface, the pressure, of course, gradually getting less, until atmospheric pressure is again reached at the ground surface.

from one well. The gradual lowering of the water levels naturally reduces the rate of discharge proportionally, but the quantity yielded from a bore-well compressed air-lift under suitable conditions is considerably in excess of that given by ordinary deep-well pumps in the same size bore-well. In an air-lift system there is the great advantage of having no complicated mechanism in the well itself, such as rods, pump-valves, or other working parts, which may get out of repair.

The rising main is continued up to discharge into the top of a stand-pipe

20 ft. above the ground line to give sufficient "head" to deliver the water at the required elevation, or the discharge may be passed through the lower branch, near the ground-line, into the stand-pipe, if desired.

The effect of compressed air upon deep-well water is very beneficial to its use for public supply. It has the effect of aërating the water and hastening the precipitation of any iron that may be contained therein. It is also stated that in America, in cases where the capacity of wells have shown signs of decreasing the application of the compressed air-lift thereto has resulted in increasing the volume of water flowing from the well.

THE HORIZONTAL COMPOUND STEAM ENGINES AND DOUBLE STAGE AIR COMPRESSORS.

Each compressor consists of one high-pressure steam cylinder, one low-pressure steam cylinder, one first stage and one second stage air-compressing cylinder, designed to be capable of delivering sufficient air to raise 16,000 gallons of water per hour from a varying depth of from 88 ft. to 150 ft. below the surface, to a tank over a standpipe at a height of 20 ft. above the surface of the ground.

The high-pressure steam cylinder is 8 ins. diameter, and the low-pressure steam cylinder is 12 ins. diameter. The 1st stage air-compressing cylinder is of 10 ins. diameter, and the 2nd stage air-compressing cylinder is of 6 ins. diameter. The stroke of all is 14 ins.

The compressors were designed to give the greatest efficiency in steam consumption when the depth of water is from 100 ft. to 150 ft. below the surface of the ground.

The high-pressure steam cylinder, the high-pressure air cylinder, and guide bar, all are bolted tandem-wise to one bedplate, and the low-pressure steam and low-pressure air cylinders are bolted to a second bed-plate, one fly-wheel running in between the two bedplates.

The bedplate is of box section, 9 ins. deep, and has 3 ribs, 9 ins. deep, running the full length of the plates, two of which, forming the outside, have ample beading at bottom. The general thickness of metal is not less than ¾ in.

The bedplates are planed all over the bottom surface, the top surface being planed where needed to take cylinders, guide-bar, pedestals, and the necessary brackets.

In the air compressors both the first and the second stage air cylinders and the end covers are water-jacketed. The air is first compressed by the first-stage cylinder into an intermediate water-cooling vessel, from which it is drawn and further compressed to the full pressure required by the second-stage air cylinder. The piston-rod is connected to the tail-rod of the steam cylinder. The cylinder is of special close-grained cast-iron accurately bored to take pistons.

The compressor valves of all cylinders are of Messrs. Hughes & Lancaster's patent Corliss type, and operated by single eccentrics.

The specification provided that the arrangement of valves should be such that the following conditions should be obtained:—

(1) The valve to be opened and closed mechanically for suction to avoid any "wire-drawing," and to make certain that the valve shall close at the right moment viz.,—at end of stroke of piston, to prevent any leakage or slip past the valve.

(2) The delivery valve to be shut mechanically to prevent slip, but to be opened automatically by the pressure in the cylinder. The delivery passages to be as small as possible consistently with keeping sufficient area.

(3) The clearance in the cylinder to be not more than 1 per cent. of the volume swept out by the piston. The air imprisoned in the Corliss valve to be returned to the cylinder during the compression stroke to prevent any further loss in volumetric efficiency.

(4) The valves to work without shock, and to be practically noiseless when running at the highest speed the compressors are likely to be run at.

(5) The valves to be capable of being removed for inspection and replaced with the minimum loss of time.

(6) The driving gear to be so arranged that the valve can follow up its wear readily.

(7) The pressure on valve faces to be so balanced that there is no undue friction, and yet there shall be sufficient pressure to make a perfect joint between inlet and delivery passages.

(8) The barrel of cylinder and as much as possible of cover to be water-jacketed, but so arranged that they can be readily

cleaned out in case any sediment should be deposited in water-jackets.

(9) The incoming air must not come in contact with any heated surface till it reaches the inlet air valve.

The steam cylinders are made of special close-grained cast-iron, accurately bored to take liners; the steam chests are the full length of cylinders and of ample width, the liners are of the very best close-grain cast-iron, free from blow-holes and accurately bored to fit pistons.

The space between liner and cylinder forms steam jacket and is about ¾ in.

The cylinders, end covers, and steam-chest covers, are lagged with fossil meal and sheet steel, and are provided by drain cocks, tallow cups, and the necessary copper pipes, valve, etc., for connecting steam jackets to steam chest and steam traps. The drain cocks are connected by lever in such a manner that both can be operated by one movement. A sight feed lubricator is provided on steam branch to high-pressure steam cylinder.

The pistons are of cast-iron of good construction and fitted with broadcast iron-spring rings.

The piston-rod and valve-rods are of steel turned accurately to gauge.

The slide-valves of the high-pressure steam cylinders are on the Meyer cut-off expansion principle and are capable of being adjusted whilst the engine is running, so that the cut-off in the cylinder may be altered from quarter to three-quarter of the stroke. A pointer shows accurately on a scale the position of the cut-off.

The slide-valves of the low-pressure steam cylinders are of the ordinary "D" type.

The crosshead is of improved design, made of cast-steel, and fitted with adjustable cast-iron slippers top and bottom, having very large wearing surfaces.

The connecting-rod is of marine pattern, is made of steel, and machined bright all over. The large end is fitted with gun-metal steps, having large wearing surfaces.

The eccentric straps and sheaves are of cast-iron, and the rods of mild steel finished bright all over. The straps are fitted with sight-feed lubrication arrangements.

The crank-shafts are of mild steel, finished bright all over, made in two pieces, and are accurately turned where required to fit plummer-blocks, connecting-rod brasses, fly-wheels, etc.

The fly-wheel is about 15 cwts., 5 ft. diameter by 4½ ins. wide, is turned on face and edges. It is keyed on to its crank-shaft by two keys.

The steam cylinder is provided with a screw-down stop valve of approved type.

The valve-rod glands are of gun metal, and the piston-rod glands are of cast-iron, bushed with gun metal.

The lubricating arrangements are such that the compressors can be run without stopping for a considerable length of time. All lubricators are of the siphon or sight-drop types; guide bars, crosshead pins, eccentrics, and main pedestals are lubricated by adjustable sight-drop lubricators.

The engines are neatly painted, and are provided with the requisite foundation bolts and plates, and a set of spanners.

In a test recently run 321,870 gallons of water were raised in 10¼ hours from one bore-well from a lift of 133 ft.

COMPRESSED AIR-LIFT AT ARAD.

Another interesting example of air-lift is that at the Arad waterworks in Hungary, where there are two 9-in. boreholes each capable of delivering about 32,400 gals. per hour, only one of which, however, is usually in use at the same time, as this rate of delivery is found sufficient for the present needs of the town.

The water supply is obtained in the gravel stratum below an impervious bed of clay about 20 ft. in thickness, the bottom of which is some 63 ft. below the ground surface.

The compressed air is carried down the bore-pipes by means of wrought-iron tubing, issues through a suitable nozzle, and raises the water into the cast-iron service well or unfiltered water-tank.

The steam-engine air compressor for generating the air supply have compound steam-jacketed cylinders 11 ins. in diameter and 18 ins. stroke. The exhaust steam from the engine is carried to a surface condenser placed below the floor of the engine-house. The circulating water for the condenser is supplied by the pipe conveying the water from the service well to the filters.

There is an automatic arrangement in connection with the air-lift for intermittent working, as the supply of water reaching the well is insufficient for a constant flow. The water is cooled and aërated by the action of the compressed air. This plant was laid down by Messrs. Hughes & Lancaster.

THE WALLASEY AIR LIFT.

To meet the growing needs of their district, the Wallasey Urban District Council recently found it necessary to utilize fully their existing available water sources, and decided to install an air-lift plant for raising water from No. 1 bore-well at Poulton, being satisfied that a much larger quantity could be obtained therefrom than it was found possible to extract with the old deep-well pumps.

The air-lift plant was installed by the British American Well Works, of Queen Victoria Street, London, and consists of a set of horizontal combined engines and stage air-compressors, the steam engines being placed side by side and work tandem on to the air-compressors. After leaving the low-pressure cylinder the air passes through an inter-cooler and then on to the high-pressure cylinder. Water-jackets surrounding the air-cylinders also cool the air during compression. The high-pressure air is led away through an air main to a receiver, and from there to the wells.

The Poulton well is of 10 inches diameter and 700 feet deep. The old pumping machinery was giving about 7,200 galls. per hour, and the makers of the air-lift undertook to increase this yield to about 32,000 an hour.

The system is in use at various breweries, public baths, and manufacturing establishments in various parts of the country.

BORE-WELLS.

Where suitable geological conditions obtain, the sinking of bore-wells to secure deep-seated waters is a useful means of largely augmenting the sources for purposes of public supply.

These wells are sunk in diameters varying from 3 inches up to about 45 inches, and to almost any required depth up to about 3,000 feet.* Two borings of the Wallasey Urban District Council, in addition to those already referred to, are each of 33 inches diameter, and 810 feet and 910 feet in depth respectively. These were sunk by Messrs. Mather & Platt, Limited, of Manchester. The same firm have put down, amongst many others, a boring at Lackenby (near Middlesboro') of 1,806 feet in depth, and two of large diameter (40 inches) at Rickmansworth.

*At Schladebach (Prussia), the deepest bore-hole in the world was put down, it having reached a total depth of 5,734 feet.

Borings of this class are sunk by the aid of the "Rig Boring Machine," a plant made by Messrs. Mather & Platt, which comprises the requisite steam engine and hoisting gear, etc., all combined in such a manner that one man can control all the several working parts.

With this machine the boring is done by means of a round rope 2½ inches diameter, at the end of which is suspended the jars, and the boring-bar and head into which is fitted from one to four chisels.

The up-and-down movement is obtained from the walking beam, whose motion is actuated by means of a crank driven from the engine driving the boring plant. The boring bar is turned round by the man on the surface, who moves it by means of a lever attached to the rope.

In the Mather & Platt machine a flat rope is used, and the up-and-down movement is performed by means of the steam pumping cylinder between the uprights of the machine; the boring bar turns round automatically by means of the ratchets on the top portion of the bar.

With each type of boring machine, a similar type of sludge-pump is used for getting the *debris* out of the bore-hole.

The general principle of boring in hard rocks is the piercing or cutting a hole by continually repeated blows of sharp chisel-ended drills, or a number of such fixed in a metal block, a rotation being kept up so that no two blows in succession strike on the same spot.

In commencing operations a well or pit of about 8 ft. to 10 ft. diameter is sunk to about 10 ft. or 12 ft. deep, and the boring then put down at the centre. The boring tools are attached to iron rods, which are screwed together in 10-ft. lengths as the boring descends.

The various tools and plant employed in boring the wells we have had under consideration are of interesting variety, and have to be selected and changed from time to time according to the class of materials met with in the sinking of the bore. The under-mentioned are some of the principal tools used, as made by Messrs. J. Warner & Sons, of Cripplegate, with their various purposes assigned thereto (Figs. 16 to 52).

Fig. 16.—Shell Auger, for boring in clay and hard soils.

Fig. 17.—Shoe-nose Shell, with loose valve for boring in sand and loose soils.

Fig. 18.—Auger-nose Shell, with loose valve for boring in loamy sand.
Fig. 19.—Bell-mouth Shell, with loose valve for boring in shingle and coarse sand.
Fig. 20.—Auger Shell, with metal valve for boring in sharp sand or fine grit.
Fig. 21.—Diamond or Drill Point-Chisel, for boring in hard soils and sandstones.
Fig. 22.—Flat Chisel, for boring in flint or stone.
Fig. 23.—Tee Chisel, for boring in flint or stone.
Fig. 24.—S Chisel, for boring rocks.
Fig. 25.—X Chisel, for boring rocks.
Fig. 26.—V Chisel, for boring rocks.
Fig. 27.—Worm or screw Auger, for boring soft stone.
Fig. 28.—Parallel Worm Auger, for boring chalk or marl.
Fig. 29.—Plug Drill, for clearing and straightening boreholes.
Fig. 30.—Bell box, with cleats, for withdrawing broken rods by passing over the swelled joints.
Fig. 31.—Bell Screw, for withdrawing rods by catching broken rod screws.
Fig. 32.—Spiral Worm or Miser, for withdrawing loose stones or broken rods from bore-pipes or holes.
Fig. 33.—Bow Dog, for lowering or raising bore-pipes.
Fig. 34.—Spring Dart, with extra tongues for raising faulty pipes.
Fig. 35.—Crow's Foot, for extracting broken rods.
Fig. 36.—Swivel Rod, for turning the tools without twisting the rope.
Fig. 37.—Boring Rods, in 10-ft. lengths, with turned joints and universal male and female screws, made of
- 1 in. sq. iron for 2-in. and 3-in. borings to 100 ft. deep.
- 1¼ in. sq. iron for 4-in. to 6-in. borings to 400 ft. deep.
- 1½ in. sq. iron for 7-in. to 8-in. borings to 600 ft. deep.
- 1¾ in. sq. iron for 9-in. to 10-in. borings to 1,000 ft. deep.

Fig. 38.—Tillers or Levers, for turning rods.
Fig. 39.—Lifting Dogs, for raising or lowering rods.
Fig. 40.—Spring Hook, for attaching to rope for lifting purposes.
Fig. 41.—Rod Wrenches or Hand Dogs, for screwing and unscrewing rods.
Fig. 42.—Scotches, for holding up rods over on boring boards whilst being screwed together or being disconnected.
Fig. 43.—Auger Cleaner, for removing clay, marl, or chalk from augers.
Fig. 44.—Auger Boring Board, for resting and guiding tools for cleaning, connecting, or examination.
Fig. 44a.—Snatch Block, for lifting rope.
Fig. 45.—Rope Pulley, for lifting rope.
Fig. 46.—Tee Screwdriver, for varied purposes among tools.
Fig. 47.—Shear-Leg Fittings, for connecting and binding ends of legs.
Fig. 48.—Pipe Tongs, for making joints.
Fig. 49.—Steel Pipe Shoes, for protecting and sharpening cutting edge of pipes.
Fig. 50.—Cast-iron Screwed Driving Cap.
Fig. 51.—Flush Screw-Joint Bore Tubes of welded wrought-iron, made in 6-ft., 8-ft., or 10-ft. lengths, with lapped joints.
Fig. 52.—Swelled-Joint Bore Tubes of welded wrought-iron, made in 6-ft., 8-ft., or 10-ft. lengths, with lapped joints.

A complete set of boring tools suitable for boring to 800 ft. or 1,000 ft. deep, with the necessary strong 1½-inch boring rods with turned screwed joints, may be obtained at a cost of about £200.

An interesting example of an artesian well sunk through the oolitic strata in 1856, in this district, yielded about half a million gallons of water per day under a pressure sufficient to supply the town without the aid of pumping power.

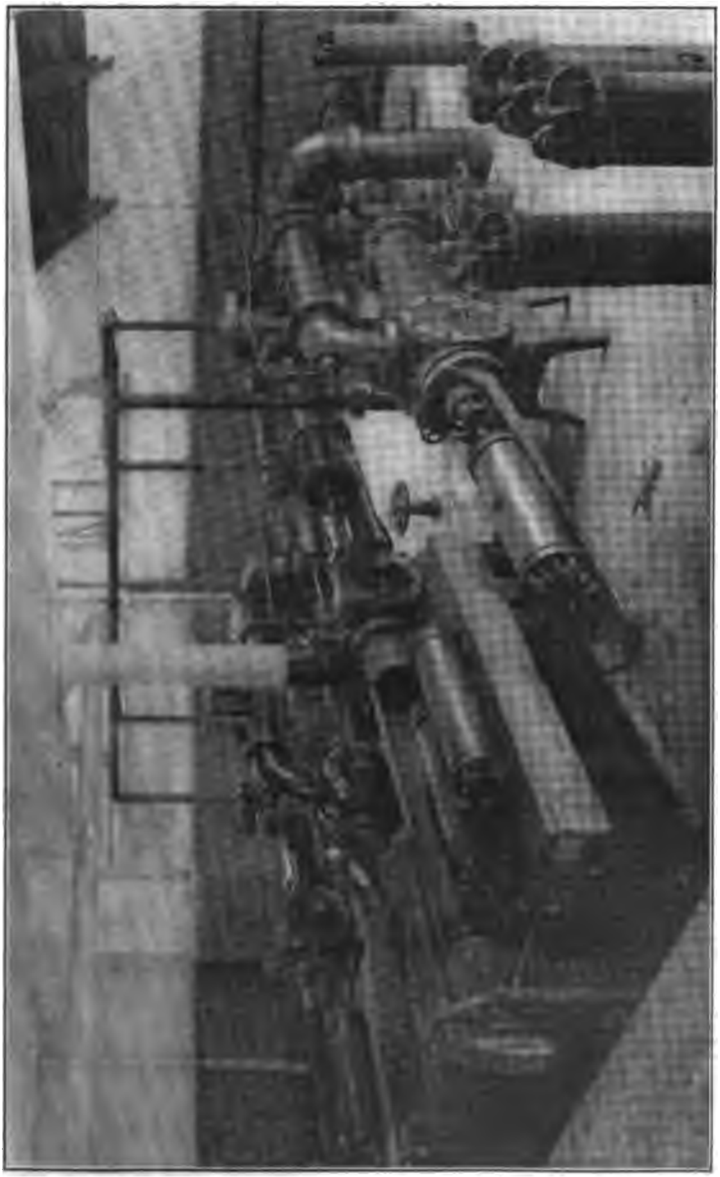
In the earlier portion of the present article particulars were given of the raising of water from deep bore-wells by means of a compressed air lift; at the site of the same works there are also two bore-wells fitted with steam-driven deep-well pumps.

The bucket and suction valves are placed at a depth of about 203 ft. below the engine-house floor in a gun-metal pump barrel 4 ft. 9¼ in. in length and 8½ ins. in diameter. The plant, running at 27 revolutions per minute, delivers about 16,000 gallons of water per hour. The pumps were installed by the well-known firm of Messrs. James Simpson & Co., Ltd., of Pimlico, and have been working for about six years with every satisfaction.—William H. Maxwell, A. M. Inst. C. E., in *Feilden's Magazine*, London.

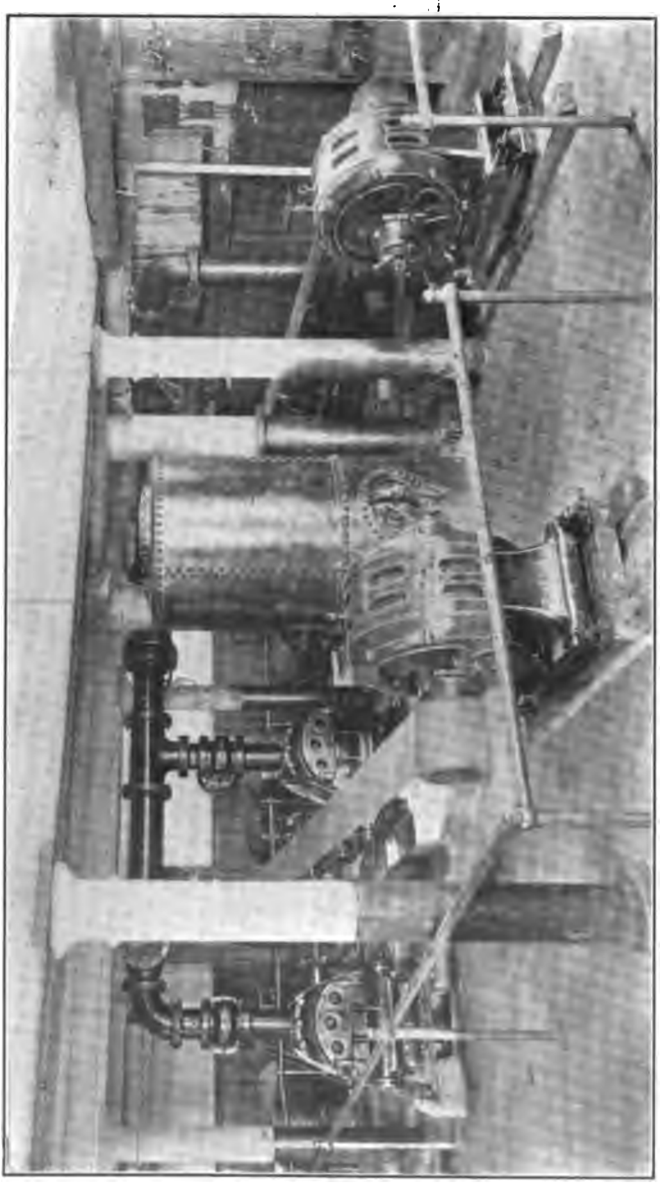
The Boston Pneumatic Tube Service.

The problem of delivering packages is one that confronts every retail dealer in every line of goods. The wholesale merchant can confide his goods to the railroad or steamship company, knowing that at the other end his consignee will unload and take care of the shipment. But the distributor is facing a different problem. He must leave his goods at the homes of numerous customers, each and every one of whom expects his order to receive immediate attention. This becomes a serious matter in the large cities where the population covers a vast area.

The American Pneumatic Service Company has instituted a novel method of distributing parcels by installing an underground pneumatic tube system in Boston. A central station has been erected in the very center of the retail shopping district at the head of Harrison avenue. From



TERMINAL STATION.—BOSTON PNEUMATIC TUBE SERVICE.



ELECTRICAL DRIVEN AIR COMPRESSORS.—BOSTON PNEUMATIC TUBE SERVICE.

this station two pairs of tubes are laid, one pair running to the Back Bay sub-station on West Newton street near Huntington avenue. The other pair runs to the south end sub-station on Washington street, near Brookline street. From the south end the line is continued to the Dudley street station in Roxbury, near the terminal of the elevated road, and from Roxbury it runs to the Dorchester sub-station at Upham's Corner. The parcels are collected from the stores by teams and brought to the central station. There they are sorted and sent by tubes to the sub-stations above named, and delivered from them by team or messenger. The average time of transit from the central to the Dorchester station is about 10 minutes as against 40 minutes by team.

compressor. Only such air has to be dried as is lost through leakage or used for operating the machines.

The compressors are duplex belt-driven with 24 in. x 12 in. cylinders. There are two each at the main, south end. and Roxbury stations, and one each at Dorchester and Back Bay. The compressors are driven by 50 H. P., three-phase induction motors of the internal resistance type. The idea of belted compressors and electric motors was adopted after a long investigation into the relative merits of steam, gas and electric power. Steam was early abandoned because of the necessity of having a licensed engineer at each plant, and on account of the room required for boilers, coal bunkers, etc., gas engines appeared attractive on the score of economy,

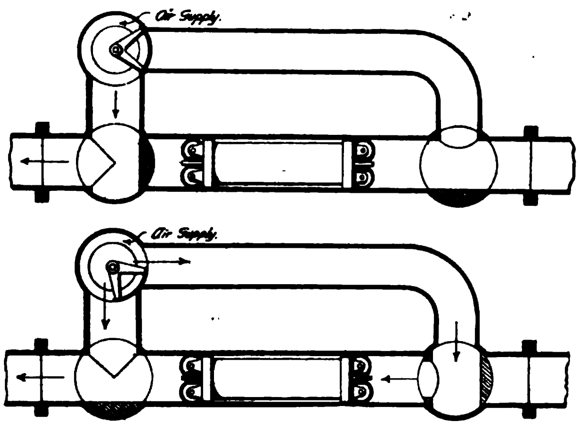


DIAGRAM SHOWING AIR LOCK.—BOSTON PNEUMATIC TUBE SERVICE.

The tube is operated by compressed air, which forces a carrier along in a manner similar to that in use in the familiar store service cash system. The air required is about 1,400 cubic feet per minute at an average pressure of 1.9 lbs. With the lines filled with carriers this pressure may rise to as much as 2.1 lbs., and in the shorter lines, with no load, it falls off to 1¾ lbs.

Before entering the compressors the air passes through a tank filled with calcium chloride, which effectually removes all moisture. This tank is open to the atmosphere, and the pipe connections are so arranged that the air of the incoming line passes through the tank and returns to the

but it was decided that a power was needed that could be more easily controlled; that is, one where the starting or stopping of the compressor would be an easier matter. Turning naturally to electricity, the decision lay between direct and alternating current. The induction current motor with no commutator to burn out, with no danger of burning out the armature, and its high efficiency at half load, was finally adopted. The motors have been running for a year, without giving the least trouble, and with a total bill of repairs of less than five dollars, all of which was for paint.

The carrier used is a complete departure from all previous designs. Instead of using felt or some other substance for bearing rings on which the carrier can slide, five wheels are placed on each end of the carrier. The heads which carry the wheels are slightly flanged and it is found that the air that leaks by is not sufficient to be noticeable. The cover is hinged on the side, opening the whole length of the carrier, and nearly one-half its circumference. It is locked by a trident at each end which slips into holes drilled in the head. Such a heavy carrier cannot be allowed to come out of the open end of the tube the way that small carriers do in the store service systems. The receiving terminal is an air cushion closed at one end by a revolving valve which is opened and closed by a cylinder and piston operated by compressed air from the tube. Normally this valve is closed. When the carrier enters the receiver it compresses the air in front of it. This pressure affects a small auxiliary valve. When the carrier is brought nearly to rest the auxiliary over-balances and moves the controlling valve of the main cylinder. This opens the revolving valve and allows the carrier to roll out. Just at the end of the receiver two vanes are mounted so that the pressure of the air behind the carrier tends to move them. This motion is made use of to restore the auxiliary valve to normal position and close the receiver. As the current of air is kept flowing all of the time, it is necessary to have some method of introducing the carrier into the tube. This is done by a simple adaptation of the air lock (see diagram). The valves are moved in the proper sequence by one cylinder controlled as in the receiver.

PARCEL CARRIER.—BOSTON PNEUMATIC TUBE SERVICE.

The pipe used is cast-iron water pipe, machined at the joints to make a close fit. It was laid in the same manner as water pipe, with lead and yarn joints. The curves are of cast-iron, 12 feet radius to center line, the circular section of the straight pipe becoming elliptical at the bend. The bends were cast in sections, the standard 90-degree bend consisting of three 30-degree sections bolted together. In laying, the usual obstacles of manholes, sewers, water and gas pipes and electrical conduits were encountered. To add variety to the work, the foundations of the elevated road and the roof of the subway had to be avoided. On Harrison avenue a long stretch of soft mud was encountered which made it necessary to excavate below grade and put in a bed of good bank gravel. This, when well rammed, made an excellent foundation. Work was commenced Sept. 4, 1900, and the first carrier was sent through on March 10, 1901. Business was commenced June 1, 1901, and has been carried on steadily ever since.—E. D. SABINE, in *Railroad Gazette.*

Water Supply from Deep Wells by Air Power.

The results obtained from the trials made with the air lift pump installed at the Ilford District Council's electric power station go to show that a revolution in the economical raising of water from deep wells has been accomplished. As a consequence of this invention of Mr. Joseph Price, C.E., of Messrs. Le Grand & Sutcliff, it is likely that the expensive deep well pump will before long be superseded. These deep well pumps, which require to be fitted immediately above the bore well in order to provide water for use in towns, for supplying power stations, or for draining mines, have been the source of much trouble. A breakdown of a single detail of the pump machinery overhead or a little grit or sand in the foot valve underneath has frequently caused the supply of water to be cut off for periods ranging from three days to three weeks at a time. The introduction of the air lift pump will reduce these failures to a minimum, and any quantity of water will be provided from artesian wells sunk in batteries each at a convenient spot, while the air power for working them will be distributed through a small and inexpensive pipe from a central station conveniently situated alongside the railway line, by the coal mine or at the waterfall. Formerly each well required an expensive deep well pump and a house for protection directly over it, now twenty or thirty wells may be supplied with power from one machine under one roof, and each bore pipe will supply more than double the quantity of water which would have flowed from it under the old conditions.

As far back as 1797 Mr. Carl Emanuel Löscher, surveyor of mines, described a system of raising water by aerostatic apparatus by means of which well water could be raised to a height of 375 feet. In this experimental apparatus of Loscher a pipe was placed in a receiver filled with water, part of the pipe being above water and part under the water, while a current of air under pressure was forced down an inner pipe, the bottom of which was open to the outer pipe. The air forced down the water which had risen in the inner pipe, and mixed with the water inside the outer pipe. The air mixing with the water made it lighter and caused it to rise in the annular space between the two pipes. The water thus lightened rose above its ordinary level to a certain height which depended on the pressure of the air rarifying the water. By making an opening in the outer pipe below the level to which the water had risen in it the water could be drawn off from the receiver. Thus water could be pumped from a well by the apparatus with a supply of air.

Löscher's was simply an experimental apparatus, for no practical application was made of it. It was not until 1846 that Mr. Crockford in America took up the idea and constructed apparatus, on the principles explained above, to pump petroleum from several Pennsylvanian wells. Dr. Pohlé applied the principles on a large scale for raising water in America. In 1885 Mr. Werner Siemens fitted out a number of pumping plants in Germany on this system, and then Messrs. A. Borsig, of Berlin, began to construct and fit the apparatus for pumping under the name of Mammoth pumps. One of these pumps was presented to the Machine Laboratory of the Technical High School at Berlin.

The observations made while this pump was working at the Technical High School are interesting, and a record of them goes some way to supply an explanation of the principles under which the apparatus has been designed, so we give them here. There is an artesian well pipe of 6¼ inches diameter sunk to a depth of 100 feet below the surface of the ground. The pump proper and its two pipes are fixed at the bottom into a foot box. To allow of observation being made the upper part of the rising main was made of glass tube. It was arranged that the rising main should discharge freely into a reservoir. When the air is pumped down the air tube it flows out at the foot into the box and then up the rising main and causes the water to rise. Air bubbles are seen to ascend, and by an entraining action draw the water after them. The water is indeed seen to be mixed with air bubbles of the size of peas and with foam. In some of the intermediate spaces the mixture contains very large volumes of air, which fill the whole section of the rising main, so that there are alternately layers of foamy water and layers of air. The water is sometimes seen to fall back a little, in consequence, probably, of the air going up and leaving the water behind.

The force which causes the water to rise in the rising main is the pressure of water round it, and the pressure depends on the height it stands in the well. The height to which the water can be raised will therefore depend on the pressure outside. To obtain greater pressure of water in the well it must be sunk deeper, so that the height to which the water has to be raised determines the depth to which the well must be sunk. As a rule the water column should be from one to one and a-half times the height to which it is desired to raise the water.

It has been mentioned that one of the great advantages of the air lift pump is that the working parts may be at a great distance from the well, and, indeed, in the power station under easy control of the engineer. Another advantage, which is really a consequence of the above, is that as soon as the pressure of air in the supply pipe has been raised to that of the water at the foot of the well the pump begins to give off water. This is brought about simply by the turning of an air cock. There is a yarn spinning factory at Zurckau, where a water engine takes 4 cubic metres of water per minute from the river Mulde, and raises it to a height of about 30 feet at the works, a distance of 1,000 yards away. In this case the water first frees itself of air and then flows into an open receiver. This receiver or supply tank requires to be placed at a considerable height to give sufficient head to drive the water through the pipes. The tank stands at a height of 44·16 feet. The air at the required pressure for driving the pump is obtained from the factory by means of a steam compressor. During the winter, when the pumping appliances are not in use, the upright portion of the discharge pipe which is not sunk in the ground is provided with an automatic discharge valve at is lowest point, so as to protect it from frost. It is arranged to be so connected with the compressed air pipe that it is opened by a spring so soon as there is no more pressure. It has been mentioned above that a much greater discharge of water can be obtained from the air lift pump than from a deep well pump of equal size. At Poulton the Urban District Council of Wallasey had an old deep well pump which lifted 7,200 gallons of water an hour. An air lift pump was fitted in of the same dimensions, and it now gives a discharge of 32,000 gallons an hour. At another place the well has been sunk 200 feet down through the Wadhurst clay into the Ashdown sands, from which the water is obtained. The well is formed of 15-inch tubes above, and perforated steel tubes below of 13½ inches diameter. When no pumping is going on the water stands in the tube at a level of 74 feet from the ground, but when water is being pumped from the well at the rate of 32,000 gallons an hour for ten hours a day, the water level sinks down to a point 120 feet below the level of the ground. The lowest point the water has reached is 150 feet from the ground. Inside the bore well tube there is suspended a rising main of 7 inches diameter. The air supply pipe is suspended inside of that, originally this pipe was 1½ inches diameter, but by increasing its diameter to 2½ inches diameter the engineer-in-charge found that he could reduce the pressure of the air supply from 105 lbs. to 91 lbs. with advantage. The pressure of 91 lbs. is exactly equivalent to the water level in the wells.

The efficiency of the ordinary system of deep well pumping at the beginning, when everything is new and it is working very smoothly, is as high as 50 to 60 per cent. Afterwards, when wear and tear and valve troubles have set in the efficiency may be reduced to about 40 per cent. The efficiency of the air lift system is not so high. At the Kent waterworks the efficiency is probably as high as anywhere, and yet it does not come above

25 per cent. Still there is the advantage of the system requiring only one power house at any convenient spot supplying power to any number of wells as against the deep well pump with a complete pumping plant and house to cover it above every well.

The new air lift pump designed by Mr. Price saves some of the waste of power inherent in the design of the ordinary air lift pump. The rising main of the ordinary air lift pump is of equal diameter throughout, and it has been seen in the experiments made by Prof. E. Josse that layers of air rise in the main alternately with layers of water. It is of interest, and an explanation of the action of the air as it rises in the tube will be suggested if its changing conditions throughout the passage upwards be considered.

Take, for illustration, a case where the lift is 80 feet and the corresponding immersion is 120 feet, thus making the total length of the rising main 200 feet. To overcome the 120 feet resistance of immersion the air must be compressed to 60 lbs. gauge pressure or five atmospheres absolute pressure, and will thus occupy one-fifth of its original volume. Now as a layer of air rises in the main the pressure above it will become less and less, and at the top will only have the pressure of the atmosphere on it. If it can it will expand gradually on its way upwards until at the top it will occupy a length of tube several times greater than it did at the bottom. In order to permit this expansion the water above the layer of air must have been caused to travel very much faster than it did at the bottom. That is to say, much of the energy of the air has been uselessly applied to give a rapid motion of the water in the upper parts of the tube.

In order to get over this difficulty, Mr. Price, of Messrs. Le Grand & Sutcliff, has introduced a rising main narrow at the bottom and gadually widening towards the top. By this arrangement the air can expand laterally, and the layers of water travel with little greater speed at the top of the rising main than they did at the bottom. There is thus a saving in the expenditure of energy in giving more momentum to the water.

Results have been obtained from an air lift pump constructed to effect economy in the air supply at the electric lighting and power station of the Ilford District Council. The well is sunk in the yard, and the immersion is 1½ to 1 of lift; this lift being 130 feet. The air pipe is 1½ inches diameter at the top of the well, and this is reduced to 1¼ inches lower down. The air is supplied by an Alley & McLellan compressor, which on trial gave the following results:—When the air pressure in the receiver was 80 lbs. the mean i.h.p. of the air cylinders was 18·83, when 100 lbs. 22 i.h.p., and when 120 lbs. it was 24·3 i.h.p. On trial with one of these air compressors directly driven with a steam engine the loss was only 6 per cent. At Ilford the compressor is driven with a Bruce Peebles motor.

Starting from rest the full pressure is shown in the receiver in quarter of a minute, and water is running through the pipes after one minute. A curious phenomenon is seen just after the water runs out of the supply pipe. There is a relief or head tank fitted some distance from the well, and as soon as the water begins to run a great rush of air and water springs up through a hole in the top of the tank. Placing the hand over the hole when the pump is in action one feels a curious throbbing action. The hand is alternately blown upwards and sucked into the tank. It is probably in consequence of a layer of air suddenly expanding and blowing everything out in front of it and then the atmosphere pushing back and reasserting itself.

A notch gauge for measuring the quantity of water supplied by the well has been fitted up, and the quantity measured is 12,000 gallons an hour. A deep well pump which would go down the same boring would only deliver from 4,000 to 5,000 gallons an hour. The speed of the motor is 790 revolutions, and the pump makes 71 revolutions per minute.

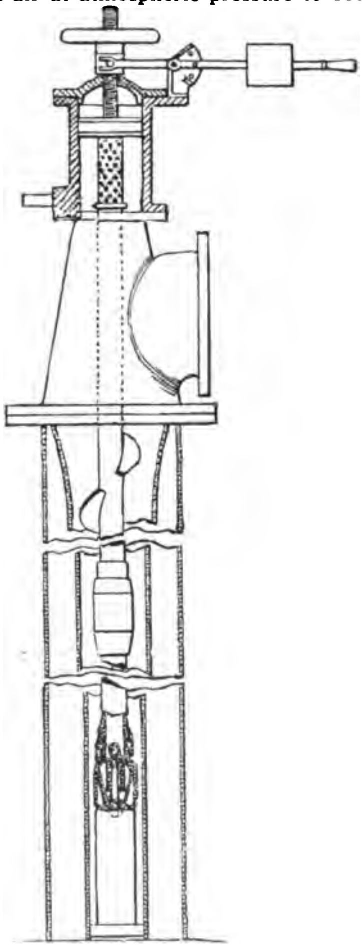
As regards economy and efficiency, the system has been compared with similar steam deep well pumps and ordinary air lift pumps. To do this the efficiency of the air compressor when driven by a direct-acting steam engine must be taken. It has been mentioned that the loss on trial of a compressor driven by direct-acting steam engine was found by Messrs. Alley & McLellan, the makers, to be in one case 6 per cent. Taking 10 per cent. as the loss at the compressor, and 20·5 as the mean i.h.p. of the compressor cylinders, then with a supply of 12,000 gallons an hour, a pressure of air at 90 lbs. and a lift of 130 feet, which were the figures read at trial, the efficiency works out at 35 per cent. Improvements on these first few installations will increase the efficiency, so that when the cost of repairs, maintenance, and small comparative supply of the deep well pump, and the wide range and large supply afforded by these new air lift pumps are considered, the working cost in all charges, it is apparent, can easily be brought down below that of the deep well pump. When this pump is compared with the ordinary air lift pump with straight rising main it is only necessary to point out that the efficiency is 42 per cent. higher even in the first wells tried at the Central London Railway, Shepherd's Bush, and at Ilford power station.

Since we wrote the above, further trials of the plant have been made. The efficiency test of the plant was made on the 16th of July, 1902, and the following were the particulars supplied by the contractors. The well is bored 10 inches diameter to 400 feet in depth. The height to which the water rises when at rest before pumping is 44 feet below the surface.

The plant was arranged as for raising a supply of 10,000 gallons from 130 feet below to 20 feet above the surface and (excepting as regards the design of the tubes) on lines dictated by the best American and German practice for parallel rising mains. The wells of American and German design require about 144 cubic feet of air to be compressed for the above duty, equalling a ratio of at least 5½ volumes of air to one of water, and a ratio of submergence to lift of 3 to 2.

The rising main of Mr. Price's pump consists of tubes increasing in inside area. As the air expands in rising, the friction of the water is greatly reduced as compared with pumps with parallel rising mains. The internal air tube has an adjustable annular ejector to enable those operating the pumps to economize the air used. By this means the velocity of discharge of the air at the depth of 336 feet below the surface is utilized. The water, while the trials proceeded, was discharged at 5 feet above the surface over a weir fitted with a gauge for recording the quantity of water discharged per minute.

In the case of Ilford the air compressor is about 50 feet from the well. It is of the two-stage type with intercooler, and has been found to compress 144·2 cubic feet of air at atmospheric pressure to 100



PRICE'S PUMP SHOWING TAPERED RISING MAIN.

lbs. pressure when working at 115 strokes a minute and indicating 22 h. p. in the compressor. The compressor is driven through gearing by an electric motor fixed on the same bed-plate.

Under the contractor's trials the plant was run for fourteen days and nights, and kept the water lowered to an average depth of 127 feet from the surface, the lift being 132 feet. The average flow over the weir gauge was 11,660 gallons per hour, that is 195 per minute.

During the run it was found that the compressor working normally was doing much more than was required, and that a quantity of the air could be allowed to leak away without in the least reducing the flow of water. The quantity of air leaking away in this manner was measured, and found to be about 44 cubic feet. So that really the quantity of air required to lift the quantity of water measured was only 100 cubic feet per minute. This works out to be a ratio of 3·2 volumes of air per volume of water lifted under the conditions stated.

On the completion of the above test arrangements were made to slow the motor down, and this was done until the pump made 83 revolutions per minute. At this speed the quantity of water raised was 200 gallons per minute, the total lift being 124 feet. With these data the volume of air is 3·25 volumes per volume of water. This comes out about the same as was found by the leakage operation.

From these figures it becomes an easy matter to calculate the efficiency of the system of pumping water. For lifting 200 gallons of water through a height of 124 feet is equal to performing 248,000 foot-lbs.; and the power used in do this is 15·88 h.p., which is equivalent to 524,000 foot-lbs. This shows an efficiency of 47 per cent.

But in this case the pump was working under certain disadvantages. The excess of the submergence over the standard was 31 feet, and the temperature was 80 degrees Fahr., that is, 25 degrees Fahr. above the normal temperature. Making corrections for excess of submergence and temperature, the efficiency works out at 55·5 per cent. As has been pointed out, the old air lift pump has an efficiency of about 25 per cent., and the deep well pump often goes below 50 per cent. Under these conditions Mr. Price's pump should be favorably received by the engineers of power stations throughout the United Kingdom and Ireland.—G. HALLIDAY, in *The Electrical Times*, London.

In A Country Engine Room.

One of the compensations for the comparative loneliness of a country location is the fact that the engine-room is the Mecca of all the engineers who visit the place, and that the occupant thereof has consequently the chance to collect a great variety of information (with sometimes a little misinformation) from his numerous callers.

Some time ago when we were having some trouble with an air compressor which was too small for the work assigned to it, a Western visitor volunteered the following account of his experience with one of the same kind of machines:

"We had been trying for quite a while to make about a 20 horse-power compressor do 40 horse-power of work without having very good luck. Then the superintendent took the head office into his confidence, and they sent word that they had one at another place which was a good deal larger which they could spare from its present location. Perhaps though it might be too large? Oh no! the old one was 14x12x14 and the other is only 18x20x18 inches—not so *very* much larger. So, without consulting me in any way, the larger compressor was ordered loaded up and shipped to our plant. A week or two afterward it got to us and after some delay was unloaded and set up. Now, the work which it was expected to do, was to force air at 120 pounds pressure through an inch pipe, to raise water for a large mill. As 120 pounds was the limit of our steam pressure when steam was turned on, the machine ran along all right until the receiving tank was full, then stopped as suddenly as a man would if he ran against a stone wall. This was a surprise apparently to manager, superintendent and master mechanic, who had all gathered 'round to see the big machine start work. Then an effort was made to start it again, but she wouldn't budge. Then the end of the lever safety valve was lifted up with a pole and held up till the receiver was empty, and the compressor was given steam again. As before, she went off all right, but when the pressure in the receiver got up she stopped again with 'a dull thud.' It being now about 6 o'clock, further proceedings were postponed till next morning. I shall probably never get over thinking myself a big fool for my part in the next chapter in this work; for, if I had been consulted, I could have told the management beforehand what would happen. But I went home that night thinking of how a machine might be made to circumvent the laws of nature, but could think of no plan until I was eating my breakfast next morning. Then it occurred to me that if I could fix the compressor so that only enough air could get into the compressor to keep the pipe full the machine might be able to run right along. I submitted my plan to the master mechanic when I got to the mill, but he only shook his head and said 'no good.' But I was determined to try it, so took a sheet of packing and covered the 6-inch inlet pipe with it, cutting a 2-inch hole in the center for the air to get in at. But the opening was still too large and I had to cover up a little more than half the remaining opening before the machine would run. After we found that the compressor could be made to work that way, we made a wooden cover for the inlet pipe with a 1½-inch hole in the center, to which was fitted a shutter, so that when we started up the machine a good supply of air could be let in until the receiver was full, then the air supply could be cut down, so that the compressor would keep in motion. Yes, it was a good deal of bother to look after the big old thing, because it had to be run so slow that when the steam pressure went off a little it was liable to stop, and it was quite a job to start it again. However, after the firm had spent a few hundred dollars in repairs, they discovered that they needed that machine back in its old place, and they got a new one for my mill."

Now, some people may doubt the truth of this account, and find it impossibe that any man in charge of a plant would not stop to figure the probable capacity of an engine and its suitableness for his use before ordering it or allowing it to be shipped to him. Yet I have known of a manager offering a 5x7x7 air compressor for use when the pressure required in the receiver was 10 pounds above the available steam pressure.

By the way, the compressor mentioned in the beginning of this article has been supplemented by a "two-stage" compressor. Now it looks a little curious to me to see a steam cylinder of 14 inches diameter running an air cylinder of the same size and stroke, and in addition one of 8 inches in diameter, yet getting an air pressure as high as that of the steam by which it is driven.

Yet it does this right along, so we shall have to admit that it must be in accordance with natural law. One of the greatest troubles with the old compressor was the burning out of the packing of the piston rod from the extremely high temperature of the compressed air, which at 120 pounds per square inch pressure is somewhat over 500 degrees Fahr. In the two-stage compressor, however, the partially compressed air passes through an intercooler, thus reducing the final temperature and saving all trouble about the packing.—F. RIDDELL, in *Power*.

A Large Air Compressor.

With the view of increasing the capacity of the compressed air power transmission plant which is largely used for underground haulage , the Powell Duffryn Steam Coal Company in September last placed an order with Messrs. Fraser and Chalmers Limited, of Erith, for a very large air compressor of the King-Riedler vertical type, and this machine is now ready for erection at the colliery. Its capacity is 8,300 cubic feet of free air compressed in two stages to 60 lb. pressure at 70 revolutions per minute, with 95 lbs boiler pressure, and at this speed the indicated horse power is 1,050. Probably it is the largest machine built in this country. The machine is in reality two compressors built into one machine, each side being connected to a common flywheel shaft and being readily disconnectable so that either half can run independently by uncoupling the connecting rods. The flywheel is 16 feet in diameter and weighs about 16 tons. On each side there are high and low pressure steam cylinders, and the corresponding high and low pressure air cylinders are placed above them, the high and low pressure pistons being tandem on their respective piston rods, which are connected to the flywheel shaft by the King connecting rods. This arrangement reduces the height of the machine very considerably, practically 11 feet of head room and much material being saved.

The diameters of the steam cylinders are 23 and 38 inches, and of the air cylinders 23 and 37 inches. The stroke is 48 inches. The air cylinders are water-jacketed by means of a liner forced into the barrel and caulked in place with copper rings. Hand holes in the barrels permit cleaning. Between the two stages of compression the low-pressure air from both sides flows around the pipes in a cooler placed underground. This is built of boiler plate about 4 feet in diameter and 12 feet long over all, with numerous

¾ inch brass tubes through which water flows. One suction and one delivery valve is placed in each cylinder head of the four air cylinders, and they are closed automatically at the ends of the piston stroke through rocking valve-spindles by links worked by hardened steel cams on the wrist plates of the Corliss gear. The lift of the high-pressure valves is 1¼ inches, and of the low-pressure valves 1½ inches. They are very light and strong considering the work they have to do, and as they have no springs and are positively closed there is a complete absence of dancing and slamming which is often so noticeable in other air valves. The advantages of the Riedler positively-closed valves both for air-compressors and for pumps is well known and generally acknowledged at the present time. The outlet valves close before the returning piston can draw back the compressed air, and the inlet valves close directly compression begins, so that the waste of cylinder space due to slow closing is reduced to a minimum. Arrangements have been made for the insertion of liners in the low-pressure cylinders, so that air-pressures up to 75 lbs. may be attained if desired at a later date.

The steam cylinders have Corliss valve gear, and are bolted together, leaving ample receiver capacity between them. The distance pieces resting on them to support the air-cylinders consist of four castings, which can be removed when the steam cylinder covers have to be lifted for examination of the piston. There is forced lubrication for all moving parts, the oil being supplied by a separate pump on each side, and a sight-feed being placed at all the points where oil is delivered. With this arrangement all parts get their due proportion of lubricant.

A special feature of interest in this machine is the governing arrangement. One of Whitmore's patent governors is fitted on each side of the machine and are connected together when both sides are running. This governor is a combination of the centrifugal ball type with air cylinders, so that both the speed and the air pressure control the steam, but some play is allowed in the connection of the two parts, so that steam is never cut off entirely. With this device, if there is no call for compressed air, the pressure will lift the govenor to such an extent that the engine will just crawl round. On the other hand, if the compressed air is drawn off very rapidly or an air pipe breaks, the engine will not exceed its maximum speed by more than 5 per cent. To anyone who has seen an air-compressor started, the advantages are obvious, and as the speed can be reduced to about six revolutions per minute, the amount of air blown to waste is reduced to a minimum with the least waste of steam and fuel. At all intermediate speeds the supply and demand of air will keep pace with each other and the hunting of the governor is practically negligible. All the air and steam pipes are fitted with Hopkinson gate valves so that any portion can be cut off at very short notice in case of accident. At the time that our representative visited the works the machine was not running, but elsewhere in the shops a smaller single two-stage compressor of somewhat similar design was supplying compressed air, and this machine ran exceedingly smoothly and at a high speed.—*Colliery Guardian.*

A Resume of the Use of the "Baby" Air Drill at the Gold Bank Mine.*

After a good deal of persuasion the Compressed Air Machinery Company consented to make us a small drill on the same general principles of their larger or giant drill for our mine. The only specifications I gave them was that the drill should weigh about 100 pounds.

The first drill was made and delivered the last of August, 1898, the diameter of the cylinder being 2¼ inches, their larger drill in use at this mine being 3⅛ inches. A thorough test could not be conveniently made during September, though it was run more or less; but the drill was given a thorough and severe test all through the month of November, with the most satisfactory results, being used principally in the stopes, though it was tried in the drifts and raises.

In the latter part of November, 1898, I ordered four more drills of the same size, advising strengthening of various parts that experience had shown were weak; received them in December, and on the first of the year 1899 I had introduced them throughout the mine to do the stoping, with the gratifying result that I could dispense with the services of sufficient miners to reduce my pay roll an average of $1,500 a month.

*Abstract of a letter to the *Mining Reporter* from the manager of the Gold Bank Mining Company, Forbestown, Cal.

Before the introduction of the "Baby" drills all the stoping of the mine was done virtually by hand, a large drill occasionally being used in the stopes, whereas at the present time there is not a single hand driller in the mine, all the work being done by the air drills, the "Baby" drills doing all the stoping and occasionally being used to run raises; and they have been used with success in a drift where the formation was not too hard.

I am at present using a "Baby" drill to widen down the shaft, the shaft being originally an upraise from a crosscut tunnel, and we are now widening down one side of it to make it large enough for shaft purposes working underhand. Most of the rock is of the hardest kind of green-stone, and there were doubts about the small drills being strong enough to stand the work, but so far we have cut down about 100 feet, without any apparent detriment to the drill. It takes a whole shift of ten hours to put in five or six holes, but each man gets in his round, and we have averaged five feet a day of two shifts.

The "Baby" drills as now made weigh about 105 pounds, and are easily handled by one man. As a rule, the miners require no help in rigging up and getting ready to run. They never need help with their drills after they have the bar in place. It frequently happens that a miner is sent from one part of the mine to another to change his place of drilling, and he shoulders his machine, takes his wrenches, etc., in his hand, and moves about without any help from others. That illustrates the ease and facility with which the machines can be used underground.

"BABY" AIR DRILL IN GOLD BANK MINE.

The mine does not run but six days in the week, while the mill, forty stamps, runs seven. The mill crushes an average of 3,200 tons a month of hard quartz. I consider the quartz above the average in hardness. The stamps weigh 1,000 pounds, drop 103 a minute, discharge through a No. 7 slot-punched screen with low discharge, there being no inside coppers in the mortars. Four "Baby" drills running day and night supply the mill with quartz. Of the average of 3,200 tons a month. 580 were broken by the larger machines, leaving an average of 327½ tons a month, one shift a day to the "Baby" drills.

A "Baby" drill can be used wherever a man can work single-handed. We proved that conclusively, the machines having taken the place of hand drillers, and we do not take down the hanging wall when the ledge is too small to stope without it. We have in the mine jack bars ten feet long and others only twenty inches long.

We always supply water to the miners under a pressure, running a water pipe wherever we run an air pipe. I cannot recommend such a course too urgently upon mining superintendents. The work done by the drills and the time saved by the men more than compensate for the extra expense. We used water here when we had to pump it out of the mine, and know its economy. We run our drills under an average pressure of thirty-five pounds. We use seven-eighths-inch steel for the short drills and three-quarter for the long ones. Experience has taught us that the air required to run a 3⅛-inch drill, under thirty-five pounds pressure, will run three and a half "Baby" drills.

I can safely recommend the use of small machines in mines, and predict a great future for them.

Air Brake "Parasites."

The consumption of air pressure generated by the pump of the air brake system for use by other devices than air brake, on locomotives and cars of the modern railroad train has become quite an important matter. Originally the full work of the air pump on the locomotive was to supply pressure for the use of the air brake system. Now it is quite different. Persons recognizing the conveniences and characteristically favorable qualities of compressed air for other purposes began using it. Its first use, aside from air brakes, was to raise water in sleeping cars from tanks underneath the floor of the car. In the early days this operation gave much trouble to the air brake system. Air was taken direct, through a non-return check valve, from the train pipe of the sleeping car to the water tanks under the floor. Later, an improvement was made whereby the pressure was made to pass through the triple valve and auxiliary reservoir of the air brake, through a governor and non-return check valve to the water tanks. This arrangement prohibited the water-raising system from receiving its air until after the air brake system had accumulated almost its own maximum pressure of, say, about 60 lbs. This system has given very little trouble, and is in successful operation at the present time.

The use of air pressure for operating auxiliary devices on locomotives is greater than is such use on cars, and to-day we see on the modern locomotive such pneumatically operated devices as the automatic sander, traction increaser, fire-door opener, grate shaker, smoke consumer, bell ringer, water scoop and other similar devices. In the aggregate these devices consume a very considerable quantity of air, and, in fact, equally as much as, if not more than, the air brake system itself. It is, perhaps, not the actual amount of air required for the legitimate operation of these devices that demands attention, so much as it is the waste or leakage from indifferent and careless maintenance of these devices. If they and their pressure connections were carefully inspected and properly maintained the amount of air consumed would be very much smaller, and the complaints made against such devices would be much fewer.

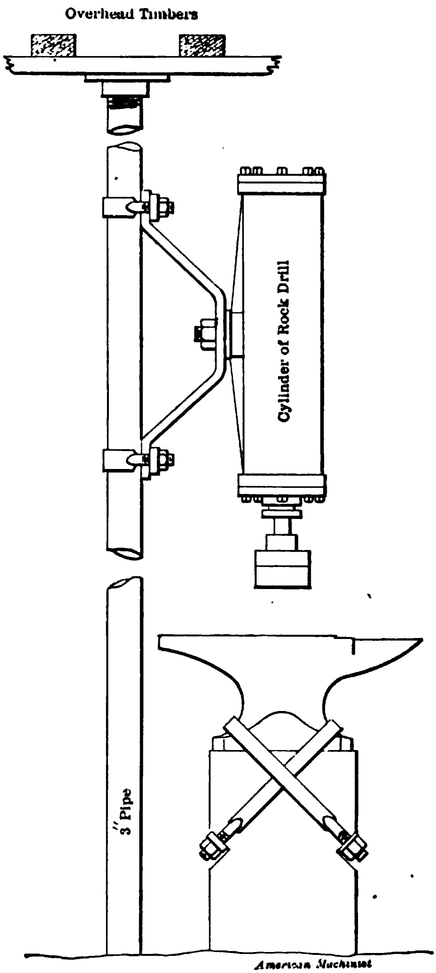
So serious have the complaints against these devices commonly known as air brake "parasites" become, that relief of some kind has been asked for, and in some cases, demanded. An investigation into the situation and a careful consideration of means for meeting the issue has pointed out two or three ways of escape from the trouble. One is to use steam pressure on all such devices on the locomotive as will permit of it. This, however, has its objections, inasmuch that steam leakage leaves a sediment which is unsightly and unclean, and is quite different from that caused by clean air pressure. On the other hand, with the use of steam, leakage would manifest itself at the several bad joints by the forming of sediment and scale, thereby directing the attention of the inspector to the leakage, when the repairs could be easily and quickly made. On such devices as the sander, the use of steam would, of course, be impossible. The other devices, however, or a large number of them, at least, would do as well with steam for their operation as they do with air.

Another means of overcoming the difficulty mentioned would be to supply engines with a second air pump, whose duty would be to deliver pressure to a reservoir separate from the air brake system, and thus independently supply the "parasites." Still another means would be to use a larger pump than is now used on engines, pumping into the main reservoir of the air brake system, then reducing out of that to a second and separate reservoir for the "parasites." This would be similar to the arrangement of the water-raising system on sleeping cars. The first mentioned remedy would undoubtedly be preferable, inasmuch that the "parasites" would be independent of, and isolated from, the air brake system, which it could not interfere with as it does at the present time. Possibly an attachment might be made to send the over-supply of the "parasite" reservoir to the main reservoir of the air brake system, thus aiding and assisting the air brake system, instead of interfering with it and taking from it, as at the present time.

The seriousness of the situation seems to be sufficient to warrant some such scheme for relief. Even at the present time, with the above named devices or "parasites" in operation the air pump is frequently overtaxed in supplying the train pipe leakage of the train, leaving very little pressure to be diverted for the use of the "parasites." In the future we may expect to see additional pneumatically operated devices such as reversing gear, throttle opener, whistle operator, oil distributor and smoke consumer for the locomotive, and window hoists, seat turners and ventilating fans, etc., for the coaches, to say nothing of possible coupling and buffing devices operated by compressed air. With the experience of the past, the conditions of the present and the possibilities of the future, some disposal of this extra work on the air brake pump should be made, else complications will surely arise, and, at a critical moment, may seriously interfere with the operation of that great safety device, the air brake, ending possibly in disaster.—*American Machinist.*

A Rock Drill as a Blacksmith's Hammer.

A correspondent writes the *American Machinist* as follows: "While visiting the Elkton Mine at Cripple Creek, Col., last summer, I was interested in the ingenious way in which a rock drill had been rigged up to take the place of



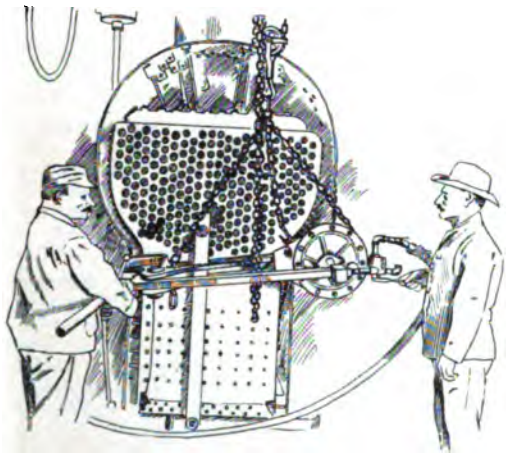
A ROCK DRILL ARRANGED AS A STEAM HAMMER.

one or two blacksmith helpers in the blacksmith's shop. The drill, minus the tripod, was fastened to a vertical support.

An ordinary anvil was fixed in a position under the ram, and the necessary air connections were made with the cylinder. When a blacksmith has some heavy hammering to do, he has some one, as usual, to manage this contrivance, while the smith takes care to have the blows struck in the proper place, as with a steam hammer, except that the blows are not as heavy, but a sight more numerous for a given space of time. At the time that I saw this improvised (?) steam hammer in operation the blacksmith was working down a piece of steel or wrought iron, about three inches wide at its widest part, one inch thick at its thickest part, 2½ feet long, tapering in both width and thickness, and the hammer appeared to be doing excellent service. It appeared to me to be a very simple, effective and quite inexpensive apparatus, especially considering the fact that it, excepting the hammer head, was rigged up from material to be found in any mining outfit, and that it could be very easily resolved into its original parts and their former duties resumed, since neither drill nor anvil suffers any from this somewhat unusual use."

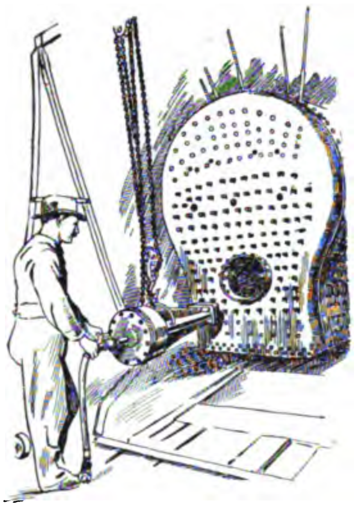
Pneumatic Staybolt Appliances.

A simple device, yet a labor-saver, is the staybolt breaker shown in the accompanying illustration and made by the Baird Portable Machine Co., Topeka, Kan. Designed to cut out old fire-boxes, it can be operated by one man, with a boy assistant to handle the valves, and is capable of cutting out the largest size fire-box in ten hours. It is claimed that an average saving of $18 a day can be made by the use of one of these staybolt breakers. In using the tool, the makers consider the more economical way is first to separate the fire-box from the forward part of the boiler; although if it is desired to remove the fire-box by taking out the door sheet and back head, no difficulty will be experienced in operating the machine. It weighs but 800 lbs.



BAIRD STAYBOLT BREAKER.

The staybolt cutter, an illustration of which is also shown, was designed for cutting off the ends of staybolts after they have been screwed into place in the fire-box. The machine is a cylinder and frame combined, the cylinder diameter being 15 in., and may be operated either by steam or compressed air, preferably the latter. With a working pressure of 100 lbs. it will cut off staybolts up to 1⅛ in. in diameter, at the rate of 1,200 per hour, and at a proper distance from the sheet to allow for heading over. Use of this tool prevents loosening the bolts in the plates, as frequently occurs where a hammer and chisel are used. The weight of the appliance is 450 lbs, and one man can handle it. A



BAIRD STAYBOLT CUTTER.

larger machine, the No. 2, is similar in design, and will cut off bolts up to 1¼ in. diameter.—*Railroad Gazette.*

Pneumatic Tube Service in Modern Factories.

A saving appliance, which has for its attainment an increase in the efficiency of the several departments in a manufacturing establishment, by cutting down to a minimum the necessary time consumed in issuing orders, and such additional information that may be necessary for their prompt and proper execution, such as notices, changes, drawings, etc., should receive most careful consideration, and if found to possess those merits peculiar to all successful devices, should be promptly adopted and installed.

Many different systems of department communication are in use to-day, each one of which doubtlessly possesses more or less merit, and while all may be properly classed as efficient factors, very few can demonstrate their right to a perfect title of sufficiency.

While speaking-tubes and telephones may be extensively used and are a satisfactory means for verbal communication (where conditions are favorable), still they must necessarily have additional assistance that the present growing demand of shop requirements, such as the quick and safe delivery of written orders, drawings, etc., may be met.

An efficient telephone service in conjunction with a pneumatic tube system is probably the best equipment the market has to offer the manufacturer, in which all the requirements are satisfactorily met, though the pneumatic tube system could of itself be made to serve both purposes.

The Dodge Manufacturing Company, at their main office and works (Mishawaka, Ind.), have recently added to their very complete telephone service an extensive pneumatic tube system, known as the Miles Pneumatic Tube System of New York, and speak in the most eulogistic terms of its efficiency.

The central station is located in their present telephone booth which in itself is situated in their main office, both being in charge of the same attendant.

The system comprises thirteen sets of tubes leading to and from the central station, in connection with which an auxiliary station is situated at foundry office, from which all matter directed to warehouse and isolated departments can be transferred.

Departments handled exclusively from the central station are, draughting room, advertising department, machine shop office, foundry office, wood shop office, shipping department, stock keeper's office; balance of tubes leading to the several departments of main office.

The tubes in this system are two and one-half inches in diameter, and all bends are of sufficient radius to allow for free transmission of cartridges eighteen inches long.

The compressed air for this system is carried in separate pipes, and therefore air is only used when transmitting the cartridges.

It is obvious that under such a system orders, written instructions, etc., can be promptly and safely transmitted to and from the different departments.

The many uses of a pneumatic tube system can't be thoroughly appreciated until one has seen it in actual service, when its manifold uses pronounce it as being pre-eminently the most prompt and greatest labor saving device in use.—*Power and Transmission.*

A Pneumatic Water Supply System.

The problem of water supply is often very serious in buildings which are isolated and have not the facilities for connecting with a general water-distributing system such as is provided for a town or city. Those who are thus situated will be interested to hear of the recent invention of Mr. Edward D. Deeter, of Milford, Ind. The invention provides a peculiarly constructed pump, adapted for elevating water from a well, and forcing it into a sealed tank against the air confined therein, so that the pressure of the air will force the water from the tank into a system of water pipes for the supply of one or more buildings. The construction of the pump is such that it will pump air with the water into the receiving tank, thus maintaining a suitable pressure for the service pipes. The construction further permits adjustment of the mechanism or the exact graduation of the amount of air pumped, or an arrest of the air-pumping operation, as may be found necessary. The pump is situated at the top of the lift pipe, from which water is forced through a pipe at right angles thereto, and is conducted into the tank. A clack-valve covers the top of the lift pipe and prevents regurgitation of the water lifted into the cylinder. A hollow plunger-rod extends into the cylinder and is provided at its lower end with a cup-shaped packing-ring, which engages the inner side-wall of the cylinder, and a disk valve which, on upward motion of the plunger, is adapted to close the openings in the base-plate of the plunger-head. The lower end of the hollow plunger-rod is closed by a plug which serves to hold the base-plate in position. The central passage extending through this block is closed by a valve under spring tension. The stem of this valve extends upward and is engaged near the top by a tappet-lever hinged to and passing through the wall of the hollow plunger-rod An upright post secured to the upper end of the cylinder is provided with an opening at its upper end which affords a bearing for the plunger-rod.

The operation of the main plunger is similar to that of the ordinary pump. On the upward stroke water is drawn past the clack-valve into the main cylinder, and on the downward stroke it is forced past the disk-valve into that portion of the cylinder above the plunger head. On the next succeeding stroke the water is forced into the receiving tank. An ordinary check-valve prevents a return flow of the water. As previously stated the pump is designed to supply air pressure to the tank so that the water may be forced to the upper story of a high building. The air is fed into the pump in the following manner: When the plunger-rod is traveling upward, at a predetermined point the outer end of the tappet-lever mentioned above encounters a spring-limb secured to the guide-post, and is thereby thrown down, its inner end lifting the valve from its seat in the plunger-rod plug. The lever is secured in this position by a pair of spring clamping-arms situated directly below, and is thus held until released by a V-shaped pressure-block at the top of the guide-post, which spreads the springer-arms apart. Air is thus admitted to the cylinder at each stroke, in quantities which can be regulated by the position of the spring-limb on the guide-rod, and from the cylinder the air is pumped with the water into the receiving tank. To stop the pumping of air it is necessary merely to raise the spring-limb to its highest position, where it cannot engage the tappet-lever.

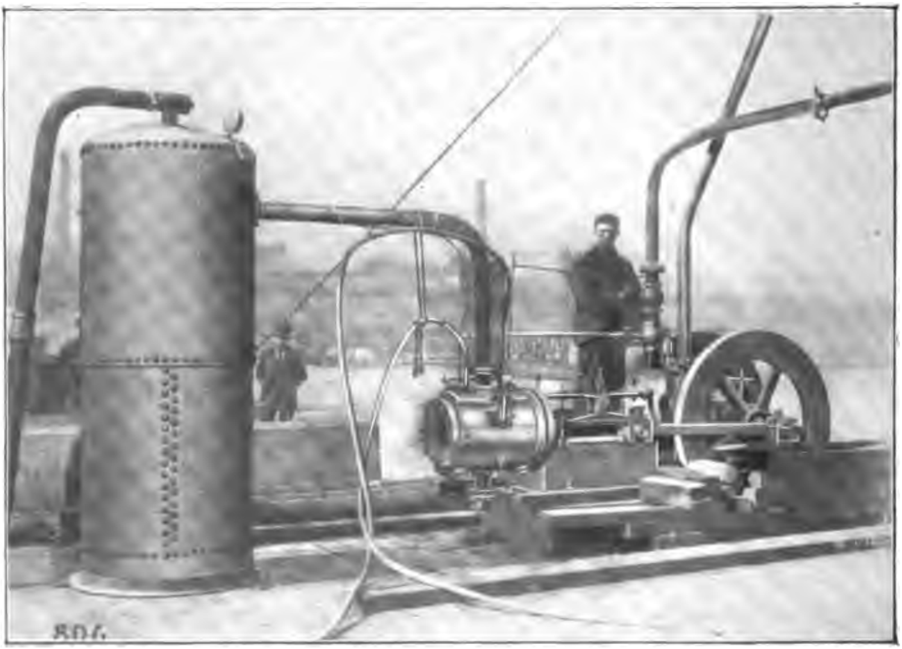
Though the pump, as stated above, is designed for use in furnishing a water supply for buildings not connected with the general water-supply system,. it will readily be seen that the invention would be useful in connection with a general water supply for the elevation of the water to a greater height than could be otherwise reached. The pump will also be found useful.—*Scientific American.*

A Novel Air Compressor.

An interesting air compressor, containing no piston nor any moving part save valves, has recently been described in the "Revue Universelle des Mines et de la Metallurgie." It is due to Mr. Emile Gobbe, and has been tried with some success at the Monceau Company's blast furnace. The arrangement consists of an explosion chamber, the outlet of which leads to a chimney. A throttle valve which tends to remain open by its own weight is introduced between the chimney and the explosion chamber. Two conduits, one for gas and the other for air, lead to this chamber. At some distance from the points at which they enter the combustion chamber each conduit is provided with an inlet and an outlet valve, the latter communicating respectively with the receivers for compressed air and compressed gas. A draught having in any suitable way been started up the chimney of the plant, charges of air and gas are drawn in and mix in the combustion chamber. The mixture is then fired by an electric spark. The explosion closes the valve to the chimney, and forces a portion of the air and gas back along their respective conduit pipes and through the discharge valves into their receivers. When the pressure falls sufficiently, the valve at the base of the chimney opens automatically again, and a fresh charge is drawn in and the action repeated as before. In the experimental plant erected at Monceau, the explosions followed each other at the rate of twelve to fourteen per minute; but the plant proved to be in need of considerable modifications if satisfactory working was to be obtained. In a laboratory apparatus since constructed and designed to work with town in place of blast-furnace gas, good results have been obtained in the matter of regularity of working, and the inventor claims that with a large plant carefully designed very considerable economy could be relied on, and the capital cost would be extremely small.—*Science and Art of Mining*, London.

American Compressor in Scotch Shipyard.

We show here an example of how extremely careful American manufacturers should be with instructions which they send out with machinery for foreign customers. The picture illustrates a small size steam actuated air compressor and a vertical receiver of American manufacture, sent to a Scotch shipyard and installed temporarily, as shown in the picture. Although careful instructions accompanied the machine as to the method of placing the oiling devices, the picture shows that they put the sight-feed steam-cylinder lubricator on the air cylinder and air-cylinder lubricator on the steam cylinder. The illustration also shows the method of making turns in pipes which finds general use in England and on the Continent.



AMERICAN AIR COMPRESSOR IN SCOTCH SHIPYARD.

Compressed Air Car in Severe Service.

We are all more or less familiar with the good record made by the compressed air cars used in the all-night service on the Clark street line of the Chicago Union Traction Co. The illustration herewith shows the results which can be obtained with compressed air even under most adverse conditions, the car being at work in deep snow.

FIG. 1.—COMPRESSED AIR CAR WITH SNOW PLOW.

The advantages offered by an independent motor for car service under exceptional conditions are well known and it is also appreciated that there are various applications for air as an auxiliary in many cases where the overhead trolley is the most economical and desirable for regular service. The mechanism of an air motor being similar to that of the steam engine is quite as reliable and has the same range of speed and power.

The Compressed Air Co., of New York, has extended its field of operations and is preparing to build mining locomotives; its later designs of street car motors have the running parts made heavier than in the earlier types.—*Street Railway Review.*

Compressed Air Mine Hoists.

Compressed air is used for hoisting, both inside of the mine and on the surface. Either steam or compressed air is preferable to other media for hoisting, and the majority of hoists are built to use either one or the other medium, and the fact that they can be used in the same hoist proves an advantage in many places.

For underground work most of the hoists are small and are operated on winzes. Except in particularly favorable places, these hoists are operated with cold air, and are, therefore, not economical, as far as power is concerned; but they are extremely useful.

A winze hoist should be backed up by a large receiver near by.

Compressed air timber hoists are an extremely useful appurtenance for underground work. They are light, weighing five or six hundred pounds, have small reels and small geared engines, and are of powers ranging from 5 to 10 h.p. For hoisting timbers and drills into an uprise, or for hoisting timbers into shops or around a mine generally, they are very useful. These hoists are also made on trucks so that they may be taken from one part of the mine to another very easily. All these underground hoists consume from 20 to 25 cubic feet of free air per horse-power of actual work done.

Surface hoists operated by compressed air are much in vogue, especially where the power is electrically transmitted to the mine. A portion of the electrical power is converted into compressed air to be used for the hoists. The most economical way to use this air is to so arrange the plant that the electrical power is practically constant and the compressor is just large enough to absorb the power. There must be large storage capacity, so that when the hoist is not in operation the power may be stored.

The hoist itself should be a compound first-motion hoist to be a thoroughly up-to-date machine. A compound geared hoist is not quite so economical in air. The hoist cylinders should be jacketed. The air, after passing from the receivers, should go through a heater having two compartments, one for high-pressure and one for low-pressure air. In the first compartment the air is heated to about 400 degrees and passes around the jackets of the initial cylinder and finally into the cylinder itself being exhausted from there back to the second compartment of the heater, where it is heated again to about 400 degrees, passes to the low-pressure cylinder of the hoist, and from there escapes to the atmosphere. A hoist of this character requires from 7 to 8 cubic feet of free air per horse-power, a vast difference as compared with the requirements of a cold air hoist. The cost of reheating is very small. —*Engineer and Iron Trade Review*, London.

The New York Rapid Transit Tunnel.

An interesting publication entitled "New York Rapid Transit Tunnel" has recently been issued by the Rand Drill Company of New York. Turning over its pages we are impressed by the beauty and practical value of the illustrations and by the clearness of type and the admirable plan by which the reader gets a clear and comprehensive view of the subject treated. Beginning with a brief history of underground tunneling in New York and describing the work of the Rapid Transit Tunnel as it is at the present time, the publication ends with a brief statement of the "future of rapid transit," in which attention is called to inevitable extensions of this system, and "thus New York City," it is said, "is likely to see an era of tunnul building in its endeavor to keep up with the great growth of the five boroughs of the city." The general construction of the work is shown by sections and plans and the route of the tunnel is outlined. Special attention is called to the use of compressed air as the power for driving the machinery. This large and important piece of work is really an object lesson to contractors in the use of compressed air for excavation. It is known, of course, that the Rapid Transit Tunnel is not altogether a tunnel, but a succession of subways and tunnels; in fact, the word subway applies more properly to the case. Even in open work compressed air is used and has been found to give better results, not only because of the freedom from steam and smoke in the streets, but because the power may be transmitted some miles from the generating station with safety and economy. This work is equipped with air compressing plants from the City Hall to Harlem, and the use of air has here been proved to be of great practical value.

Vaporization Experiments.

The experiment of freezing water by its own evaporation is more often described than performed, as it succeeds only with an unusually good air pump. A similar experiment with melted camphor is less impressive in one way, for the temperature required to freeze the camphor is not very low, but the experiment is far more showy, can be exhibited to a greater number at once, and is very easy to perform. A very slight diminution of pressure brings the boiling point below the freezing point, so that if a flask or test tube of melted camphor be connected to an air pump, and but one or two strokes taken, the liquid will boil under the reduced pressure, and almost immediately flash into a bulky, porous, solid mass, puffed up by the vapor that was coming off during the act of solidification.

By heating the camphor under diminished and varying pressure it is easy to change at will from sublimation to distillation. If a cold rod is thrust down a test tube in which the camphor is boiling, the cooler vapor in the upper part of the tube condenses on the rod in sparkling crystals, like frost, while lower down the hotter vapor is condensing to liquid. In fact, camphor may be made to illustrate, not only the appearance, but the true cause of formation of frost, snow, etc., while in its pleasant odor, it has an advantage over many substances used in experiments of this kind.—W. P. WHITE, University of Wisconsin.

"Pneumatic Chipping Hammer."

The accompanying half-tone illustrates a somewhat novel application of the ordinary pneumatic chipping hammer in a quarry in England. It will be noticed that the man in the foreground is trimming the edge of a piece of flagging, using the ordinary pneumatic chipping hammer just as would be done in the case of a piece of steel. By means of this tool the work of trimming up the stone is done far more rapidly and quite as satisfactorily as could be done by hand.

A NOVEL APPLICATION OF THE PNEUMATIC HAMMER.

Ingersoll-Sergeant Drill in Hawaiian Islands.

Our illustration here shows a new use for the rock drill and has a double interest from the fact that the picture was taken in the Hawaiian Islands.

The drill in question is an old Ingersoll-Sergeant machine and is one of the four built for the Hawaiian Government.

As shown, it is mounted on a wagon and is being hauled by an Ohio Road Roller, which also furnishes the steam for operating the drill. The combination formed one of the features in a Fourth of July parade.

The incident is simply another illustration of how rapidly our new possessions are becoming Americanized and calls attention once more to the fact that after all there is some truth in the statement that "Trade Follows the Flag."

INGERSOLL-SERGEANT DRILL IN HAWAIIAN ISLANDS.

Notes.

It is stated that the Philadelphia Pneumatic Tool Co. will increase its capital stock to about $2,000,000 in order to take care of its rapidly growing business and to prosecute extensions of it into all parts of the world.

Women civil engineers may figure later in the profession. In any event, three women have signified their intention of taking the civil engineering course at Cornell University for next year. They are the first to take the Cornell course.

The American Air Compressor Company's Danish representative at Copenhagen, has just published a pamphlet describing the American Air Lift Pumping system with reference to their air compressors and governors. It also contains cuts and matter pertaining to the direct acting air compressor manufactured by the Union Steam Pump Co.

The contracts for the new plant of the Cleveland Pneumatic Tool Company have been awarded to Messrs. J. A. Reaugh & Son, of Cleveland, Ohio. It is expected to have the plant completed and ready for operation within ninety (90) days. The plant will be equipped with the most modern machinery and appliances for turning out the largest amount in the shortest time.

The W. J. Clark Company, of Salem, O., who make the "Quick-as-Wink" couplers for compressed air hose, are very busy with orders for that new style of couplers. They are said to be much more convenient for use than the old style couplers and as connections can be made or broken in about one-tenth of the time required when common couplers are used, the new style of couplers work a saving of time in shops where air hose is used.

It is reported from Chicago that John Condon, the blind race track owner and turfman, is recovering his eyesight, through the treatment of Dr. Gary, a Baltimore specialist. Condon said to-day that objects only dimly visible before commencing the treatment could now be plainly distinguished.

He has tried many European specialists in vain. The treatment is by a new apparatus, in which compressed air and electricity are used.

The Librarian of Congress, Washington, D. C., writes that they are short of several numbers, which they are very anxious to have in order to complete the file of COMPRESSED AIR for the Congressional Library. If any of our readers can furnish any of these numbers, a list of which we give below, it will be very much appreciated:

Volume 1. Nos. 5, 6, 7, 8, 9, 10, 12.
Volume 2. Nos. 1, 2, 3, 5, 6, 7, 8.
Volume 3. Nos. 2, 3, 4.

Ash hoists are used in many forms for raising ashes from the ash-pits. Compressed air is generally used to raise buckets from the pits. The ash-pit is supplied with a number of clam-shell buckets, resting in cradles, with wheels to run on the pit rails beneath the engines. The hoist dumps these buckets into a car on the adjacent tracks. One large road is preparing to install an electric traveling crane over its ash-pits, believing that this will be the most satisfactory device which can be used for this purpose.

A large grain elevator has recently been put into service by the Iron Elevator & Transfer Co., of Buffalo, N. Y. This is made entirely of concrete and steel, and is situated on the Lake Shore & Michigan Southern. Compressed air is distributed to all points of the elevator. This air, at a pressure of 100 lbs. per sq. in., is used for blowing dust out of the motors, for sweeping floors and beams, and for syphoning any water that may collect in the drain pits under the elevator. A blacksmith's forge is also supplied with air from this system.

Bids were recently opened by the acting postmaster general for the rental of pneumatic tube service in Boston, New York, Brooklyn, Philadelphia, Washington, Chicago, and St. Louis, several of the bidders or their representatives being present. The bids greatly exceed the appropriation of $500,000 granted by congress to be used for the purpose for the fiscal year 1903 and it was announced that no awards would be made at present, as it will be necessary to make some adjustment among the different cities in order to come within the appropriation.

Among the accessories at the power plant of the Berkshire Street R. R. Co., Pittsfield, Mass., is a system of compressed air pipes with five outlets distributed about the engine room, arranged for ¾-inch hose connections for cleaning purposes. The air is furnished at 70 pounds pressure by a Westinghouse compressor connected with a receiver. A system of lubricating oil pipes has also been installed, including an oil purifier, oil reservoirs, etc. The oil is distributed by air pressure furnished by the air pump above mentioned, the oil tanks being placed in the engine room basement.

It is sometimes the case that gas engines have air inlets too small and compression spaces too large for satisfactory work in a rarified atmosphere. When a gas engine is intended for high altitudes it should have a larger air inlet and a smaller compression space than when the same engine is to work at sea-level. For altitudes of more than five thousand feet the engine should have a plate attached either to the piston or to the cylinder head, in order to reduce the compression space. Gasoline at high altitudes evaporates at a much lower temperature than at the sea level, and it is well, therefore, to use the heavier grades at high altitudes.

The compressed air plant in connection with the Westinghouse electrical equipment of the C. & C. Shaft of the Consolidated California & Virginia Mining Co., at Virginia City, Nevada, supplies the air for drilling a number of underground hoists and the hydraulic pump. This plant consists of a 16½ in. x 30 in. Rand & Waring single stage air compressor, driven at 73 R.P.M. by a 100 H.P., type "C" Westinghouse motor. The motor speed is 580 R.P.M., which is reduced by a counter shaft with wooden rim pulleys and rubber belting. No automatic regulator is used at the present time, as the compressor is working to its full capacity and the motor is developing 96 H.P.

The water used to drive the water wheel in a water power air compressor can be used afterwards to cool the air compressed. It is good and economical practice to cool the air before it enters the compressor, to cool it again while being compressed, to give it a third cooling between the compressors, where a two or three-stage compression is made, and finally to cool it after it leaves the last compressor. Each cooling saves power employed in making compression. If the same water used for power is used for cooling the cost of cooling is only interest and repairs on the cooling plant. After the air leaves the receiver and before it is used, the quantity of heat that has been taken from it put back into it again adds to its effective working value.

Nearly all mechanics and engineers who use compressed air for the transmission of power imagine that the using of it for such purposes is something new, but that is not correct. To be sure, its use for mechanical purposes has been greatly developed since George Westinghouse used it for transmitting power to brakes, but it is more than one hundred years ago since William Murdock, so closely associated with James Watt, transmitted power through the engine works at Soho, near Birmingham. He drove the machinery of several shops by air compressed by the blowing engine, and he built a lift which also was operated by compressed air. Among the other purposes to which Murdock applied compressed air was the transmission of packages through tubes. He was really the inventor of the pneumatic air tube transmission which has been used so successfully of late years.

One of our correspondents living in Cincinnati, Ohio, writes us that the outside of the Grand Opera House in that city, has just been cleaned by the application of the compressed air sand blast, and that the contractors have been heavy losers. Each night when an inventory has been made it would be found according to our correspondent's story, that they were minus tons of sand, supposed to have found its way into the open mouths of the wondering spectators.

A man standing on the scaffold suspended from the eaves high above the passing crowds operated a hose, through which the compressed air passed. The air was filled with fine sand which was driven with great force against the stones, which were crusted over with coal soot. The impact removed the sooty surface revealing the original color of the stone. The sand was very fine, and the operator wore a canvas mask to prevent the particles from entering his throat, eyes, nose and mouth.

At the Fore River Shipyard, Quincy, Mass., electricity and compressed air are used throughout. Those responsible for the equipment of the works possessed one advantage of the greatest importance. All of the appliances, no matter of what description, and no matter of what value relatively, were to be new. There was absolutely no old and antiquated machinery for which space had to be provided. All the buildings came under the same category, as the ground was free of all incumbrance. These circumstances gave the designers a perfectly free rein and permitted them to construct and equip unhampered by any preexisting conditions. The result is a shipyard admirably arranged for the quick and convenient handling of all material. The power house is centrally located, as far as various buildings are concerned. In this building are two air compressors of the Rand & Ingersoll-Sergeant types, which supply all the pneumatic tools. Air is distributed through the works at a pressure of 100 pounds.

The exhibition of ship riveting which the Chicago Pneumatic Tool Company are making in Glasgow, Scotland, is proving highly successful. The work there is in charge of Mr. E. Guennell, for many years superintendent of the Chicago Shipbuilding Company at South Chicago, Illinois, and he reports most favorable progress and great interest on the part of the shipbuilders on the Clyde. To further assist him in his work, the Chicago Pneumatic Tool Company have sent two expert riveters from the Chicago Ship Yards to Glasgow. The Chicago Pneumatic Tool Company are injecting American methods into their European business, and have recently sent Mr. F. D. Johnson, manager of their New York office, to push business there, and have also sent Mr. George H. Hayes to take charge of the mechanical work in their London works.

Mr. W. H. Armstrong, from the headquarters of the Chicago Pneumatic Tool Company, at Chicago, will have charge of the New York Office of that Company.

There is a valve setting machine in operation at the shops of the Cleveland, Lorain & Wheeling R. R. at Lorain, O., by means of which it is said two men can set the valves of a locomotive in four hours, including the moving of the eccentric blade, etc. The machine is turned under the driving wheels by means of a No. 1 Little Giant air motor, through the gearing of an old-style cylinder boring bar, the ratio of which is 17½ to 1. The rollers supporting the main driving wheels are made of cast iron 6 ins. in diameter, with faces 2 ins. wide, the latter and the shafts turning together, the rollers being keyed to the shafts by gib-end keys. The key-ways are made ½ in. longer than the keys to permit of lateral movement, which is necessary to prevent the rollers breaking or chipping off. Two sprocket wheels and driving chains are utilized for conveying motion to the back pair of rollers from the motor-driven shaft. An especially advantageous feature of the driving mechanism is a slow motion device to be operated by hand when near the end of the valve travel. A left-handed ratchet attachment is placed opposite the air motor, and when the main drivers are nearing the centre the air is shut off and the ratchet mechanism employed to move the wheels to the exact centre.

The water supply for general cooling in the factory and refrigerating apparatus at the Power Plant of the Central Lard Co., Jersey City, is obtained by means of the air lift from three driven wells on the premises, the wells being located in the corners of a triangle, the shortest distance between any two being about 75 feet. One well is 500 feet deep and two 300 feet, and all are 8 inches in diameter to rock and 7 inches through rock. The air lift apparatus was furnished by the Pneumatic Engineering Company, of New York, and consists of two steam-driven, central crank and double flywheel, Rand Drill Company air compressors automatically regulated to maintain the desired pressure in two air reservoirs in the engine room. One compressor is operated ordinarily to compress to 20 pounds for factory purposes, and the other, drawing from the 20-pound pressure reservoir to compress to 110 pounds for the air lift. The air reservoirs are 3 feet in diameter and 8½ feet high. The water is delivered into two tanks in the factory basement and pumped therefrom by a 300-gallon double-acting Stilwell-Bierce & Smith-Vaile triplex pump. In connection with this system are three storage tanks on the fourth floor, and the water can be pumped to these for a gravity supply to the factory.

Sanding Plants.—Where the demand for sand is large, as on roads with a concentration of a large number of engines in a small territority, it seems advisable to install central sand drying outfits and distribute the dry sand in box cars.

At Middletown, N. Y., the New York, Ontario & Western has a sandhouse of brick 25 x 46 ft. in size. Sand is received in gondola cars and shoveled through one of the windows. From the dryer it falls into a hopper and passes into a sand reservoir, from which it is elevated by compressed air into the dry storage for delivery to the engine on the tracks outside of the building. Other tracks may be reached from the storage bin if desired.

At Collingwood, on the Lake Shore, sand is received over the coal-chute trestle, at the end of which it is dropped from the car into a storage bin. It is shoveled into a steam dryer and falls into either of two sunken reservoirs. From these it is elevated through straight vertical pipes into the dry storage above. and is ready for the engines. On applying air pressure to the sunken reservoirs. the air first passes through a vertical cylinder. It raises the piston of the cylinder and closes the entrance from the dryer by means of a large rubber ball. When this ball-valve is closed the piston is high enough to uncover the opening to the pipe which admits the air to the reservoir and elevates the sand.

The Internal Combustion Engines, which work by passing air through a fire and thus expanding the volume at constant pressure, imposes on the fire some conditions which must not be left unsatisfied.

Air must be compressed into the firebox, and at each delivery of the compressor there will be a pressure increase on the fire; similarly at each admission to the engine cylinder there will be a pressure drop, and while we may call the system a constant pressure combustion system, this cannot be strictly true. What is constant is the mean pressure, and even this may vary after a limited time, for variation of admission and cut-off will change it. So that a fire to work successfully in this apparatus must be unaffected by pressure variation whatever may be its extent or suddenness.

One of the greatest advantages that may be derived from this type of engine over the explosive, for example, is the possibility of employing the cheap and safe heavy oils. But to realize this advantage we must add to our conditions one imposing the requirement that heavy oils shall be burnt. And finally, the products of combustion must be delivered at a constant temperature, and that as high as possible. Moreover, this maximum must be known to the designer who proportions his cylinders and mechanism for some particular volume expansion dependent on this maximum.

It has been reported from Binghamton, N. Y., that John Reap is under arrest for killing Elmer Cook, a fellow-workman, by means of compressed air. Reap is a New York machinist, working in the Ontario and Western car shops at Norwich.

In the shop is a powerful pump for compressing air, which is capable of raising the pressure to a high degree. The men about the factory have been accustomed to turning a small current of the air on their clothing to dust them off. The air is conveyed from the tank through a hose furnished with a nozzle similar to a garden hose.

Elmer Cook, on finishing his day's labor, took the nozzle to dust off his clothes. The air was turned on slightly and a small jet was blowing the dust from his clothing when Reap appeared. It is said ill feeling had existed between the men. Reap tried to seize the nozzle for his use and Cook objected. Reap snatched the nozzle from Cook and placing it against Cook's body, turned on the full force of the compressed air.

It hurled Cook across the room and he became violently ill, dying in a short time. An autopsy showed that the air had ruptured the intestines in such a manner as to cause hemorrhages and acute inflammation and thus cause death. Recorder Hyde issued a warrant for Reap's arrest.

He was arraigned in Court and entered a plea of not guilty.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

St. Louis, Mo., Aug. 27, 1902.

COMPRESSED AIR, 26 Cortlandt St., N. Y.

Gentlemen: We note in your July issue, page 1915, that F. J. Matchette, proprietor of the St. Charles Hotel, Milwaukee, was the first hotel in the world to install a permanent plant for cleaning by compressed air. This is an error, as this company had installed compressed air plants and cleaned hotels with compressed air and operated in the St. Charles Hotel, Milwaukee, two years prior to this alleged permanent plant. The plant in the St. Charles Hotel is not a permanent plant, and we have a suit pending in the Federal Court against F. J. Matchette's Company for infringement of our patents. We would, therefore, thank you to make a correction of this statement in your next issue.

We are sending you enclosed our illustrated catalog. Yours very truly,

GENERAL COMPRESSED AIR HOUSE CLEANING COMPANY.

J. S. Thurman, V. P. and G. M.

U. S. PATENTS GRANTED JUNE AND JULY, 1902.

Specially prepared for COMPRESSED AIR.

703,127. ELEVATOR. Melancthon Hanford, Malden, Mass. Filed Aug. 29, 1901. Serial No. 73,743.

In combination with an elevator car, air cylinders secured in the upper part of the wellway, free elastically-moving pistons in said air-cylinders, suspended depending safety-ropes attached to said free moving pistons, a clutching device secured to the car for the purpose of grasping the elastically-suspended safety-ropes; an endless rope attached to the clutching device which travels with the car and revolves a speed-governor, the said governor, a brake-wheel, stop-pins in brake-wheel, a brake-wheel friction-band and hooks connected to the brake-wheel band, said brake-wheel friction-band operated by the governor for the purpose of throwing the clutches into action by arresting the movement of the traveling endless rope; all arranged substantially as shown and for the purposes set forth.

703,356. DRY ORE-CONCENTRATOR. Robert E. Waugh and Eugene Waugh, Denver, Col. Filed May 27, 1901. Serial No. 62,-153.

In a dry-ore-concentrator, the combination with a suitable stationary frame, of a vibratory apron-frame constructed to form an air chamber, an endless traveling apron through which the air from the chamber passes, the apron closing said chamber at the top, an auxiliary air chamber arranged in suitable proximity to the main air chamber, means for introducing air under pressure to the auxiliary chamber, and means for vibrating the apron frame.

703,385. PAINTING APPARATUS. Henry D. Carryl, New York, N. Y., assignor to James R. Hay, Nutley, N. J. Filed Aug. 9, 1901. Serial No. 71,433.

In a portable apparatus for painting or cleansing surfaces, the combination of a chamber and a suitable base or stand, a supplemental chamber connected therewith, a receptacle for containing the painting or cleansing material, a pump connected with the principal chamber and arranged to be connected with the receptacle for introducing the material into the chamber in convenient quantities, an independent air-compressor connected with said supplemental chamber by a suitable pipe for causing the air in the chamber to be compressed and the material to flow automatically therefrom, a portable hand-tool arranged to paint or cleanse, a flexible conducting-hose connecting the chamber with the tool, whereby the painting or cleansing material can be introduced into the tool, and a valve in the handle of the tool for controlling the supply of the material to it through the hose.

703,400. FOG-HORN. Ernest A. Gill, Gloucester, Mass. Filed May 24, 1901. Serial No. 61,818.

A fog-horn made up of a casing; a bellows; means to operate said bellows; an air-compressor below said bellows; a horn above

said casing; a reed; and an air-conduit connecting the horn with the air-compressor.

703,419. MEANS FOR DRIVING SHUTTLES OF LOOMS. John Houston, Sunderland, England. Filed Oct. 12, 1900. Serial No. 32,876.

In looms and other textile machinery, a cylinder piston and piston-rod attached to the desired part of the machine and adapted to be operated by compressed air, said piston-rod having a projection for throwing the shuttle, a valve controlling the admission of compressed air to the cylinder aforesaid, a valve-rod carrying said valve and having a roller or wheel attached thereto, a cam carried by an intermediate rod and engaging with the roller or wheel aforesaid, a pivoted lever engaging with the end of said intermediate rod, a projection carried by one of a train of gear-wheels driven from the main shaft and adapted to periodically engage with and operate the pivoted lever aforesaid, substantially as described and for the purpose set forth.

703,480. AIR-BRAKE MECHANISM. William H. Sauvage, Denver, Colo., assignor, by direct and mesne assignments, to the Sauvage Duplex Air Brake Company, Denver, Colo. Filed Feb. 8, 1901. Serial No. 46,573.

703,611. ATOMIZING APPARATUS. John Robertson, Cincinnati, Ohio. Filed Apr. 11, 1898. Serial No. 677,191.

703,637. PNEUMATIC SIGNALING APPARATUS. Joseph H. Brady, Kansas City, Mo. Filed Dec. 26, 1901. Serial No. 87,342.

A pneumatic signaling apparatus comprising an air-storage receiver, separate outgoing distributing-pipes for the compressed air, a detonating fluid signaling device connected with one of said pipes, and a fluid-cylinder upon the end of the other outgoing pipe, a piston and a piston-rod and coacting with the detonating fluid signaling device, and a combined back-pressure relief and cut-off valve in the pipe leading to the cylinder, and a spring extending around the piston-rod, within said cylinder and bearing upon the opposite side of the piston subject to the pressure of the fluid.

703,732. STEAM AND AIR FEEDING APPARATUS FOR BOILER-FURNACES. James Marshall, Dunfermline, Scotland. Filed Dec. 21, 1901. Serial No. 86,813.

703,758. PNEUMATIC RIVETING-TOOL. John W. Birkenstock and Richard W. Funk, New York, N. Y., assignors to the Empire Pneumatic Tool Company, New York, N. Y., a Corporation of New York. Filed Dec. 14, 1901. Serial No. 85,911.

The combination, with a casing provided with supply channels and ports, of a handle at one end of the same, a tool guided in the opposite end of the casing, a piston-valve located at the interior of the casing, said piston-valve being hollow and provided with circumferential grooves and an opening in one of said grooves, a return-channel connecting the rear end of the casing with the front end of the same, a sliding hammer in the casing, a cushioning-spring located between the piston-valve and handle, a channel connecting the interior of the casing with the space behind the valve, and shoulders at the rear end of the casing for arresting the spring and the piston-valve in their forward motion, substantially as set forth.

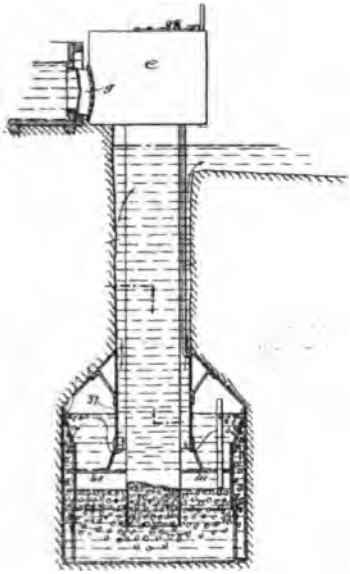
703,855. AIR-VALVE ATTACHMENT FOR TRAPS. Charles A. Tilly, Brooklyn, N. Y. Filed Apr. 2, 1901. Serial No. 54,038.

703,886. AIR AND VACUUM VALVE. Everett P. Allen, Chicago, Ill., assignor, by direct mesne assignment, to R. M. Wilbur, Chicago, Ill. Filed Mar. 25, 1901. Serial No. 52,703.

703,983. BOOT OR HOUSING FOR PNEUMATIC ELEVATORS. Chester Bradford, Indianapolis, Ind. Filed Nov. 19, 1900. Serial No. 37,061.

704,059. HYDRAULIC AIR-COMPRESSOR. William J. Linton Woodstock, Canada, assignor to the Taylor Hydraulic Air Compressing Company, Limited, Montreal, Canada, a Corporation of Canada. Filed Feb. 21, 1900. Serial No. 6,044.

In a hydraulic air-compressor, a pair of subchambers located one above the other, a vertical water-conduit communicating at its lower end with the lower subchamber; a water-passage leading from said lower to said upper subchambers; a water-conduit leading from the upper subchamber to the



overflow of the compressor; an air-pipe leading from the lower to the upper subchamber and air-pipe leading from the upper subchamber to the point of consumption.

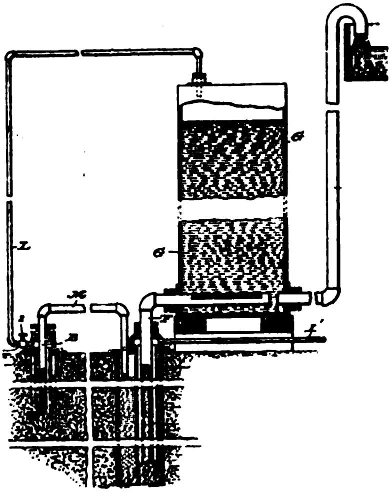
704,098. PNEUMATIC LASTING-MACHINE. Chas. K. Pickles, St. Louis, Mo., assignor to himself, Louis Bry, St. Louis, Mo., and Ike Block, Memphis, Tenn. Filed May 18, 1901. Serial No. 60,844.

704,360. BLOWER AND COMPRESSOR. Christian Neumann, St. Louis, Mo., assignor to the Natural Power Co., St. Louis, Mo. Filed July 3, 1901. Serial No. 66,-960.

704,509. AUTOMATICALLY-INFLATED POLISHING-WHEEL. Isaac P. Cadman, Beloit, Wis. Filed Nov. 11, 1901. Serial No. 81,875.

A pneumatic polishing-wheel having an air-cushioned polishing-surface, a funnel for catching air as the wheel is rotated, an opening communicating between said funnel and the air cushion, and an air-valve in said opening.

704,608. APPARATUS FOR RAISING WATER. George R. Young, Ridgewood, N. J., and Clifford Shaw, New York, N. Y., assignors to the Bacon Air Lift Company, a Corporation of New Jersey. Filed Nov. 23, 1898. Serial No. 697,263.



In combination in a water-raising system, an air-lift well, an uptake therefor, means for aerating the column of water in the uptake to raise it, a separating vessel or tank to which the uptake delivers, a pipe for delivering water from the separating vessel or tank to a higher level without aeration, and means for discharging the air from the separating vessel or tank while maintaining the requisite pressure within the tank, the said separating vessel or tank being of such considerable height vertically as to act as a regulator or compensator as distinguished from a mere separating vessel or tank of height incapable of effecting such regulation or compensation, substantially as set forth.

704,694. SYSTEM OF DISTRIBUTION. John L. Creveling, New York, N. Y. Filed Sept. 11, 1901. Serial No. 75,015

In a system of distribution for railway-trains the combination of a generator and current-utilizing devices and pneumatic device for affording delivery of current to the current-utilizing devices always in the same direction, the said pneumatic devices being actuated by a change in the direction of the pressure in a pneumatic system on the train.

704,737. AIR-BRAKE APPARATUS. Edward P. Donnelly, Boston, Mass. Filed Mar. 5, 1902. Serial No. 96,766.

704,782. AIR-PRESSURE REGULATOR. Joseph H. Dickinson, Detroit, Mich. Filed June 25, 1901. Serial No. 65,946.

An air-pressure regulator comprising a collapsible bellows having an elongated exhaust-port, a valve pivoted at one end adjacent to said port and a connection between the opposite end of said valve and the movable wall of the bellows adapted to cause the gradual closing of said port by the collapsing of the bellows.

704,912. PNEUMATIC IMPACT-TOOL. Samuel Oldham, Philadelphia, Pa. Filed Nov. 4, 1901. Serial No. 80,969.

In a pneumatic impact-tool, a cylinder, a piston or hammer adapted to reciprocate in said cylinder, a housing adapted to close said cylinder at one end thereof, a chamber arranged in said housing transversely to said cylinder, a valve adapted to reciprocate in the chamber of said housing, means adapted to conduct live air or fluid to the interior of said valve and means controlled by the movement of the piston for admitting live air or fluid to the valve-chamber in rear of said valve substantially as and for the purposes described.

705,310. PNEUMATIC CONVEYER. John W. Seifert, Waco, Tex., assignor of one-half to Louise Eikel, Waco, Tex. Filed July 6, 1901. Serial No. 67,299.

705,407. PNEUMATIC STACKER. Edward Huber and Jacob W. Miller, Marion, Ohio. Filed Apr. 12, 1902. Serial No. 102,620.

705,415. AIR-BRAKE ATTACHMENT. Thomas C. Manson, Lake Charles, La., assignor of two-thirds to Charles Smith and Archie Pierce Sale, Lake Charles, La. Filed Feb. 19, 1901. Serial No. 47,961.

705,436. AIR-TOOL. Nino Pecoraro, Spezia, Italy. Filed Aug. 24, 1901. Serial No. 73,181.

In a pneumatic tool, a cylinder, a piston therein, shoulders upon the extremities of said piston, a valve movable on said piston, between said shoulders and provided with ports extending therethrough, inlet-ports in said cylinder, an inlet-passage in said piston leading upwardly therethrough, an inlet-passage therein leading downwardly therethrough, an exhaust-passage in said piston extending to the end thereof and having the ports and an inlet-passage in said piston for enabling said valve to be operated.

705,515. JOINT FOR USE IN PNEUMATIC APPARATUS. Chas. L. Davis, Chicago, Ill., assignor, by direct and mesne assignments, to Engelina Heuer, William H. Heuer, and A. Miller Belfield, Chicago, Ill. Filed Apr. 30, 1900. Serial No. 14,976.

In a pneumatic apparatus, the combination of a metallic pipe having its end provided with a laterally-projecting lip or flange, a support or holder for said pipe, the said support or holder being composed of wood, and the pipe or tube being fitted into the same, so that the lip or flange overlaps the surface of the wood, and a member having a port or passage adapted to form a continuation of the bore of the said pipe or tube, the said member being fitted against the wooden support or holder for the pipe or tube, so that the port or passage in the member registers with the bore of the pipe or tube and also so that the rim of said port or passage abuts against the lip or flange which overlaps the surface of the support or holder, and which thus lies and fits closely between the abutting surfaces of said support and said member, substantially as set forth.

705,585. PNEUMATIC DUST COLLECTOR AND SWEEPER. Jno. T. Hope, Kansas City, Mo. Filed July 20, 1901. Serial No. 69,001.

A pneumatic dust-collector comprising a vehicle, a motor, a suction and blast apparatus upon said vehicle, actuated by said motor, a transversely-extended air-suction and vacuum-forming dust-receiver having a longitudinal opening upon its under side for the entrance of the dust and movable upon the surface of the ground, conductors for the dust connected with said receiver and also connected with the induction-opening to the said suction and blast apparatus having swivel-joints, and aprons hinged to the said receivers, means for vibrating the receiver laterally in position on the side of the vehicle and elevating devices connected with said hinged aprons and adapted to raise and lower said aprons alternately.

705,592. AIR-BRAKE SYSTEM. William G. MacLaughlin, Windsor, Canada, assignor to the MacLaughlin Railway Brake Company, Detroit, Mich., a Corporation of Michigan. Filed May 11, 1901. Serial No. 59,741.

705,757. PNEUMATIC TRACK-SANDER. Edward M. Hedley, Depew, N. Y. Filed Mar. 19, 1902. Serial No. 98,884.

705,830. PNEUMATIC MOTOR FOR CAR FANS AND VENTILATORS. Clarence A. Evans, Upland, Pa. Filed Nov. 24, 1900. Serial No. 37,585.

705,884. INLET FOR PNEUMATIC-DESPATCH TUBES. Fred R. Talsey, Indianapolis, Ind., assignor to the Talsey Pneumatic Service Company, Indianapolis, Ind., a Corporation of Indiana. Filed Oct. 14, 1901. Serial No. 78,558.

Chicago Pneumatic Tool Co.,

General Offices: Fisher Building, Chicago.
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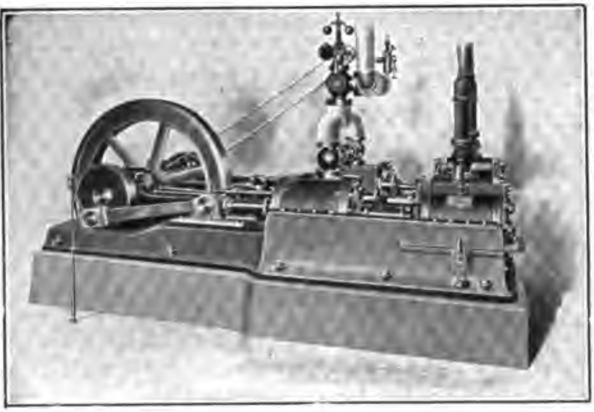

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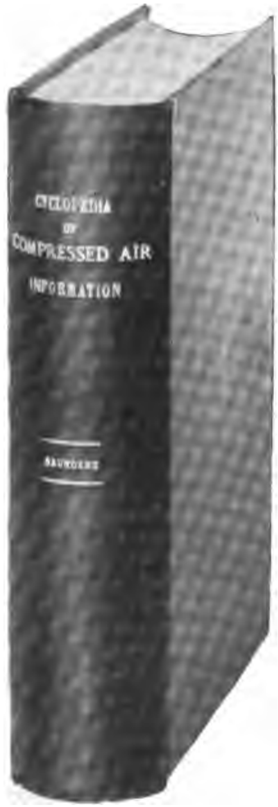
A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, OCTOBER, 1902. No. 8.



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The Use of Low Grade Oil and its Effect upon the Air Discharged from a Compressor.

In the present days of keen competition when work is being done upon a very narrow margin of profit, it has become necessary in every branch of business to economize and reduce to its lowest figure the cost of material and labor necessary to produce the required results.

This condition, with its many advantages over the more or less lax methods of former days, is apt to bias one's judgment in the endeavor to reduce as much as possible the immediate expenditures, with the inevitable results that many times what was thought to be a saving may cause, in the end, a great expense.

This is very aptly shown in the common practice of using a cheap grade of oil for lubricating machinery.

A very interesting phenomenon has recently been brought to light which was entirely due to this cause.

The readers of this paper may remember seeing some time ago a very complete article which described the methods of construction of the Rapid Transit Tunnel now being driven under Boston Harbor, between Boston proper and East Boston. In this work it has been necessary to maintain an air pressure, starting from a few pounds and increasing as the tunnel reached lower levels, until at the present date a pressure of approximately 25 lbs. per sq. in. is required.

As the tunnel increased in length and the accompanying necessity of carrying a higher air pressure, it was found that the air became more and more impure, until the conditions became so serious as to appreciably affect the working capacity of the men, making them drowsy and greatly affecting their endurance.

Tests taken at the time of the air in the tunnel showed a very large proportion of carbon dioxide. Every means that could be thought of was employed, with no appreciable results, in an endeavor to overcome this difficulty. Lime was placed around the floor of the tunnel to absorb the CO_2. The intake air pipes to the compressors were led without the station and a practicable means of artificially supplying oxygen was being contemplated, but, fortunately, before this had been undertaken, the trouble was practically remedied in a very simple manner.

Here it may be advisable to explain of what this plant consists. Besides the necessary boilers, etc., there is one 20 in. and 18¼ in. and 12¼ in. by 12 in. Class "A" Compound Steam Driven Air Compressor, which delivers air at 120 lbs. pressure to the winding engine that is placed within the tunnel and used to draw up the loaded cars. The exhaust of the engine is led into the side wall drifts. Besides this high-pressure machine there are three low pressure compressors, discharging into the main supply pipe which leads to the face of the tunnel.

What greatly perplexed the engineers was the fact that an analysis made of the air when taken near the discharge pipe from the machine seemed to contain a greater percentage of CO_2 than tests made of air from other parts of the tunnel. This led to the thorough washing out of all the compressors with soap suds, in order to clean them of all oily deposits; after which an analysis showed the remarkable drop of over 20 per cent. of the CO_2, a high-grade, non-oxidizing oil being used.

Upon investigation it appeared that a cheap oil had been used for some time, with the natural consequence that with the high temperature of the compressed air a continuous oxidation or slow combustion was going on and the products of combustion, of course, were discharged with the air, making it almost inadequate to support life.

Machinery Department at the Düsseldorf Exposition.

On visiting this exhibition one is immediately impressed with the extensive scale on which the exhibits of many firms are carried out, and which could not have been made for the sole idea of advertising those particular companies, but with the idea of impressing the world at large with the resources for manufacture in the German Empire, and more particularly in the province of Rheinland and Westfalen. For instance, Frederick Krupp has his own building, in which is exhibited a complete propeller shaft for a large warship—battleship turrets, ship frames, many guns for marine and land service, with the projectile cartridges, etc., pertaining to each. A large exhibit of armor plate is also made, both new and tested; in fact, the exhibit sets out in an impressive way the vastness of his line of manufacture.

The "Bochumer Verein" and others have also exhibited in the same way, but one is still more strongly impressed by the spirit of "Germany for ever," when visiting the machinery halls, where the co-operation of the manufacturer and the mine owner is exemplified. Under the Harpner Bergbau A. G. exhibit, Hanel & Lueg, have a large pumping engine with triple expansion steam cylinders erected. This machine has the following sizes of cylinder (as given in an outlined drawing on the wall):

H. P. steam..........	950 mm.	(37.2")
Interm. steam	1500 mm.	(59.0")
2 L. P. steam	1650 mm.	(65.0")
Stroke	1700 mm.	(67.0")
R. P. M.............	60	

Capacity, 25,000 litres (6600 gallons) per minute from a depth of 500 metres (1650 ft.).

Under the exhibit of the same mining company, and built by Eisenhütte Prinz Rudolph, is a vertical compound hoisting engine equipped with conical drums.

The H. P. cyl. is 820 mm. diameter (32.3"); the L. P. cyl. is 1150 mm., diameter (45.5"); the stroke is 2600 mm., diameter (102.0").

This engine is capable of raising a net load of 4400 kg. (9700 lbs.) from a depth of 1200 metres (4000 ft.). In connection with this hoisting engine is erected a steel tipple with an exhibit of cages, cars, etc.

The steam engine exhibits are extensive and comprise many large engines, but one of the most striking features of the machinery is the evident high development of the gas engine for utilizing the waste furnace gases. Under this could be mentioned the following

"Gasmotorenfabrik Deutz" have a 1,200 H. P. engine connected to blowing cylinders. (The engine is duplex with two gas cylinders on a side and the two blowing engine cylinders parallel to the others are connected by extending the crank shaft, direct.)

A 350 H. P. gas engine is exhibited by Louis Soest & Co., m. b. H. This company advertises the engine as capable of developing 300 to 350 H. P., with waste furnace gases and 350 to 400 H. P. with generator gas. The machine was operating lightly loaded.

Next to the above is a 700 H. P. engine built by Gebr. Klein. This engine is connected to a set of rolling mill rolls through rope drive. The exceptional feature of this engine is that its explosion cylinder is double acting, one end being fitted with a stuffing box. The cylinder is 750 mm. (29.5") diameter and has a stroke of 1,300 mm. (51.0"). Rated speed is 85 to 90 R. P. M.

Next in order comes another gas engine of the same power connected directly in a straight line to a blowing cylinder 1840 mm. (72.5") diameter. The common stroke is 950 mm. (37.4"). Revolutions, 100 p. m.

There were other exhibitors in this line, but not so important.

PRINCIPAL EXHIBITORS OF PERCUSSIVE ROCK DRILLS.

Rudolf Meyer:

One drill mounted on single screw column as a coal cutter, but with lever instead of Eisenbeis sector.

Two medium size drills mounted on columns.

One small drill on column.

One drill wagon complete with four large drills.

In this drill exhibit is an electrically driven air compressor mounted on a narrow gauge truck with the air receiver on a separate truck. Compressor capacity about 90 cu. ft.

One puncher coal cutter is also exhibited with the above. It has every appearance of being a new production on the general lines of Ingersoll-Sergeant and other cutters of this type.

Frölich & Klüpfel:

Two drills, medium size, mounted on column.

One drill, medium size, mounted on tripod.

One drill, mounted on column as a coal cutter with a lever instead of sector.

H. Schwarz & Co.:

Two medium sized drills on column.

F. A. Münzner:

Two drills mounted as coal machines with sectors.

Paul Hoffman & Co.:

Two medium sized drills mounted on one column.

One medium sized drill mounted on tripod.

One small drill mounted on shaft bar.

P. W. Dinnendahl:

One medium sized and one small drill mounted on one column.

Heinrich Korfmann:

One medium sized drill on column.

One drill, mounted as coal cutter with lever (no sector).

Duisburg Maschinen-Fabrik:

Two medium sized drills on shaft bar.

One medium sized drill on tripod.

Two medium sized drills on columns with arms.

Two medium sized drills on columns, one as coal cutter with lever, one as drill, sector shown separately.

One drill as coal cutter with sector.

Siemens & Halske—Electric:

One drill on tripod.

One drill on column.

Union (Marvin Drill)—Electric:

One drill in water tank shown in operation under water.

One drill on tripod.

Two drills on columns.

Gebrüder Sulzer:

One drill wagon with the usual hydraulic horizontal column and two Brandt hydraulic rotary drills mounted on it.

All of the above are in one drill hall where stone is delivered and many of the machines are shown in operation each afternoon.

Where the terms "medium size drill" has been used above, it refers to a drill corresponding in size to Ingersoll-Sergeant C or D; "small drills" to their baby, "large drill" to their F.

The coal cutter drills would come under the medium size.

The above exhibits are all in the special hall for rock drills, while Flottman & Co. have their exhibit in the main machinery hall in connection with an air compressor exhibit by Gebr. Meer. They have four or five drills mounted on one long column and also one "E" drill (80 mm.) mounted on a tripod. This "E" drill is allowed to operate by pounding with a stub steel on an iron block, the same as usually done in factory drill testing.

AIR COMPRESSORS.

The exhibit in this class of machinery is the strongest evidence that the German manufacturers are thoroughly aware of its importance and that they intend to place themselves in a position to meet the ever-increasing demand.

In looking over the compressors exhibited one might easily gain the idea that the German standard and aim was based on the following qualification and in the order given:

1. Noiseless operation.
2. Efficiency of operation.
3. Fine finish and appearance.

While these are given in order they should all be placed as first considerations as they are evidently so closely allied in the German mind.

In all the compressors exhibited it is hard to find one that makes more noise than the ordinary steam engine; all with one or two exceptions have planished steel jackets around the air cylinders with the water connections made from the bottom of the cylinder, so that the pipe connections are practically invisible to the ordinary observer. All oiling systems can properly be called "systems," as they consist of pump arrangement with pipe lines running to all the different parts.

PRINCIPAL EXHIBITORS IN THE AIR COMPRESSOR SECTION.

Schüchtermann & Kremer, Dortmund:

One duplex double compound horizontal compressor of about 400 to 600 H. P. engine fitted with the drop cut-off poppet valve and the air cylinders with the Collmann "Oelkatrakt" poppet valve.

Rudolph Meyer, Mülheim:

One high duty duplex horizontal compressor with compound steam engine of the poppet valve type and compound air cylinders fitted with his newly patented "Plattenringventil." These valves are placed one at each end of the cylinder, top and bottom, for discharge and inlet respectively, so that the air cylinders present a very simple (uncomplicated) appearance. This compressor is for about 350 H. P. and works very smoothly. Ninety-eight per cent. vol. eff. is advertised.

Neumann & Esser, Aachen:

One horizontal double compound air compressor of about 200 H. P. in size. The air cylinders of this compressor were so thoroughly enclosed with planished steel that one could not ascertain what valve system was used.

Pokorny & Wittekind, Frankfort a/M.

These people have two medium large compressors exhibited. One horizontal half duplex compressor with tandem compound steam cylinders, which are also tandem to the one air cylinder which is for low pressure air on one end and high pressure on the other, the general principle being the same as our compound single-acting class "E's," but more compact. The capacity of this compressor was stated as 1,800 cu. mtrs. per hour, or say 1,000 cu. ft. per minute to 6 atm.

One vertical compressor having compound steam cylinder and two air cylinders (each compound) and for a rated capacity 3,500 cu. ft. was exhibited.

Th. Calow & Co., Bielefeld:

These people had a very neat looking horizontal double compound compressor exhibited and of about 1,000 cu. ft. capacity. The valve motion on the high pressure steam cylinder was of the Rider type.

The air cylinders were fitted with the Patent Strand system of valves, which is a Corliss intake with the popet discharge, these *discharge valves being set in the Corliss intake valve itself,* similar to Nordberg's American system.

Stahl & Eisen A. G.
Vormals Julius Soeding, Hoerde, i. W.

One horizontal double compound air compressor of about 150 H. P. capacity. This machine was fitted with Riedler air valves and the Stumpf system of drop cut-off poppet steam valves.

Gebr. Meer:

One horizontal double compound air compressor of 150 H. P., with poppet steam valves and a "Lenker Ventil" air cylinder.

There were several other compressors exhibited, but not so extensively, namely:

From Maschinenbau-Anstalt Humboldt, Kalk, a-Rh.

From Frölich & Klüpfel.

From Paul Hoffman.

From Jul. Soeding & Co., Heyde.

H. L. Terwilliger.

Compressed Air Haulage.*

A COMPARISON OF THE SEVERAL FORMS OF MOTOR HAULAGE—THE PARTICULAR ADVANTAGES OF COMPRESSED AIR FOR MINE WORK.

For underground haulage in large mines there is a choice of four methods: by mules or horses, or locomotives operated by steam, electricity, or compressed air.

Animal power, the most costly of the four, is often employed, to a limited extent, in collieries and elsewhere, in connection with one or other of the systems of locomotive haulage, for making up trains and handling the individual cars in and out of the mine workings. Steam locomotives for underground service are rarely used except in collieries, and then only for long hauls, where the trains are conveyed through tunnels or entries directly to the surface. Haulage by steam

* Written for *"Mines and Minerals,"* by Robert Peele.

locomotives is rendered practicable in collieries chiefly by the fact that the fuel is a product of the mines themselves, and is therefore chargeable at a low cost. Their principal disadvantage lies in the serious vitiation of the mine atmosphere, and interference with ventilation, caused by the discharge into the workings of smoke and gases of combustion. Obviously steam locomotives cannot be used in the presence of fire damp.

Locomotives propelled by electricity or compressed air divide between them a much wider field of operation. Both are applicable to mines of all kinds, whether collieries or metal mines; for either long or short hauls, from a few hundred feet to several miles; they may be employed underground in shaft mines where cars cannot be brought in trains through a tunnel to the surface, but must be hoisted on cages; and they do not vitiate the mine atmosphere, nor influence the direction of the ventilating currents.

Comparing compressed air and electric haulage, and omitting questions of cost of plant, there are three advantages possessed by compressed air: First, it may be used in collieries with perfect safety in an atmosphere charged with fire damp*; second, since the power is stored in the locomotive itself the compressed-air system of haulage is more flexible. The locomotives can enter all parts of the workings, wherever track is laid, far beyond the limit of the supply-pipe line, and are not, like electric locomotives, dependent upon wiring, which must accompany every foot of advance; third, it costs little or nothing when not in actual use, and its full power or but a fraction of it are equally available at all times. During the unavoidable periods of idleness of the locomotives no power is lost, because, although the compressor may continue in operation, it is engaged only in storing up power in the receiver and pipe line. It may be mentioned, also, that the exhaust of the compressed air locomotive discharges pure air into the workings, thus improving rather than injuring the ventilation. This, however, is a minor consideration. Both electricity and compressed air must be looked upon merely as transmitters and distributors of power, depending for their production upon either steam or water-power as a prime mover.

*While it is true that recent improvements in electric motors have done much to prevent the occurrence of serious sparking, it cannot be denied that some risk from this cause still exists, and, moreover, the possibility of sparking from a ruptured conductor can hardly be averted.

Arrangement of the System.—The essential parts comprised in the installation are: the air compressor, pipe line, charging stations and locomotives. The capacity of the system naturally depends upon the size and character of the mine and the output desired. Formerly it was customary, for mines worked through tunnels, to omit the pipe line altogether, and to charge the locomotive at intervals from a large receiver outside, near the compressor. At present, however, the pipe line is nearly always carried underground, and at one or more points charging stations are established. The location and distance apart of these stations is determined by the requisite length of haul and the storage capacity of the air reservoirs or tanks carried by the locomotives. It is evident that the last, or innermost, charging station must be at a point from which the locomotive can reach the end of its trip and return for a fresh supply of compressed air.

It is not necessary to provide receivers inside the mine for charging the locomotives, though this may be done if desired. The pipe line itself acts as a storage reservoir, and must be of a diameter which, in proportion to its length, will furnish a cubic capacity sufficient to charge the locomotive tank quickly without serious loss of pressure. In other words, when the locomotive is connected with the pipe line, and the charging valve opened, the pressure in the locomotive tank and in the pipe, on equalizing, should not fall much below the stated pressure which the locomotive is intended to carry. With this end in view, it is desirable that the volume of storage in the main (or main and receiver) should be at least double the reservoir capacity of the locomotive. When several locomotives are served by the same pipe line, it is rarely necessary for mine work to design the system for charging more than one at a time. The relatively slight drop in gauge pressure after charging is soon recovered by the compressor, which, excepting in some small plants operating a single locomotive, is kept in nearly constant operation. In case additional locomotives are required after the installation of the system, the same pipe line may still serve, provided the compressor is of sufficient size to charge it to full pressure at shorter intervals. The piping, which generally varies in diameter between 3 and 5 inches, should be of the best material, with sleeve joints made with the utmost care to prevent leakage. It is advisable not to bury the pipe alongside the track, but to carry it entirely uncovered along one side of the tunnel or gangway, either on the floor or on brackets, so that leaks will at once attract attention and be stopped.

The charging apparatus for the locomotives consists of a short right-angled connection inserted in the air main by means of a heavy tee, Fig. 1. This connection projects from the main a sufficient distance for conveniently coupling to the charging pipe of the locomotive. It consists of two parts, as shown in the cut: a vertical, rigid branch, containing a strong, accurately fitted 1½-inch gate valve, and a short horizontal pipe, attached to the rigid

comotive must first be released. This is done by opening a small "bleeder valve," placed just above the gate valve. The joints then become loose and are readily manipulated. The time occupied in charging is very short (usually only a fraction of a minute), owing to the high pressure in the main and the relatively large diameter (1½ inches) of the charging pipe.

Construction and operation of the locomotive.—For mine service, compressed-air locomotives carry either one or two cylindrical tanks for storing the air. These tanks, with the cylinders, piping, and other appurtenances, are mounted on a frame provided with springs similar to those of a steam locomotive, and supported by four or six driving wheels. Where there are sharp curves in the track,

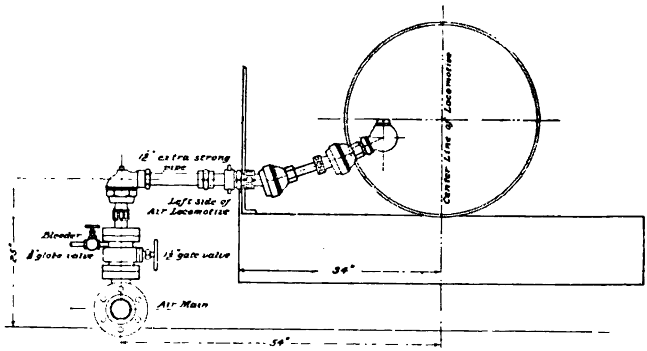

FIG. 1.—AIR CONNECTION FOR CHARGING LOCOMOTIVE.

upright by means of a ball-and-socket or flexible joint. The movable section is thus capable of being swung back out of the way when not in use. By an easily manipulated union it is coupled to the locomotive charging pipe. In the locomotive connection are two ball-and-socket joints, together with a check valve close to the tank. After coupling on the locomotive at the charging station, the gate valve is opened, whereupon the air pressure immediately forces together the parts of the ball-and-socket joints and makes a perfectly tight connection. As soon as equilibrium is established between the pressure in the air main and that in the locomotive tank the valve is closed. To break the coupling the compressed air remaining in the connection between the gate valve and the check valve on the lo-

the wheel base must be short, but for curves of longer radius large locomotives often have six wheels. The height over all of the locomotive depends somewhat upon the conditions existing in the mine, as to thickness of vein, head room of the haulageways, etc., and is rarely more than 5 feet. The length varies greatly, mainly according to the capacity required, and the degree of curvature of the gangways. The tanks are cylindrical, with dished or approximately hemispherical ends, and are built of extra heavy steel plate, say ⅞ of an inch think. They are generally constructed to carry a working pressure of from 500 to 700 pounds per square inch, though it is customary to test them to 800 or 1,000 pounds. When extremely high pressures are required, tanks of large diameter cannot safely be employed, and are replaced by a series of heavy steel tubes—for example, Mannesmann seamless tubes. Tubes of this kind, 9 inches in diameter and 11-32 of an inch thick, will carry working pressures of 2,000 to 2,500 pounds per square inch. A number of them are laid closely in a group, parallel to one another, and bound together by belts or straps. They are then inclosed in a light sheet-iron shell to protect them from wet and rust. Such high pressures are unnecessary for ordinary systems of mine haulage.

From the tanks the air passes into a small auxiliary or distributing reservoir, and thence to the cylinders. This reservoir is merely a section of 8-inch or 9-inch wrought-iron pipe, say 10 feet long, with closed ends, and is laid alongside the main tank. By means of an automatic reducing valve the pressure in the auxiliary reservoir is adjusted to the requirements of the engines. The cylinder pressure adopted generally ranges from 125 to 150 pounds per square inch, or say one-quarter of the pressure in the main tank. From the auxiliary reservoir the air passes through a balanced throttle valve to the cylinders. This arrangement permits the maintenance of a constant working pressure, prevents the waste of air which would be likely to ensue if air at full tank pressure were admitted to the cylinders, and makes the locomotive more manageable. The cylinders, moreover, need not be made so heavy as would be required for the high pressure. In starting a heavy load, excessive slipping of the drivers is avoided, and with light loads the reducing valve may be readily and quickly regulated to produce any required diminution of pressure in the auxiliary reservoir. For small scale mine work the air is sometimes admitted to the cylinders throughout nearly full stroke, and consequently, as the exhaust is at a high pressure, the efficiency is lower than it should be. This practice is doubtless due to the tendency to use as small a motor as possible for the service required, on account of the limited head room and narrow, crooked gangways so common in mines. Better economic results are obtainable, however, by using a cut-off and increasing the size of the locomotive and the weight on the drivers. This is most always done with large locomotives. Ample reserve power is available when necessary, since full tank pressure can be admitted to the cylinders in starting a heavy load, or in pulling on steep grades and sharp curves. In using the air expansively, as can be done with properly proportioned cylinders, there should be no trouble from freezing of the moisture. Although the cold developed will produce a low cylinder temperature, yet, as the initial working pressure is so much higher than is employed for pumps and other compressed-air machinery, the expanded air becomes relatively dry,† and the force of the exhaust would still be sufficient to keep the ports clear of accumulated ice. To this end the exhaust ports should be large, straight and short. If the high-pressure air from the main tank were used in the engines, both pistons and cylinders would have to be made excessively heavy, and any reasonable degree of expansion would produce a degree of cold difficult to deal with.

To calculate the motive power required, several factors must be known, viz., the tractive resistance of the loaded cars per ton on a level, the resistances due to gradients and curves, the weights of empty and of loaded cars, and the number of cars to be hauled in each train. The values of all these factors are known approximately or easily ascertained, with the exception of the resistance due to curvature of track. The latter has been determined experimentally for ordinary surface railways, but underground mine track is apt to be roughly laid, with curves of varying or irregular radius, and the elevation of the outer rail improperly adjusted. With sufficient weight on the drivers, however, sticking on a curve may be avoided by temporarily admitting air at full tank pressure, as noted above. In this respect compressed-air locomotives possess a material advantage over those driven by steam, in which the working pressure is practically constant. The average tractive force required per ton depends not only upon the condition of the track and roadbed, but upon the character and condition of the running gear of the cars. On level mine track it should usually be taken at from 30 to 40 pounds per ton, though the resistance may be considerably higher than this in starting the load. With track in exceptionally good condition, the tractive force may be as low as 20 pounds per ton. The grade resistance is 20 pounds per short ton, for

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† In this connection reference may be made to an article by the writer in MINES AND MINERALS, April, 1902, page 411.

each 1 per cent. of grade. Colliery cars carrying $2\frac{1}{2}$ to $3\frac{1}{2}$ tons will weigh from 1,800 to 2,300 pounds, while those used in metal mines, where mechanical haulage is employed, vary between say 1,000 and 2,000 pounds. Many cars of the last named weight are in use in the iron mines of the Northwest.

With a given air pressure the capacity required for the locomotive storage tanks depends primarily upon the length of the round trip to be made with a single charge of air. When this distance is from, say, 1 to $1\frac{1}{2}$ miles, the tank capacity generally varies between 50 and 150 cubic feet, according to the load, which, in turn, together with the track and grade resistances already referred to, governs the dimensions of the cylinders. Cylinders of 5 in. by 10 in. up to 9 in. by 14 in. are commonly used for mine service, the larger sizes being adapted for heavy work in collieries. Still more powerful locomotives are used for some kinds of surface work. In several installations, since 1897, at mines of the Philadelphia & Reading Coal and Iron Company, the compressed-air locomotives have been provided with compound cylinders. For long runs, of over $1\frac{1}{2}$ miles, it is often desirable to increase the air pressure, rather than build tanks of very large size. Another plan, however, is to supply a tender which carries one or more additional tanks. Very long runs can be made in this way.

On account of the cold produced by the reduction of pressure from the main tank to the auxiliary tank, and to increase the efficiency of operation, reheating is found to be advantageous, though not essential. It may be accomplished conveniently by applying heat to the auxiliary reservoir. If steam be available a quantity may be injected into this reservoir each time the locomotive is charged. Or, in mines where there is no danger from fire damp a small reheating apparatus for burning oil or coke may be carried on the locomotive. When reheating is adopted, a quantity of water should be kept in the auxiliary reservoir. An incidental advantage of this arrangement is that the moisture from the hot water, which passes with the air into the cylinders, assists in lubricating the valves and pistons. The cylinders should not be lagged with non-conducting covering, as is so necessary for steam cylinders to minimize condensation. By exposing the surface of the cold cylinders to the warm air of the mine, some heat is absorbed and added energy is imparted to the compressed air. Sometimes the exterior surface of the cylinders is cast with corrugations, in order to present the largest possible surface to the warm surrounding air of the mine.

Compressors for Haulage Plants.—For compressing the air to the high tension required by compressed-air locomotives, the work must be done in at least three stages, and four-stage machines are sometimes employed.‡

When the mine is already provided with an ordinary low-pressure plant, for operating machine drills, etc., and which has some surplus capacity, a two-stage compressor may be installed, to take air from the low-pressure system and bring it up to the tension required for the locomotives. But, while some reduction in the cost of the plant may thus be effected, care must be exercised in making such a combination. If the quantity of air produced by the low-pressure system should at times be insufficient to furnish the necessary excess, at ordinary gauge pressure, for the locomotive charging compressor, the latter might be compelled to compress from too low an initial pressure. This would cause excessive development of heat, and, aside from the difficulty of maintaining proper lubrication, might possibly raise the cylinder temperature to the flashing point of the oil and cause an explosion.

It is always preferable to install an independent three-stage compressor for the haulage service. With such a compressor the final temperature can be kept down to a moderate degree—say 200 degrees to 300 degrees F.—provided the plant is not too small for its work. Moreover, as the demand upon it is somewhat irregular, with frequent reductions of speed, and even stoppages, the air cylinders are prevented from being overheated. Intercoolers are, of course, placed between the successive cylinders to cool the air as thoroughly as possible between stages of compression.

Examples of Compressed-Air Haulage Plants for Mines.—In illustration of the preceding notes, some of the details of a few successful installations may here be given:

‡ Notes on the theory and operation of stage compression were given by the writer in MINES AND MINERALS, January, 1910. It would be inappropriate here to enter into further discussion of the subject.

1. At the Empire Gold Mine, Grass Valley, Cal., in 1898, a small air locomotive was put on the 2,000-foot level, for hauling five cars, each carrying 1 ton, Fig. 3. The distance traveled in a round trip is 5,000 feet, the tank measuring about 36 inches diameter by 48 inches long, and carrying a pressure of 500 pounds per square inch. The dimensions over all are only 5 feet long by 30 inches wide by 4 feet 4 inches high, the gauge of track being 18 inches. Instead of ordinary engines, a pair of Dake rectangular piston engines are used. They are very simple and compact, with no dead centre, and have no exposed parts liable to be broken. As the haulageways of many mines are wet and muddy, there is an obvious advantage in having the moving parts of the driving engine inclosed. The locomotive was built by Edward A. Rix, of San Francisco. Another of his air motors for the same mine has two tandem tanks, on separate trucks, and is provided with a reheater, operated by a Primus kerosene burner.

2. The Peerless Colliery, Vivian, West Va., has two air locomotives built by H. K. Porter & Co., which have been running satisfactorily since 1896, Fig. 2. They measure 10 feet 5½ inches long by 5 feet 8 inches wide by 4 feet 5 inches high; have four driving wheels 23 inches in diameter, gauge 44 inches, and weigh 10,000 pounds. The main storage tank has 47 cubic feet capacity, carrying a pressure of 535 pounds; cylinders, 5 in. by 10 in.; charging time, 20 seconds. The working pressure in the auxiliary reservoir is 125 pounds. The main pipe line is 3 inches in diameter, with a total capacity of the locomotive tank. It carries a pressure of 715 pounds. The trains consist of six cars, each weighing, loaded, 8,500 pounds. Grades range from level to 2½ per cent., most of them being in favor of the load. The curves from the entries into the "rooms" are of 23 feet radius, though the locomotives are designed to work on curves as sharp as 15 feet radius; 16-pound rails are used; length of maximum round trip, 9,000 feet; maximum speed, 10 to 12 miles per hour. These locomotives make mule haulage unnecessary, as they can enter the rooms or breasts to bring out single cars for making up trains. Cost of each locomotive, $1,800.

3. At the Wilson Colliery of the Delaware and Hudson Coal Company, a large air locomotive was installed in 1897 by the Dickson Manufacturing Company. It has three pairs of 26-inch connected drivers; gauge, 30 inches; wheel base, 7 feet; cylinders, 9 in. by 14 in. There are two tanks, 30 inches diameter by 18 feet 6 inches, and 15 feet 6 inches long, respectively, having a total capacity of 160 cubic feet, and carrying a pressure of 600 pounds. The 3-foot space at the end of the shorter tank allows room for the operator, and as the cylinders are placed at this end, the connections are short. The pipe line, 4,100 feet long, carries a pressure of 700 pounds, and the ratio of its capacity to that of the locomotive tanks is 7 to 1. A charging station is placed at each end of the line; time required for charging, 1 minute 25 seconds. An equalizing pipe between the tanks is provided with a valve for shutting off either tank if desired. Below the main tank is the auxiliary reservoir, in which the pressure is reduced to 125 pounds. Reheating is employed. The trains regularly hauled consist of 30 cars, each weighing, loaded, 5,850 pounds, though the locomotive has a capacity of 50 cars. The grades vary from 9 inches per 100 feet against the load, to 12 inches per 100 feet in favor of the load. Total time for the round trip of 8,200 feet, together with a switching distance of 800

FIG. 2.—H. K. PORTER LOCOMOTIVE.

feet, is 16 minutes. It is said that the haulage cost, per ton mile, is 1¼ cents.

4. In *Mines and Minerals*, September, 1899, a description was given of a Vauclain compound air locomotive, built by the Baldwin Locomotive Works, and installed at the Alaska Colliery of the Philadelphia and Reading Coal and Iron Company. A test gave the following results: An average of 26 empty cars, weighing 7,600 pounds, were hauled up an average grade of 1¼ per cent., 2,400 feet long, with 49.4 average indicated horsepower, and an air consumption of 114 cubic feet, at 200 pounds pressure. The compressor furnished this air at 750 pounds, with an expenditure of 95 horsepower, the efficiency being thus 50 per cent.

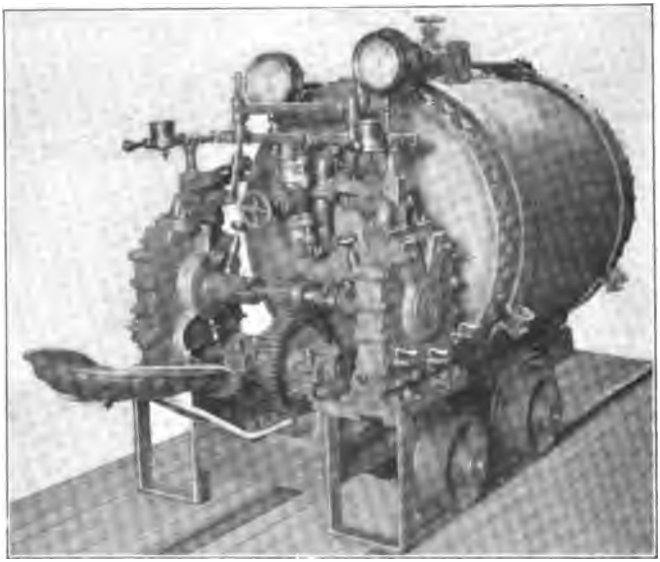


FIG. 3.—RIX COMPRESSED AIR LOCOMOTIVE.

5. The Anaconda Copper Mine, Montana, is provided with air locomotives having the following dimensions: height, 58 inches; width, 58 inches; length from end to end of bumpers, 10 feet 4½ inches; four driving wheels, 23 inches in diameter; 3-foot wheel base, designed to run on curves of only 12 feet radius; gauge, 18 inches; cylinders, 5 in. by 10 in.; pressure in main tank, 550 pounds; in auxiliary tank, 125 pounds; capacity of main tank, 47 cubic feet; total weight, 10,000 pounds; charging time, 60 seconds. Length of haul, 1,200 feet (2,400 feet round trip); load six cars, weighing empty, 950 pounds, and loaded 3,450 pounds, each; track nearly level. The locomotive is built to make two round trips, or 4,800 feet, with cold air, without recharging, but it is found that by reheating with hot water, three or four round trips per charge can be made. This group of mines has now nine compressed-air locomotives.

Few records are available as to costs of haulage by compressed-air motors. In this connection, however, the reader is referred to a valuable article on the "Compressed-Air Haulage Plant at No. 6 Colliery of the Susquehanna Coal Company, Glen Lyon, Pa.," published in the Transactions American Institute Mining Engineers, Vol. 30, page 566*. Many useful data are given, including detailed comparative costs of mule and air haulage, showing for the former, 5 1-3 cents per net ton mile, as against 1.9 cents for the latter, during a period of 179 days. On the basis of 300 days' work per year, it was estimated that the cost of the compressed-air haulage would be reduced to about 1 cent per net ton mile.

*An illustrated description of the plant was printed in the Colliery Engineer and Metal Miner, May 1896.

Compressed Air and Air Compressors.

BY OTTO LUHR.

Compressed air is coming into use more and more every day and in some establishments has come to be as valuable as steam or electricity. A boiler shop or a machine shop without compressed air is now-a-days considered out of date.

Compressed air is used for various purposes. It is used to drive riveting hammers, chisels, drills, and hoists. It is used for cleaning purposes, such as carpet cleaning, also for cleaning the seats in railroad cars. Cleaning by compressed air requires less than one-tenth the time, and is more efficient than the old way with a stick and brush. Compressed air is used for driving machinery at a long distance from the boiler room with much greater efficiency than could be done by direct steam. It is used for drying purposes, for pumping water or oil from wells of great depth, for cleaning boiler flues, for purifying water and many other purposes.

While compressed air is very valuable for so many business branches, it is, like all other power sources, likely to be very costly and troublesome if not understood. On the other hand, it can be made very economical if properly installed and operated.

The pipe arrangement through which the compressed air is to flow is in many cases unnecessarily complicated, and great friction is liable to be created which results in a serious loss of power. The greater the velocity of the flowing air, the greater the friction. The velocity should never exceed 20 feet per second. One elbow offers as much friction to compressed air as 20 feet of straight pipe. From this it follows that the pipe should not be taken too small, and that all unnecessary short bends should be avoided, which rules are frequently neglected.

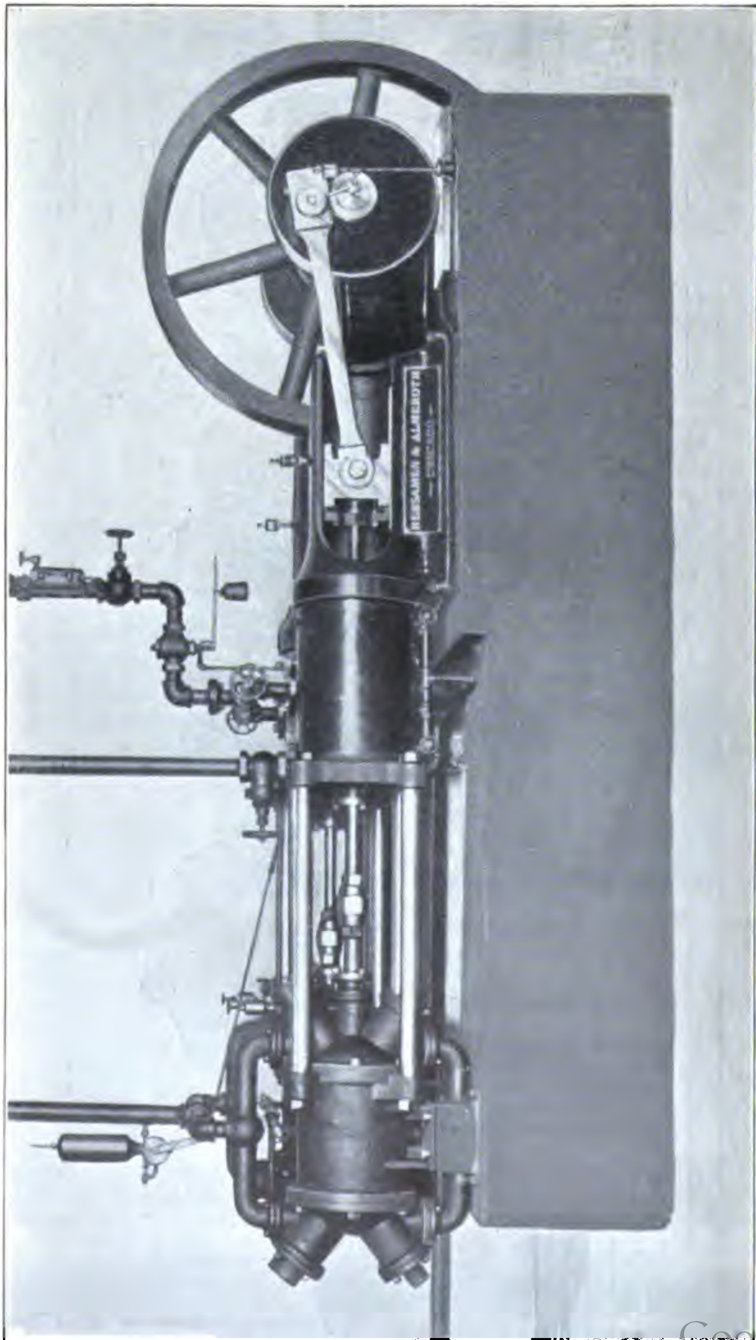
It is also a remarkable fact that so many people buy the weakest, smallest and cheapest compressors in the market, and then expect the hardest work from a machine of that kind. With a cheap machine, trouble is of a daily occurrence. Many people after some such experience, are apt to say there is nothing in compressed air, it is a failure, because they do not understand and do not care to learn.

In many plants the wrong kind of compressor is installed. There is no necessity of buying an air compressor with a separate steam cylinder when there is a power engine running at all times for other purposes. The air compressor should in this case be of the belted type, especially if the power engine is of the automatic cut-off type and able to produce a horse power per hour with thirty pounds of steam. If the compressor, however, has a separate steam cylinder of the usual slide-valve type, it will use nearly fifty pounds of steam, and in many cases more per horse power per hour. If the air, which the compressor furnishes, is not all used, a very simple releasing device can be attached to the compressor, which prevents the suction valves from closing, or the releasing device may be made to close a valve on the inlet pipe automatically if no more air is needed. A compressor so equipped furnishes no more air than is required, and consequently uses no unnecessary power with the exception of the friction of the compressor.

There is, however, a more economical and simple way to regulate the amount of air for a belted or otherwise driven compressor, if the air pressure to be carried is nearly equal to, or in excess of, the pressure of steam carried in the boiler. If nearly equal, a connection from the discharge pipe of the air compressor may be led into the steam space of the boiler with a check valve closing towards the compressor. If the air pressure to be carried, however, is in excess of the boiler pressure, then a simple reducing valve should be placed between the check valve and the air compressor. The excessive amount of air will then enter the steam boiler and become very valuable, for it produces the same power as the steam when doing work, with the advantage of lessening the condensation of the steam with which it is in contact. This has, to my knowledge, never been practiced, but I have no doubt that it will prove of great economy.

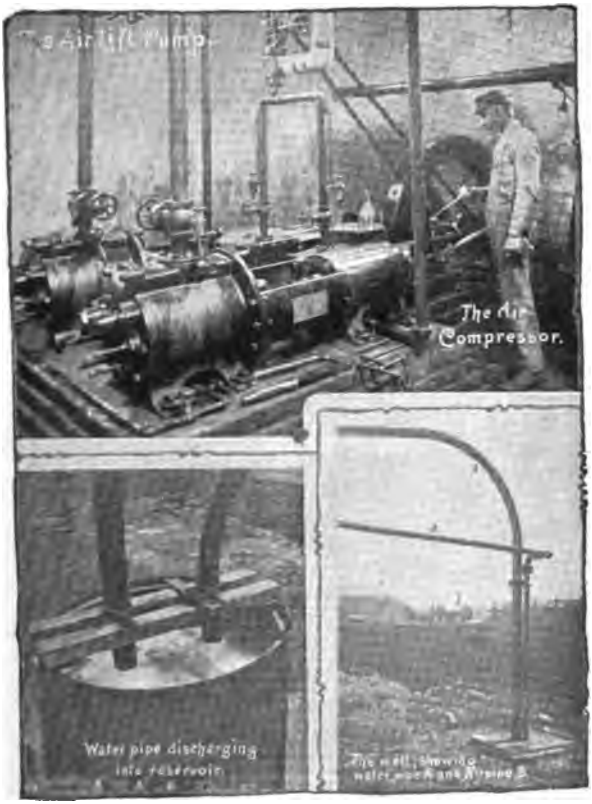
If the air is used for driving machinery I would, furthermore, make a new suggestion, which must be of great benefit, viz., that the compressed air be led through a series of coils placed in the bridging so that the hot flue gases heat the air to nearly the temperature at which they leave the boiler. This has the advantage of increasing the volume of the air considerably without cost, and prevents the freezing up of the exhaust pipe of the air driven machines, which is caused by the sudden expansion of the compressed air cooled under pressure.

It should be borne in mind that air,



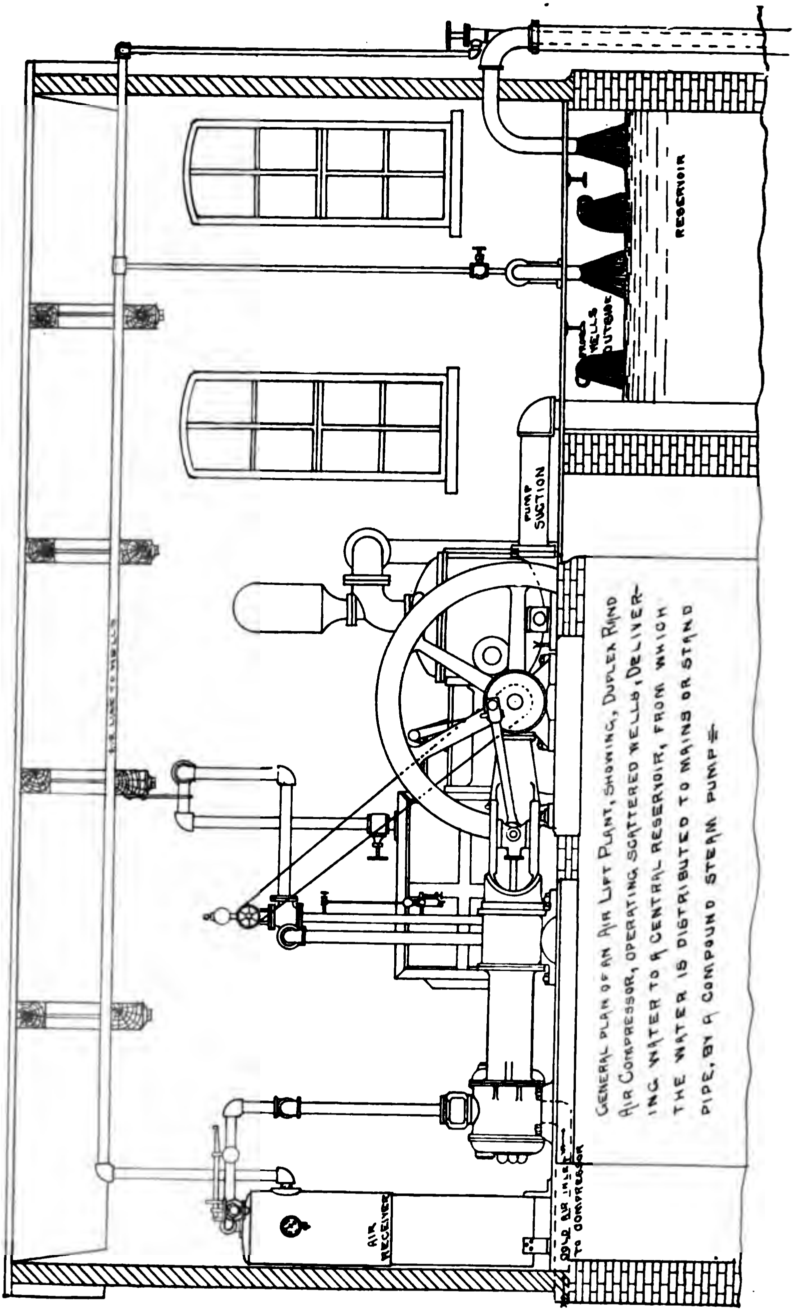
STEAM-DRIVEN DUPLEX AIR COMPRESSOR.

taken into a compressor at atmospheric pressure and ordinary temperature, gets very hot when it is compressed. The final temperature after compression is found by the following formula: $T_1 = T\left(\frac{P_1}{P}\right)^{\frac{k-1}{k}}$ in which T_1 = final temperature, T = initial cooling $(60 + 461) \times \left(\frac{100+15}{15}\right)^{0.29} = 952 - 461 = 491°$ F., which is 150 degrees hotter than the temperature of steam of 100 pounds. All air compressors are therefore equipped with a so-called water jacket to cool the cylinder walls to a certain extent. By this cooling process and by radia-



AIR COMPRESSOR FOR LIFTING WATER FROM A WELL.—SHOWING THE WELL WITH AIR AND WATER PIPE.

temperature, P_1 final pressure, P = initial pressure, and k = the ratio of specific heat of constant pressure to the specific heat of constant volume, therefore $k = \frac{0.23751}{0.16844} = 1.41$. The pressures and temperatures are absolute. The final temperature, for instance, of 60° F. air, compressed to 100 pounds gauge pressure would be without tion the compressed air loses considerable heat and consequently volume. If this air is suddenly reduced to atmospheric pressure it must lower its own temperature far below what the initial temperature was, on account of the heat that was taken away during the time it was under pressure. The general result is that the moisture in the air freezes to ice and hence exhaust pipes of air-driven machines frequently



GENERAL PLAN OF AN AIR LIFT PLANT, SHOWING, DUPLEX RAND AIR COMPRESSOR, OPERATING SCATTERED WELLS, DELIVERING WATER TO A CENTRAL RESERVOIR, FROM WHICH THE WATER IS DISTRIBUTED TO MAINS OR STAND PIPE, BY A COMPOUND STEAM PUMP.

freeze up solid. If, therefore, air is used to drive other machinery, it is of great benefit to heat it first, provided it can be done without additional fuel, which is possible if done the way mentioned above.

It is of great importance to have the least possible clearance in air compressors. Air or any other gas cannot be pumped like a liquid, for it acts like a spring. If all, or nearly all, of the air is not discharged out of the cylinder it expands as the piston goes back, and prevents new air from coming in. Excess of clearance is, therefore, very poor economy, and reduces the capacity as well. In buying an air compressor the percentage of clearance should be specified in the contract.

The general construction of an air compressor should be of the best workmanship, and everything of heavy pattern. It should be so constructed that every part can be easily examined, and that everything can be easily reached. Air compressors should be lubricated with graphite instead of oil. The air is thus kept cleaner, and the cylinder walls lubricated much better and cheaper. Graphite is a better and cheaper lubricant than oil or grease, generally, the only difficulty being to feed it regularly, which should be done much the same way as with an oil lubricator.

The friction in a steam driven air compressor is about 10 per cent. of the total horse power required, whereas in a belt driven compressor it is frequently less than 5 per cent. The number of horse power which is necessary can easily be determined by calculation. Practical tests, however, have shown that it requires about 0.2 of a horse power to compress 1 cubic foot of free air to a gauge pressure of 100 pounds, about 0.189 H. P. for 80 pounds, and about 0.159 H. P. for 60 pounds pressure. If it is desired to get a compressor to deliver 125 cubic feet of free air and compress it to 100 pounds pressure, it would require 25 H. P. to do this. For 80 pounds it would require 23.6 H.P., and for 60 pounds of pressure about 20 H. P.

For transmitting power to a long distance, f. i., about one mile from the compressor, the maximum percentage of useful effect between the compressor and the out-turn of the motor should not be taken at more than 30 per cent. To demonstrate this, we may assume 90 per cent. efficiency of the steam engine when working the air compressor direct connected, 75 per cent. efficiency in compressing, 10 per cent. loss in transmitting one mile, and 50 per cent. efficiency of motor to be driven by air. Then we would get from 100 I. H. P. of a steam engine: $100 \times 0.90 \times 0.75 \times 0.90 \times 0.50 = 30.375$ per cent. efficiency, out of 100 steam horse power. The efficiency obtained by compressed air transmission falls about 10 per cent. short of the efficiency obtained by electrical transmission for an equal distance.

Compressed air is used extensively for lifting water or oil from deep wells. More water can be gotten out of a well with air than any other way, providing the installation is made properly. In most cases the installation is faulty somewhere, and the success consequently poor. The proper requirements for an air lifting system are very imperfectly understood by the average engineer, because there has been little published about it. The experiments that have been made in this line are also very limited, and in most cases one-sided and unreliable.

The following rules have been tested by the writer and seem to hold good:

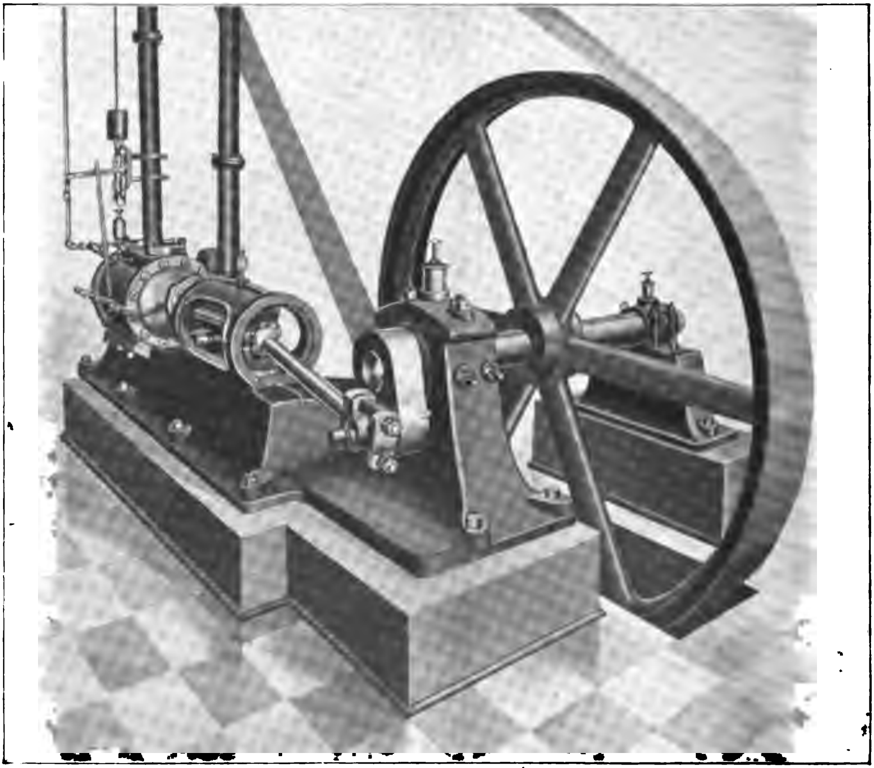
The length of air pipe must extend down into the well three times the distance from the water level in the well to the highest point to which water is to be lifted. If, for instance, the surface of the water is 60 feet below the tank into which it is to be lifted, the air pipe should extend into the well $3 \times 60 = 180$ feet.

The amount of air necessary to lift a certain quantity of water a certain distance, can be determined by multiplying the quantity of water in gallons by the distance to be lifted in feet, and dividing by 125. This will give the number of cubic feet of free air required per minute. For instance, if 100 gallons of water are to be lifted 60 feet, it would require $\frac{100 \times 60}{125} =$ 48 cubic feet of free air per minute. If, however, the number of cubic feet of air is given, and it is desired to find how much water can be lifted, the number of cubic feet of free air should be multiplied by the constant 125, and the result divided by the distance the water is to be lifted. Thus, we have 100 cubic feet of free air and the water is to be lifted 60 feet; how many gallons can we get? In this case we can get $\frac{100 \times 125}{60} = 208$ gallons per minute.

One point seems to have been hitherto neglected. As far as the writer knows, it has never been determined what is the most efficient velocity of the water, and experiments in this line are wanted. Whenever this is known, we can easily determine the proper size of water and air pipe we should have in the well. In a great many cases the water pipe leading down the well is too narrow, and the amount of water obtained, therefore, too small regardless of the amount of air pressure applied. It is evident that only a limited supply of water mixed with air can run through a pipe of a given size.

As the air contains plenty of moisture when in its natural state, this moisture comes down like rain in the air receiver when the air gets compressed to a higher pressure. It is, therefore, advisable to place a regular steam trap below and connect it to the bottom of the tank, when the trap will discharge all the water without losing any compressed air. This device is new, but works like a charm, and keeps the air almost perfectly dry.

The most economical way to compress air is to do it in stages, that is, to use two or more cylinders, compressing it to a low pressure in the first, then passing it through a cooler to cool it to nearly the temperature of the cooling water, and then further compressing it to a high pressure, cooling it again and compressing it again, and so on according to the pressure required, the two-stage or compound compressor being used for pressures between 60 and 300 pounds, the three-stage or



KROESCHELL AIR COMPRESSOR.—DRIVEN BY BELT, FROM A LINE SHAFT.

triple compressor between 300 and 1,000 pounds, and so on. To compress 100 cubic feet of free air to 75 pounds would require about 16 H. P. with a single cylinder, and 13.75 H. P. with a compound cylinder. But if the air is to be compressed to 500 pounds pressure there would be required 40 H. P. with a single, and 30 H. P. with compound cylinder, constituting a saving of 14 per cent. for 75 pounds of pressure and 25 per cent. for 500 pounds of pressure by the compound cylinder. It is thus evident that compounding is very economical for higher pressures.

The colder the air is to start with, the better. It should be always taken from as cold a place as possible For every 5° that the intake air is colder than the air in the engine room, a saving of 1 per cent. is effected in running the machine. The capacity is also increased. If the air in a brewery is taken from the cellars at a temperature of 35° F., instead of from the engine room in the summer time, where the temperature may be 85° F.. a saving of $(85 - 35) \div 5 = 10$ per cent. is effected by doing so.

At greater altitudes the atmospheric air is more rarified, representing less pressure per square inch, as shown by the following table:

At sea level	14.7 lbs. per sq. in.
At ¼ m. above sea level	14.2 lbs. per sq. in.
At ½ m. above sea level	13.33 lbs. per sq. in.
At ¾ m. above sea level	12.66 lbs. per sq. in.
At 1 m. above sea level	12.02 lbs. per sq. in.
At 1¼ m. above sea level	11.42 lbs. per sq. in.
At 1½ m. above sea level	10.88 lbs. per sq. in.
At 2 m. above sea level	9.88 lbs. per sq. in.

This table shows an approximate reduction of ½ lb. per square inch for every 1,000 feet of ascent. The losses at great altitudes, for which allowance should be made when buying an air compressor, are about 7 per cent. for ¼ mile, and 34 per cent. at two miles or the increase is about 4 per cent, for ⅛ mile.—*National Engineer.*

Comparison of Compressed Air with Steam and Electricity at Rossland, B. C.*

Compressed air has become so generally used in connection with mining operations, and so well recognized as the most useful and economical power, with its unlimited range of uses, and special adaptability to underground work, that an introductory to this paper on the subject would be superfluous to mining engineers.

The comparative economy of prime movers for air compressing engines is, however, of great interest to all, and a subject on which any engineer can read with interest. This is particularly the case with engineers practicing in British Columbia, where a large number of the mining problems include the extraction and reduction of large bodies of low-grade ores and the consequent necessity for a thorough study of economical methods for mechanical handling.

The general mobility of compressed air as a power allows a wide range of generators, or prime movers, but we can, in nearly all cases, rely upon having to adopt primarily, one of two sources of power, viz., water or heat.

Water, the first of these, can, as we know, be used in many ways, each terminating finally at the mine, as compressed air ready for service. The initial water power may come from one or more sources situate either at the mines or many miles distant, and can be used either as a directly connected unit of power for the compression of air, or as a prime mover for some intermediary power.

British Columbia has been fortunately blessed with magnificent water power, more particularly in the Kootenays. In many cases these water powers are situated close to the mines; in others, as at Rossland, they are several miles away.

Distances over which power can be economically transmitted by electricity are yearly becoming greater until it seems that distance is no longer an obstacle, and it has become simply a question of capital investment to successfully transmit the power generated by water almost any distance.

Heat, the second great source of power for the generation of compressed air, has been successfully used as steam for many years, even in places which seemed to be utterly inaccessible either for the erection of the necessary machinery, or the securing of fuel after the machinery had been installed and made ready for operation. So accustomed have we become to surmounting difficulties of this kind, that we are apt to look with suspicion upon any suggestion to utilize distant water powers, preferring to resort to steam as being the power we best understand, and one which has been successfully installed

*Paper read at the Nelson meeting of The Canadian Mining Institute, 10th September, 1902.

and economically operated under very adverse circumstances.

British Columbia has been abundantly provided with fuel, in fact, we can say the supply of coal is practically unlimited. Enterprising capitalists, year after year, extend railways between the coal fields and the consumers, so that no producing or promising mining district has long to wait for an unlimited supply of this fuel. The mines at Rossland are exceptionally favored in this respect, all the leading mines having access to two lines of railways, and, through them, the coal fields of both British Columbia and the State of Washington.

Rossland is also favored by having the immense water power at Bonnington Falls, less than 40 miles distant, immediately available. The enterprise of Sir Charles Ross and associates in the West Kootenay Power and Light Co. have rendered this available for any service at each mine, as a competitor of the steam power, which mine managers would otherwise be compelled to adopt.

The question of the selection of power supply to be made by mine managers at Rossland is almost entirely removed from chance, and may be based on ascertained facts. Railways being at hand for the transportation of any kind of machinery, reasonably cheap fuel in quantities required is assured, and electric power for any size machinery or service is available. Therefore the problem simply resolves itself into *"Which of these powers will give the best service in operating the machinery used in connection with mining operations?"*

The same privilege applies to nearly every other mining district in Southern British Columbia; therefore, the writer feels that the results obtained in the air compressing plants at Rossland will be of special interest to the members of the British Columbia section of the Canadian Mining Institute, and mining engineers.

The steam and electric plants described further on were modelled on the design and erected under the personal supervision of Mr. Bernard Macdonald, then general manager of the Le Roi and Nickel Plate mines, assisted by the writer. The steam plant was erected for the Le Roi Mining Company, Limited, and consists of the following, viz.:

Boiler Plants.—Two 250 horse-power Heine safety water tube boilers, arranged to burn coal as fuel. These were intended to generate steam to run the air compressors, and were set so as to work, if desirable, in connection with the nine 125 horsepower steel shell return tubular boilers, designed to operate the hoisting and surface plants. These boilers are arranged to be interchangeable to either service. A general description of this plant will be found in volume V., page 309, of the Journal of the Canadian Mining Institute.

During the test, the water-tube boilers were used at a gauge pressure of 150 pounds per square inch, using Crows Nest coal as fuel, which cost, laid down in front of the boilers, $5.55 per ton of 2,000 pounds.

Air Compressing Plant.—The steam driven plant consisted of two compound condensing Corliss valve engines, direct connected to two stage air cylinders, equipped with intermediate cooling devices, each machine having a rated capacity of 4000 cubic feet of free air per minute, or a combined capacity of 8000 cubic feet of free air per minute at sea level.

A more detailed description of these engines would be as follows:

	No. 1 Engine. INCHES.	No. 2 Engine. INCHES.
Diameter high pressure steam cylinder	22	22
Diameter low pressure steam cylinder	36	36
Diameter high pressure air cylinder	22	22
Diameter low pressure air cylinder	36	38
Length of stroke	48	48

Intercoolers, horizontal multitubular type; condensors, independent jet.

The Electrically Driven Air Compressing Plant.—This plant was erected by the Rossland Great Western Mines, Limited, and was originally intended to be operated in connection with the steam plant previously described, the intention being to supply power from a central station to four mines, owned by different companies. This arrangement would have given each mine power at the lowest possible cost, and have ensured continuous operations by reason of the compressing plant being arranged in separate units. Each company would pay its share of operation, maintenance, of plant, *pro rata* to its consumption of air.

When it was found necessary to erect the third unit to the compressing plant, unforseen difficulties presented themselves in the shape of shortage of water for condensing and cooling purposes. On examination, it was found that a satisfactory supply could not be secured without heavy capital expenditures for erection of flumes, etc., to convey the water to where it was required for use.

It was, however, found that a supply of water, barely sufficient for the intercoolers and waterjackets, was available about three-fourths of a mile distant from the steam plant. This supply was so located that it must either be pumped or else the plant located at this distance away from the main steam plant. By conserving this water supply, cooling, and reusing, it was decided a sufficient supply of water for the air cylinder jackets, and intercoolers could be secured.

The results obtained from the steam plant had proven so satisfactory that it was considered questionable if any electric plant could be installed that could successfully compete with steam, even when running non-condensing, unless very favorable rates for power could be secured. After negotiations with the Power Company, it was decided to erect an electrically driven plant, a short description of which is as follows:

Electrical Equipment.—Three phase, S.K.C., synchronous motor, designed for 2200 volts, with a rated capacity of 660 kilo watts, equivalent to about 825 horsepower. The motor is provided with a separate starting motor, mounted on the main frame, exciter and Italian marble switch-board, on which all operating switches and instruments are mounted.

There is a 54 inch Frisbee clutch set intermediate between the driving pulley and the motor. The motor is of a four bearing type, fitted with self-aligning and self-oiling sleeves. The entire machine is mounted upon a solid cast iron base set upon massive concrete foundations. The driving pulley is 60 inches in diameter, grooved for 22 1½ in. ropes, and runs at 270 revolutions per minute.

The three compressors were built by the Canadian Rand Drill Company, of Sherbrooke, Quebec, and are especially designed for constant service.

The electrical equipment is also entirely of Canadian manufacture, the entire apparatus being manufactured by the Royal Electric Company, of Montreal, who are the Canadian manufacturers of the S.K.C. apparatus.

All tests were conducted under the personal supervision of the writer, and extreme care was taken to arrive at actual facts. Indicator diagrams were taken off both the steam and air cylinders every half-hour, and the results tabulated. Coal consumed was weighed, and all other supplies, such as waste, oil, etc., charged as used.

Readings were also taken and recorded by means of a delicately adjusted kilo watt metre, connected to the primary mains, of the amount of electric power used. The test extended over a period of thirty days, without interruption, both plants being run under exactly similar conditions as to air pressure.

Each of the plants tested being modern and representative of their respective types, gave an opportunity for a comparative test that rarely falls to the lot of an individual engineer under such favorable conditions, as to work being performed, and for this reason is the more valuable as data for basing calculations as to problems of power.

The average results of the thirty days' test is recorded in Tables I, II, III, IV, and V following:—

TABLE I.

Work Performed by Steam Plant.

Average indicated horse-power at steam cylinders of the combined machines	730 h.p.
Free air compressed per minute from atmospheric pressure to 95 lbs. per square inch.....	5432 cu.ft.
Free air compressed per hour..	325,920 cu.ft.
Average horse-power required at steam cylinders to compress 100 cubic feet of air per minute, to gauge pressure......	13.4 h.p.
Pounds of coal consumed during test	1,038,000 lbs.
Pounds of coal consumed per day of 24 hours...........	36,400 lbs.
Average pounds of coal consumed per horse-power per hour during test...........	1.9 lbs.

TABLE II.

Work Performed by Electric Plant.

Average h.p. registered at switch-board	540 h.p.
Free air compressed per minute from atmospheric pressure to 95 pounds gauge pressure...	3,319 cu ft.
Free air compressed per hour..	199,140 "
Average horse-power required at motor to compress 100 cubic feet of free air per minute to 95 lbs. gauge pressure......	16.3 h.p.

TABLE III.

Cost of Operating Steam Plant.

Total cost of fuel consumed during test...	$2,880.45	
Total cost of wages for employes	710.00	
Total cost of oil, waste, etc.	147.30	
Total cost for 30 days, exclusive of maintenance and depreciation		$3,737.75
Cost per horse-power per month for fuel.......	3.96	
Cost per horse-power per month for oil, etc....	0.20	
Cost per horse-power per month for wages....	0.97	
		$5.15
Cost per horse-power per annum.		$61.56
Cost for each 100,000 cubic feet of free air compressed........		1.56
Cost per drill shift.............		1.25

Note.—80,000 cubic feet taken as the average consumption per shift of one 3¼ in. drill.

TABLE IV.

Cost of Operating Electric Plant.

Cost of current for 30 days	$1,744.26	
Cost of employees' wages	270.00	
Cost of oils, waste, etc.	73.00	
Total cost for 30 days, exclusive of maintenance and depreciation		$2,087.86
Average cost per horse-power per month		3 87
Average cost per horse-power per annum		46.44
Cost for each 100,000 cubic feet of air compressed............		1.46
Cost per drill shift............		1.17

Note.—80,000 cubic feet taken as the average consumption per shift of one 3¼ in. drill.

TABLE V.

Showing Comparative Results between the Two Types of Compressors, based on each 100,000 cubic feet of air compressed from Atmospheric Pressure to 95 Pounds Receiver Pressure.

Cost for each 100,000 cubic feet of free air compressed by steam plant (see Table III)........	$1.56
Cost for each 100,000 cubic feet of free air compressed by electric plant (see Table IV).........	1.46
Result, saving by electricity over steam	6.4 per cent.

The saving shown in Table V would be affected adversely if the electric plant was operated singly and the entire air compressed was not used. For the reason that electrically driven compressors must be operated at constant speed, and loss of air at safety valve would be considerably increased over the same loss at steam plant, which could be run at the speed required to compress the amount of air actually required. This loss would, however, be slightly off-set by the increased cost per horsepower by working the steam compressors on underload.

I wish to draw special attention to the noteworthy results obtained from the system of intercooling used on the compressors tested.

In Table I it is shown that the steam plant required 13.4 horsepower to compress 100 cubic feet of air to 95 pounds gauge pressure per minute. The best power factor recorded that has come under the writer's notice, for doing the same amount of work by a two stage compressor, is 14.5 horse power, which shows a saving of 8 per cent. resulting from the use of specially designed intercoolers, for which the manufacturers are entitled to receive the credit.

How this result is obtained can be best understood by reproducing the average of a number of tests made on the efficiency of the intercooler during the progress of the power test. The results of these tests are shown in Table VI.

TABLE VI.

Temperature of cooling water at inlet of intercooler..........	42 deg. F.
Temperature of cooling water at outlet of intercooler..........	50 deg. F.
Rise in temperature of cooling water while passing through intercooler	8 deg. F.
Temperature of air at outlet of low pressure cylinder and before passing through intercooler	196 deg. F.
Temperature of air at inlet of high pressure cylinder after passing through intercooler...	54 deg. F.
Reduction in temperature of air after passing through intercooler	142 deg. F.

In conclusion, permit me to state that this paper has not been prepared with the idea of recording the performance of these two plants, except, in so far as comparisons can be drawn between the relative efficiency of the two systems, so that engineers, knowing local conditions, can have some record of actual performance before them.—Wm. Thompson, for *Canadian Mining Review.*

The Corrington Air Brake.

The Corrington air brake was, it will be remembered, mentioned in some of the discussions at the June conventions at Saratoga. Some time ago this system was tested on one of the principal railways and the result led to the formation of a company in which a number of railway officials are interested. This was done after the patent question had been gone into carefully and was believed to be safe. The Corrington Air Brake Co., having now secured a plant in which it is installing machinery for preliminary operations, our readers will be interested in learning what they have to offer and the claims which are made for their system. The following is its own statement on these points:

"The Corrington system utilizes all of the auxiliary reservoirs, brake cylinders, cut-off cocks, air pumps and governors, exactly the same style and manner as now in use. The triple valve, engineer's valve and high speed pressure valve of the Corrington system are interchangeable as to position with the Westinghouse system, as they can be placed in identically the same position respectively as they now occupy on the locomotives and cars equipped with the Westinghouse system. Consequently, the new results offered by the Corrington system may be obtained by the railways on all new equipment without increased cost, and all old equipment can be altered to secure the same results at the slight cost necessary to change the triple valves on the cars, and if desired, the engineer's brake valve on the locomotive.

The new brake gives increased control both in setting and releasing, and overcomes to a much greater extent than do the brakes hitherto in use, the difficulties presented by dirty or defective triple valves or irregularity of brake cylinder piston travel. This is accomplished by a device automatically applying full train line pressure to release the brakes, when required. Overcoming the irregularity of release due to the causes stated above, is of the greatest importance, reducing, as it does, the danger and expense incident to breaking trains in two, especially at slow speeds, where the failure to release one or more brakes toward the rear end of the train is now the too frequent cause of the parting of freight trains.

Another and more important feature is that the auxiliary reservoir may be recharged without releasing the brakes, thus dispensing with the retaining valve, the insufficiency of which to give the desired control is especially evident in the case of loaded gondola cars of high capacity. On roads with long, steep grades this advantage is self-evident, although rather costly experience, even on roads without such grades, has demonstrated that this is a consummation greatly to be desired. The control of the train is thus placed entirely in the hands of the engineer, avoiding the necessity of the train crew acting independently, and too often disastrously. One road has gone so far as to discontinue the use of the air brake on all freight trains when descending a heavy grade, and as a consequence is handling down this grade its heavy freight traffic by hand brakes, at a slow speed. The ability to keep air brakes continuously applied, and maintain auxiliary reservoir pressure with which to stop when necessary, means to this and many other roads speed and safety in descending grades.

As corollaries to the recharge without release feature of the new apparatus: (1) The brakes may be set and released any number of times without the possibility of the engineer finding no air in the auxiliary reservoir to meet an emergency. (2) With the engineer's brake valve handle in the recharge position sufficient pressure to offset train line leaks is thrown into the train line while the brakes remain applied, thus preventing the brakes applying harder than intended, which is at present of frequent occurrence, owing to the failure of the present systems to supply air to offset such leaks when the engineer's valve has been placed in the "lap" position. (3) With the return of the engineer's brake valve handle to the recharge position, after each reduction of train line pressure, the air pump starts immediately and main reservoir pressure is regained simultaneously with the recharge of the auxiliaries. The importance of this much more continuous use of the pump, instead of the spasmodic and necessarily violent calls made upon it by the apparatus in use at present, can hardly be overstated.

As the air pump is used more evenly and continuously, it requires less capacity in the pump and main reservoir. Consequently, it will not be necessary to increase the size of the pump and main reservoir as is now being done to accommodate the heavier train loads, and owing to the avoidance of spasmodic action of the pump by the adoption of the Corrington system, the cost of maintenance of the pump will be considerably reduced.

Another important advantage of the Corrington engineer's valve and high speed and high pressure control apparatus is its simplicity. In order to provide for the two feed valves necessary for all high speed or high pressure control apparatus, the low or normal pressure feed valve must, in the present system, be cut out when the high pressure feed valve is to be used. In the Corrington system both feed valves are attached directly to the engineer's valve, and are thrown in or out of action by the brake handle alone, thus dispensing with detached feed valves and with the cut-out or reversing cock and connecting piping, simplifying the operation of changing from low to high pressure. This result is attained by a novel rearrangement of ports and cavities in the rotary valve and valve seat without increasing the size of the engineer's valve. The entire high speed and high pressure control apparatus of the Corrington system is much simpler than the apparatus in present use, consisting only of about one-half the number of parts.

The advantages of the results to be secured in the Corrington system involves no transition period. The triple valve is constructed in two parts, so designed as to make it practicable to cut out the recharge release part in a similar manner to the operation of the present retaining valve. The object of this is apparent. It is to be expected that the extra switching necessary to get cars equipped with the Corrington recharge release device next to the engine will be as willingly performed as was the case before the present nearly universal use of the Westinghouse brakes was attained. If, however, owing to circumstances, it is inconvenient to place the car so equipped next to the engine and it should be left in the train among its predecessors, then if it is desired the recharge feature may be cut out as conveniently as the retaining valve is now operated. The Corrington triple then performs its functions in a similar manner to its neighbors with the advantage obtained from the Corrington release mechanism, insuring the release of the brakes on that car when normal train line pressure is attained should the release not have been previously effected. With the engine and tender alone equipped with the Corrington recharge release mechanism in the place of the present engineer's brake valve and triple valve, the advantages in train control are apparent. The addition of each car at the head end of the train is so much more gained in train control with no disadvantage whatever as far as the operation of the other brakes on the train is concerned."—*Railway and Engineering Review.*

Reheating Air for a Compressed Air Mine Hoist Driven by Electric Power.*

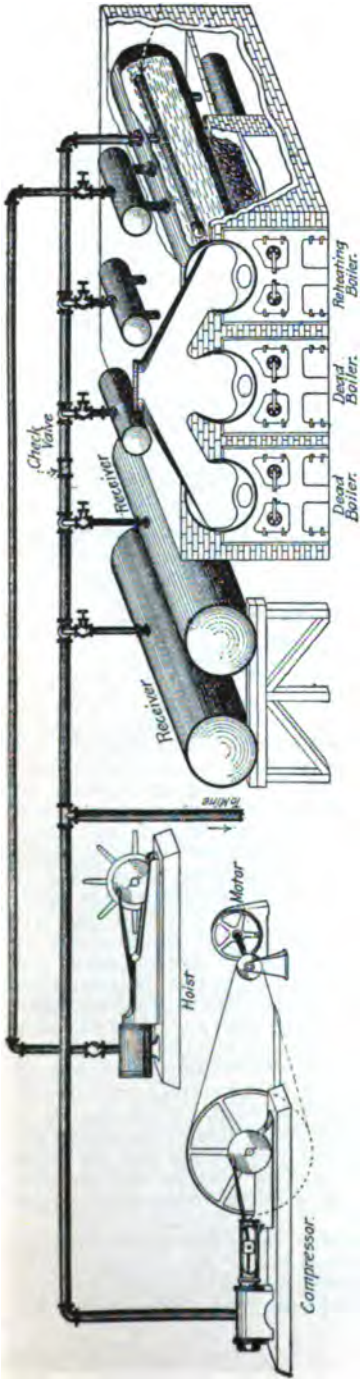
BY C. O. POOLE,‡ M. AM. INST. ELEC. E.

The mine superintendent takes kindly to the electric motor for all purposes except for hoisting, and to my mind his exception is well taken, for until a simple, better and more reliable electrical hoist is developed, I will hesitate to recommend them to a customer. In my opinion, compressed air is going to be universally used for hoisting purposes, where cheap electric power is obtainable and when an air compressor is required for other purposes in the mine. In the ordinary use of a compressor at a mine, it is not used to its rated capacity more than 40 per cent. of the time. If, then, receiver capacity be available to store the air at times of light demand upon the compressor by the drills, and thus enable the compressor to be operated at full load all the time, the motor and compressor would be run at their highest efficiency, and sufficient air could be stored to operate the hoist under ordinary conditions, and quite efficiently, too, by reheating the air. It is not generally known that a pound of coal used for reheating air will produce a horse-power hour, while it requires from 4 to 5 lbs. of coal to give the same result with steam; but such is the case if the air be used in an engine fitted for the purpose.

But, for the sake of argument, let us suppose that we use the air without reheating, and assume that air and steam are equal as far as expansive effects are

*Extract from a paper read at the Sixth Annual Convention of the Pacific Coast Electric Transmission Association.

‡Manager Standard Electric Co., San Francisco, Cal.



ARRANGEMENT OF BOILER PLANT FOR REHEATING COMPRESSED AIR.

concerned; then, if electric power costs $6.50 per H. P. per month, and the compressor has an efficiency of 60 per cent., the cost for air delivered to the engine will be $10.83, and by using a small amount of fuel for reheating, these results can be far exceeded.

At the Lightner Mine, Calaveras county, Cal., electric power has been used exclusively for several years. A 150 H. P. motor drives a two-stage compressor 13x 21x22 in. stroke, and running at 75 revolutions per minute. The saw-mill, a pump and a blower are also driven by the same motor. The relief pipe from the air receivers is connected to the steam boilers, two of which act as additional receivers, and another one of them being used as a reheater. About one cord of wood is burned per day in reheating. There is operated a 60-stamp mill, which is driven by a 100 H. P. induction motor; a 20 H. P. motor drives the rock crusher, and a 5 H. P. motor is used for operating a telpherage system for carrying sulphurets to the chlorination works. All the hoisting is done with compressed air, as is also the lifting of all the water, which is taken from the 600-foot level. In addition to this work, seven 3¼-in. drills are supplied with air from the same compressor. The total power bill for January, 1902, was $1,457.50, including the cost of the wood used for reheating purposes, which makes the power cost per ton of ore milled to be 21 cents, including all power charges.

The engraving herewith shows the arrangement of compressor and receivers that have given such excellent service at the Lightner Mine. It will be observed that a check valve is placed in the relief pipe, between the mine receivers and the boilers. Any excess of air flows through check valve into the boilers, and the air that is used for hoisting is all taken from the reheating boiler; the air passing into this boiler enters through a perforated pipe, which is submerged about 6 ins. below the surface of the hot water. This arrangement permits all of the air to come in contact with the hot water, and is very rapidly heated. As air is drawn from this boiler by the regular steam pipe, and the pressure is lowered, air from the other boilers and receivers immediately flows in, thus utilizing all of the receiver capacity for the hoist during moments of heavy demand. Between skips, the compressor has time to recharge the receivers.

With an installation of this kind properly proportioned as regards motor, compressor and receiver capacities, to my mind, it leaves little to be desired from the point of economy, convenience and reliability.

At the present time there are several large compressed air plants in course of erection in Amador county, all of which are to be electrically driven, and reheated air is to be used for hoisting.—*Engineering News.*

A New Clam Shell Dredge Operated by Compressed Air.

Interest is taken by dredging contractors, engineers, and in army and navy circles in the recent inventions of Mr. E. Chaquette, of New Rochelle, N. Y., covering an application of compressed air by a new and ingenious method to close and open automatically a clam shell for subaqueous excavation.

As shown by Fig. 1 of the accompanying cut, a hemispherical shell consisting of two hinged halves is mounted upon a suitable frame. A valveless cylinder is attached to the outer side of one of these halves and its piston to the outer side of the other, with mechanism by which the admission of air to one side of the piston opens and to the other side closes the clam. The clam is supported by three cables preferably; the outer two for counterbalances being attached to the extremes of the cross bar of the clam frame. The middle or hoisting cable is attached to a slide which passes through the center of the cross bar, and is surrounded by a coiled spring, which automatically controls the admission of compressed air to close and open the clam. This air is fed through a journal box to the drum pulley carrying the air pipe, which is mounted on the same shaft with the center or hoisting pulley; or on an independent drum with gear which meshes with the hoisting pulley, so that there is a simultaneous feeding and rewinding of the air pipe, and the counterbalance and hoisting cables, effected by the same motor.

Upon the clam is mounted a guide rod or rods to which a cylinder and its operating piston is suspended by arms

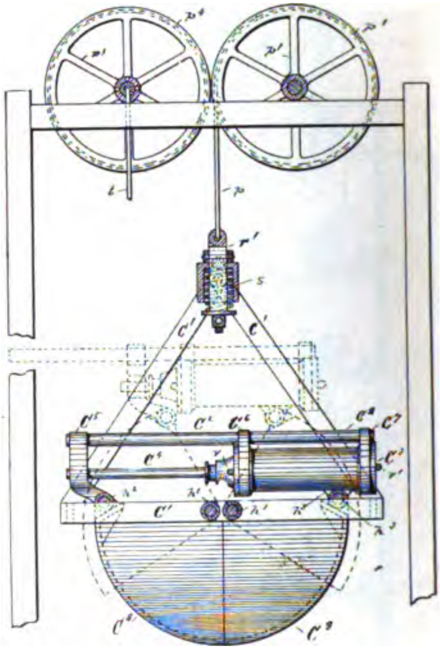


FIG. I.

which are adapted to slide along such rod from an extended to a contracted position, the cylinder rising and sliding on the guide rod as the clam is opened, and vice versa. In cut 2 dotted lines show the cylinder elevated and the clam open. The cylinder is provided with ports at each end, and with suitable exhaust ports.

Hence, as the guide rod holds the cylinder and itself parallel, the in-stroke of the piston raises the piston, guide rod and cylinder bodily, and at the same time draws upward and together the two upper outer sides of the clam and apart its lower or cutting edges. When the arm traveling on the guide rod engages the head of the cylinder it is at its highest point, and the clam is wide open. When the air is shifted to the other side of the piston the reverse action takes place and the clam is closed; and so held by the pressure until the air is shifted to open and empty the clam.

A three-way valve diverts air from its pipe to either end of the cylinder. This is so adjusted that as the clam settles in the material open, the slackening of the center or hoisting cable turns the valve and admits the air under pressure against the piston, forcing the piston rod out,

FIG. 2.

causing the guide rod and cylinder to settle, thus closing the clam which cuts into the material, and is then filled and ready to be lifted by its hoisting cable..

At an elevation suitable for dumping a tappet engages the valve and diverts air to the reverse side of the piston, causing it to make its in-stroke, thereby lifting the guide rod and cylinder and opening the clam.

For the operation of this compressed air clam, a float or barge of any desired width is provided, across the front of which is built a projecting frame-work (Figs. 2, 3 and 4) for supporting dredge carriages adapted to move automatically for a distance even greater than the beam of the boat. On this framing are travel carriages supporting two or more independent clams, which rise and fall vertically.

As the clam descends a collapsible apron or trough (Figs. 2 and 4) drops with it, follows it up when the clam is raised, and receives the discharged material. This trough may be adjusted to discharge either side, forward, or into diverging troughs fitted with agitating chains to carry to scows alongside, or converging troughs to carry to the center of the float; or the trough will discharge aft onto a movable apron, which will carry material astern of the scow, as will be seen bv reference to Fig. 3 and also Figs. 2 and 4, which show this trough in both positions.

Provision is made to attach cables to

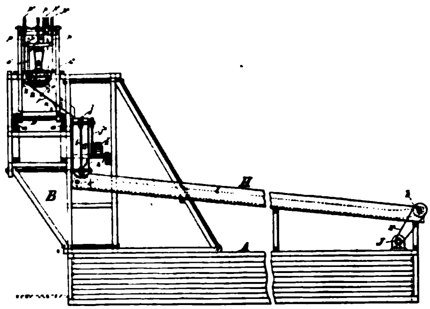


FIG. 3.

the extremes of the frame of the clam, to lead to the top of the dredge carriage and over sheaves aft, to support counterbalancing weights adjusted to the character of the excavation; so that power is required to lift only such proportion of the weight of the clam as may be necessary to give it penetration. These cables take the place of poles formerly used to hold the clam steady and prevent it toppling over on hard bottom, and permit work at great depths.

Figs. 2 and 4 show a working model of the clam and dredge carriage. In Fig. 2 the clam is lowered onto wet packed sand, its top contracted and cylinder elevated, with the beveled cutting edges of the clam open and ready to bury themselves when air is applied to the left end of the cylinder, which will then settle down as the outer circumferences of the clam are forced apart and its cutting edges together.

The trough has dropped by gravity, and is ready to follow the clam up when its frame engages the arm projecting into the upper part of the framework, which arm is vertical when the trough is raised.

In Fig. 4 the clam is hoisted and open, having discharged its load onto the inclined trough.

FIG. 4.

Arrangements are well advanced for constructing a dredge under these patents, and its practical operation is awaited with great interest. The first claim for the clamshell is its admitted efficiency in bringing up a maximum load every trip in hard material, due to its closing and burying itself deeply by the automatic application of a controllable power, independent of the lifting power.

If this clam is fitted to the present type of dredge with swinging boom, there will be a substantial saving in the time required to fill, with the advantage of a full load in clay or hard pan; and with no dripping or leakage in soft material.

By the use of the projecting framework it is clamed that two dredges will be combined in one, with consequent economy in initial cost and maintenance, wages, etc. There will be greater uniformity of excavation. Should one clam get out of order, work could continue at reduced capacity pending repairs.

With the boom about 30 per cent. of the time of a trip is required to swing the boom, and from 15 to 30 per cent. in filling. Consequently, by this new method for excavating and elevating material, it is claimed trips would be made from 25 to 30 per cent. quicker than at present, which would conservatively make the capacity of a Chaquette dredge equipped with two three-yard compressed air clams, 500 cubic yards per hour for a machine costing no more than a present type dredge with one three-yard clam, the operating expenses of each being about the same.

Some time ago an engineering project in New York harbor was abandoned because eminent engineers were unable to find a dredge which would satisfactorily excavate at the depth of 150 feet. We understand that it was frankly stated that had this compressed air clam been on the market at the time it would have been favorably considered.—C. E. DAVENPORT.

Gas Producer Working with Compressed Air.

The Gardie gas-producer, shown by the accompanying elevation (Fig. 1) and vertical section (Fig. 2) is distinguished from all other machines of this sort by the circumstance that it is supplied with compressed air, which may be produced by a compressor, an air-pump or a blowing engine, and the gas produced has the same pressure as the compressed air, and may be used directly for motive power, as well as for firing furnaces, while the use of compressed air permits of obtaining continuously a large volume of gas with a producer of small size. Inasmuch as the gas is generated as required, without any necessity for storage, a gasometer is unnecessary. The adoption of high pressures insures a complete gasification of the fuel employed, and the gas obtained is free from the usual impurities, tar and ammoniacal liquor, so that suppression of scrubbers and condensers are not needed.

The producer case, a (Fig. 2), is made of steel plate, in three parts, connected by the angle-iron rings, bb, bolted together, while the dished bottom, d, is riveted to the cylindrical portion. The fire-clay lining, e, leaves a space in the middle for receiving the fuel, this space being cylindrical generally, but assuming a conical form below for ensuring a regular distribution, through the mass of incandescent fuel, of the compressed air that supports combustion. On the dished top there is a short pipe, f, carrying a cast-iron plug-valve, g, (worked by the lever H I H), through which the fuel is admitted to the producer in accordance with requirements, falling from the spherical receptacle, h, which is closed by the screw cover, B, and contains a charge sufficient for two hours' working. The inverted funnel, i, is calculated so that the height of the fuel shall remain constant inside the producer. Apertures, j j, left in the fire-clay lining, permit of removing cinders or clinker, these apertures being closed by the screw doors, AA. Along the center line of the producer, and having its top flush with the bottom of these evacuation apertures, is a vertical steel tuyere, k, which fits on to and above the pipe, l, that brings up the air supporting combustion.

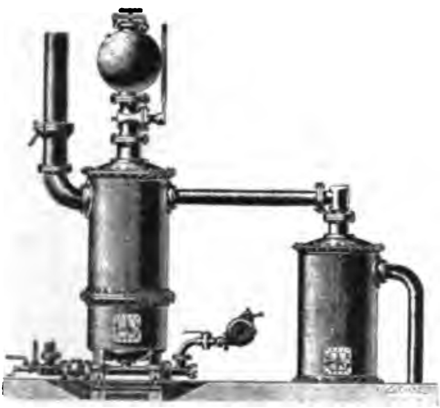


FIG. I.

The compressed air, led to the distributing receiver, S, fitted with the pressure-gauge, K, and safety valve, L, makes its way by the pipe, E, fitted with the stop-cock, G, into the bottom of the producer, mingled with water spray delivered by the injector, p; and a check-valve, q, at the entrance to the producer, prevents any return of the gas generated into the air receiver, the quantity of water being regulated by turning the handle. The gas issuing from the producer is led by the pipe, r, to a dry scrubber, s, for being freed from its dust, and it goes directly from this latter to the motor or furnace, as the case may be, where it is to be utilized.

The chimney, T, is only required for firing up the producer, and when, on the latter being started, the gas burns regularly at the chimney entrance, all the apertures are to be closed and compressed air admitted, when gas will be produced continuously in proportion to the volume of air. Owing to the water spray, the clinker adheres so little to the producer sides that it can be easily removed; and, as the air pressure is constant, the volume and composition of the gas do not vary, so that this producer is especially suited for providing gas to be used directly in motors. It is well adapted for large gas engines, and the floor space occupied by a producer with its accessories for a 500-horse motor does not exceed 10 sq. m. (11 sq. yds.).

Any non-bituminous coal that does not cake and contains less than 8 per cent. of volatile matter, though it may contain as much as 20 per cent. of ash, will serve for this producer; the fuel should be pea or nut size. As the whole of the fuel is turned into gas, the proportion of carbonic acid never exceeds 2 per cent., so that the calorific power is considerable, thus affording the high temperatures required in iron and glass furnaces. This arrangement is also economical, because the fuel is consumed exactly in proportion to requirements, and the production of gas ceases with shutting off the compressed air supply, so that the expenditure of gas can be strictly limited to the work it has to perform.

The use of combustible gases under pressure permits of a slow or quick working of the furnace, as may be required; and the use of compressed air as the supporter of combustion permits of regulating this working, while also affording a reducing, neutral or oxidizing flame, as may be required. A characteristic of the use of gas under pressure is combustion without smoke, an invaluable feature for large towns.

The chemical composition of the gas, on which the calorific power depends, is variable at will between the two limits corresponding with (1) air gas and (2) mixed gas with 15 per cent. of hydrogen, the following being the composition by volume of these two gases:

AIR GAS.	
CO_2	1.86
CO	30.54
CH_4	1.72
H_2	1.70
AZ_2	64.18
	100.00

MIXED GAS.	
CO_2	1.75
CO	30.10
CH_4	1.75
H_2	15.00
AZ_2	51.40
	100.00

The calorific power of the air gas is 1,100 calories per cu. m. (about 125 B. T. U. per cu. ft.) at zero cent. (32 degs. Fahr.) and a pressure of 760 MM. (29 in.), while that of the mixed gas is 1,500 calories per cu. m. (170 B. T. U. per cu. ft.) at the same temperature and pressure. This producer can, therefore, yield a gas the composition and calorific power of which varies between these limits, the composition of the gas being varied according to requirements by suitably proportioning the quantities of air and water introduced into the producer as already explained.

The Gardie gas-producer has been subjected by M. Leroy, the French concessionaire, to several experimental trials, first at a laboratory and afterwards in small works at Ivry-sur-Seine, where it was seen working a 100-horse Charon, driving several lathes, by M. A. Lombard, Ingenieur des Arts et Manufactures, who reported the above particulars to the *Chronique Industrielle,* of Paris, from which the accompanying illustrations have been reproduced. J. W. P.

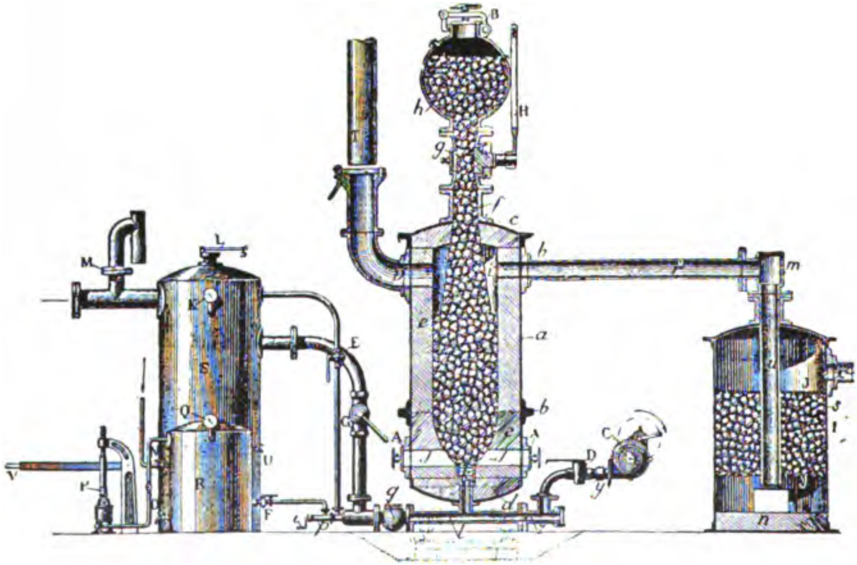


FIG. 2.

Big Rock Blasting in Wales.

Two unusually large blasts took place recently in Wales, one at the Pier Works, Goodwick. Pembrokeshire, and the other at the Welsh Granite Quarries, Trever, Llanaehairn, Carnarvon.

At the Pier, Goodwick, it took nine days to clear away the rock thrown down by the blast, so that some idea can be formed as to the extent of the fall.

Only about 7,000 tons have been cleared away, a very light impression on the mass still to be cleared. According to the original calculations, a piece of rock, 150 feet long, 120 feet high, and 60 feet deep was intended to be removed. This would mean a little over 73,000 tons. But in one direction the blast struck 100 feet further, and it is now calculated that much over 100,000 tons of rock was dislocated. Altogether it may rank as a historic blast.

The Messrs. Treglown, while they show no objection to congratulations on such a feat of engineering, place much of the credit for the successful operation to the excellent powder supplied to them by the Chillworth Powder Company. Without reliable powder the finest calculations are apt to go agley. Another tunnel for a big blast will soon be started on the Wyncliffe Hotel side of the projecting Clogwen, and the blast will take place early in December. We may say that the pier now is 600 feet long, and its grateful shelter is already availed of by coasting vessels.

The other big blast at the Trever Quarries, Carnarvon, brought down some 60,000 tons of rock.

In this blast, six tons five cwts. of black gunpowder were used, placed in two chambers. The length of the two tunnels were 90 feet and 30 feet respectively, and the fuse ignited by electricity. It is said that the quarries have been very active for some time and the men are earning high wages.

One cannot help remarking that in the granite rock blast of the Trever Quarries the heading took nine months to drive, nearly a ton more powder was used and the fall, according to estimates—more or less correct—was less than in the Pier works fall. The one driven by Messrs. Treglown, at Goodwick, occupied about three weeks or a month at most, with but one drilling machine worked by compressed air and two men. Of course, granite is harder than the rock on the pier, but even then there would seem a wide margin. It would have been interesting if the explosion on the "opposite" shore could have been heard on this side.

One huge square lump of rock is estimated to weigh nearly a thousand tons, and will require splitting before it can be tipped into the breakwater. The immense advantage of such a lump, if it were possible to dump it into the sea, is obvious.

Arctic Ice and Cold Storage Company's Compressed Air Pumping Plant.

This plant was installed February 19, 1901, for the purpose of pumping two wells, one eight inches in diameter, 225 feet deep, and the other five inches in diameter, 225 feet deep, water in both wells standing sixteen feet below the surface when not pumped. Prior to the time of installing this air plant both these wells were pumped with two Blake Deep Well Steam Pumps. The size of the pump in the eight-inch well was 9 in. by 24 in. with a 5½ in. working barrel, and the size of the pump in the 5 in. well was 7 in. by 24 in. with a 3½ in. working barrel. Both these pumps running at a speed of fifty-five strokes per minute, furnishing about ninety gallons of water per minute pumped to the surface. The water then was pumped by a duplex steam pump to a tank over their condensers, which necessitated the handling of this water twice from the well to the condensers. An Ingersoll-Sergeant class "A" compressor 12x12¼x14, equipped with a Mason governor and a Pohlé foot piece, is attached to the discharge pipes and wells. The eight-inch well is equipped with a 3½ in. discharge pipe and a 1½ in. air pipe. The five-inch well was equipped with a 2½ in. discharge pipe and a 1¼ in. air line. When the air was first used on these wells, both wells yielded about ninety gallons of water per minute with seventy pounds air pressure and compressors running about seventy revolutions per minute, and water raised to a tank fifty-five feet above surface. This condition lasted for several months, when the chief engineer, Mr. J. C. Ferguson, found upon investigation and test that from the eight-inch well he could get about ninety gallons of water per minute. So far this year number one well has been giving them all the water they require without pumping nmber two well at all. They are now getting from number one well about one hundred gallons of water per minute, compressor running seventy revolutions, at eighty pounds pressure. In connection with pumping these wells they are running seven air fans sixteen inches in diameter, with seven hundred and fifty revolutions per minute. These fans are the electric type fan with the exception that Mr. Ferguson, the chief engineer, equipped them with a wheel something similar to a water wheel, from which the fans derive their power. The size of the opening in the pipe to admit the air to the fan is 3-64 of an inch in diameter. These fans are used to furnish fresh cold air to their storage rooms, where delicate fruits are stored, and also to exhaust the foul air from their rooms. This arrangement accomplishes all that is desired and works very nicely. In connection with their cold storage process, they keep their rooms at a very normal temperature with no evidence whatever of the foul air being in the rooms. In connection with their cold storage plant they also turn out about sixty-five tons of pure ice per day. They also have two ice machines, one a fifty and one a seventy-ton engine.

The class "A" compressor in connection with the eight-inch well furnishes all the water necessary for the condensers, both these machines, and for a coil for cooling water from the condensers. The water from this eight-inch well is delivered to the latter at a temperature of about forty-five degrees.

This plant was started the first of April of this year and has been running night and day without a stop.

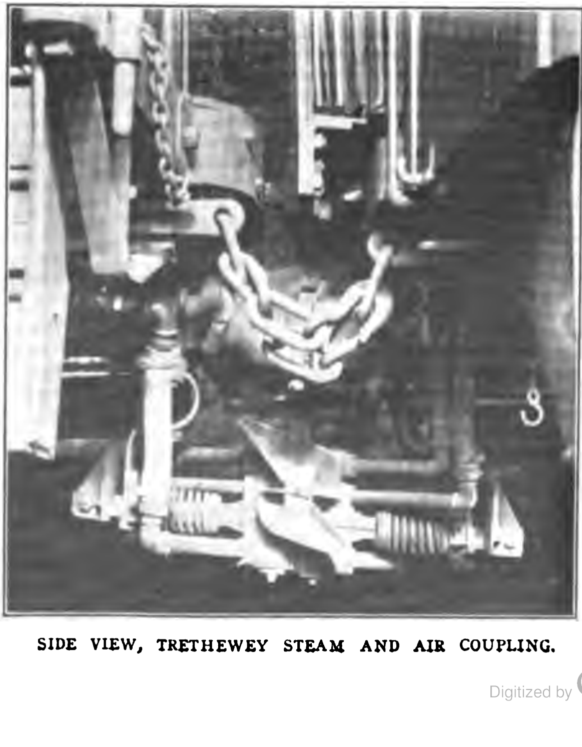
Mr. Ferguson states that he can run this compressor with about one-half of the steam consumption that is required to run the 9x12 Blake Deep Well Pump, at the same time giving about seventy-five per cent. more water.

E. P. Mooney.

The Trethewey Automatic Train-Pipes Coupling.

An automatic coupling for the steam and air lines on trains should be flexible, should maintain tight joints and always be positive in action. The variety of conditions met with in the service to which such a device must be subjected presents numerous obstacles to be overcome in order that the system be successful. An interesting example of one of the most recent of these devices which may be said to be successful is shown in the accompanying engravings. It is the Trethewey coupling, designed by Mr. W. G. Trethewey, of Montreal, Canada, and is now in service on trains on several roads.

The device consists of two castings, a hanger and the necessary pipes for connection to the train pipes. The head is a malleable iron casting having two diagonal guide horns, with a flattened shank at the rear. These heads are cast from one pattern and are, therefore, interchangeable. The flat sides of the shank are placed vertically. The shank projects back through a slot in the hanger and has rigidly at-



SIDE VIEW, TRETHEWEY STEAM AND AIR COUPLING.

tached at the rear end the second casting above referred to. which is a supporting bracket, the form of which may be seen plainly in the engraving. The hanger for supporting the coupling is made of a piece of flat steel ½ x 4½ in. It runs along under the stem of the coupler, from which it is supported by two U-bolts passing around the stem, each carrying on the lower end a slotted yoke, through which the hanger passes. At its forward end the hanger is semi-circularly curved and from the lower side of this curve it drops vertically, the slot through which the flattened shank of the coupling passes being at the lower end of the vertical part. The forward part of this hanger may be seen in the illustrations. Between the hanger and the head is a helical spring which is under compression when the train is coupled up.

END VIEW, TRETHEWEY STEAM AND AIR COUPLING.

The arrangement and application of the device having been explained. the reason for its flexibility in service will be readily understood. Each coupler is supported at but one point—the slot in the hanger. When uncoupled. the shank and head are maintained in horizontal alignment by the supporting bracket on the rear end of the shank. the face of which is held against the hanger by the helical spring. As will be seen from the engraving, when the train is coupled the brackets are forced away from the hangers by the compression of the springs, permitting the heads to move freely in any direction about the points of support.

The arrangement of pipes and hose connections is apparent from the illusrations. Short lengths of pipe are screwed into the heads, extending back to points vertically below the car pipes, or approximately so, and these points are at each side of, and close to the point where the shank passes through the hanger. This arrangement permits the use of short lengths of hose: and the connections to the pipes at the lower ends being near the point around which the head moves, the hose is not disturbed by the motions of the latter.

Referring to the engraving of the end view of the car, the lower opening in the coupler head is the steam duct. This is placed a sufficient distance below the air and signal ducts so that the soft rubber gaskets used in the latter will not suffer impairment from the heat. Provision is made for the introduction of steam pressure back of the steam-joint gaskets to insure their being held tightly together in service. preventing leakage. The steam duct is also provided with an automatic drip valve to carry off condensation and prevent freezing. Arranged in the signal and steam connections are valves which are reciprocally opened by the coming together of the cars so that in switching and making up trains these parts require no attention.

For coupling with cars not equipped with this device a detachable hood is provided having ducts to register with the air and steam ports on the coupling head. At the back of the hood. nipples screwed into the ducts have hand couplings attached, to which latter the usual air and steam couplings may be connected. The device is easily and quickly attached to a car, no changing of parts being necessary. and it is claimed that an entire train can be fitted up in half a day's time.

All of the preliminary trials for testing and improving the device were made on the Canadian Pacific. and that road is so well satisfied with their experience with the device that they have decided to adopt it at once on 100 cars. The Imperial Transcontinental Limited trains of the Canadian Pacific are fitted with these couplings, and we understand that the Delaware & Hudson has three trains so equipped and the Intercolonial of Canada has ordered equipment for ten cars.

The Trethewey Automatic Steam and Air Coupling Co., Limited, Montreal, Canada, Mr. T. A. Trenholme, president, has been formed to place this device on the market.—*Railroad Gazette.*

An Unusual Water Supply Plant.

The town of Arad, in Hungary, derives its supply of water from a gravel stratum underlying an impervious bed of clay. The wells are driven to a depth of about 135 feet and the water is raised by means of an air lift. It is then filtered by means of the Fischer system of plate filters, descriptions of which have appeared from time to time in *The Engineering Record,* passes into a storage reservoir and is then pumped into the town mains by two triple expansion Worthington pumps. Before final distribution the water passes through a large air chamber to equalize the pressure in the various mains. The following description of this plant, which combines so many interesting and unusual features, has been taken mainly from an account of the works published in *Engineering* some time ago.

The wells, of which there are two, 9 inches in diameter, are about 135 feet in depth, and pass through a layer of clay 20 feet thick, the bottom of which is about 63 feet below the surface. Below that point the material passed through is mostly gravel and sand, with a few thin streaks of clay. Each well is capable of delivering 540 imperial gallons per minute, and only one is ordinarily in operation at a time, as that is found to deliver sufficient water for the needs of the town. The supply of compressed air for raising the water is carried down the well by means of a wrought iron tube. The air issuing from the bottom of this tube through a suitably arranged connection, raises the water through the casing of the well into a small cast iron well at the surface. The compressor furnishing air for the lifts has compound steam-jacketed cylinders, two in number, each being 11 inches in diameter, the stroke of all the cylinders being 18 inches. The exhaust steam from the engine is carried to a surface condenser fixed below the floor of the engine house, the circulating water required for the condenser being supplied by connecting thereto the pipe which conveys the water from the cast iron service pipe well to the filters.

The Fischer filter plates were first devised at the city of Worms because the capacity of the sand filtration plant there had been reached and no further extensions could well be made along the old lines. The engineers in charge of the works, noting that the actual work of purification was effected by the top layer of sand, 3 or 4 inches thick, set to work to devise a means of supporting this filtering film in a manner more economical of space than by means of a horizontal bed of sand. Their studies resulted in the production of a hollow artificial stone block about 39 inches square and 8 inches thick, the interior space being about 0.8 foot wide.

These blocks or plates are made of quartz sand carefully washed to free it from clay or earthy matter and then mixed with powdered glass. This mixture is placed in suitable molds and burnt at a temperature of from 1,800 to 2,100 degrees Fahrenheit. By this means the glass is melted and binds the grains of sand together without filling the interstices to an appreciable amount.

In the filter chambers the plates are placed vertically in the water, thus giving a considerable filtering surface, though occupying a small area, and the plates being hollow, the filtered water, which accumulates in the interior, is removed by means of pipes to the filtered water reservoir. The operation of cleaning is effected in the simplest manner in the case of the Fischer plate filters, by reversing the direction of the flow, thus allowing the filtered water to percolate through the plates from the inside to the outside, which is said to clean the surface of the plate in about ten minutes. An installation on the Fischer system, it is stated, only occupies one-eighth of the space required for a sand filter of equal filtering capacity.

In the works at Arad there are four filter chambers with concrete walls and floors, each 27 feet long by 10 feet 2 inches and 12 feet 2 inches deep. They are covered over with brick and concrete arches similar to those used for the filtered water reservoir. Each of the chambers contains 100 filter plates placed on edge in two tiers, each two plates being connected at the top to the horizontal collecting pipes running lengthwise of the chambers. In the inlet chamber an overflow pipe is arranged so that the level of the unfiltered water will not exceed a fixed height. The collecting pipes for the filtered water are connected in a central valve chamber to the force main for the purpose of cleaning the filters. At the other end of the valve chamber are the two outlets into the filtered water reservoir, which is divided into two sections with a total storage capacity of 66,000 imperial gallons.

From the reservoir the water passes through a 12-inch pipe into the pump well sunk in the basement of the engine house, the pumping engine and the air compressors for the air lift being housed in the same room. The water is pumped from the well into the town mains, by means of two triple expansion Worthington pumps, each having six steam-jacketed steam cylinders in three pairs of 6, 9 and 16 inches diameter respectively. The pumps are provided with surface condenser and two double-acting water plungers of 10 inches diameter, all having a uniform stroke of 15 inches. Each pump is capable of delivering 666 imperial gallons of water per minute against a head of 125 feet. From the main pipes the water raised is carried into and through a large air vessel of wrought iron 20 feet high by 5 feet in diameter, for the purpose of equalizing the pressure on the town mains; and, as an additional security, a safety valve is attached to each of the town mains (in duplicate) leading from the air vessel. For the purpose of supplying steam for the steam-engine, the air compressors, and the various pumps, two marine type boilers are provided.

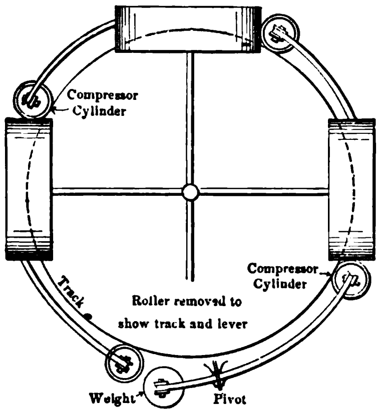
In connection with the compressed air lift an arrangement for intermittent working is used which suits cases like that at Arad, where the supply of water flowing to the well is not sufficient for constant working. Messrs. Hughes & Lancaster, of London, were the engineers and contractors for these works.—*The Engineering Record.*

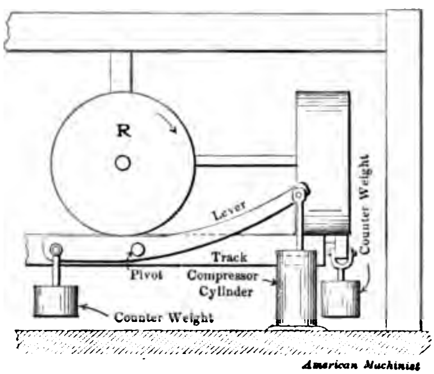
A "Power Multiplying" Air Compressor.

In a small shop in the Middle West, some weeks ago, I found a machine that may interest your readers enough to excuse me for describing it. It was called an "air compressor," but so far as my knowledge of such things goes it stands alone.

Abstract of a letter written to *American Machinist.*

The sketch is intended only to illustrate the principal parts and their general arrangement. The machine consists of a vertical shaft driven by a steam engine, through a suitable arrangement of shafts and bevel gears. This shaft stands in the center of a circular track about 14 feet diameter, and carries four equally spaced radial arms about 2½ feet above the track. These arms each carry on their outer ends





A POWER MULTIPLYING AIR COMPRESSOR.

a huge, cast-iron, cheese-shaped wheel or roller. These rollers rest on the track and are made to move around the central post more by a wondrous arrangement of chains and chain wheels than by the strength of the radial arms. No attempt is made to show the chains, as they are only a minor detail. The rollers are broad enough on the face to overhang the track and act as depressors for the air compressor pistons by over-riding the long lever attached to each piston as shown. When the machine is in motion, the rollers, moving in the direction indicated by the arrow, will each depress a piston and send a charge of compressed air through a suitable system of pipes to a reservoir common to all four cylinders. The counterweight at the short end of the lever returns the piston to its former position, ready to meet the next roller.

What I have already told may seem somewhat novel, but when you are told that the application of 10 horse-power to this machine will give a return of 100 horse-power at the reservoir, I am sure you will admit the machine is unique. On making some inquiry about the wonder, I was told that a real-estate man had put $15,000 into it. Possibly a *real-estate* man can get it out. WM S. ROWELL.

[The device here shown is practically identical with one built a few years ago at Bridgeport, Conn., on a much larger scale, financial and otherwise, which we described and commented upon at the time. As long as the atmosphere endures there will probably be those who can be caught by these something-for-nothing devices for compressing it.—Ed.]—*American Machinist.*

A New Means of Using Compressed Air in the Manufacture of Glassware.

In the production of hollow glass vessels there have always been two obstacles which from time immemorial have very seriously hampered the glass-blower. Of these obstacles, the first is that the inlet opening of the hollow vessel can never be larger than the end of the blowpipe. The second is that the hollow vessel thus produced can never be greater than the volume of air which a strong man can blow through the pipe, or the mass of glass which he can conveniently handle. The first obstacle has been partially, though indifferently, overcome by subsequent reheating and manipulation. By spurting water through his blowpipe, the glass-blower has succeeded in producing fairly large receptacles, for the expansive force of the steam generated assists the air from his lungs. But despite these ingenious makeshifts it has not been possible to blow a glass receptacle larger than a carboy having a capacity of 25 gallons.

Since the glass-blower's lungs have but a limited power, it was but natural that inventors hit upon the idea of employing compressed air. Philip Arbogast, of Pittsburg, as early as 1881, took out a patent for an invention which contemplated the use of compressed air and which has served as a foundation for subsequent attempts. But although compressed air has been widely employed in the manufacture of certain articles, it has never supplanted the human glass blower, particularly in the making of large receptacles.

A German inventor, Paul T. Sievert, now comes to the fore with a process that bids fair to solve the problem of blowing large vessels and overcoming the difficulties which have hitherto baffled the glass manufacturer. By means of this new process vessels varying in size and shape from the tiniest watch-glass to the largest bath-tub can be blown with a facility which has never been hitherto attained. That the Sievert process is capable of fulfilling these claims has been clearly shown. Many of these vessels can be completely blown without any subsequent grinding or cutting. The time in which these receptacles are made is almost incredible. The production of a bath-tub is a matter of not more than five minutes. Several days in the cooling oven is, however, still required before the tub is ready for use. Moreover, the process of making these vessels is singularly clean. No rubbish heap of broken glass is to be seen anywhere in the Sievert plant in Dresden.

The apparatus employed, by which glass is blown into pots and tubs of any size, consists of a thick, perforated cast-iron plate having the form of the opening of the tub to be produced. On the raised margin of the plate a separable frame is placed, held in position by locking-levers, which frame serves the purpose of confining the outer edge of the glass mass within the limits of the cast-iron plate. The combined plate and frame are mounted on a hollow shaft, journaled in suitable bearings and arranged to turn. By means of the hollow shaft and the perforated iron plate, compressed air can be forced into the molten glass. From a ladle suspended from a traveling-crane a sufficient quantity of molten glass is poured on the iron plate.

The liquid glass flows over the entire

plate and beneath the superposed frame surrounding the plate. Since the metal cools more rapidly at the margin. the glass begins to congeal and stiffen first at its outer edge. When this marginal rigidity has been reached, the entire plate and frame is turned through a half circle. The glass lies on the plate in a smooth, glittering layer. It is still hot, but not self-luminous; and for that reason its color is black in our pictures.

The glass no longer rests on the plate, but hangs therefrom, supported by the chilled and now rigid outer edge. But the central portion being still ductile and plastic begins to sink. In order that the glass may thus fall uniformly throughout its mass, a bed-plate, operated by rack-and-pinion and a chain-gear, is brought into contact with the slowly sinking bag of plastic glass. Upon this bed the glass spreads and forms the bottom of the tub.

By allowing the bed to fall slightly the glass is pulled down and the walls of the tub formed. The glass has become cool and tough by this time. Through the hollow shaft and the perforated iron plate compressed air is now forced into the forming tub, the operator so controlling the current that the tub's walls can be given any inclination. When the tub has been given the desired form the air blast is cut off.

In order to release the finished tub from the perforated iron plate the parts of the superposed frame (now, however, located beneath the plate) are separated by means of the levers previously mentioned; the bed is allowed to descend still further; and the finished bath-tub, rigid, though still hot, is liberated from the grip of the frame and iron plate. The hot glass tub is now hauled on a cart to a cooling oven.

In exactly the same manner a glass receptacle of any size or shape can be blown. The weight of the plastic mass is no longer a hindrance to the glass-blower; it is even utilized in the production of the finished product.

The Sievert process is not limited to the making of pots, trays, tubs, bottles, and like utensils. It seems destined to have no small influence on our methods of making plate-glass. From the recent articles which have appeared in the *Scientific American,* our readers will understand that the window-glass which we employ is rolled out and then polished. Herr Sievert, however, intends to dispense with all rolling machinery and to blow his plate very much as he blows his bath-tubs and pots. So far as we are at present informed two methods are pursued in blowing plate glass.

The first of these methods consists in blowing a cylinder after the manner previously described; in allowing this cylinder to cool; in cutting it lengthwise into two parts and severing the bottom from the body; and in causing these severed portions to flatten into plates by the application of heat. The second of these methods consists in blowing glass into the form of a huge box by means of a cubical mold and in breaking away the five plates formed by the bottom and sides. This box represents a gigantic bubble of glass 4 feet high and 5 feet wide, the thickness of the walls being somewhat more than one-tenth of an inch.

Although the Sievert process can be followed in blowing all kinds of receptacles, it is found in actual practice in the making of small utensils that the glass chills too quickly to be blown into shape. Another method has, therefore, been devised no less ingenious than the first.

We all know that a drop of water that has fallen upon a hot object—a stove, a glowing sheet of glass—does not come in contact with the hot surface, for the reason that it is buoyed up by a cushion of vapor. Nor does the drop boil rapidly away. It is slowly converted into steam and then gradually disappears. This "caloric paradox," as it is sometimes called by physicists, is profitably employed by the glass-blower; for, the water does not cause the glass to crack, and generates enough steam to assist in expanding the vessel at the end of the blow-pipe. Upon the same phenomenon Herr Sievert bases his method of forming small glass utensils, reversing it, however, by placing his hot glass on a layer of water instead of blowing water into his hot glass.

In order to make a developing tray such as every photographer uses, very hot and therefore very liquid glass is poured on a sheet of wet blotting paper. The glass does not touch the paper, does not even scorch it, but dances on the wet surface as it flows in all directions. By means of a wet roller, such as every housewife uses in flattening dough, the glowing mass is distributed evenly in a thin layer. The plate thus formed is lifted with a pair of tongs and laid on a sheet of wet asbestos upon which it still continues to dance. Upon the plastic plate a mold of the tray to be produced is then placed. The steam generated, which is the cause of the restlessness of the plate, then forces the plastic mass up into the mold. The tray is finished. And thus it is possible to produce a glass vessel of any shape whatever.—*Scientific American.*

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Joplin, Mo., Sept. 22.

Editor COMPRESSED AIR, New York:

Dear Sir: I read with much interest your editorial on the "Abuse in the Use of Compressed Air," which appeared in the September number of your magazine. Thinking it would interest you, I call your attention to a similar case which recently occurred in the Joplin lead and zinc district of Southwest Missouri.

In a lead and zinc mine operated by Col. Thomas J. Steers several years ago, all of the drill runners were strong, well-built men, and high-grade machine runners, having had considerable experience in mine and tunnel work throughout the country. The rock was a very hard blue flint and as a rule the drilling was done without water. After three years of hard and constant work some of the men had to give up, owing to weakness, accompanied by a slight cough. It was soon noticed that all the men were affected in the same way, and within eighteen months twelve of them died with the same disease (said to be miner's consumption, brought on by flint dust in the lungs). This case was particularly noticeable owing to the fact that all of the men were employed as drill runners in the same mine and were above the average in physical health and strength. Yours truly,

A. A. BONSACK.

Notes.

In compressing air to high pressure, so much heat is generated that, without suitable means of cooling the cylinders an explosion of the oil used to lubricate the compressor is possible.

The Philadelphia & Reading is to install a new interlocking plant of 36 levers at Norristown, Pa., and one of 56 levers at Bridgeport, Pa. In both cases the contract is given to the Pneumatic Signal Company, of New York and Chicago.

J. G. Slatter, 68 Victoria street, London, S. W., has patented a device which consists in propelling a vehicle by pneumatic transmission and employing any suitable form of combustion engine to compress air, which is used to work an expansion engine propelling the vehicle.

Messrs. Manning, Maxwell & Moore, 85-89 Liberty street, New York, are building new shops at Plainfield, N. J., which will be devoted to the building of an entire line of compressed air machinery, consisting of air compressors, pneumatic hoists and railroad tools. The principal machine shop will be 100x500 ft.

Chas. G. Eckstein of Berlin, Germany, Importer of American Machinery, especially pneumatic tools, has arrived in this country for a short visit. Domestic Manufacturers in the machinery line, who wish to communicate with Mr. Eckstein on business matters, should write to his New York office, 249 Centre Street.

News from Summitville, Ind., informs us that despite the recent decision of Judge Ryan enjoining the Richmond Gas Company from using compressors or any machinery for forcing gas pressure, the big pumping station of the Consumers' Trust Company of Indianapolis, is active. The station has two big compressors driven by gas engines, and every preparation has been made for the winter.

The North-Eastern Railway Company at Tyne Dock have installed an electro-pneumatic signalling system by Messrs. McKenzie and Holland. It consists of two electro-pneumatic frames, one of 71 levers and the other of 35 levers, and it is estimated that if the old style of mechanical locking had been adopted a cabin containing not less than 259 levers would have been required.

The compressed air water-lifting system carried out by B. A. Well Works, 145 Queen Victoria street, London, is now used by a large London brewery. Just fancy! No pump or pump rods, no valves, no machinery down within 25 feet of bottom of well or in any portion of the well. All machinery is on the surface, and that consists only of an air compressor. The only things below the surface are the rising main and the pipe for compressed air.

Lecturing before the French Society a few nights ago on the adaptability of liquefied air to navigable balloons. M. Georges Claude gave it as his opinion that it can never be used for purposes of locomotion. According to a report, M. Claude finds that 20 lbs. of liquefied air only achieve results that can be secured by one lb. of petroleum. It can be used, however, for inhalation at high altitudes. and for enabling specimens of the upper atmosphere to be secured for subsequent analysis.

Coal gas is explosive when mixed with air in the proportion of one volume of gas to sixteen of air, this being the inferior limit at which combustion will take place when the gases are fired at atmospheric pressure. Any proportion between this and one volume of gas to four of air may be ignited at atmospheric pressure. The best mixture to use in an engine is about ten to one of gas, though this is necessarily subject to variation on account of the different qualities of gas produced from coals of different grades.

In the Galena-Joplin lead and zinc district power drills are largely taking the place of hand drills, but as they are as a rule operated by steam instead of air, considerable inconvenience and trouble are experienced in their use. When a mine is large enough or is connected with a mill, and an air plant is installed, the most satisfactory results are obtained. As the formation is so extremely variable in hardness, it is difficult to give an average speed, but a range of from 3 to 6 feet per hour is common for a hole 1¼ inches in diameter.

At the convention of the American Electro-Chemical Society, held at Niagara Falls, Sept. 15, the question arose as to the proper system of pumping liquids, or, more broadly, that of handling and treating liquids. It is a simple one in general, but becomes a very difficult one in the case of electrolytic work. A number of the gentlemen present advocated the air-lift system for handling liquids such as described. It was said to be of almost universal applicability, and to be of particular value when the aeration and resulting oxidation of the solution is advantageous.

What will they not use compressed air for next? Here is a fire brigade in Southwark Bridge Road, London, with a new fire ladder. The appliance, consisting of a three-section light, telescopic steel ladder, which in less than a minute can be raised to a vertical position of eighty feet. The motive power is carbonic acid gas, mixed with compressed air, stored in cylinders. The total length of the appliance when lowered down is 26 feet. The machine was manufactured in Frankfort, by a German artillery captain (who is now chief inspector of the city police) and was manipulated with great success by two firemen after they had only received ten minutes' instruction.

A contract has just been signed between the British Pneumatic Railway Signal Company Limited and the London and South-Western Railway Company, whereby automatic and power signalling will be installed on the company's main line between Woking and Basingstoke—a distance of twenty-four miles. The installation contracted for includes eight pneumatic interlocking plants, averaging seventy levers each, and thirty-one sets of automatic signals to be erected on bridges spanning the four tracks of the railway. The basis of the installation is to divide the line between the points named into 1,000 yards sections, thus more than trebling the number of sections now existing.

A pneumatic rock scraper is an appliance in use on a gold dredger. The dredger on which it is used consists of three pontoons, instead of two, so that two wells are provided. One well accommodates the bucket ladder, the other the pneumatic scraper. The apparatus consists of an iron tunnel, swinging upon an axle, which allows the lower end of the tunnel to be raised or lowered at will down to a depth of 65 feet. The tube is let down flush onto the bottom after the buckets have done their work, and the water is then expelled by pneumatic pressure. Men can then enter the tunnel and work at the bottom, scraping out the cavities in the rock which can not be reached by the buckets.

The engineering department of the North British Railway Company have made a vast improvement of late in their Cowlairs locomotive work-shops in connection with the use of compressed air for hand-drilling the sides of the locomotives and other pieces of machinery. The air is forced into a tall receiver, from which it is delivered under pressure to suitable spots by two-inch and one-inch pipes, which are eventually connected up to the drilling machine, the working of which is done by two workmen. Each of these drilling machines does the work of at least six skilled workmen. The friction caused by the long carriage of the air does not seem to diminish the drilling power to any material extent. The drilling machine is an American invention.

In speaking of the capacity of a certain compressed air plant as being equivalent to forty drills, this power is true of the machinery only at sea level. The altitude of Rossland, B. C., being 3410 feet above sea level, means the pressure of the atmosphere is not equivalent to a column of mercury 30 inches in height, but to one of something less than 27 inches, hence the mechanical power of the engine has first to overcome this greater tenuity of the air before it can begin to compress the atmosphere to a greater density, so as to develop power at the drills employed. The size of the drills also makes a difference. The power of a compressor at sea level and calculated to work steels 2½ inches in diameter, which can be expressed at forty drills, would in Rossland, at a higher level, with a larger drill, be better expressed by a 22 per cent. reduction.

The Sandycroft Foundry Co.'s air compressor is an electrically-driven air compressor, has cylinders 8 in. diameter by 12 in. stroke, and is running at 110 revolutions per minute. It is fitted with "Daw" patent balanced valve gear, in which the valves are controlled and balanced by the fluid pressure, thus enabling the compressor to be run at a high speed with a minimum of wear and tear. The compressor is fitted with an automatic unloading device, by which, when the receiver pressure reaches any desired limit, the piston of the compressor is put into equilibrium and the compressor runs light until the pressure falls, when compression recommences. The motor is of the four-pole semi-enclosed type, capable of developing 14 h. p. at five hundred revolutions per minute. It is supplied with current at a pressure of five hundred volts. The enclosed starting switch used with this motor is a new type of liquid switch recently introduced by the Sandycroft Foundry Co., Limited, of Chester, who exhibit this compressor. The makers state that practically no evaporation of the liquid takes place, and that sparking is impossible. It is provided with "no voltage" and "overload" automatic releases.

Solomon says there is "nothing new under the sun," but then Solomon did not live in 1902. A new hose coupling has been put on the London market by Lacy-Hulbert & Co., which firm make a specialty of designing and contracting for compressed air installations. They claim that in the "Boreas" coupling, as it is called, the hose is so firmly compressed that air or liquid under pressure cannot enter between the layers of the fabric and so cannot disintegrate the hose. The construction and action are as follows: A nipple (provided either with a plain screwed end or with a union nut) is inserted in the end of the hose; this end is surrounded by a conical bush, split into four segments, and contained in a conical sleeve, which is provided with a bellmouth of appropriate radius. By screwing up the nut, the cone, and through it the end of the hose, is compressed on the nipple, and is thus securely held in position. The bellmouth, it is claimed, prevents abrupt bends and the consequent damage to the hose. The coupling is made in sizes to fit hose of from ⅞-in. to 1¾ in. external diameter.

It has been known for some time that experiments have been proceeding with a view to the adoption of pneumatic tools on British men-of-war. We are now in a position to announce that the order for the first complete installation for this purpose has been intrusted to the International Pneumatic Tool Company of London, whose works are at Chippenham. The plant is shortly to be placed on board H. M. S. "Assistance," which it is intended shall act as a workshop to the fleet in time of peace, and it is being fitted up with this object. The installation, so we gather, is to consist of a motor-driven air compressor, drills and hammers of various types, air receiver, piping, etc., all designed for the special conditions under which they will have to work, and so arranged that they will be available for use within a few moments of switching on the motor. The whole idea reflects great credit on the Admiralty, for such a repair ship as it is evidently intended to make the "Assistance" should prove of immense value, particularly during manœuvres. The addition of a pneumatic tool installation should greatly add to its effectiveness, for it will enable work to be carried out in places otherwise inaccessible. There is every indication that pneumatic tools have a wide field of usefulness on board ship—not only on warships, both in times of peace and war, but also in the mercantile marine.

We are all tunnel mad, there is no doubt about it; here they are turning up everywhere. The one in Chicago built 40 feet below the surface of the street, has been making great progress.

All this work of excavating and forming has been done under an air pressure of 10 pounds to the square inch, this pressure serving to hold back the water, at the same time making a perfect setting for the concrete. Air compressors and reservoirs were installed at each shaft, and a system of perfect air locks was placed at the bottom of each shaft and at the mouth of the tunnels leading therefrom. The construction of these air locks, whereby material could be admitted to the tunnels or taken out without disturbing the pressure, is familiar to our readers.

The construction work has been remarkably successful. A walk of hours can be made through the tunnels without any inconvenience. The walls are clean and white, with a perfectly smooth surface, and the air is pure and wholesome.

Three million dollars have already been expended, and seven millions more will be spent in completing the work. The enterprise has now progressed so far that a slope, which has its mouth on the river near Congress street, will be used for the removal of all excavated clay. There it is dumped into scows and towed away by tugs.

Advantages of Compressed Air.—1. It can be taken by pipes to any point and used there expansively, just the same as steam, and in the same engines.

2. The pipes and the air are cool and the air loses practically nothing by transmission, except by leakage and a slight drop of pressure from friction in transit.

3. The exhaust is cold, invisible and wholesome, being free air at a low temperature, which may be much below freezing point; a welcome help to ventilation.

4. The engines, being cool, are easy to lubricate and to handle.

5. The air does not corrode the pipes internally.

6. No part of the compressing plant need be in the pit—in fact, it is almost always on the bank.

7. The cost of it can be kept down easily to that of steam as a motive power if properly installed.

For a moment let us see how this compares with steam, electric or hydraulic power.

Steam requires boilers, usually below ground. These introduce heat where it is already too hot, the steam pipes and motors are hot, their exhaust is a cloud of hot steam, slow in dispersing and condensing; in fact, impossible to use in detail in the headings and roads for haulage and pumping. Steam engines are, therefore, only usable near the upcast shaft where the heat and exhaust can be got rid of.—*Coal and Iron Trade Review.*

The Batcheller Pneumatic Tube Co., of Philadelphia, has submitted proposals to the French government for equipping Paris and other large French cities with underground pneumatic conduits for intramural transmission of mails. After some days' consideration the minister of posts and telegraphs appointed a technical commission to investigate the project. The correspondent is assured that the commission is already disposed to report favorably regarding the idea as likely to obviate the delay and inconvenience caused by mail wagons in the congested thoroughfares of the citv. The commission is already greatly impressed by the fact that the new system promises a greatly accelerated service such as has been long desired in Paris. One of the strongest arguments laid before the commission is the discovery that the complicated underground electric railway in Paris has not proved a solution of the difficulty, as was hoped, since it is too slow and necessitates too frequent loadings and unloadings. Should the Batcheller plan be adopted, however, the Metropolitan underground line would be utilized for the passage of tubes. The commission asked for details regarding the success of the system, which is now working in several American cities. The company has sent a representative to Berlin and St. Petersburg, where it has been asked to explain the system with a view to its adoption for government use.

At the works of the American Steel Hoop Company much trouble was found in handling long lengths and in getting the pieces fast enough from the mills. The pulling out by boys limited the length of the pieces, the speed of the mills and thereby the product, and on hot days the boys sometimes refused to work. The roller conveyors, of which a number of different types were tried, while better than pulling out by hand, necessitated frequent repairs and stoppages, worked too slow, and were unfit for long lengths. These troubles were overcome by the Vollkommer pneumatic conveyors, which were a success from the beginning. A pneumatic conveyor 375 feet long was installed at a cost of less than £1,000, against a roller conveyor system offered for £5,000. At present the American Steel Hoop Company have eight pneumatics in operation and more under construction. The principle of operation of the conveyor is very simple.

Air from a fan at low pressure is driven into a conduit, or air box, from whence it escapes through the air ports in the running plate or face of the conveyor, forming an air cushion on which the strips float without friction. Theoretically for each 1-8 inch thickness of plate a pressure of 1 1-8 ounces is required; in practice, however, a small excess of pressure is needed, the more the narrower the strips are. It will easily be understood that they will work still more economically on wider material than on narrow band iron, where the air can easily escape sideways. In most cases the running groove was laid into the level of the mill floor instead of having it raised, and one can walk or drive over it when it is in operation. It also does not obstruct the mill for rolling other shapes, as bars, rounds, etc., which may be run out in the same groove without air pressure. The American Steel Hoop Company have acquired the right for sizes up to 8 inches, while Mr. T. J. Vollkommer, the patentee, of Pittsburg, has still the right for wider sizes.

The past few decades of this country's history has been replete with wonderful enterprises and the advances made in architectural and mechanical lines alone has been almost phenomenal, owing principally to the numerous labor-saving devices which have been and are continually being originated in the fertile minds of inventors and by them placed on the market for the mutual benefit of humanity and, in most cases, themselves also.

Among these inventions one which has proven of vital importance to the mechanical world in general, is the use of compressed air as a motive power and in connection therewith the various pneumatic appliances, such as drills, hammers, riveters, hoists, etc., which now with but slight effort do the larger portion of the work which was formerly slowly and with infinite labor performed by hand. Even the most skeptical would be convinced of this fact should they visit any of our principal shipyards, foundries or railroad shops and observe the methods of reaming, caulking, tapping, chipping, drilling, riveting, hoisting, etc., now in use and contrast them with the laborious hand methods formerly in practice.

In this connection one fact is brought prominently to mind, and that is—to invent and patent an idea is one thing and to secure the confidence of the public at large and force them to see the benefit to be derived from a practical use of this invention is another; and while, of course, great credit must be given the inventor and originator of the pneumatic tool idea, yet to those whose energy and untiring efforts have brought these tools into prominence and caused the general public to become familiar with the benefit and advantages to be derived from their use, just credit must also be given, and undoubtedly the Chicago Pneumatic Tool Company, whose recent European negotiations have again brought them into public prominence, deserve the wonderful success which has fallen to their lot.

The career of this company has indeed been attended with astonishing results. Commencing, as they did, at the very foot of the ladder, they have risen with rapid strides until to-day they practically control the pneumatic tool business of the entire world and have also gained the goodwill of all concerned by their fair and impartial methods of doing business.

U. S. PATENTS GRANTED AUG. 1902.

Specially prepared for COMPRESSED AIR.

706,004. PNEUMATIC MOTOR. Gustaf B. Anderson, Chicago, Ill. Filed Aug. 2, 1901. Serial No. 70,607.

The combination with a casing having a central opening and air passages and chambers communicating therewith, of valves to open and close said passages, two bellows located in said opening, means to inflate and deflate a portion of each of the bellows alternately, a power wheel or pulley journaled near the casing and means connecting the pulley and bellows whereby the pulley is rotated, substantially as described.

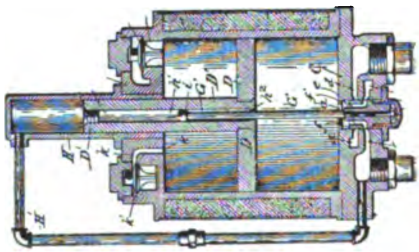
706,021. DEVICE FOR INFLATING PNEUMATIC TIRES. Frederick W. Claesgens and John G. Magin, Rochester, N. Y., assignors of one-third to George A. Claesgens, Rochester, N. Y. Filed Feb. 15, 1902. Serial No. 94,280.

706,037. PNEUMATIC STACKER. John H. Elward, Pretty Prairie, Kans., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Original application filed Jan. 5, 1898. Serial No. 457,328. Divided and this application filed Dec. 9, 1901. Serial No. 85,253.

706,050. MIXING-VALVE FOR GAS OR GASOLENE ENGINES. Roy E. Hardy, Detroit, Mich., assignor, by mesne assignments, to Hardy Motor Works, Limited, Port Huron, Mich., a Corporation of Michigan. Filed May 6, 1901. Serial No. 58,864.

706,252. AIR-BRAKE. Frank A. McKelvey, Knoxville, Pa. Filed June 17, 1901. Serial No. 64,881.

706,276. COMPRESSOR. John Stumpf, Berlin, Germany. Filed May 9, 1901. Serial No. 59,514.



In a steam actuated aeriform-fluid compressor, the combination of a single cylinder forming both the steam-chamber and the compression-chamber, a piston working in the cylinder exposed on one side to the steam and performing on its other side the work of compression, a steam inlet and outlet slide-valve, means for positively moving the valve consisting of a stem connected at one end to the valve and provided at its other end with a shoulder, said stem being movable in a chamber in the piston, a shoulder at the lower end of the chamber adapted in the upward movement of the piston to engage the shoulder on the stem to close the valve, a shoulder at the upper end of the chamber adapted in the downward movement of the piston to engage the end of the stem to open the valve, and piston-returning means opposing the force of the piston-moving means.

706,291. SYSTEM AND APPARATUS FOR TRANSMITTING CARRIERS IN PNEUMATIC-DESPATCH TUBES. Birney C. Batcheller, Philadelphia, Pa. Filed Nov. 3, 1899. Serial No. 735,652.

706,293. PNEUMATIC TREAD OR TIRE. Frank L. Beamond, Sutton-Coldfield, England. Filed Oct. 11, 1901. Renewed July 9, 1902. Serial No. 114,961.

706,363. AIR-BRAKE ATTACHMENT. Arthur L. Tibbits, Chicago, Ill. Filed Nov. 15, 1901. Serial No. 82,432.

706,425. HOT-AIR PUMPING-ENGINE. John T. Lally and James J. English, Wilmington, Del. Filed Jan. 28, 1902. Serial No. 91,590.

706,454. CARBURETER. Clark Robinson, Hartley, Iowa. Filed Jan. 27, 1902. Serial No. 91,436.

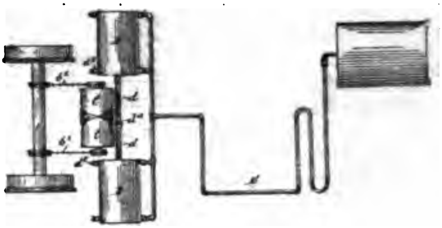
A carbureting apparatus comprising in its construction a chamber containing carbureting-tanks, means for introducing air into one of said tanks, a hydrocarbon-liquid reservoir, a pipe for conducting a supply of the hydrocarbon liquid to the aforesaid chamber, devices for controlling the supply, and apertures in the walls of the carbureting-tank for permitting the liquid to flow from the aforesaid chamber into the carbureting-tanks, substantially as and for the purpose set forth.

706,574. PNEUMATIC PIANO-PLAYER. Samuel B. Locklin, Boston, Mass. Filed Aug. 10, 1901. Serial No. 71,595.

In an automatic piano-player, a series of fingers adapted to operate the keys of the piano, and automatic finger-operating mechanism, each of said fingers having integral therewith a yieldable projection carrying a hammer, and an adjusting device in the end of each finger constructed to adjust the said projection relative to the finger.

706,639. PNEUMATIC-DESPATCH APPARATUS. James T. Cowley, Lowell, Mass., assignor to the American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Nov. 27, 1899. Renewed Dec. 14, 1901. Serial No. 85,912.

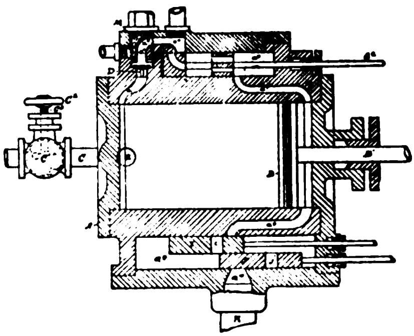
706,653. MEANS FOR UTILIZING COMPRESSED AIR. Eugene Hayward, Chicago, Ill., assignor of two-thirds to John T. Lueder and John B. Morris, Chicago, Ill. Filed Feb. 15, 1901. Serial No. 47,490.



The combination with a boiler of an air-compressor, means for operating the same, a metal-cased pipe located transversely in the fire-box and leading into the dome of the boiler and adapted to deliver thereinto heated and compressed atmospheric air.

706,716. PNEUMATIC MALTING-KILN. Bernard Berg, San Francisco, Cal. Filed Dec. 30, 1901. Serial No. 87,746.

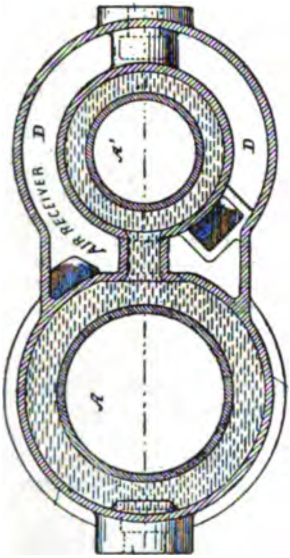
706,871. AIR-COMPRESSOR. George H. Abrams, Brooklyn, N. Y. Filed May 15, 1896. Serial No. 591,641.



In a combined air compressor and expander, the combination of a cylinder and piston for compressing air to a high tension, an outlet therefrom adapted for connection with a suitable cooling device, an inlet thereto adapted to receive the air upon its return from said cooling device, means whereby the compressed air may expand in the rear of the piston, and suitable means whereby the air first compressed may be led directly to the rear of the piston instead of first passing through a cooling device, substantially as described.

706,944. PNEUMATIC-TIRE VALVE. Harold W. Hodgetts, New Haven, Conn., assignor of one-half to William J. Hodgetts, Wallingford, Conn. Filed Dec. 28, 1901. Serial No. 86,882.

706,979. COMPOUND AIR-COMPRESSOR. George E. Martin, Philadelphia, Pa., assignor to the Pedrick and Ayer Company, Philadelphia, Pa. Filed Aug. 15, 1901. Serial No. 72,115.



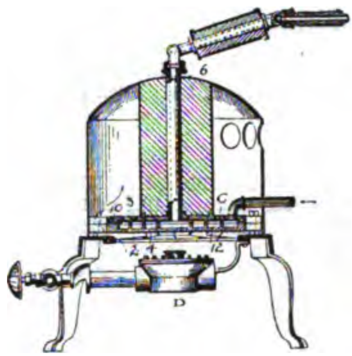
A compound air-compressor provided with an air-receiver intermediate of and adjacent to the respective compression-cylinders having its inner wall in contact with the circulating water-jackets of said cylinders, and cooling-jackets inclosing the connecting air-spaces, whereby the air is in contact with cooled surfaces during the entire period of its passage, as set forth.

707,053. AIR-FEEDING DEVICE. William D. Douglas, Chicago, Ill. Filed Mar. 5, 1902. Serial No. 96,846.

In an air-feeding device, the combination with a casing having a plurality of openings in its walls, of an outwardly and downwardly projecting collar or piece located thereon above said openings, and a skeleton frame located on the lower portion of the casing, substantially as described.

707,071. PNEUMATIC TIME-LOCK FOR PNEUMATIC-TUBE SYSTEMS. Birney C. Batcheller, Philadelphia, Pa. Filed Oct. 11, 1900. Serial No. 32,681.

707,111. COMPRESSED-AIR-HEATING APPARATUS. George W. Hopkins, Cleveland, Ohio, assignor to the Terry Heater Company, Cincinnati, Ohio, a Corporation. Filed Apr. 10, 1902. Serial No. 102,198.



In a compressed-air-heating apparatus, a hollow air-confining member having inlet and outlet pipes, a delivery-tube for the air connected with said outlet-pipe and comprising jointed sections, a discharge-tip of non-heat-radiating material at the end of said delivery-tube, and means to heat the air in its passage through said hollow member, substantially as described.

707,134. APPARATUS FOR CLEANING AIR FROM SAND-BLAST APPARATUS. Jeremiah E. Mathewson, Broad Heath, near Manchester, England, assignor, by mesne assignments, to Benjamin C. Tilghman, Jr., and Richard Tilghman, trading as The Firm of B. C. & R. A. Tilghman, Philadelphia, Pa. Filed Sept. 20, 1901. Serial No. 75,743.

The combination with a sand-blast plant and an exhaust-conduit pipe leading from said plant and adapted to draw dust-ladened air from said locality, of an exhaust-fan coupled to said conduit and a nozzle arranged to throw a jet or jets of water upon the rotating blades of the fan, whereby said water is finally divided and thoroughly mixed with the dust-ladened air.

707,246. PNEUMATIC POWER-HAMMER. Harold F. Massey, Withington, England. Filed Mar. 1, 1901. Serial No. 49,384.

In a pneumatic power-hammer the combination of a pump-cylinder and a hammer-cylinder with passages to connect the two ends of the one with the two ends of the other and furnished with openings to be opened more or less or closed in order to regulate the flow of air between such cylinders.

707,437. HOT-AIR FURNACE. Thomas J. March, Pottstown, Pa. Filed Feb. 5, 1902. Serial No. 92,729.

707,515. PNEUMATIC HAMMER. Henry J. Kimman, Chicago, Ill., assignor to the Chicago Pneumatic Tool Company, Trenton, N. J., a Corporation of New Jersey. Filed June 24, 1901. Renewed July 19, 1902. Serial No. 116,243.

In a tool of the class described, the combination of a cylinder provided with a reciprocating piston-hammer, a handle-base provided with a cylindrical projection extending into the rear end of the cylinder to close the same and provide an annular valve-chamber between it and the cylinder, and a tubular controlling-valve reciprocatingly mounted in such valve-chamber to govern the admission of the motive fluid to the cylinder, substantially as described.

707,527. SAND-BLAST APPARATUS. Ambrose G. Warren, Philadelphia, Pa., assignor of one-half to J. W. Paxson Company, Philadelphia, Pa., a Corporation. Filed Apr. 1, 1902. Serial No. 100,905.

A sand-blast apparatus comprising a closed casing or reservoir, having a substantially cone-shaped hopper-base, a sand-discharge opening therein, a communicating tubular sand-conduit leading therefrom to a combining-tube, a hand-hole opening in the inclined wall of the conical hopper contiguous to said discharge-opening therein, and a removable cover therefor; said elements being constructed, combined and operating, substantially as set forth.

12,022. PNEUMATIC STACKER. John H. Elward, Hutchinson, Kans., assignor, direct and mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed May 5, 1902. Serial No. 105, 917. Original No. 688,400, dated Dec. 10, 1901.

707,634. VESSEL FOR HOLDING AND SHIPPING LIQUID AIR OR OTHER LIQUID GASES. James F. Place, Glenridge, N. J. Filed Feb. 10, 1902. Serial No. 93,289.

In a receptacle or container for liquid air or other liquefied gas, comprising an inner liquid-holding bottle or vessel and an outer case; an air-tight covering or impervious inclosure inclosing said receptacle, one part of which is infolded within itself in form of a cul-de-sac, and which serves as a lining to the inner liquid-holding bottle, and the other part or fold of which incloses a vacuum jacket or chamber around said liquid-holding bottle or vessel, substantially as shown and described.

707,661. PNEUMATIC TIRE. Moritz Weiss, Vienna, Austria, Hungary. Filed May 14, 1902. Serial No. 107,309.

707,821. AIR-PUMP. Theodore N. Case, Mount Vernon, N. Y. Filed Dec. 4, 1901. Serial No. 84,598.

In an air-pump the combination of a pumping-cylinder, a pumping-piston therein, a governor air-chamber, a connection between said pumping-cylinder and said governor air-chamber and positively-actuated means for opening said connection just prior to the opening of the pumping-cylinder discharge-ports and maintaining it closed at all other times, said means being independent of said pumping-piston.

707,911. COMBUSTION APPARATUS FOR STEAM-BOILERS. Joseph R. Fraser, Dayton, Ohio. Filed Oct. 24, 1901. Serial No. 79,828.

The combination with a steam-boiler, of the furnace attachment described, the same comprising an air-compressor, an oil-tank having a pipe extending thereinto, an air-pipe connecting the tank with the compressor, whereby air-pressure is applied upon the surface of the oil, a combustion-chamber, or fire-box, extending into the boiler and opening below the normal water-level therein, an air-pipe arranged in the fire-box, and an oil-pipe within the air-pipe, both having nozzles, located in the upper portion of the combustion-chamber, which are provided with coincident end openings for escape of air and oil, and an electrical igniting device arranged in the combustion-chamber directly below the air-pipe, where the oil is atomized, substantially as shown and described.

707,920. PNEUMATIC HAMMER. Charles H. Haeseler, Philadelphia, Pa. Filed June 20, 1901. Serial No. 65,342.

In a pneumatic-hammer, the combination of a handle provided with a cylindrical portion having an internal screw-thread and a larger portion having an internal screw-thread of the opposite pitch, with a cylinder having a screw-threaded end adapted to engage the smaller screw-thread in the handle, and a nut adapted to engage the larger screw-thread in the handle.

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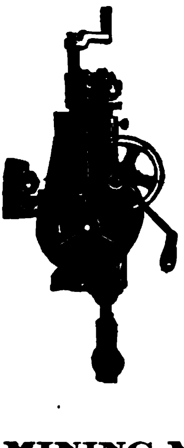

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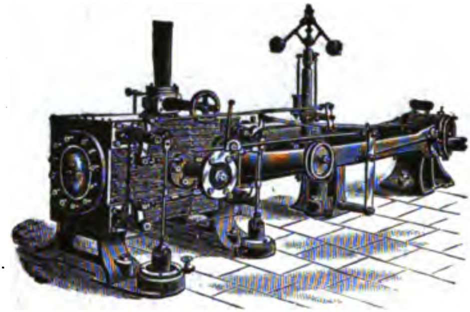

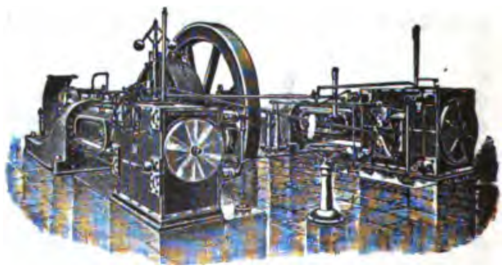

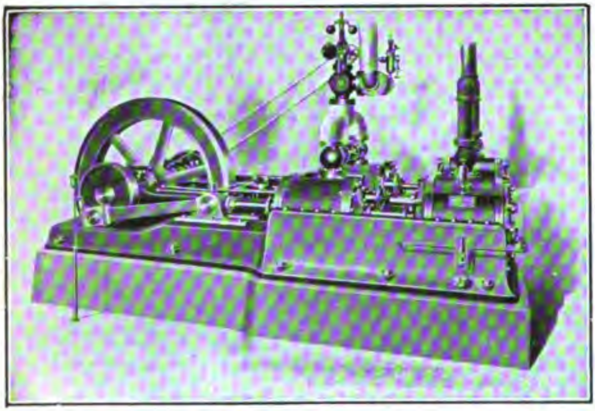

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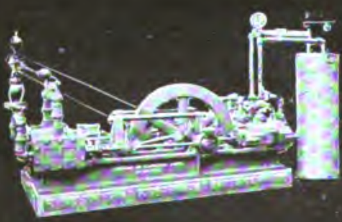

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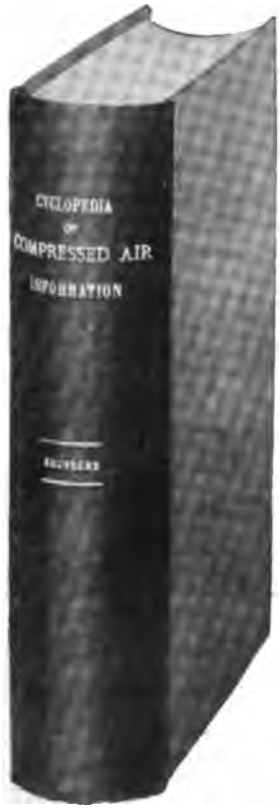

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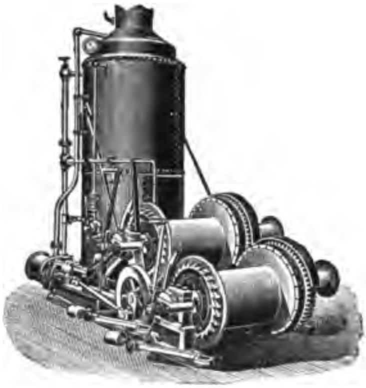

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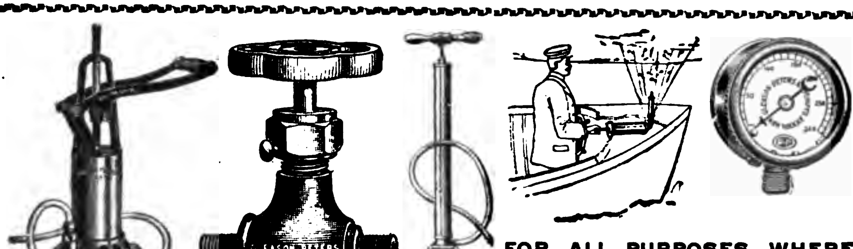

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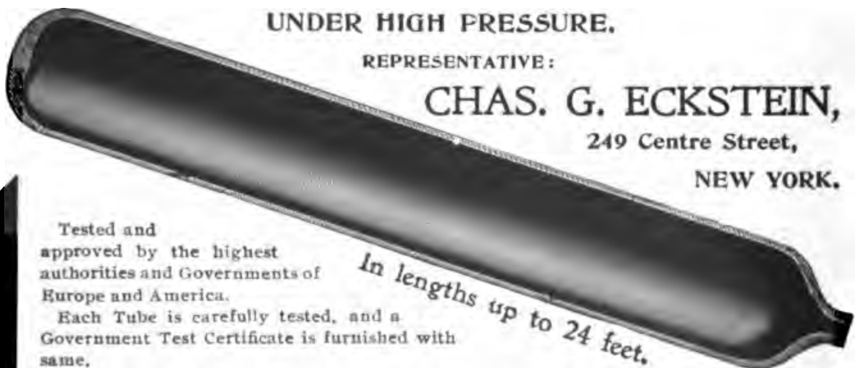

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VOL. VII. NOVEMBER, 1902. NO. 9.

Test of a High Lift Air Lift Plant at Grinnell, Iowa.

The subject of compressed air for raising water from artesian or deep wells is receiving more and more attention, and considerable information is being accumulated, obtained from actual experience, which cannot help but be of great value to anyone interested in this subject. In this connection the recent tests of a high lift air lift made at the water works of Grinnell, Iowa, are of considerable interest.

The air lift plant at this place consists of a 12 and 12x12-in. Class "F" Ingersoll-Sergeant Compressor for low pressure, and a 12 and 5½x12-in. Class "F" of the same make for high pressure. There is also a receiver 6 inches in diameter and 20 feet long, and an intercooler for reducting the temperature of the air, consisting of 50 feet of 2-inch pipe placed in a water box. The available boiler pressure for operating the compressor is from 70 to 80 pounds.

The well uses the Pohlé system of piping with a 3½-inch water pipe and a 2-inch air pipe placed outside of the water pipe. The depth of well is 2,000 feet, and the length of the air pipe from 504 to 557 feet. In the tests the water was discharged at 3 feet above the ground, and all measurements were taken from this point. The well has a 10-inch casing at the top down to the rock, where the diameter is reduced to 6⅝ inches. The water stands in the well at about 242 feet below the ground surface, when the well is not being pumped.

The compressors used in the test were second-hand machines, and were not in very good condition, and all the pistons and valves on both steam and air ends were very leaky. On this account the actual free air obtained was much less than the stated piston displacement capacity of the compressors.

The following table gives the results of the test:

TEST NUMBER.	2	8	16	18
Date: August	8th.	12th.	16th.	19th.
Feet of air pipe	504	557	557	504
Starting pressure	113	138	138	113
Running pressure	106	133	132	108
Air friction	3	2	1	1
Net well pressure	103	131	131	107
Lift in feet	267	258	258	254
Per cent. submergence	47%	53.6%	53.6%	50%
Gallons per minute	136	129	123	104
Speed rev. low pressure comp	110	110	90	100
Cu. ft. piston displacement	165	165	135	150
Cu. ft. air per gallon	1.2	1.28	1.1	1.5
Per cent. efficiency	32.5	25.4	29.6%	
Intercooler pressure	52	50	55	
Speed high pressure compressor	135	110	80	

Referring to these tests, it should be noted that the water obtained in test No. 2 was measured in a barrel. In the later tests a reservoir was used, giving more accurate results and showing that the ratings obtained when the barrel was used were too high for identical conditions.

Test No. 16 was the official six-hour run and the figures given are averages for all observations during the run.

The intermediate tests, 3, 4 and 5, etc., are not included, as they were only experiments to determine the most economical speed.

By way of comparison a test was also made of this well, using a deep well pump. The results obtained with the deep well pump during a period of five hours are as follows:

Average amount of water pumped, 75 gallons per minute.

Feed water used, 390 gallons.

Quantity of water pumped, 22,500 gallons, or 57.7 gallons per gallon of feed water.

Referring to test No. 16 in the above table, which was a six-hour run, 44.4 gallons of water were pumped for each gallon of feed water. The difference between this figure and the 57.7 gallons pumped with the deep well pump being accounted for by the fact that the exhaust from the steam pump was partially condensed in an open heater and only cold water was metered, while in the case of the compressor test only the exhaust from the low pressure compressor was used in the heater. It was considered that this was sufficient to account for the differences.

Colliery Ventilating Machinery.*

In the operations of coal mining, which, in the United Kingdom alone, produce something over 225,000,000 tons a year, and find employment for nearly three-quarters of a million of people, there is nothing of more vital importance than the continual supply of a sufficient volume of fresh air for diluting the noxious gases prevalent in the mines and for enabling the underground workers to breathe a comparatively pure atmosphere. It may be said of modern mines that the efforts to provide this air have, in the majority of cases, been attended with so much success that the atmosphere of a modern coal mine is superior to the atmosphere of the forge or factory on the surface. The particular amounts of air required at the various collieries depend somewhat upon the nature of the mine, whether non-gaseous, or slightly gaseous, or very gaseous; also upon the number of human beings and animals employed in the mine; and on the amount of coal produced, which is not always in proportion to the number of persons engaged therein.

Taking all classes of coal mines, a fair and liberal consumption (and the allowance so as to be sufficient for all contingencies should be liberal), in the writer's opinion, is from five hundred to one thousand cubic feet of air per minute for each human being employed in the mine. Authorities differ very much as to the quantity, and even the lesser of the amounts stated will, in many quarters, be considered excessive; but they are not exaggerated amounts, and there are exceptional cases where even the larger quantity could, with advantage, be greater rather than less. Taking the total number of persons employed in and about the mines of the United Kingdom as three-quarters of a million, nearly 600.00 of this number will be employed underground, and the consumption of air, on the lower basis stated, for such an army of workers will amount to something like eighteen thousand million cubic feet per hour, representing in terms of weight more than half a million tons.

Making a comparison between the weight of the coal raised and the weight of air which passes through the mine in the length of a year, it has to be remembered that whilst coal production is not continuous, and in many cases occupies less than half of each twenty-four hours, and not always six days in the week, good ventilation at collieries means that the current is practically continuous from January 1 to December 31, day and night, Sunday and week day. Following out the

* Written by C. M. Percy, F. G. S., for *Cassier's Magazine*.

figures given above, it is found that the weight of air which ought to pass through the mines of the United Kingdom in a year is not less than four thousand million tons, or something like twenty tons of air for each ton of coal produced. It is not too much to say that, taking the coal mines of the world, the weight of air passing through them for purposes of ventilation exceeds the weight of all the minerals raised, even if the generous, although necessary, maximum estimate of one thousand cubic feet per minute per individual be reduced one-half.

In the days of our forefathers, when the coal mines worked were very shallow and the output was very limited, the ventilation provided was trivial, and in not a few cases was obtained by the action of the mine itself, the difference in temperature of the atmosphere of the mine and of the atmosphere at the surface being sufficient to generate some current.

Coal mining is very different at the present day. Nearly all the mines in the United Kingdom are of considerable depth, measured in hundreds of yards. The great expense of putting down a colliery to such depths, and the cost of machinery to deal with coal from such depths, make a large output from a large area necessary, and require the employment in one mine of a large number of persons. Such a condition of things demands so large a volume of air for ventilation that it can be supplied only by artificial means.

In the first half of the last century what is known as furnace ventilation was almost universal. A large fire was maintained at the bottom of the outlet or upcast shaft, and the heat, acting upon the air in this shaft, caused expansion, diminishing the weight of the column in this shaft, and enabling the colder and heavier air in the inlet or downcast shaft to descend; thus a current was produced. This method of ventilation was effective and capable of very large volume, but was not economical; it also entailed danger from fire. As a matter of fact, very few such furnaces have altogether avoided setting on fire the coal in their vicinity, and they did not possess the facility necessary for maintaining a uniform current, or, when necessity required, for varying the volume expeditiously. During the latter half of the last century all methods of producing the ventilation of a colliery except the mechanical have been gradually falling into disuse, and practically all new collieries adopt machinery for this purpose.

That useful piece of machinery so common at every colliery, namely, the pump, has proved itself so excellent for dealing with volumes of water, however large, that it was not strange for some of the first attempts with mechanical ventilators to proceed on those lines. These ventilating pumps were not measured in inches of diameter or even feet, but by yards, and were encumbered with numerous, and large, and heavy clacks or valves. The chief efforts in this direction were by Struve, and Goffint, and Nixon, and from experiments made, when working at a low speed and dealing with a small volume over a short period, seemed to give encouraging results; but the great size and weight of the reciprocating parts made anything approaching a high speed impossible; and the wear and tear of the valves and the machinery generally caused frequent stoppages for repairs. This latter defect was fatal; colliery ventilation cannot be effective unless it is continuous. It was not long after the first attempts at mechanical ventilation—although a variety of contrivances were designed by Lemielle, and Fabry, and Cooke, and Root, and were constructed and worked with varying and inconsiderable success—before it became evident that the effective machine, before which all others would disappear, was the centrifugal fan. This combined simplicity and practically everlasting wear, and efficiency with economy; and at the present time at least 90 per cent. of all the ventilating appliances at work are of the fan type. The fan is connected with the outlet or upcast shaft at the top of the shaft by a drift or airway entering that shaft at or just below the surface, and arrangements are made that no air can reach the fan except from the mine through the upcast shaft. The air enters the fan at one side, or both sides, the latter being preferable.

There have been discussions at times as to whether air should be forced into a mine at the downcast shaft, or drawn from a mine at the upcast; so long as we get the needed volume through the mine, however, it matters little which method is adopted. Although the large majority of colliery ventilators are exhausters, they might probably with equal advantage have been applied as pressure ventilators. In some special cases the arrangements made are such that the same fan can work either as one or the other. In the pressure system we have a less volume, because nothing passes the fan except pure air, and the fan is not exposed to the corrosive influence of noxious gases. In the exhaust ventilator we have probably less pressure and strain upon the fan itself. The most reasonable explanation for the almost universality of exhaust ventilators is that, having no strong reason to the contrary, and the pioneer appliances, such as the steam jet and the furnace, having been associated with the outlet or the upcast shaft, the modern appliance followed on the same lines.

The useful work of ventilation is represented by the volume of air that passes through the mine, and all leakage in from the surface to the fan is so much work lost; hence means have to be adopted to prevent air getting into the fan except from the mine, and special precautions must be taken, because air will so much more easily enter from the surface than through the long passages of the mine. The best modern practice is to use the outlet or upcast shaft for ventilation only, and under these conditions the course is clear and this shaft is covered over. But generally the outlet or upcast shaft is a regular winding shaft, and the arrival and departure of the cages complicate the situation and make some leakage inevitable.

There seems no simpler or more effective plan under such conditions than that which was first introduced, namely, to enclose the pit framework and have on each side of that framework a commodious chamber for loading and unloading the cages. There are doors between these chambers and the pit bank outside, and there are doors between these chambers and the outlet or upcast shaft; these enable the cages to be loaded and unloaded without any serious leakage. It might be said that such an arrangement prevents the winding engineman from seeing the cages; but this is not necessarily so, because glass may be inserted and the electric light applied; and even if the winding engineman cannot see the cages, there is no difficulty with an effective code of signals, which in any case must be the only communication between the winding engineman and the cage at the bottom of the shaft.

The centrifugal fan easily separates itself into three great classes, namely, first, the open running; second, the close casing and enlarging chimney; third, the spiral casing terminating in a chimney; and as practically all the good ventilating machines used belong to one or other of these classes, this article will confine itself to them, the purpose being not to discuss all manner of ventilating machinery, but simply its most important and successful forms.

OPEN RUNNING FANS.

We include in the open-running class all fans which take air in on one side or both, and discharge it freely all round the circumference into the open. In Nasmith's arrangement there was simply a revolving wheel between two fixed sides, and a number of deep, rectangular, radial blades. The Biram fan was rather different, the blades being not nearly so deep, measuring only a tenth of the radius of the revolving part; that was a disadvantage. The blades also were inclined backwards, so that the root of one blade was in a radial line with the tip of the next blade; that was an advantage. In the Hopton fan the blades, which are of conconsiderable depth, are arranged to curve backwards, and each blade passes tangentially into the circumference. The Marsden fan dispenses with blades, and the connection from inlet to circumference is by means of a number of tubes which curve backwards; the sides revolve with the fan.

A very popular form of open-running fan is the Waddle. The air enters on one side only, and the whole appliance revolves, thus making leakage at the sides impossible. The passage from the inlet, to the vertical plane of the fan, is curved, and the cross-section area of each division diminishes so that the circumference at any point, multiplied by the cross section area at that point, is a constant quantity. The blades or partitions, which incline backwards, do not extend to the periphery, and the space within the fan beyond the tips of the blades is bellmouthed.

CLOSE CASING FAN AND ENLARGING CHIMNEY.

Quite a number of different types of this class of fan have been introduced on the Continent of Europe, but the only one that has made any headway in the United Kingdom is that which bears the name of the Belgian engineer Guibal. We owe a great deal to this inventor and his invention. Previous efforts to introduce mechanical colliery ventilators had proved so far from successful that it almost appeared as if such men as Nicholas Wood and William Fairbairn were right when they stated that no machine could do for colliery ventilation what furnaces were doing. The Guibal fan was from the first a substantial success. The air enters on one side, or both, and the blades, which are deep and rectangular, incline backwards, and curve at the tips radially with the circumference. The casing is a fixture, and comes within simple clearing distance all round the circumference except for about a tenth of the whole, near the bottom. This opening, which can be increased or diminished by a sliding shutter, delivers into a chimney which increases in cross-sectional area to the top. There is no doubt that the success of the Guibal fan was, and is, due to its chimney.

Recognizing that the air must leave the revolving part of the fan at a high velocity, representing so much energy, the enlarging chimney receives the air at that high velocity and, by its increasing area, diminishes the velocity, and utilizes the liberated energy in overcoming all pressure within the chimney and actually producing a partial vacuum. A two-fold benefit arises—the delivery from the fan itself is expediated because resistance is removed; and the air passes easily out of the chimney into the open.

There have been at least two distinct improvements in the original Guibal fan. Cockson modified the form of the blades so as to give a uniform passage for the air through the fan, and to make the pressure uniform on the blade. Messrs. Walker Brothers, of Wigan, modified the shutter, which, being rectangular, caused each blade to lose all its pressure instantaneously, producing as many shocks and vibrations in each revolution as there were blades. This caused a good deal of wear and tear, and limited the speed. The Walker anti-vibration shutter, formed like a reversed elongated letter V, so A, avoids absolutely the shock of each blade passing the shutter; this made a considerable increase of speed,—therefore volume and water gauge,—possible with less wear.

SPIRAL CASING FANS.

In these fans there is a spiral casing which affords an opening from the revolving part all round the circumference, the cross section area of the spiral casing increasing to the chimney. The Schiele fan, which appears to have led the way in this class, has blades slightly curved backwards at the tips, just the reverse of the Guibal. The other portion of each blade is straight and inclined backwards, and the edges are so formed that the passages through the fan maintain a uniform cross-section area from inlet to circumference.

What is known as the Walker "Indestructible" fan has been before the mining community for many years, and, so far as the United Kingdom is concerned, more fans of this class than of any other have been applied at collieries. The chief points aimed at by the makers were to produce a ventilating machine which should obtain a high percentage of useful effect, without the great weight, unwieldy dimensions, or expensive foundations of the large direct-driven fans; and which should possess the strength, rigidity, and durability of the smaller fans whilst avoiding their excessive speed and probable trouble with heated bearings. There are two strong cast-iron bosses, carefully bored out and made a good fit on the fan shaft, to which they are secured by steel keys. The extension lengthwise of these bosses distributes the weight of the fan over the shaft. Between the bosses are two discs of steel which fit the fan shaft. Each disc is in halves, the joints being placed at right angles, thus forming one double disc of great strength. Between the two discs the iron arms of the fan are fixed "sandwich"-like and gripped tightly. These arms extend from near the axis of the fan to its periphery, the discs supporting them half way. Angle irons are riveted to the fan arms beyond the discs, and to these angle irons the blades, usually eight in number, are firmly secured. The blades, which spring tangentially from a small circle concentric with the fan shaft, are curved longitudinally, to the arc of a circle of a certain radius, and are cut away from the edge of the inlet of the fan shaft, to minimize central resistance.

It is very necessary to minimize the slipping of the air between the sides of the blades and the walls of the fan chamber as far as practicable. The blades, being strong, cannot be brought close to the walls, as in the event of any side movement of the fan on its bearings they might "catch." The clearance, therefore, is made up by attaching strips of pliable hoop iron to the sides of the blades.

The Walker anti-vibration shutter (although a spiral casing surrounds the fan), referred to elsewhere in this article, is applied with effect to this fan. It may be of interest here to relate that several years ago Messrs. Walker Brothers had erected three ordinary Guibal fans for ventilating a portion of the London Metropolitan Underground Railway, and, although the fans were effective enough in producing volume of air, the pulsations or vibrations exercised an injurious influence upon the windows and doors of the surrounding buildings, and unpleasant proceedings were threatened. The application of the anti-vibration shutter saved the situation in this particular case, and the appliance has now become a useful appendage to ventilating fans at hundreds of collieries. The Capell fan has two parts revolving together, the inner part being really a drum with openings in the circumference, and the outer part being open to the spiral casing. The blades are curved backwards in each part, and the claim is that there is a utilization of energy not only between the outer part and the spiral casing, but also between the inner part and the outer. There always seemed to be room for doubt as to whether this double endeavor to utilize this energy was necessary or desirable, and later improvements would appear to be on lines depending on the conversion of the energy at one operation between the fan and the casing and chimney into which the air discharges. The chimney of the Capell fan differs from the Guibal as the cross-section area increases more rapidly; in the former the enlargement is on two sides, whereas in the Capell the enlargement is on all four sides.

The advantage of the open-running fan is its simplicity, and there is no elaboration of the surrounding structure; the air is not obstructed in leaving the fan at any point of the circumference. But the inseparable defect would seem to be that the air cannot avoid leaving the fan at a high velocity, and the energy represented in this velocity may be very serious and is wasted. In the close casing and the enlarging chimney this is avoided. The defect of the close casing would seem to be that it prevents free outlet for the air, and forcing some of the air through nine-tenths of the circumference against its natural inclination must generate friction and absorb work. Also there must be an increasing pressure on each blade from the time of passing the outlet to arriving at it again, and such an inequality of pressure does not encourage high speed.

The fan with the spiral casing terminating in a chimney would appear to combine whatever is advantageous in the two other classes, and avoids their defects. The spiral casing affords free outlet from the revolving part of the fan all around the circumference, and extends the advantages of the enlarging chimney for diminishing velocity and utilizing energy all around the circumference.

Opinions differ as to the correct form of fan blades. It seems right that the passage for the air through the fan should be in as direct a line as may be. Mere revolution means simply "churning" the air and setting up frictional resistances. A particle of air moving radially along a revolving disc traces a line more or less curved backwards, according to the speed of revolution of the disc and the radial speed of the particle; and this backward curved line will pass easily into the circumference. That would appear to be the correct form of the blades, and in the open-running fan that should be the form of the blades; but in the close-casing fan, such as the Guibal, this would hardly apply, because the air, however it travels from the inlet, can leave the fan only at the place provided. And it is probably not of very great importance in the fan with the spiral casing, because whatever velocity the air may possess in leaving the fan is taken from it before being discharged into the open. Still, any change in form of fan blades from the radial should be backwards and should be curved.

When ventilating collieries by machinery was new and there was no experience to guide the makers or purchasers, a good deal of constructing was done by rule of thumb. But years of experience with many thousands of ventilating installations under all possible conditions have enabled the laying down of fairly accurate practical rules of design.

It is quite evident that no fan, however excellent, will produce a current unless the passages in the mine will allow the air to get to the fan. Strange as it may seem, many mines have excellent fans, but deplorably poor air-ways. What is called the "equivalent orifice" of a mine is the smallest area in square feet which will pass a given volume of air in a minute with a given water gauge in inches. Assuming the orifice to be through a thin plate, the rule for its area is—multiply the volume of air in thousands of cubic feet per minute by 0.37 and divide by the square root of the water gauge in inches. With this as a basis we may design a fan. Each of the two inlets should be equal to the "equivalent orifice" so as to make allowances for resistances within the fans, and the passage through the fan should be equal in area to at least that of the inlet or inlets.

It will be seen that for a given volume the "equivalent orifice" will be larger for a low water gauge and smaller for a high water gauge. The writer has assumed a medium water gauge for mines in the United Kingdom of two and a half inches, and has also adopted two inlets, each being equal to the "equivalent orifice." Laying down a practical rule that each inlet shall equal the "equivalent orifice," that the fan shall have a diameter equal to twice the diameter of the inlet, and that the width of the fan shall be approximately one-third of the diameter of the fan, we arrive at the results given in the table.

With proper conditions, the water gauge will depend upon the speed of the circumference of the fan—will, in fact, increase and decrease as the square of the velocity. The water gauge itself is a bent glass tube,

Cubic Feet of Air per Minute.	Diameters of Each of Two Inlets. Feet.	Diameter and Width of Fan. Feet.
50.000	4	8 x 3
100.000	6	12 x 4
200.000	8	16 x 6
300.000	10	20 x 7
400.000	12	24 x 8
500.000	13	26 x 9
600.000	14	28 x 9
750.000	15	30 x 10

open at both ends and fixed vertically, one end connecting with the open atmosphere, say, in the engine house, and the other end with the airway or drift leading to the fan, and preferably, for accuracy of result, sufficiently far removed from the fan itself to be free from contending currents and eddies which are unavoidable in the inlet, or close to it. There is water in this appliance, and the influence of the fan lifts the water in one leg and depresses it in the other. Of the difference in level, each inch represents a pressure of 5.2 pounds per square foot, being simply the weight of a column of water one inch high and a square foot in area. Knowing the speed of the circumference of the fan in feet per second, we square it, and divide by 64, which gives us the ventilating column in feet. Brought into inches and divided by 800 (because water is practically 800 times heavier than air at atmospheric pressure), we arrive at the water gauge in inches for a given speed of circumference of the fan. The friction of the air increases as the square of the velocity; therefore the water gauge produced increases with the square of the speed of the fan. The power has to overcome increased friction and increased volume; therefore the power increases as the cube of the speed of the fan. The horse-power of ventilation is the quantity of air in cubic feet per minte multiplied by the water gauge in inches and by 5.2 and divided by 33,000. The usual effect or efficiency of a fan is the proportion of the power consumed to the power of the fan engine.

The general method of arriving at the efficiency leaves much to be desired. The power of the engine usually taken is the indicated horse-power, which includes the engine resistance, representing perhaps 20 per cent. of the indicated power. Why should a fan be charged in its balance sheet with power that it never receives, and how can we compare two fans on these lines, if one has a good engine and the other has a bad engine? The engine power should be the useful work which an engine has available after accounting for its own resistance, which resistances are rarely the same in any two engines. Then, again, the water gauge is often not taken with sufficient accuracy, and, still further, the actual volume of air passing is not known because the linear velocity is not measured correctly, and the same remark applies to the area of the passage leading to the fan. There is much to improve upon in determining the useful effect or efficiency of a fan. The method laid down in this article for determining water gauge from speed, or speed from water gauge, is not that which is usually adopted and which gives a water gauge twice as great as here set out; but the water gauge obtained by modern rules is the "manometric depression," or theoretic efficiency of a fan; and as the water gauge in practice is rarely more than one-half of this theoretic quantity, the rule followed in this article is not necessarily in contradiction, and simply brings us to the actual and practical water gauge obtained by a fan by a shorter route.

So far as the fans themselves are concerned there are now any number of admirable examples, excellent in design and construction, capable of running with absolute truth upon their bearings with a minimum of resistance, and also of running continuously for many years without any necessity of stoppage for repairs. The method of driving, however, is not nearly so universally good. There are, it is true, some very good examples of fan engines, but the majority are not of that kind. The extravagance of colliery machinery generally is not a creditable feature of the age. In connection with one important class—winding engines—some excuse can be found for it. Such engines work intermittently, rarely for as long a period as a minute for a journey; start from rest and reach a high speed, then fall away from that high speed to rest—all within this just-mentioned short period; and they must be easily capable of starting from and stopping at any point. But even with this class of engines improvements are being made, and condensing and compounding are being introduced.

With ventilating machinery the work is almost absolutely uniform and continuous, without stoppage, day and night, from January to January. Such a condition of things invites and encourages all that is perfect in the economics of engineering. But it would be no exaggeration to say that a considerable proportion of fan engines are still not only non-condensing, but only very slightly expansive. An engine of that type will consume from six to eight pounds of coal per horse-power per hour, as compared with a pound and a half of coal per horse-power per hour in a truly economical engine.

The best arrangement of engines for driving a fan would probably be a pair of horizontal, triple-expansion condensing engines, placed at right angles, attached to separate cranks, and so arranged that they can work together as a pair, or, if repairs should be necessary, one engine could be disconnected and the other engine alone continue to drive the fan. If the first expense could be met, an even better arrangement would be to have two distinct and self-contained ventilating plants, so that with two fans and two engines there would be opportunity for overhauling one fan and one engine without interfering with the ventilation. There is at least one colliery known to the writer at which such an arrangement has been adopted.

In the early mechanical ventilators, which were usually on a large scale, and did not make a great number of revolutions per minute, the engine was connected direct to the fan, and this caused a two-fold defect as time went on. Either the engine had to run very quickly indeed, which is not desirable even now when running continuously for months, or the fan had to be made very large in diameter to obtain a sufficient circumferential speed. The massive fans of a quarter of a century ago, of 45 feet and even 50 feet in diameter, were cumbersome structures, requiring large and expensive foundations, and absorbing much power simply to keep them in motion.

It has been proved that in coal mining practice such mammoth sizes are not necessary as regards volume. A million cubic feet of air per minute at the ordinary water gauges can be produced with a diameter of 30 feet, and no one mine is likely to need so much; and as regards the amount of depression or water gauge required, that depends not on the diameter, but on the speed of the circumference. A fan 5 feet in diameter, running at 500 revolutions per minute, will have the same speed of circumference, and therefore produce the same water gauge, as a fan 50 feet in diameter running fifty revolutions per minute.

The best modern practice is to run the fan engine at a moderate speed, say, 400 piston-feet per minute, and to get up the requisite speed in the fan by gearing. Spur wheels have nothing to recommend them except their positive action, which, with a fan, is not absolutely essential. Straps have answered well enough, and are fairly noiseless, but there is a difficulty in the transmission of large powers in obtaining straps of a reliable quality and sufficiently flexible. Round cotton ropes, usually about 1½ to 2 inches in diameter, running in carefully prepared grooves, answer admirably; there is scarcely any wear and tear upon the ropes, because, as a large number is usually applied to drive the fan, the amount of pull on each single rope is only slight. The ropes give a better grip even than flat straps, and, if anything, are more free from noise in action.

The speed of the fan depends altogether on the amount of depression or water gauge required, which in the mines of the United Kingdom does not often exceed about 4 inches, unless in exceptional parts of the mine, where small auxiliary fans may be applied. But all well-designed and constructed fans of the present day should be capable of running without injury at a circumferential velocity of, say, 12,000 feet a minute, which would obtain a water gauge of nearly 12 inches. There is really no difficulty in speed, so far as the fan itself is concerned; that is merely a question of sufficient strength, accurate balancing, and true bearings. There have been difficulties in keeping the fan shaft journals from heating, but those difficulties are disappearing before modern mechanical engineering improvements.

It will have been gathered from this article that in the United Kingdom no ventilating machine has been largely and successfully applied to collieries except the centrifugal fan, which, being a simple wheel, if made strong enough and properly balanced, can run at any reasonable speed, and has really nothing to get out of order. These fans should be of moderate dimensions; a diameter of 30 feet might be taken as a maximum for a volume extending to, say, three-quarters of a million or even one million cubic feet per minute. There should be two inlets to each fan; the diameter of the fan might be taken for any particular case as twice the diameter of the inlet; and the width one-third of the diameter of the fan, which should be driven by a pair of triple-expansion engines transmitting their power through rope gearing.

The fan should be of the class with spiral casing terminating in a chimney, and should have a strong central diaphragm, preventing the meeting of the currents from the two inlets. Such an arrangement might be used effectively either to force air into the inlet or downcast shaft, or to draw air out of the outlet or upcast shaft, and in either case careful means should be adopted for sealing the pit shaft at which the fan is placed, so that, if situated at the downcast shaft, there is no passage other than through the fan, and, if located at the upcast, also no means of communication except through the fan. The water-gauge appliance, for measuring the effective depression, should be a few yards distant from the fan itself; the useful effect or efficiency of the fan should be based not upon the indicated horse-power, but the useful horse-power of the fan engine. The colliery manager or mining engineer should not be content with providing ventilating machinery of the highest character, but should remember that as no pump can deal with water unless the suction passages are clear, and as no winding engines can raise a load unless the rope is attached to the cage, no fan can do justice to itself or its owner unless the passages in the mine are sufficient to allow the air to reach the fan.

First Aid to the Injured in Mining Accidents.*

The causes of mining accidents are too numerous and varied to permit of a distinct classification. Those most constantly operative are falls from roof and sides, use of explosives, foul gases, operation of hoisting and traction machinery, explosion of inflammable gases (coal mines), traversing ladder ways, placing of timbers. Under the term miscellaneous may be grouped all others which contribute in any degree to the production of accidents. While many accidents from the nature of things are unforeseen and unavoidable, it is to be regretted that a certain percentage far too great is due to either carelessness or disobedience of the rules established for the protection of all, including those who habitually transgress them. It seems almost incredible that men should persist in dangerous and forbidden practices which imperil the lives of others as well as their own merely to save time or avoid a little additional work; yet this is often done with no apparent concern as to what may happen in consequence. This indifference to danger is perhaps not intentional;

* A paper read by Dr. G. W. King, Helena, Mont., at the Butte, Mont., session of the Mining Congress, September 3, 1902. Specially reported for the MINING AND SCIENTIFIC PRESS.

constant exposure without injury begets a disposition to underrate the liability to accident and the necessity of guarding against them. This fact, however, does not excuse one who commits a rash act or who by negligence sacrifices the lives of his fellow-workman instead of contributing his share to their preservation by more careful attention to duty. The most reliable guarantee of safety must be based upon the practical knowledge possessed by the miner himself. He is expected to understand the nature of the ground in which he works, the proper manner of breaking it, the support required during and after the extraction of the ore, the precautions to be taken for the safe handling of explosives—in short, the whole procedure is in his hands and the safety and efficiency of the work depends upon the skill and judgment exercised in its accomplishment. Self-protection is a matter of individual responsibility in so far as the immediate surroundings are concerned, and should be the first consideration in all that is undertaken. The conditions which pertain in mining differ materially from those that exist in ordinary labor above the surface of the ground. The miner, for instance, must work by the aid of a candle or safety lamp, and such light may prove inadequate for the close inspection of loose rock in the roof and sides of levels and stopes, and unless special care is taken dangerous indications may be overlooked even by a careful and competent observer.

These are some of the common and ever recurring situations under which the work is done. Something more than the mere ability to perform manual labor is demanded; there must be skill to direct and govern every act; mistakes are perilous by the swift and destructive consequences which may follow. To become skilled as a miner an apprenticeship more exacting than that practiced for the various trades must be accepted as the true method of training.

Looking a little further into the causes of mining accidents we find an appreciable number chargeable to the use of explosives. The agent most generallv employed is nitro-glycerine, known to the trade as dynamite or giant powder. This substance is reasonably safe at a moderate temperature and under ordinary atmospheric conditions, but is always to be regarded with suspicion and few liberties taken with it, as no one can as yet determine the exact explosive point at any time or place, much less the influences which lead up to it and induce a state of extreme sensitiveness which responds to the slightest jar or vibration. It possesses the disadvantage of readily congealing at a lowered temperature, necessitating the application of heat to expel the frost before using. This latter process is a source of real danger and ought not to be trusted to inexperienced hands, or to any one for that matter without the proper appliances for regulating the heat to safe limits. The method which gives the best security is that by which a moderate and uniform temperature is maintained, the placing of a competent man in charge of the process whose duty it is to supply the miners with powder and fuse upon requisition. Accidents which occur while charging the holes or from mistakes in length of fuse, neglect in signaling, defect in arranging facilities for retiring to a safe distance, are for the most part preventable and the fault lies with the workmen themselves.

The equipment of shafts operated by means of cages has been so well perfected that comparatively few accidents are noted if we take into account the amount of work done and the number of men transported to and from their work from month to year in the various mines that are in active operation. When an accident does occur in connection wth the working of a shaft it is usually a serious one. The parting of a cable, the sudden giving of the brake upon the hoisting engine, a failure of safety clutches, overwinding and precipitation of the cage to the bottom of a deep mine—any one of these unfortunate mischances must necessarily be attended with loss of life.

In sinking winzes and working shafts in the less pretentious mines, buckets are used to convey men and for general use in hoisting. The bucket when working without guys is not under absolute control, and when propelled at a high rate of speed assumes a rotary motion,, which is apt to cause vertigo in some individuals to such a degree as to render them incapable of retaining their grasp upon the cable, as in one instance coming to the writer's notice, that of a miner falling from a bucket in making a descent of 200 feet in a vertical shaft. No other cause could be assigned. Closing the eyes tightly will in a measure counteract the sensation of vertigo and prevent accident.

The speed should, however, be regulated within reasonable limits. The practice of riding upon a loaded bucket is unsafe and should never be done. Here is a case in point: Two miners were riding upon a bucket in which some pieces of lagging were being hoisted; neglecting to lash the top of the poles securely they came in collision with one of the timbers of the shaft, the cable was broken and the bucket, with its contents, was precipitated to the bottom with fatal results.

Other cases might be cited to prove that the practice referred to is a dangerous one, but the fact is too apparent to need further comment.

The handling of heavy timbers has its quota of mishaps, such as the breaking of ropes, slips and sliding ground risks that are usually unavoidable.

Machine drilling in mines is not especially dangerous. The few accidents that come under observation happen while setting up the machine or from the giving away of ground upon which it stands. Small particles of steel from the drill are liable to injure the eyes by becoming imbedded in the cornea. They are, however, readily extracted by applying cocaine, and using a magnetized instrument of suitable size. If the foreign body penetrates into the interior of the eye, the loss of that organ is a probable result.

Accidents met with in loading and coupling cars are usually of a minor class, and are in the majority of instances due to the want of care on the part of the workmen thus engaged.

Accidents from the inhalation of poisonous gases is a subject of special interest to miners, on account of their frequent exposure while working underground. The best ventilated mines are not entirely free from this danger, and as a consequence, miners are sometimes overcome by breathing gases collected or generated in stopes on recesses that cannot be wholly purified. Where good ventilation has not been provided, as in shafts and tunnels projected by prospectors, the danger is proportionally increased. The attempt to return too soon after blasting has occasioned loss of life. The introduction of compressed air as a motive power in the larger mines is of signal service in this particular. After blasting the air is turned on and the obnoxious gases driven out before the men resume their labor. The candle test for unsafe air is observed by miners generally. They know that an atmosphere too poor in oxygen to support the flame of a candle is unfit to breathe, and precaution must be taken to avoid such localities when it is possible to do so. They should also understand that this test is not infallible. There may be, and often is, an admixture of gases capable of supporting the flame from a candle, and yet deadly when inhaled. Experienced miners cannot have failed to note the behavior of the candle flame under these conditions. It flares up with a pale, bluish light, due to the presence of a gas known as "carbon monoxide." It is one of the most poisonous gases with which the miners come in contact. A product of imperfect combustion, it is generated by the detonation of explosive compounds, and being colorless, odorless and tasteless, its presence is only made apparent by certain symptoms produced by its poisonous action when introduced into the blood by continuous inhalation.

Associated with the ordinary carbon dioxide which infests mines in as small a proportion as 1 per cent., it may prove injurious. A combination of the two gases seems to increase the toxicity of each other. Carbon dioxide is fortunately less active than the monoxide; moreover, it has a slight taste and odor, and can therefore be more readily detected. The two gases are generally associated together, and the chief concern is to be able to determine when their percentage in the atmosphere has passed beyond the limit of safety.

It is true that a difference exists among individuals in regard to their susceptibility to the action of these gases. One may be overcome in a place where another suffers but slight inconvenience. This fact often encourages the latter to take unnecessary chances. Men of experience and judgment, however, rarely go into a place where the air is known to be bad without being prepared to retreat promptly upon the first indication of danger. What these indications are should be as familiar to the trammer as to the miner himself, for it is among the former class that accidents from inhalation of foul air is most liable to occur. Their work necessitates the handling of loose earth, which is more or less permeated by the gas which is easily freed by the disturbance and becomes mixed with the air we are to breathe. Poisoning by carbon dioxide is at the time so insidious that the warning symptoms are unnoticed until too late to escape.

SYMPTOMS OF POISONING BY CARBON DIOXIDE.—The smell and taste of the gas is usually quite perceptible, and this indicates its presence when the percentage is small; nothing more than a dryness of the throat and a slight headache may be experienced. In large amounts the headache becomes more intense, a peculiar throbbing pain is felt over the brow and back of the head. Vertigo supervenes and the sight becomes dim and the limbs weak. There is a nausea and vomiting. An uncontrollable desire to sleep comes on and the person falls never to rise, unless carried out immediately. In an atmosphere completely saturated with carbon dioxide these progressive symptoms are not noted, for the reason that all is over in a very few moments.

The result is practically the same as being submerged in water. To rescue those who are insensible a systematic plan of relief should be adopted. To rush in excitedly but complicates the work, very likely adding to the number already disabled. By forming a relay of men and instructing the one who is to enter to apply a sponge or handkerchief saturated with water or preferably with vinegar over the mouth and nostrils, then go quickly forward, take hold of the one insensible and drag him to the entrance as far as he can with safety to himself, then retire to give place to the one who stands ready to succeed him, will render the rescue work less hazardous to all concerned. Operating in a shaft is more difficult and dangerous. When the descent is made by a bucket for any considerable distance through a poisoned atmosphere, it is impossible to stand erect within it and maintain an equilibrium after the paralyzing effects of the gas is experienced. A sitting or kneeling posture should therefore be assumed to avoid the possibility of being precipitated from the bucket. Should descent by ladder way be undertaken, a rope fastened about the waist and manned from above is recommended as a wise precaution. A second rope may be lowered, if necessary, and made fast to the person to be brought up by means of a loop drawn snugly around the body close under the arms. The act of hoisting an unconscious person by the aid of a rope must be conducted with reasonable care, the tension ought to be steady, lest too forcible contact wth jutting timbers or rocks result in serious injury.

The treatment of asphyxia produced by inhalation of poisonous gases will be referred to in appropriate connection.

The prevention of mining accidents has been the subject of much study, and investigation is continually being made by engineers and practical mining men. Legislatures have also endeavored to surround the miners with additional safeguards by legal enactments. Improvement has certainly been made, and with the advent of electricity for the purpose of lighting and motive power further progress will be made evident in the equipment of mines that are to be operated in the future.

Were it possible to exclude the accidents which are clearly preventable, the occupation of mining would be less hazardous and the mortality lessened, a result most helpful and worth striving for, since at best there will be fatalities enough and to spare.

Taking the practical view, then, that with the best equipment and most efficient service accidents may and do happen, the care of the injured must be considered with reference to their immediate necessities. To be prepared for emergencies is the first essential. This refers to the few medicines and appliances that may be needed for temporary use. These articles should be kept in reserve at the most accessible station within the mine, and plain and concise directions for their proper and legitimate indications posted in a conspicuous place, that all may learn how and what to do for others in case of need. To avoid unnecessary complications, the list of articles must be limited to the actual requirements, enumerated, it would appear, as follows: One-half dozen bandages, 2½ to 3 inches in width and 1 yard in length; one package of absorbent cotton; one roll of adhesive plaster; one dozen safety pins; galvanized wash bowl, soap and towel; temporary splints for the limbs; a litter; one cylinder of compressed oxygen gas, with inhaling mask; medicines other than stimulants are not indicated. Two ounces of aromatic spirits of ammonia, with a small flask of brandy, are added for the latter. The medicines and dressings may be stored in a tin box with a tightly fitting cover, and the whole protected from moisture. After an accident the danger to be apprehended to those who are severely injured depends in a measure upon the length of time which must elapse before medical aid can reach them. This period varies from a few moments to several hours, according to circumstances. During this interval of waiting what is to be done? In some instances nothing; in others prompt action must be taken to save life. Upon those who are present, or first to arrive, devolves the duty of attending to the immediate necessities, whatever they may be, as best they can. The demoralizing effect of an accident upon those who witnessed it is apt to be harmful in two ways: First, by causing delay when time is the important factor; second, by inciting too energetic attempts at rendering assistance. It is, therefore, well to remember that, however alarming the situation, calmness and presence of mind are all-important.

Undue excitement contributes to render the chances of succor less certain, if not impossible. One who is competent to do the right thing whenever and wherever such service is imperative exerts an influence most assuring and helpful to those in peril, and to those who must assist in their care. Gentleness without timidity is of inestimable value in this service under all conditions.

In caring for the injured there are certain things to do, applicable in all cases, and we, therefore, begin by placing the individual in a recumbent and easy position, and proceed to loosen the clothing about the neck and chest, and if the patient is able to swallow and there is no excessive bleeding, external or internal, from wounds or concussions, a moderate amount of whiskey or aromatic spirits of ammonia may be given as a temporary stimulant. If stunned and unconscious, no attempt to give fluids by the mouth ought to be made, owing to the liability of their entering the windpipe and causing suffocation. Cold water may with advantage be sprinkled upon the face to excite effort at breathing. Friction applied to the extremities, being careful to select those which are injured, is a healthy measure. Heat applied externally is indicated when the surface of the body is cold and the circulation feeble. When reaction has become established the limbs should be examined, one by one, and in the same careful manner the chest, abdomen and head. In this way the injuries cannot fail to be noted. When there is dangerous hemorrhage caused by wounds, and fainting from loss of blood ensues, appropriate means to control it must be employed promptly. To arrest bleeding different methods are employed, all more or less mechanical. Pressure is the readiest and most effective means for the temporary control in urgent cases. To apply the fingers over the course of an artery and compress it sufficiently to shut off the current of blood requires but an instant, and this advantage in time is not to be overlooked, especially when a large vessel is wounded.

Troublesome bleeding from wounds in the palm of the hand is effectually checked by similar methods. Digital compression of the large arteries of the thigh is more difficult owing to the large mass of muscles by which it is surrounded. Resort must be sought in more effective methods. The limb should be elevated and a small, firm pad placed over the artery, then a handkerchief or piece of rope is made to encircle the limb over the pad, a sharp stick introduced into the loop and twisted upon itself until the bleeding is effectually controlled.

Cold is an effective means of checking oozing from small arteries or veins. Ice, snow or cold water is placed in contact wth the bleeding surface. Heat is equally serviceable, and is applied by means of compresses dipped in hot water. In deep wounds, when the source of bleeding is obscure and the condition of the patient critical, packing the wound with strips of gauze, or with absorbent cotton, is permissible. After removing blood clots the gauze or cotton is forced into the bottom of the wound, and the cavity filled and a bandage firmly applied to the parts. In these manipulations absolute cleanliness is to be insisted upon to prevent infection. The hands of the operator should be thoroughly scrubbed with soap and water and the dressings kept free from contamination with as much care as possible.

Internal bleeding, induced by serious injuries, is, unfortunately, not amenable to active treatments, and we must content ourselves with insisting upon perfect quietude, administering cool drinks, and applying cold compresses over the affected region. These simple means may appear insignificant and of doubtful utility in the presence of grave conditions, and the temptation to do something more radical in the way of treatment is at times difficult to resist. A moment's reflection upon the indications to be met should establish the fact that the immoderate use of stimulants or active movements of the patient tend to deviate the object we have in view, viz.: to favor the formation of a clot at the point of rupture of the artery or vein —nature's method of arresting hemorrhage; fainting is a saving incident, and may be so regarded, unless the weakness is progressive and the shock so profound as to threaten immediate death. In the latter emergency, stimulation and warmth must be the treatment. It is to be understood that surgical skill is required to deal with such extreme cases. The suggestions above outlined are for the benefit of those who are uninstructed in the treatment of severe injuries. First aid applies only to the temporary care of those who are disabled and helpless; with that its utility ceases. Some injuries disable without endangering life, as instanced in the case of fractures of the limbs. Here some support is needed to steady the fragments during transportation. The resuscitation of those who have been overcome and rendered unconscious by inhalation of poisonous gases is necessarily first aid work. The question of how to accomplish this object must be considered. Little can be done before removal to a location where the air is comparatively fresh. Then cold water dashed into the face and friction applied to the limbs will stimulate the resumption of breathing. Should it fail to do so, artificial respiration must be resorted to at once. It consists of forcing air into the lungs by imitating the natural act of breathing. The steps of the procedure are as follows: Place the patient upon his back with head and shoulders slightly elevated; loosen the clothing and cleanse the mouth and nostrils; pull the tongue forward and bring it out at the angle of the mouth, to remove all obstruction to the entrance of air. The operator then kneels at the head of the patient, and, reaching forward, grasps the arms near the elbows, carries them up in an extended position. This maneuver creates a vacuum in the lungs, allowing air to enter; the arms are held in this position for two seconds, then carried downward and pressed firmly against the sides, forcing air from the lungs by compression. This to and fro movement is kept up at the rate of fourteen to fifteeen per minute, until there is a return of natural breathing, usually shown by a voluntary gasp on the part of the patient. This is the most reliable of all methods of restoring suspended animation, caused by inhaling carbonic dioxide; air must be gotten into the lungs ,either by force or natural act of breathing. Otherwise the case is hopeless. This is true for physiological reasons, which cannot be discussed here; suffice it to say that under normal conditions oxygen freely enters the blood by way of the lungs, and its presence there is essential to life. As soon, therefore, as the breathing becomes regular, the inhalation of oxygen gas may be begun and continued until the livid color of the skin becomes less marked and consciousness returns. In the absence of the oxygen gas stimulants are next to be thought of ,as soon as there is ability to swallow. Whiskey or aromatic spirits of ammonia are choice. Ammonia has the property of quicker action, but less durable than that of alcohol. Sniffing the fumes of ammonia is also useful. When patients begin to revive there is apt to be cramping of the limbs, or general convulsions. This requires no treatment beyond protecting them from injuring themselves by the convulsive movements. The cases need watching for some hours, for it may happen that those who are apparently out of danger will suffer a relapse and become again unconscious and die if left to themselves. The lifting and carrying of the injured is apt to be awkwardly done by men inexperienced in such service. Many injuries are of such a nature that misapplied force will further complicate the lesions which already exist, if indeed it does not lead to irreparable damage. A simple fracture of the leg may be converted into a compound one by injudicious handling. An unnecessary laceration of tissue is produced and consequent suffering, beside adding to the gravity of the case. This is but one of the many things which may happen to the disadvantage of the patient during transportation. To lift an injured person properly requires three bearers. Two should stand upon opposite sides in a position to support the upper part of the body, the third where he can conveniently take care of the lower extremities. Then, with the patient upon his back, all drop upon one knee, the two principal bearers, pushing their arms under the back, lock hands firmly together. The third pushes both arms under the limbs. At a given signal all arise to their feet. The weight is thus so evenly distributed as to be easily borne, and there is no appreciable jar or sudden twisting of injured parts.

A litter devised by the writer is adapted for underground work and insures safety in whatever position it may be placed. By its use in mining accidents the difficult problem of getting those severely injured to the surface, without discomfort or danger, is satisfactorily solved. The litter, with its burden, may be put upon a cage or in a bucket, and, when fastened in appropriate position, can be brought up without disturbing the position of the patient. To the litter a rope is attached to one end, and a guy line to the other, the latter being used to steady it during transit. When the upright position cannot be maintained—owing to syncope, from loss of blood—a semi-horizontal or even reverse position may be chosen for the time being, in order to allow the remaining blood to gravitate towards the heart and brain, an expedient that is sometimes useful in extreme cases. The fastenings are so arranged that the position of the patient is not changed with reference to the litter while executing the different movements of hoisting or transporting through narrow passages, thus affording additional security and dispensing with an extra number of bearers. In practice this plan is proven an excellent one. The litter is inexpensive and durable; after being brought up to the surface the injured are given over to the care of a physician, or placed in an ambulance for conveyance to the hospital, and the duties pertaining to the first aid are practically ended.

In rendering first aid to the injured simple methods are to be preferred; they are always available and, moreover, within the comprehension of anyone possessed of ordinary intelligence, and can by them be easily put in practice at the time and place most urgently demanded.

Officious and meddlesome interference is to be avoided. It is never necessary and may do harm. There are certain definite things to be done in sudden emergencies. Common sense and prudence should indicate the course to pursue in every instance. The rule to do no harm is a good one and should be kept in mind at all times. Its observance is never a cause of regret, but, on the contrary, an evidence of a true desire to keep within the limits of safety—a most commendable qualification in the non-professional when called upon to take an active part in the care of the injured.

Hydraulic Compression of Air.*

Methods of Compressing Air by Falling Water—The Efficiency of This Method.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydraulic air compressor which operated as an entrainment apparatus. This was the well-known water bellows or trompe of the Catalan forges.

This apparatus, briefly described, consisted of a bamboo pole, disposed at a slight inclination from the perpendicular, into the upper end of which a stream of water was led, entraining air with it in its downward passage. The low end of this bamboo pole was introduced into a bag made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes or tuyeres to the forge, the water being allowed to escape from the lower edge of the bag. From this original device a great many improvements have been worked out, and besides this a number of other forms of hydraulic air compressors, or of compressors using other liquids for compressing air or other gases, have been designed.

One of the first inventions carrying out this idea was made by J. P. Frizell, Boston, Mass. His invention made use of an inverted syphon having a considerable horizontal run D between the two legs A and B. A stream of water was led into the upper end of the longer leg A, and at the top of the horizontal run D between the two legs of the syphon was provided an enlarged chamber C in which the air separated from the water. The water was then led off from the lower part of this air chamber and passed off through the short leg B of the syphon, the pressure of the air accumulated in the air chamber being therefore due to the height of water maintained in the shorter

* From a paper by Wm. O. Webber read before the N. E. Cotton Manufacturers' Association and reprinted in *Machinery*, to whom we are indebted for the illustrations.

leg of the syphon. This application of carrying upward the water, after the air was separated from it, so as to produce a considerable pressure upon the air, seems to have been original with Mr. Frizell, and in this feature his device differs from the old trompe.

Another device, Fig. 2, differing somewhat from that of Mr. Frizell, was invented by A. Baloche and A. Krahnass in 1885, and consisted of a syphon B carrying water from an upper to a lower reservoir, the lower end of the syphon being projected through an inverted vessel R placed nearly at the bottom of the second reservoir. Just beyond the bend of the syphon and in line with the axis

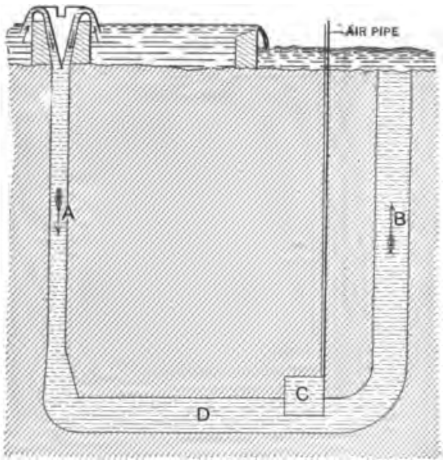


FIG. 1. FRIZELL SYSTEM.

of its longer leg, an air pipe T projected into the descending leg of the syphon. This entrained the air with the descending column and carried it down into the inverted chamber R, from which the air escaped at the top, while the water passed out from the bottom into the lower reservoir. This apparatus produced pressure on the air in the top of the inverted chamber, due to the height of the water column upon it.

Another device, Fig. 3, patented by Thomas Arthur in 1888, differs from the last in having a stream of water led directly into the top of the vertical pipe A. Inserted into the mouth of this pipe was a double cylindrical cone C forming an annular air passage between it and the walls of pipe A.

Owing to the increase in the velocity of the water in passing through the narrow throat of the double cone, air is inhaled through the pipe D, through the annular space mentioned and through perforations in the lower cone, and is entrained with the falling water.

Through the downflow pipe A rises a vertical delivery pipe Z for the compressed air having its lower end H enlarged and open at the bottom. Projecting upward into this enlarged air-delivery pipe was a water escape pipe F through which the water passed after having parted with the air. The escape pipe was in the form of an inverted syphon and maintained on the air in the delivery pipe Z a pressure due to the elevation of the water at the discharge point above the air line in the large end of the delivery pipe.

A number of other patents on apparatus of tnis type have been issued to Charles H. Taylor. His invention, Fig. 4, consisted principally of a downflow passage having an enlarged chamber at the bottom and an enlarged tank at the top. A series of small air pipes project into the mouth of the water inlet from the large chamber at the upper end of the vertically descending passage, so as to cause a number of small jets of air to be entrained by the water, Taylor seemingly having been the first to introduce the plan of dividing the air inlets into a multiplicity of smaller appertures evenly distributed over the area of the water inlet.

The first of these compressors on the Taylor principle was installed at Magog, Quebec, to furnish power for the print works of the Dominion Cotton Mills Company. The head of water is 22 feet; the downflow pipe extends downward through a vertical shaft 10 feet square in cross section and 128 feet deep. At the bottom of the shaft the compressor pipe enters a large tank, which is known as the air chamber and separator.

A series of very careful tests demonstrated that with 19.5 feet head, using 4,292 cubic feet of water per minute, was recovered the equivalent of 1,148 cubic feet of free air per minute, which would represent 248 cubic feet of air per minute compressed to 53.3 pounds pressure, showing that out of a gross water horse-power of 158.1, 111.7 horse-power of effective work in compressing air was accomplished, giving therefor an efficiency of 71 per cent. In the tests at Magog 81 horse power was recovered, using as a motor an old Corliss engine without any changes in the valve gear; this would represent a total efficiency of work, recovered from the falling water, of 51.2 per cent.

When the compressed air was pre-heated to 267 degrees Fahrenheit, before being used in the engine, 111 horse-power was recovered, using 115 pounds of coke per hour, which would equal 23 horse-power. The efficiency of work recovered from the falling water and the fuel burned would be, therefore, about 61½ per cent. On the basis of Prof. Riedler's experiments, requiring only 425 cubic feet of air per brake horse-power per hour, when pre-heated to 300 degrees Fahrenheit, and used in a hot air jacketed cylinder, the total efficiency secured would have been about 87½ per cent.

In what follows will now be given an estimate of the probable efficiency of different methods of using the power of a water fall. First are tabulated the results that it is reasonable to expect when using turbines and transmitting power by belts and shafting; second by electrical transmission from generators connected to turbines; and finally by an hydraulic air compressor. The compressor, it will be seen, gives the apparently remarkable result of over 100 per cent. efficiency. This is due to pre-heating and moistening the air, however, and not to a reversal of mechanical laws.

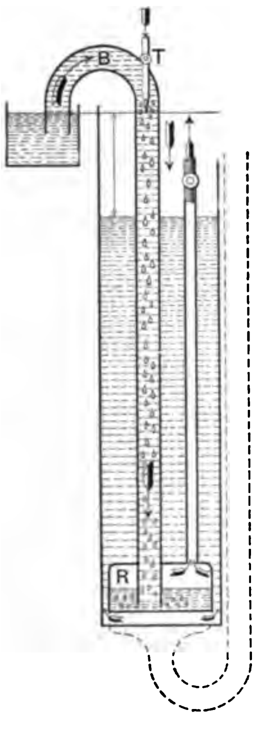


FIG. 2.

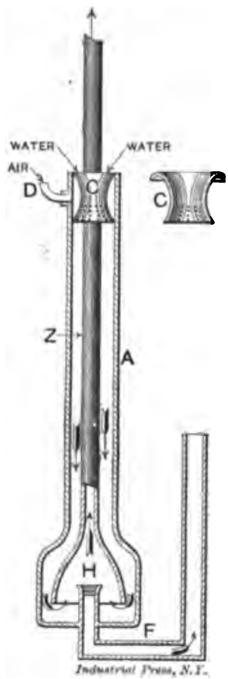


FIG. 3.

Given horse power of water....1,000 h. p.
Wheels at 85 per cent. efficiency .... 850 "
Shafting, pulleys and belts at 80 per cent (net).............. 680 "
or a total net result of 68 per cent., wheels being at full gate and allowing the minimum loss for friction of shafting.

With wheels as usually run at part gate, the results would be as follows:

Given horse power of water...1,000 h. p.
Wheels at 75 per cent. efficiency 750 "
Shafting, pulleys and belts at 50 per cent. (average).......... 375 "
or 37½ per cent .of the whole power; both of the above being directly at the site of the water power.

and direct connected with motors at 90 per cent. efficiency..... 565 h. p.
or 56½ per cent. of the whole,
or if belted at 90 per cent. efficiency .... 508 "
say 51 per cent. of the whole.

By the use of an hydraulic air compressor:

Horse power of water.........1,000 h. p.
Hydraulic compressor at 75 per cent. efficiency .... 750 "
Pipe line efficiency at 98 per cent. 735 "
Pre-heating dry air adds 50 per cent. .... } 1,470 "
Moistening dry air adds 50 per cent. ....
= 100 per cent.............

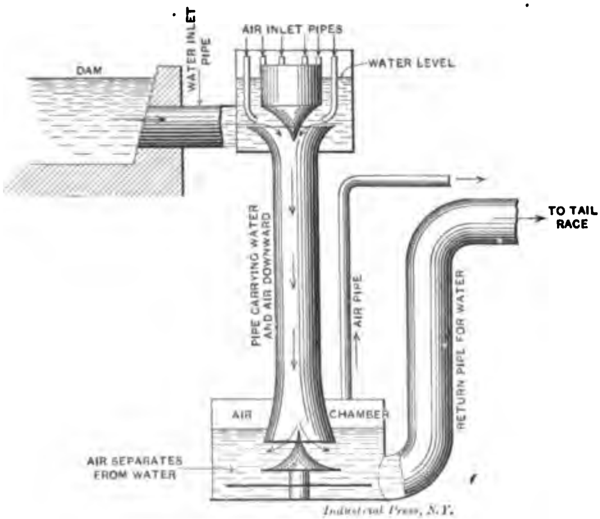


FIG. 4. TAYLOR SYSTEM.

In order to transmit power to a distance, we must take again:

Horse power of water........1,000 h. p.
Wheels at 85 per cent. efficiency 850 "
Generators at 92 per cent. efficiency .... 780 "
Transformers at 92 per cent. efficiency .... 720 "
Line at 95 per cent. efficiency.. 680 "
Converters at 92 per cent. efficiency .... 625 "
or about 62½ per cent. of the whole.

Air engines or motors at 78 per cent. efficiency ....1,145 h. p.
or 114.5 per cent.
and if belted at 90 per cent. efficiency ....1,030 "
or 103 per cent. of the whole as a resultant effect.

To estimate the efficiency of hydraulic compressing, taking into account the water absorbed by the air and the coal used in heating the air, we have the following:

The weight of a cubic foot of compressed air at 85 pounds at 70 degrees Fahrenheit, equals .58.

One thousand horse power would represent 750,000 cubic feet of 85-pound air per hour; this would equal 382.000 pounds of air, and as one pound of air will absorb .58 pounds of water, we would require 221,500 pounds of water per hour. The labor represented by forcing 221,500 pounds of water per hour, equal to 3,700 per minute, against 85 pounds pressure, equals 195.5 feet would be $\frac{195.5 \times 3700}{33,000}$ equals about 22 horse power, and as pumps give an efficiency of 50 per cent., equals 44 horse power of work by pump, or 4.4 per cent. of the whole 1,000 horse power, this is therefore to be deducted: The coal used in heating the air, which is about one-half pound per horse power per hour, would also represent an amount of work equal to 75 horse power, or 7½ per cent. of the whole 1,000 horse power. This added to the 4.4 per cent. as above would equal an amount of 13 per cent. to be deducted, equals 87 per cent. of the whole horse power, or 1,030 × .87 = .896, or 89.6 per cent. as a final result of all, as against 56½ per cent. by electricity, or 68 per cent. by water wheels at their best, or 37½ per cent. by water wheels at the average.

That our results are within the bounds of reason is shown by the fact that 75 per cent. × 98 per cent. × 200 per cent. × 78 per cent. × 87 per cent. = 99.5 per cent.

Economy Derived from Reheating Compressed Air.*

The object of the experimenters in these tests was to ascertain the exact gain derived from reheating compressed air used in small motors, with the idea also that some such method as this could be advantageously put into application in connection with the use of compressed air in railroad shops, mines, etc., where compressed air is extensively used.

A small 2 horse-power vertical engine with a shaft governor was used as the motor. The compressed air coming from the compressor, was first passed through a meter, and then before being admitted to the engine, was passed through a reheater. The arrangement of the apparatus is plainly illustrated in the accompanying diagram.

The amount of air used in each run was recorded by the meter, which was furnished for the test by the Equitable Meter Company, of Pittsburg. The meter was especially designed to withstand high pressures. The air passed through the meter at the temperature of the atmosphere.

The meter was calibrated for the pressures used in the experiments, before and after the runs were made. The meter readings were then corrected from this calibration. The results therefore show accurately the amount of air used in each case.

The reheater was constructed out of pipe. It consisted of a coil of three lengths of 1¼-inch wrought iron pipe, which was surrounded by an outer casing of 6-inch pipe. This casing was also covered with an asbestos non-conducting covering, which prevented the escape of heat. The construction of the reheater is indicated in the diagram.

Gas was used for fuel, and was burned in a burner placed at the base of the reheater. Gas was selected as the fuel on account of the ease with which the supply of heat could be governed. A gas meter recorded the amount of gas used in each run. The amount of heat supplied to the reheater is then easily computed, when the heat value per cubic foot and the number of cubic feet of gas supplied per hour are known.

The engine was equipped with a Prony brake, and an indicator was attached to the cylinder, which enabled both the developed horse-power and the indicated horse-power to be computed.

In every case the temperature of the air was taken at the meter, and again after it had passed through the reheater, at a point as near to its entrance to the engine as possible.

In conducting the experiments, three series of runs were taken, as follows:

Series I., in which six runs were taken, all at about 57 pounds gauge pressure, while the temperature of the air entering the engine was varied from 60° F. to 401° F.

Series II., in which five runs were taken, all at about 82 pounds gauge pressure,

* Tests performed by W. G. Edmondson and E. L. Walker, students in the Railway Engineering department of Cornell University.

General Results—Series 1.

1	Number of run	1	2	3	4	5	6
2	Length of run, hours	1	1	1	1	1	1
3	Barometer	29.41	28.97	28.89	28.89	29.0	29.32
4	Gauge pressure at meter (corrected)	57.6	55.	55.4	57.8	58.7	58.7
5	Gauge pressure at engine	55.	58.	58.8	56.	57.	57.0
6	Temperature at meter	51.2	86.8	86.3	79.1	81.5	74.3
7	Temperature at engine	59.	176.5	256.	306.	348.	401.
8	Temperature of exhaust air	7.	87.6	147.	177.	198.	236.
9	Temperature of room	48.	79.	88.	78.	76.	70.
10	Temperature of flue in heater	—	220.	309.	358.	—	421.
11	Cubic feet of air per hour from meter	371.	319.5	300.	270.	248.5	234.
12	Cu. ft. of air per hr. corrected from calibration of meter	377.	323.4	303.4	274.4	252.6	238.
13	Cubic feet of air per hour at standard conditions	1,877	1,445	1,367	1,295	1,204	1,150
14	Increase in temperature of air by heating	—	89.7	169.7	226.9	266.5	326.7
15	Corresponding increase in volume, per cent	—	16.4	31.0	42.0	49.4	61.1
16	Weight of air supplied per hour, pounds	143.5	110.4	104.4	99.0	92.2	87.8
17	B. T. U.'s absorbed by air per hour	2,659	2,350	4,210	5,340	5,840	6,820
18	Cubic feet of gas per hour from meter	—	9.5	16.5	22.2	—	28.8
19	Cubic feet of gas per hour, actual	—	8.7	15.7	21.4	—	28.0
20	B. T. U.'s contained in 1 cubic foot of gas	580	580	580	580	580	580
21	B. T. U.'s supplied to heater, per hour	—	4,615	8,320	11,350	—	14,840
22	Efficiency of reheater	—	51.0	50.6	47.1	—	45.9
23	Average cut off, head and crank, per cent	56.	36.5	35.	32.2	29.4	28.
24	Average ratio of expansion	1.79	2.74	2.86	3.11	3.40	3.57
25	Range of temperature of air in engine	52.	88.9	109.	129.	150.	165.
26	Revolutions per minute	330.5	368.	375.	378.9	381.5	357.5
27	Brake load, pounds	5	5	5	5	5	5
28	D. H. P.	.629	.698	.7175	.7285	.727	.682
29	I. H. P.	.909	.976	.945	.956	.910	.860
30	Mechanical efficiency, per cent	69.2	71.	75.9	75.6	79.9	79.3
31	Cubic feet of free air used per D. H. P. hour	3,080	2,085	1,901	1,790	1,658	1,688
32	Cubic feet of free air used per I. H. P. hour	2,650	1,480	1,446	1,355	1,330	1,338
33	Cubic feet of free air used per D. H. P. per min	50.5	34.75	31.75	29.86	27.7	28.15
34	Pounds of air used per D. H. P. hour	228.	159.8	145.5	137.	127.	128.9
35	Cubic feet of free air saved per D. H. P. hour	—	945	1,129	1,240	1,372	1,352
36	Gain in air saved, per cent	0	31.2	37.25	40.9	45.25	44.6
37	Equivalent H. P. from heater per hour	0	.196	258	.296	.329	.304
38	Percentage of power from heater	0	31.2	32.25	40.9	45.25	44.6
39	Heat equivalent of work done per hour, (I. H. P.)	2,315	2,485	2,450	2,436	2,320	2,190
40	Work done per lb. of air (n=1,408) adiabatic expansion, B. T. U.	9,170	5,180	5,000	4,690	4,600	4,630
41	Efficiency of the fluid, per cent	253.	48.5	49.0	51.8	50.4	47.2
42	Thermal cost of air saved per D. H. P. hr., B. T. U.	—	6,670	11,600	15,700	—	21,800
43	Thermal cost of equivalent amount of air from compressor, B. T. U.	—	131,500	15,700	172,500	191,500	188,500
44	Ratio: Cost of air by compressing / Cost of air by heating	—	19.7	18.5	11.0	—	8.62
45	Thermal cost of air from compressor in B. T. U.'s per D. H. P. hour	415,000	292,000	264,200	249,000	231,000	234,000
46	Total thermal cost of air used per D. H. P. hour	415,000	298,670	275,800	264,700	—	255,800
47	Gain in economy, per cent	—	28.1	31.2	36.3	—	38.4

General Results—Series II.

1	Number of run	1	2	3	4	5
2	Length of run, hours	1	1	1	1	1
3	Barometer	29.4	29.28	29.24	29.38	29.34
4	Gauge pressure at meter (corrected)	79.6	81.	82.	82.5	82.
5	Gauge pressure at engine	76.6	78.	79.	79.6	79.2
6	Temperature at meter	64.	63.	66.	64.2	63.
7	Temperature at engine	63.	160.5	252.5	307.5	395.
8	Temperature of exhaust air	9.	81.	146.	192.4	248.
9	Temperature of room	51	63	63	58	64
10	Temperature of flue in heater	—	218.	299.	360.	425.
11	Cubic feet of air per hour from meter	315	293	252	237	214
12	Cu. ft. of air per hr. corrected from calibration of meter	331.5	308.5	266.	252.	226.
13	Cubic feet of air per hour at standard conditions	2,105	1,992	1,725	1,646	1,474
14	Increase in temperature of air by heating	—	96.5	186.5	243.8	332.
15	Corresponding increase in volume, per cent	—	18.5	35.5	46.5	63.5
16	Weight of air supplied per hour, pounds	161.	152.2	132.	125.7	112.8
17	B. T. U.'s absorbed by air per hour	—	3,490	5,840	7,259	8,870
18	Cubic feet of gas per hour from meter	—	13.5	19.4	22.	33.6
19	Cubic feet of gas per hour, actual	—	12.7	18.6	21.2	32.8
20	B. T. U.'s contained in 1 cubic foot of gas	—	530	530	530	530
21	B. T. U.'s supplied to heater, per hour	—	6,780	9,850	11,220	17,380
22	Efficiency of reheater, per cent	—	51.8	59.3	64.6	57.1
23	Average cut off, head and crank, per cent	30.	26.2	20.2	18.5	17.4
24	Average ratio of expansion	3.33	3.82	4.95	5.4	5.75
25	Range of temperature of air in engine	54.	79.5	106.5	115.7	147.
26	Revolutions per minute	360.	395.3	396.	408.3	396.
27	Brake load (net) pounds	5	5	5	5	5
28	D. H. P.	.685	.753	.755	.770	.755
29	I. H. P.	.999	1.11	1.027	.953	.903
30	Mechanical efficiency, per cent	68.5	67.9	73.6	.806	.835
31	Cubic feet of free air used per D. H. P. hour	3,120	2,650	2,286	2,137	1,951
32	Cubic feet of free air used per I. H. P. hour	2,110	1,800	1,682	1,725	1,682
33	Cubic feet of free air used per D. H. P. per min	52.	44.16	38.1	35.6	32.5
34	Pounds of air used per D. H. P. hour	235.	202.	175.	163.2	149.
35	Cubic feet of free air saved per D. H. P. hour (from 60 degs. F.)	10.	480.	844.	993.	11.79
36	Gain in air saved, per cent	—	15.35	27.	31.7	37.7
37	Equivalent H. P. from heater per hour	—	.1158	.204	.244	.285
38	Percentage of power from heater	—	15.35	27.	31.7	37.7
39	Heat equivalent of work done per hour, I. H. P.	2,544	2,825	2,616	2,430	2,300
40	Work done per hour by air (n=408) adiabatic expansion, B. T. U.	8,200	7,760	6,720	6,420	5,750
41	Efficiency of fluid	31.	36.4	39.	38.8	40.
42	Thermal cost of air saved per D. H. P. hr., B. T. U.	—	8,930	13,050	14.600	23,000
43	Thermal cost of equivalent amount of air from compression	—	73,100	129,000	152,000	180,000
44	Ratio: Cost of air by compression / Cost of air by heating	—	8.2	9.88	10.4	7.84
45	Thermal cost of air from compressor in B. T. U.'s per D. H. P. hour	470,000	404,000	350,000	326,400	298,000
46	Total thermal cost of air used per D. H. P. hour	470,000	412,930	368,050	341,000	321,000
47	Gain in economy, per cent	—	10.	22.7	27.5	31.7

while the temperature of the air entering the engine was varied from 60° F. to 395° F.

Series III., in which two runs were taken at about 77 pounds gauge pressure, and the temperature of the entering air 42° F. and 266° F., respectively.

The average results from each "run," were then taken from the log of each run, and are shown on the general result sheet.

The tests were performed during the month of April, 1902, in the mechanical laboratory of Sibley College, Cornell University.

The term "cubic foot of free air" is used to represent the volume of air at standard conditions, which are taken in this case to be at a pressure of 14.7 pounds, absolute, and at a temperature of 60° F.

CONCLUSIONS.

The net gain in economy obtained with the lower pressure was 38.4 per cent.. while with the higher pressure it was but 31.7 per cent. with the same conditions. In other words, we get a reduction of from 31 to 38 per cent. in the cost of the production of compressed air, by reheating the air from 60° F. to 400° F.

The curves on Plate I illustrate how the economy is raised by increasing the temperature. It is seen that the increase in economy is gradually lessened after the temperature reaches about 300° F. By continuing the curve it would indicate that the point would soon be reached where an increase in the temperature would not cause any further increase in economy, this point being reached at about 450° F.

The results obtained in these experiments afford an interesting comparison of the effects produced by different degrees of reheating, as well as by the use of different working pressures. Of the three dierent series of runs taken, the one employing the lowest pressure (56 pounds) seemed to give the most efficient results.

It was not considered advisable with our engine to raise the temperature of the entering air much above 400° F., on account of the bad effect it would have upon the packing in the valve-rod and piston-rod glands, and also upon the lubricant; however, a much higher temperature could have been attained with the reheater used.

Although the economy derived from the application of heat to the air may result from the increased volume, we are led to believe that the high results obtained

General Results—Series III.

1	Number of run..	1	2
2	Press. at meter..	76	78
3	Press. at engine.	73	75
4	Temp. at meter.	44	67
5	Temp. at engine.	42	266
6	Temp. of exhaust air	—	149.5
7	Temp. of room..	42	65
8	Temp. in flue of heater	—	—
9	Cu. ft. of air per hr. from meter.	367	249
10	Cu. ft. of air per hr. corrected from calibration of meter..	383	259
11	Cu. ft. of air per hr. at standard condition	2,430	1,606
12	Increase in temp. of air by heat'g	0	199
13	Corresponding increase in volume, per cent...	0	38.
14	Wt. of air supplied per hr., lbs.	185.6	122.7
15	Bt. T. U.'s absorbed by air per hour (from 67 degs.)	—	5,790
16	B. T. U.'s required to raise temp. from 42 degs. F.......	—	6,500
17	Total thermal cost of air used per hour, B. T. U.	352,500	146,000
18	B. T. U.'s supplied to heater per hour (from 42 degs.)	—	13,000
19	Efficiency of reheater (assumed), per cent............	—	50.
20	Revs. per minute.	392	396
21	Brake load......	5	5
22	D. H. P.........	.73	.755
23	I. H. P.........	1.40	.974
24	Mechanical efficiency, per cent.	52.1	77.5
25	Cu. ft. of free air per D. H. P. hr.	3,380	2,130
26	Cu. ft. of free air per I. H. P. hr.	1,735	1,700
27	Cu. ft. of free air saved per D. H. P. hour...	—	1,200
28	Gain in air saved, per cent......	—	36.4
29	Thermal cost of air saved per D. H. P. hour, B. T. U......	—	13,000
30	Thermal cost of equivalent amt. of air from compressor, B.T.U.	—	174,600
31	Ratio: Cost of air by compressing. / Cost of air by heating	—	13.4
32	Gain in economy, per cent......	—	30.2

13.091 cubic feet of air at 60 degs. F. and 14.7 ft. pressure equals one pound.

are due partly to other changes of condition in the working of the engine resulting from the higher temperatures. By reheating the air the engine is relieved from the difficulties due to freezing of the moisture in the exhaust passages, and the choking up of the valve.

It was noticed that as the temperature of the air was raised while the pressure remained constant, that the speed of the engine was increased, the cut-off was made shorter, and in general the operation of the engine was rendered much more smooth.

The results appear to be approximately those that are indicated theoretically with the same conditions, and prove conclusively the many advantages to be gained by reheating, which was the object of the investigation.

For instance, it is seen that the reduction in the air consumption of a small motor is in almost direct proportion to the increase in temperature. By referring to the curves on Plate I. it is seen that the decrease in the consumption of air is in almost direct proportion to the increase in temperature, until the higher temperatures are reached, when the decrease becomes more gradual and finally ceases, when the temperature is raised above the limit of practicability.

In Series I., which employed a pressure of about 56 pounds, it is seen that a saving of 44.6 per cent. of the air used cold was

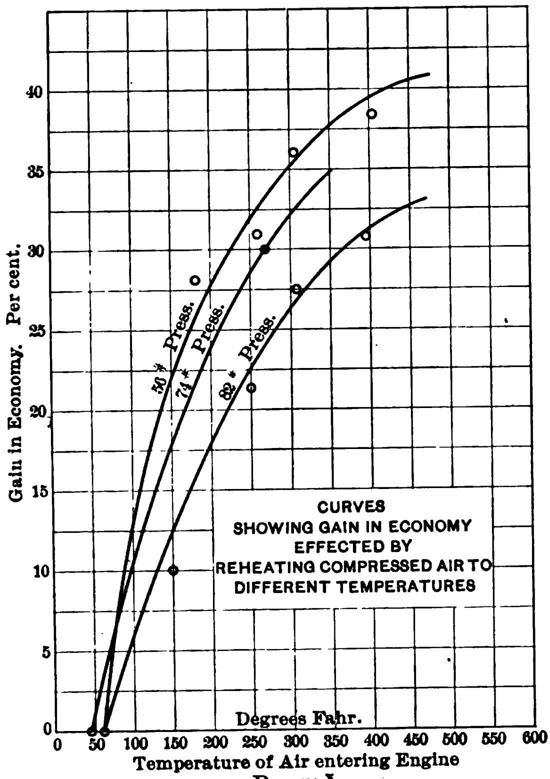


PLATE I

effected by reheating it from the temperature of 59° F. to 401° F.

With Series II, and III., in which higher pressures were used, the gain was not quite as much on account of the lower efficiencies which always accompany higher pressures with compressed air.

As shown by item No. 44, on the result sheets, the results obtained by applying heat in this manner to compressed air are from eight to eighteen times more important than would be obtained if the same amount of heat were expended under the boiler back of the compressor.

The results obtained in these experiments may be represented clearly by means of a simple proportion. Referring to the results obtained in Series I., we find that the maximum gain in air saved with the highest temperature is 44 per cent. of the amount of cold air required to produce the same amount of power.

Let us assume that 100 pounds of compressed air at 60 pounds pressure are required to produce 1 horse-power per hour at 60° F. Then if we reheat this air to 400° F. we effect a saving of 44 per cent., and we will then require but 100 — 44 = 56 pounds per horse-power hour. At this rate if we take 100 pounds of cold air and reheat it to the above temperature, the increase in the power produced will be:

$$56 : 100 :: 100 : x.$$
$$x = 178.6$$

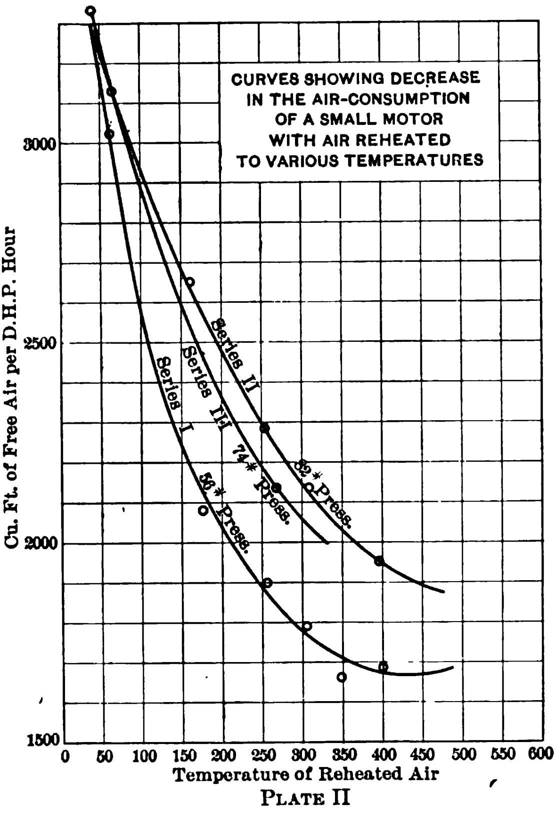


Plate II

which indicates that the power derived from the same weight of air would be increased about 78 per cent. by reheating it from 60° F. to 400° F. In other words, a compressor which is able to supply 100 horse-power at the motor with cold air, could be made to supply 178 horse-power by the use of reheaters.

The percentages of gain given in the results refer to the developed horse-power, and the increased mechanical efficiency caused by the use of heated air must have a considerable effect upon the results. The increase in mechanical efficiency is shown by the curves on Plate III.

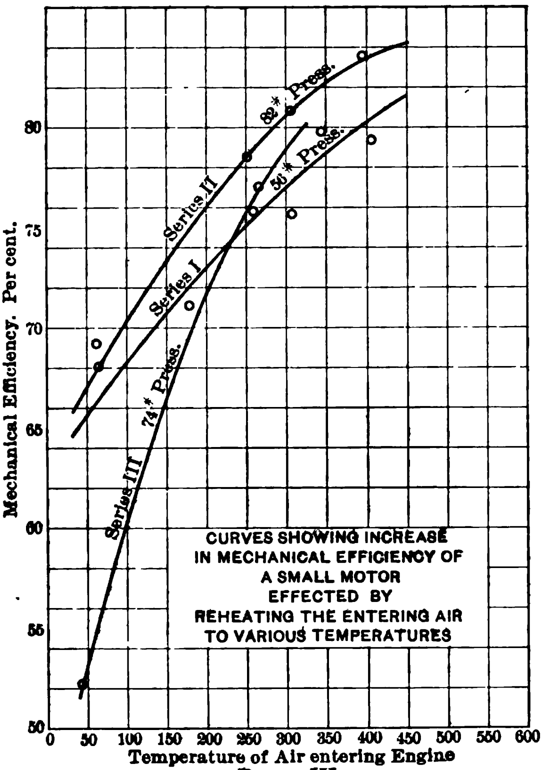


PLATE III

As the increase in volume obtained by raising the temperature of the air from this amount is only 65.3 per cent., it will be observed that the increased saving must be due partly to the more favorable conditions that the heated air provides for the engine.

Thus three important points are secured by the use of a reheater:

1. Absence of freezing.
2. Reduced cost of plant throughout.
3. Great increase in permanent economy.

—Engineering and Mining Journal.

Quadruplex Two-Stage Air Compressors.

A recent issue of *The Engineer* of London describes a type of stationary quadruplex two-stage air compressor, made by Reavell & Co., of Ipswich. Referring to this compressor *The Engineer* says the machine is constructed generally on the lines of the smaller air compressors, but it differs in a number of details, notably in that the air is compressed in two stages. There are other points of difference which would, we think, be of interest to our readers, and we therefore propose with the aid of the accompanying illustrations to give a full description of this interesting plant.

It is, as we have already stated, of the quadruplex type, that is, it has four cylinders, arranged radially, at equal distances round a common crank pin. It is single-acting, and has a relatively small stroke, so as to permit of a high revolution speed. This has been done so as to allow of direct connection to high-speed engines. In the particular instance which we are describing, however, the compressors, of which there are two, are not—as will be seen from the illustration—direct-coupled to the engine, but through the medium of a Hans Renold chain. The circular compressor tanks on each end of the frame of the machine are exactly similar to one another, and each constitutes a complete two-stage quadruplex compressor. In Fig. 1 we give sectional views of one of these tanks, showing the internal arrangements. The compressor tank or casing is so called because, while the cylinders are placed in it, it also affords space for inter-cooling, as we shall describe later on.

The makers inform us that they have arranged this machine for a two-stage compression for two reasons. First, because they have found that with machines of 120 to 150 cubic feet per minute capacity and upwards it is a distinct economy to go to the extra expense of performing the compression of the air in two stages, with pressures of 80 lbs. to 100 lbs. per square inch as used for pneumatic tool work.

In support of this contention they inform us that quite recently they have had to investigate a case of an American single-stage compressor of the same delivering capacity as the machine we are describing, namely, about 285 cubic feet. This machine required 55 brake horse-power when delivering this amount of air at 100 lbs. pressure. The Reavell air compressor, so the makers tell us, requires 58 indicated horse-power, and as the efficiency of the engine is 85 per cent. the power available at the engine shaft is 49 horse-power. The efficiency of the chain drive is taken at 92 per cent., leaving some 45 effective horse-power as the amount required to drive the compressor. These figures show a gain of about 20 per cent., and Messrs. Reavells assure us that this quite agrees with other figures which they have obtained. They have even found in some cases a saving of 25 per cent. by the use of two stages in large size compressors, with pressures of 100 lbs. In addition to this economy there is certainly an advantage in two-stage over single-stage machines, in that the former bring up the air pressure to the delivery point with a jerk at the end of each stroke, which the latter do not, thus causing more wear and tear in the single-stage than is experienced in two-stage machines.

The other reason is that the arrangement enables each line of parts to maintain a constant thrust upon the connecting-rod, gudgeon, and crank pin, so that silence in working is secured after considerable wear has taken place. As a matter of fact, the machine which we saw at work had been running almost continuously for several months, and we were struck with the practically complete absence of noise, either from the running parts or from the air valves. The air cylinders are 10 ins. and 5 ins. in diameter respectively, the ratio between them, therefore, being as 3 to 1, since the larger cylinder is annular in form. The piston stroke is 5 ins.

The air is admitted to the center of the tank through the openings at the end and through an automatic inlet arrangement, which can be seen in Fig. 1. This is an ingenious device, whereby the supply of air is controlled by the pressure of the air on the delivery side, so that when no air is required from the compressor the inlet valve is automatically closed. The way this is brought about will be readily understood from Fig. 2. Here it will be seen that the inlet consists of a valve formed of two concentric rings, one fixed and the other movable, fitting closely together, and both provided with port openings. These to a spindle, which also has attached to it a lever carrying a weight and provided with a spring. Fastened to the under side of the lever is a small piston-rod, the piston of which is inside a cylinder, the under side of which is in communication with the air delivery pipe. When the

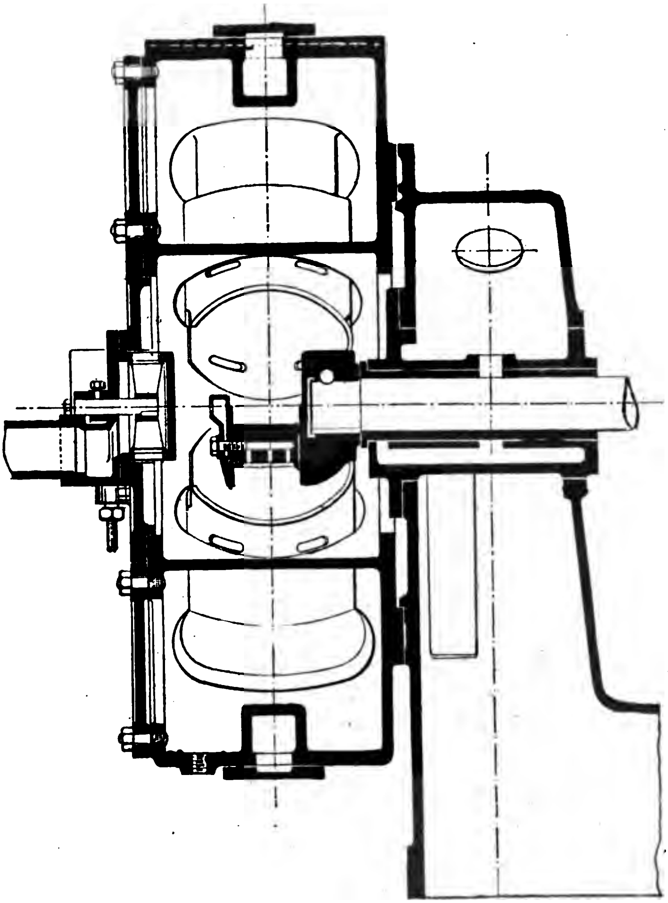


FIG. 1. THE REAVELL AIR COMPRESSOR.

are so arranged that by the revolution one way or the other of the movable ring they are either open or closed, the holes in the outer and inner ring coinciding in the one case and being covered up in the other. It is the inner ring, or piston valve as it really is, which moves. This is fixed compressor is working normally, and the compressed air is being used for doing work, the valve is in the position shown in the figure, that is to say, the ports are open. Should, however, the demand for air cease, the pressure will at once tend to rise in the delivery pipe, and when it has reached a certain amount the piston is lifted in the cylinder sufficiently far to cause the lever to rise, and in doing so turn the valve so as to close it. No air can then enter the compressor tank, and consequently it will be easily seen that very soon a vacuum is formed in the suction chamber, and the machine, since it is doing but little work, absorbs proportionately less power.

The governor is provided with three speed pulleys—a custom which we understand is always observed by the makers—so that the driver can set it to run within the limitations thus provided at the speed best suited to the average amount of air required for the time being. In addition to this there is a governing device on the throttle valve which acts on the same principle as that which governs the air inlet regulator already described. A small

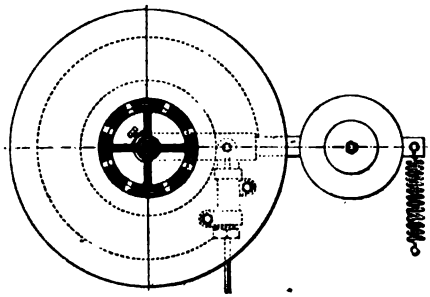


FIG. 2. AUTOMATIC AIR INLET VALVE

cylinder is in communication with the air delivery pipe, and the piston-rod of this cylinder is so connected with a lever on the throttle valve that when the pressure reaches a certain limit the throttle valve is closed, saving for a small bye-pass, which allows just sufficient steam to reach the cylinder of the engine to prevent the latter from stopping. When the air pressure in the delivery falls below the limit the throttle valve is again opened, and automatically tne engine speed is quickened. We watched the working of this apparatus on the occasion of our visit to Ipswich, where we were enabled, through the courtesy of Ransomes & Rapier, in whose works the plant is installed, to examine it carefully. The variation in air pressure was not much over one pound, and the engine and compressor were working entirely by themselves and without attention. Messrs. Ransomes & Rapier informed us that they had every reason to be satisfied with the whole apparatus, which had given practically no trouble at all, and which had been of very great assistance to them in the carrying out of the contract for the Nile Dam sluices, which contract had, largely owing to their having installed the compressor and adopted pneumatic tools, been completed well in front of time.

Turning now to a further examination of the sectional drawings, it will be seen that each of the gudgeons on the connecting rods is provided with two milled-out passages. These coincide with two ports in the piston during the suction stroke, but are blinded from these ports during the delivery stroke. Thus, during each suction stroke the air is admitted on to the top of each piston without having to pass through any suction valves, and when the piston is completing its suction stroke and the crank is turning the bottom center, the piston overruns ports cast in the side of the cylinder and allows a free communication of air from the suction chamber to the top of the piston. This is done with the object of allowing the cylinders to fill with air at atmospheric pressure without any attenuation. On the delivery stroke the air is forced through the delivery valve and passes into a receiver, or space, between each of the two cylinders of each compressor. These spaces are all inter-connected with copper pipes, thus equalizing the pressure in the different parts of the machine, these pipes being zigzagged so as to make the capacity as large as possible.

The cranks to which the compressor rods are attached are so arranged that when any one of the four low-pressure cylinders is compressing its air the opposite high-pressure cylinder is performing its suction stroke. There is, as explained, a complete connection between all the receivers, and hence the air, as it is delivered from the low-pressure cylinder on one side, has to pass completely round the tank to the opposite high-pressure cylinder, through the zig-zagged pipes, becoming cooled to normal temperature in its passage, the pipes, of course, being in a water bath. The air passes through the suction valves in the high-pressure cylinders, and on the delivery stroke is forced into a port cast round the periphery of the casing. Three sides of this port are in contact with the cooling water in the casing or tank. The air can be taken off at any one of the four positions indicated. The valves used throughout are of the maker's special multiple type. Only one size of valve is employed in the construction of all the different sizes of these compressors, the number of separate valves employed being governed by the requirements of each size of cylinder. We drew attention to this form of valve when we described the former compressor, but we may say here that they are very thin and light, each valve weighing less than an ounce. The travel is only 1-16 in., and they work to all intents and purposes noiselessly. Indeed, when the machine is at work it is almost impossible to detect any noise from them. As each compressor has four cylinders, and as the second delivery valves open soon after half-stroke, there is nearly a continuous stream of air delivered by the machine. In the double-ended type, such as that which we are describing, the crank of one machine is set 45 degs. in advance of the crank on the other end, with the result that there are eight deliveries of air per revolution. With the machine running at 250 revolutions per minute, there are therefore 2,000 deliveries per minute, or 30 per second, and the makers claim that this continuous stream of air delivered from their machine enables a large reservoir to be dispensed with in many cases where the quantity of air required is steady and normal.

Messrs. Reavell have supplied us with a detail of a test made of this machine before it was delivered. This test, though very interesting, is too long for us to print in full; but from it we gather that at 222 revolutions per minute—the normal speed being 250 revolutions—a displacement efficiency of 91·4 per cent. was attained. This meant a piston displacement of 287 cubic feet per minute, the pressure being 93·5 lbs. above atmosphere.

Reavell & Co. are now engaged in building various plants where chain-driving and gearing is being done away with. In one case, the steam engine is being fixed directly between two compressors. This method has already been adopted with single compressors. An example of one of these is shown in the case of a compressor supplied to the war office for the cordite factory at Waltham Abbey. There is also being introduced a combination of compressors, with a slow-speed motor placed directly between them. We have had an opportunity of inspecting the arrangement of one of these machines, which was in course of construction at the time of our visit. The whole machine has only two bearings, the compressor bearings being made to serve for the motor as well. The motor is of the variable speed type, and is provided with a special form of automatic controller.—*"The Engineer,"* of London.

An Air Compressor for Driving Model Engines.

The pump here described was designed expressly for the use of amateurs who make a specialty of building model steam engines. The main object kept in view was to provide a quick and ready means of supplying compressed air for driving models upon occasions when the trouble and time taken up in getting a boiler ready would not be convenient. The apparatus will also be of use for driving a "show" model, which, as fixed in its glass case, would be spoiled if handled or driven by steam in the regulation way. It would also be handy during the construction of a cylinder and piston for a model engine, when it would prove advantageous to know whether the piston was a perfect fit without escape of air.

I take it that nearly every model engineer possesses a lathe of some sort, and this air compressor is constructed so as to work off the faceplate of lathe.

Briefly, the pump consists of two cylinders and pistons worked from a crank pin on faceplate of lathe.

A reservoir is also provided, and is coupled to the ends of cylinders by means of two elbows for maintaining a constant pressure. The whole is fixed on to a base which is placed at right angles to bed of lathe, and is securely held to the bed by means of a bolt and nut.

The drawings (Fig. 1.) show the arrangement clearly enough, but perhaps a description of a few of the important details will not be amiss.

It should be borne in mind that the proportions here shown are for a lathe of 3 in. centers ,and the cylinders are 1⅛ ins. diameter, and of necessary length to permit of a 1½ in. stroke; therefore, anyone contemplating making a pump must make the wooden base and other details to suit his own particular lathe.

The cylinders are of cast brass of about ⅛ in. thickness, with a flange at one end and a stiffening rib at the other end. A bottom flange is provided, through which four holding-down studs pass, and are screwed into the wrought iron plate, which forms part of the base of the whole. The cylinders should be accurately bored, and smoothly finished, and the flange at end should be faced up from the surface plate, so as to bolt up tightly without the necessity of packing.

Next to the end flange is the valve plate of 1-16th in. thickness brass. This should be quite flat, so as to present a smooth surface to the sheet-rubber valve, which is fastened to it by means of a copper rivet and washer.

Eight holes are drilled, as shown in the end view, for the passage of air, and six holes to take the bolts which couple up this valve plate to the flange of cylinder and also the elbow leading to reservoir.

The elbow is a brass casting ⅛ in. thick, with flanges the same diameter as the flange on cylinder, and drilled to suit.

The reservoir, to which this elbow is attached, is made of copper tube 1⅜ in. diameter outside, and about 5-32nds in. thick. It should be well annealed and then filled with melted resin, so as to obtain a bend without a kink. When the correct length of tube is obtained, a flange the same diameter as the one in elbow must be brazed on the ends with bolt holes in it to correspond. A short piece of tube should be brazed in the center on top of reservoir to take a flexible strong india-rubber tube to the model.

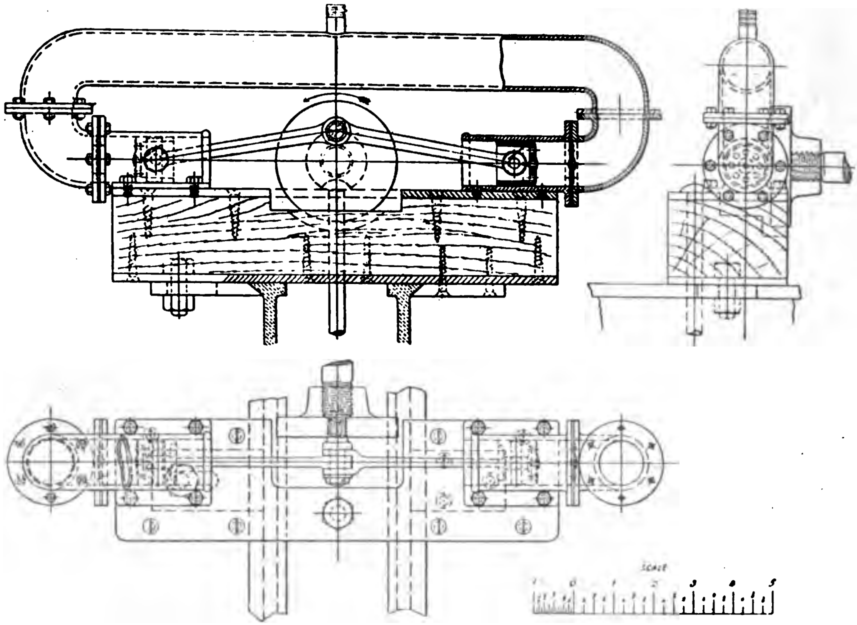


Fig. 1.—General Arrangement of Air Compressor.

The pistons are provided with bosses on the inside, and are drilled to take steel pins for the piston rods to oscillate freely upon. The pin should be a good fit so as to be quite tight and immovable in the boss. A groove should be cut on the outside of piston to receive a well-greased leather to keep it tight. The back of the piston is drilled with eight holes in a similar manner to the valve plate for the air inlet, and a circular disc of rubber is attached to it in the center by a rivet and washer.

The connecting rods are of steel, and one of them has a fork end as shown in plan, while the other is furnished with a solid end of such a size as to fit nicely in the fork end.

The small ends of rods in the pistons must fit between the inside bosses of pistons without side play, and are drilled to fit pin so that it shall work smoothly without any knock.

The crank pin is of steel carefully turned and is screwed in tightly to faceplate. It is provided with a collar to take up any side play of piston rods, and at the front end it has a washer fitted tightly on to it with a taper pin passing through each.

The base of all this is composed of two pieces of wrought-iron plate, about 3-16ths

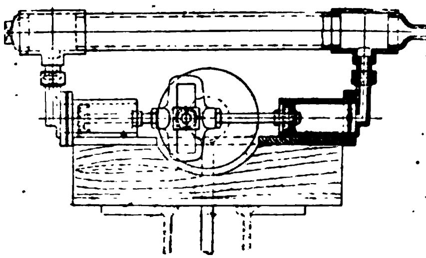


FIG. 2. ALTERNATIVE DESIGN OF AIR COMPRESSOR.

in. thick, and a hard wood block of such a depth as will suit lathe center. The plates are at the top and bottom of the wood block, and are fixed to it by countersunk wood screws.

A portion of the wood block must be recessed and the top plate cut away to allow the faceplate to stand in, also to give clearance for connecting rods. At the bottom of this base are two pieces of iron about 1½ ins. wide, one being fixed to base and the other free to move by means of a slot. These pieces of iron are necessary to prevent any play of the pump on the bedplate of the lathe, and in addition to these a holding down bolt ⅜ in. diameter, which passes right through the base and is fastened to a washer plate under bed of the lathe, should be provided.

For those who prefer a straight action, I submit an alternative arrangement (Fig. 2). The reciprocating motion is obtained through a slotted link which is coupled to a crank pin on the faceplate of lathe. In this case the pistons are tightly screwed on the piston rod, and pieces are fixed at the front end of each cylinder to act as guides. The valves are constructed in a similar manner to the one just described, and the reservoir in this case is made of ordinary gas barrel and tees. It is attached to the back of the cylinder covers by coupling nuts. The description of base for the previous arrangement applies also to this one.

The lathe should be driven in the ordinary direction—that is, towards you. The speed will, of course, depend upon the output of air, and will be controlled by the size of the model, the speed at which it is run, etc.

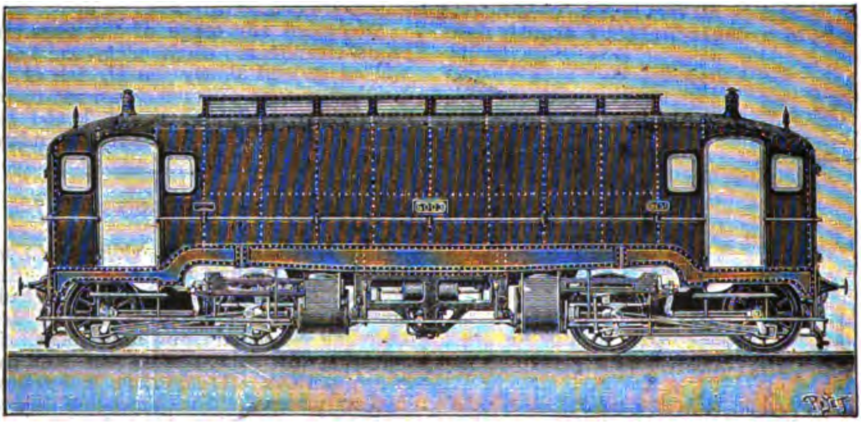
The great advantage of the apparatus is its cleanliness; often when one has a well-made and showy model, one is not tempted, except on rare occasions, to put steam into it.—W. E. S., in *Model Engineer and Amateur Electrician,* London.

Compressed Air Locomotives.

The Invalides station, which the Compagnie des Chemins de Fer de l'Ouest has just constructed, is designed principally for the service of the great lines of Brittany and Normandy, and consequently for relieving the Saint-Lazare and Montparnasse stations. To do this, it has been necessary to establish a short line between the old junction that skirts the Seine and the Viroflay station a little beyond that of Versailles (left bank). At this place the trains will reach the main line, upon which they will be able to run in all directions. The short line, of which the part comprised between the Invalides and Meudon is already under exploitation, is established wholly for electric traction. It constitutes the first railway line in France of which the trains are currently actuated by electric motors, for we cannot consider the two miles of the Compagnie d'Orleans comprised between Orsay and Austerlitz stations as an exploitation properly so-called.

The electricity is furnished by a central station situated at Issy, and the current is led by a third rail that accompanies the line for its entire length, and upon which bear the contact shoes of the motor cars, in order to take up the power needed. This system offers a host of advantages that we shall not enumerate here; but it presents one drawback, and that is that it causes interruptions of the conductor at the changing and crossing of tracks. Upon the main line and at the approach to the stations this is a matter of no great importance, since the speed acquired by the train easily permits of crossing switches without sensible retardation. But this is not the case in the switching about and making-up of trains at stations. Now, since the company, by reason of the contract made with the city, cannot employ steam locomotives in the interior of the Invalides station, it has had to look for a style of smokeless locomotive capable of performing yard services. It is with such an object in view that it has recently had constructed three compressed-air locomotives which theoretically fulfill all the conditions desired. These locomotives are designed likewise for aiding trains that happen to be momentarily in distress upon the line as a consequence of the interruption of the electric current. They have been constructed in such a way that they can make the round trip between the Invalides and Versailles stations without recharging. Compressed air, employed as a motive power, especially for street car propulsion, has not given very good results; so that, upon certain lines, it has become necessary to discard it; notwithstanding the existing installations, the efficiency was deplorable. With the locomotives of the Compagnie de l'Ouest the conditions are no longer the same, since the engines are not intended for use on the line. They have to make long trips only exceptionally, and are of interest merely for yard service at stations. The foregoing remarks as to the inconveniences found in regular service are, therefore, not applicable to them.

The compressed air necessary for these locomotives is produced by a small plant installed below the Esplanade des Invalides, at the level of the subterranean tracks of the new station. This plant consists of three independent groups, each formed of a synchronous triphase current electric motor, which receives a 5,000-volt current from the central station at Issy, and of a Mekarski vertical air compressor of 200 horse power, making 100 revolutions a minute, and raising to a pressure of 1,422 pounds to the square inch the air that the Compagnie de l'Ouest purchases from the Compagnie Parisienne d'Air Comprimé at a pressure of 85 pounds to the square inch. Each compressor consists of four cylinders mounted in pairs in tandem, so that the same connecting rod serves for actuating the two pistons of the same group. The two cylinders of each of these two groups do not have the same duty to perform.



A COMPRESSED AIR LOCOMOTIVE OF THE COMPAGNIE DES CHEMINS DE FER DE L'OUEST.

The upper one effects the compression of the air only in the portion situated above the piston, while the lower one acts only for that of the part comprised beneath its piston. From the viewpoint of work, then, the two cylinders of a tandem may be considered as one and the same cylinder. Let us see how the compression is effected: The lower cylinder draws in the air at 85 pounds to the square inch and compresses it to an intermediate pressure, and then sends it into a reservoir, whence it is sucked by the upper cylinder in which the compression is carried to 1,422 pounds to the square inch. In order to prevent heating of the metal, the cylinders are surrounded with jackets within which circulates a current of cold water. On another hand, water is allowed to flow likewise in the interior of the cylinders, so that the air coming from the compressor is always accompanied with humidity, and must be dried before it is used. The air thus compressed is stored up in an accumulator composed of six groups of twenty reservoirs. The locomotives, according to their requirements, come to these latter to obtain their supply of pneumatic power. The adoption of a system of compressed air accumulators, such as those above described, was indispensable, since, as we have seen, the plant is supplied by the electro-motive power of the line, and, as the locomotives are partly designed for the relief of the electric trains in cases of an arrest of current, it follows that the plant could not operate in cases of distress, and would be unable to render the services for which it was installed if it were desired to employ recently compressed air.

Each of these three groups of compressors is capable of giving 4,400 pounds of air under pressure. Let us add that the plant is arranged in such a way that it can furnish special portable boilers designed for reheating the compressed air upon the locomotives.

These locomotives are carried by two two-axled bogies. They have the form of a baggage car, provided with two cabs, one at each end, for the engineer. This arrangement does away with the necessity of turning the engine around for running in the opposite direction. The entire mechanism, which is extremely simple, is situated under the body of the engine so that it can be easily inspected, cleaned and repaired when need be.

The main part of the locomotive contains thirty-three reservoirs of compressed air, which the engineer can connect with the cylinders of the motors from either cab. The motors are two in number, and situated near each of the cabs. The air passes into an intermediate reservoir before entering the motors, each of which is provided with two cylinders placed outside of the frame of the car. The first is a high pressure one of 284 pounds to the square inch, and the second a low pressure one of 143 pounds. At its two extremities the engine is provided with special arrangements for the charging of the compressed air. It carries likewise portable steam boilers for the heating of the air.

The engineer's cabs are provided with all the apparatus necessary for operating and controlling the different parts.—For the above details we are indebted to *La Nature.*

A High Drop Test of an Elevator Safety Air Cushion.

A test of the air cushion installed at the foot of the elevator shaft in the Philadelphia City Hall tower was made on September 29, in the presence of several hundred invited guests. As most of our readers are aware, the tower of the Philadelphia City Hall attains the greatest height of any building ever erected. It is 500 feet from the pavement to the base of the statue of William Penn, which surmounts the tower. An elevator in the tower carries visitors from the upper floor of the building to a point just below the base of the Penn statue.

The test consisted in letting the regular passenger elevator car, weighing about 2,500 pounds, drop from the top of the shaft, a free fall of 290 feet, before entering the well-like chamber 75 feet in depth called the air cushion. In the car were a lighted lantern, six rats, fifty incandescent light bulbs, and several dozen eggs. A New York reporter begged for the privilege of accompanying the rats, but was refused. At 1:30 P. M. the car was cut loose, and four seconds later it shot like a flash out of sight into the air cushion. Two seconds afterward there was a cannon-like report, accompanying the escape of the suddenly compressed air through the valves. The sliding steel door of the air cushion chamber was then drawn back, and inspection showed that while the lantern was upset, and a few of the eggs were broken, the rats were unscathed save for a bath of kerosene oil, and the incandescent bulbs were unbroken. The elevator car appeared to be uninjured. The test is a remarkable one in that the total fall, 365 feet, exceeded by 65 feet any previous test. The velocity of the car upon entering the air chamber after a free fall of 290 feet, neglecting air and guide friction, was about 136 feet a second, or nearly 93 miles an hour. A 2,500-pound car, after falling 365 feet, friction neglected, would possess 912,500 feet pounds energy; and if this energy were overcome by opposing a uniform resistance during the 75 feet of fall in the air cushion, its necessary resistance would be more than 12,000 pounds. The area of the car floor was approximately $5 \times 6 = 30$ square feet, so that the pressure upon the floor under the conditions assumed would be 400 pounds per square foot, or about 3 pounds per square inch. The maximum pressure was, of course, much greater than this, probably more than double, for the pressure starting at zero increased as the car descended until a maximum was reached. A 150-pound man under similar conditions of uniform retardation would experience an upward pressure of 720 pounds upon the soles of his feet, and probable not less than double, or say 1,500 pounds at the moment of stopping, while the pressure upon the hip joints would be about two-thirds that on the feet. A Sandow would readily sustain such a load without weakening at the hips or knees, but an ordinary man would almost surely collapse, although, of course, with injurious results by no means comparable to those that would follow a free fall of much less height. Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Company, has himself many times dropped six stories without the least injury.

Relative to the egg as a means of testing the effect of a sudden stopping of a falling elevator car, some experiments made by a member of the *"Engineering News"* staff, and were described in their issue of July 28, 1898. It was there shown that an egg pressed between flat surfaces was crushed by a pressure of 4 1-3 pounds, which was thirty-eight times the weight of the egg. Bearing also upon this point, we are in receipt of the following letter from Mr. Charles L. Duenkel, M. E., formerly Chief Engineer of the Ellithorpe Safety Air Cushion Company, and designer of the air cushion in the Philadelphia City Hall tower:

Sirs: I have given the subject of tests of elevator air cushions recently made in a public building in Philadelphia, Pa., my careful consideration. Guided by a considerable experience as chief engineer of a local air cushion company, I feel obliged to protest against the claims for safety alleged by the placing of eggs in an elevator cage and then permitting the cage to fall and be checked by the action of the air cushion.

The conditions imposed are in no sense correlative with that of a human being falling in the cage. The degree of pressure at which an egg will rupture is about 95 times its weight when the major length of egg is set horizontal, and about 140 times its weight when its major length is set vertical. A human being can safely receive a pressure from the conditions imposed not to exceed five times his weight.

I submit for your consideration a summary of the tests made by me in the falling of elevator cages loaded with eggs to an air cushion, each egg weighing about 2 ounces.

First. The major length of egg set horizontal the result was:

					times its weight
1.	Crushing force,	9.66	lbs.;	77.35	
2.	" "	13.35	"	106.8	
3.	" "	11.49	"	91.98	
4.	" "	14.3	"	114.4	
Total	" "	48.80	"	390.53	

Average crushing force per egg, 12.2 lbs., or 97.63 times its weight.

Second. The major length of the egg set vertical the result was:

					times its weight
1.	Crushing force,	16.79	lbs.;	134.35	
2.	" "	14.77	"	118.2	
3.	" "	24.63	"	197.05	
4.	" "	16.20	"	129.60	
Total	" "	72.39	"	579.20	

Average crushing force per egg, 18.1 lbs., or 144.8 times its weight.

I believe the data submitted will disprove the fallacious claims for safety advanced in the test referred to, and I trust induce tests of a safer character to be imposed on the installation of air cushions.

Yours very truly,
Chas. L. Duenkel.

120 Liberty St., New York City, Oct. 2, 1902.

From the results of these tests it is quite evident that, provided no jar took place, an egg would stand a drop in an elevator car falling a distance of at least thirty-eight times the depth of the air cushion, according to *Engineering News* tests, and 95 to 145 times the depth of the air cushion, according to Mr. Duenkel's experiments, assuming a uniform retardation in the air cushion. In the 365-foot fall in the Philadelphia City Hall tower, where the ratio of air cushion depth to total drop is about one to five, it is manifest that the few eggs which broke were broken by jar at the time the car struck the bottom, and not by pressure developed by their inertia.

While pressure developed by inertia would not crack the eggs, it would, as we have shown, cause a man to feel as if he literally weighed a ton, and might result in serious injury.

The egg test is, therefore, very unsatisfactory, as proof of the effectiveness of the air cushion as a safety device. The fall of animals in the car without injury is much more convincing, and the larger the animal the more convincing would such a test be.

So far as one could judge by the sound there was no perceptible rebound of the car when it reached the bottom of the air cushion, the air escaping through the valves preventing a rebound.

THE AIR CUSHION.

In ordinary building construction the air cushion is located in the basement, but in the Philadelphia City Hall it is suspended in the tower proper, with its base a few feet above the third story floor.

In proportioning the air cushion it has been found necessary to make its depth from 1-6 to 1-4, usually 1-5, the maximum possible drop of the elevator car. The sides of the air cushion chamber in the Philadelphia City Hall tower are of 5-16 sheet steel, stiffened with horizontal 5-inch I-beams, 19 inches c. to c. At the bottom is a heavy sliding steel door which is of course closed after the entrance of passengers into the car. There is a clearance of about ½ inch between the elevator car and the sides of the air cushion. An air escape vent is provided in one side of the air cushion, and is triangular in shape. Its base, 4 inches wide, is located at the top of the air cushion, and its vertex is 35 feet below. Fifteen feet below the vertex of the escape vent is an escape valve having a circular opening 15 inches in diameter, and 10 feet from the bottom of the air cushion is another similar escape valve. The springs of the valve, as shown in Fig. 2, are so proportioned that at a pressure of about 3 pounds per square inch on the valve surface it will begin to open, and at 9 pounds per square inch the valve will have reached its maximum opening. Near the bottom of the air cushion is a check valve which permits air to flow inward and prevents the formation of a vacuum under the car when it begins its ascent.

We would suggest that the use of the triangular opening or vent near the top of the air cushion is not mechanically correct, for at the moment that the car enters the air cushion the pressure of the enclosed air is zero, and instead of providing means for the escape of the air at that moment, it should rather be confined, in order to bring the air pressure up and begin retarding the car as quickly as possible.

The valves should then be set to blow off at a pressure that will provide for uniform retardation of the car in its passage down the air cushion and at a rate which will just suffice to bring it to a full stop when it reaches the bottom of the air cushion chamber.

Four ordinary compound elevator springs are provided at the bottom of the air cushion to act as bumpers. The springs are about 5½ inches diameter, 16 inches high, and susceptible of a 7-inch compression.

It will be evident that in case the car should fall into the air cushion from some point below the top of the shaft and the valves were the only means of escape, the car would be stopped before it reached the bottom of the air cushion, or more quickly than necessary. As actually installed, however, there is a narrow air space all round the sides of the car, between it and the walls of the chamber, and the air escapes here as well as through the air valves in case a car falls into the cushion.

The total weight of steel in the City Hall air cushion is about 120,000 pounds, and the contract price in place was $25,000.

Similar air cushions have been in use for many years in office buildings, among which may be mentioned the 20-story Empire Building, and the *World* Building in New York City; the Frick Building in Pittsburg, and the Temple Court Building in Minneapolis. Government officials are said to be contemplating putting an air cushion in the elevator shaft of the Washington Monument. The height of the monument, it may be observed, is 550 feet.

A good deal has been said for and against the air cushion as a safety device. A fair conclusion seems about as follows: An air cushion should only be regarded as an emergency appliance, supplementary to a first-class equipment of automatic safety catches on the car. As such an emergency appliance it should prove a valuable adjunct in saving lives and limbs in case all other safety appliances fail and the car falls.

We are indebted to Mr. F. T. Ellithorpe, President of the Ellithorpe Safety Air Cushion Co., of New York, and to Mr. Charles L. Duenkel, M. E., former Chief Engineer of the same company, for courtesies and aid in securing material for this article.—*Engineering News.*

Referring to the above article, a correspondent writes *Engineering News* as follows:

Sir: I noticed the interesting account of the test of an elevator safety air cushion in the Philadelphia City Hall tower and your comments thereon. Permit me to suggest a simple method by which a real test of such a cushion may be made. The spectacular "egg test," as you well show, amounts to nothing.

Support a weight of 150 lbs. on three helical springs of such dimensions that they will be about 6 ins. high when loaded with 50 lbs. each (the static weight of the slab resting on them) and 4 ins. high when loaded with say 150 lbs. each. Place under the center of the load a cylindrical plug, sliding, with some friction, in a hole in a wooden block. Let the weight when quietly resting on the springs push the plug a short distance into the hole, and measure the distance the plug extends out of the hole. When the elevator falls and is brought to rest by the air cushion, the maximum compression of the springs will be measured by the distance the plug has been pushed in. Then by merely piling weights on top of the 150-lb. weight until the deflection of the springs equals the maximum recorder deflection, we may know what weight a 150-lb. man would have to support.

Of course this would still leave unsettled the question how many times his own weight a man can safely sustain when subjected to retardation such as that effected by the air cushion. It seems a great pity—on this and other accounts—that the yellow journal reporter who was so anxious to accompany the rats in the falling elevator car at Philadelphia the other day was not permitted to do so.

Very truly, K. W.

New York, Oct. 9, 1902.

Pumping Oil Wells by Compressed Air.*

Mr. Knapp has installed a plant for pumping and handling oil by compressed air at Chanute, Kansas. He has built a central power house, in which is a Westinghouse gas engine and an air compressor, from which compressed air is conducted to all points desired. It is believed this is the second plant in America using compressed air to pump oil, the other being at Corsicana, Texas.

The power station is a one-story brick building, used both for power house and office. It shelters a 3-cylinder 11 by 12-inch Westinghouse gas engine of 85 horsepower capacity,and a Rand air compressor 11 by 5 by 16 inches, class D, belt driven, which, with 120 revolutions per minute, has a capacity of 210 cubic feet free air per minute raised to a pressure of 350 pounds, requiring from 65 to 70 horsepower to operate it. The excess power of the gas engine over that required for the air compressor is used in part to pump oil from the large tank into the oil cars, and in part for pipe threading and as a matter of safety.

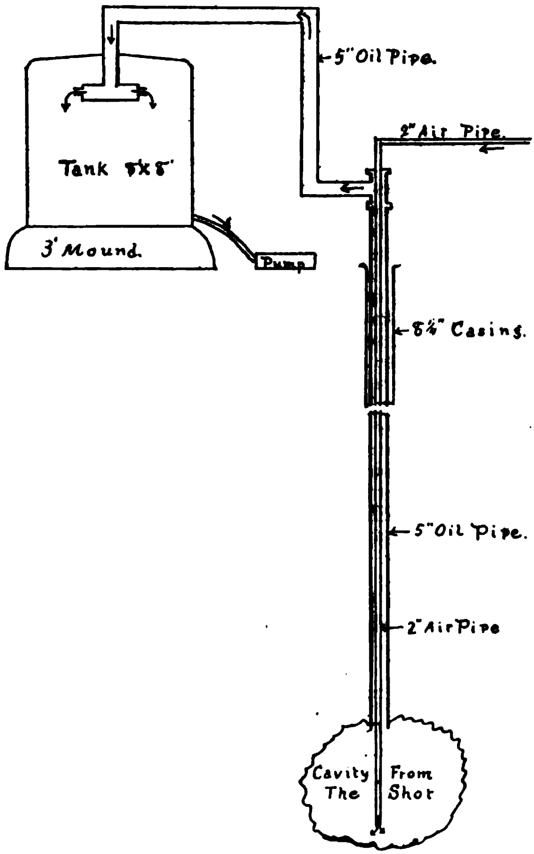
The compressed air is conducted through 2-inch pipes all over the oil field. It is used to blow oil out of the wells, and also to run the pumps for pumping oil from the small local tanks into the larger tank near the power house. The arrangement at each well is the same, and consists of a small oil tank 8 feet high and 8 feet in diameter, with a capacity of about 70 barrels, connected with the well and pump by a system of pipes, as shown in the illustration. In drilling a well, an 8-inch casing about 25 feet long is used to shut off surface water. Inside this a 6-inch casing is put down 200 feet or more and afterward withdrawn. Lastly, a 5-inch casing is put in, which goes down 600 feet and which remains as long as the life of the well continues. At the upper end of the 5-inch casing a 5-inch T is screwed on, from which a 5-inch conduit leads to the tank. Through an opening in the top cap the 2-inch air pipe enters and passes down to the bottom of the well, as is also shown. When valves are properly opened compressed air escapes at the lower end of the 2-inch pipe and literally blows the oil out through the 5-inch pipe and into the tank. The tank is placed on a little mound of earth about 3 feet high, partially to guard against damage from flood water, but principally to let gravity feed oil from the tank into the pump near by. A 2-inch pipe is inserted at the bottom of the tank, which leads to a small pump and ultimately to the large storing tank.

* Abstract of an article in the *Engineering and Mining Journal,* Oct. 11, 1902.

The pipe carrying compressed air likewise leads to the same pump, supplying power for running it.

Wells producing but 2 or 3 barrels per days are blown once every 24 hours, while those producing 20 to 30 barrels are blown 6 times every 24 hours, experience having shown that more frequent blowing does not increase the production. Ordinarily the air pressure used is about 300 pounds, but it frequently runs down to 250 pounds. A Bristol recording pressure gauge is used, which automatically produces a continuous record.

The large central tank is 50 feet in diameter and 40 feet high, with a capacity of 14,000 barrels. It is situated in the angle between the Missouri, Kansas & Texas and the Santa Fe railroads. Near by, on each line, are the loading tracks, where five oil cars may be stationed at a time. A 3-inch pipe leads from the large tank to each loading rack, and is so arranged that oil flows directly from the tank into the car. The racks of the Missouri, Kansas & Texas are on lower ground than the tank, so that loading is done by gravity, but those on the Santa Fe are on higher ground, loading being done by pumping.



DETAILS OF OIL WELL PUMPED BY COMPRESSED AIR.

The Chanute fields are interesting in a number of ways:

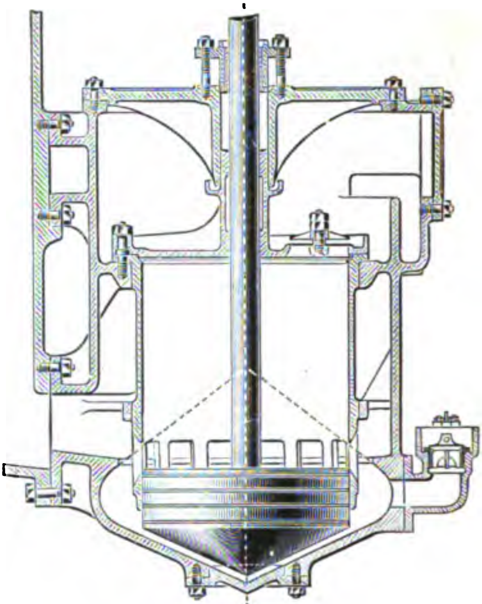
1. It is now known to a certainty that the oil and gas bearing sands are not very uniform, and not continuous over the entire area. A number of instances are known like the following: Three wells, 500 feet apart, are in a straight line. The two extremes are producers, showing a good amount of oil sand; the middle one, only 500 feet from each of the others, is a failure, showing practically no oil sand. In other instances the oil sand is entirely missing, but the lower gas sand is present, yielding large quantities of gas, and in two cases no oil nor gas sand was found at all.

2. In the Chanute field the gas bearing sands uniformly lie below the oil sands, and are separated from them by about 40 feet of shale. This is so different from conditions previously observed in other oil and gas regions that it is quite remarkable. Similar conditions have been reported from other Kansas areas, but probably nowhere else in the State are they so well shown. Here, in quite a number of instances, a fair oil producer has been changed into a gas producer by drilling through the 40 feet of separating shale.

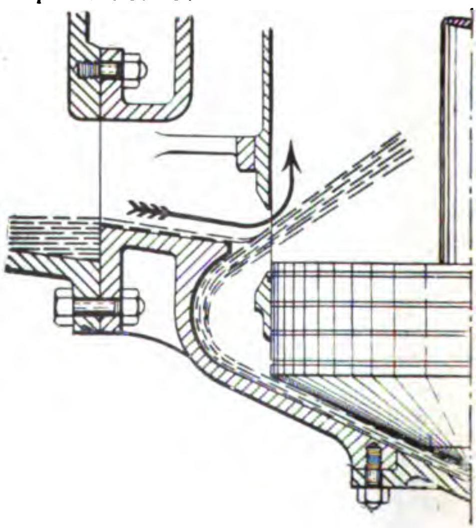
3. The Chanute field was pronounced a failure by the first prospectors, which resulted in the territory lying idle for a number of years. It is so spotted that here and there are barren areas. Unfortunately, the first few wells were in those places. How many other good localities in the State have been similarly abandoned cannot be known at present.

The Edwards Air Pump.

The Edwards air pumps are of a unique construction. It will be seen from the illustrations that this type of air pump uses no inlet valves, either in the suction chambers or in the pistons, this form of air pump being known as the suction valveless type, the only valves being in the discharge plates, where they are readily accessible. In the action of the Edwards pump, the condensed steam flows continuously by gravity from the condenser into the base of the pump, and is there dealt with mechanically by the conical bucket working in connection with a base of similar shape. Upon the descent of the bucket the water is projected si-



lently and without shock at a high velocity through the ports into the working barrel. The rising water is followed by the rising bucket, which closes the ports, and, sweeping the air and water before it, discharges them through the valves at the top of the barrel.



In this pump the speed of the water corresponds to the speed of the bucket, and the pump, having a small and regular quantity of water to deal with at each revolution, is designed to work at high speeds.

In the design of these pumps clear air inlets are maintained through the mechanism, as herewith shown. In the Edwards pump the question of satisfactorily dealing with the air is considered as of primary importance. Under ordinary working conditions, when the bucket descends and the ports open, there is no obstruction between the condenser and the pump and the air has a free entrance into the barrel, while immediately afterward the water is injected into the barrel at a high velocity, the intent being that instead of obstructing the entrance of the air; the water tends to compress that already in the barrel, and to entrain or carry in more air with it.

The Wheeler Condenser & Engineering Co. of New York, for whom Chas. C. Moore & Co. are the Pacific coast agents, control the sole rights to manufacture these pumps in America. Chas. C. Moore & Co. say they have put in a large number of these pumps in plants lately constructed on the Pacific coast, and that the results are satisfactory throughout.—*Mining and Scientific Press.*

A New Trap for Compressed Air Mines.

In the case of air mains of any considerable length, or those exposed to sudden or considerable changes of temperature, it has been found desirable, and in many cases necessary, to provide for the accumulation of moisture condensed from the air.

Among the devices employed for this purpose may be mentioned the Flinn Differential Trap, manufactured by Richard J. Flinn, of West Roxbury, Mass., shown in plan and elevation by Fig. 1.

The operation of the Flinn trap is as follows:

Water of condensation enters at the upper opening of the ball and following the surface of the ball-shaped opening, passes between the outer and inner pipes and into the receiving chamber below the diaphragm. This column of water acting on the under side of the diaphragm forces the valve to its seat against the counter pressure of the spring. Any additional water which now flows to the trap passes through the inner pipe into the chamber on the upper side of the diaphragm. When the column of water reaches about midway the height of the pipes, the effect of this column of water, plus the pressure of the spring, balances

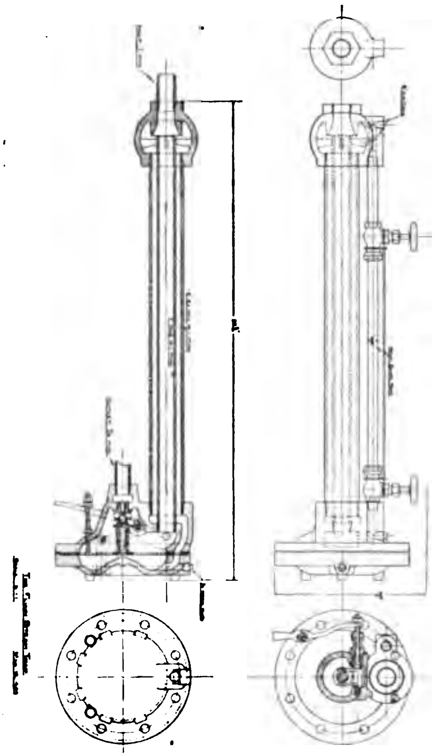
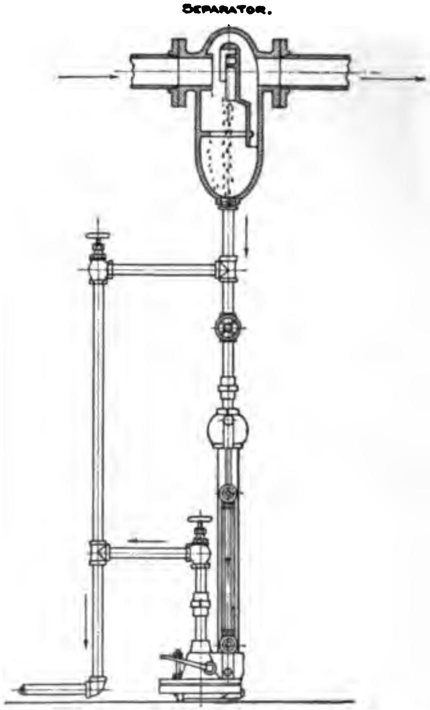


FIG. I. PLAN AND ELEVATION OF FLINN TRAP.

the effect of the column of water between the pipes on the under side of the diaphragm. Any further increase in the height of water in the inner pipe causes a depression of the valve, which allows the water to escape until the column has fallen to a level a little below the middle of the pipe, when the valve closes again. This action is repeated at intervals, according to the quantity of water entering the pipe. So long as the water keeps coming in, in sufficiently large quantities, the valve remains wide open. The valve acts every time the water rises above the water seal line and every time it falls below it. As stated before, this water seal line is about midway the height of the pipes. The diaphragm is not affected by the working pressure—whether one pound or 200 pounds—as there is the same pressure on both sides, top and bottom. There are but three working or moving parts: the spring, diaphragm and valve itself.

The Flinn trap opens freely for water and closes tight before the air can be blown out. It handles water at any temperature and responds instantly without readjustment for any pressure from 0 to 200 pounds. The valve of this trap is either wide open or tightly shut. This prevents wire drawing, which cuts the valve seats. The trap works by the weight of the water, which enters the inlet pipe of the trap. The first water that comes to the trap water seals it; the very next ounce of water opens the valve. The valve stays wide open if the water keeps on coming, but the valve closes instantly after discharging to its water seal level. It is claimed that the operation is just the same as instantaneous, and as reliable, with pressures of one pound, fifty pounds or two hundred pounds, and that the temperature of the water may be as high as 400 degrees.

In operation the valve, when only a small quantity of water is coming, does not merely part from its seat and stay there, but, instead, opens to its limit and stays there only so long as the water entering the trap is sufficient to hold valve open. Its action, therefore, gives an intermittent discharge when the trap is giving small or variable quantities of water, and a steady flow when the quantity is large or whenever there are sudden flushes. This feature, that of a valve which always makes a positive movement, when the time for opening comes, is one of the most valuable a trap can possess. In nearly every other trap on the market the valves opens according to the quantity of water entering, and, in consequence, the wire-drawing that takes place, it is claimed, quickly cuts the valve faces and seats. This trap will work against any back pressure less than the pressure in the trap or will discharge to a higher level than the trap, that is, to a height of about two feet for every pound of pressure carried. The special construction with one pipe inside another allows the water to impinge directly on the upper side of the diaphragm so that a copious flow of water will by its impact open the valve wide and relieve the trap immediately. The trap has a very large capacity and is built for pressures up to 240 lbs. per square inch.



THE FLINN TRAP CONNECTED TO A SEPARATOR FOR DRAINING COMPRESSED AIR MAINS.

THE BY-PASS PIPING ALLOWS THE SEPARATOR TO BE BLOWN OUT INDEPENDENTLY OF THE TRAP AND ALSO ALLOWS THE TRAP TO BE EASILY REMOVED FOR EXAMINATION.

FIG. 2.

The lever shown in the cut is for outside adjustment of the spring. It also serves to open the valve for blowing out the trap. This is sometimes necessary when grit and dirt comes from the air lines and gets under the valve. By depressing the outside lever the valve is thrown wide open and trap can be blown out.

For draining air lines, the trap should be arranged with separator something like the sketch, Fig. 2. This separator can be made out of piping or can be bought from any of the dealers in steam fittings who carry these separators for steam, which are equally good for compressed air. The Flinn Differential Steam Trap attached to these separators works automatically to drain off moisture and water which collects in these air lines.

Letters by Tube.

The network of gas pipes, electric wires, water mains, and other underground services, which lie buried beneath the London streets, may soon be added to by a pneumatic letter tube, which will whiz letters from post office to post office at a rate of forty miles an hour.

The pneumatic tube system is not a new idea, for it was in 1853 that the first tube for delivering messages was constructed in London, and the General Post Office is today connected by tubes with all the sub-post offices.

These tubes, however, are but two-and-a-quarter inches in diameter and never more than three, and they are used only for the transmission of telegrams and messages.

Our up-to-date cousins across the Atlantic long ago recognized the advantages of the introduction of the system on a larger scale, and while the British postal authorities have been dallying with the idea they have for several years had it in actual operation in New York, Philadelphia and Boston.

During its last session Congress voted $800,000 per annum, or £160,000, for the extension of an 8-in. tube system to all the principal cities, and a few days ago the American Government, which had invited tenders from several inventors, gave the award to the Batcheller Pneumatic Tube Company.

While the United States has thus been pressing forward, the British Government has been merely negotiating, and the matter is still "under consideration" at St. Martin's, although there is some hope under the new Postmaster-General of a definite step in the matter being taken.

The latest proposal made by the Batcheller Pneumatic Tube Company to the British Postal authorities is to construct an 8-in. tube from the G. P. O. to the branch at Mount Pleasant as an experiment, and let it to the authorities.

The London representative of the company yesterday explained the system to an *Express* representative.

"The time has come," he said, "when a tube service in London would not only simplify the problems of the Postmaster, but would effect a large saving.

"One great advantage to the business community would be that letters could be posted much later and be received much sooner.

"The sending and receiving apparatus are very simple, and 8-in. tubes or 12-in. tubes are at present in use. The mail matter is contained in metal carriers, which are shot through the tube by pneumatic force, a matter of a few seconds only being employed, as against the slow transmission by mail-carts.

"We know how difficult it is here for mail-carts to travel quickly through the congested streets, especially in the city.

"It makes no difference to the working of our system whether the tubes turn corners, describe circles, or go up or down inclines.

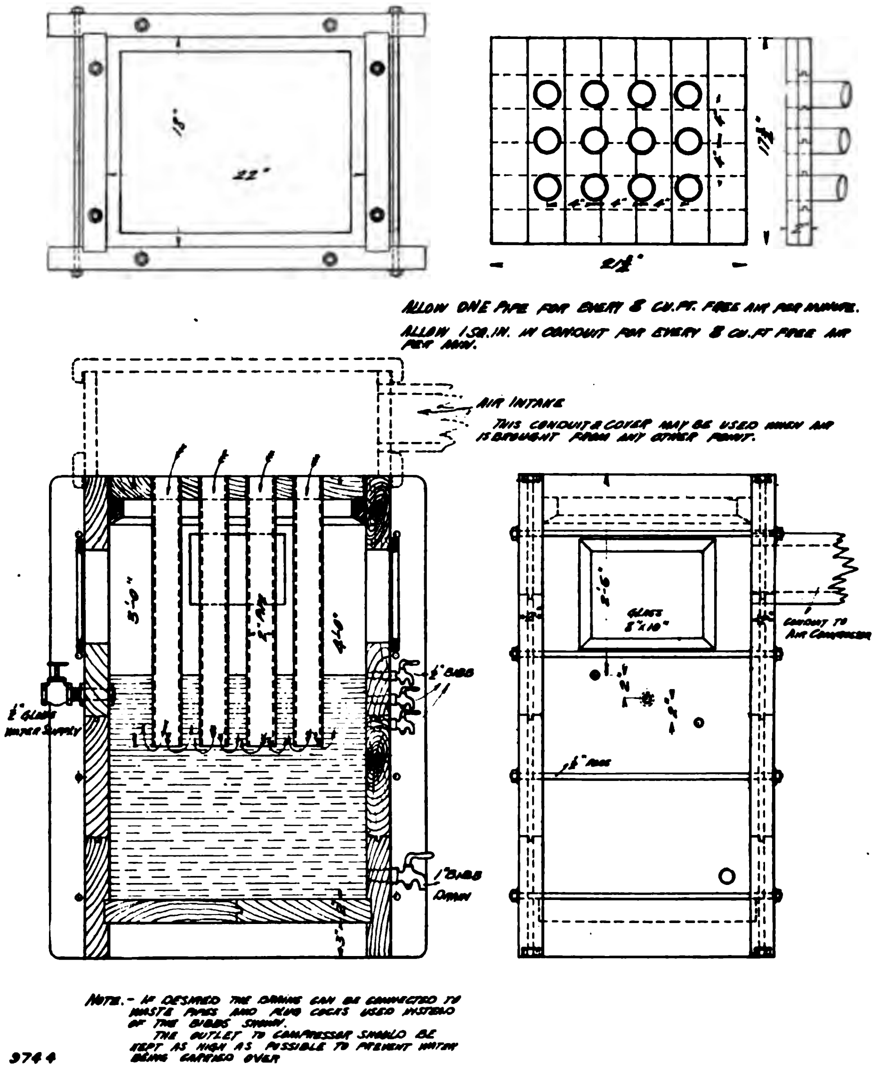
"It has been found that nearly 70 per cent. of the parcels sent through the post office are small enough to be projected through an 8-in. tube, while, by using a 12-in. tube, 90 per cent. of the goods sent out by the large shops and stores could be delivered in the same way.

"The German Government are now arranging for the introduction of the system in Berlin, and no doubt other cities will follow suit after a time."—*Daily Express*, London.

Air Washer for Compressor Inlets.

Air compressors are frequently installed in places where a great deal of dust is present in the air, and is, consequently, drawn into the air cylinder, where it mixes with the lubricating oil in the cylinder and forms a gum which sticks the valves, causing excessive wear of valves, piston and glands.

The surest cure for this is to use an ounce of prevention and locate the compressor where there is no dust, or the inlet pipe can be run to the outside, where clean air can be obtained. In many cases this cannot be done, and it is necessary to provide some means of removing the dust and cleaning the air. We illustrate herewith a simple device intended for this



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purpose which, so far as we know, has given very good satisfaction.

Referring to the cut, it will be noticed that this air washer, as it is called, consists of a tank built of wood and provided with glass windows and three pet cocks at the side like a boiler to determine the water level. There are also suitable water supply and drain taps. The tank has a series of tubes inserted in its top, which tubes project down into the water, and must have at least 20 per cent. greater total area than the inlet to the compressor to reduce the velocity of the entering air. Over the top of the tubes, and forming part of the washer, is a chamber which is connected with the outside air. The inlet of the compressor is connected to one side of the upper part of the box just above the water. In operation the air is drawn into the upper box and down through the tube, and bubbles up through the water into the space above the water. From there it passes into the compressor inlet. In this way all the air must come in contact with water, and all dust, lint and grease is retained by the water. The air, therefore, enters the compressor clean and free from anything which can increase the friction of the wearing parts or clog the valves or air discharge passages.

The washer should be drained and cleaned from time to time to prevent accumulation of dirt.

This device is simple, and we believe that the illustration given herewith is so complete that any of our readers will be able to construct a washer if they are experiencing trouble from dust.

We are indebted to The Ingersoll-Sergeant Drill Co. for the material from which this description was prepared.

Oils and Lubrication.

We cannot too strongly insist on the use of the best grade of air cylinder oil for lubricating air cylinders. Cheap or poor grades always contain light oils, such as gasolene and benzine, which volatilize at the temperatures frequently encountered in the air cylinders, especially in the case of simple compression to 100 pounds. Such oils also contain residue, which collects about the valve or in the discharge passages and intereferes with the proper operation of the compressor. Where oils are used which volatilize easily the gas formed collects in the discharge pipe and receiver, and when mixed wth the air coming from the cylinder and contained in the receiver forms an explosive mixture under pressure and at a temperature which requires only a slight increase to cause spontaneous ignition, and a more or less serious explosion results. Such explosions rarely occur, but unfortunately are usually accompanied by injury to the operator and damage to the machinery, and they can usually be traced to poor oil and lack of care in cleaning.

In any case, even with the best grades of oil, care should be taken to feed very little oil to the air cylinder, and after the compressor is adjusted and working smoothly previous to beginning regular service, the air cylinder lubricators should be adjusted to feed regularly. The amount of oil will depend upon circumstances, but range from one drop in three minutes to a drop each minute, according to the size of the compressor and the speed at which it is operating.

The cylinder lubricators should always be closed the minute the compressor is shut down to prevent oil accumulating in the cylinder. These should also be cleaned frequently and carefully looked after to insure proper operation.

In addition to using only a small quantity of oil, lubricators, cylinder, valve and discharge passages should be cleaned thoroughly to remove any accumulation of oil or deposited residue. Probably the best method for this is to fill the oil cup or lubricator with a rich soap and solution with proportions about one part soft soap to fifteen parts of water instead of oil, and run the compressor in the usual way, feeding the solution liberally for perhaps two or three hours; then open the receiver blow-off and drain off the accumulation of oil and water. To prevent rusting, let the soap suds feed out of the lubricator, fill cups with oil, adjust to feed properly and continue to run the compressor until the soap suds water has worked out and the compressor is again running with oil. This cleaning process should be repeated from time to time, the interval depending on the service of the compressor. If running at full capacity for twenty-four hours per day, about once every week or two will be sufficient. If on light load and running for ten hours per day once every month or two will do. In any case blow off your receiver frequently.

Baldwin Pneumatic Bench Vibrator.

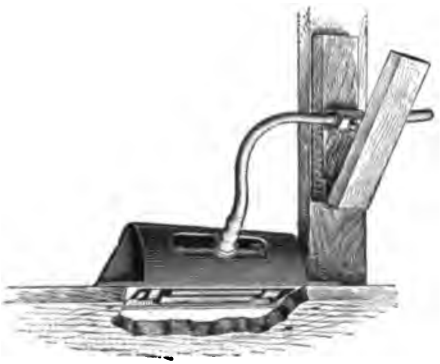
Have you ever thought how much time is lost by using two bench moulders to draw a pattern? This time is saved by using a Baldwin Bench Vibrator.

In the old way, when the moulder is ready to lift off his cope, he calls his partner, waits for him to come and rap on the bench after he has finished the work in hand.

In the new way, when the moulder is ready, he presses his knee against the valve opener, gets a much better vibration and lifts off cope with absolutely no waste of time.

This invention is of very simple construction and the only care it requires is a little oil to keep the piston from rusting.

It consists of a pneumatic vibrator in a cage connected by rubber hose with a valve which is opened by pressure of moulder's knee. The case is screwed to under-side of bench, or if bench is very



rigid, to a board laid on top of bench and the valve attached to one of the bench legs, or any other convenient place.

Experience has shown that a much more efficient vibration is obtained by placing the vibrator loosely in a cage than by attaching it to the bench itself.

As the vibrator is not attached to the pattern, no expense or loss of time is incurred in changing from one job to another and it gives equally good results, whether one or more patterns are in the flask. It also saves rapping through the cope in many cases.

As the amount of compressed air required is very small, an inexpensive air plant, run either by present steam or electric power, can be used, if a compressor is not already installed.

Notes.

Mr. W. C. Stephens, the patentee and manufacturer of the "Climax" and "Climax Vixen" rock drills, has left Cornwall for South Africa to look after his large interests in the Transvaal.

Pneumatic tubes are proposed for carrying mail between Paris and Berlin. A letter dropped in a box in Paris can be delivered in Berlin in an hour, sometimes in 30 minutes.

Theodore F. Faass, of Utica, has been appointed as foreman and mechanical repairman of the compressed air plant at Hoffmans, for the New York Central Railroad.

Bright, chatty and attractive literature continues to arrive from the Chicago Pneumatic Tool Company, and we believe that Circular No. 30, and also the pamphlet illustrating and describing the Pneumatic Hoist, which have lately been sent us, are especially worthy of notice and mention.

In Chicago the West Park boulevards will be sprinkled by compressed air. The park board yesterday decided to allow a St. Louis company to make a test of the method. The system is used in St. Louis and New York, and is said to be a success. Not only will the boulevards be sprinkled, but they will also be thoroughly flushed and cleansed.

Col. Jay H. Northup has let the contract for the establishment of a compressed air plant of large capacity for the Torchlight mines, the machinery to be delivered by November 1st. These mines are on the Big Sandy branch of the Chesapeake and Ohio Railway, five miles east of Louisa. The mines have heretofore been operated by hand.

A. W. Maconochie, member of the English Parliament and business associate of Sir Thomas Lipton, arrived a few days ago on the *Fuerst Bismarck* from Southampton. Mr. Maconochie is chairman of the board of directors of the Consolidated Pneumatic Tool Company of Great Britain, which, in turn, is owned by the Chicago Pneumatic Tool Company, and his visit to this country is to inspect the company's works in the West, preparatory to the building of a large plant by the company in Scotland.

Compressed air would seem to be dangerous when it is not skilfully used. That, at all events, must be the reflection of a switchman on a Californian train who was coupling two carriages. He picked up the compressed air pipe to attach it to the car, but before he finished the air was turned on and the blast struck him in the mouth. As soon as he recovered from his surprise he found that three upper and three lower teeth had disappeared, as if by magic, and they were blown down his throat.

At the recent meeting of the Western Pennsylvania Central Mining Institute, Mr. B. F. Jones read an exhaustive paper on the different methods of mine haulage. He discussed the advantages and disadvantages of mule haulage, locomotive haulage (steam, electric and compressed air), and rope haulage. Each method, he showed, has some peculiar feature that especially fits it for certain conditions. Nothing but a careful study of each case as it presents itself can determine what system is best to use.

The Dominion Compressed Air Dustless House Cleaning Company, of Montreal, Canada, has been incorporated to carry on the business of employment of cleaning, renovating, deodorizing and disinfecting carpets, tapestry, furniture, fabrics, hotels, hospitals, clubs, theatres, churches, stores, residences and other buildings; capital, $99,500. John S. Thurman, St. Louis; John Bryce Kay, John Irvine Davidson, Thomas Craik Irving, John Taunton King, Watson Telfer Bradshaw, Henry Winnett, Douglas Kay Ridout, John Dawson Montgomery, Toronto, are named incorporators.

While it is known that air can be made solid as well as liquid, up to the present comparatively few experiments have been made in this direction. A scientist recently converted a certain quantity of liquid air into a small solid mass, and on examining it found it was as transparent as clear ice and as elastic as rubber. To test its elasticity he struck it with a hammer, and the latter immediately rebounded. That solid air may prove to be of commercial value is the opinion of some scientists in Germany, but it is admitted that many more experiments will have to be made before any certainty on this point can be arrived at.

A 16 and 12x18 compressor, if in good condition, should be capable of operating three 2¾-inch drills or two 3¼-inch drills with 80 pounds air pressure. A 6 and 6x6 air compressor is not large enough to run any drill, as the capacity would be only about 25 cubic feet of free air per minute. This calculation is based on the three 2¾-inch drills using 260 cubic feet of free air per minute, or two 3¼-inch drills using 252 cubic feet of free air per minute. To calculate the free air capacity of the compressor, multiply the effective area of the air piston in square feet by the piston speed in feet per minute, which, in this case, is about 270, based on a speed of 120 revolutions per minute.

The Philadelphia Pneumatic Tool Company states that its anticipations in regard to the volume of business for the month of September were fully realized, the sales for that month having amounted to 20 per cent. more than any previous month. During the current month the monthly record for foreign shipments has already been broken, large orders having been received from Great Britain, Germany, France, Italy and Denmark.

Mr. Chas. G. Eckstein, the German representative of the Philadelphia Pneumatic Tool Company, arrived in New York on the 17th inst., and will probably remain some weeks in this country.

N. A. Christensen, the founder and general superintendent of the Christensen Engineering Company, has resigned his position with the company, and will hereafter devote his time to the manufacture of patent air compressors which he recently patented. Mr. Christensen retains his stock in the engineering company and will be connected wth the firm in the position of consulting engineer. A few months ago Mr. Christensen conceived the idea for a new compressor which could be used to advantage in oil wells, and after securing the patents on them decided to manufacture them himself rather than form a new company or turn the rights over to the old company.

Report comes from Cleveland, Ohio, that in attempting to take to pieces the air compressor which is used in connection with the new Holly engine for the high service district reservoir, employees at the Division street station broke some of the vital parts so that it could not be used. The pump could not, of course, be used without the air compressor, and all further attempts to supply the high service district direct with water were abandoned for the time being. The engineers and experts connected with the Holly Manufacturing Company, the makers of the mammoth engine, improved their time by going over the machinery and adjusting it for the final test, which will be made in a few days.

Herr Kruger, of Berlin, Germany, director of the company which has been formed to exploit Professor von Linde's process of applying liquid air for cooling purposes, was summoned to Hubertusstock recently to explain the principle to the Kaiser and Kaiserin. Experiments which were conducted during lunch convinced their Majesties of the extreme practicability and usefulness of the new process not only for cooling the atmosphere of large buildings but for domestic purposes, and it will be used in future in the Imperial household. Liquid air is easily transportable, and Her Majesty was specially interested in experiments showing how much more advantageous and convenient it will be in hospitals and similar institutions than the customary ice.

The work of some twenty housemaids in sweeping and dusting will be done in a twinkling in Judge Seaman's courtroom at Milwaukee, Wis., when the suit of the American Compressed Air Cleaning Company, of Milwaukee, against the Wisconsin Compressed Air House Cleaning Company, a subsidiary company of the General Compressed Air House Cleaning Company, of St. Louis, will come up for trial. The plaintiffs claim infringement on a patent originally held by Enoch Nation of Indianapolis in 1893. The basement of the Federal building is now filled wth machinery necessary as exhibits in the case, and it is probable that compressed air will be pumped from the basement to the courtroom to demonstrate the operation of the cleaner over which the contest wages.

We are glad to learn that the leaders of the Rand industry have no intention of waiting for the compulsion of legislation before taking in hand the terrible scourge of phthisis which afflicts the mine-workers, owing to the dust from the percussive drills. Prizes (the first £500 and a gold medal) are offered by the Chamber of Mines for the best suggestions and devices for combating the cause of the disease. Mr. Francis Fox suggests to a contemporary the use of the Brandt hydraulic drill, which is being found so efficacious in the Simplon Tunnel work; but as Mr. Fox himself suggests that it might possibly not be suited for employment in stoping, and as the scarce water supply has also to be taken into consideration, the Johannesburg Chamber's competition appears desirable.

The Chicago & Sonora Mining Company, which has a very rich gold property near San Antonio de la Huerta, and has obtained handsome results from a small prospecting mill during the prosecution of development work, has now had built and ready for shipment a new 20-stamp mill air compressor, tramway, and other machinery which will be set up and put into operation as soon as possible after arrival. Wagon roads, pumping plant and pipe line are already complete and ready for operation. Large reserves of ore have been exposed by the development work, and there is sufficient in sight to run for a long time such a mill as the new one ordered, the capacity of which will be increased as development progresses. Dr. R. C. Coy, of Chicago, is president of the company.

Something new in rock drilling for deep holes is reported from Frankfort, Germany, where Howarth and Walski have a device for utilizing the flushing water instead of the boring rod to convey motive power to the borer, the boring being done by a hydraulic motor attached to the bottom of the rods, water under pressure being forced through the hollow rod to the motor, the escaping water doing the flushing. The engineers mentioned say that with a drive pipe and piston 2 inches in diameter and a working pressure of 170 pounds, the test motor gave twelve strokes per second, consuming 1.1 gallons of water, and that the 8-inch bit drilled through hard standstone at the rate of 26 inches per hour; in soft sandstone at the rate of 23 feet per hour.

Three handsome catalogues have been received from the Gardner Governor Company of Quincy, Ill. Their air compressors are driven by belt, electric motor or steam. The duplex air compressor consists practically of two straight line machines placed side by side upon one bed plate and coupled to one crank shaft with one fly wheel for both. Their duplex steam pumps are built in a wide line of sizes and patterns, adapted to almost every service. Their standard Class A governor is of the gravity action, and has an automatic safety stop and speeder. It is made in sizes from 1¼ to 16 inches, and is especially adapted to the larger type of stationary engines. The centrifugal force of the balls is opposed by the resistance of a weighted lever, and the speed is varied by the position of this weight on the lever.

To measure the difference of height between two places with a barometer, first measure the air pressure, P, at the lower station, and then the air pressure, p, at the upper station. Calling T the measured temperature Fahrenheit, the vertical distance in feet between the two sections

$$= (60{,}360 + [T\text{-}32^\circ]\ 122.68) \log \frac{P}{p}.$$

If one has a pattern made of soft pine put together with nails, an iron casting made from it will weigh 16 pounds to every pound of the pattern. If the casting is of brass it will be 18 pounds to every pound of the pattern. A metal that will expand in cooling is made up of nine parts lead ,two parts antimony and one part bismuth. This alloy is of practical value in filling holes in castings.

The pneumatic tube service between the Brooklyn and Manhattan Post Offices and between the Manhattan office and several sub-stations has been resumed. The first few batches of letters which were sent across the bridge were heavier than the tube is supposed to handle, and there was some delay resulting. The men who were operating the service are not yet thoroughly familiar with it, and did not know the exact capacity of the cases.

The mails were handled much faster than at any time for a year. After the first few loads of letters had been sent across the men learned the game and the cases arrived very fast. A special delivery letter which was mailed uptown in Manhattan, addressed to a law firm in Fulton street, near Borough Hall, was delivered exactly twelve minutes after it was posted.

A correspondent writes to the editor of the *American Machinist*: "A mandrel 3-16 inch in diameter and 120 feet long is unusual, yet that is just what I saw recently at the Boyer plant of the Chicago Pneumatic Tool Company, spinning away merrily at the rate of several thousand revolutions per minute.

"This mandrel is used for coiling the piano wire closed springs which are used instead of belts to drive the Boyer speed recorder, and it is rotated by means of an air drill at one end, while the other end runs in a bearing attached to a post. An ordinary wooden clamp, faced with hard fiber, held in the operator's hands, governs the feed of the piano wire and hence the closeness of the coil; and, to the lover of physics, not the least interesting feature of the operation is the manner in which the long, thin mandrel is thrown into loops and nodes during its rapid rotation."

We give below a letter written to *Engineering News* and the editor's reply.

Dear Sir: We would like very much to learn something of the process of blowing cement into the sand of river beds for the purpose of solidifying the same. Will you kindly give us some information on the subject?

Yours truly,
Beardsley Construction Co.,
By R. C. Beardsley.

Elkhart, Ind., Oct. 4, 1902.

[We are able to give no information relative to a pneumatic process of forcing cement into quicksand. Possibly our correspondent has in mind the Harris process of pumping cement grout into quicksand. This process was patented by the late Robert L. Harris, M. Am. Soc. C. E. (patent No. 464,771, Dec. 8, 1891), and was described in our issues of Apr. 28, 1892, and June 28, 1894. The process consists of (1) sinking pipes into the quicksand; (2) pumping out the sand so as to leave a chamber, and (3) forcing cement grout into the chamber, so that a hard cemented floor is produced. If any of our readers know of any process of forcing cement into quicksand by air pressure we shall be pleased to hear from them.—ED.]

Chicago's City Council have been asked to give a franchise, the passage of which has already been taken for granted and a contract entered into with the Government on that presumption. The Illinois Pneumatic Service Company wants the franchise in order to lay pneumatic tubes beneath the surface of the streets, and that company, which is a branch of the American Penumatic Tube Company, a $15,000,000 corporation of Boston, was awarded by the Government on September 27 last a contract for carrying the mails by air pressure through tubes which are still in the air.

Aware that the Council will not pass again an ordinance like that of the Illinois Telephone & Telegraph Company's, free from any limitation as to the size of the tubes which can be put under the streets, the company in its request for an ordinance agrees that its tubes shall not exceed fifteen inches in diameter. For compensation the company proposes to pay the city 3 per cent. of its gross receipts for five years and 5 per cent. for the remaining twenty of the twenty-five years for which it asks that the franchise be granted.

The Chicago Pneumatic Tool Company report that owing to the vast amount of business they are receiving from the Southwest territory, they have deemed it advisable to again place a representative in that district, and therefore have located their Mr. W. C. Walker in St. Louis, with headquarters at 325 Lincoln Trust Building. They believe this arrangement will greatly facilitate handling the volume of business received from that territory, and will be very advantageous to both themselves and their numerous customers.

The most valuable feature of the gas engine manufactured by the Westinghouse Machine Company is its ability to start at a moment's notice without even the preliminary "warming up" which is required for steam engines of large size. This is accomplished by means of compressed air, which is stored in a steel tank for this purpose. One cylinder is momentarily isolated for utilization as a compressed air motor by which the engine is given a few turns. It then enters upon regular four-cycle operation, and the starting cylinder being converted to a power cylinder, full load may be at once applied. These starting operations may be completed within half a minute after the starting signal is given, and it is immaterial whether the engine to be put in service is entirely cold or has been but recently shut down.

The board of naval experts appointed to investigate the value of oil as a fuel for American warships recommends that one-third of the torpedo boats and destroyers now in commission shall be fitted with oil-burning plant. It is reported that the engineering difficulties have almost been solved. The commercial obstacles are due to the lack of oil supply in some parts of the world. The high cost remains to be solved.

The board reports that oil is practicable for use in torpedo-boats, army transports, and naval auxiliaries which cruise between points where the oil supply is plentiful. It has been tried on a torpedo-boat with good results. The problem of safe stowage, without danger from explosion of the oil fumes, which, mixed with the gases from cooking-galleys, is like gunpowder, is the great difficulty to the introduction of oil fuel into warships. The board states that most of the experiments have heretofore failed because it was attempted to burn the oil instead of atomising it with a compressed air spray.

On October 15, at Scranton, Pa., Alton F Clark, Conrad Lutz, Louis Conrad and W. M. Bingham, constituting the Correspondence Institute of America, were arrested there at the instance of Post Office Inspector Hugh Gorman, charged with a fraudulent use of the mails. They were taken before United States Commissioner Searle and held in $1,000 bail each for a further hearing.

The Correspondence Institute of America must not be counfounded with the International Correspondence Schools of Scranton. The Correspondence Institute of America was a heavy advertiser. It spent thousands of dollars in informing the people through the leading newspapers what it proposed to do, and it advertised to give instruction by mail in journalism, electricity, stenography, art illustrating, and advertising writing. Inspector Gorman says he has discovered that the concern did not possess facilities and instructors to carry out their promises.

The *Scientific American* describes two arrangements invented by Mr. W. B. Heyburn, Wallace, Idaho, to prevent the telescoping of trains in collisions. One is to so construct a guard on both the locomotive and the rear end of the train, that derailment can be substituted for the crushing of trains, and as a protection against disastrous results, such as throwing a train down a steep embankment, the second arrangement has been devised. The guard is provided with a V-shaped impact surface, and the guard on the locomotive is capable of adjustment to the one side or the other. Normally this pilot or guard will be held, by strong coil springs, with its point midway of the track. A cylinder on the locomotive, which is shown in section, is provided with a piston connected to an arm on the pilot. This piston may be operated by steam, but will preferably be operated from the compressed air system of tne train. Suitable connections are provided, whereby the engineer may admit the compressed air to one side or the other of the piston-head, so that in event of an impending collision he may quickly swing tne pilot to one side or the other, thus choosing the most favorable side for the derailment.

The air used between the cylinders of a compound pump can be interheated by inserting an ordinary feed water heater into the suction or discharge line through which the water is pumped, the cold exhaust air passing through this heater on its way to the low pressure cylinders in the same manner as boiler feed water. Exhaust air is often several degrees below zero, and as compared with that temperature, mine water at 60 degrees is effective as a means of heating. Under this system there is no freezing and the air consumption is cut in two. This may be carried into triple or quadruple expansion for large plants of heavy duty. A hoisting engine can be arranged for reheating very readily, but in all cases the heater must be placed as close as possible to the cylinders using the air. The heater should be carefully covered with magnesia and all hot pipe connections and cylinders using the air fully protected. The usual reheating temperature does not exceed 350 degrees, a temperature that gives no trouble with lubrication, stuffing boxes, etc. The usual rule is not to heat to a point higher than will result in the exhaust being at mine temperature, thus in no way interfering with comfort or ventilation. The exhaust of a rock drill on a hot day may be below zero, though the air be used full stroke and without expansion; but with the air heated to a point which results in an exhaust temperature about equal to the atmosphere that 95 per cent. efficiency may be secured. With a small amount of heat the results are often six times more important than results from the same amount of fuel burned in a boiler furnace.

Transformers are almost double in permissible output by the simple application of an air blast to carry away the heat that would otherwise be imprisoned in the casing. Why cannot the principle be applied with advantage to railway motors, especially those intended for heavy traction? The large increase in motor capacity obtained by leaving the cases opened, a device permissible in elevated work, is well-known. Why not carry the matter a little farther and force the air through with a blower? This device would at once change the load limit from a temperature limit to one of commutation, efficiency and similar considerations, and would possibly have the effect of making the present hour rating a continuous one, which in interurban work is a consummation devoutly to be wished. The increased life of the windings and the absolutely tight casing also offer advantages which in themselves quite counteract the disadvantage of maintaining the little motor and blower which would be necessary. A further consideration, with reference to the device, is rather radical, but nevertheless attractive. Taking a 200 h. p. equipment, a fair interurban figure, working at a net efficiency of 60 per cent., counting the use of resistance in control, it is safe to say that of the 40 per cent. losses one-half could be absorbed by the air of the blower system. Twenty per cent. of 200 h. p. is 29.84 kws., or about the energy absorbed by five ordinary sets of car heaters. It looks as if the heaters would pay for the motor, blower and piping. To keep the motors and resistance cool, the passengers warm, and save the entire heater current by the process, sounds too good to be true. Of course motors do not always run at full load, and these figures require shaving, but they can withstand the process.

As to the energy for the blower motor every particle of it will appear as heat in the car atmosphere. The energy consumed in arc headlight resistance is not only ample but available for such a motor. An electric car is rather a wasteful combination after all.

Since the cheapening of air-compressing machinery, the Tilghman's sand blast process for cutting hard substances, sharpening files, and removing the scale from iron and steel plates, forgings, castings, etc., preparatory to galvanizing, tinning, enamelling, painting, etc., has come largely into use, its superiority over the older processes of planing, grinding, pickling and galvanizing, etc., being obvious, involving as it does the minimum of loss of material and retaining the strength of metals intact. With the several designs of machines, devised for special purposes, placed on the market by Tilghman's Patent Sand Blast Co., Ltd., Broadheath, Manchester, it is even possible now to adapt it to an increasingly wide range of industries beyond those of metal, and glass working, gold and silver smithery, stone, slate and granite cutting and carving, brick, tile and pottery manufacture, and photography and block-printing are all alike benefited by its services. In the machines devised by this firm, portability and adaptability are the keynotes, and they are so made that they can be taken to the work and not the work brought to them. The designs include the sand blast apparatus with a flexible blast pipe for cleaning castings, etc., which requires a separate room for its operation, the blast pipe being directed by the hand of the operator; the complete sand-blast plant, wth automatic sand elevator and dust separator, consisting of an air compressor, receiver, sand blast apparatus with cyclone separator and valves, auxiliary cyclone separator, exhauster, air-washing arrangement, and sand-blast room, the compressor being driven by belt or steam—a plant which has received the most extended use in a variety of industries; the rotary table sand-blast apparatus for cleaning castings of flat shape; the improved sand-blast tumbling barrel, with automatic sand elevator and sand and dust separator, for cleaning small castings, stampings, etc.; and the continuous sand-blast tumbling barrel, in both which the articles are treated within the barrel, a method which renders the process entirely free from dust. The general utilities of these appliances indicate a wide field of employment for them in the mining areas of South Africa.

The cleaning of the railway passenger coach is a problem which the companies find serious in case of blockades. Last winter during one of the heavy snow storms many trains were unable to leave on schedule time from this city, owing to the fact that time had to be taken after the arrival of the delayed trains to give the car cleaners an opportunity to do their work. In the South the railways in some places use compressed air, which is quick and thorough. At the end of the cleaning tracks there is a large tank where the air is stored, and it is conveyed to the place needed through a rubber hose. The method of application is rather interesting. The air emerges from the nozzle, not in a round stream as in a watering hose, but through a device known technically as the comb. It is an elongated orifice several inches long, out of which the air emerges in a jet perhaps a thirty-second of an inch in width. It is not employed every time a car is to be cleaned, but only occasionally, being so effective that the alternate overhaulings are little more than sweepings and dustings off.

It takes four men to clean each car, two inside and two out. The former take all the seats down or move them around so as to be approached at all points, dust and wipe them off, or, if the occasion demands it, beat them with rods, or again apply the air. Every bit of the woodwork is wiped, and if looking dim is oiled and polished with waste. The brasswork is similarly treated, and is not left until its brightness is mirror-like and its surface immaculate. The outside men have not been idle meanwhile. If the day has been rainy the water hose has been brought into play, and the car is given a bath until its cuticle, if such a term may be thus employed, is without stain. Then it is wiped dry, and every now and then is rubbed off with a preparation similar to the pomade used to clean the brass, only that it is more fluid. Down below the under men have been at work on the facings of the journals and the casings of the axle boxes, and pretty soon the whole car is clean. The inspector comes along, passes on the work; the waterman mounts the roof with his pipe, fills the tanks with drinking water; the gas man attaches his hose to cocks placed at regular intervals along the track, loads up the gas tanks under each car, and it is ready for another trip whithersoever the will of the yardmaster shall designate.

An important experiment in a pneumatic sewer system which for several years past has been in operation on the Continent was recently inaugurated at the little village of Stansted, in Essex, England.

Stansted is the first place in this country in which the system—the Liernur—has been installed, and its introduction is in the nature of an experiment by means of which it is hoped by the promotors of Liernur's English Syndicate, Limited, to convince the Local Government Board of its utility.

Stansted is situated in a very hilly district, and has given the local authority considerable trouble in connection with its drainage. The new system drains by suction, and the pipes can therefore follow the contour of the ground, no incline being necessary. No man-holes are required, and flushing or ventilating columns are unnecessary.

It therefore appealed strongly to the Stansted District Council, and they decided to adopt it. The Local Government Board would not, however, sanction a loan for the system until they had seen it in operation for two years. With the object of introducing it into this country the syndicate have borne the whole of the cost of laying down the installation, and are working it for two years on the understanding that if at the end of that time it gives satisfaction the Stansted Council will take it over at cost price, otherwise the syndicate loses its money.

About a third of the householders have voluntarily connected their houses with the new installation, and over a mile of piping has been laid.

A large party attended the opening ceremony, including Sir James Blyth, Sir John Cockburn, Mr. Dobbs, Agent-General for Tasmania, and many eminent engineers. Mr. Liernur, the inventor, was present, and acted as guide.

In the pumping house, which is situated in a large meadow, is a receiver with a capacity of 3,000 gallons. By means of a vacuum pump the sewage is brought by a violent suction through four-inch instead of the usual fifteen-inch pipes.

The suction is at the rate of 6,000 gallons per hour, and the entire sewage of the village can be drawn into the pumping houses in a few minutes, leaving the pipes clean and dry.

So far, the Liernur system has been in use for some years in Trouville, the French watering-place, in the greater part of Amsterdam, in St. Petersburg, and in several German and Dutch towns.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Editor COMPRESSED AIR:

In the March number of COMPRESSED AIR I notice a water trap for compressed air mains described. Mr. Covell says that at the bottom of the separator is a ¾ in. safety valve set to trip when water reaches height of fifteen or twenty inches, thereby discharging water.

This will act all right when the pressure in the separator is constant, but should the air pressure increase two or three pounds this increase in pressure, which is equivalent to head of water of four to six feet, would be sufficient to open wide the safety valve, discharging all the water in lower part of separator, and blowing a large quantity of air through the safety valve until the pressure dropped sufficiently to allow the safety valve to seat again. You will readily see this is a wasteful proceeding, as in most machine and boiler shops where compressed air is used for operating the tools and machines, the pressure fluctuates often as much as ten pounds and a trap of this kind would, therefore, waste a large amount of compressed air. The Flinn trap will work the same under any pressure and will not allow the air to blow through no matter where the trap is located or what pressure or temperature under which it works.

RICHARD J. FLINN.

October 8th, 1902.

Editor of COMPRESSED AIR:

DEAR SIR—We have been reading your journal with great interest. We have fixed a good many permanent air lift installations and have made a good many tests in this country. Should you desire to have particulars we shall be very pleased to furnish you with same.

There is one little matter we notice in your article on "Compressed Air in Bored Well," page 1959, September, 1902, issue, wherein you say, "The various tools and plant employed are made by Messrs. J. Warner & Co." As a matter of fact, we bored the wells for the

Tunbridge Wells Corporation, and all tools were made by ourselves, as we are makers of boring tools. We should be glad if you would notify this through your paper. We put down four bore-holes for the Tunbridge Wells Corporation at Pembury, and it was at out instigation that the compressed air installation was adopted. We are now doing some further work for them.

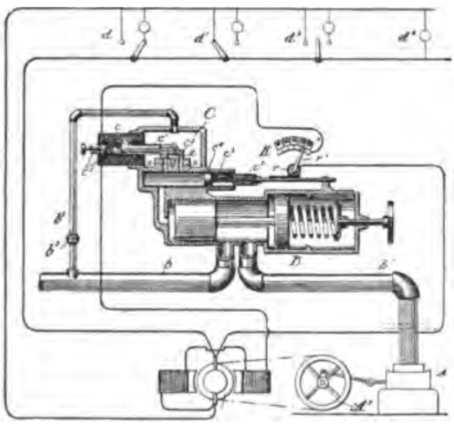
Trusting this little matter will receive your kind attention, we remain,

Yours faithfully,
Messrs. C. Isler & Co.,
Bear Lane,
Southwark, England.

U.S. PATENTS GRANTED SEPT. 1902

Specially prepared for Compressed Air.

708,026. ELECTRIC CONTROLLER. William H. Clarke, New York, N. Y. Filed Oct. 11, 1901. Serial No. 78,317.



An electric regulator, the combination of a motor, a differential piston controlling the motor, a generator operated by said motor, an electric circuit connected therewith, a rheostat in said circuit, and means governed by the differential piston and rheostat for maintaining a constant speed of the motor.

708,027. AERO-STEAM ENGINE. Severinus J. Corrigan, St. Paul, Minn. Filed Sept. 3, 1901. Serial No. 74,055.

The combination in an engine in which four strokes of the piston and two revolutions of the crank-shaft are comprised in a working cycle, of a cylinder, a piston contained therein, a connected crank-shaft, an air-chamber, heating means therefor, and valves interposed between said air-chamber and piston-cylinder said parts being so arranged and connected that air is compressed by the piston from atmospheric pressure and temperature into said air-chamber and the clearance-space of the cylinder, during the latter half of the second stroke of the cycle, retained in said chamber and heated therein during the third and fourth strokes of the cycle, and expanded from said chamber into the cylinder during the first stroke of the following cycle.

708,092. AIR-BRAKE VALVE. Frederick Strattner, Salisbury, Md. Filed Oct. 15, 1901. Serial No. 78,742.

In air-brake apparatus, an air-cylinder and its piston for applying the brake, an air-storage cylinder and its piston arranged for simultaneous coaction with the first-referred-to piston, for releasing the brake, and air-pressure valve mechanism operatively connected to the train-pipe and to said cylinders, comprising a primary valve and an automatic supplemental valve carried by, and independently operative of, said primary valve.

708,308. GAS AND AIR MIXER. Stephan Broichgans, Milwaukee, Wis., assignor to the Perfect Gas Machine Company, Milwaukee, Wis., a Corporation of Wisconsin. Filed Dec. 30, 1901. Serial No. 87,784.

The combination of a mixing-chamber having a gas-inlet port, a mixed air and gas eduction port, and an air-inlet port, the latter adapted to deliver air to said mixing-chamber, a float within the chamber, means for suspending the float, a pivoted lever within the mixing-chamber, a connection between the float and the lever, whereby said lever is turned on its fulcrum when the float is moved, a valve for controlling the air-inlet port, and a connection between the valve and the lever, whereby the movement of the lever causes the valve to be moved away from or toward its seat.

708,408. COMBINED LIFTING-JACK AND AIR-PUMP. Joseph G. Schmidt and William P. Mueller, Milwaukee, Wis., assignors of one-third to Charles P. Herrmann, Milwaukee, Wis. Filed Oct. 25, 1901. Serial No. 79,927.

An upright air-pump having a hollow piston stem and an attachment in the form of a shank vertically adjustable in said stem.

An upright air-pump having a head-bracket, a hollow lever-controlled piston-stem, a retractive spring-controlled pawl carried with said piston-stem for the engagement of a rack-toothed shank engageable with said bracket and stem to be vertically adjustable therein, a shank-detent in connection with the aforesaid bracket, and means for holding the pawl in retracted position.

708,552. SUBMARINE OR OTHER GUN. John P. Holland, Newark, N. J., assignor to Electric Boat Company, a Corporation of New Jersey. Filed Sept. 13, 1898. Renewed Feb. 10, 1902. Serial No. 93,451.

A gun for discharging a torpedo or other projectile, having means for first setting the projectile in motion with compressed air, having regulable, mechanical connecting means between the projectile and an igniter for afterward igniting an explosive charge when the projectile shall have traveled far enough to act forcibly on the igniter through said connecting means, and having a special, stationary chamber for the explosive charge independent of the projectile.

708,669. APPARATUS FOR RAISING LIQUIDS BY MEANS OF STEAM OR COMPRESSED AIR. Albert Scholl, Mannheim, Germany. Filed Jan. 27, 1902. Serial No. 91,487.

The combination of a pressure vessel having a compressed-air space at its upper part and inlets for liquid and compressed fluid and an outlet for the liquid to be raised, a stand-pipe extending into said vessel and in communication with said air-space, a valve in said compressed-fluid inlet, a valve-plate rigidly connected with said valve and adapted to close communication between said stand-pipe and air-space and opening the compressed-fluid valve on overpressure existing in the vessel, and means for putting the pressure vessel into communication with the atmosphere on cessation of overpressure therein.

708,847. AIR COOLING AND PURIFYING APPARATUS. Carl W. Vollmann, Montreal, Canada. Filed Apr. 13, 1901. Serial No. 55,783.

An air cooling and purifying apparatus, comprising a closed chamber consisting of a cylinder having one end closed by a cap, and its other end closed by a hollow head; a series of perforated pipes within said cylinder and extending longitudinally thereof, and having one end of each closed and the other ends thereof rigidly secured to and communicating with the interior of said head, means for forcing brine into said hollow head; a brine-exhaust port in said closed cylinder, and an air supply to and exhaust from said cylinder.

708,880. SAND-BLAST MACHINE. Frank J. Heidegger, West Bridgewater, Pa. Filed Oct. 8, 1901. Serial No. 77,965.

A sand-blast machine, the combination with a closed chest mounted on a vertical axis, a horizontal spindle journaled on said chest and having a work-holder and means for turning the chest on its axis and for revolving the spindle, of a sand-nozzle projecting into the chest, an air-pipe to which said nozzle is connected, an air-valve on said pipe, and means for closing said valve automatically when the chest has turned the requisite distance.

708,944. AIR-PUMP. Edward Walther, Washington, Iowa. Filed Jan. 21, 1902. Serial No. 90,644.

The combination with the storage-bell and a pumping-bell connected by a pipe supplied with check-valves, of a motor-barrel having a piston therein connected to said pumping-bell, a valve constructed to regulate the flow of water into and out of said pumping-bell, a lever connected to operate said valve, a pair of cam-bearing levers, one located on each side of said levers in position to engage and operate said lever, and means connecting said bell and said cam-bearing levers to operate said levers.

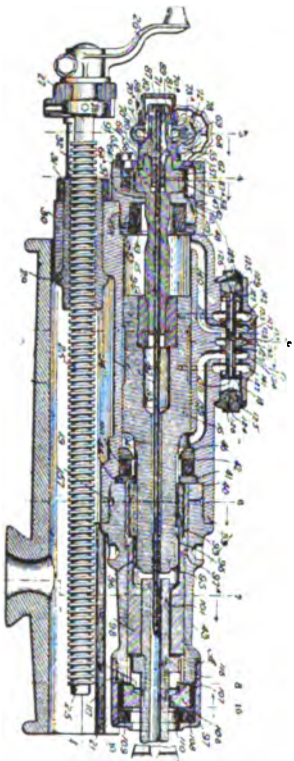
708,973. PNEUMATICALLY-OPERATED LUBRICATOR. Hermann Schmidt, Hamburg, Germany. Filed Dec. 13, 1901. Serial No. 85,765.

In pneumatic lubricating apparatus the combination of a transparent oil-reservoir, a supply-pipe for compressed air leading to the lower part of the said reservoir, an oil-pipe leading from the lower part of said reservoir to the part to be lubricated, an oil-supply reservoir above the level of the part to be lubricated and a pipe leading from the said supply-reservoir to the transparent reservoir.

708,984. METHOD OF TREATING AIR FOR FORCING MALT LIQUORS FROM KEGS. Charles A. Bartliff, St. Louis, Mo. Filed Nov. 8, 1901. Serial No. 81,612.

The herein-described method of treating air for forcing malt liquors from kegs, the same consisting in removing foreign particles from the air, passing the cleansed air through a chamber containing hop-leaves, and delivering the cleansed and impregnated air, under pressure, to the surface of malt liquor in a keg.

709,022. ROCK-DRILLING ENGINE. John G. Leyner, Denver, Colo. Filed July 18, 1901. Serial No. 68,808.

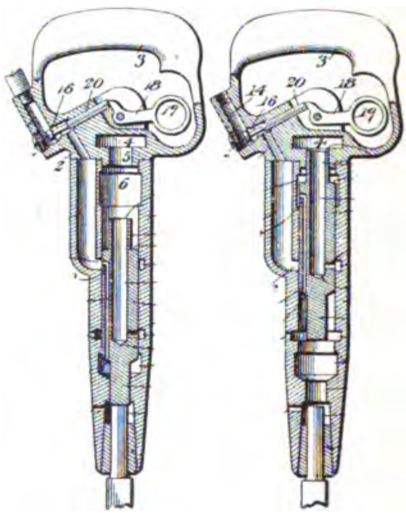


A rock-drilling engine, the combination with the cylinder having a piston-bore and a plurality of counterbores in its front end of different diameters, of a front cylinder-head comprising a tubular member threadedly secured to the largest counterbore of said cylinder, and a steel ring seated in a counterbore against the end of said cylinder-head, a buffer-ring seated in a counterbore against said steel ring, and a steel ring seated in a counterbore against said buffer-ring.

709,030. COMBINATION AIR AND VAPOR MOTOR. Alexander McCahon, St. Joseph, Mo. Filed Aug. 27, 1900. Serial No. 28,155.

The combination in a motor of a vapor-chamber, and the plungers and plunger-guide therein, of a square vertical shaft, of the friction-wheel carried on the bottom thereof, of the main axle and the hub keyed thereto and adapted to contact with said friction-wheel, of a horizontal disk carried by said shaft through a square opening in the center of said disk enlarged at both top and bottom, of the disk-pockets, an aperture leading into the vapor-chamber and with which the disk-pockets are arranged to successively register during the motion of said disk, of the wires thereon, of the spring arranged to contact therewith, of the pipe connection between said pockets and the gasolene-tank which pipe is provided with any suitable means for heating and generating the gas therein, and the means through which to transmit the pressure caused by the explosions into the vapor-chamber from said disk-pockets as each pocket registers with the aperture provided.

709,067. VALVELESS HAMMER. Daniel S. Waugh, Chicago, Ill. Filed Nov. 30, 1900. Serial No. 38,202.

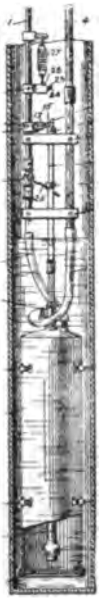


An automatic hammer comprising a casing, a hammer movable therein, means for directing a fluid-pressure against a reduced area of the hammer during its initial movement and against the whole pressure area during the remainder of its movement in one direction, and means supplemental to the normal exhaust for relieving the compression opposed to the hammer during the final portion of its movement in the opposite direction.

709,181. SAND-BLAST APPARATUS. Theodore A. Sippel, Newark, N. J. Filed Apr. 18, 1902. Serial No. 103,651.

In a sand-blast apparatus, comprising a casing, with the lower portion formed as a hopper for the abrasive material used; a valve to govern the flow of such abrasive material to an inner ejector-nozzle; and a pipe governed by a valve to convey an air-blast to such ejector; said pipe being attached at an angle downward so that the blast it carries may impinge upon and encircle the lower parts of such inner ejector-nozzle, and thus draw the abrasive material with it and force it through a fixed metallic tube connected thereto and adapted to carry it from the ejector at the bottom to a detachably-exchangeable blast-nozzle at the top of said casing, which nozzle extends downwardly therein.

709,212. PNEUMATIC PUMP. Ralph W. Elliott, Oakley, Cal. Filed Feb. 19, 1902. Serial No. 94,784.



The combination of vertical rigid air-inlet and water-outlet pipes, upper and lower horizontal guides extending between the said pipes and connected thereto at their ends, a tank, a rod extending vertically from said tank and slidably guided by said guides, a three-way valve in the air-inlet pipe communicating in one of its positions with the atmosphere, means actuated by said rod for operating the three-way valve, a rigid water-delivery pipe extending to the interior of the cylinder near the bottom thereof, a flexible pipe connection between said latter pipe and the vertical rigid water-outlet pipe, a flexible pipe connection between the air-inlet pipe and the upper end of the tank, and a check-valve in the water-delivery pipe.

709,258. PNEUMATIC RAILWAY-SIGNAL. Cyrus S. Dean, Fort Erie, Canada. Filed Nov. 27, 1901. Serial No. 83,863.

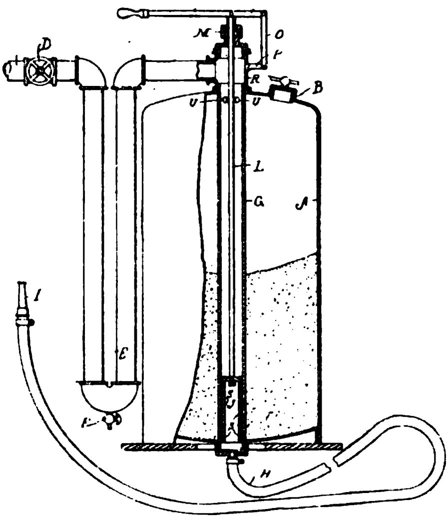
In a railway signaling device, rails, a pneumatic-operated signal, a plurality of air-compressing cylinders, a walking-beam, having connection with the pistons of said cylinders and operating-bars connecting to the extremes of the walking-beam and extending above the rails, whereby the walking-beam is rocked from a passing train.

709,335. PNEUMATIC TORPEDO-FIRING APPARATUS. Simon Lake, Bridgeport, Conn. Filed Jan. 30, 1902. Serial No. 91,-871.

In combination, a submarine boat provided with a conning-tower, rising above the hull of the same and normally separated therefrom by a water-tight wall or partition and a torpedo-tube, a compressed-air reservoir and a connection therefrom to the inner end of said torpedo-tube, and devices controlled by means within the conning-tower for admitting compressed air to the torpedo-tube for expelling a torpedo therefrom.

709,448. SAND-BLAST-CONTROLLING APPARATUS. Joseph Shaver, Milwaukee, Wis. Filed Aug. 5, 1901. Renewed July 2, 1902. Serial No. 114,132.

A sand-blast controlling device, the combination of an air-tight sand-receiving reservoir; a cylinder, provided at its lower end with a plurality of apertures through its vertical walls, extending longitudinally through said reservoir; an air-duct communicating from the source of pressure through the upper end of said cylinder with said sand-



reservoir above the sand therein; a hose connected with the lower end of said cylinder; a vertically-moving hollow plunger, provided with apertures at its upper end, located within said cylinder, and adapted to control the passage of sand through said apertures; a rod communicating from said plunger with the exterior of said reservoir; and means for raising and lowering said plunger, and opening and closing said apertures.

709,520. AIR-COMPRESSING APPARATUS. Edward J. St. Croix, Madrone, Wash. Filed Dec. 23, 1901. Serial No. 86,979.

An apparatus for compressing and storing air; a reservoir, a main conduit adapted to convey air under pressure to said reservoir, a gate-valve to control said conduit and a second gate-valve in the conduit closely adjacent to said reservoir, an auxiliary conduit adapted to convey steam to the main conduit and a gate-valve to control same, a driving-cylinder, a branch conduit leading from the main conduit to said cylinder and having a gate-valve therein, a double series of air-compressing cylinders each of less length of bore than said driving-cylinder, said series arranged within the cylinders in tandem and disposed at opposite sides of the center line of the driving-cylinder, a conduit leading from one head of each compression-cylinder to the reservoir and a port of ingress in said end, a check-valve in last said conduit, and a check-valve arranged to control said port, a piston-rod for each series of cylinders and a like rod for the driving-cylinder, oppositely-disposed levers operably connected to the rod of the driving-cylinder and arranged to drive the piston-rods of the compression-cylinders, valve-operating mechanism for the valve of the driving-cylinder operably connected to one of said levers, and a manually-operative air-pump connected to said reservoir.

709,579. APPARATUS FOR SPRAYING AND BURNING LIQUID FUEL. August Köhler, Hamburg, Germany. Filed May 23, 1900. Serial No. 17,634.

An apparatus for spraying and burning liquid fuel, the combination with air and fuel reservoirs and pipes leading therefrom, of a distributing-box having a pivotal connection with said pipes, tubes leading from the distributing-box, and burners carried at the opposite end of said tubes, each of said tubes being pivotally jointed intermediate its respective burner and the distributing-box.

709,647. CARBURETER. Alvin M. Rosenberry, Shelby, Ohio, assignor of one-half to Mack H. Davis, Shelby, Ohio. Filed Dec. 2, 1901. Serial No. 84,404.

In combination with a carbureting-chamber; a normally closed hydrocarbon-feed leading to said chamber; a suitable air-supply also communicating with the chamber; a valve for opening and closing the hydrocarbon-feed; and means connected to said valve and operated by the air passing to the carbureting-chamber from the air-supply, said means opening and closing the valve in proportion to the amount of air-gas withdrawn from the carbureting-chamber.

709,683. ROTARY SLIDE-VALVE FOR PUMPS, COMPRESSORS OR MOTORS. Louis Roedel, Passaic, N. J. Original application filed Mar. 24, 1900. Serial No. 10,026. Divided and this application filed June 28, 1900. Renewed June 10, 1902. Serial No. 111,007.

The combination with two stationary cylinders arranged axially in line with each other and provided with interior inlet and outlet channels, of conical slide-valves at the ends of said cylinders, means for imparting rotary motion to the slide-valves, plungers guided in said cylinders, and means for imparting reciprocating motion to said plungers.

709,763. APPARATUS FOR COOLING AND FILTERING COMPRESSED AIR. Friedrich Grumbacher, Charlottenburg, near Berlin, Germany. Filed June 7, 1902. Serial No. 110,684.

An apparatus for cooling and filtering air comprising a filtering-chamber the filtering layer of which is penetrated by a central pipe, the upper end of the latter fitting tightly into the cover of the filtering-chamber and connected to a supply-pipe, and the lower end of the said central pipe being open, in combination with a system of cooling-pipes arranged within the central pipe and provided at one end with a closed common chamber and connected at the other end respectively with a collecting-chamber and supply-pipe.

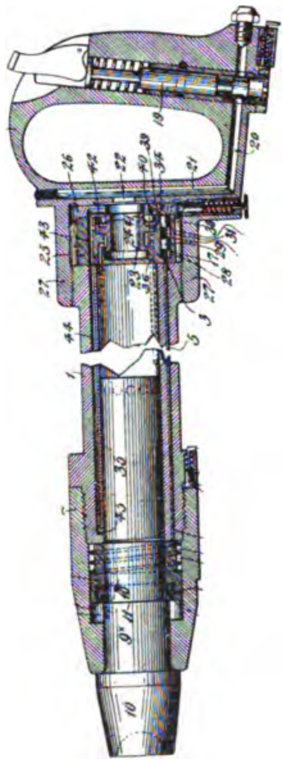
709,830. GAS-BLOWPIPE. George B. Snow, Buffalo, N. Y., assignor to the Snow Dental Company, Buffalo, N. Y., a Corporation of New York. Filed July 27, 1900. Serial No. 24,985.

A gas-blowpipe having a valve-casing, a gas-valve and an air-valve located therein and adapted to be opened by pressure of the finger, a spring for closing said valves, and a screw-cap, threaded upon one end of the casing, whereby said valves are confined therein and suitably adjusted.

709,832. AIR-COMPRESSOR. Willie J. Stevens, Skowhegan, Me., assignor to the Stevens Air Brake Company, Skowhegan, Me., a Corporation. Filed Jan. 3, 1902. Serial No. 88,307.

A compressor, the combination of cylinder, a piston therein, a hollow shaft suitably mounted, a clutch member on the hollow shaft, a pin slidable in the hollow shaft, a second clutch member moved by the pin into engagement with the clutch member on the hollow shaft, an eccentric on the hollow shaft, a piston-rod and eccentric-strap, a controlling-cylinder on the cylinder-head of the first-named cylinder, a piston therein, a spring engaging the piston, a reservoir, a valve between the reservoir and controlling-cylinder, a piston-rod extending through one head of the controlling-cylinder, and levers connecting the piston-rod and pin.

710,196. PNEUMATIC TOOL. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Filed Sept. 20, 1901. Serial No. 75,764.



A pneumatic riveter or other tool, the combination of a nosepiece adapted to have the shank of a working tool inserted therein, and a retaining device contained within said nosepiece and adapted to engage said shank, in combination with a distribution-valve, means for controlling said valve and mechanism intermediate said retaining device and said means for controlling said valve, whereby the latter is operated.

710,197. PNEUMATIC RIVETER. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Filed Mar. 22, 1902. Serial No. 99,490.

A pneumatic riveter, a cylinder, a handle, an extension or sleeve on said handle in threaded engagement with said cylinder, a valve-box within said extension, a distribution-valve and a stop-valve contained within said valve-box, lugs projecting from said ex-

tension, a slot between said lugs, and a threaded bolt passing freely through one of said lugs and being in threaded engagement with the other of said lugs, said bolt having a jam-nut therefor.

Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VII. NEW YORK, DECEMBER, 1902. NO. 10.

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN, }

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Another Instance of Electricity in Coal Mines.

Our attention has been called to a circular letter recently sent out by a mine inspector in one of the Pennsylvania coal mining districts, the purpose of this circular being to call the attention of mine operators to several important provisions of the bituminous mining law and to urge upon them the necessity of a strict compliance with this law in order to better safeguard the lives of their employees.

The letter refers particularly to the sections of this law dealing with means for preventing explosions from accumulation of gases. The first portion refers particularly to the necessity of using locked safety lamps in all places where there is the slightest indication of the formation of explosive gases, and is of interest, but we wish to refer especially to the latter portion of this circular letter which quotes Section 5, Article 5, of the Bituminous Mining Law and relates to the use of electricity in mines. This section reads as follows:

"In all mines or parts of mines worked with locked safety lamps, the use of electric wire and electric currents is positively prohibited unless said wires, machinery and all other mechanical devices attached thereto and connected therewith, are constructed and protected in such a manner as to secure freedom from the emission of sparks or flame therefrom into the atmosphere of the mine."

Commenting on this the circular goes on to say:

"Up to the present there has been no device perfected, so far as known to me, that will positively prevent the emission of sparks or flame from such electric wire or machinery; therefore, whenever they are placed in any such mine, or parts of such mine, they are placed there in direct violation of said law, and I respectfully request you to comply strictly with the provisions of the law."

To our mind this a very important evidence of a serious danger which always surrounds electrical apparatus when installed in coal mines. So certain is this danger as to call forth a very strong remonstrance on the part of mine inspectors to the use of any form of electrical apparatus in mines where there is the slightest chance for the formation of gas.

We have all along contended that an electrical installation in coal mines is not the most approved engineering practice in all cases, and in instances where such plants have been installed with an idea of economy the risk of serious accident has been increased to such an extent that any local economy has been more than off-set, and while in the majority of cases no accidents have resulted from sparking or flaming of broken wires (the accidents being restricted to injury to operators), we believe that the time will come when mine operators will realize that economy, when looked at from all sides, will mean the installation of compressed air plants.

The circular letter which we have quoted is only one of many evidences of the trend of events towards this conclusion.

FIG. I—A SAND BLAST TUMBLE BARREL.

Compressed Air in the Machine Shop and Foundry.

BY WILLIAM L. SAUNDERS.

An industry like that of compressed air, which has recently made such strides in its useful applications, may be studied with interest from time to time with something new always available. In the notes that follow, an effort has been made to put together such data on the subject as may be useful to a general manager of a manufacturing company, in ascertaining whether pneumatic appliances which have reached the successful stage are suitable to meet the conditions which exist in his case, and what will be the approximate cost of installation, operation, and maintenance. He may also gain some hint as to whether or not it will pay to invest money in a compressed air plant.

Compressed air and electricity are broad and new fields for industrial research; hence we will always find failures in the field of experiment, and in the literature on the subject we too often see ideas set forth which are really nothing more than theories, dangerous in themselves, because, being presented to the public in a plausible manner, persons are apt to invest money in them only to find that before reaching the point of usefulness an experimental period and further expenditure of money have to be encountered.

Electricity, having advanced beyond compressed air in its industrial march, appeals to the investor with greater confidence, because of the numberless cases where it has paid to use it. With compressed air there have been too many unreliable experimenters and writers, and both confidence and money have, therefore, been lost.

A single branch of the subject has been selected for treatment here—the use of compressed air apparatus in the machine shop and foundry—and the writer would say at the outset that he does not by any means advocate the adoption of every pneumatic device that is offered. Many of them, in fact, are to be avoided quite as carefully as perpetual motion and other kindred schemes; but there is a wide range through which compressed air appliances will work marked economies.

There are some pneumatic devices whose action is certain and whose limitations are fully known and well-defined, and in adhering to these the shop manager will find means to improve works output and decrease the labour involved in its production.

Taking the matter up logically, let us examine the elements essential to a plant using such standard forms! First we must have the equipment consistently planned after a study of the conditions. Generally speaking, it is best to have the air compressor installed in a central position convenient to boilers and cooling water and where the existing engineering force can take care of it. From this point air pipes are run to the several departments where the air is to be used.

Some idea should be formed of the amount of apparatus to be installed for present wants, the quantity of air it will require, and the location of this apparatus. An allowance should then be made for a natural growth. These data will enable the air mains to be properly proportioned and a compressor, or compressors, selected to give the best results.

In a foundry from one to several sand sifters and rammers can be used to advantage in the preparatory work, and sand blasts, sand blast tumble-barrels, pneumatic hammers and chippers, grinders and scratch brushes in the cleaning and finishing up of the castings, the extent of the outfit depending upon the size of the individual establishment and the class of work it is turning out, that is, whether small, medium or large castings are made.

Any attempt to differentiate between the various makes of such apparatus would be out of place at this time. It is sufficient to say that no one maker has the best of everything, and that several have very good forms of these special machines.

The sand blast tumble-barrel, Fig. 1, speaking from experience with it, is a great improvement over the old forms. Briefly described, it consists of a tumble-barrel revolved by rollers running on its outside, and the whole is encased in a box with a sliding door. At the centre, where the bearing would be in the old form, is an inclined sand blast jet. As the barrel turns, the castings are tumbled again and

FIG. 2—A PNEUMATIC SAND SIFTER.

again in front of the blast, and every part is exposed to its cleaning effect as if held in front of the jet by hand. The illustration herewith represents one of these barrels and shows some castings both before and after cleaning, giving a fair idea of the character of work done.

A feature of this tumble-barrel is the rapidity with which it cleans the castings, an ordinary charge ranging from twenty to thirty minutes. On account of the small amount of tumbling necessary, fragile castings castings can be tumbled without risk of rounding edges, bruising, or projections being worn or broken. Useful as has been the dusty old "rattler," this new form is much its superior. For its operation about the same quantity of air is required as for the regular sand blast.

The usual sand blast, and, in fact, the tumble-barrels, should always be operated in a special room, built at one side or in a corner of the foundry, or, what is better, in a seperate building so situated that the dust and grit cannot drift into machinery or through the entire foundry to cause wear to the machines and men alike. This "cleaning room," Fig. 5, can be so placed as to avoid any extra handling. But it will be economy to isolate it in any case. The floor should be a grating, and should be connected with an exhaust fan so that dust will be drawn down and carried off into a dust collector.

It is also necessary that the operator be provided with a helmet with a fresh air supply hose attached to it, because, at best, the atmosphere in the sand blast room is filled with an impalpable dust which would be harmful without the breathing helmet. The dust collector is somewhat like a separator, and generally consists of an enlargement in the pipe into which water is sprayed. The dust is caught by the water and alllowed to settle or run off into a drain.

In cleaning out cores and inside spaces the sand blast is indispensable, as it does the work rapidly and far more thoroughly than any other means yet devised. Formerly, with intricate castings, requiring, a great deal of core work, one of the difficult parts of the task was to remove the cores from the narrow parts of the castings. Usually this was done by digging and scraping away with chisels and hooks. Now the sand blast is employed, and it has been found that one of the simple adjuncts will accomplish more than formerly could be done by from six to ten cleaners. Not only does it do the work more quickly, but the casting is left in far better condition for the succeeding machining processes, as scales, burned spots and oxide are cut away without injury to the solid metal. For the best work of the sand blast apparatus pressures ranging from ten to thirty pounds per square inch and a volume of about 120 cubic feet of free air per minute are necessary. Air for operating may be obtained from a low-pressure compressor for this purpose alone, or from the receiver between the high and low-pressure cylinders of a compound compressor used for shop purposes in general.

Pneumatic sand sifters may be regarded as somewhat novel, but several forms have been devised which will prove of service, and where compressed air is in use, or where its adoption is under consideration, the use of these is warranted. One form of such sifter, Fig. 2, consists of a suitable frame supporting a cylinder with a piston connected to a frame which it vibrates rapidly, shaking the attached sieve leaving the moulder free to shovel. These sifters can be fastened to a column or to the wall wherever convenient, or the portable form may be placed close to the work. It is claimed that one man with such a machine can do in one hour as much as he could do in five hours without it. The average air consumption when working is about 12 cubic feet of free air per minute at a pressure of eighty pounds.

FIG. 3—A PNEUMATIC SCRATCH BRUSH FOR CLEANING CASTINGS.

Another special device receiving attention in foundries where large work is turned out, or where moderately large pieces are produced in quantity, is the pneumatic sand rammer. Some foundrymen dispute the value of this device, but it unquestionably does remarkable work where the conditions are in any way favorable. Several forms have been brought out, all more or less bulky and crude; but even these made such good records that the device has been perfected and to-day may be classed as one of the permanent fixtures of an up-to-date foundry engaged in general work of any size. The smallest size of hand rammer made is useful in ramming up flasks, piece ramming on large work, ramming concrete, and similar work. A small valve in the handle puts the machine under perfect control of the operator. Complete it weighs 20 pounds, and strikes from 250 to 300 pounds, using 11 cubic feet of free air per minute at a pressure of from 60 to 100 pounds. Fig. 4 shows one of these rammers.

A somewhat heavier form of this device weighs 45 pounds. With air at from 50 to 100 pounds pressure it also strikes from 250 to 300 blows per minute and uses 15 cubic feet of free air per minute. It has two handles and removable rammer butts, and makes a good record for moderately heavy ramming on loam or ramming up converter bottoms in steel works, etc.

Another type is intended to be worked suspended from some form of crane. It is much heavier and is more powerful than the other forms. The air supply is taken through the upper end of the elevating screw which passes through a block, in turn swivelled to the suspension straps—an arrangement which allows the freest movement.

FIG. 4—A PNEUMATIC SAND RAMMER FOR MEDIUM AND SMALL WORK.

Pneumatic moulding machines are known and in daily use in many places, but their value is not fully understood by a large proportion of manufacturers. A typical machine of this class consists of a very substantial table, the standard of which is an inverted air cylinder whose size depends upon the dimension of the work to be done. Over this table is suspended a ramming head or solid back, to the ends of which are attached side rods running down to the base of the machine per square inch, then lifts the entire table, with flask, pattern, and sand, up against the head, not with a steady pressure, but forcibly with a blow. Frequently one blow is sufficient, at other times two or three are found necessary, all depending upon the character of the mould. Turning the valve further exhausts the air from the cylinder and allows it to drop. The operator then cuts the sprue holes and turns a

FIG. 5—READY TO SAND-BLAST CASTINGS.

where they are hinged to allow the ramming head to be swung back to clear the flask. At one side is a three-way controlling valve which admits air to the cylinder or opens the exhaust.

In operation the "flask" is put on the table, filled with sand, the head is swung into position and the valve is turned. The air, under a pressure of 70 to 80 pounds thumb-screw to start a pneumatic rapper or vibrator, which frees the pattern from the mould far better than hand rapping. Another lever is then thrown and the flask is stripped or carried free of the pattern. This pneumatic vibrator causes the entire pattern to quiver or shiver in such a way that it is absolutely freed from the sand without enlarging the mould and distort-ing the shape, thus maintaining the size and effecting a considerable saving in the amount of metal used in the casting.

Following in natural sequence we come to pneumatic chippers for cutting off feathers, risers, sprues and general trimming-up of the rough castings as they leave the sand or the tumble-barrel. Too frequently castings are sent into the machine shop with edges and excrescences which, if removed in the foundry, would save valuable time and reduce the amount of machining necessary, besides reducing the wear and tear on tools and machines alike. Regarding the wisdom of pneumatic chippers for this work there can be no question. These tools are made in different sizes to meet different conditions, but for general foundry trimming a medium size gives the best result.

The number necessary depends entirely upon the class of work; but, generally spaking, there are too few of them rather than too many. There are probably few foundries that could not use from one to five of these handy little cost reducers.

PNEUMATIC HAMMERS.

In a general way pneumatic hammers may be divided into two general classes. Valveless hammers, or those in which the piston is the hammer, and, in its movement, opens or shuts the inlet and exhaust ports; and valve hammers, or those in which there is a distinct and separate moving valve. The former are invariably short-stroke hammers, and find their greatest field in calking and chipping. Their piston speed is high, from 10,000 to 15,000 strokes per minute, being not uncommon.

Valve hammers, on the contrary, are of comparatively slow speed, working at between 1,500 and 2,000 blows per minute. The travel of the piston or hammer is proportionately longer and the blow heavier in like degree. For this reason hammers of this type, or at least the long-stroke ones, are not so well adapted to chipping, serving a better purpose in riveting work.

The piston diameters of pneumatic hammers range from ¾ inch to 1¾ inches, and the length of stroke from half an inch to 5 inches. The lightest hammer weighs about 3 pounds, from which figure the weights run up as high as 26 pounds. Pneumatic hoists of various kinds occupy prominent positions in the foundry. As an example of this form of compressed air apparatus Fig. 6 is of interest, representing a corner of the foundry of the Lidgerwood Manufacturing Company. Three overhead cranes span the spaces occupied by pneumatic moulding machines and enable the heavy flasks to be picked up, placed in the machines, turned over and taken away with the least handling and in a minimum of time. Each of these cranes has a capacity for lifting 2,000 pounds to a height of 6 feet. They are set perfectly level, and have bushed bearings so that they will roll at the slightest touch. In the same works is another foundry crane with a span of 48 feet and a capacity of 5,000 pounds. The hoisting is done with an air hoist having a 10-foot lift attached to a trolley actuated by hand ropes from the floor. The crane travel is obtained through electricity power, the motor being operated from the floor also by conveniently arranged hand ropes. This is a most convenient crane for general use.

It is claimed that the air hoist will do about half again as much work as any other form of hoist for lifting copes, drawing patterns, and shifting cores. In any case, its slow, steady movement closely resembles hand lifting, and as such hoists are under the most perfect control of the operator, permitting the most delicate handling—an essential in handling cores and moulds—they are most useful devices in the foundry. Hoists of this type are made in almost every size, from the smallest to those lifting as much as 10,000 pounds. Generally, they have a lifting speed of from 10 to 36 feet per minute. With the air hoist we may leave the foundry and enter the machine shop, for we now have our castings made, cleaned and trimmed, ready for the lathe, planer, milling machine or other tool, as the case may be. One crucial factor in the economical administration of a machine shop is first to have as few men as possible involved in any given operation, and, second, to keep every man and every machine busy on productive work every minute of the working day.

The speed of operation of a given machine is fairly well fixed, especially when operating steadily on a certain class of work, making, for instance, the same piece day after day. The number of machines a man can operate is fixed, in some places by physical limitations, in others by the dictates of labor unions. In the former

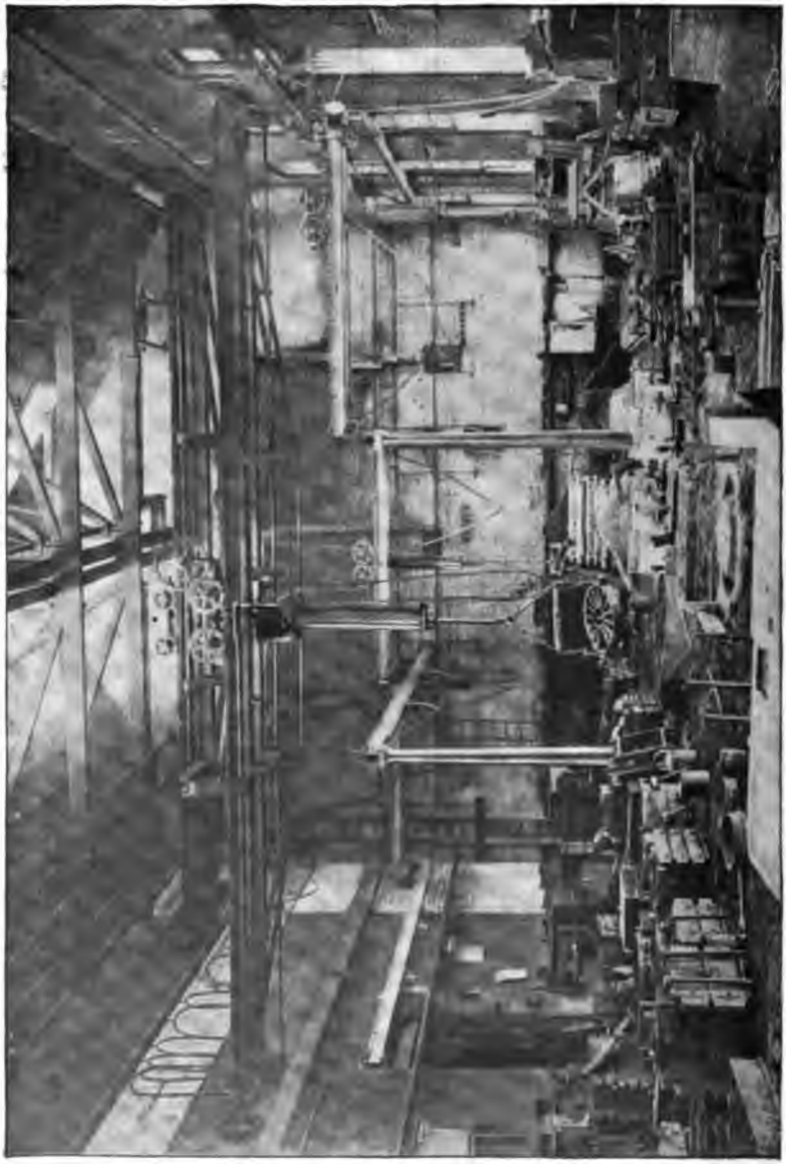


FIG. 6—PNEUMATIC HOISTS AND CRANE IN THE FOUNDRY OF THE LIDGERWOOD MFG. CO., BROOKLYN, NEW YORK.

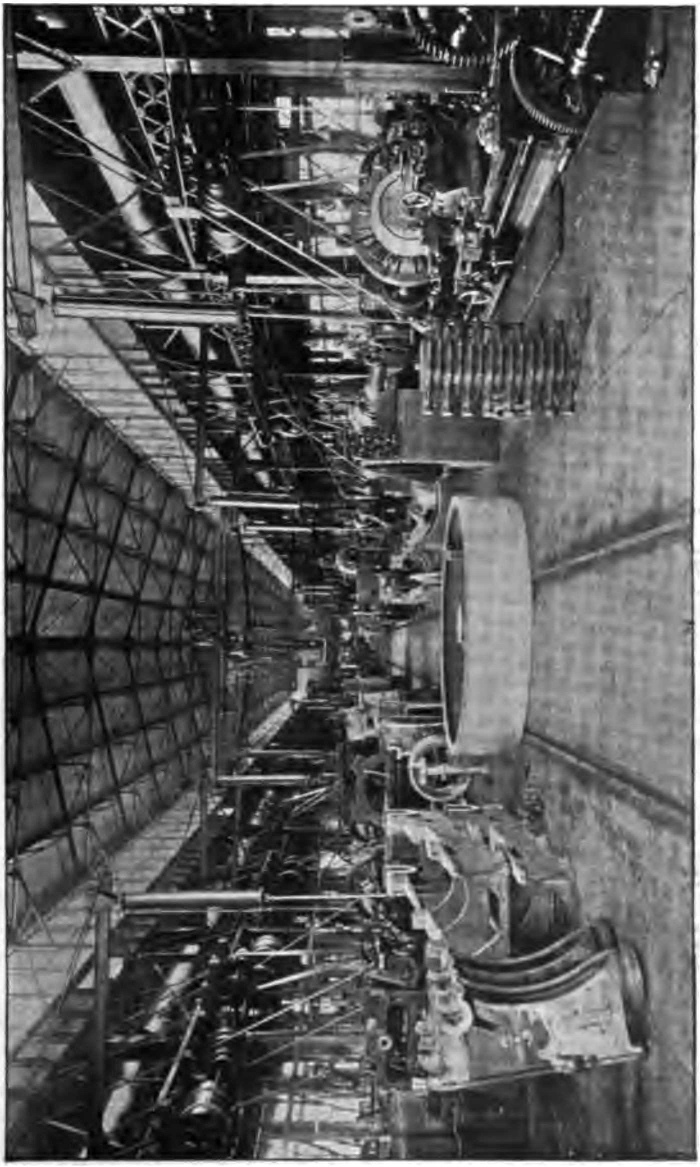


FIG. 7—PNEUMATIC HOISTS ON SWINGING BOOMS AND A PNEUMATIC TRAVELLING CRANE IN THE SHOPS OF THE INGERSOLL-SERGEANT DRILL CO., AT EASTON, PA., U. S. A.

case and where the pieces to be handled are heavy, a means for handling them decreases the idle time of each man and machine, besides lessening the actual physical wear on both operator and tool. The old way of calling an operator from a neighboring machine when a change of work was to be made, lifting the finished piece out and putting in a rough piece, has passed away forever in progressive works, and now the plan shown in Figs. 7 and 9 must be used if it is desired to keep up with the march of progress. These two illustrations represent two types of air hoists employed in the works of the Ingersoll-Sergeant Drill Company, at Easton, Pa., U. S. A.

Fig. 6 shows the familiar single straight-away lifts, hung from swinging arms and arranged to life the smaller pieces and swing them over lathes, planers, or other tools. The same picture shows a large travelling crane, also operated by air. This spans the shop and handles the heaviest pieces with ease. Air to operate this crane is supplied by a hose which is suspended from special hangers along the centre of the shops, and loops up or straightens out according to the direction in which the crane moves.

Fig. 9 represents several more compact forms of hoist in which the cylinders are placed horizontally. The piston in each has a rack cut in it which engages a gear on the shaft of the winding drums. This form, as will be seen, is suitable for use in a shop with fairly low ceilings. The illustration represents several of these hoists mounted on iron beans running transversely across the shop over the machines.

The purpose of this form of hoist is very well shown. Castings or other pieces too heavy for a man to lift are easily picked up from the aisles and carried over to any machine where they are held until properly centered; or the finished pieces are quickly lifted from the lathe and placed on the floor out of the way, without the operator touching them.

In another department of the same works long-cylinder pneumatic hoists are mounted on swinging arms, giving them a

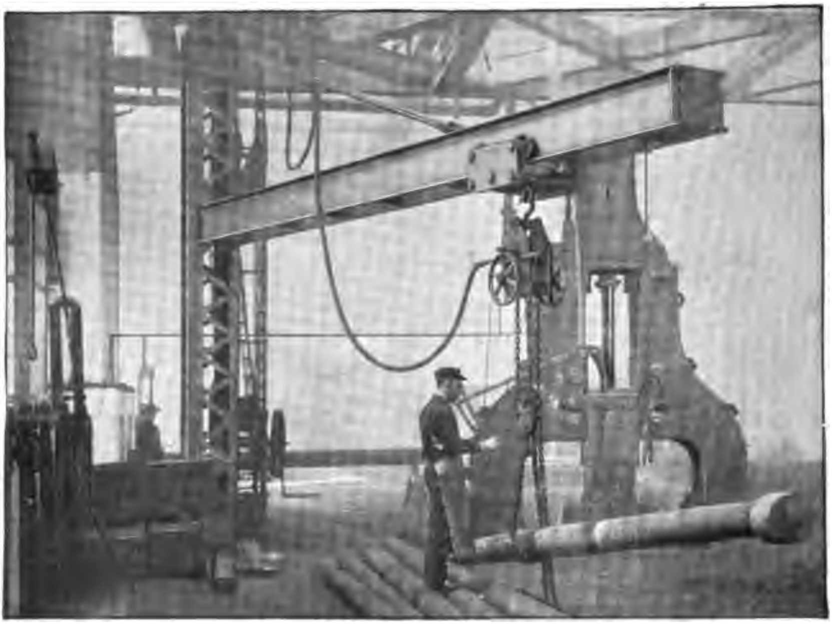


FIG. 8—A PNEUMATIC CHAIN HOIST IN A FORGING SHOP. MADE BY THE EMPIRE ENGINE & MOTOR CO., ORANGEBURG, NEW YORK, U. S. A.

considerable range. Another type of pneumatic hoists uses a small motor and a differential system of gears, giving it greater lifting power than is possible with the direct lift with the same amount of air. Fig. 8 shows such a hoist as used in a blacksmith shop to handle steel bars in and about the hammer. This class of work is a severe test under which these machines stand up admirably. Unlike electrical apparatus, dust and grit cannot hurt them beyond increasing the frictional wear.

The application of an air motor to the usual form of crane drum, consists of a reversible motor, enclosed to protect it from dust and dirt, geared to a winding drum in the same way that an electric motor would be used. This arrangement can be mounted on the boom of a crane and makes a very satisfactory form for yards, or foundry and forging shop cranes. The same motor is often bolted to the cross beams of a travelling crane when a shop travelling crane is desirable. In this case the hose loops up or straightens out as the crane moves along. A revolving pneumatic crane is a form of yard crane for loading or unloading cars or trucks. It can also be used in a machine shop, foundry or elsewhere for placing pieces in machines.

We next come to the use of compressed air for operating special tools, such as drills, boring machines, flue-beaders and millers. At the present time there are a number of excellent forms of pneumatic drills on the market. These are made in different sizes for large or small work. One of their chief claims is the fact that these are easily portable and may be used in out-of-the-way places where other forms of drills could not be applied; or they permit drilling to be done on large pieces where they stand, without moving such pieces about, thus saving time and heavy lifting apparatus. In other words, the tool is taken to the work instead of the work being brought to the tool.

WORKING RESULTS WITH PNEUMATIC DRILLING MACHINES.

					No. 1 Machine.							
Drilling	½	-inch	hole	through	1¼	-inch	mild steel	plate,	3	minutes,	15	seconds.
"	¾	"	"	"	1¼	"	"	"	4	"		
"	1	"	"	"	1¼	"	"	"	6	"	25	"
"	1¼	"	"	"	1¼	"	"	"	8	"	10	"
					No. 2 Machine.							
Drilling	½	-inch	hole	through	1¼	-inch	mild steel	plate,	5	minutes,	20	seconds.
"	¾	"	"	"	1¼	"	"	"	7	"		
"	1	"	"	"	1¼	"	"	"	11	"	30	"
"	1¼	"	"	"	1¼	"	"	"	13	"		"

By the use of such drills holes may be put in, ranging from ¼ inch to 3 inches, at a rate many times that possible by hand. The smaller sizes are very handy for putting on cylinder casings, name plates, and for general finishing work in and about large machines. They are extremely light and compact, use very little air, and are remarkably durable. The larger sizes, too, find a wide range of uses in any machine shop. The table above shows what some of these drills will do.

All these pneumatic tools may be provided with chucks or taper sockets, so that a variety of tools can be used. Once installed, they constantly suggest new uses, and prove their value from the start. In the boiler, machine, and other shops pneumatic tools of various sorts are installed for cutting stay bolts, reaming, and drilling out boiler tubes, expanding new tubes, riveting, etc. A variety of other uses, more or less novel, have been introduced from time to time, all effecting marked savings in the respective operations to which they are applied.

Riveting may be regarded as apart from machine shop work, but here and there special work is turned out on which these tools can be used to excellent advantage.

The table entitled, "Results Obtained with Pneumatic Tools," given further on, is of interest and value as giving a definite statement of the saving in cost and time which may be effected by the use of pneumatic tools of different kinds. It is, as far as the writer is able to determine, accurate, and may be used in estimating on results to be obtained.

From a study of your product, conditions and process of manufacture in the light of the data given, it will be possible to determine upon what apparatus will be applicable to your case. Having selected the types, sizes and number of pneumatic tools or apparatus you want, the total quantity of air necessary for immediate use can be determined. Allowance should be made for an increased demand, which

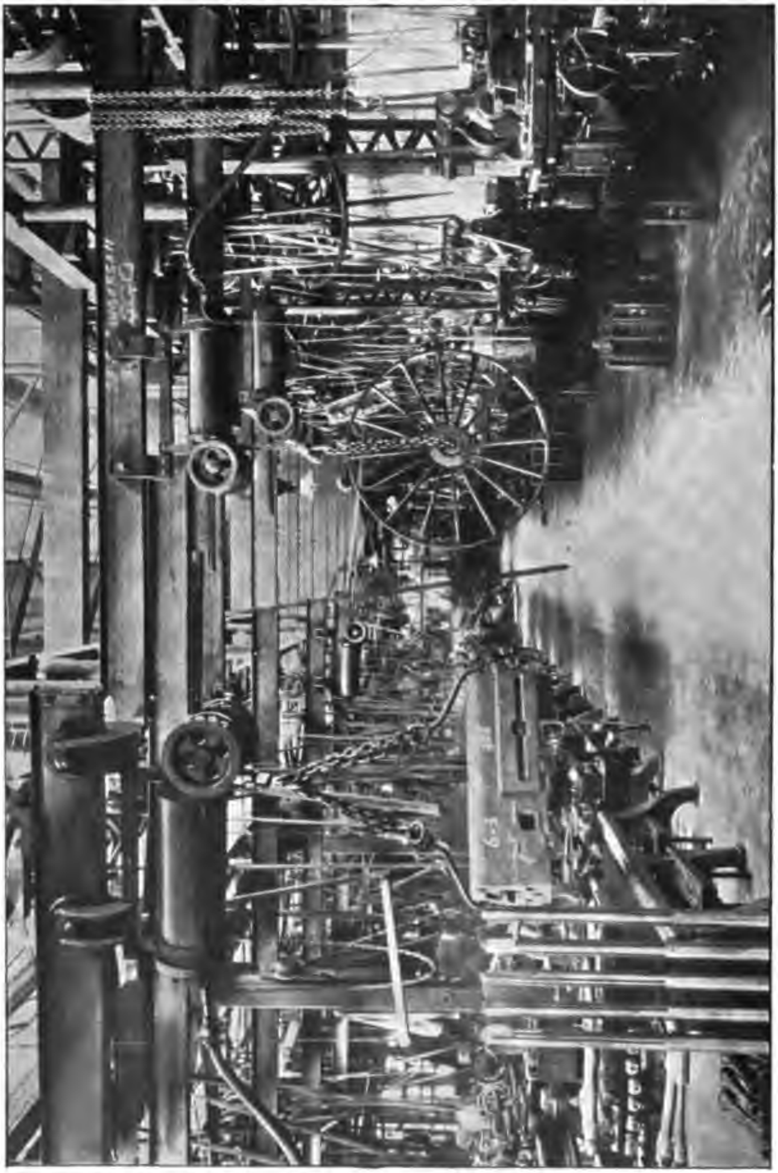


FIG. 9—OVERHEAD HORIZONTAL PNEUMATIC HOISTS FOR HANDLING MACHINE WORK IN THE SHOPS OF THE INGERSOLL-SERGEANT DRILL CO., EASTON, PA., U. S. A.

invariably results after a plant of this kind is installed. The sum of these quantities determines the capacity of the compressor or compressors necessary.

Having determined on the number and location of the tools and the volume of air necessary, a piping or transmission system should be laid out, based on this information. Starting from the location of the compressor, the piping should be run as direct as possible to the shop or shops where the air is wanted. Turns, elbows and joints should be avoided as much as possible, as each of these imposes a certain amount of resistance to the free flow of air, and hence entails a loss of

and permits the entire shop floor to be served with short lengths of hose.

Valves should be avoided as far as possible, as they also offer resistance to the free flow of the air. Where necessary, a type should be selected which has a wide opening without offsets or crooked passages, except in the smaller sizes, where, though desirable, these refinements are not ssential.

In erecting piping, full lengths should be used, care should be taken to avoid couplings and joints, and the work should be done as thoroughly as with steam mains. Joints should be leaded, or, if flanged joints are used, gaskets should be

RESULTS OBTAINED WITH PNEUMATIC TOOLS.

Tool	General Character of Work.	Saving — Per Cent. of Cost.	Saving — Per Cent. of Time.
Pneumatic hammer	General foundry work—chipping	67-75	67-75
" "	Riveting on mud ring and fire-box	67	..
" "	Chipping flue sheet	84	75
" "	Beading flues	75	75
" "	General boiler shop work	60	..
" "	Cutting out broken fire-box stays	70	70
" "	Cutting off stay-bolt heads	58	..
Riveter	Boiler riveting	66	50
Drill	Drilling saddles	70	70
"	In general machine shop work	75	75
"	Drilling for stays	50	50
"	In general boiler-shop work	75	75
"	Facing steam pipes	75	75
"	Tapping for stays	65	..
"	Reaming crown sheet	70	..
Breast drill	General work	90	90
Staybolt nippers	Cutting off stays	73-90	75-90
Driving-box press	Pressing brasses	68	..
Paint sprayer	Painting box cars	67	67
" "	Painting car trucks	87	87
Paint burner	Cleaning off passenger cars	67	67
Sand blast	Cleaning tanks	90	83
Air jet	Cleaning cushions	50	50

pressure. Where these cannot be avoided long bends, Y branches, and 45-degree elbows should be used.

The table, given further on, entitled "Friction of Air in Passing Through Globe Valves, Elbows and Tees," shows the importance of this point and gives, in feet of straight pipe, the additional length which will cause a reduction of pressure equal to that caused by globe valves, elbows and tees.

Generally, the air mains are run overhead, along the roof trusses close to main columns, down which branch pipes are run at frequent intervals to within a height of about 4 feet above the floor. These branches are usually closed by globe valves, fitted with a nipple to which the flexible hose may be attached. This arrangement admits of the greatest flexibility

carefully cut and fitted. This seemingly excessive care will pay for itself many times over in the saving of air. It should be borne in mind that every 5 cubic feet of free air require one H. P. for compression to 100 pounds per square inch. The pipes should be firmly supported, to avoid vibration or working; but expansion joints are not necessary, as the temperature of the air in the mains remains practically constant at about that of the shop interior, unless it is conveyed some distance in exposed pipes.

In some cases where the works are scatered over a considerable area it is necessary to put underground the mains leading to the remote shops. For this purpose they may be laid in the ground the same as water mains or drain pipes, or they may be supported in tunnels, boxes, brick ducts or the like. This however, is not essential. More often the pipes are placed on the ground surface or supported along the sides of buildings. Where the lines are long and exposed to the outside air, it is well to put in drip tanks or give the pipes enough slope to drain towards low points, where traps or drip loops should be put to take care of any moisture which may collect. These traps should be drained from time to time, either automatically or by hand. The reason for this is obvious when it is remembered that compressed air, as usually produced, contains moisture which will precipitate when the air comes in contact with cooler sections of the pipe line. In any event, especially if the system is permanent, as is the case with a factory, all mains, both inside and out, should be securely supported and protected from material falling on them, rust and other abuses.

A valuable feature of such a system of piping, to which attention should be called, entering the building, and its temperature is considerably increased, with a resulting increase in volume. This reduces the velocity of the air flowing in the transmission main. It is stated that for short distances, not exceeding 500 feet in the case of a given pipe-line, the same results may be expected with air as with water; but for longer distances the efficiency of air transmission increases considerably. In any case, reheating is advisable where motors, hoists or other devices are employed which use a considerable volume of air expansively. Average experience shows that by this means the available air may be increased from 20 to 40 per cent.

The question of best size of mains is one calling for the balancing of a number of factors. When the actual amount of air to be used has been settled upon, the drop in pressure becomes the next point of importance. The smaller the mains, the greater the drop, the same as with the transmission of electricity; but, unlike electricity, an increase in the size of the

FRICTION OF AIR IN PASSING THROUGH GLOBE VALVES, ELBOWS, AND TEES.

GLOBE VALVES.

Diameter of pipe, inches.....	1	1½	2	2½	3	3½	4	5	6	7	8	10
Additional length, feet......	2	4	7	10	13	16	20	28	36	44	53	70

ELBOWS AND TEES.

Diameter of pipe, inches.....	1	1½	2	2½	3	3½	4	5	6	7	8	10
Additional length, feet......	2	3	5	7	9	11	13	19	24	30	35	47

is its utility in case of fire. For this purpose connection may be made to a suitable water supply, either city, private reservoir or fire pump. On a prearranged signal, the air can be shut off and the water turned on, affording at once an abundant supply within a few feet of any part of the works in addition to any regular hydrant and sprinkler system.

When air is transmitted some distance to scattered shops, it is a good plan to place a receiver tank where it enters the building and to connect the shop piping system to this, the object being to reduce the velocity for a minute or so and permit any moisture to be precipitated, as already explained. The receiver also acts as a balance spring and assists in maintaining a constant air pressure in the mains and at the tools. But it is not necessary, nor advisable, to have this large enough to act as a reservoir.

Sometimes when the air has been transmitted long distances, it is reheated after line works a double advantage, for it at once reduces the loss in pressure, and the larger the pipe, the greater the reservoir capacity.

A "rule-of-thumb" to use in laying out piping systems for small plants is to avoid all pipes less than ¾ inch and not exceed in diameter the size of pipe given by the maker of the compressor as the diameter of the discharge pipe. In case two compressors are used, naturally the pipe from the receiver to where the air is used would have a section double the discharge area of the two compressors. The largest pipe should be nearest the compressor or receiver, and the size should be reduced after each branch. The ¾-inch size refers to the cylinder branches to which the flexible hose is attached.

It is well to insist on an inspection of the piping system at regular intervals to avoid leaks which are wasteful and altogether unnecessary. On account of escaping air being harmless and invisible, it is often the case that leaks are tolerated which, if water or steam were used, would bring severe criticism on the engineering staff. When it is remembered that a pipe or reservoir containing air at 100 pounds gauge pressure will leak about 6½ cubic feet of free air per minute, or 3,870 cubic feet in ten hours, through a 1-16 inch hole, which means something over one horse-power, the importance of

FIG. 10—A PNEUMATIC CHAIN HOIST MADE BY THE INTERNATIONAL PNEUMATIC TOOL CO., LTD., LONDON.

a tight piping system is apparent. Ten or a dozen such leaks will constitute quite an item, and one which can be avoided entirely by proper inspection when erecting, and a little care from time to time afterwards. We have now traced the subject backward from the use of compressed air through the means of transportation to its origin, and it now remains to treat only of its production. There are a few places where compressed air can be produced by means of the hydraulic or falling water system, which may be called the reverse of the Pohle air lift pump. There are other places where compressed air can be produced by water power-driven compressors, and there are many opportunities where compressors of this sort could be installed and the power transmitted long distances. Many such compressors are in operation in mountainous districts for mining plants. But by far the larger number of factories are so situated that air must be obtained by means of steam compressors, or belt or electrically-driven machines, and the writer will, therefore, confine himself to these types.

On the proper selection of the air compressor is dependent very largely the entire success of a compressed air installation. The compressor is the source and regulator of the power, and as all the working apparatus and the final results rest on the character of the compressor, this certainly should not be the weakest link in the chain. Often, after a due regard of the features already mentioned, works managers neglect the pivot on which turns the entire plant and install a cheap or inefficient machine. An air compressor is a machine very different from a pump or even a steam engine, both in design and construction. Many things are permissible in steam engine construction which should not be tolerated in an air compressor, especially if intended for high pressures. It is doubtful if most people and many engineers realize this point, but it is a fact that cylinders, coolers, pipes and other parts apparently good and which, if used for steam pumps or engines, would pass a careful inspection, must often be rejected for compressed air service because they are porous and allow air to leak through.

It must be remembered that the compressor becomes part of the central power plant, the shutting down of which for twenty-four hours, resulting from a serious accident, may cause as much loss to the user as would half pay for the machine. Constant repairs, even though each single one may be small in itself, when added together may more than equal the extra amount in the cost of a better compressor at the start. It is possible and often wise to experiment with the small things about works in an effort to reduce costs; you can afford to buy several hundred files of some new make, or two or three pneumatic tools of this make or that, and give them a test, because these are incident to the business. But the compressor, like your boiler, forms part of the heart of your establishment, which must throb whenever called upon, and you cannot afford to experiment with it. The safest rule in this respect is to get the best, but do not expect to get it as cheaply as the inferior article. Another point to bear in mind when selecting a compressor is to allow the manufacturer to advise you, presuming that you are dealing with a reputable concern. Many people fail to realize that it is to the compressor builder's interest to satisfy the purchaser. All the types of compressors he makes will compress air, but each type is designed for a certain class of work, and he knows better than you which machine will best fulfill your wants. Anything that compresses air is not an air compressor from your standpoint. Air brake pumps compress air, but they use from four to five times as much steam as a regular air compressor

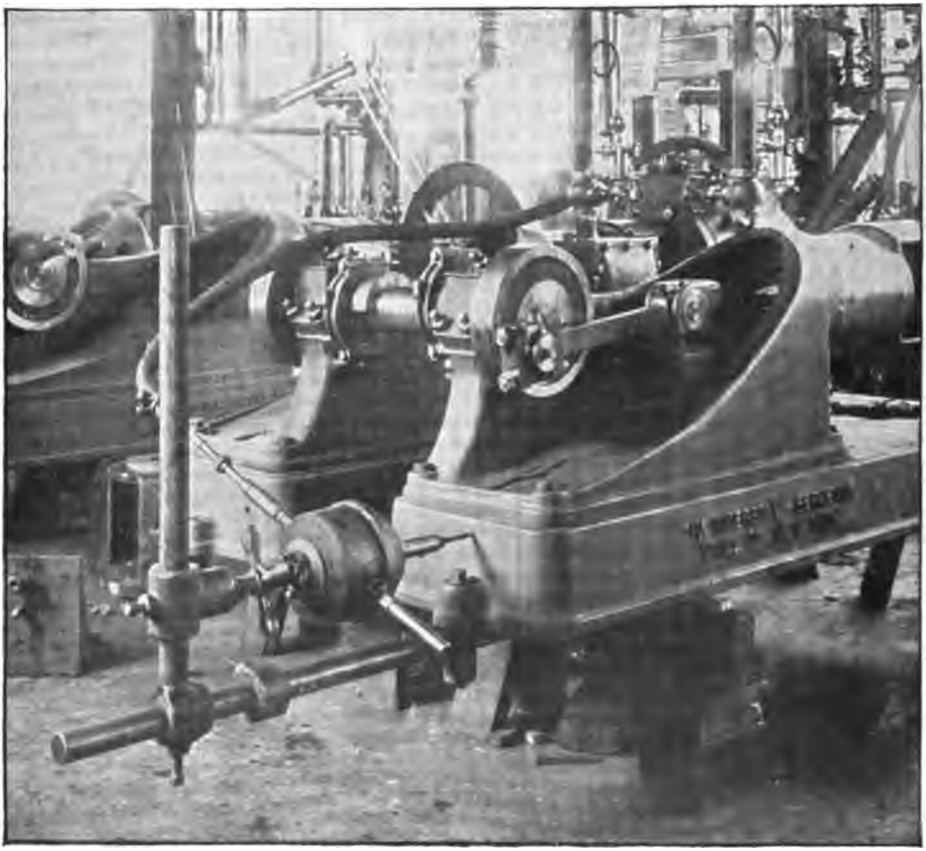


FIG. II—A METHOD OF MOUNTING A PNEUMATIC DRILL, ILLUSTRATING ITS PORTABLE CHARACTER.

APPROXIMATE DATA ON WEIGHTS, CAPACITY, COSTS AND OPERATING EXPENSES OF STANDARD AIR COMPRESSORS ON A BASIS OF 100 LBS. AIR PRESSURE (GAUGE AT RECEIVER) AND 100 LBS. STEAM PRESSURE (AT THROTTLE).

Type of Compressor.	Form of Valve Used.	Steam Consumption lbs. per H.P. per Hour. Non-condensing.	Steam Consumption lbs. per H.P. per Hour. Condensing.	Weight of Compressor per cu. ft. of free Air Piston Displacement.*	Compressor Capacity in Cubic Feet of Free Air (Piston Displacement.)	Cost of Compressor per Cubic Ft. of Free Air Piston Displacement.*	Cost of Compressor per Indicated H.P. Steam 100 lbs.	Cubic Feet of Free Air (Piston Displacement) per 1 H.P.†	Total Cost of One Cubic Foot of Free Air Piston Displacement. Considering a 10-Hour Day, Coal at $5 per Ton, Usual Labor, Depreciation and Interest Expenses.††
Straight Line......	Simple-slide and Meyer's	35	28	58 to 29	24 to 1875	$17.00 to $4.50	$89.00 to $23.00	4.9 to 5.	.002 cts. to .004 cts.
Duplex type self-contained..	Meyer's adjustable.......	35	28	76 to 28	50 to 470	18.00 to 5.10	90.00 to 26.60	4.8 to 5.	.007 cts. to .004 cts.
Duplex extension frame..	Meyer's adjustable.......	35	28	31 to 24	345 to 2200	7.00 to 3.00	32.00 to 24.00	4.6 to 4.7	.003 cts. to .004 cts.
Compound extension frame..	Meyer's adjustable.......	29	20	43 to 32	320 to 1900	9.00 to 4.00	47.00 to 25.00	5.5 to 6.	.0038 cts. to .002 cts.
Corliss compound steam duplex air..	Corliss...................	—	20	75 to 58	550 to 5700	7.00 to 4.30	41.00 to 21.00	5. to 4.8	.0029 cts. to .0017 cts.
Compound steam compound air..	Corliss...................	—	18	71 to 47	600 to 3700	7.30 to 4.70	42.00 to 23.00	5.3 to 5.7	.003 cts. to .001 ct.

* Not including condenser. † Working full load. †† Considering full output.

of the same capacity requires. Some one in your neighborhood may have a small compressor of given make running a sand blast, but it does not follow that the same concern will build for you a larger compressor to work as well.

The rapid increase in the use of compressed air has brought into the field new concerns, but you need not feel that they were born, Venus-like, "full-grown." They are learning by experience something which cannot be injected, like opium, with a hypodermic syringe. Nor does it follow that the oldest is the best, for sometimes the "old-fogy" element creeps into compressors, as well as into other things.

Many manufacturers in buying supplies will look ahead weeks and months and lay in an ample supply of raw materials. It may be a thousand tons of coal in excess of what is wanted, because prices are low, or it may be a six-months' supply of pig iron or the like; but when they come to buy an engine or an air compressor they almost invariably buy only what is needed for present wants. New uses for the compressed air arise constantly, and devices formerly driven by steam, water or electricity, or worked by hand, are found to operate better with air, so that in a surprisingly short time the capacity limit of the machine is reached, and often exceeded, with the result that, without much thought, the compressor is criticized for poor performance when really it is overworked, and hence abused, and a new and larger machine must be bought, the total cost of all this being greater than the cost of the larger machine would have been in the beginning. It is always better to work a little under the rated load and speed.

In discussing air compressors, remember that the manufacturers' invariable rule is to rate their capacities according to the theoretical output of the cylinder, making no deduction for piston rod clearance, friction, heating, or slip. It should be distinctly understood whether theoretical or practical capacity is given. The table, referring to the approximate weight and capacity of air compressors, will be of assistance in figuring on costs of installation and operation; but the cost figures should not be taken too literally, as they are intended to give maximum values which are safe.

The style of compressor to be selected depends upon what may be termed local conditions, that is, whether water-power is available, or whether electricity can be obtained at a reasonable rate, or is produced in a central power station and transmitted to several shops; or whether it is desired to use a belt compressor or a steam-driven type. Compressors designed for each of these conditions are available in the market, and in various modifications of each class.

In conclusion it may be of interest to know the experience of a few large con-

FIG. 12—A PORTABLE PNEUMATIC PUNCH MADE BY MESSRS. F. F. SLOCOMB & CO., WILMINGTON, DEL., U. S. A.

cerns who have adopted compressed air apparatus. One of these is the Passaic Rolling Mills of Passaic, N. J., a concern employing about 1,200 men, with a monthly output of about 5,000 tons of structural material. A complete system was installed, with an air compressor conveniently placed and air mains run to various departments scattered over an area of about twenty-five acres. Air is used for almost every variety of work that can be found about an establishment of this character. In connection with the transfer tables and rolls the use of air permitted four men doing the work formerly requiring thirteen, and trebled the capacity of the roll. The cold saws operated in conjunction with the rolls were arranged to be elevated by air. Forty cylinder hoists, twelve riveters, and two chipping tools were also installed, and have been giving excellent satisfaction.

A second case, of a different type of plant, which could hardly be called a machine shop, yet serving as an example of the utility of compressed air, is that of the Tide Water Oil Company, of Bayonne, N. J., where fourteen pumps and other machines, all previously driven by steam, were arranged to be driven by compressed air, with a saving which, to say the least, was remarkable, as the necessary boiler capacity was reduced 178 H. P. by the introduction of the central plant. In this way a yearly saving of $4,450 was effected. Another example is the repair plant of the Manhattan Elevated Railway, in the city of New York. In this plant a number of air hoists and pneumatic cranes were installed, enabling one man in one minute to do work which formerly required two men four minutes.

Still another example, and perhaps one more generally interesting, is furnished by the Baldwin Locomotive Works, of Philadelphia. The present equipment of compressed air shop appliances at these works consists of the following:

A generating plant of ten compressors of various types aggregating 450 horse-power, according to the builder's rating. These compressors range in size from 6 horse-power to 80 horse-power capacity. They are run night and day up to their full capacity, and the actual power developed is generally considerably above the builder's rating. Local conditions render it impossible to utilize a central power station. It was, therefore, necessary to locate the generating plants at three distant points, the supply of air from two of

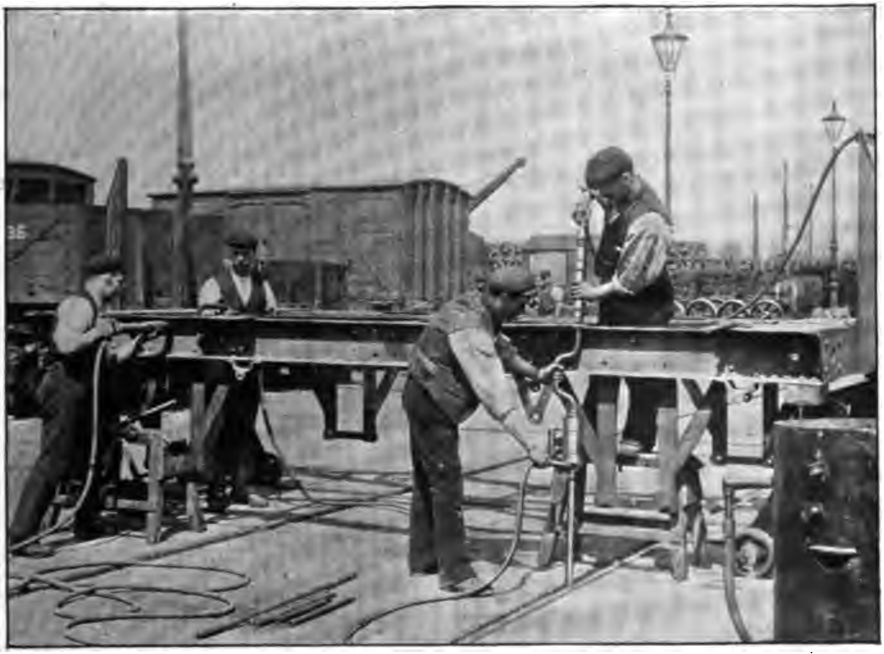


FIG. 13—A PNEUMATIC RIVETING HAMMER AND HOLD-UP AT THE TEMPLE MILLS WORKS OF THE GREAT EASTERN RAILWAY. MADE BY THE NEW TAITE HOWARD PNEUMATIC TOOL CO., LTD., LONDON.

these stations being connected, and the third being entirely independent of the other two. Nine air reservoirs are installed in connection with the compressors, having an aggregate capacity of 1,650 cubic feet with a maximum pressure of 90 pounds per square inch.

There are in operation 115 drills, of which 83 are in use in the boiler shop, 20 in the erecting shop, and 11 in the tank and tender shop for reaming and tapping for stay-bolts. The advantage of being able to bring the tool to the work in place of taking the heavy work to the tools effects a considerable saving. Previous to the adoption of compressed air machinery in this plant this class of work was done entirely by hand. Considerable annoyance was at first experienced by the oil, necessarily used in large quantities, coming in contact with and softening the rubber hose used for supplying the air to the drills. After some experimenting, a hose covered with duck and treated with boiled linseed oil was adopted, resulting in quite a reduction in the cost of maintenance.

Three bolt-cutting devices are used for cutting off the projecting ends of boiler stay-bolts after they have been screwed into place. These have proved themselves not only labor-saving, but the results obtained are much more satisfactory than with the old method of chipping the ends off by hand, as the use of the hammer and the chisel was liable to loosen the bolts in the thread. This is entirely avoided by the improved process. The apparatus, when swung from a jib crane, can be easily managed and operated by one man, and will cut off the stay-bolts much more rapidly and neatly than by the old method.

Seven hammers for calking the seams if tender tanks are used in the tender shop in addition to a number of heavier hammers in the boiler shop for chipping purposes.

Pneumatic moulding machines in the foundry are used to mould small patterns which are symmetrical, and where a large number of pieces from the same pattern are required, such as brake heads, brake shoes, etc. The process is completed with great rapidity, and the capacity of the machine is limited only by the speed with which the operator removes the finished flakes and supplies fresh ones to be operated upon.—*Cassier's Magazine.*

Efficiency and Capacity Test of the Ingersoll-Sergeant Drill Co's Plant Installed for the Boston Transit Commission, Boston, Mass.

In the early months of this year (1902), the engineers of the Boston Transit Commission undertook an accurate investigation of the properties of the soil and the exact conditions which were to be met in excavating Sections "C" and "D" of the East Boston Spur of the Boston Subway. These two sections are to comprise that part of the subway which connects the submarine tunnel, now being driven from East Boston by the Boston Tunnel Construction Co., and the present subway at Scollay Square. After careful study, it was decided to drive Section "C," running from State and India streets, to Atlantic avenue, by means of a shield, similar in design to the one now being operated in Sections "A" and "B." The quality of the soil and the many large buildings to be passed, made it seem advantageous to excavate Section "D" by the slice or cut and cover method.

Most of the readers of this journal know that to make use of all the advantages obtainable in the operation of shield driving unless the ground through which the tunnel is being carried is of an extremely self-supporting character, it becomes necessary to employ compressed air to support the face and walls of the tunnel, and in many cases to prevent flooding if water is encountered. In the present instance the tunnel leads through a blue clay of a favorable character and while no serious difficulty was expected in the completion of this section, it was considered advisable to use compressed air.

Bids were asked to cover the complete compressor plant, the contract being awarded the middle of March to The Ingersoll-Sergeant Drill Co., for the institution of the following Figs. 1 and 2:

Two 20" & 18¼" & 12¼" x 24", Class "AC" "Straight Line" Steam Driven Air Compressors with compound air cylinders, each having a capacity of 800 cubic feet of free air per minute, which is compressed to 120 lbs. per square inch, this pressure supply being used for the necessary hoisting and winding engines.

Two 18" & 24¼" x 24" Class "A" "Straight Line" Low Pressure Air Compressors, each with a capacity of 1,150 cubic feet of free air per minute, and capable of compressing to 40 lbs. per square inch. These machines are to furnish air to the tunnel at a pressure of from 15 to 25 lbs.

Two 54" x 12' Air Receivers and one 42" x 10' Air Receiver.

Besides these "straight line" compressors a battery of three 150 H. P. return tubular boilers, a 60" x 130' steel stack, the flue connection of which is fitted with a main damper operated by a

without effecting the operation of the plant.

A by-pass is also furnished between the high and low pressure air pipe lines which makes it possible to throw any or all of the compressors into either system in case of necessity.

The water from the air cylinder jacket is discharged into the boiler feed tank, the greater part of which is used in the boilers and the remainder may be used in mixing the concrete for the tunnel walls.

It might be interesting to state that

FIG. 1—COMPRESSOR PLANT, SECTION "C," BOSTON TRANSIT COMMISSION.

lock automatic damper regulator, the uptakes being furnished with individual dampers, one 500 H. P. Berryman feed-water heater, two 6" x 4" x 6" duplex feed pumps, all of which are thoroughly by-passed, making it possible to remove any or all without shutting down. All the feed water piping is of brass and all the valves above 2" are of the gate pattern. All the air and steam piping is arranged so as to enable the cutting out of any boiler or compressor

this plant was erected within a time limit of ten (10) weeks from the awarding of the contract, there being a forfeit imposed of fifty dollars ($50.00) per day if this time was exceeded. To prevent any manipulation of figures, or speeding up of compressors, the bidders were required to guarantee an actual delivery of the required air capacity, stating the necessary steam consumption in pounds of water fed to the boiler to deliver this quantity of air at the required pressure.

The terms which covered this guarantee and were embodied in the contract are as follows:

CAPACITY AND EFFICIENCY OF COMPRESSORS.

As soon as practicable after the plant is erected it shall be subjected to

"Efficiency test."

"Capacity test."

Each may be of about ten consecutive hours duration.

The "efficiency test" will be made on one of the low pressure compressors and one of the high pressure compressors. The choice of the compressors to be subjected to these tests will be made by the engineer.

The contractor hereby guarantees that each of the high pressure compressors will under the conditions of said test deliver 760 cubic feet of free air per minute compressed to 120 pounds per square inch and each of the low pressure compressors will under said conditions deliver 950 cubic feet of free air compressed to 40 pounds.

The actual number of pounds of water fed to boilers shall be determined by weighing.

In case the efficiency of the compressors in the said "efficiency test" falls short of that guaranteed by the contractor a fine shall be deducted from the contract price of the whole plant, to be calculated by the engineer from the following formula:

$$\text{Fine in dollars} = \left\{ \left(\text{Actual number of pounds water fed to boilers per hr.} \times \frac{{}^{*}950}{\text{Actual number of cubic feet free air per min. delivered.}} \right) - \left(\begin{array}{l}\text{Guaranteed number of lbs. water fed to boilers per hr.}\\ \text{while } {}^{*}950 \text{ cu. ft. of free air per min. is being}\\ \text{compressed to 40 lbs. per sq. in.}\end{array} \right) \right\} \times 12$$

FIG. 2—BOILERS FOR COMPRESSOR PLANT, SECTION "C," BOSTON TRANSIT COMMISSION.

The foregoing formula is for the pair of low pressure compressors. The formula for the pair of high pressure compressors is arrived at by substituting 760 in place of 950 and 120 in place of 40.

The total fines will be determined by the sum of the fines of the two efficiency tests.

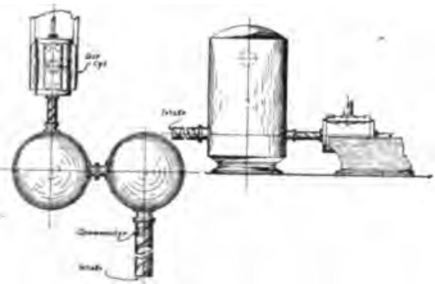


FIG. 3—ARRANGEMENT FOR TESTING COMPRESSOR CAPACITY.

The "capacity test" will be made on the boilers and compressors. All the compressors are to be run for about ten consecutive hours at one time, both the high pressure compressors at their maximum rated capacity (800 cubic feet of

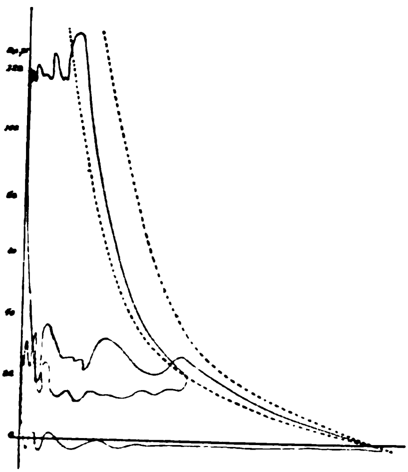


FIG. 4—COMBINED AIR CARD HIGH-PRESSURE COMPRESSOR.

free air per minute against a pressure of 120 pounds per square inch) and both the low pressure compressors at the required capacity of 1,000 cubic feet of free air per minute against a pressure of 25 pounds per square inch, and the boilers must be of such capacity that they can easily supply the necessary amount of steam at 100 pounds pressure with the natural draught.

If the boilers provided are unequal to this the contractor shall without additional expense to the commission increase the capacity of the boiler plant until these requirements are easily met.

Each boiler feed pump shall be capable under easy running of supplying the boilers when all are being run at their maximum capacity.

The steam piping shall be so arranged as to be secure against leaking due to expansion and contraction.

All the main steam pipes shall be covered with a sectional covering of magnesia 1 inch thick.

The following is the method employed to correctly measure the quantity of air

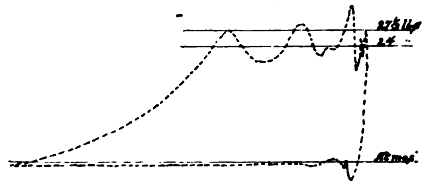


FIG. 5—AIR CARD LOW-PRESSURE CYLINDER.

without going to so great an expense for apparatus as to make a test prohibitive.

Referring to Fig. 3, the two 52" x 12' receivers furnished with the plant were connected together at their upper nozzles. To the lower nozzle of one was attached a galvanized iron tube leading to the air intake of the compressor, while to the lower nozzle of the remaining receiver was fastened a 12 ft. galvanized iron tube having a diameter of approximately 12". In this tube near its innermost end was placed an anemometer, which has previously been calibrated (by Professor Berry of the Boston Institute of Technology), by means of a standard nozzle under similar conditions of pulsation and velocity. This, of course, furnished a positive method of determining the quantity of air taken into the compressor, and what is most interesting, the results practically coincided in the high pressure test with the figures offered by the manufacturer, while the results from the test of the low pressure compressors were far in excess of the required capacity, giving a very high volumetric efficiency, as shown in the following figures as officially taken by the Boston Transit Commission.

		Amount specified in contract.
Easterly high pressure engine. September 10th, 1902.		
Actual number of pounds of water fed to boilers per hour	4,767	4,800
Actual number of cubic feet free air delivered per minute at 120 lbs. receiver pressure.......	778.6	760
Easterly low pressure engine. September 11th, 1902.		
Actual number of pounds of water fed to boilers per hour	3,292	3,680
Actual number of cubic feet free air delivered per minute at 40 lbs. receiver pressure.......	1,021.1	950

As it will be seen from this report two separate tests were made, the one on Sept. 10th, lasting for four hours and being run on one high pressure compressor. 100 lbs. steam pressure was carried upon the boilers, the air being compressed to 120 lbs. in the receiver. Under these conditions the machine was run with a 5-16 cut-off and showed a steam consumption of approximately 25 lbs. of water per I. H. P. per hour with an air capacity of 92.7 per cent. of the piston displacement.

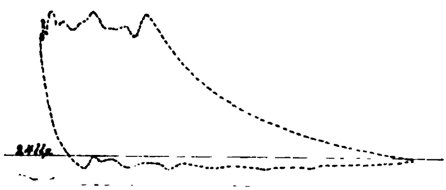


FIG. 6—AIR CARD HIGH-PRESSURE CYLINDER.

On the following day the test upon the low pressure machine, lasting four hours, showed a capacity of approximately 93 per cent. of the piston displacement with a steam consumption of approximately 26 lbs. per I. H. P. per hour, with a boiler pressure of 100 lbs. and a terminal air pressure of 40 lbs. in the receiver.

The steam consumption as given above was determined by weighing the fater fed to the boiler, no allowance being made for the steam required to operate the feed water pumps.

We also show cards obtained at the time

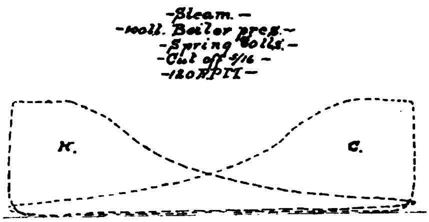


FIG. 7—STEAM CARDS LOW-PRESSURE COMPRESSOR.

of the test, Fig. 4 being a combined card for the air end of the high pressure compressor. Fig. 5 is a low pressure air card from the same compressor, while Fig. 6 is from the high pressure.

Fig. 7 is a double card from the steam end of the low pressure compressor, and Fig. 8 is an air card from the same machine.

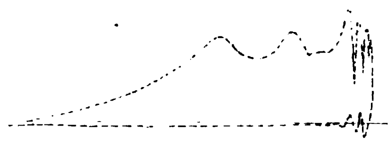


FIG. 8—AIR CARD LOW-PRESSURE COMPRESSOR.

It will be seen from these figures that the efficiency of these compressors was in excess of the guarantee, and as the plant up to this date has passed all the requirements upon the pumps, boilers, piping, etc., it has been a means of great satisfaction to all interested.

R. S. CARTER, M.E.

The North River Tunnels by the Sooysmith Freezing Process.

Mr. Charles Sooysmith has brought forward a plan for driving the Pennsylvania tunnels across the North River by the freezing process. In general it is proposed that the tube tunnels shall rest on a substantial pile foundation, and that they may be anchored to this foundation if there is any apprehension that the tunnels will float up or shift laterally. It is the opinion of

Mr. Sooysmith, however, that there need be no apprehension of displacement of the tunnels by reason of their comparative buoyancy. The material at the depth at which it is proposed to place the Pennsylvania tunnels is comparatively firm and compact, but probably it is not sufficiently so to resist the vibration of moving trains.

Among the various methods which have been brought forward is one for dredging a channel, driving piles in it, and then lowering the tunnel sections through the water; and another is to run the tunnel sections out by the use of a shield and the pneumatic process, occasionally sinking a pier as the tunnel proceeds. The plan proposed by Mr. Sooysmith avoids one of the great objections to the former of these two methods, namely, constant interference by river craft. On the other hand, it is believed that it will give a better result than the second method suggested in that the foundation will be continuous, and that the tunnel does not require the large amount of metal necessary to give it transverse strength as if it were to be carried from pier to pier—at once a tunnel and a bridge. The pneumatic shield method necessitates the use of a very heavy lining of cast iron, and some engineers consider that there is danger of rupture from the pounding of moving trains. Further, the tunnel can be driven through the frozen material exactly as a land tunnel is driven, by open headings, without compressed air and without trouble from water.

Outline Description of the Method.—The plan contemplates a foundation or anchorage of piles along the line of the tunnel. To get these piles down to the great depth desirable, a tube somewhat larger than the pile will be driven by water jet to about the level of the bottom of the tunnel. The pile is then telescoped through the tube, being driven by a Nasmyth hammer lowered down into the tube. This would be worked by compressed air. The hammer is enclosed in an air-tight shell which extends to below the top of the pile and the water is kept out by compressed air.

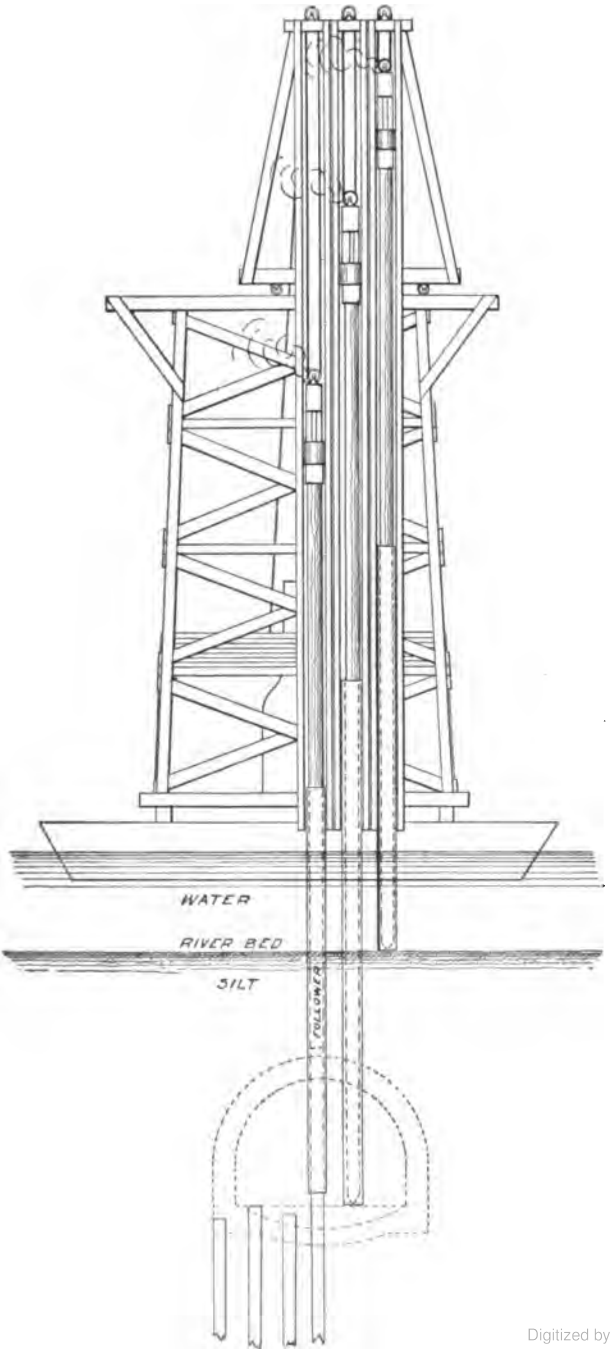
Over the piles along the center line of each tunnel will then be driven by compressed air a small pilot tunnel, 6 or 7 ft. in diameter. The pilot tunnel is to serve as a refrigeration chamber from which to freeze the material around and to such a distance outside of it that an excavation for the full size tunnel may be safely made within frozen material. The means for doing this will be those commonly employed in cold storage and ice-making plants. The rate of freezing, the distance out to which the freezing can be done, the strength of the frozen material, and all data necessary to establish the practicabilitv and safety of this procedure have been obtained chiefly from work already done by the freezing method and from actual experiments with Hudson River silt made with this particular work in view.

Within the space excavated, as before described, the paramount tunnel structure will be built upon the piles, cut off at the required depth as the frozen material is excavated. Having provided a continuous rigid foundation and a clear space of the requisite dimensions any desired tunnel structure can be built.

Pile Driving.—Pile driving plants will be specially prepared for this work with adequate anchoring devices, and provision will be made for handling two or more piles without change of position of the supporting barge. The leads as a whole will be made adjustable on the barge so that more than one bent of piles can be driven without a relocation. The machinery of the barge will include pumps and special hoisting drums for raising the guide tubes.

A tube somewhat larger in diameter than the wooden piles to be used, being suspended in the leads and provided with suitable arrangements for application of water jets will be sunk so that its bottom will be at about the level of the bottom of the proposed tunnel structure. Experience shows that a tube can be thus sunk to a depth of 50 ft. in less than two minutes. The pile may be placed in the tube before it is sunk into the bottom; the follower or Nasmyth hammer will then be placed on the pile, and the latter driven home.

The steel tube will serve to attain an accurate location; as a means of overcoming the frictional resistance down to the point to which the top of the pile will be driven; and as a guide for the pile and driving devices. The tubes will not be withdrawn till they have served as locating guides for the next tubes and piles to be driven. The pile driving begins near the shore where operations will be easy, and it nowhere runs into conditions of excessive difficulty; into none, in fact, as troublesome as have in other localities been overcome by simple means.



PROPOSED METHOD OF DRIVING PILES IN THE HUDSON RIVER.

Refrigerating of Pilot Tunnels.—Assuming that two tunnels only are called for in the first construction, small tunnels 6 or 7 ft. in diameter will be driven, one on the center line of each proposed large tunnel. These small or pilot tunnels can be built at a rate of at least 10 ft. a day after work is well inaugurated, indeed at considerably greater speed. In the construction of the first 1,500 ft. or more of the Hudson River Tunnel, no shield was used, but the compressed air was counted upon to hold back the material at the heading some 22 ft. high. To hold the material back at the bottom there was a constant necessity to make the air pressure much greater than the hydrostatic pressure at the top of the tunnel. Then at intervals blow-outs occurred lowering the pressure and causing an inflow of material. These difficulties led to the employment of a shield for the work last done. Soon after starting the old Hudson River Tunnel, and up to the time of the employment of the shield, that is, throughout a distance of over 1,500 ft., a small tunnel called the "pilot" was driven in advance of the main heading, as a means for lessening the size of the main heading and for affording a centering for the bracing. The construction of this pilot tunnel gave no difficulty, but it was rapidly and cheaply built without the use of a shield. The small exposed face of the pilot tunnel made its construction easy and safe without the use of a shield, even when further progress with the main heading became difficult and costly. These statements are based upon the personal experience of Mr. Sooysmith, who was for months almost daily in the heading of the old Hudson River Tunnel.

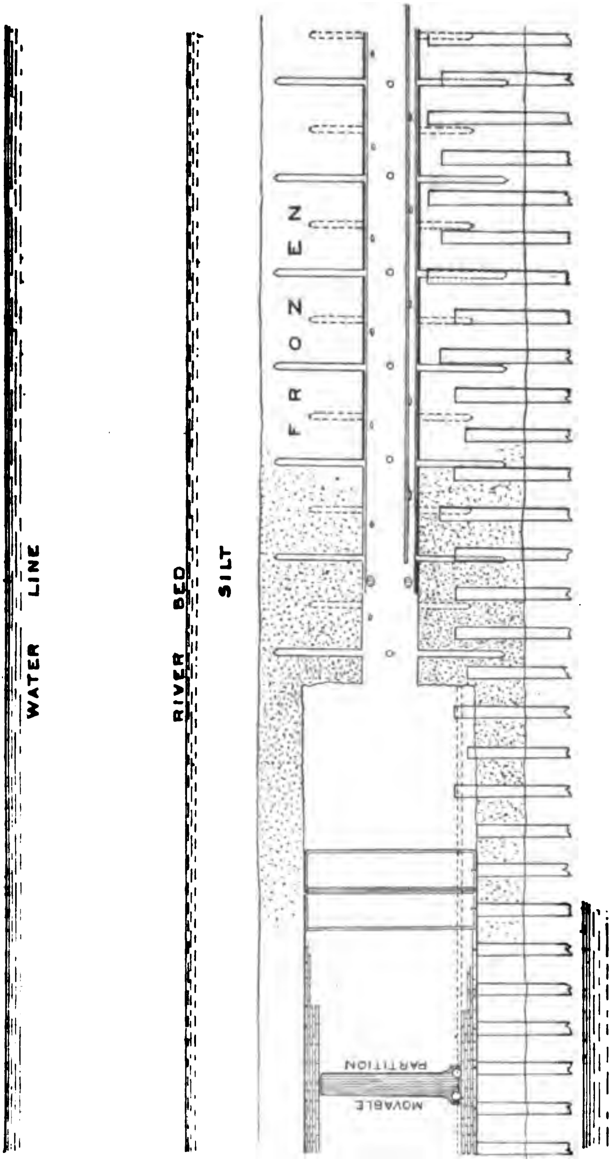
As fast as the pilot tunnels are advanced the necessary freezing pipes may be put in place and the circulation of the cold brine commenced—or if cold air is to be used it may be introduced at once. It may prove more advantageous to do the freezing and excavating at the same time, always keeping the excavation a safe distance from the limit of the frozen material.

In order to enable the freezing to be commenced before the completion of the pilot tunnels, it is proposed to build a third small tunnel simultaneously with the other two, to be used as a working tunnel, locating this on the center line of a prospective third large tunnel, or it may be between the first two large tunnels to be built, and in the future use be made of it for conduits or other purpose.

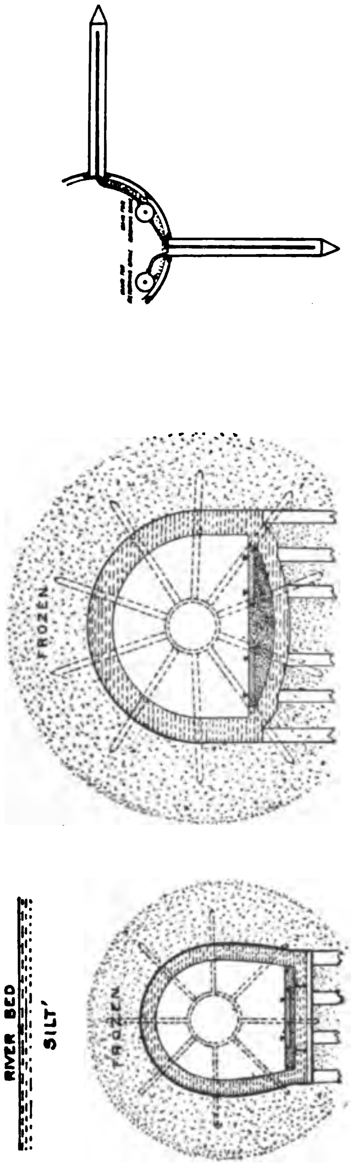
This third tunnel would serve as a working passage-way to the headings of the two refrigerating tunnels by means of connections between the three tunnels at intervals of a few hundred feet. For instance, after the three tunnels have been completed to a distance of say 500 ft. from the shaft, cross connections between them will be made and the two for refrigerating service will be put into use for this purpose. At a further distance of say 500 ft. another crossover will be made and then 500 ft. more of two of the tunnels can be put into use for freezing. In connection with the location of the refrigeration plants, it may be mentioned that brine is now being circulated for refrigerating purposes a distance of at least half a mile from the machinery.

Ice Machines.—With a compression machine, a brine temperature of — 20 deg. F. can be easily maintained, and the absorption machine works economically at still lower temperatures. There are great numbers of both kinds of machines in use, and their employment for the object in view will differ in no manner from uses to which they are now put. The ice machine used at Iron Mountain, Mich., froze at the start two cubic yards of saturated earth per day per ton of refrigerating capacity. Later, when the abstraction of the heat had to be through a long distance of frozen material, the efficiency was reduced to half this amount, or one cubic yard per day per ton capacity. Assuming that the entire distance from shore to shore for two tunnels is 10,000 ft. of tunnel, and it is desired to freeze it in 365 days and, providing for a frozen wall at least 5 ft. outside of the line of excavation, there will be 287,400 cu. yds., or 787 cu. yds. per day to be frozen. This, assuming the average efficiency between the maximum and minimum rates of freezing for Iron Mountain above-mentioned, will call for a total refrigerating capacity of 525 tons, or 1½ cu. yds. per ton per day. One of the advantages of the freezing method is that a serious breakdown of the machinery, even could it disable the entire plant for several days, will not cause a disaster to the work.

Pipes for Circulation and Freezing.—In the work at Iron Mountain the freezing was done by circulating the brine



MR. SOOYSMITH'S METHOD OF UNDER-WATER TUNNELING BY FREEZING.

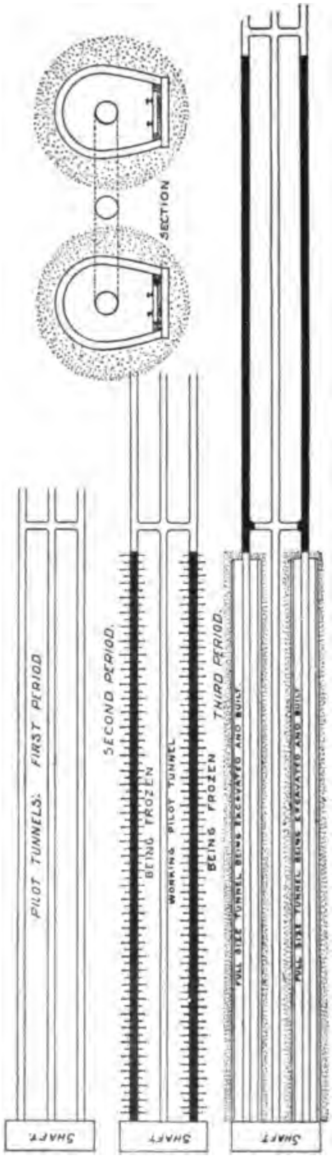


MR. SOOYSMITH'S METHOD OF UNDER-WATER TUNNELING BY FREEZING.

through pipes 8 in. in diameter. At the end of 72 days the material was frozen for a distance of 9 ft. from the circle of pipes. It is probable that in a tunnel construction, particularly where material not easy to penetrate with pipes is encountered, the freezing would be done by the circulation of cold air or brine through the pilot tunnel or through pipes laid in the same. In the case of a double track tunnel where it might be impracticable or take too long to freeze the requisite distance, the excavation might begin when the frozen wall outside the pilot was 5 or 6 ft. thick. Two or three feet of this would be excavated outward from the pilot, and in this way by successive annular cuts let the excavation follow the freezing, instead of waiting until the entire mass is frozen. In case the work is done in the same way as for shaft work, radial pipes will be pushed out in sections at intervals from the pilot. They will extend three or more feet beyond the limit of the space to be excavated, and their number and location will be such as to give the same absorption area per cubic yard to be frozen as was provided by the pipes at the Iron Mountain work.

This provision will leave no question as to securing a continuous frozen mass to at least 5 feet outside of the space to be excavated, and this within a period less than 60 days; this too, on the supposition that the circulated brine will be at a temperature not lower than—10 deg. F.; the ice machine used will be capable of producing a much lower temperature. In each of the pipes and to nearly its outer end will extend a pipe 1 inch in diam., and the systems of large pipes and small pipes will be connected together in such a way that the brine will be constantly circulating through the large pipes.

In order that temperature observations may be made, small test pipes will be put out at short intervals, these test pipes extending 10 feet beyond the space to be excavated. The temperature observations which will be constan'ly made will afford information at all times as to the progress and extent of the freezing. Owing to the uniformity of the material under the Hudson, this freezing will be uniform with uniform circulation and temperature of brine. With the system proposed, it will be possible to freeze most rapidly and make the wall thickest at the points of greatest pressure, or at



Progress Sheet—Plan and Section.

UNDER-WATER TUNNELING BY FREEZING.

points where any recesses in the tunnel structure (should any be desired) or any enlargements of the structure itself may call for an enlargement of the excavation.

Strength of the Frozen Material.—The frozen wall will be of a material very compact and perfectly saturated, though, owing to the pressure which it is under having only enough water to fill the voids (about 30 per cent.). This condition gives the maximum strength for a frozen mass. Its temperature will be considerably below the freezing point, which adds much to its strength and prevents it from thawing as the excavation proceeds, even though the excavated chamber were warmed. The excavated chamber will remain for weeks at a temperature much below the freezing point unless artificially warmed, and the thickness of the frozen wall will continue to increase for many days after the circulation through the pipes has been discontinued. This is because the temperature in the frozen mass will have been lowered materially below the freezing point; in other words it will act as an exceedingly cold body still absorbing heat. An illustration of this may be noted in the behavior of the earth in some parts of Siberia and of Alaska, where the earth is perpetually frozen to many hundred feet in depth. Tests show the compressive strength of frozen silt from the bottom of the Hudson River to be from 400 to 600 lbs. per square inch.

Excavation.—Frozen silt or quicksand has about the appearance of sandstone, and a good deal of its character. Under low temperature it is very tough. It may be drilled and blasted without effect on the mass of material a short distance from the charge fired. It can be picked or chipped by hand at a speed that would be permissable for the work in question, but one of the two following methods will be employed for its excavation.

Sections of the pilot tunnel and the circulating pipes will be successively removed a few feet in advance of the excavation. The circulating pipes when emptied of brine will be warmed by a circulation of steam or otherwise for a moment or so till they are loosened and can be withdrawn. The holes so left in the frozen mass will serve as a means of breaking off into the heading large masses of the frozen material. This will be done by power wedges specially designed for the purpose, or by lime cartridges.

Or it may be found preferable to use a chipping machine run by electricity or compressed air, to chop the material from the heading. Should speed require it, the excavation may be done in two or more offsets or the entire heading may be kept in a conical shape to afford large working surface. As the piles are encountered in the excavation, they will be sawed off or dressed, as called for by the plans.

Summary.—It is claimed that while no tunnel has ever been built on the plan proposed it involves only processes, the success of which has been fully established by work already done. The plan described provides:

1. A method of driving piles, the success of which, in the light of work done in many places by means of water jet and steam hammer pile driver, cannot be questioned.

2. The construction of small tunnels in the Hudson River, the practicability of which has been established by the pilot tunnel in the old Hudson River work, and by numerous small tunnels through soft material under the lakes, and other places.

3. The solidification of the material about these pilot tunnels by the common methods widely in use for refrigeration and ice-making, and the application of which to the freezing of the material in the bed of the Hudson offers no problems or difficulty the solution of which has not been demonstrated by the work done by Mr. Sooysmith at Iron Mountain, Mich. The rate at which this material can be frozen, and its strength and capacity to sustain surrounding pressure when the tunnel space has been hollowed out, were demonstrated by the conditions existing at Iron Mountain by the tests made there, and more particularly by the strength of material taken from the bed of the Hudson River, frozen and tested by Prof. Denton. By the test pipes at frequent intervals the extent of the frozen wall will at all times be known, and it is claimed that the method outlined is freer from possibility of accident and unexpected delay than any other plan yet suggested, including the various schemes of building in sections and lowering from above.

The projected tunnels of the Pennsylvania Railroad and the Rapid Transit Co. under the East River will pass through much more difficult materials to excavate than the uniform silt of the Hudson. The formation consists of peaks of rock and pockets of mud, gravel, sand, quicksand and clay, and it will be very difficult to maintain air pressure in a shield. These difficulties are much less in the building of a small pilot tunnel for freezing purposes. Inasmuch as the rocky material contains little water, the freezing process there will progress rapidly.

One of the merits of this plan is that a double-track tunnel can be readily and cheaply built, or single-track tunnels easily connected. And it is specifically claimed that tunnels can be built in this manner cheaper and quicker than by any other possible method.—*Railroad Gazette.*

American Manufacture of Ping Pong Balls.

A correspondent writes to the editor of the *American Machinist* as follows:

"You have recently published an article, entitled "British Triumph," referring to the making of ping pong balls, which was taken from the *London Graphic*. The said article was quite sarcastic, claiming a victory for the British, and saying that the Americans could make almost everything except a ping pong ball. In the same issue the *American Machinist* said that there was about one hundred patents issued in the United States on golf balls, and suggested that by the time there were a hundred patents on ping pong balls the American ball might be as good as the English.

Up to the present only one American inventor has challenged the British in making ping pong balls. From the picture, Fig. 1, it may be seen that the first man who began to file patents is already embossing 220 half-balls in one operation in less than two minutes' time, while the English are embossing their balls one by one. According to this, 60,000 half-shells are embossed every ten hours. That means a daily output of 30.000 balls through one press alone.

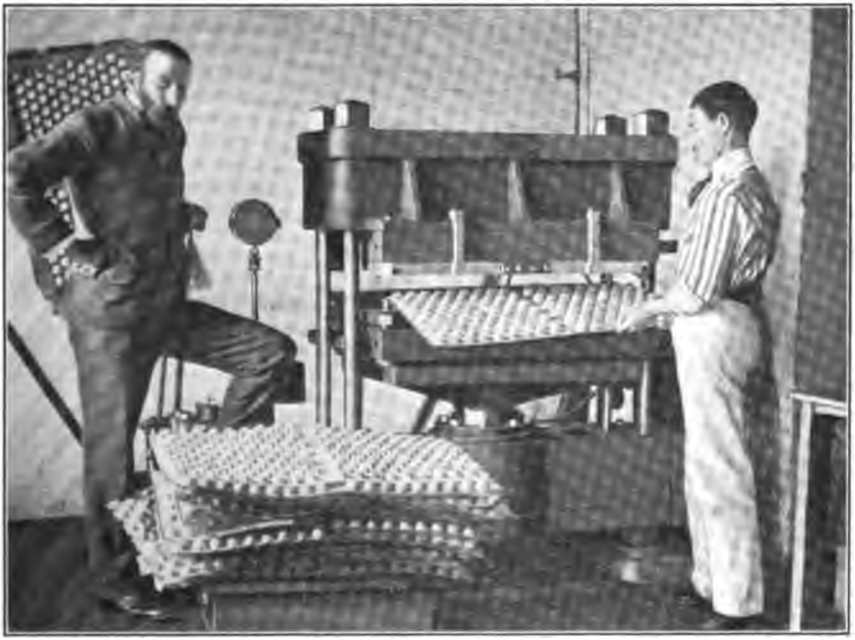
This is not the best we can do as yet, so says Mr. John Whitehouse, the inventor of this process. At the time he started to make ping pong balls he had made himself acquainted with every conceivable means for stretching celluloid, which indeed is a very peculiar material. The male and female die is the first thing a person will think of, but owing to the fact that celluloid will not draw into a die like any metal will, but, on the contrary, that it has to be held firmly and the embossment stretched out of the thickness of the material, naturally, if a sheet of celluloid is taken, say, 1-100 inch thick, and a half-shell of a ping pong ball is embossed of the same, if it cannot draw in (as it will not) through the stretching the celluloid will take a variety of thicknesses. The bottom of the half-shell in the die will be much thinner than its sides. Owing to this fact it is very expensive to make a male and female die that will have the proper clearance according to the stretch of the material. It has been found that a metal female die and a male die made of paper work quite satisfactorily, by reason of the elasticity of the latter, if both are heated to about steam temperature.

This is the method shown in the half-tone picture. An entire sheet of celluloid is taken and placed in the machine and 220 half-shells are the result per operation. This is over one hundred times as fast in making ping pong embossments as that of our English friends. Yet this American inventor is anything but satisfied by being one hundred times as fast as the English. He says that soon he will have metal male and female dies, and he will then be able to produce these goods ever so much faster, for the reason that metal will heat ever so much faster than paper will, as after each operation both the male and the female die have to be cooled while under pressure, or otherwise the hot celluloid would shrink out of shape. The reason that it does take two minutes to make one embossment of 220 half-shells is because paper is a non-conductor of heat, and for that reason is slow in heating and cooling.

The only thing left to do, says Mr. Whitehouse, was to devise some means through which a metal male and female die could be made in an inexpensive way, which he says is as follows. He makes his cast-iron female die as usual and secures a sheet of flexible rubber equal in thickness to that of the celluloid to be embossed over the die, which then is placed in an electrolytic copper bath. The tank which contains the copper solution has a cover which is closed, and an air pressure of 50 pounds per square inch is produced therein. The solution under pressure will force and stretch the rubber into the female die and keep the rubber there until a deposition of copper of about ⅛ inch in thickness takes place. As rubber will stretch exactly the same as celluloid does when heated, the above mentioned necessary clearance according to the stretch of the material is hereby secured, and the method of embossing as the result is much faster than with the male and the female die when the former is made of paper.

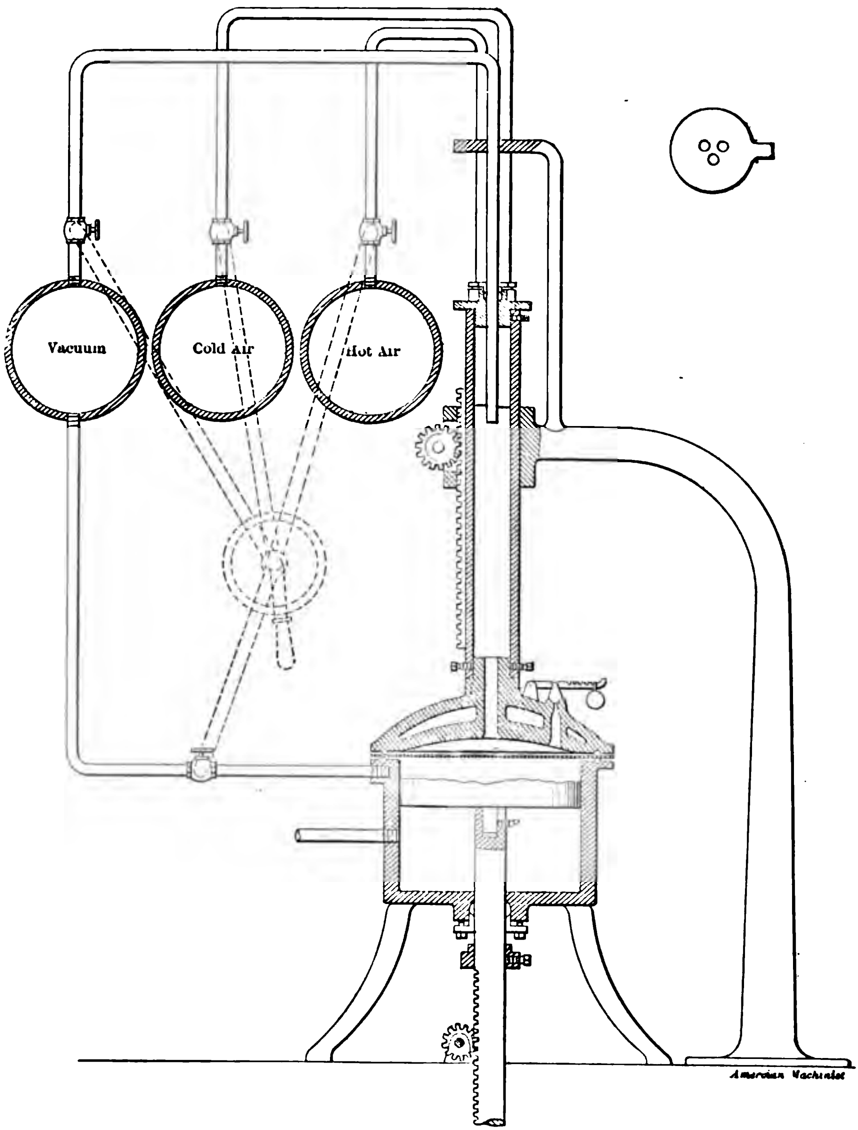
The inventor is not fully satisfied with the result obtainable from a metal male and female die. In a short time he will build a large machine through which he will be able to emboss as many as 250,000 half-shells per day. When embossing an entire sheet of celluloid in one operation quite a number of difficulties have to be overcome. If a sheet of celluloid is placed over a die so that the air is enclosed in each of the cavities and becomes hermetically sealed therein with the celluloid, it is quite hard to get rid of the same.

The accompanying outline sketch, Fig. 2, of the air machine shows how it will operate. The celluloid is held in a frame by its edges and becomes a diaphragm, and as such it is placed over the die and is held on a packing ring. The female die is vertically movable and is lowered away from the diaphragm of celluloid to be embossed. The air is exhausted from the female die and it is then brought back to its original position to be in contact with the celluloid. In this way a partial vacuum takes place in the die. The upper half of the machine is brought down on the celluloid and through a packing ring it is hermetically sealed on its outer edge. It is now ready to be embossed. Compressed air at a temperature of about 220 degrees Fahr. and with a pressure of 100 pounds per square inch is admitted. The celluloid through the heat and pressure instantly stretches into all the cavities, no mater how deep.



EMBOSSING PING PONG BALLS.

It is claimed that with this method celluloid of only 1-100 inch thick can be embossed to a depth of from 5 to 7 inches. The peculiarity of celluloid is that if the same is not cooled under pres-



CELLULOID EMBOSSING PROCESS.

sure while in the die it will shrink considerably. To this end, while the pressure is kept up by the compressed air the same is rapidly cooled through a circulating stream of cold air or water. The whole operation takes place in about 90 seconds. The vacuum pump almost instantly produces the vacuum in the female die. The hot compressed air (which is connected to the male die) almost instantly performs the embossment. The jet of cold water (or cold air) quickly performs the cooliing. After all this the finished embossment is taken out and replaced with a new sheet to be embossed.

This machine will not only make ping pong balls at an enormous speed, but it will emboss designs and figures of every kind, and the most beautiful work in the line of embossments can be readily performed on this machine at a very low price. Considering that celluloid always retains its high polish, no matter how deeply embossed, the most intricate work with the sharpest of corners and the minutest of detail can be performed, even if there should be undercuts on the picture or design.

This is only the beginning of the products of one inventor who has started in to challenge the British. He is not satisfied with being able to turn out 100,000 ping pong balls daily with one machine. How about the other ninety-nine inventors?

JOSEPH MISKO.

A New Type of Air Compressor.

This machine represents the latest product in this exacting field and is designed to meet the growing demand for higher efficiency in air compression, that naturally attends the steadily increasing adoption of pneumatic machinery in all branches of industry. It is known as the Class C. S. C. pattern, designed for a delivery air pressure of 100 lbs. per square inch, with a steam pressure of 100 to 150 lbs. The compressor illustrated has low pressure steam cylinder 31 in. diameter, high pressure steam cylinder 20 in diameter, low pressure air cylinder 28 in. diameter and high pressure air cylinder 16½ in. diameter, all cylinders being 24 in. stroke.

The capacity of the compressor is 1,710 cubic feet of free air per minute when operated at 100 revolutions, or 2,052 cubic feet at 120 revolutions.

In design, the frames follow the most approved Corliss construction and are of exceptional strength, to withstand extreme strains without producing mechanical distress. The steam and air cylinders are tied tandem to each other with heavy tie rods and are rigidly supported by a sole plate, which extends beneath all four cylinders. The pillow blocks have extra broad pedestals and all frames are planned perfectly true on the bottom, assuring a perfect alignment.

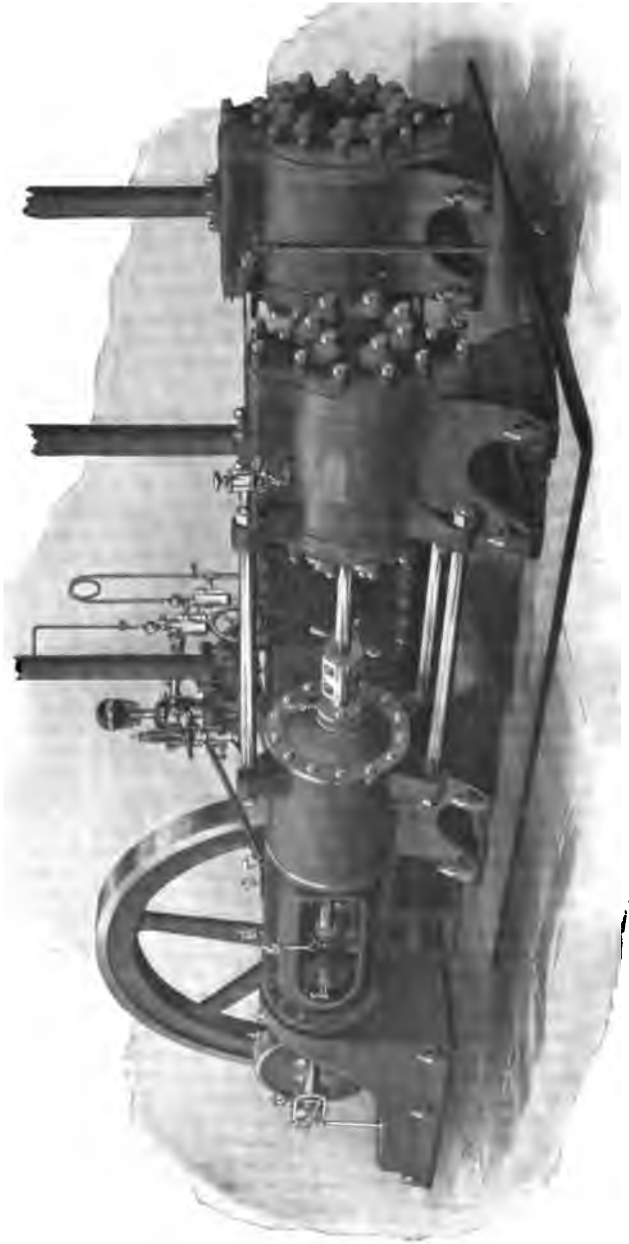
All cylinders are of extra close grain iron, with appropriate thickness for reboring, and are bored absolutely true and parallel.

Steam and air pistons are of solid type, cored hollow to avoid unnecessary weight, and are provided with snap rings of special iron carefully fitted to place. They have no followers or bolts, thus avoiding liability of accident. Stuffing boxes are of ample depth. Piston rods are of steel, turned true and polished.

The air cylinders and cylinder heads are thoroughly water jacketed. Provision is made for a circulation of cold water the entire length of the cylinder, the water passing also through the heads, its cooling effect being especially concentrated around the discharge valves, which naturally sustain all of the heat due to compression and friction that has not been eliminated by the water jacket during the actual process of compression.

A novel feature, the value of which as a safeguard cannot be over-estimated, is an outside water connection for conducting the circulation of water between air cylinder and cylinder head, excluding the possibility of serious accident through water entering the interior of cylinder should the gasket between cylinder and head become ineffective.

The bearings are exceptionally large and well proportioned. The main bearings are provided with removable shell boxes and only the best phosphor bronze and genuine babbitt metal are used. All bearings are adjustable for wear, with ample provision for oiling. Steam valves are balanced slide valves, adjusted to realize the highest attainable ecenomy in the consumption of steam and are provided with Meyer independent adjustable cut-



CROSS COMPOUND STEAM-DRIVEN AIR COMPRESSOR, CHICAGO PNEUMATIC TOOL CO.

off. All valves have provision for readjustment when required by wear.

The air inlet and discharge valves are of the poppet type, placed in the cylinder heads from the outside and immediately accessible for adjustment or repair without removing the cylinder heads. The valve, valve stem and head are forged in one piece, entirely avoiding the use of flange nuts, jam nuts, split pins or other contrivances intended to serve as a head for the stem, needing constant supervision, with continual liability to work loose. A feature of more than ordinary importance embodied in this valve is the fact that the valve seat is a part entirely separate from the cylinder proper and may be removed, replaced or renewed whenever occasion requires. In most forms of air compressors employing poppet valves, the valve seat forms an integral part of the cylinder head, affording no opportunity for renewal when it becomes worn. The valve and seat form a complete piece of mechanism which may be examined, re-ground and adjusted separate from the compressor.

The valve seats are of bronze and the springs of steel, light enough to minimize resistance in opening, yet strong enough to promptly seat the valve in closing. The proportion of valve area to cylinder area is exceptionally liberal, enabling the cylinder to fill freely at each stroke, without volumetric loss or impaired efficiency due to the wire-drawing effect of insufficient valve area.

The cylinder flanges are recessed to effectually prevent the valves from falling into the cylinders, avoiding the necessity of a guard plate and the consequent clearance loss resulting from its use.

The cranks are of disc pattern, made from best quality charcoal iron. Shafts and crank pins are forced to their places, the former being keyed and the latter riveted, especial care being exerted to have the shaft and pins absolutely parallel. Crank pins are of special ground steel. Crank shafts are of unusual strength, made from best hammered machinery steel, accurately turned and finished.

Connecting rods are made from best forged steel, carefully finished. Boxes are adjustable for wear, and accord with the most approved practice in all classes of compressors.

The guides are bored and crossheads are provided with babbitted shoes at the top and bottom with wedge adjustment for taking up wear.

A combined speed and pressure regulating governor is provided, having a connection to the air receiver, and regulates the steam supply to the compressor to suit the air consumption, maintaining a constant unvaried air pressure, even though the demand be intermittent. Working in combination with this governor is a speed governor for regulating the speed of the engine.

The inter-cooler furnished with this type of compressor consists of a set of tubes encircled by a steel shell, into the heads of which the tubes are fitted, suitable provision being made for expansion and contraction. A constant circulation of cold water is maintained through the tubes, and the compressed air from the initial compressing cylinder enters the inter-cooler on one side and after thorough distribution and contact with the tubes discharges from the other side, passing to the next compressing stage. Adequate provision is made for readily cleaning the interior of the inter-cooler, and the tubes, being of composition metal, do not rust or become foul.

In many forms of compound compressors the advantages to be derived from two-stage compression are not realized because of inadequate cooling surface in the inter-cooler, or because the air comes in contact with the cooling surfaces but once in passing through the inter-cooler.

Complete provision is made for automatic oiling, sight feed lubricators of ample capacity being furnished for steam and air cylinders, centrifugal oilers for crank pin bearings, and oil cups of approved pattern for all wearing parts.

Steam and air cylinders have indicator connections, and indicator diagrams are taken under the exact working conditions.

This type of compressor is manufactured by the Chicago Pneumatic Tool Co., and is built in three sizes ranging in capacity from 500 to 2,000 cubic feet of free air per minute and is also built with simple steam cylinders, for plants where the available steam pressure does not warrant compounding. Single and Duplex Compressors in a variety of sizes are also manufactured.

A Pressure System of Pneumatic Tubes.

A pressure system of pneumatic tubes, that is, tubes operated by the expanding force of compressed air, is the only system founded upon good mechanics.

As the compressed air is let out from the generating plant it can be introduced into a tube to make the transmission of a carrier, and then be shut off as soon as the transmission has been effected; but where the air is drawn towards the operating machinery, as in tubes on the suction principle, the power cannot be shut off, and the current has to be maintained constantly through the tubes when carriers are not being transmitted. Such use of power is in obvious great waste, as average tubes are only used to the extent of a small fraction of their possible use.

In a vacuum like the suction system there is no reserve of power, and hence stoppages of carriers in the tubes occur, and make it necessary to take the tubes apart to remove the carriers. And further, in suction tubes, as the current can travel only in one direction, two lines of tubing are required between each two points of communication.

The advantages of a compressed air system are:

I. Economy in the Cost of Maintenance.—An air pump and a storage tank for air pressure generate and maintain the power for operating the tubes.

The air pressure is carried by ordinary iron piping to the terminals of the tubes.

The tubes are normally open to the atmosphere. When a carrier is to be transmitted the air pressure is introduced into the tube which draws off some of the supply from the storage tank.

An automatic regulator, which controls the starting and stopping of the pump, is operated by the rise and fall of air pressure in the storage tank. The pump stops when it has produced the normal pressure of the system. It automatically starts into action when air is drawn off to make the transmission of a carrier. There is accordingly no waste of power. In an average system of tubes a saving of upwards of sixty per cent. is made.

II. Reliability in Operation.—There can be no stoppages of carrier in a tube, making it necessary to take the tube apart to remove it.

There is an abundant reserve of power to force the carrier through the tube.

The air supply pipe is smaller in area than the tube, and consequently while the carrier runs freely through the tube the air pressure from the supply pipe becomes expanded in the tube to a lighter degree of pressure. Hence if a carrier tends to foul in a bend or other part of the tube it forms a resistance, and the air pressure behind it instantly makes up to the full degree of the pipe pressure, and so the carrier is automatically relieved and pushed along. Beyond this, by adjusting the regulator, the pressure in the system can be raised many pounds, to the full capacity of the pump, and this high pressure can be used to free the tube in case the necessity arises from accident or misuse.

III. Single Tubes can be Used Between Two Points of Communication.—As the air pressure is admitted into the end of the tube to make the transmission of the carrier, it can also be admitted into the other end of the same tube, and carriers can therefore be dispatched alternately from either end of the same tube to the other end. As an average transmission is made in a few seconds' time no practical inconvenience is experienced by using one tube for transmissions in opposite directions. The use of single tubes saves room in the passageways and walls of a building, which is often a point of considerable importance.

The question may be asked, What prevent carriers from being dispatched from both ends of a tube at the same time? This does not happen, because when a carrier starts from one end, the atmospheric air in the tube immediately rushes out of the other end, and a carrier cannot be inserted until the first carrier arrives, which is a matter of only a few seconds' time.

Double tubes can be used between each two points, but the additional tube is entirely unnecessary, as has been proven in the widest application and in the most exacting service. Why pay for more brass than is required? Why fill passageways and walls with useless piping?

IV. Automatic Dispatching Terminals.—The important element of the compressed air system is the dispatching terminal at the end of the tube.

Great improvements have been made in the form of terminals. A gate or cover, being normally open, is closed, shutting off the tube from the atmosphere, when a carrier has been inserted for transmission. The act of closing the cover automatically opens an air valve which controls the supply of compressed air.

Recent inventions have produced a very simple device for shutting off the air pressure automatically when the carrier has completed its transmission. The gate or cover becomes locked in its closed position, and the automatic device is adapted to unlock the cover at the proper time, permitting it to return to its normal open position, and permitting the air valve to close, shutting off the air pressure. This tripping device is made a part of the dispatching terminal, and is operated by the air pressure where it is located without the use of any other agent, or of mechanism running between the two ends of the tube. These new terminals embrace principles of the utmost importance. They are essential to a first-class system.

You would not equip a building with electric lights to burn everywhere all the time, in order to have light in occasional dark hours. Why keep a blower continually running on the suction principle to maintain a constant current of air through pneumatic tubes for occasionally dispatching a carrier?—*Power and Transmission.*

The Locke Electric Rock Drill.

This is the invention of H. B. Locke, a mining engineer of thirty years' experience who considers it the long-sought for perfect electric drill. It uses no flexible shaft, but the motor is attached to the drill mechanism by means of a telescope shaft, which travels the whole length of the hollow motor shaft. The motor is a ¾-H. P., 220 volts direct current, and is both dust and water proof. It makes 2,500 revolutions per minute, and runs in ball bearings, so that the drill can work at any angle.

The feed of the drill is 18 inches, and the steel used is ⅞-ineh octagon, or 1-inch star steel. The size of the bit is 2 or 2¼ inches, according to the desired depth of holes.

The drill can be handled by two men as the total weight, including motor, is 239 pounds, but one man can separate it into three parts in less than one minute, when the parts will weigh as follows: Motor, 95 pounds; drill, 91 pounds; base, 53 pounds.

The drill makes 360 blows per minute and the spring which actuates the piston is 720 pounds. In other words the power that pushes the piston forward is 720 pounds, which gives a great velocity to the piston and drill. The rate of drilling is about one inch per thousand blows in the Platte canon granite.

The machine is a ball-bearing one, and the strong spring is compressed by rolling a large steel ball around a helical cam; the release of the spring strikes the blow.

Mr. Locke informs us that one of these drills has been run for four months at the factory of the American Bicycle Company

THE LOCKE ELECTRIC ROCK DRILL.

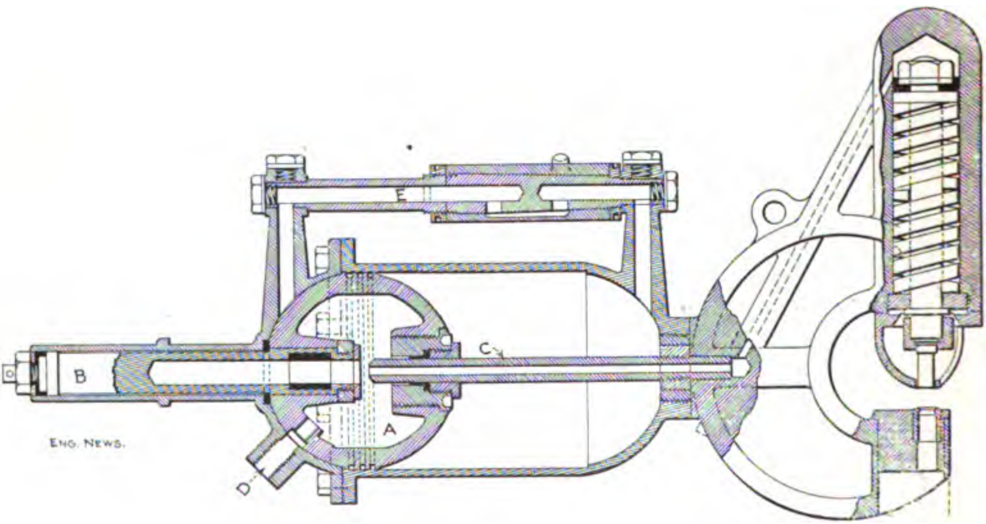
at Hartford, Connecticut, where the drills are made, without showing any wear or breakage.—*Mining Reporter.*

A Punch Operated by Combined Air and Hydraulic Pressure.

We illustrate in the accompanying cut a sheet metal punch whose construction and mode of operation present distinctly novel features. Briefly described, it is a portable puch operated by air and hydraulic pressure coacting by means of a special mechanism to drive a punch plunger. The new tool is known as the Caskey pneumatic punch and is being made and sold by F. F. Slocomb & Co., of Wilmington, Del.

The illustrattion shows clearly all the essential structural features of the new punch. As will be seen, the punch consists of a cylinder in which works a spherical hollow piston. This piston carries a tail rod which works through the rear end of the cylinder, and, also slides in a stationary hollow rod extending inward from the cylinder head. This stationary hollow rod connects with a passage leading to the cylinder of the punch plunger. The piston and its hollow tail rod, the stationary hollow rod, and the passages leading to the punch plunger cylinder are kept filled with oil. The pressure of this contained oil in the punch plunger piston, when the air cylinder piston is actuated by air pressure, operates the punch. The working of the several parts described to bring about this action are as follows:

Referring to the illustration which is a longitudinal sectional elevation of the punch, A, is the hollow ball piston carrying the tail rod or intensifier, B, and sliding on the stationary hollow rod, C. When the piston is at the rear point of its stroke the end of the rod, C, is approximately at its center. To drive the piston forward air is admitted to the cylinder at D. At an early period in the forward movement of the piston the rod, C, telescopes into the tail rod, B, and seals communication between its cavity and the interior of the piston. As the movement forward of the piston continues the entire air pressure behind it is concentrated upon the columns of oil



DETAILS OF PORTABLE PUNCH OPERATED BY COMBINED AIR AND HYDRAULIC PRESSURE.
F. F. SLOCOMB & CO., WILMINGTON, DEL., BUILDERS.

contained in the rod, C, and the passage leading to the punch ram chamber. When the piston has completed its working stroke a hand valve is turned in the by-pass, E. This admits the air to the other end of the cylinder and equalizes the air pressure on the two sides of the piston, but the area of the rod, C, being less than that of the tail rod, B, a greater force is exerted on the forward face of the piston than on the rear face, and it is driven back into position for another forward stroke. The punch plunger is meanwhile returned to a similar position by the coiled spring.

From the preceding description of the operation of the punch it will be seen that one cylinder full of air accomplishes both the forward and the return stroke of the piston. Further, the volume of oil in the piston, its rods and the connecting passageways being just sufficient to depress the punch a certain distance, as soon as the hole is punched no further downward motion of the punch is possible, and all jarring and undue strain is prevented. The makers point out further, that owing to the peculiar construction and arrangement of the ball piston and the parts coacting with it, it is impossible for any air to get into the high pressure passages, unless the oil level in the piston is permitted to fall below the top of the opening in the tail rod, when the piston must be refilled at once.

The punch described is made in a number of sizes for plate work, and is also made with a special auxiliary stroke attachment for work on structural shapes or wherever it is necessary to clear any projection. The "auxiliary stroke" is actuated directly by air pressure admitted to the auxiliary piston chamber, and may be given any travel desired, but after clearing the projection the punch is operated as described above. The punch is portable, and can be operated by one man. —*Engineering News.*

A Compound Air Compressor.

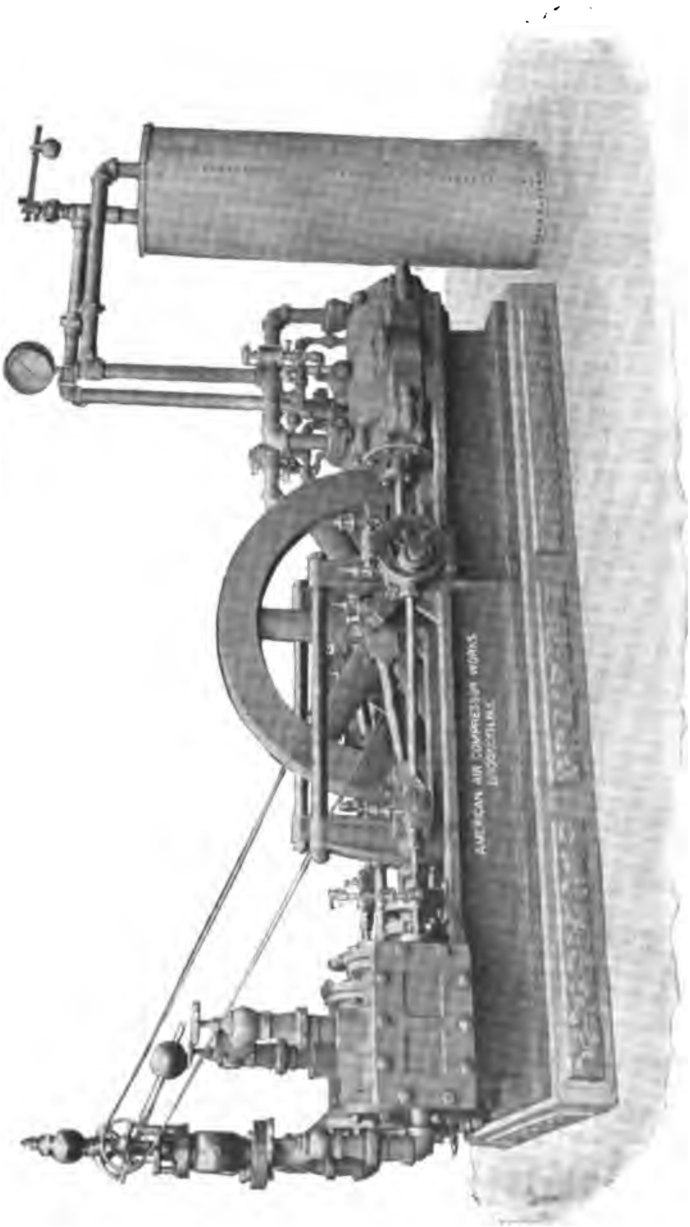
A new type of compound (two-stage) air or gas compressor is being manufactured by the American Air Compressor Works, of Cortlandt St., New York. The demand for compressors of this kind has become so large that the leading manufacturers are devoting much attention to this class of machine. The American compressors as will be seen from the halftone, are simple and compact in design and it is intended that every working part shall be readily accessible. The makers have discarded useless coverings and complicated devices as far as possible with a view to having any engineer of ordinary caliber capable of making the necessary adjustments, etc.

The air valves are designed to reduce the amount of clarance in the cylinders to a minimum and the valves instead of being located in the top or bottom of the cylinder shell are placed in the heads. The valves are made of the best phosphor bronze and aluminum and the man in charge can at once inspect the inlet and discharge valves by removing the cylinder covers. This is considered preferable to having the valves located at different parts of the cylinder, in which case each one must be removed and inspected separately.

With the valves placed in the head, as previously described, there is an opportunity for a complete circulation of water around the entire shell of the cylinder, an advantage which is put into practice. The company does not, however, water jacket the cylinder heads because it complicates the valve arrangement and in the second place there has not seemed to be any urgent requirement for this addition to the present design. The suction valves are in the bottom of the cylinder head and are therefore away from any heated surface and the air is thus permitted to enter the cylinders at a normal temperature.

The intercooler is open at the top and consists of a plain tank and a series of coils. It is so arranged that it can be disconnected from the compressor and the latter may be thus operated without injury. The builders point out that in some types of air compressor the intercooler is placed underneath the machine, in some cases forming part of the bedplate, and in such instances it would be necessary to remove the compressor from the foundation should a break or other defect occur in the intercooler and require inspection.

The steam cylinders have been carefully designed to attain high economy in steam consumption and the workmanship and materials—in fact the compressor as a whole—is guaranteed against any defect. The American Air Compressor Works manufacture these machines for pressures

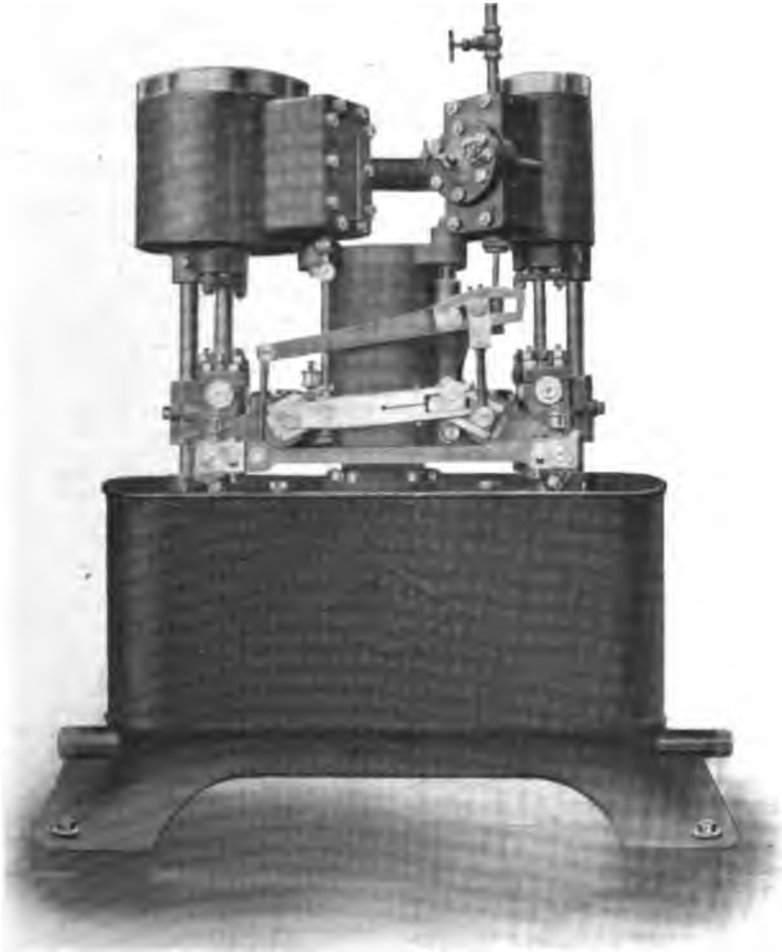


THE AMERICAN AIR COMPRESSOR WORKS' NEW COMPOUND MACHINE.

from 80 up to 500 pounds, according to the individual requirements. The machines are built for the higher air pressures with compound air cylinders and the different machines are also made to operate by belt or other gearing as desired by the purchaser.—*Iron Trade Review.*

The Heisler Air Compressor.

The steam end of this compressor is of the same general construction as that used in the Heisler pumps. The air end consisting of two air cylinders of usual construction with the usual form of



THE HEISLER AIR COMPRESSOR.

poppet inlet and discharge valve. The cylinders are submerged in a tank, which can be readily removed. This tank has a large volume of water around the cylinders, preventing clogging of cores about the cylinder, and gives a much larger percentage of cooling surface.

The entire cooler is of cylindrical form, arranged vertically and centrally in the machine, it forming part of the support for the steam cylinders which are separated from it by use of non-conductors. The compensating mechanism is mounted upon this inter-cooler; the steam cylinders have a volume ratio of approximately 6 to 1, the high pressure cylinder usually cuts off at nearly half stroke, giving about 12 steam expansions. This pair of engines has given an I. H. P. (when made cross compound) on 30 lbs. of steam per hour, running non-condensing with 112 lbs. steam pressure. When running triple expansion it has given an I. H. P. on 26 lbs. of steam per hour, which we think is remarkable when considering that the engine is of such small size, having steam cylinders 7½ and 16 inch bore and 10 inches stroke. The air cylinders are 7 and 14 inches bore.

In the larger machines Corliss inlet valves are sometimes used. The tank is also made in sections so a portion of it can be readily removed.

The Pumping Stage at Beaumont.

Most of the big producing wells on Spindle Top Heights, Beaumont, Texas, are either being agitated by compressed air or pumped, or preparations are being made to install pumps. A number of the wells, but not many, will gush when uncapped. New wells which come in on the famous heights are still invariably gushers. But there is no cause for apprehension on the part of shareholders in Texas oil companies.

Since oil was first produced on a commercial scale wells have come in spouting oil, often over the tops of the derricks. Sooner or later they settle down to pumpers. Some of them, notably upon the Fox farm near Foxburg, Pa., have continued for years to pump as much oil as when first struck. In time every great well in the Baku region of Russia becomes a pumper, but it produces thousands of barrels of oil daily. Baku is to-day producing more oil than it ever did.

Gas is almost invariably struck with oil. As long as the gas pressure lasts the well spouts oil. When it ceases the well has to be agitated with compressed air. That is precisely what is being done by oil producers of the Beaumont district today. Beaumont can only be likened to Baku. Never have such great oil producers been struck in the world's history as at Baku and Beaumont. The oils of both regions are heavy and closely resemble each other in every respect. They seem to come from the same strata and are probably due to the same period of the world's formation.

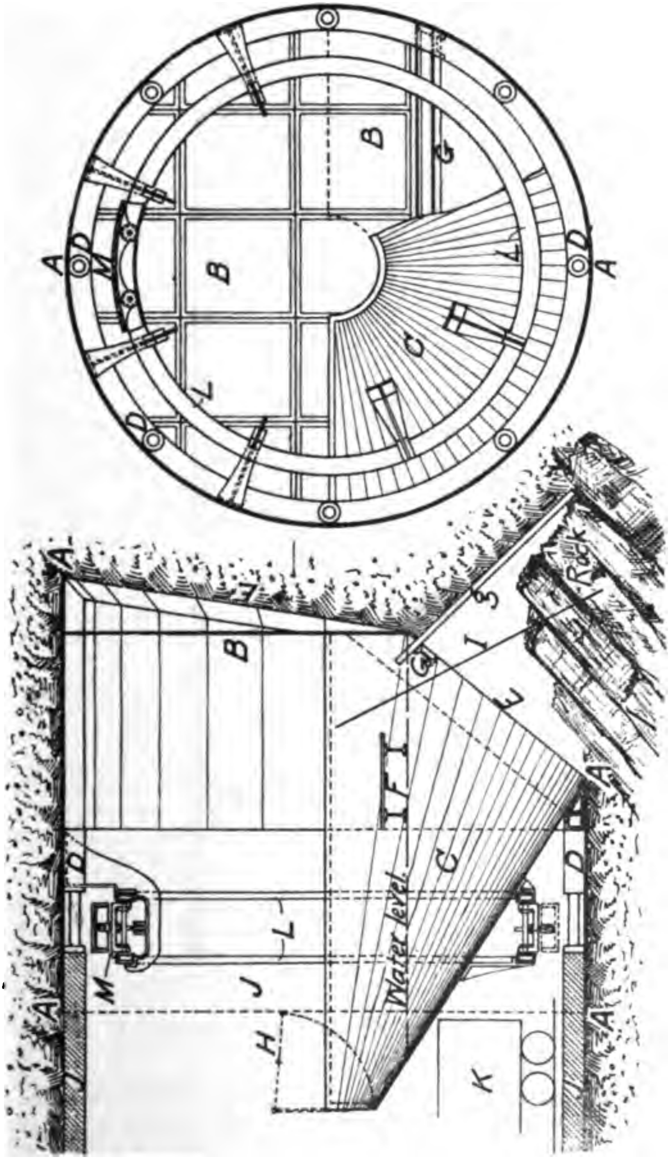
When the gushers of Spindle Top were all spouting oil only last winter contracts were made for its sale as low as 3 cents per barrel, and some companies could not sell their oil at any price. It is now selling at 20 cents at the well and 30 cents on board cars at Gladys City. Experienced oil refiners, carriers and selling companies agree that Texas oil will probably be selling for 50 cents per barrel on January 1 next.

Experience in agitating the Beaumont wells with compressed air and by pumping shows that it is only a question of the capacity of the machinery to force the oil to the surface as to what the wells will produce. Some of the companies are introducing pumps that will lift 10,000 barrels of oil to the surface each day from one well. As everybody knows, the lakes of oil are there, and each well fitted with machinery necessary to do the work is turning out more money each day than when it was a so-called gusher.

Taking the history of the Baku fields on which to base an estimate the wells in Texas will be producing a generation or two from now at least, and before that time doubtless every company having other Texas holdings will have brought in new gushers which will inevitably in time become compressed air wells and then pumping propositions.—*National Reporter.*

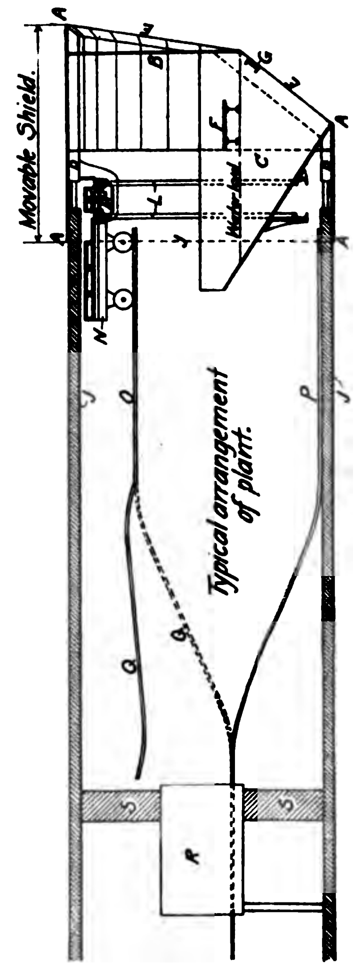
Cooper's Pneumatic Shield.

Mr. Theodore Cooper, of New York, has just patented a pneumatic shield for driving tunnels and sewers in waterbearing materials, which is shown in the



PART OF COOPER'S PNEUMATIC SHIELD.

(See next page for descriptive matter.)



PART OF COOPER'S PNEUMATIC SHIELD.

A—External shell.
B—Partial forward hydraulic bulkhead fitted with the usual traps and exploration openings.
C—Sloping and tapering after hydraulic bulkhead.
D—The operating and adjusting rams.
E—The cutting edge, the lower part cut back to expose the material of the bottom and the upper part given any desired slope.
F—The working platform.
G—Removable beam for holding the poling bars g.
H—An emergency door, if desired.
J—Tunnel with completed lining.
K—Car for excavated material.
L—Circular tram for segment carried M.
N—Segment delivery car on upper track O.
P—Lower track for material car.
Q—Vertical switch.
R—Air lock in compressed air bulkhead S.
—Railroad Gazette.

engravings. The purposes of the various parts are clearly indicated by the table.

It will be observed that the fundamental fact underlying this device is the use of a water seal in the bottom of the shield. The water is allowed to enter in the taper and sloping bulk-head placed back of the usual bulk-head, and this water is, of course, balanced by the air pressure in the shield. It will be at once apparent that this water seal will simplify the matter of driving through material of varying character. As the shield penetraets very loose material the air is still held by the water seal and the necessity does not arise for covering the bed of the river with clay to prevent the blowing out of the air, as has been done at great expense in some recent operations. This again permits the tunnel to be driven closer to the bed of the river, thus lightning the grades of the approaches. Engineers who have driven shields underneath rivers will remember occasions when it would have been a great comfort to them to feel sure that the air could be held.

It will be noticed that this tapering after bulk-head permits the placing of the permanent lining rings close up to the front of the work.

The special merits of this shield are summed up by Mr. Cooper, as follows: While maintaining the balanced water level, it gives ready access for excavating and the use of excavators for silt, sand or gravel; it allows drilling, blasting and removal of boulders and rock ledges; it permits the sinking of piles under the bottom as the work progresses; soft material may be forced by the rams to flow directly into the material cars; it delivers the materials inside of the lined portion of the tunnel without interference with the placing of the tunnel lining, so that both operations can be carried on at the same time; it materially reduces the time and cost of construction; it needs no earth cover to prevent air blowing out.

The reader will, of course, understand that the drawings do not pretend to show those details which are common to all shields of this sort, but special attention is called to the device for delivering the segments of the lining rings and for putting them in place.—*Railroad Gazette.*

The D'Auria Air Compressor.

A correspondent writes to the editor of *American Machinist*:

"I have long been ambitious to invent an air compressor, something new and wonderful and, like a certain water wheel once tested at the Holyoke flume, having an efficiency of 115 per cent. (Fact, this statement was made in the makers' catalogue. I cannot swear to the exact percentage, but it was considerably over 100.)

"In searching for similar devices already on the market which I might conflict with when my ambitions should be realized, I came across the D'Auria compressor, described on page 661, Vol. 24, by Mr. Morris. (A description of this compressor has also appeared in COMPRESSED AIR June, 1901.) It is decidedly the most remarkable machine I found in my search, and I would like to find out how its most remarkable feature impressed some of your other readers. Generally, when anything of this sort comes out, they are inclined to discuss its merits, but in looking over my files I cannot find that the D'Auria compressor was even touched upon.

"It is certainly a machine of exceptionally handsome design, one which doesn't give a fellow a feeling that he would like to whittle it down in some places and tack on it in others, but where every part seems to be just about right for what it has to do. This is a quality that makes any piece of machinery look handsome to mechanical eyes, and without it no machine is likely to be more successful than that Gothic bird cage typewriter whose frame was designed by a celebrated architect or World's Fair fame.

"While I cannot pick any flaws in the general design of the D'Auria compressor, I am wondering if the fundamental principle on which it is based, the "hydraulic compensator," is really much more of an improvement to an air compressor than a Gothic frame is to a typewriter. Mr. Morris certainly gives some pretty convincing statements as to its smooth running, but as he does not give the address of the makers and I have not been able to get a copy of their catalogue and study into the matter I shall have to admit I see no reason why a given weight of moving water confined in tubs should have any greater effect on smoothness of running and general efficiency than an equal weight of iron, perhaps in the form of a flywheel, moving at the same velocity. The cuts show the area of the compensator piston to be four times the sectional area of the water passage, which increases the speed of the water column to that amount and gives it a corresponding leverage on the piston when it is helping the latter out on the last part of its stroke. At 340 strokes per minute, the speed at which it was running when Mr. Morris was able to balance a 5-cent piece on edge upon it, although it was not bolted to the floor, I should look for considerable water friction in those curved passages.

"Mr. Morris tells us that in the larger compound machines, weighing 46,000 pounds, the work done is equal to that of a crank-and-flywheel compressor whose flywheel alone would weigh 45,000 pounds. If my assumption as to the relative efficiency of the water column and flywheel is correct, this size of the D'Auria compressor must be handling 45,000 pounds of water, or some over 5,000 gallons, so I must be off the track somewhere.

If there is any particular advantage in the reciprocating motion of the water column over the rotary motion of the flywheel, certainly a reciprocating counterbalance of iron can be easily arranged, and if it were connected to the piston rod by a 4:1 lever connection, why would it not have precisely the same action as the column of water? I should expect it to have considerably less working friction than the water column with its extra piston and rings and, by shortening the length of the machine, make it stronger for a given weight of frame.

"If this reciprocating counterbalance, of either water or iron, is the correct thing, why have none of our locomotive designers given it a trial? I have always understood that it was the excess of counterbalance in the drivers over what was needed for the connections alone that made an engine pound hollows in t' track at high speeds and ride with a motion comparable to that of a "racking" horse. If the D'Auria theory is correct, the weight of the connections only should be counterbalanced in the drivers and that of the cross-head, piston, etc., might be taken care of by a 'hydraulic compensator' or some other form of reciprocating counterbalance.

"The elimination of this faulty counterbalancing was one of the principal points claimed for the Heilmann electric locomotive, a machine which generated its own current as it went along from a dynamo driven by a high-speed engine with two cylinders placed, if my memory is correct, crosswise of the frame. Perhaps by the time anything of this sort gets a chance for a practical test the steam turbine will have relieved us of all our trials in connection with counterbalancing reciprocating motion as far as engines are concerned, but in the line of air compressors there doesn't seem to be much to show in rotary machines, at least for pressures above what is needed to blow a furnace or a church organ.

"Most of the compressors used in this section are of the belt-driven type, and, in spite of their two heavy flywheels, they are very hard on driving belts. There is no question about finding a good market for such a machine as I spoke of at the beginning of my letter, even if the efficiency does fall a trifle below 115 per cent."

E. R. Plaisted.

[The reason why the weight of the water in the compensator of the D'Auria compressor is so much less than the weight required in the flywheel of the usual type of machine is, as we understand it, that the motion of the water is stopped at the end of each stroke. In other words, the entire stored energy of the water is available for completing each stroke of the machine, whereas with a flywheel only that portion of the en(which is represented by the comparatively small loss of velocity which is permissible in passing the center is available for that purpose. We do not know whether the weight of the water is considered as part of the weight of the machine or not. As as operative machine it is part of it, but it costs nothing and does not have to be transported, neither of which can be said of a flywheel. Considered as a machine to be bought, shipped and paid for, the water is not part of it. We believe that Prof. D'Auria did considerable work on the idea of a reciprocating mass of iron before arriving at the hydraulic compensator. We are not acquainted with all the reasons which led to the device finally adopted, but perusal of the article referred to will show that the water compensator possesses a valuable safety feature which the mass of iron does not. The compensator piston has a number of slots so arranged that in case the piston, for any reason, should over-run its intended length of stroke, a by-pass will be opened and the compensator piston will be relieved of the pressure due to the moving water. The smoothness of running is due to the fact that in one leg of the water passage the water moves in one direction, while in the other leg it moves in the opposite direction, the combined inertia displacement effect of the water being *nil*. The reciprocating parts tend to displace the machine, but they are light and, moreover, the law of acceleration and retardation is more favorable than in crank machines. In the latter the acceleration and retardation are at a maximum at the end of the stroke where the speed is at the minimum, whereas with the D'Auria machine they are more nearly constant, and hence have a less value than the maximum of the crank machine. The machine was made by the I. P. Morris Company, of Philadelphia.—ED.]

The Homestake Hoist and Plant.

The Ellison hoist of the Homestake Company, in the Black Hills, South Dakota, has been in commission long enough to get limbered up, its bearings polished and adjusted and to show its power, endurance and capacity for the generations of work before it in hoisting rock from the Homestake mines.

The hoist of the Anaconda copper mine of Butte, Mont., is a duplicate of the Ellison, and these are the two most powerful mine hoists known, with the possible exception of the great hoist of the Calumet & Hecla copper mine of Michigan, which raises ore from a shaft more than one mile in depth. It may be truthfully stated that the Ellison hoist has no peer on a gold mine in this hemisphere, if in the world. The Comstock lode in its prime of production set the pace for gigantic mining operations of the past in pumping and hoisting machinery, operating for a depth of 3,500 feet, yet it had no such monster of mechanical strength and power and skill in construction, as the Ellison hoist.

The present building, housing the machinery of the Ellison equipment, is 350 feet long by 100 feet in width, 80 feet in height, over the central portion, and yet a large annex to be constructed. The hoist engine was built by the Union iron works of San Francisco, Cal.—the same shops that turned out the great warship Oregon. It has two steam cylinders 30 by 72 inches and two steel reels 16 feet in diameter, which wind and pay out a flat steel cable seven inches wide by a full inch in thickness: The two cables at present are 1,500 feet in length each, with the intention of splicing an additional 1,500 feet to each when necessary as depth is acquired.

The hoist engine is partitioned off from the big building with a glass front toward the shaft. In this compartment are placed two small air compressor engines, auxiliaries for handling and governing the movements of the great machine. The clutches, post brakes, disc brakes and reverse gear are operated by compressed air and are entirely controlled by a set of three levers and one pedal, conveniently placed on an elevated platform from which the engineer has a full view of all the machinery and the shaft. The engineer touches a button, as it were, in answer to signals from the depths of the mine, and the vast complex machinery moves at his bidding.

The gallows frames are of a special design, consisting of steel beams and braces covering a large quadrangle on the rock foundation, giving firmness and stability to the pillow blocks.

The shaft has three compartments, in two of which are operated a double deck cage. Each cage carries four cars. When ore is supplied sufficient to keep the hoist moving, eight tons of ore are raised to the surface every two minutes from the 800 level; three top men dump the cars, feeding the ore to four No. 6 Gates crushers and return the empties to the cage. This is equivalent to 5,700 tons in 24 hours. The crushers occupy a space across the west end of the building about 50 feet from the shaft, and are placed below the floor sufficient to alllow good dumpage for the cars. The crushed ore drops down into underground bins of 3,000 tons' capacity. The tramway on the floor of the tunnel leading to these bins is 65 feet below the floor of the hoist. A steel viaduct is laid across Gold run with railroad track connecting these ore bins with the mills across the gulch. The ore train passes into the tunnel, loads from the crusher bins, delivers its load to the mills, returns in 20 minutes for the round trip and delivery of 40 tons of ore—equal to 2,880 tons in 24 hours—capable, however, of being increased to the capacity of the hoist.

The boiler capacity furnishing the steam power for the hoist consists of eight Scotch marine boilers with a total capacity of 1,600 horse power. These boilers were made in the shops of W. J. Solberg & Son, of La Crosse, Wis.

In another compartment of the building are placed the crusher engine and an air compressor. This machinery was manufactured by Frazer & Chalmers, and consists of a cross compound Corliss engine of 265 horse power, driving the four large rock crushers. The air compressor is a three-stage high-pressure machine for furnishing the power for driving the air motor of the ore train, capable of increasing the pressure to 90 pounds per square inch.

An excavation is made in the rock below the floor of the hoist, 35 by 75 feet, for installing one of the largest air compressors heretofore built by the Ingersoll-Sergeant Drill Company. It will have a capacity for operating 125 machine drills. The power of this mammoth compressor will be furnished by a battery of eight boilers of 200 horse power each, which will occupy an annex to the hoist building. The Homestake company has two large air compressors installed—one at the Old Abe and one at the Highland hoist—from which a system of pipes radiate throughout the mines for conveying the power for running the rock drills convenient to points of usage. The power has been drawn upon heavily by the addition of many drills, thereby reducing the pressure below the maximum. The re-enforcement of 1,600 horse power will bring the pressure up to a high point of efficiency.

One is impressed with the solidity of the machinery, construction and all appointments of this stupendous equipment of mechanical skill, and marvels at the rapid yet easy and noiseless movements of the ponderous machines. The Ellison hoist, with viaduct, ore bins, tramway and all accessories, represents, approximately, a total cost in construction of $1,000,000. It was made possible as a vast economic auxiliary to mining and moving stupendous quantities of gold bearing rock known only on the great belt of the Black Hills. *—Lead Daily Call.*

The Hydraulic Air Compressor at Norwich, Conn.

In *Engineering News* we find an interesting letter addressed to the editor and the latters replay, which COMPRESSED AIR has taken the liberty of reprinting as follows:

Sir: It is to be regretted that Mr. Knight, in his article on "The Hydraulic Air Compressor at Norwich, Conn." (*Eng. News*, June 12, 1902), should have given so little account of the details of the essential feature of the apparatus, viz.: the compressor. For example:

(1) No dimensions of the air or separating tank are given.

(2) The position of the safety pipe is not shown; there is no indication as to how much the lower end of this pipe is above the lower end of the downflow pipe; nor is its diameter given. To be told that these last are "such as to prevent the water being forced below the bottom of the downflow pipe" does not convey any clear idea for lack of other data.

(3) What is the head-piece? Fig. 4 of the article does not tell. It is a part of the downflow pipe? Apparently not, because we are told that it "is situated vertically over the top of the downflow." If not a part of the downflow pipe, how far is it vertically above the latter? And how is it connected therewith?

(4) "The head-piece consists of a large number of tubes." . . . How many are there, and what is their diameter?

(5) "Means are provided for operating the head-piece for securing the proper immersion of the tubes and for regulating the amount of water passing through the head-piece." While it is not difficult to imagine means by which to do all this, it would be none the less interesting to know the means adopted in this special case.

(6) How is the outflow arranged after the water has passed out under the sides of the compression chamber? Is the outflow near the bottom or at some point further up not shown in Fig. 4?

(7) What pressure is obtained in the air main at the compressor, and what at the point of distribution? In other words, what is the loss of head in the four miles of main?

F. A. MAHAN,

51 Avenue Montaigne, Paris, France, Aug. 2, 1902.

(We give space to the above letter, because it illustrates very well the information which contributions to such a professional journal as *Engineering News* ought to contain, and in the second place, it illustrates the difficulties under which editors and contributors often labor in securing such information.

The reason why more detailed information concerning the apparatus was not given in the article as published was that the company preferred to have no further details concerning it made public.—ED.) *—Engineering News.*

Re-heating.

The editor of the *American Engineer and Railroad Journal,* referring to the article on the "Economy Derived from Reheating Compressed Air," which was published in the above-named paper and in the November issue of COMPRESSED AIR, says:

"It is generally understood that a saving results from reheating compressed air before its use in motors, but the figures given by Messrs. Edmondson and Walker indicate that the real importance of reheating is not appreciated. If it were, the principle would be more generally employed by the larger users of compressed air.

"The experiments described show a maximum gain, by reheating, of 44 per cent. in the amount of air required to produce a given amount of power, and that a compressor which is able to supply 100 H. P. at the motors with cold air may be able to supply 178 H. P. by the use of reheaters. This means that many compressors, which are now overloaded and are running too fast, may be made more effective, and the day of replacement by larger machines put off, by installing reheaters. A reduction of 30 to 40 per cent. in cost of production of compressed air by reheating it from 60 to 400 deg. F., just before using is thoroughly worth while, especially when the simplicity of the reheating is considered.

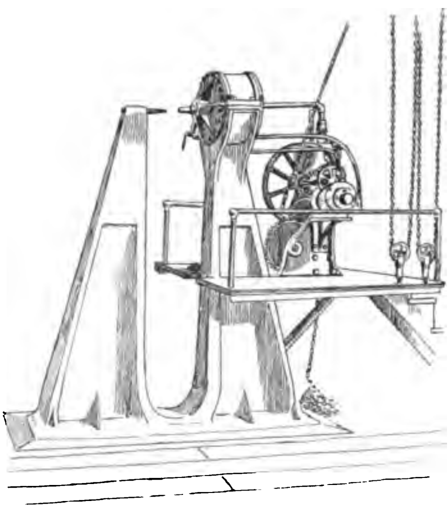
The contractors constructing the new Rapid Transit Subway in New York, who are using compressed air very extensively, appreciate reheating and employ it very effectively. On one of the sections, where reheaters are used, the heaters are of cast iron, made all in one piece cored out, in the form of stoves with small grates for the fires. These are placed near the air drills and are left out of doors and unprotected. The expense of the fire and its attendance is insignificant in consideration of the great gain in power.

The above-mentioned paper is presented in a way to give the results at a glance to busy readers. The comparisons are presented in curves, in which not only the figures of comparison are given, but also the probable limits to the practical economy of reheating are indicated. The heater used was capable of producing much higher temperatures of air delivered, but about 450 deg. seemed to be the highest temperature for satisfactory use in the small engine employed. It is important to notice that the speed of the engine increased with reheating of the air, also that the engine ran more smoothly and the cut-off was shortened. That is to say, the increase of volume of the air is not by any means the only saving due to reheating. The action is somewhat similar to that of superheating for a steam engine. There is, of course, no freezing of the exhaust with reheated air.

Plants may be installed at reduced cost throughout and the economy of operation is increased permanently by using reheaters. This is most effectively stated by the authors when they point to the fact that the results obtained by applying heat in this manner to compressed air are from 8 to 18 times more important than would be the same amount of heat expended under the boiler which drives the compressor.

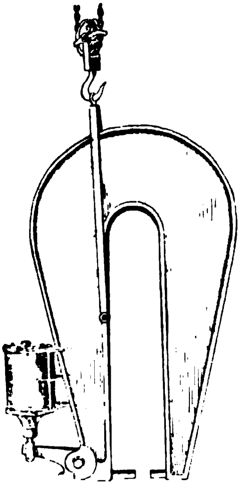
Pneumatic Tools.

Here is a ten foot reach riveting machine. which also includes a radial crane with a pneumatic reversible hoist capable of lifting a load of 10 tons in either



FIXED PNEUMATIC RIVETER.

direction very readily. This machine is claimed to be one of the most simple and easily handled on the market. The tonnage can be instantly changed at the will of the operator, to suit light or heavy work; and having a cylinder designed with two separate compartments, each containing a 26 inch piston head, both secured to one piston rod, the closing of one compartment reduces the tonnage one-half; using both heads gives 50 tons on rivet dies, at a working pressure of 100 lbs., 40 tons being sufficient for all classes of ordinary boiler work; but the simplicity of this machine lays in the fact that it dispenses with high-pressure accumulators and pumps; requires no discharge pipes, hydraulic pipe, or expensive high-pressure valves, and the penumatic machine can be used in any climate, winter or summer, either indoors or out, without danger of freezing; and last, but not least, it is always ready for work, and there is nothing to get out of order.



PORTABLE PNEUMATIC RIVETER.

And also a 73 inch riveter especially designed for water and oil tanks, gasometers, stand pipes, ship and bridge work, having a gap of 12 inches; and unlike other machines, where the power is applied through toggle connections, there is no trouble in adjusting the dies to suit the many thicknesses of plate to be riveted, but has the required 50 tons pressure on the rivet dies at any point of the stroke, which is 3 inches. The machine is hung from a gravity point by a bail, and can be operated in any position to suit the work. The main frame of this machine is made of cast steel.

This riveter weighs 2,000 lbs., and exerts 30 tons pressure on the rivet dies at 100 lbs. pressure.

Both machines are built by the Baird Portable Machine Co., of Topeka, Kansas.

An Improved Hose Coupling.

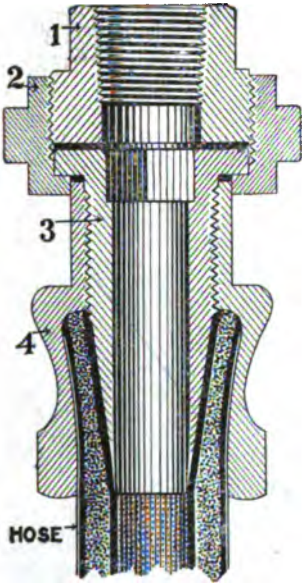
Many dollars are annually wasted by leakage in compressed air lines. This waste is principally at the points where connections are made with the main line rather than in the main line itself. The accompanying illustration shows a hose connection, which has been designed to obviate these losses, especially when working under heavy pressures. The "G. E." hose coupling, as it is called by the makers, holds the hose securely compressed in a metal pocket, without the use of outside clamps.

Another feature claimed for this coupling is the increased size of the air passage, which is larger in the G. E. coupling than is possible in the old style couplings, where the hose is drawn over the corrugated end of the coupling. This coupling is suited for working under very heavy pressure. The ordinary coupling, although it fastens the hose to the coupling with clamps, will not prevent leakage at the end of the hose. In the G. E. coupling, the end of the hose is in a metal pocket and leakage is impossible.

As will be seen from the illustrations the coupling is of substantial proportions, and designed to give long wear. It consists of four parts, and is entirely self-contained, not requiring the additional purchase of hose clamps, nor involving the expense of their renewal.

Other advantages claimed for the G. E. hose coupling besides those above mentioned include its efficiency when working under heavy pressures. The first couplings made were tested to 700 pounds pressure without leaking. Its substantial propositions and the absence of projecting bolts secure a longer life than is possible with the old style couplings using outside clamps.

In the G. E. coupling, the hose is firmly secured by the pressure of the tapered portion of part 3, the latter being screwed into part 4 by means of the square socket at the larger end. There are several



THE G. E. HOSE COUPLING.

slight depressions in the walls of part 4, into which the pliable hose imbeds itself, making it impossible to withdraw the hose until uncoupled. A rubber gasket is used between the faces of part 1 and 3, and in making connections with this coupling, part 1 having a female end, may be attached directly to the pipe line without the expense of a pipe coupling.

The couplings are manufactured in both malleable iron and brass by the American Engineering Works, of Chicago.—*Engineering and Mining Journal.*

The Miller Air or Liquid Pump.

In the *Iron Age* of July 23, 1896, was described and illustrated very completely the Chaquette air compressor built at Bridgeport, Conn. This was the most stupendous effort ever made to capture that *ignus fatuus,* perpetual motion, or to obtain something for nothing. In theory it was false from the foundation up; in design it possessed many beautiful features; as a mechanical construction it was gigantic; and as an investment it cost $100,000; the result, it was sold under the hammer and brought less than $5,000 as junk.

The explanation of its action was refreshingly simple and remarkable for its muddy lucidity. A heavy weight rolled along a path could be made to do a little work and never know the difference. This was demonstrated by loading a truck, driving a few nails part way into the floor, then blindfolding a man and having him draw the truck over the nails, which were forced entirely into the floor by the wheels. The secret was revealed and Dame Nature was astounded at the audacity of an experiment which revealed her inmost laws. Man, full of wisdom and knowledge even when blindfolded, could not detect when the wheel drove the nail into the floor; ergo, how could a lump of iron, not a sentient being, perceive what man could not? Therefore, since neither the man nor the truck knew they had done any work in driving nails, they had lost no power.*

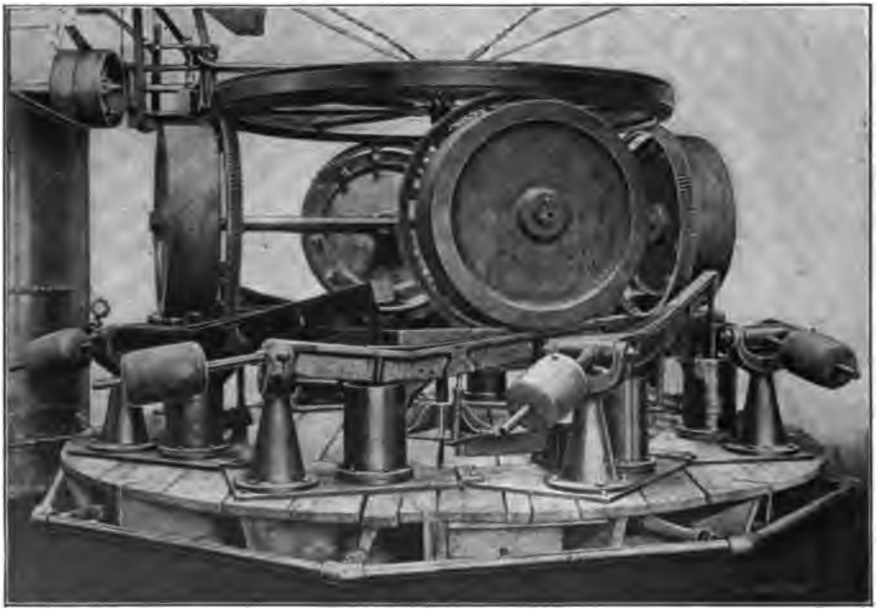
The principle having been demonstrated and, incidentally, sufficient capital having been secured, it was only necessary to put the idea to practical use and, again incidentally, of course, gather in the shekels. So the men of Bridgeport made them a motor that was to run everything in the town except the Mayor. Mechanically, it was a splendid piece of work, made upon the interchangeable plan although repairs would never be needed, no variation of more than one-quarter of a thousandth allowed, bearings scraped to a fit, and so on. But there was one serious drawback—the thing wouldn't work. That was its only disadvantage; in all other aspects it was simply dear (lovely and $100,000 here implied). A big tank which had been made to hold the compressed air and the talents of gold and of silver, never had an ounce of the one nor a grain of the others in its midst. So the promoters fell down, the company fell down and the machine fell under the hammer. Peace to its scrap.

*These experiments were actually performed and were used as an argument in favor of the correctness of the Chaquette theory—that a moving mass could be made to do work and not lose any of its power.

The machine consisted of a horizontally disposed circular frame over 80 feet in diameter. This frame was formed with ten spokes, each of which carried at its outer end a cast iron wheel weighing some 15 tons, or 150 tons for all the wheels. These wheels were loosely mounted on their journals and traveled around a track. The frame was mounted on a pivot at its center and was turned by an engine through suitable gearing. In the path of the wheels were placed 100 air compressors, 50 within and 50 without the circle. These were arranged in pairs and the pistons of each pair were connected to the same lever. The levers were placed in the path of the heavy wheels and were so disposed as to be operated by them in their travel around the circle. The levers resembled the walking beams of a steamboat except that they had a piston at each end. At each revolution of the frame there were 200 strokes of the pistons.

The scheme will now be understood. Here was a weight of 150 tons, not counting the frame, moving along a level path. This great weight would actuate the levers and the compressors thereby be brought into operation. The boiler supplying the engine by which the frame was moved was only an incident. It was to be used only to start the machine and run it until the tank had been filled with air at a certain pressure. Then it was to be cut out and the air used to drive the engine.

It is only at this point of our story that the wonderful simplicity and transcendant money making power of the plan come into evidence. Mr. Chaquette said that out of 100 horse-power generated by the machine he only required 5-horse-power, or 5 per cent., to run the machine. He therefore had 95 horse-power out of every 100 produced to sell to the power consumers of Bridgeport and the rest of the United States. This meant that if you gave him 1 horse-power he would hand you back 19. Each one of these 19 horse-power could be made to yield another 19, and so on. This is a progressive



THE MILLER AIR OR LIQUID PUMP.

ratio, marvelous in its possibilities. A few of these plants, properly located, would do all the work of mankind, and there would still be enough power left to rock the cradle of industry.

But if Mr. Chaquette could return 19 for 1 why did he want even the 1? Why didn't he give 20 for nothing? Simply because he needed it in his business. He could multiply power—that was easy—but he could not overcome friction. Therefore he had to have just a little to run his machine because he did not know how to annihilate that bugbear, friction.

THE MILLER PUMP.

J. B. Miller, of Muncie, Ind., is not blushingly and retiringly modest in the claims he makes for his apparatus. The following simple statement explains the position of this invention: "I made the discovery many years ago where all power is lost." We first describe the machine, using information furnished by Mr. Miller as far as possible.

The machine, as shown in the engraving, is built on a platform upon which are placed eight iron plates for the eight pumps and posts to rest upon. The track is octagonal in shape and along each side is a lever, one end of which is attached to a pump plunger, which is 9 inches in diameter and has a 12-inch stroke. At the other end of each lever is a weight acting as a balance. The piston ends of the levers rise 12 inches above the track. Moving around the track are four wheels weighing together 14,000 pounds. On the shaft of each wheel is a bevel gear engaging a large bevel gear mounted on the central pivot and which is driven by a belt. In this way the four wheels are made to revolve around the track and operate the plungers.

The levers are balanced, we are told, as the beam on a pair of scales and "there is no power lost in this machine. All the actual power necessary to operate this machine is to roll these four wheels." Here is the inventor's explanation of this phenomenon: "Now for an illustration you can load a railroad car with 100,000 pounds and, having the car on a level track, you can take a pinch bar and start the car to moving, and after it is once started one man can keep it moving by pushing the same. Now take the weight of this 100,000 pounds as a power producer; it means 100,000 pounds power by the aid of one man power. This power producer is nothing more than a rolling weight." This is the Chaquette idea revivified as the late Mr. Keeley of motor fame would express it. "The machine now built is but 10 feet in diameter, while if it were 30 feet in diameter, so as to give the wheels greater momentum, the large machine could then be operated with less power than the small one." The wheels move forward and never find out that they are doing any work. The inventor claims that this machine will save at least 95 per cent. of the power now required by any other machine in use. The inventor does not claim any perpetual motion, he merely says that he has "accomplished some better things." "This machine could pump 800 gallons of water 50 feet high per minute with an expenditure of 3 horse-power." This means that with 3 horse-power this contrivance would actually exert 10 horse-power, as represented by the 800 gallons lifted 50 feet a minute. While this not perpetual motion it is a fine example of the multiplication of power; but this is a ratio of only 3 to 1 instead of 19 to 1. The Connecticut inventor still leads the Indiana inventor by a ratio of at least 6 to 1.

History repeats itself even in vagaries. These two machines are precisely alike, except as to unimportant details. Both depend upon heavy rolling weights which unknowingly operate pump pistons. In both the cylinders are arranged around a circular path, and for both extraordinarily absurd claims are advanced. History also repeats itself in the fact that bright men can be fooled in the most ridiculous way and, again incidentally, made to give up their dollars.—*Iron Age.*

A Little Story with a Moral.

The picture shown herewith illustrates a shed in which stands a 24 and 24¼ x 30" Class "A" Ingersoll-Sergeant Air Compressor.

This is the second attempt to work this well by compressed air, the first one proving entirely unsatisfactory, and as this factory is reported to have cost nearly one million dollars, and has always been crippled by lack of water, it has proved itself an exnpensive proposition. The water in the well stands 120 feet below the surface, and when pumping, drops 190 feet.

Having heard of the failure of the first air lift compressor to work properly, the writer paid a visit to this plant in order to investigate matters, finally making them a proposition to pump 1,000,000 gallons of water per day or no sale. This plan was accepted and the compressor shipped them. It took just half an hour for the compressor to demonstrate its ability and satisfy the would-be purchasers.

The air lift, scientifically applied, removed all trouble in this particular case. Applied wrong, it put them to much expense for nothing, and caused the abandonment of the well as of no value, though it had cost a large sum originally.

Moral: Use the air lift, but do it right.

From the photo you will note that the stream of water is as large as a man's body, the diameter of the stream at the point of discharge being 14 inches. Flowing down a trench it made a stream 43 inches wide by 4½ inches deep, moving 100 ft. per minute. H. P.

AIR LIFTING 1,000,000 GALLONS IN 24 HOURS.

Compressed Air.*

In English Mines—Arrangements Which Result in Losses, and the Methods of Overcoming Them.

In transmitting and distributing energy by means of compressed air; we find exactly the same conditions as with other physical agents; we have to generate heat in the act of compression, and we transmit the power most economically, the more nearly we dissipate the whole of the heat as it is generated. Compressed air tends to genterate heat during transmission, and this rise in temperature should be avoided for economical reasons.

Again, the heat generated by the agent in the operation of transmission, which in this case is due to friction, obeys the law—the friction and the attendant heat vary inversely as the size of the conductor. On the one hand it is possible, where the power to be transmited is limited, and the distance over which it is

* Written for *Mines and Minerals* by Sidney F. Walker.

to be transmitted is also limited, to arrange so that the loss due to friction and the atendant conversion into heat, is practically negligible; and on the other hand, if both the power and the distance to be worked over are large, the friction of the pipes, and the conversion into heat from that friction may easily be so great that, not only is the final efficiency of the system very low, but conditions may even arise where the whole of the pressure will be wiped out by the friction of the pipes, and the whole of the energy generated in the cylinder of the driving engine will have been uselessly expended in heat in the pipes themselves. This case is the analogue to that of the horse which is only able to lift his own weight, and to that of the rope system, in which all the power is expended in friction and where heat is again uselessly generated. These cases are by no means fancy ones.

An examination of colliery working will reveal many instances where, if the power is not actually all swallowed up in the transmission, very little is left for work at the face, or wherever it is to be used. Taking the case of large powers at long distances from the generating plant, we have conditions, which are now rapidly maturing in the coal mines of the United Kingdom. The mines are getting deeper, the distances, over which haulage and pumping have to be done, are getting larger, because the area worked by one pair of pits is increasing in extent, and the problems which arise are assuming serious proportions in consequence. In the writer's opinion, though electricity has gone ahead very much recently, to a large extent from this cause, if compressed-air engineers will tackle the problem in the same way in which the electrical men have tackled it, by careful measurement, compressed air will not only have a good show, but it has more than a chance of being *the* power, for coal mines at least.

This leads at once to the question how is it to be done; and to the answer, by the same means by which the electrical men have attacked the problem—by increasing the pressures, and by providing conductors—pipes for the conveyance of the air—properly proportioned to the power they have to carry; further, by eliminating the water which is in the air before it arrives at the motors, by reheating the air also before it is delivered to the motors, and by redesigning the motors to take full advantage of the properties of air.

Up to the present, in the United Kingdom at any rate, the problem of transmission by compressed air has really hardly been atacked in the way it should be. Instead of calculating the sizes of pipes, and other accessories, it has been assumed that, say a 6-inch or a 7-inch pipe would deliver sufficient air for that purpose, or if the machine was short of air a larger one was necessary, and that was an end of the matter.

In a description of a large compressed-air plant, which was given in a prize essay in one of the technical papers in this country, careful measurements were made upon the working of the plant, and then the curious result was observed—curious to the writer of the essay apparently, but a result which might have easily been forecast by a simple calculation—that while the pressure, at the throttle valve of the engine using compressed air, was 52 pounds when the engine was at rest, as soon as the engine commenced to do its work the pressure went down to 40 pounds, 30 pounds, and finally to 20 pounds, while for a short period, during which the engine was doing work at a rather rapid rate, the pressure went down to 18 pounds per square inch.

The further curious result followed. The compressor at bank was arranged to deliver compressed air to the receiver at bank at 52 pounds, but when the haulage engine was working, in the manner described, the pressure it was able to maintain was only 40 pounds, and that only by increasing its speed from 20 revolutions per minute to 26 revolutions. And yet the author of the essay in question does not appear to have seen that this was evidence of extremely bad design. He is fully alive to the fact that the reduction of the pressure from 40 pounds to 20 pounds doubles the quantity of air to be delivered to the engine, to enable it to perform certain work, and that this increase of the quantity of air also increased the friction very rapidly, while the efficiency of the plant was reduced as low as 15 per cent. and in coal cutting machines worked from the same air supply to 12 per cent. It is easy to conceive of circumstances in this particular case, where the pressure and the efficiency would have been completely wiped out.

It is a practice in most British collieries to add machine to machine, in fact it is a practice pretty nearly everywhere, where they do not stop to calculate, pile on the load till something refuses to work, then add more power, and so on. It would only have been necessary to have had one other machine, say a coal-cutting machine, taking power freely, and therefore making a large demand for air from the compressed-air service, to have had the pressure so much lowered that practically nothing would have been done till some of the work had been taken off. It must be remembered that. with a pipe of a given size, the frictional charge acts in a compound ratio. The friction first lowers the pressure, that increases the quantity of air passing, and the velocity at which it is passing, and as the friction increases as the square of the velocity, the increased quantity of air passing adds very much to the frictional charge and to the reduction in pressure.

The whole thing points to the higher pressures. Figure upon it well before actually setting to work. In the case mentioned, the pipes in the shaft and on the roads were 7 inches in diameter, and doubtless the original contractors thought that they were providing amply. Those pipes ought to pass air enough for anything. But as the sequel showed they did not. If the pipes had been of sufficient area to pass the whole of the air with only a negligible loss, the efficiency of the system would have increased at least 30 per cent., but in that case it would have been necessary to increase the size of the pipes very considerably.

On the other hand, if the pressure had been doubled, the quantity of air would have been halved for the same work, and the frictional charge reduced by 75 per cent. for the same size of pipe. Assuming an initial pressure of 100 pounds, in place of 50 pounds, the loss in pressure corresponding to the work that was being done by the engine should not have exceeded 5 pounds in the 7-inch pipes, the air, therefore, arriving at the engine at a pressure of 95 pounds. But at this pressure the quantity of air would be again reduced, to a little over one-fifth that of the quantity required with the 20 pounds pressure, so that the loss by friction would be wiped out, or the pipes themselves could be considerably reduced in section.

For mining work, the reduction of the size of the pipes is in itself a great boon. Mines are subject to constant working, creeping, etc., which acts upon the pipes, tending to open the joints, to start leaks etc. With smaller pipes the tendency to this will be less, while the pipes themselves can be made stronger, as they are smaller, to meet the working of the mine and the increased pressure.

In the writer's opinion, the increase of pressure should be carried much higher than the figure given above. There is not the same danger in doing so as there is with electricity, and there should be no difficulty in carrying out an installation at 200 pounds pressure, with care in designing, and in execution. Pipes and joints would have to be carefully made, and leakage would have to be guarded against. At the present time, in the British collieries, it is leakage which is the cause of the major part of the low efficiencies, which electrical men are so fond of parading. Leakage affects the matter in two ways; it wastes the air and lowers the efficiency of the system. A certain power is expended in compressing a certain quantity of air, and if a percentage of the air is lost on its way to the motor engine, it is equivalent to that percentage of the power being lost; and in addition, the leakage uselessly increases the frictional charge made by the pipes behind it.

But it should be as easy to preserve good pipes, with proper joints, in a mine, as it is to preserve pipes, which stand high pressures in refrigerating apparatus in carbonic-acid refrigerating apparatus, for instance, the pipes are tested to a pressure of 3,000 pounds per square inch, they have to stand a regular pressure in work of 1.300 pounds, and the pipes are made up into coils of 2.000 feet in length. Surely it should be possible to make pipes which will stand a pressure of 200 pounds and to make joints which will stand that pressure and the creep of the mine as well. It is also worth considering whether it is not possible to make pipes which are slightly flexible, so as to give to the creep of the mine. Very tough steel should meet the requirements.

Another point that is worth considering is the possibility of forming a complete circuit with the compressed air pipe—the engine to exhaust into a receiver, from which the compressor would draw its supply. This, which is not a new idea by any means, would get over some of the difficulties, while necessarily introducing others. Thus, there would be two sets of pipes to fix, instead of one, but this would not be a serious matter if the two pipes were small. Also the friction of the second set of pipes would have to be added to the first, in calculating the loss, as the compressor would have to draw the supply of air through them, in opposition to the friction of their inner surfaces, just as it has to force the air outwards, in opposition to the friction of the outgoing pipes. Such an arrangement would get rid of all possibility of trouble from moisture, as, once eliminated, it should not get into the air again, and it should place at the command of the engineer the possibility of working at higher pressures, without incurring all the loss of compression to the higher pressure. Thus, the exhaust could be at any pressure the engineer chose, and the work could be done between the two pressures, the quantity of air being in proportion.

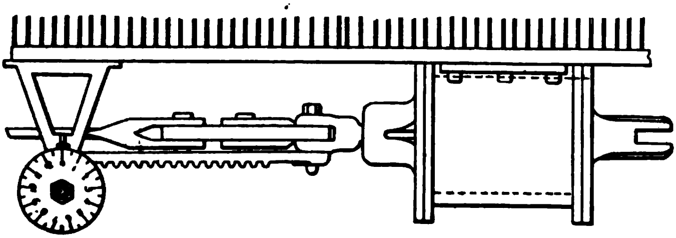
It is also worth considering whether reheating might not be carried out by means of electric currents, the air being caused to pass through coils of wire, or some similar arrangement, at a high temperature. The heat required is not large, and though this method would not be so economical as a simple coke fire, it would be much safer. Some years ago the writer carried out something of the kind in connection with an engine working at a pit bottom, and driven with compressed air, the engine itself driving an electric-light machine. This was in the very early days of electric lighting. The trouble was the usual one of ice in the exhaust ports, and this was stopped completely by wrapping a wire round the air pipe just before it entered the cylinder, and through which a current was allowed to pass. The writer has not figures as to the economy of the arrangement, but it did the trick.

The suggestion to use higher pressures will probably be objected to, as low pressures are more economical. So they are when you can use them. Nothing has yet beaten the old Cornish pumping engine—on its own ground—yet it is nowhere beside a Worthington Triple Expansion pumping engine, in work for which the latter is adopted. It is the old tale, the equation is right, and infallible when you have all the terms on both sides.

The writer has not entered into the question of efficiency, as it has been so fully discussed, but he is of opinion that, if all the items are taken into account, including all costs and high pressures are used, compressed air will show at least as well as any other agent for mining work.

Piston Travel Recorder for Air Brake Cylinders.

The importance of a device for registering maximum piston travel on air brake cylinders is indicated by the necessity of maintaining uniform piston travel. Not only does unequal piston travel cause slid flat wheels but it is oftentimes the cause of trains breaking in two, due to a short piston travel on rear of trains, both in freight and passenger service, where the trains are very long. By the installation of a device whereby car inspectors may adjust the brakes, every car will be made to do its proportional part of the braking, the breaking power of the whole train will be increased and the amount of air used will be reduced.



PISTON TRAVEL RECORDER FOR AIR BRAKE CYLINDERS.

Such a device is shown in the accompanying line drawing. With this device, which always registers the maximum piston travel, the amount of travel may be seen at a glance at the attached dial, which is so placed as to be seen from either side of the car. The dial is balanced so that shocks which cars might receive in switching have no tendency to change its position. The construction and operation of the appliance is such that when the piston travels out it effects a rotary motion in the dial in one direction only. When brakes have been adjusted the car inspector simply turns the dial back to O, and by observing the dial when the application of air is made, the travel of the piston is readily seen indicated on the face of the dial.

The device was originated by Mr. Frank Robinson, division foreman of the Maine Central Railroad, to whom we are indebted for the information and drawing. —*Railway Master Mechanic.*

Portable Oil Rivet Forge.

This forge is indispensable in connection with pneumatic riveters, and is used throughout the country in all the leading shipyards, boiler works and structural steel plants.

It carries a high, soft, uniform heat, and is always under control of the operator and the rivets are always in plain sight, quickly heated and easily reached. The forge will heat up to 1½ ins. diameter and on the average of 500 per hour, and with an oil consumption of from one to two gallons per hour, depending on the number of rivets heated.

Compressed air at 15 lbs. pressure or higher is required to operate this forge and with a volume of from 15 to 20 cubic feet per minute.

Fuel oil or kerosene can be used for fuel.

This forge is manufactured by Rockwell Engineering Co., 26 Cortlandt street, New York. They also manufacture fuel oil burning appliances and furnaces for every purpose.

PORTABLE OIL RIVET FORGE.

The Pneumatic Fire Fighting Tower.

This is the latest addition to the equipment of the Pittsburg Fire Department. The apparatus, says the New York *Tribune*, consists of four ladders, each mounted on a tube. The carriage is also provided with a tank containing an acid fire extinguisher, a small hose about 200 ft. long, and a large hose about the same length, as well as axes, lanterns, crowbars, and a standpipe, to which can be attached three sets of hose. But the extension of the ladders is the novelty in this mechanical creation. The four ladders are attached to steel tubes, which telescope into each other. These are mounted on a steel tank, which contains the air. The pressure carried is 200 lbs., and is supplied at the engine-house. The ladders can be raised and lowered with 50 lbs. of air, and are equal to about six lifts before the pressure has to be replenished. To do this the machine has to be taken back to the engine-house. But it is supposed that it will only be necessary to raise the ladders once or twice at each fire. The whole is mounted on steel trucks. When the ladders are to be raised the standpipe is erected by pneumatic pressure. In front of the air tank is a small air tank which contains a piston. The piston rod from this air tank is connected with the ladders, and as a valve is opened the ladders begin to rise by the plunger forcing the tubes with the ladders upright from the inclined position. The lift is supplemented by chains on the ends of the ladders, which pull while the ends of the ladder are down. After the standpipe is upright a fireman climbs up to the top of the first elevation, which is stationary after it is erected, and supports the tubes on the inside. By opening a valve the air pressure is admitted under the first tube, and it is raised to its full length, 20 feet. A second valve permits the raising of the second joint of tubing, and the third the same, there being a separate valve for each section. It is the custom to fasten a man to the top section before it is hoisted. He can take a line of hose, hook it to the ladder, and have it raised with him. With other extension ladders hose has to be carried up by hand. This ladder standing in the air will permit a fireman to play water into a window without having to have his ladder against the building, so that the flames shooting from a window will not scorch the firemen. In Germany there are aerial trucks carrying ladders that can be raised 150 ft. high. They consists of additional telescopic tubes. These tubes are polished, and are greased as they are raised and lowered by automatic means, and act much as the plunger or piston in an air pump. There is no limit to the strength of the ladders, as they will hold as many men as can be placed on the rungs.

Notes.

With air compressed to 100 pounds gauge pressure 1 cubic foot corresponds to 7.82 cubic feet free air; at 80 pounds pressure, to 6.46 cubic feet; at 60 pounds, 5.10.

Compressor explosions may be due to the use of an inferior oil or the use of too much good oil. Any deposit of oil on the parts of the compressor should be removed.

Mr. T. C. E. Hunter, of the Compressed Air Machinery Company, of San Francisco, recently secured a contract for a 120 H. P. compressor plant for A. C. Brokaw, of Quartz Valley, Cal.

We acknowledge the receipt of a small pamphlet on air compressors, in which is illustrated several types of steam and belt driven conmpressors, being introduced by Herron & Bury Mfg. Co., Erie, Pa.

At the Dusseldorf exhibition, which has just terminated, the highest award of merit, the gold medal, was awarded the "Hunt" conveyor. This conveyor is manufactured by the C. W. Hunt Co., West New Brighton, New York.

The Chicago Pneumatic Tool Co. (Fisher Building, Chicago, and 95 Liberty street, New York) issues a new catalogue of 72 pages, devoted to a description of air compressors made at the Franklin (Pennsylvania) works.

Like a bombshell in the ranks of Scotch toolmakers came the announcement, recently, that the American Pneumatic Tool trust has acquired extensive lands near

Fraserburg, and would immediately begin there the erection of machine and tool works.

The Christensen Engineering Company of Milwaukee have just completed the foundation of a 250-foot extension to their main machine shop, which is 186 feet wide. The new building will be three stories and will provide 88,000 additional square feet of floor space.

The new Allis-Chalmers shops at West Allis are approaching completion so far as exterior is concerned. Recently the large floor plate in machine shop No. 1 was completed. It is practically a perfectly level platform, 25 feet wide and 200 feet long, and grooved at intervals of every foot.

An air compressor at 3,000 feet altitude, to furnish air for twenty-five 2½ inch rock drills in rock of ordinary hardness, the drills being 2,000 feet from the compressor, would require 272 H. P.; a duplex air compressor with 18-inch steam cylinders; 20-inch air cylinders; 24-inch stroke, making 175 strokes per minute.

Air drills are supposed to be supplied with air at pressures between 60 and 100 pounds per square inch, and the best results are obtained only when the compressor is working against the pressure for which it was designed. The practice of allowing the drills to draw the pressure down below sixty pounds in the receiver is to be strongly condemned.

A new company, called the British Compressed Air Cleaning Co. Ltd., was registered Oct. 10, by Pains & Co., No. 14 St. Helene Pl., E. C., London, having a capital, they say, of £22,500. This company will turn to account patents relating to the cleaning, disinfecting and restoring of carpets, curtains, upholstery, furniture, fabrics and materials, and will carry on the general business of a cleaning works.

Two enterprising builders of Battle Creek, Mich., have been awarded the contract for erecting the new factories of the Advance Pump and Compressor Co. to be located on South Division street, adjacent to the Michigan Central Ry., and running back on Flint street. The buildings will be rushed forward to completion if possible by the first of the year and will be an ornament to the city as well as a credit to the strong company that will use them.

A new hoisting engine, built by the Sullivan Machinery Co., has lately put in an appearance at the Savoy-Sibley shaft of the Oliver Iron Mining Co.'s Mine near Ely, Minn. Special features of this machine are its two sets of auxiliary brakes, one set being operated by compressed air and the other by a hand wheel on the engineer's platform. Another advantage of the brake gear is the automatic pressure valve, which will automatically substitute air for steam, or steam for air, in the case of failure of either operating medium.

Mr. S. S. Caskey, who for a number of years past has been the superintendent of mechanical instruction with the Harlan & Hollingsworth Co., has accepted a position with the F. F. Slocomb Co., of Wilmington, Del. Mr. Caskey is a recognized expert in pneumatic engineering, and is the inventor of a number of well known appliances in this line, among the number being the Caskey Portable Pneumatic Punch, and the Caskey Pneumatic Riveter, both of which are manufactured, with all latest improvements, by the Slocomb Company.

Cars swept by compressed air. The railways in some places use compressed air for car cleaning. At the end of the cleaning tracks there is a large tank where the air is stored, and it is conveyed to the place needed through a rubber hose. The air emerges from the nozzle, not in a round stream as in a watering hose, but through a device known as a comb. It is an orifice several inches long, out of which the air emerges in a jet perhaps a thirty-second of an inch in width. It is not employed every time a car is to be cleaned, but only occasionally, being so effective that the alternate overhaulings are little more than dustings.

Most blasting experiments with liquid air have proved failures, but the results seem to have been better in recent bridge building work at Munich. Paper cartridges were filled with a spongy absorbent and provided with a detonator. When ready for the blast the liquid air was brought to the spot in a vacuum-jacket vessel, and the cartridges were plunged into it until the absorption was thought to be sufficient. The cartridges were then quickly placed and fired by electricity or other means. The effects seemed to equal those of dynamite. Cartridges failing to explode become harmless in 15 minutes from evaporation of the air.

The Ship Owner's Dry Dock Co., of Chicago, made some very quick repairs on the "City of Rome." They estimate that they have saved one week in time over that usually required on such a job, by means of the compressed air tools and other methods of work employed, says the Marine Review. They put in a new stearn, new forefoot, part of her keel, new garboards and several new planks, besides calking all over. The company is more than pleased with the dispatch obtained with the new air tools, as it enables vessel owners to get their repairs done in much less time than is usual with wooden vessels, and the point is one that will be generally appreciated as soon as it is known.

The Christensen Engineering Company, of Milwaukee, Wis., is issuing some very handsome catalogues. One of these, a pamphlet of 52 pages, describes the Christensen air brakes for use on electrical railways, and contains views of the company's air-brake shops and a long list of electrical railway companies using the brakes. Another pamphlet, containing 54 pages, describes the company's "Ceco" electrical machinery, including direct current motors and generators, and alternating current generators and transformers. The descriptions are clear and concise and the half-tone cuts of unusual excellence. Still another catalogue, a pamphlet of 58 pages, describes the company's straight air-brake equipments with independent power compressors for use on electric cars.

It has been whispered among the ladies that a substitute for the old powder puff has recently been patented by Marie L. Gumaer of New York city. This new device consists of a perforated face-plate of any soft fabric stretched on a frame and connected with the metallic disk at the rear by a band of chamois leather, inside which is a coiled spring serving normally to hold the disks apart. The handle screws into the center of the base, and is removed to insert the powder in the puff. In operation the perforated surface is pressed against the skin, when the compression of the air inside and consequent discharge through the perforations drive the powder out also, causing it to adhere to the surface against which the puff is placed.

Mr. J. W. Duntley, president of the Chicago Pneumatic Tool Company, sailed Tuesday, November 4th, for Europe. He expects to spend about four weeks on the Continent and states that it is his intention to establish, either in England or Scotland, a new plant for the manufacture of pneumatic tools. The design of this new plant will be practically the same as that of the factory now being operated by his company at Detroit, Michigan, which is the finest equipped manufacturing establishment of its kind in the world.

This move was made necessary by the large increase in the amount of business received by this company from England during the past few months and is a sure indication of the fact that pneumatic appliances are gradually becoming invaluable to the European trade as well as to the various industries of this country.

There is a quiet revolution going on at the present time, and very little is being said about it. Had this revolution taken place at the beginning of the last century we would probably have had warm discussions at the meetings of the trade guilds, followed by a meeting round the market cross and then an angry assembly round the gates of shipbuilding and boiler-making establishments. The maker and inventor of the first spinning Jenny had his machine broken and burned, while he had to fly for his life, and if the same conditions obtained now as then the makers of pneumatic chisels, hammers and air-driven drills would have their workshops burned about their ears. All that is changed now. Systems of pipes are being laid throughout every shipyard to carry compressed air to the portable machines driven by it, and the men like the system, for they have simply to hold the chisel against the work in order that it may be chipped to the dimension they may wish.

Recently Street Cleaning Commissioner Woodbury made an official test of the new "Squeegee" outfit on the asphalt pavement near Madison Square, New York. The squeegee is operated in conjunction with a compressed air sprinkler which does not flood the surface, but allows to fall like a gentle rain a well-distributed spray.

The compressor takes precedence in line of procession only over the now feared squeegee, which is practically a towel which wipes off the face of the street, leaving it dry and clear.

This was thought to be especially advantageous to the automobiles and a number were on hand to experiment. The results, according to hearsay, are as follows:

"Six automobiles were on hand. Their chauffeurs shivering in the thirty-second degree of atmospheric chilliness, put the autos through their poses over the squeegeed surface.

"But alas! The frost had got in its fine work, and a thin coating of ice was formed to the dismay of the automobilists. Their machines 'skidded for fair'—cut Philadelphia grapevines, figure eights and all kinds of curly kews. The Commissioner had maintained that once a squeegee was used no known auto would misbehave.

"But the frost, he hadn't figured on. Now, he is figuring out a heating device which will be used co-jointly with the squeegee—this will make it a squeezizzer."

A midget motor power engine has made its appearance at Washington, creating much interest and also no little amusement. Though tiny enough to be carried in a small hat-box, yet it is powerful enough to run a steam launch.

This little rotary engine can be used any place where power is needed, and can be run by steam, compressed air, or water, or with gas or liquefied air. In fact, there is scarcely any machinery from a farm implement to a steamship which cannot be run by this little motor. It has been tried in automobiles, and runs smoothly and without the slightest vibration of the vehicle such as is experienced in most of the machines.

There is no flywheel such as would interfere with the general application of its power and it can be used in propelling airships. It has been used in the generation of electricity on a large scale, but acted equally well when for house lighting it was worked by water pressure from an ordinary spigot.

During its operation in the navy department it was illustrated that the little circular affair, scarcely bigger than a wash basin, could, while in any position whatever, whether vertical or otherwise, be used with the same advantage as when standing in its proper position on the base constructed for it. The inventors of the motor, Nicholas Jean Fortunesco, a Roumanian, and Alfred Georges, a Belgian, have just had American patents issued to them on the machine.

Senator George G. Vest, of Missouri, is in Baltimore, and has placed himself in the hands of Dr. Henry F. Garey, the specialist and inventor of the ophthalmic oscillator.

Senator Vest's sight is so seriously impaired that he requires the services of an attendant in order to get about. He is suffering from a disease of the retina of the eye.

Compressed air is the important thing in Dr. Garey's treatment. An electric motor compresses the air. Two rubber tubes attached to the air reservoir have on the ends two glass cups which fit down close over the face and touch the eyeballs.

The daily treatment which Senator Vest will receive is interesting. The glass cups first are pressed against the head at the base of the brain. There are two apertures in the surface of the cups, through one of which air under considerable pressure is forced against the head. Through the other air is drawn in. Thus the surface to which the device is applied is agitated, something like massage. This is continued for four minutes. Then the cups are fitted over the eyeballs and the same operation performed on them. The treatment is not painful.

The application to the back of the head acts as a stimulant to the blood vessels which supply the optic nerve. The application to the eyeball, which acts directly on the optic nerve, produces a sort of friction on the nerve further back than any other treatment that has ever been tried.

If there is a spark of life remaining in the nerve it may be restored to its normal condition. Senator Vest has not received sufficient treatment as yet for improvement to be noted.

W. A. Coles, the blind entertainer of Boston, came to Dr. Garey for treatment last month and is showing marked improvement.

A writer in the *National Engineer,* in connection with cooling water by means of compressed air, says the cold, expanded pipe should only be led through a pipe or coil of pipe dipped into the water to be cooled, then exhausted into the atmosphere, and recalls a fact of personal experience when in charge of some tunnel work. A ventilator fan blowing fresh air to the front was actuated by a small steam engine working with compressed air, the exhaust of which was led into a closed chest containing tin tumblers filled with water. On its way to the discharge orifice the current of air was passing along the row of tumblers, and some ten to fifteen pounds of ice were thus daily made quite readily. The miners felt interested in the progress of the refrigeration, and the men of the outgoing shift would seldom fail to dip a dusty finger into some of the tumblers, whose main peculiarity was the existence of a black core at the center of the block of ice.

The air which has done expansive work behind a piston moving in a cylinder escapes at a low temperature and at a moderate speed, and is fit for use as a refrigerating agent. In the air which is simply released through a valve the whole expansive work is converted into velocity and almost instantaneously transformed into heat by friction with the surrounding atmosphere or against the neighboring bodies. The result is that no cold can practically be produced in this manner.

Besides, the use of an expansion cylinder coupled to the compressing cylinder reduces to a minimum the actual amount of work required by this process of refrigeration. Its efficiency is low, and it is not economical on a large scale, as compared with the ammonia process; but it possesses advantages of simplicity, of cheapness and of safety which in many cases will make it quite valuable.

The editor of the *Petroleum and Industrial Review* writes as follows:

"Is the air compressor useless for oil? This is a question which naturally rises to one's mind on reading the contradictory reports which emanate from various fields. In regard to the air compressors in use in the Russian fields we hear little about them. It has, we know, been stated that the output of certain wells, where the compressor has displaced the baler or pump, has been considerably increased. On the other hand, quite the contrary is reported from another quarter, in an article by Mr. Nagel, in recent issues of this paper. According to his account the cost of exploiting a well by baling amounts to 391 roubles per month, raising 4,000 poods of oil and 2,000 poods of water per 24 hours, working out at 0·326 copecs per pood. When, however, the air compressor is used, the writer of the article states that the cost per month would amount to 1,108 to 1,365 roubles, or ·92 to 1.14 copecs per pood. But in giving these figures, the writer of the report has not taken into consideration that the air compressor can always raise a larger quantity oil than the baler, which means in regard to the figures given that a much larger production could be obtained for the same outlay. Moreover, Mr. Nagel has omitted to take into account that one air compressor is capable of raising oil from two wells at the same time, thus reducing the cost very considerably.

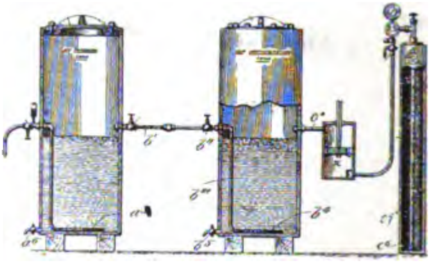
In regard to the American fields, the air compressor is apparently regarded as a useful and profitable apparatus there, although we have no definite figures to go on, while reports from the Texas fields are also contradictory, and we should, for the benefit of all interested in petroleum exploitation, like to have further data on the matter.

Mr. Peter Brotherhood, the mechanical engineer who, by the invention of a new type of steam engine, and afterwards of a special high-pressure air-compressing pump, greatly assisted in the development of the automobile torpedo, died at his residence, 15 Hyde Park gardens, on Monday afternoon. He was in his 65th year, having been born at Maidenhead in 1838, the son of Rowland Brotherhood, railway contractor, of Chippenham, Wilts. Having passed through a four years' applied science course at King's College, he received a practical training in several egnineering works, including the Great Western Locomotive Works at Swindon, and Messrs. Maudslay, Sons, and Field's marine engineering establishment at Lambeth, and began business on his own account in 1867, his present works by the riverside near Westminster bridge being opened in 1881. It was in 1872 that he invented the special engine with which his name has since been identified. It has three cylinders set at angles of 120 deg. round a central chamber, and all three connecting rods operated upon one crank within the central chamber. When exhibited at the Vienna Exhibition in 1873, it aroused great interest, and its first application as a steam motor was for driving dynamos and also centrifugal pumps in the French warship Richelieu. The Woolwich authorities recognized that, if arranged for working with compressed air, it would be greatly superior to the ordinary vertical oscillating cylinder engine then in use in Whitehead torpedoes, the new motor admirably accommodating itself to the limited and circular section of the torpedo. The first Brotherhood three-cylinder air engine made for this purpose proved a success, and it has since been applied almost universally for torpedoes. It has also been adapted for hydraulic power, and is largely used for capstans. As a steam engine, however, it has been supplanted by high-speed engines of the vertical type using steam expansively in two or more cylinders. Mr. Brotherhood also introduced important improvements in the pumps for compressing air on board ship for use in torpedoes, and his compressors have been largely used in British and foreign ships since first applied in the first British torpedo boat "Lightning." He also invented a vertical direct-acting engine, the first of which was made in the remarkably short period of 27 working days, for Queen Victoria's yacht—the "Victoria and Albert," in special circumstances. Mr. Brotherhood took little part in public life, being entirely devoted to his engineering work. He is survived by a widow, two daughters, and one son.

U. S. PATENTS GRANTED OCT. 1902

Specially prepared for COMPRESSED AIR.

710,404. METHOD OF TREATING AIR FOR FORCING MALT LIQUORS FROM KEGS. Charles A. Bartliff, St. Louis, Mo. Filed April 20, 1901. Serial No. 56,696.



The method of treating air for use in forcing malt liquors from kegs, which consists in heavily impregnating said air with hops, compressing the same and maintaining the same in a compressed condition in contact with a preparation of hops.

The method of treating air for use in forcing malt liquors from kegs, which consists in heavily impregnating said air with hops, compressing same, and storing the air while compressed in a suitable receptacle having a solution of hops, where it remains in contact with hops until drawn from said receptacle for use.

710,480. AUTOMATIC AIR-VALVE FOR WATER-MAINS. Christian E. Loetzer, Towanda, Pa. Filed Dec. 28, 1901. Serial No. 87,574.

An automatic air-valve for water-mains comprising a chamber having a lower water-inlet passage, a cup-like seat within said chamber above said passage having a lateral water-port, an air-vent tube depending within said chamber, and a hollow open-bottom float fitting within said cup-like seat, said float having an upper tube constantly fitting said air-vent tube and adapted to close and open communication therewith as the float rises and falls according to the height of water in the chamber.

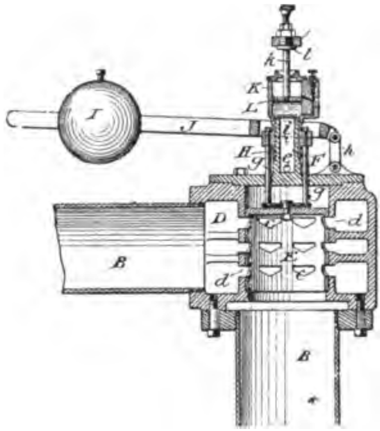
710,514. FLEXIBLE PIPING FOR THE AIR, STEAM OR OTHER PIPING FOR RAILWAY-CARS. George Riexinger, Buffalo, N. Y. Filed April 25, 1902. Serial No. 104,647.

In railway-cars, a metallic, flexible, connecting-piping consisting, essentially, of a T-shaped member attached to the stop-cock of the air and other pipes, a sleeve and lock-nut on the T end of this pipe, a main member having two forks as described, a cross-piece in one of these forks, an auxiliary pipe having a fork connected with said cross-piece, and a slip-joint member attached to said auxiliary member.

710,522. AUTOMATIC SAFETY-LOCK FOR AIR-BRAKE SYSTEMS. William H. Sauvage, Denver, Colo., assignor of one-fifth to Richard McKnight, Denver, Colo. Filed Feb. 14, 1902. Serial No. 94,147.

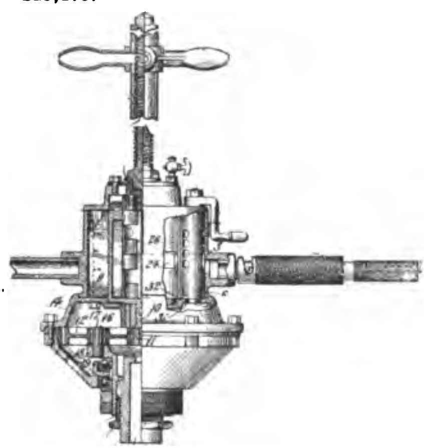
An automatic air-brake locking device for air-brake systems of railway-trains, the combination with the auxiliary reservoir, the brake-cylinder and its piston, of air-brake systems of a supplementary cylinder arranged in juxtaposition to said brake-cylinder, a piston and piston-rod operatively arranged in said supplementary cylinder, a compressed-air pipe connected between one end of said supplementary cylinder and said auxiliary reservoir and a compressed-air-pipe connection between the opposite end of said supplementary cylinder and the air train-pipe of said air-brake system, and means connected with the piston of said supplementary cylinder and the piston of said brake-cylinder, including a gripping device for automatically gripping and locking said brake-cylinder's piston in operative set-brake position.

710,712. REGULATOR FOR AIR-COMPRESSORS. William Prellwitz, Easton, Pa., assignor to the Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Nov. 13, 1901. Serial No. 82,073.



The combination with a valve for closing or choking the inlet to a compressor, of a stationary cylinder to which there is an inlet from the receiver to which the compressor delivers, a movable outer cylinder fitted to the exterior of said stationary cylinder, connections between said outer cylinder and the valve, and a double-acting liquid dash-pot the cylinder of which is carried by said movable cylinder and the piston of which has a stationary support.

710,782. PORTABLE PNEUMATIC ROTARY DRILL. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Filed Aug. 13, 1902. Serial No. 119,479.



A portable pneumatic drill, a cylinder, a rotary engine therein, an inlet-passage for the motive fluid, a plurality of chambers intermediate said passage and engine, an upright reversing-valve arranged parallel to the axis of said engine and located intermediate of said passage and chambers, and an exhaust-chamber below said cylinder, said reversing-valve exhausting downwardly directly into said exhaust-chamber, and serving to simultaneously connect either of said passages with the inlet-passage and the other with the exhaust-chamber.

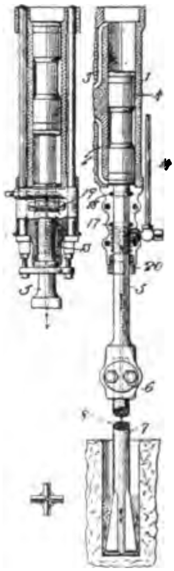
710,855. PNEUMATIC SAND-FLUE AND NETTING CLEANER. Robert W. Gibson, Palestine, Tex., and William N. Best, Los Angeles, Cal., assignors of one-half to John H. Best and Ezra Best, Quincy, Ill. Filed Dec. 4, 1901. Serial No. 84,705.

A sand-flue and netting cleaner, comprising a sand-receptacle, a discharge-pipe, a pipe leading from the receptacle to the discharge-pipe, and connecting said parts together for conducting sand to the discharge pipe, an injector-nozzle, and means for controlling the discharges through said parts.

710,889. COMPRESSED-AIR RESERVOIR. Thomas D. Prescott, Philadelphia, and James C. Prescott and Henry A. Prescott, Minersville, Pa., assignors of one-fifth to Henry Bell, Philadelphia, Pa. Filed Aug. 27, 1901. Serial No. 73,494.

A compressed-air-storing device, comprising in combination, a closed cylinder having fixed upper and lower heads, an inlet-pipe connected to the lower head, a check-valve in said pipe, a valved discharge-pipe also leading into the lower end of the cylinder, a piston fitting snugly within the cylinder, a piston-rod extending out through a guiding-opening in the upper cylinder-head and provided with a threaded upper end, a spider comprising a central hub and a series of equidistant radially-projecting arms, each having at the outer end a vertically-disposed bolt-receiving opening, upper and lower nuts carried by the threaded upper end of the piston-rod and engaging respectively with the upper and lower sides of the spider-hub, thereby to permit of the vertical adjustment of said spider on the piston, and the upper nut serving not only to lock the spider in position but to maintain the same in a horizontal plane by clamping it against the lower nut, a series of eyebolts adapted one to each of the openings in the spider-arms and having upper and lower adjusting nuts, a series of coiled springs of equal size and strength, having their upper ends connected to the eyebolts, a base supporting the cylinder, fixed eyes carried by said base and in alignment with the spider-arms, the lower ends of said springs being secured to said fixed eyes.

710,922. ROCK-DRILLING MACHINE. William Prellwitz, Easton, Pa., assignor to the Ingersoll-Sergeant Drill Company, New York, N. Y., a Corporation of West Virginia. Filed Jan. 7, 1902. Serial No. 88,739.



A cylinder, a drill-holding piston having a longitudinal water-feeding duct therein, a front head having a water-feed chamber therein and means for reciprocating the piston to open and close communication between the chamber and duct.

A cylinder, a drill-holding piston having a water-duct leading from the front end of the piston-rod rearwardly therein and thence outwardly to the periphery of the rod, a front head having a water-feed chamber surrounding the piston-rod and means for reciprocating the piston to bring the duct into and out of communication with the water-feed chamber for feeding water intermittently to the drill.

711,116. HOOD FOR PNEUMATIC STRAW-STACKERS. George M. Michell, Earlham, Iowa. Filed March 28, 1902. Serial No. 100,387.

An enlarged, tapering and open-bottomed end for a tubular conveyor for straw-stackers or separators, a hood hinged to the top of the free open and enlarged end and means for adjusting the hood, arranged and combined to operate in the manner set forth for the purposes stated.

711,158. PNEUMATIC MOTOR FOR MECHANICAL MUSICAL INSTRUMENTS. Henry F. Hall, Cambridge, Mass. Filed Sept. 12, 1901. Serial No. 75,241.

A pneumatic motor for mechanical musical instruments and the like, the combination of a main block having a series of longitudinal channels therein, a series of pneumatics mounted on one face of said block and communicating with said channels, a second block provided with a series of channels forming continuations of said longitudinal channels and terminating in ports opening in the side of said second block, a chamber in said second block connected with a wind-chest and having orifices adjacent to the said ports, and a rotary valve engaging the side of said second block to control communication between the pneumatic and the wind-chest.

711,367. TERMINAL FOR PNEUMATIC-DESPATCH TUBES. Fred R. Taisey, Indianapolis, Ind., assignor to the Taisey Pneumatic Service Company, Indianapolis, Ind., a Corporation of Indiana. Filed Oct. 17, 1901. Serial No. 78.965.

A pneumatic-despatch apparatus, an air-conduit with a curve in it and an enlargement at the curve, and a discharge passage-way for the carrier located in and of less diameter than such enlargement and extending tangentially with the curve of the conduit.

A pneumatic-despatch apparatus, an air-conduit with a curve in it, and a perforated discharge passage-way for the carrier located within the air-conduit and extending tangentially with the curve thereof, said conduit being enlarged about the perforated portion of said discharge passage-way.

711,369. PAPER-BAG MACHINE. James West, St. Louis, Mo., assignor, by mesne assignments, to the Union Paper Bag Machine Company, Philadelphia, Pa., a Corporation of Pennsylvania. Filed June 28, 1900. Serial No. 21,883.

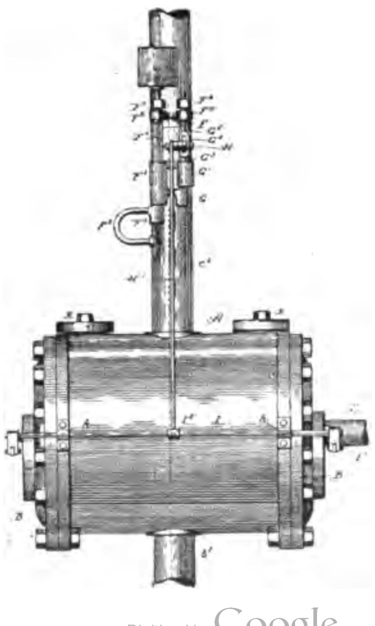
A machine of the class described, means for directing a blast of air against a bag to open up the sides thereof, in combination with folders for bending back the corners of the bag.

A machine of the class described, the combination of means for directing a blast of air against the bag to open up the sides thereof, means for folding back the corners of the bag, and means for pressing the sides of the bag down onto the corners.

711,597. MACHINERY FOR THE PRODUCTION OF LIQUID UNDER PRESSURE. Adolf Vogt and Max von Recklinghausen, Westminster, London, England. Filed June 25, 1901. Serial No. 66,007.

A machine as described, an explosion-chamber, a high-pressure and a low-pressure chamber one above the other surrounding the explosion-chamber and containing liquid, means connecting the high and low pressure chambers, a motor interposed in said means and valves controlling communication between the explosion and high and low pressure chambers, and means to ignite the charge, whereby liquid will be forced into the high-pressure chamber through the motor and low-pressure chamber up into the explosion-chamber again to compress the charge.

711,689. COMPRESSOR. Frederick Wittenmeier, Chicago, Ill., assignor to Kroeschell Brothers Ice Machine Company, Chicago, Ill., a Corporation of Illinois. Filed Feb. 15, 1902. Serial No. 94,283.



A compressor, means for unloading the compressor-piston when the pressure-supply pumped by said piston is excessive, comprising a supplemental opening in the cylinder end, a valve at said opening and means for opening said valve comprising a chamber G', a passage extending from the compression side of the compressor to said chamber, a movable diaphragm in said chamber operatively connected with said supplemental-opening valve, a weighted passage opening and closing valve F5, and lever mechanism connected with said diaphragm and supplemental-opening valve, all constructed to operate substantially as set forth.

711,859. PNEUMATIC TOOL. William M. Holden, Barre, Vt. Filed Dec. 24, 1900. Serial No. 40,939.

The combination with the casing or cylinder having exhaust-ports, and an inlet-head for the motive agent rigid with the cylinder, of the tool-operating piston having a head in front of said inlet-head and a sleeve extending rearwardly over said inlet-head and forming a recess or chamber between the inlet-head and the head of the piston, the inlet-head and piston having inlet-ports arranged to conduct the motive agent to the opposite ends of the piston and to the recess or chamber between the inlet-head and the piston-head.

711,940. PNEUMATIC ALARM FOR AUTOMOBILES. Gaston E. Cordeau, Brooklyn, N. Y. Filed Oct. 30, 1901. Serial No. 80,478.

A pneumatic alarm for automobiles, a pump, means for operating said pump by the foot and a sounding device connected to said pump by an elastic bulb.

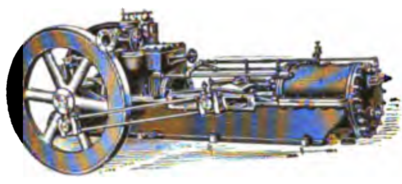
A pneumatic alarm for automobiles, an air-pump, means for fastening said pump to underneath the body of the vehicle, a sleeve, having means for fastening to the footboard of said vehicle, and a rod slidably fitted within said sleeve.

712,249. AIR-BRAKE. Joseph B. Briggs, Jr., Russellville, Ky. Filed March 22, 1902. Serial No. 99,491.

An air-brake system having an air-release valve arranged between the angle-cock valve and the coupling at the free end of the hose-section, to release the air-pressure from the hose and comprising a separate casing secured in the angle-cock casing.

712,401. COMPRESSED-AIR WATER-ELEVATOR. Willard McKee, Charleston, W. Va. Filed April 10, 1902. Serial No. 102,211.

A water-elevator comprising the pair of pumping-chambers having inlet and discharge openings, the floats operating in said chambers, the operating-valves, means for operating said valves by their respective floats, the main valves and the controlling-valve, the casings provided with chambers for said valves and with feed and exhaust ports and with ports or channels for the passage of compressed air through the controlling and main valves to the pumping-chamber and for the passage of pressure controlled by the position of the operating-valves for moving the controlling-valve and main valves into different positions.

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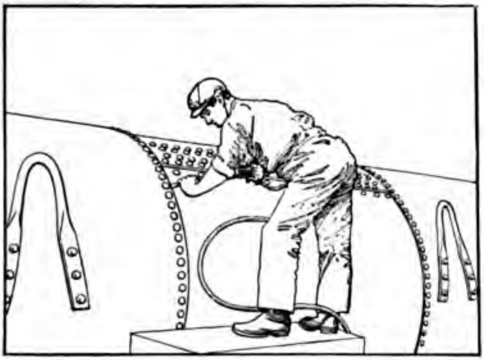

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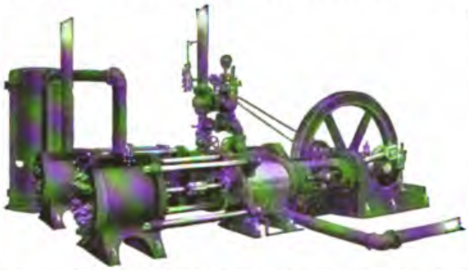

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VOL. VII. NEW YORK, JANUARY, 1903. NO. 11.



GLEASON-PETERS
No 216



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OR

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VOL. VII. JANUARY, 1903. NO. 11

Changes in "Compressed Air."

Since its first issue and until recently the cover of each number of COMPRESSED AIR has had a frontispiece illustrating some new application of compressed air or referring to an article in the body of the magazine. This undoubtedly added to the appearance of the cover and to that extent was an excellent idea, but the arrangement always involved the loss of the illustration in question when the numbers were bound up, unless the cover was included. Binding covers and advertising with the text is an unsatisfactory arrangement at best and the result has been that the frontispiece was usually lost.

In view of this it has been decided hereafter to omit the frontispiece and use the cover simply as a protection, and beginning with our March issue this space will be available for advertising. We consider this an exceedingly desirable position because the page is small so that the one or more advertisements which may appear on the front cover will stand out with unusual prominence and will not be more or less lost as is the case with papers having larger advertising pages.

Charges for the page in whole or in part for one or more issues will be furnished on request.

We wish to call attention to the cover of this issue where we advertise "Compressed Air Information, or a Cyclopedia Containing Practical Papers on the Production, Transmission and Use of Compressed Air." It is hoped and expected that by the time the present number of COMPRESSED AIR reaches you the book will be completed and ready for delivery.

As already stated the publication came about through the frequent inquiries for copies of papers which appeared in COMPRESSED AIR during the first five years of its existence and owing to the supply of these early papers being entirely exhausted and the demand continuing.

No attempt has been made to introduce new matter but the various papers, editorials and notes have been arranged in their logical order of Production, Transmission and Use, and all are indexed so that the material is available for ready reference. As the book stands it contains nearly every practical paper on Compressed Air, either in full or in abstract, which appeared in print during the five years which it covers. There are seventy-five tables and nearly five hundred illustrations and a full list of American patents bearing on compressed air and its applications. We believe the book to be one of the most practical productions which has appeared in the field to which it is devoted. We recommend it to our recent subscribers as it will enable them to have a complete file of COMPRESSED AIR.

Electric Power for General Purposes in Mining and Milling.*

This paper deals with results obtained in Amador county, Cal., using electricity at $6.50 per horse power per month, furnished by the Standard Electric Co. of California, generated at their plant at Electra, Amador county, from which about 14,000 H. P., of alternating current, is distributed through the central portion of the State. The transmission line along the mother lode from Angels Camp, Calaveras county, to the Fremont mine. 1½ mile north of Amador City, carries a 10,000 volt current, which is transferred at each mine to 550 or 600 volts for power purposes and 125 volts for lighting purposes. At the Fremont mine the superintendent. C. E. Purrington. has installed a 20½x24 duplex Ingersoll-Sergeant single stage compressor. capacity 1.700 cubic feet free air per minute. The compressor is operated by a 300 H. P. general electric motor. The air is used for all purposes, hoisting, drilling and pumping water. The plant is only recently installed, so figures cannot be given accurately, but the superintendent informs me it is giving entire satisfaction. This plant is equipped with six air receivers of 1.500 cubic feet capacity and several hundred feet 6-inch pipe for storage, besides the three steam boilers in which the air used (by hoisting engine) is reheated. This compressor has a unique unloader, being an automatically regulated valve in the pipe through which the compressor takes air, which valve is closed when the air pressure reaches any particular point it is set at. Of course, if the compressor sucks no air it pumps none, or practically so.

The Keystone Co. at Amador City saved $150 per month using electricity at $6.50 per horse power month, compared with water used under 185 feet fall at 20 cents per inch, formerly used in running this 40-stamp mill. They are now using compressed air for hoisting and drilling, the compressor being run by a 300 H. P. general electric motor with a 550 volt current. This plant is only recently installed. At the Kennedy mine a change from pine wood at $6 per cord in the furnace to crude oil at $1.50 per barrel was made. They found that $17 worth of oil did the same work as $24 worth of wood.

The article deals largely in compressed air plants, for with the exceptions when electricity is applied direct to mill rock breaker, blowers and pumps, compressed air, apparently, is the only resort, which accounts for its prominence in this paper, and as most mines art equipped with steam engines it is very easy to change from steam to air, as well as making it possible to fall back on steam in emergencies. As to electricity applied directly: Through the kindness of C. R. Downs, superintendent, and J. F. Phipps, assistant superintendent of the Bunker Hill mine at Amador City, Cal., I am informed that it costs them just one-half as much to run a No. 10 Buffalo forge blower by electric motor as by an upright steam engine, and much less care and repairs. The blower runs 1.700 revolutions per minute, blowing 4,000 cubic feet of air per minute through 2,000 feet of 11-inch pipe at a cost for power of $1.06 per day. This blower is run by a 10 H. P. general electric induction motor, consuming 5 H. P. per day; using steam it costs $2.12 per day. Here they also have a 12x14 Ingersoll-Sergeant single stage compressor running 160 revolutions per minute belted direct to a 50 H. P. general electric motor, using air for drilling and pumping. Until recently all the pumping was done by steam at 100 pounds pressure, and I am informed that they see no difference in cost of pumping by air or steam; it is about equal, with the advantage of having the air to use for drilling when needed. However, I believe from my experience at the South Spring Hill that if the steam cylinder end of the pumps were large enough diameter to use at forty pounds pressure and keep up to speed, there would be a balance in favor of air against steam. They are paying $6.50 per H. P. month for electricity and $6 for first-class pine wood in the furnace. This was proven very satisfactorily at the South Spring Hill where the pump running by compressed air was especially designed to work on air at forty-five pounds pressure, raising the water 725 feet vertically in one lift, the back pressure of the water at the pump being about 345 pounds to the square inch. This pump worked cheaper on air than it would by steam. Leakage and extraordinary heating of the air from com-

* Read by John B. Tregloan, Amador City, Cal., before the annual meeting California Miners' Association, San Francisco, Nov. 17, 18, 19, 1912.

pression make it advisable to use low pressure air whenever possible.

At the Oneida mine electricity is applied direct, a general electric 100 H. P. motor being geared directly to a Dow duplex plunger pump. This pump raises 200 gallons of water per minute, about 19 miners' inches of water, 1300 feet vertically in one lift through a 6-inch pipe for four and one-half hours daily at a cost of $3.40 per day for power; at $6.50 per H. P. month 100 H. P. of electricity is used; the actual weight of water raised 1300 feet represents 65 H. P., so that there is a loss of only 35 H. P., or 35 per cent. in radiation on line from the transformer to the motor in the mine, friction in motor, pump and pipe line, giving an absolute efficiency of 65 per cent., which compared with steam or air is about three or four times as efficient taking into consideration the amount of energy purchased.

W. R. Thomas of the Central Eureka informs us that it costs about one-half to run their blower by electricity as it formerly did by water at 20 cents per inch. When the water head is 500 feet or so I believe it to be about a standoff with electricity at $6.50 per H. P. month and water at 20 cents per inch for power purchased, with the advantage in favor of electricity by eliminating long and expensive ditch and pipe lines, with their constant repair, maintenance and delays due to breakage.

It is not necessary to cite other mines using electricity direct regarding its efficiency, and I desire to devote the remainder of this paper to the use of electricity for hoisting purposes, through the medium of compressed air. However, it seems very strange that a proper understanding cannot be had as to the feasibility of electricity applied direct to hoisting machinery.

The first essential to every compressed air plant is ample storage, so that a minimum size compressor can be used, running comparatively slow, and maintain the working pressure as nearly constant as possible. Air once stored can be used to-day or next week if properly stored. As to leakage, let me call your attention to this fact: At sixty pounds pressure air will travel through a pin hole at the rate of 600 feet per second, or 36,000 feet per minute, nearly 7 miles per minute, so however small the hole is the volume is large where a steady stream is blowing away. The same rule applies to the blowoff, so use an unloader of some description, preferably one that holds the outlet valves open, allowing the compressor to be in absolute equilibrium, forcing air into the receiver from one side of the piston and drawing it from the receiver on the other, and vice versa on the return stroke.

As to two or more stage compression I desire to call your attention. It is the ideal way to compress air, but so-called two-stage compressors are a farce, unless the intercooler is of sufficient size and proper design to return the air to something near the atmospheric temperature while it is passing from the low to high pressure cylinders. The term two-stage is used a great deal to sell inefficient compressors.

It takes power to run a compressor 60, 75 or 150 revolutions per minute even if it is unloaded, so plan the size of compressor and storage so that it runs unloaded as seldom as possible only in emergencies of idleness for comparatively long periods of the machinery using air. It is no more necessary to have the compressor running unloaded most of the time than it is to have steam blowing off continually because there is a blowoff valve on the boiler. With an induction motor and the alternating type of current used in this country it is not possible to start and stop the compressor to avoid blowing away air, so that must be accomplished by proper storage, unloaders, and more important than anything else, a proper size compressor, neither too large nor too small, so that the aggregate amount of air used in twenty-four hours will be furnished by the compressor running at a speed not to exceed 200 feet of piston speed per minute with the stroke at least double the diameter of the cylinder, for economical results. Heavy flywheels are most essential on a compressor than on a rock breaker, although generally not so considered, to prevent any jerking on the rope transmission or belt. In a 10-inch diameter compressor, at the end of each stroke the pressure changes when pumping against 100 pounds pressure from a hold back of 7,854 pounds to a shove ahead of the same amount, and the air left there due to clearance runs the motor for an instant. A total change in tension on the belt or rope of 15,708 pounds, or nearly eight tons, a heavy fly is required to steady this motion, or it will jerk the life out of the belt or rope in a short time, as well as cause slipping. Avoid countershafts by a large diameter heavy rim flywheel on the compressor and avoid a tightener on belt driven compressors which takes power to run it 800 or 1,000 revolutions per minute, by placing the motor far enough from the compressor, using a wide belt, so that the weight of the belt, with the slack side on top, will be sufficient to prevent slipping, which is another item of loss.

Now as to the efficiency of compressed air for hoisting engines, how can one expect air to be thoroughly satisfactory when the largest portion of power goes up the exhaust pipe, as well now and then it is all escaping through the blowoff on the receiver. I mention this because I have seen several plants doing this very thing and those in charge complaining about their compressor, or the electric motor, or some other reason, whereas the compressor is all right and a good, willing friend, likewise the electric motor, but the type of hoist and the storage and other things arranged by the superintendent himself are the only faulty things about the plant. Electricity and compressed air are a comparatively recent factor with which all miners must sooner or later familiarize themselves with, and when they meet this new factor with intelligence it will be as simple as hand drilling now is to the average miner. What would a superintendent say to his engineer if he continually had steam blowing off, or what would the board of directors say if there was a continual stream of water running over the waste gate of the reservoir? Yet just such extravagance has been and in some cases is being practiced with compressed air. Treat it as economically and intelligently as you would water power, wood, fuel oil, and with the electric current at not over $6.50 per horse power month it will be your best friend.

Receivers should be close to the compressors, and if possible, where the air is used for general purposes, run the air through an old boiler, submerged in water, which will compel the air, by cooling it, to drop what water is in it immediately and not drop it in the pipe line going down the shaft, so that it will not scour the pump cylinders and machine cylinders, as well as to a great degree prevent freezing at the exhaust, a common inconvenience. An old crosscut underground bulkheaded with concrete makes an efficient and at the same time large and cheap storage. Large piping and the absence of 90° elbows are very essential for economy. So much for the air plant; now for the hoisting engine itself.

Use double compound tandem engines; in other words, take an ordinary double cylinder hoist and add a low pressure of about twice the piston area of the present one, extend the piston rod through the rear head of old cylinder into the low pressure, and with the cut off added to the low pressure you have a double compound tandem hoisting engine. This allows starting the load with the two high pressure cylinders, instead of having to rely on the high pressure alone as in a duplex compound, with a high pressure on one side and a low on the other. Air does not condense like steam, so that the power in it is utilizable till it has expanded to nearly atmospheric pressure.

As to reheating air the cost is only trivial, for every twenty-four pounds of good coal or its equivalent in wood in reheating air at about eighty pounds gauge pressure an additional horse power for twenty-four hours can be obtained. Whereas, under good conditions, it requires from 96 to 120 pounds of good coal to get one horse power for twenty-four hours from steam, with first-class boilers modernly installed and operated. Using the steam boilers for reheating the air makes it possible to revert to steam in a few minutes at any time, in case of emergency, without loss of time.

In the *Mining and Scientific Press* of April 26th, this year, is a description of the plant at the South Spring Hill mine at Amador City, the planning and installation of which I had in charge. The compressor used is 10x18 duplex single stage poppet valve type, driven by a 30 H. P. general electric induction motor, and formerly run by water power. In this case the blowoff by use of an automatic valve arrangement at the air receiver was led into the steam boiler, so that unless the hoisting engine was idle there was no air wasted; however, considerable air was in this case allowed to blow away on account of the compressor not being equipped with an unloader. When the pumps and drills were not in operation all the air went to the steam boiler, there being reheated and used by the engine. The largest amount of wood used for reheating purposes was one-half cord per twenty-four hours. Under these conditions the cost of the power to operate the hoisting engines was reduced to one-half, a larger economy than has been made by oil, due mostly to the fact that forty-five pounds gauge pressure would haul the load, which means low pressure air. The compressor ran fifty-nine revolutions per minute, and furnished enough air to run two drills (3⅛x3¼ Rand), breaking sixty tons of very hard ore per day, hoist the same 550 feet, and about eighty tons of water per day with the use of one-half cord of wood. The average consumption of electricity was about 20 to 25 H. P. per day, the bills varying from $135 to $160 per month, and were more than covered by the wood saved as compared with running the hoist entirely on steam.

In milling not much needs to be said, as there electricity is applied direct. Electric motors put at least 90% of the power purchased into the belt, which, of course, discounts water or steam at prevailing prices. It is easily and cheaply installed, is a clean power, should not fluctuate, has a permanent speed regardless of hot boxes or bearings, either one stamp or all of them can be hung up without an appreciable change in speed of the cam shaft. Concentrators can be started at will without varying the speed of others, giving a proper separation at all times, so that to the maximum extent possible, in a mechanical separation there is no sand in the concentrates nor any sulphurets in the tailings. Electricity is the miners' friend, and I trust that in the future, as well as now, those estimable gentlemen who are putting their brains, as well as capital, into these large electricity generating plants, will be working side by side with the miner, for the miner will always be their nearest consumer, and as one prospers so will the other. Mines and mills need no longer be far apart, thanks to our so-called electrical friends, and the advent of electricity, which travels with equal facility up hill as well as down, in sunshine or storm, unlike water, or teams, or railroads, and lays down at our very door, continually without interruption, ready harnessed for work the greatest and most efficient power the world has ever seen, so that the miners can mine and mill on the highest mountain top as easily as in the valley, providing climatic conditions or the topography of the country do not preclude it altogether. As to electricity direct for hoisting purposes, it should be taken up and fathomed, for its successful application is a very important economic proposition.

I desire to thank the various superintendents along the lode in Amador county for courtesies extended and data freely granted.—*Mining and Scientific Press.*

Merrill-Brett Drop Hammer.

E. W. Merrill, Jr., of Brooklyn, N. Y., is introducing in this country the Brett patent steam and compressed air, semi-rotary drop hammer lifters. These lifters can be operated in two ways; either by delivering one, or a series of equal blows automatically, or by giving variable light and heavy blows—blows of the elastic nature best suited for stamping or forging, as the return of the hammer is instantaneous.

The hammer can be made to operate as fast as is consistent with the successful manipulation of the stock in the dies, and the rate of 50 to 70 strokes per minute can ordinarily be obtained. while at a very low fall 100 blows per minute can be given. When necessary, lifters can be made to operate hammers weighing several tons, and these may be as easily worked as the smaller sizes.

The steam having a clear passage to the exhaust, the hammer has a perfectly free fall. The only connection necessary to the drop hammer is a pipe to convey the steam or compressed air, and this can be placed in any convenient location of the factory, regardless of the line shafting.

Compressed air for this purpose is of increasing importance and whenever, by reason of the general use of electric drive, or of water power, live steam is not available for the drop hammer, compressed air can be used in the same manner as steam, and without changing any parts of the machine. No power is lost, while operating, in changing direction of motion, as the piston shaft has but a partial rotation in its bearings, when returning to the starting point.

The important items in the economy of power by this system are in avoiding the necessity of driving heavy line shafting and slipping belts, and in not expending power while the hammers are not actually at work. The cost of heavy engines, shafting, hangers, and long belts necessary for the usual method of drop hammer drive is avoided and the initial cost of a plant is materially reduced.

These lifters are successfully used in connection with stamping hammers having a very large striking surface; as any unevenness of striking, or looseness in the guides does not in any way affect the lifter or its connections.

The illustration in Fig. 1 shows a self contained automatic drop hammer. The two levers fastened to the right hand side of the drop hammer are respectively connected to a light rod, which controls the throttle, and automatic trip valves.

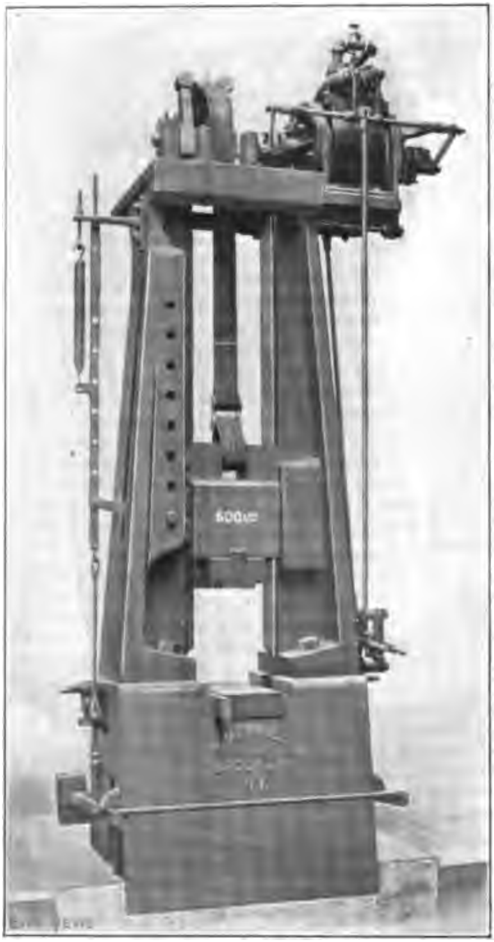


FIG. 1—SIX HUNDRED POUND DROP HAMMER WITH MERRILL-BRETT HAMMER LIFTER.

One of the levers moves between two quadrants containing a series of notches which hold the lever in any desired position. If the lever is placed in the highest, lowest or any intermediate notch, the hammer will trip automatically at a corresponding high, low or intermediate fall. This change of distance can be made in a few seconds, while the hammer is in operation or at rest.

The drop is worked automatically by releasing the latch with the aid of the treadle, the same as on a board lift drop, a repeated number of blows being given until the foot is removed. The variable light and heavy blows are obtained by operating the throttle lever, as on a steam hammer. There are no rods or slides for the hammer to strike, as the tripping is accomplished by the semi-rotary shaft and without jar.

Almost any kind of an overhead support or platform will answer, as there is no tendency of the platform to rack or sway sidewise, owing to the easy and uniform movement of the parts; the only strain upon the supports is the downward pressure equal to the lifting force. The lifters can also be placed upon the floor above the drop hammer, on the floor behind the base or at right angles to the sides and above the hammer.

The shaft, levers (or lifting arms) and piston, are fastened together to form practically one solid piece. This is the only working part and is free to rotate about three-quarters of a revolution in the cylinder. The cylinder is shown with one end cover removed, and it will be seen there is a division piece which is securely bolted to the side. The bearings in which the shaft turns are long, to give ample wearing surface and are made steam tight by ordinary stuffing boxes. The packing strips are placed in grooves in three sides of the piston blade and in the division piece, and are pressed outward by springs to keep the piston steam tight.

The pulley is strongly built of wrought steel, and turns freely on the shaft between the two lifting arms. The pulley is thus free from all strains of lifting and merely serves as an idler.

Fig. 2 shows a sectional view of the cylinder with the piston, lifting arms and idler pulley in their respective positions. With the parts as here shown, the hammer would be down and at rest. In order to raise the hammer, the steam enters the port A, presses against the piston wing B, and forces the piston to a position, say, at E. When the piston reaches the position E the live steam is cut off and the steam in the cylinder returns through the port A and out to the exhaust; at the same time the piston E returns to the starting point B, this operation being repeated any number of times desired. The lifting arm F being a part of the piston shaft C, consequently when the piston B takes the position at E, the lifting arm F will take the position K. The lifting strap H is fastened to the two arms by the cross-bar G, consequently when F takes the position K, the hammer, which is fastened to the strap, will be lifted a certain distance, this distance being varied by the position of the operating levers. D is the division block and L the relief and safety vent. It will be noticed that the loose pulley J is not

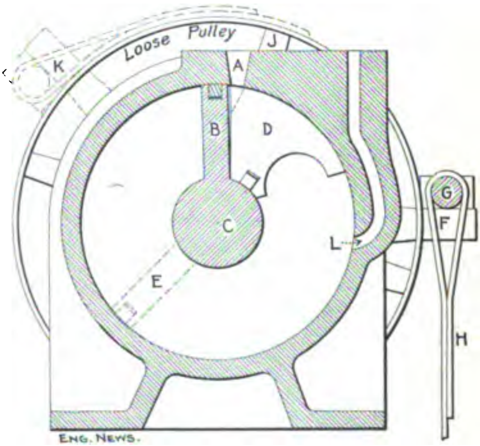


FIG. 2—SECTION THROUGH PISTON OF MERRILL-BRETT DROP HAMMER LIFTER.

fastened to the shaft, and therefore serves merely as an idler to change the rotary movement of the strap to a vertical and central lift, consequently giving a perfectly uniform movement to the hammer. Lifters can be made to raise hammers to any height desired, by increasing length of lifting arms and diameter of pulley.

The great scope of these hammers in the field of die forgings is illustrated by a soft steel locomotive piston weighing 240 pounds, drop forged by one of these large hammers.

Eighteen of these hammers are installed in the forge shop of the locomotive works of the London & Northwestern R. R. at Crewe, Eng.—*Iron Trade Review.*

Experiments with Coal-Cutting Machines in the Ruhr District.

Attempts have latterly been made on a large scale to replace hand labor by machinery in opening out and working coal-seams in the Ruhr basin. Up to within a short time ago the Garforth machine was used in only one pit (Dorstfeld) in this district, but several other collieries are now trying this machine, and, in addition, experiments have been conducted with the American Ingersoll-Sergeant machine, and more particularly with various small machines of German make.

The type of the well-known Garforth machine used in Rhenish-Westphalia is that driven by compressed air, electricity being considered too dangerous in view of the fiery character of the coal. The dimensions are: Length, 10 ft.; breadth, 31½ in.; height, including rails, 29½ in.; weight, about two tons. The machines are constructed by the Gewerkschaft Schalker Eisenhütte, and the arrangement of the cutting wheel varies according to the position of the cut, the level of the cut in each case being capable of a certain amount of adjustment by changing the wheels on which the machine runs. The depth of cut is about 5½ ft., the height only ½ in. The average rate of progress is about 200 ft. per shift, but this may be doubled under exceptionally favorable conditions, or considerably reduced where disturbances are encountered or where the going is very hard.

Wherever possible, the work is so arranged that the cutting is completed in the one shift, the coal being won and hauled during the subsequent shift, whilst during the third shift the ways are advanced, the workings packed, and the timbers put in. A more favorable result is obtained when the wall is sufficiently large for the machine to be kept travelling in the same direction during several shifts in succession, since in this event the winning, &c., can be carried on at the same time. As a rule, however, the loose character of the roof prevents the opening up of such long lengths at a time, and the fluctuations in the dip of the seam render shorter faces imperative.

Since the Garforth machine requires a free space of 40 to 48 inches in width in front of the coal face, very careful timbering is necessary where the roof is brittle; and this is performed by setting up cross timbers about 40 in. apart against the roof, one end being let into the coal face, while the other is supported by a prop 4 ft. back from the face. As soon as the machine in its forward movement has passed one of the props, the face end of the corresponding cross timber is also propped. This method answers very well, and enables the work to proceed without interruption, even where the roof is very poor; futhermore, the urgent necessity for effecting this timbering in a strictly systematic manner has led to an astonishing diminution in the number of accidents through falls of roof.

The undercut coal is got out by wedging, without shot-firing, and when this has been done and the packing has been put in, the machine is then able to retrace its steps, though it is generally found preferable to work the machine always in the one direction, in which case the wheel is dismounted and the machine returned to its starting point, *via* an incline. This is not a difficult matter to carry out. No details are at present available for the institution of a reliable comparison between the expense of cutting by the Garforth machine and by hand in the Ruhr district, but the authorities of the Dorstfeld pit contemplate publishing these data shortly; and, according to verbal reports machine cutting is the cheaper of the two, besides furnishing a larger percentage of lump coal and thus increasing the selling value. An example of a seam unworkable by hand labor being profitably worked by this machine is afforded by a 27 in. seam of gas coal (dip 10 degs.) in one of the northern pits of the Ruhr basin, the coal being too tough and the roof too brittle to render hand working feasible. In taking out this seam with the Garforth machine the face was opened out parallel to the sloping cleats in the coal, thus reducing the dip of the path traversed by the machine to about 6 to 7 degrees. The length of the face was nearly 300 ft., the depth of cut (in the under rock) 5½ ft., and the rate of working about 120 square yards of coal undercut and taken out per diem (two eight-hour shifts). The output per man (hewers and machinists) amounted at first to 1·3 tons per shift, but afterwards increased to 2 tons; the lump coal made up 60 to 70 per cent. of the total.

Owing to the long working face required by the Garforth machine, its use in Rhenish-Westphalian pits is restricted to longwall work. On the other hand, the employment of the machine enables this method of working to be more extensively pursued than was hitherto possible, the more rapid advance and the abolition of blasting helping to preserve the roof. The machine can be used better in flat than in steeply sloping seams. The limit of its employment in the Dorstfeld pit is at an angle of 30 degs.; but there does not seem any insurmountable obstacle to its use in steeper gradients if fitted with a counterpoise. An essential condition is that the coal should be fairly solid, otherwise the work is hindered by the premature subsidence of the undercut coal itself. A good roof is an advantage, but not indispensable; though an even floor is important, owing to the difficulty of tipping the large wheel in an upward or downward direction whilst cutting. Small inequalities in the floor can be remedied by putting thicker sleepers under the track, or by ripping out the floor itself; but greater changes in the dip are a source of disturbance.

All the other cutting machines tried are of the percussion type, the first to be mentioned being the Ingersoll-Sergeant machine, which makes a cut about 5 ft. deep, the arc of cut being about the same width, and the height diminishing from about ½ in. at the mouth to about 1-3 in. at the bottom of the cut. The dimensions of the machine are—length 7½ ft., height 17¾ in., breadth 20½ in., weight a little over 6 cwt. Although trials have been made with this machine in a number of Wesphalian pits, only two of them have continued to use it to any extent, the reason for abandoning it chiefly residing in its unsuitability to the conditions of stratification prevailing in the coal deposits. Another minor cause is that the machine entails considerable skill, combined with great bodily strength, on the part of the operator, and is not easy to learn, the powers of the operator being overtaxed until he has become expert in the manner of guiding the instrument.

For working the Ingersoll-Sergeant machine a flat or gently sloping seam is essential, as it cannot be used at all when the dip exceeds 15 degs. The roof must be good or great delay is caused by propping, and the coal must be solid enough to preclude risk of caving. In thin seams there is insufficient space for the machinist; and the height of the cut is a defect, as is also the fact that the cut is necessarily made next the floor. The saving in explosives is small as compared with hand labor, the form of the cut differing but little from that made with the pick. In a comparative trial, extending over three months, between the Ingersoll-Sergeant machine and hand labor under fairly similar conditions, the output per man per shift averaged 1·958 to 2·056 tons, at a cost of 2·57s. to 2·71s. per ton in the former case, and 1·423 to 1·792 tons at a cost of 2·98s. to 3·23s. per ton in the latter. The fluctuations in the output in the various months occupied by the trials, however, detract from the reliability of the figures as a basis for accurate comparison. According to the report of the pit officials, the saving effected by using the Ingersoll-Sergeant machine averaged 3d. to 4d. per ton of coal raised; but no allowance is made for the cost of the compressed air. In the experiments referred to, the machine worked at an average speed of 160 strokes per minute, at a pressure of 5 atmospheres. The consumption of air per double shift of 700 minutes is calculated at 318 cubic metres (11,230 cubic feet), on the basis of 2·84 litres (173·3 cubic inches) per stroke; or, allowing 30 per cent. for loss of energy by cooling, friction, leakage, &c., a total consumption of 413·4 cubic metres (14,600 cubic feet) of air per double shift. Now, the average cost of compressed air per cubic metre at a colliery is about a farthing, so that the cost of the air consumed in a double shift would be 8·27s., or, per ton of coal (on the basis of a 40-ton output) raised, 0·21s. (2¾d.). Consequently, the actual saving effected by the use of this machine, under the conditions of the trial, would be merely nominal; and since these conditions were of the most favorable character to be met with in the Ruhr district, there appears little probability of the Ingersoll-Sergeant machine gaining ground in Westphalian mines, more especially as the seams are generally very steep, the roof poor, and the coal of low solidity. On the other hand, the machine is of value in opening out, rapidity of advance being the most important point in this case; and it is considered that in driving ways through the coal, especially at a low gradient, the work could be done twice at fast by the machine as by hand labor.

The percussion cutters of German manufacture employed in these experiments included the Duisberg machine (Duisberger Maschinenfabrik, successors to Bechem and Keetmann), the Flottmann machine, the Froehlich and Kluepfell (Barmen) machine, the Korfmann (Witten) machine, and the "Triumph" machine (Schwarz and Co., Muelheim), all of which are driven by compressed air. All these machines are similar to the Froehlich and Kluepfel machine shown, the compressed air being admitted to the working cylinder by a reversing valve, actuated by the compressed air from the main cylinder, and either with or without shell valves. The only exception to this rule is afforded by the "Triumph" machine, wherein the admission is governed by the working piston itself. The area of the piston is greater on the rear face than in the front, so that the piston is driven forward with greater force than is exerted in the back stroke; the cushioning effect of the air left in the cylinder prevents the piston from striking against the cylinder head at the end of its travel. Twist is imparted to the cutting tool (point) during the back stroke, by means of a rifled attachment fitted to the cylinder; the forward stroke is a direct one.

The dimensions of the several machines are as follows:—The Duisberg machine weighs about 214 lb., the cylinder diameter is 3·4 in., and the stroke is 8 in.; the Flottman machine weighs 187 lb., the cylinder diameter is 2·8 in., and the stroke $7\frac{1}{4}$ in.; the Froehlich and Kluepfel machine weighs 198 lb., the cylinder diameter is 2·9 in., and the stroke 6 to 8 inches; and the Korfmann machine weighs 123 lb., the cylinder diameter is 2·4 in., and the stroke 8 in. Altogether, these machines differ little, if anything, in construction from the rock drills of the same makers, the chief point of interest being centered in the method of attaching them to the stand, and in the shape of the cutting tools, both these features being specially designed for the purpose of working the machines as coal-cutters. In addition to an adjustable sleeve or collar, gripping the upright of the stand, this connecting device is arranged so as to permit the cutting machine to be rotated. In the Duisberg machine this movement is effected by means of the Eisenbeis patent guide sector, which causes the cutting tool to describe an arc, and, being adjustable, enables the cut to be made in any required direction. A similar arrangement is fitted to the "Triumph" machine. In the other machines the connections are of a simpler character, that of the Froehlich and Kluepfel machine consisting of a clutch fitted with a lateral bore, into which fits a projecting pin on the machine. When the machine is to be used for horizontal cutting—*i. e.*, work in a plane at right-angles to the stand, it is firmly connected with the clutch, which latter then sits loose on the upright, so that the machine can be turned about the upright by means of the lever provided for that purpose. For vertical cutting the clutch is tightened on to the upright pillar and loosened with regard to the machine, so that the latter can move in a plane parallel to the axis of the pillar. A similar attachment is fitted to the Flottmann machine. In the Korfmann machine, however, the clutch is provided with two arms, one of which has a vertical bore and the other a horizontal one. For horizontal cutting, the trunnion of the machine is attached to the vertical bore, but to the horizontal one for vertical cutting; and when the cut is required to be made close against the floor an extra arm is attached to the vertical bore for carrying the machine. Taking into consideration all the relative advantages and defects of the two kinds of fittings, preference is generally accorded to the clutch form, which is in addition much cheaper than the guide sector.

The cutting points of these machines are of various design. All these points are provided with a tapering bore for attachment to the piston-rod of the machine. Numerous experiments have shown that an appreciably higher efficiency is obtained with the simpler cutting points than with the more elaborate pattern, while the advantage possessed by the latter, of being easier to sharpen, is discounted by the fact that the points are not exposed to any great amount of wear in cutting through the comparatively soft material, coal. As regards the relative defects and advantages of the German machines, that of Korfmann has the advantage of being light and therefore likely to be suitable for use in steep seams, where the heavier Duisberg and Froehlich and Kluepfel machines cannot well be employed. Whether this lightness means extra cost in repairs still remains to be proved; but the slightly inferior efficiency in cutting, per unit time, would seem to be compensated by the smaller time needed to set the machine in position for work. Both the Duisberg and the Korfmann machines exhibit the defect that they stick at the end of the forward stroke in the event of the bit failing to encounter sufficient resistance, in which case the machine has to be swung round till the bit is out of the cut, and the piston must be pushed back by hand, after closing the admission valve. This is particularly liable to occur at the commencement of a cut, and always means a certain loss of time.

Some endeavors have been made to alter the German machines by removing the twist mechanism, so as to approximate them more closely to the type of the Ingersoll-Sergeant machine; but the increased cutting capacity would seem to be counterbalanced by an irregularity of cut, and a tendency for the bit to slide off corners forming within the cut itself, though in one case this defect was found to be overcome by more skilful handling. In their usual form the German machines are generally fixed in position by setting up the pillar 30 to 40 inches way from the coal face, fitting the clutch on loosely, inserting the machine in the latter and adjusting it at the proper level for making the cut, and finally connecting up the compressed air supply. Two men are usually needed to set up the machine, and the task may occupy as much as one to one and a-half hours, according to the dip and thickness of the seam and the condition of the roof; but in a thin flat seam a light Korfmann machine can be set up by one man in five minutes. The width of the cut averages 3 to 5 inches, according to the bit used; and a depth of 10 ft. can be cut without difficulty, though it is usually preferable not to exceed 6 to 8 ft., and the breadth seldom exceeds 10½ ft. in wide faces. To prevent the coal breaking down when brittle, the undercut portion must be well spragged, as it might otherwise bring down the next portion before the completion of the cut, and thus hinder progress.

From some comparative trials made, over a period of three months and under identical conditions, with hand labor and with the Froehlich and the Duisberg-Eisenbeis machines, it appears that the rate of progress made by the machine averaged 60 per cent. more than that obtained by hand work, whilst the consumption of explosives was reduced by about one-half. The total cost of mining with the pick amounted to 26·3s. per metre run, but only 14s. with the machines, or including the estimated cost of the compressed air, allowance for waste, depreciation of plant &c., to 16s., a saving of 10·3s. The output per man per shift was increased from about 1·6 tons by hand labor to about 2·6 tons with the machines. Similar results were obtained in another set of trials with the Froehlich and the Flottmann machines, the saving in blasting material being particularly noticeable.

No data are as yet available for numerical comparison of the efficiency of the Garforth, Ingersoll-Sergeant and German machines. The Garforth machine cannot be used for opening out, but the results obtained in long-wall working show that the output of this machine is far superior to the percussion machines in all places where its use is feasible. The Ingersoll-Sergeant machine is superior to the German machines in its stronger construction; but it is rare that the conditions of deposit in the Ruhr basin are suitable for the employment of this machine. The limit of dip under which the German machines can be successfully used has not yet been ascertained; but they are apparently capable of less restricted employment than either the Garforth or Ingersoll-Sergeant machine. Up to the present the German machines have only been used in opening out work, but there seems no reason to suppose they would give less favorable results in actual winning.

So far the use of machines in the Westphalian field has been confined from hard to medium seams, and it appears questionable whether they are applicable to softer coal at all; if not, they will be shut out from a large number of the pits in this district.

In addition to the diminished cost of machine work, the latter presents certain other advantages, including a larger percentage of lump coal and less waste in winning and washing; the possibility of taking out seams hitherto unworkable; greater rapidity of working; and reduced danger in mining. The larger percentage of lump coal results from the greater extent of cut possible with machine work, and the consequent diminution in the use of explosives. The shape of the cut made by the German machines resembles that of the Garforth machine, though not so deep; and this shape makes it feasible to take out any parting in the seam, by means of the machine, and so yield a cleaner coal. The possibility of winning hitherto unworkable seams means an increase in the coal reserve, and a longer life for the coal-mining industry, as well as improved utilisation of the costly preparatory work. The greater rapidity of machine work enables the attack to be concentrated, timber saved, and the effects of rock pressure (a time factor) to be reduced. The diminished danger accruing from the use of machines is largely due to the reduction in the consumption of explosives, and is more especially noticeable in the case of falls of rock shattered by blasting. The use of machines also necessitates systematic working, since, if the timbering be defective, premature subsidence may retard working for a considerable time; and therefore it is to the interest of the men to see that the timbering is well done at first. Accidents from falls of coal are less frequent, because the machinist has the machine between himself and the face, and is therefore less exposed to danger from this cause. The statistical reports from the United States conclusively prove the favorable effect of machine work on accidents, and a similar experience has been gained in the Dorstfeld pit, where 150.000 tons were got by machining in 1900. The number of compensated victims of accident in this pit has declined since the introduction of machine work, from 7 per 1,000 miners in 1897 to 3·51 in 1900, that is to say, by 50 per cent.—*Colliery Guardian, London.*

The Brooklyn Elevated Railway Chooses the Westinghouse Electro-Pneumatic System of Train Control.*

The Brooklyn Elevated Railway Company has just given an order to the Westinghouse Electric & Mfg. Co., for 210 multiple train-control equipments, which will be used for the operation of electrically propelled trains on its lines. A few years ago the management of this road decided to discard steam locomotives and to operate all trains electrically. Before making such a wholesale change, however, it was deemed prudent to test exhaustively the different methods of handling electric trains. If the steam locomotive were to be replaced by simple electric locomotives, many of the advantages of electric traction would be sacrificed. In order to reduce the dead-weight hauled and to obtain a higher tractive effort when starting, it is better to place the driving motors on the trucks of several of the passenger cars of a train and thus take advantage of the weight of the cars than to put the motors on a locomotive, which must be artificially loaded down to give it the necessary adhesion. Other reasons for choosing a system employing a number of motor cars per train rather than a single locomotive were that, since the service is fluctuating, during a part of the day the large motors of the locomotive would be operated at a light load and consequently low efficiency. Moreover the trains could not be broken

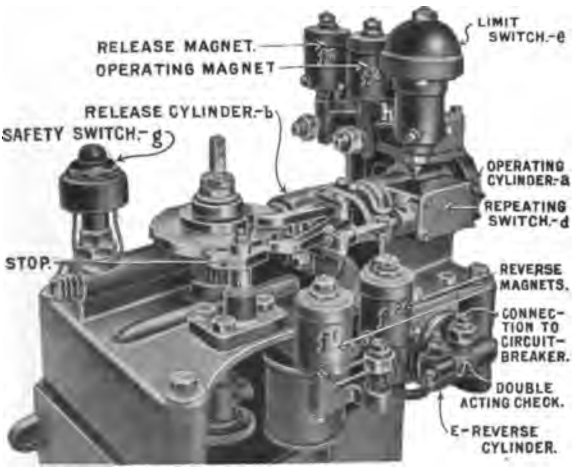
MOTORMAN'S CONTROLLER.

*We are indebted to the *Street Railway Journal* for the use of the accompanying illustrations.

up into single units, as is possible when a number of the cars carry their own motor equipments.

The Brooklyn Elevated Company, therefore, went to the leading electrical manufacturers who had developed systems for controlling a number of motor cars in a train, and asked them each to equip a number of model trains for testing purposes. These trains were placed on the Brooklyn road a few years ago and have since operated in the regular daily traffic. The companies furnishing equipments were the Westinghouse Electric & Mfg. Co., of Pittsburg, the General Electric Co., of Schenectady, N. Y., and the Sprague Electric Co., of New York City. Careful

George Westinghouse, and, on account of his long experience in railroad and electrical matters, is eminently adapted for the operation of trains under everyday railway conditions. The Westinghouse system involves the use of compressed air for moving the current-controlling apparatus, electro-magnetic valves governing the admission of air to the controlling cylinders and low voltage electric circuits running from car to car for controlling the action of the magnet valves. The connections for the low voltage circuits are the only ones which have to be established between the cars of the train, no air connections being required outside of the ordinary brake hose. A complete equipment



TOP OF CAR CONTROLLER.

records were kept of the number of miles run by each train, the number of accidents met with, the cost and time required for repairs, the comparative convenience in operation, and all other matters that might influence the decision. The result of this investigation has been the placing of the order mentioned above. All steam locomotives now in use will be in a short time replaced and trains will be operated by the Westinghouse system. In addition to the order for 210 cars, the company has already purchased about 150 equipments which have been in satisfactory operation for nearly a year.

The Westinghouse Multiple Train Control system has been developed by Mr.

for each motor car consists of two or four electric motors, a controller very similar to the controllers used on ordinary street cars, and one or two motormen's controlling switches, from any one of which all the car controllers on the train may be operated. The car controller, as stated, is similar in design to the ordinary form of hand controller which has been successfully used on electric street cars for many years. It consists essentially of two drums which revolve in bearings, and stationary contact fingers which make contact with points upon the revolving drums. The large, or main drum, opens the main circuit and makes the motor and resistance combinations; the small drum reverses the motors. A multiple control switch is placed at one or both ends of each motor car and by means of the one at the front of the leading car the motorman controls the action of the controllers on all of the motor cars in the train. Some of the points of superiority of this system over other systems may be stated as follows:

It employs compressed air for operating the control apparatus and thereby uses a powerful and reliable agency. It uses the standard type of controller and standard types of valves and magnets, the latter having been used for years in the operation of the Westinghouse electro-pneumatic system of switches and signals upon the largest railways in the world. It is the only system in which the control circuit is isolated from the main power circuit. The

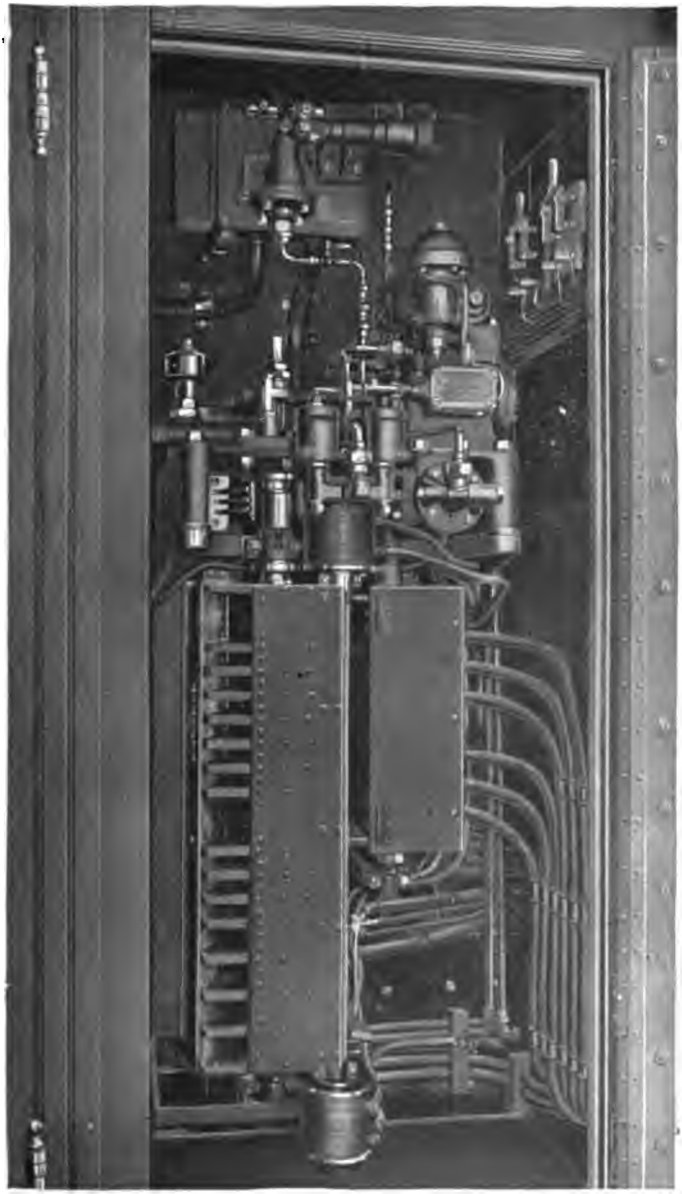
CIRCUIT BREAKER.

control circuit is, therefore, not affected by a momentary interruption of current due to ice and sleet on the rails, or other causes. With the low voltage current, grounds and short circuits at the connectors between the cars during stormy weather or fires resulting from high voltage circuits through the train are entirely eliminated. The current for the motors is simply collected from the third rail, led through the local car controlling apparatus to the motors, and then back to the service rails, and does not pass from car to car. The controlling apparatus is so located that the motorman may have convenient access to all parts from the platform.

The motor circuits on any car are automatically opened in case of excess current and they can all be simultaneously closed at the will of the motorman. All controllers are automatically turned off by the application of the automatic air brakes, which is an important point since in case of a train breaking in two the brakes are automatically applied and at the same time the power is shut off. With other systems under some circumstances, it has been found impossible to shut off the power from some of the cars, while in the Westinghouse system there are a number of ways in which this may be accomplished, greatly reducing the possibility of accident. Both controllers and circuit breakers are opened by a breaking in two of a train, this action being independent of and in addition to the effects obtained by the application of the air brake. The controllers may be operated by hand, thus permitting the train to run to a terminal station in case of any derangement of the controlling apparatus. The operation of both brakes and controllers is effected by a single air hose connection between the cars, the air compressor which furnishes air for the brakes also furnishing air used to operate the controllers.

The Brooklyn Elevated will equip all its new cars with four motors each. The 150 cars now in use equipped with the Westinghouse system have each two motors. The trains on the road are made up of five or six cars, two or three of which are usually motor cars. When tnese trains reach the suburbs they are broken up into smaller units of one or two cars, each of course containing a motor car, and the small trains branch off on different divisions. By the use of this system it is possible to operate cars individually as on ordinary trolley roads, or to make them up into trains of any length. Also, any proportion of motor cars may be usea, making it possible to obtain any desired amount of power for starting the trains quickly, which is necessary in any service involving many stops.

The significance of the investigation into the different systems of train control which has been carried on by the Brooklyn Elevated will be appreciated when it is remembered that the Rapid Transit Subway in New York will be operated by electricity and, since its trains must be operated at high speed, some system of multiple train control will have to be adopted. There is, also, the Pennsylvania tunnel system under New York,



VIEW OF CONTROLLER COMPARTMENT OPEN.

which the ordinance recently passed by the Board of Aldermen requires must be operated by electricity or some other agency not involving burning of fuel in the tunnel.

In the great transportation problems which are being solved in New York City, the Westinghouse Company has borne a prominent part. It has furnished the power equipment of the Brooklyn Elevated, also the power equipment of the Manhattan Elevated, including eight of the largest generators ever built. It has contracted to furnish the power equipment of the Rapid Transit Subway, the power-house of which will contain six units similar to those furnished to the Manhattan people, while the Brooklyn Elevated contract indicates a satisfactory solution of the train control situation.

Ventilation in Mines.

Of equal importance with safety appliances and precautions in the development, equipment and operation of mines is the necessity for an abundant circulation of pure air in mine workings. Excepting in coal mines, and certain metal mines, where fire damp occurs, though the latter are comparatively rare, too little attention is given to ventilation. Incidentally some mines, through the agency of connections with neighboring property, or by reason of having two or more shafts connected within their own lines, are splendidly ventilated. In such mines only raises, winzes and the bottoms of the main shafts are points where air is temporarily badly ventilated, but even these are far superior to the main workings of other mines not having the advantages of several shafts or outside connections.

In seeking the reason for this neglect to provide proper ventilation it is found that in the early history of the mine a ventilating fan of small size was put in and run until it became absolutely impossible to continue development without more air. A larger blower, sufficiently large for all time, it was supposed, was installed with a special engine and run it, and a new 12-inch pipe line. Down to 1,000 feet this ventilating fan and engine may have answered admirably, and made it possible to supply every drift, raise, stope and other excavation with fresh air. But mining operations do not cease, and year by year the workings become deeper and deeper, the long levels are driven out longer, and each succeeding day finds a constantly increasing need of more pure air. While the existing condition is recognized, usually from reasons of economy—false economy—nothing is done to provide better ventilation, and so the situation grows daily worse. Finally, the lower levels, at a distance from the shaft, become simply intolerable. The air is always dense, close, hot, heavily laden with nitrous and carbonic gases, and unfit to breathe. The men stagger from the freshly blasted faces and stopes, rendered weak and sick from lack of oxygen and from breathing poison. Something must be done to improve conditions or work cannot progress. Happy thought. A new ventilating fan is placed on the 1,000 or 1,200 level, run by water motor driven by mine water caught up several hundred feet above, or if sufficient power is not obtainable in this manner the fan is run by electricity. This new fan is intended to furnish "pure" air to all workings below its station. But does it accomplish the desired result? Scarcely. It will produce a current of air, but the air driven down into the lowest levels is that which is forced out of the long drifts and stopes of the level where the new fan is situated, and from the levels above, and this air is already overladen with foul gases. These old levels and stopes are full of rotting timbers, which furnish an immense amount of carbonic acid gas, beside that expelled from the lungs of the workmen, and the further exhaustion of the oxygen by breathing and the lights. In certain portions of the mine where the conditions are almost unendurable the superintendent favors the workmen by removing them, and in turn permitting them to work in various parts of the mine where the air is a little better.

Where air compressors are employed to supply machine drills the exhaust of the drills furnishes a given amount of air, but even this is laden with the oil driven into the pipe line from the cylinders of the air compressor, and not particularly agreeable to breathe if one were out of doors, but the miners gladly welcome even this small advantage in their position, if it is an advantage.

Is it economy at all to permit such a condition to obtain, or having been reached to allow it to continue? It is a recognized fact that this ventilating apparatus was at one time efficient, but the mine usually, sooner or later, outgrows it. Is it not far more economical to provide the power with a fan large enough to thoroughly ventilate the mine, and to drive a sufficient volume of pure, fresh air from the surface to every heading, raise and stope that the men may accomplish more work—and this they certainly can, and will, too, without urging.

The unfortunate miners are afflicted with "miners' consumption" and it is "hereditary," is the common expression. Nothing of the sort. It is simply that they are starved for lack of the life-giving oxygen, and though they are stout, hardy men. human endurance has its limit with the strongest of them.

It is not only proper to provide a sufficient supply of fresh air to the men below ground, but it is good business, and the increased amount of work accomplished by the miners will quickly pay for the entire expense of the new ventilating plant.

Decaying timbers in mines create a vast amount of carbonic acid gas, and the removal from the mine of all decayed timber that can be recovered will do much to improve the condition of the air, even though it be still fairly good. The practice of throwing decayed timbers in the "fill" of the mine is a very bad one, for while it is only temporarily serviceable as filling, it vitiates the air to an extent far beyond its value as filling, and it really costs little to hoist it to the surface.—*Mining and Scientific Press.*

Pneumatic Tubes for Mail Service.

Although it is not very generally known, there have been many plans on foot during the last few years to equip all the large cities of the United States with systems of underground pneumatic tubes for the transmission of mail and merchandise. This movement has already been in operation for three or four years in several cities in the East, but it is doubtful whether even the residents of these cities fully appreciate the importance of the system.

How many people living in New York, know, or if they do know it, regard it as anything out of the ordinary, that the greater part of the mail service between New York and Brooklyn is carried on through two large tubes, which run over the Brooklyn Bridge. How many know that the mail is sent from the Grand Central Station to the General Post-office through a large tube, three and one-half miles in length; or that several of the large telegraph offices in New York exchange messages through pneumatic tubes. Philadelphia has its business district and two large railroad stations connected with its post-office by tubes, and talks of installing a mercantile express tube service, stretching out in all directions from the center of the city. Boston sends most of its mail from the post-office to the railroad station through such tubes, and Chicago has adopted it to a certain extent. It is, however, in the European cities where we shall find the system further advanced and used more extensively. London, Paris, Vienna and Berlin are all underlaid with a network of tubes, and many other large cities have either already adopted the system or intend to do so in the near future.

In the very center of all the rush and roar of the New York post-office we find the terminal machines of three great lines of tubing. One runs into the heart of the business section, and ends in the Produce Exchange, another which takes care of the greater part of the home correspondence runs over the bridge to Brooklyn; while the third extends to the north and terminates in the Grand Central Station. The carriers which travel through these tubes are very similar to those in use in so many of our stores to carry change to and from the desk. They are eight inches in diameter and about two feet long, having a capacity for about six hundred letters, and weighing, when filled about twenty-five pounds. The operation of sending and receiving is very simple. A clerk hurries up with a tray, opens one end of a carrier, fills it with small bundles of letters, snaps the lid shut, thrusts the carrier into the machine, and pulls a lever. There is a roar, and then a subsiding rush, the clerk lets go of the lever and repeats the operation with another carrier. We can better see how much time is saved by the use of these tubes, when we know with what great speed the carriers travel. A carrier going from the Grand Central Station to the post-office, a distance of a little over three miles, goes the first mile in about two minutes and as the speed increases as it goes, it covers the second mile in a minute and a half, and the third in something less than a minute. Post-office officials tell us that mails now catch trains at the "Grand Central" leaving an hour ahead of those caught during the old wagon system, and that for mail going far to the north and west, this sometimes amounts to a saving of twenty-four hours during the trip. Letters coming from the west now catch steamers for Europe, which they formerly missed by a few hours and were thus delayed for several days. When we take all these things into account we see that it is almost impossible to figure the saving not only to New York, but to the entire world, affected by this one system of pneumatic tubes.

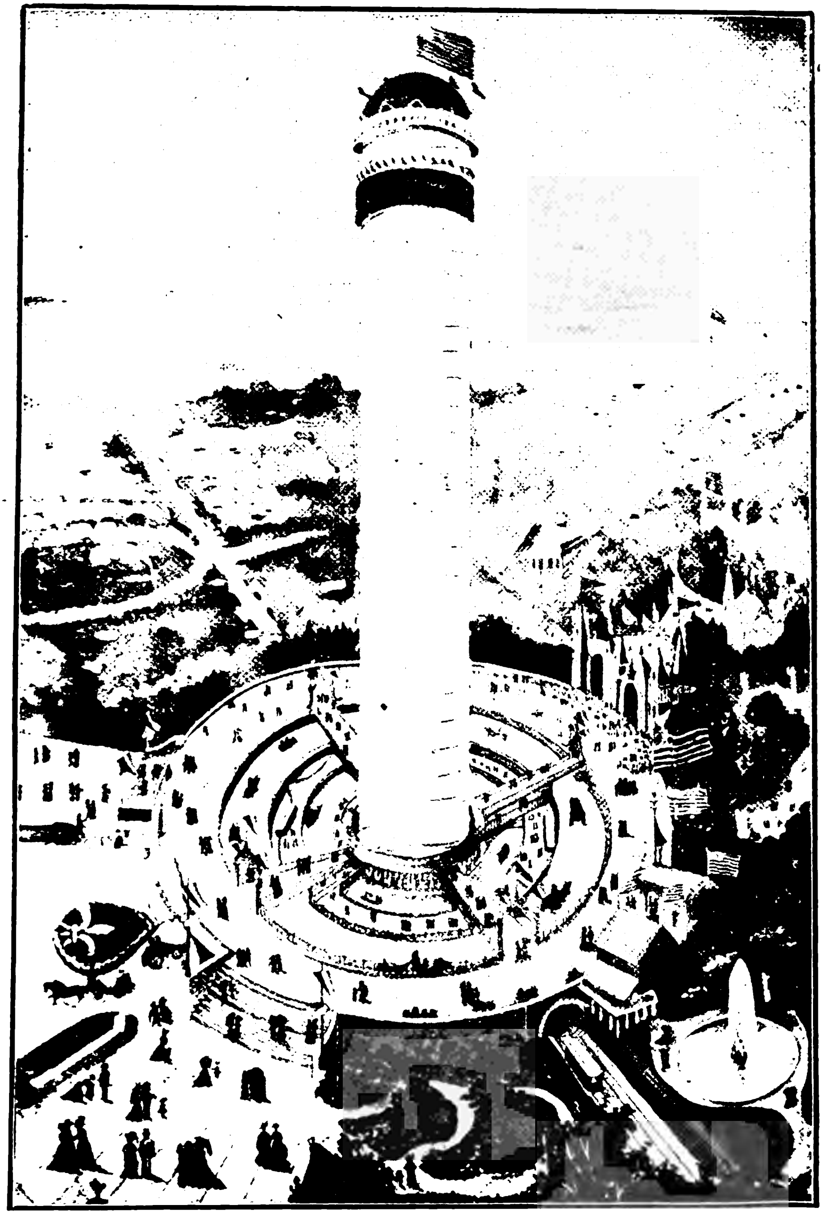
In the European cities there are two distinct systems of pneumatic tubes employed, namely the radial system and the circuit system. London employs the radial system; that is, the system is in the form of a many pointed star, the general office being in the center and the sub-stations at the points. Both outgoing and return tubes extend to all these points. In Paris, where the circuit system is used, a single pipe starts from the central office, makes a tour of all the outlying offices and returns to the starting point. London operates over thirty-four miles of tubing connecting with forty-two sub-stations. The Paris system connects only about twenty stations, but handles nearly as much mail as London. Paris thus has a great deal lower running cost than London, but on the other hand a great deal of time is saved by means of the latter system. In London when any mail goes wrong it is returned immediately upon its arrival at the first sub-station. In Paris, however, the carrier must make the complete circuit of the city before it can again reach the main office. Berlin has thirty-eight stations connected by about twenty-eight miles of tubing arranged on the radial plan, while Vienna employs the loop system.

Oddly enough in most of these cities the carriers are not propelled directly by compressed air. A short solid piston shoots through the tube and thus draws after it one or more carriers. One of the chief objections to the pneumatic tube system has been that in case of accident to one of the carriers, the tube would be blocked, and it would be almost impossible to recover the mail. The possibility of blockades caused by rear end collisions, is done away with in Paris by operating the tubes on a regular block signal system. An electric device automatically keeping more than one carrier out of each block. It has been proposed to lay a very large pneumatic tube under the English channel extending from London to Paris, but the engineering difficulties in the way of this plan are so great as to render it highly improbable if not altogether impossible.

A very complete expert investigation has lately been made into the cost and operation of the pneumatic tube service, with a view to determine whether it should be owned, leased, extended or discontinued by the government. The committee fully sustains the method as a most valuable and mechanically successful system. For New York the committee discusses a plan for the installation of eighteen miles of new line. This would involve the connection of twenty-one substations with the main office. The annual rental proposed is $398,500; but there would be a large reduction in wagon service, elevated railway service and incidental savings, which are reckoned at $101,052. If the system is extended it is proposed to reduce the charge for special delivery. For Brooklyn thirteen and one-half miles of new tubing is proposed, connecting seven new stations at a cost of $172,097. All proposals include the continuance of the existing systems.—A. W. BACON, *Yale Scientific Monthly*.

Compressed Air for World's Fair Tower at St. Louis.

Inhabitants of the world in every nation, civilized and uncivilized, have been called on to build a tower on the World's Fair grounds at St. Louis, that will be a lasting monument to the grandeur of the exposition and the most magnificent tower ever built. For this purpose a company has been organized, known as the Crystal Palace Tower Co.—of which Norton W. Bowman is president, and which has its headquarters in St. Louis. The scope of vastness and grandeur the plans comprehend are almost bewildering to the



TO BE THE WORLD'S GREATEST TOWER.

human conception. Towering to the dizzy height of 1,050 feet the great steel column, 565 feet around, will be crowned by an Acropolis containing the only exhibition of a wireless telegraph station in the world. Over this will float the largest flag staff ever made. Here too at this sky-piercing altitude will be an observatory that will have a capacity of 7,000 visitors at one time. This observatory in the clouds will be reached by inside elevators and by an endless palace excursion car, encircling the outside of the column, which will wind its way heavenward from the base by means of 114 side-wheels traversing a series of spiral railway tracks affixed to the outer walls of the column. In the accompanying illustration the car may be seen encircling the tower near the top on its way to the observatory. The motive power is to be furnished by compressed air machinery. The car is three stories high and will seat 800 people. But grandest of all will be the crystal light effect from which the construction derives it name, "The Crystal Palace Tower." A veritable cystal palace of light will be produced within the column by the suspension of millions of cut glass cystals, strung on wires suspended from the top of the tower and curtaining the entire inner surface of the column with a network of reflecting surfaces upon which a flood of vari-colored electric lights will be precipitated. The crystals will be in constant agitation and the marvelous blending of the myriad rays of mellow light will reflect all the tints of the rainbow.

A lagoon will surround the base landing of the palace car and here is to be a reproduction of ocean bathing. The bottom will be laid with salt blocks and high billows will result from a mechanical wave-producer. Other features of the structure will be the largest photograph gallery in the world, located in the Acropolis; a promenade street car and automobile landing; a grand boulevard above the street car landing; an arena for games, bicycle and automobile races; a terraced grand promenade just above the grand boulevard, from which the numerous attractions about may be viewed. After the fair the tower is to be remodeled to form a permanent exposition.—*Popular Mechanics.*

Heat, Man's Most Useful Servant.

Heat is a very interesting element. It is interesting to note that the 10 miles of air which immediately envelopes the earth contains more heat than could be produced through burning all the coal that is beneath the earth's surface, including also all the wood upon our planet. It is also a fact that there is more coal in the air in the form of carbonic acid gas than in all the coal mines put together; and when we consider that at 70 degrees Fahrenheit we are in a temperature that is 410 degrees hotter than liquid air, which still contains over 100 degrees of heat, and that the difference between 70 and 212, the boiling point of water, is only 142 degrees Fahrenheit, then we can safely make up our minds that we are living in a very hot furnace. Some great inventor will make use of this fact some day to the great benefit of mankind.

All of this heat must come from somewhere and according to our present knowledge the primary source of all energy on the earth is the sun. I will not stop to discuss the various theories as to whence the solar heat originally came, and how the enormous waste continually going on is made good. I will content myself with stating that the compound rays emitted by the sun warm the earth, produce vast movements of water through evaporation and the formation of clouds and so give us warmth and moisture, upon which the growth of the vegetable and animal kingdoms depend. Vegetation derives most of its food not from earth, into which its roots penetrate, but from the air. The lovely mantle of green which adorns the productive portions of our planet is not intended to beautify alone; the vast surface of leaves exposed to the air has the property, under the influence of the actinic or chemical rays of the sun, of decomposing the carbonic acid in the atmosphere, of assimilating the carbon, converting it into the ligneous parts of plants, and releasing the oxygen, which is essential to the life of animals. This is inhaled, and, again rejected, is restored to the atmosphere in the form of carbonic acid.

The quantity of carbon in the atmosphere is relatively small, varying from three parts by measure to ten parts in 10,000, but, absolutely, the weight of carbon thus diffused is greater than all the carbon in a solid form on the earth. The sources of carbonic acid are the expirations of animals, the combustion of vegetable and animal substances, and emanations of a volcanic character. Wood contains from 46 to 55 per cent. of carbon, all derived from the atmosphere; and because the quantity of carbonic acid there is so small, the immense leaf surface is necessary to collect sufficient for the growth of the plant. By long continued contact with moisture and warm air, wood slowly decomposes by combining with oxygen, and is converted, according to circumstances, into vegetable mould, peat, lignite, or, finally, into coal, which, in the form of anthracite, consists of almost pure carbon.

The work done by the sun's rays in decomposing the carbonic acid of the air is very great. The energy which must be exerted to separate the carbon from the exygen in carbonic acid is the same as that developed by the combination of the same element in combustion, and has been determined by experiment to be equal to 14,544 units of heat per pound of carbon consumed. By an easy calculation it can be deduced that every ton of carbon separated from the atmosphere by the sun's rays in twelve hours involves energy represented by 1,058 horse power expended by the sun, but as this energy operates over an enormous leaf surface, its effects are quite imperceptible to our senses.

Mechanically the successes of the nineteenth century have depended upon the utilization of heat.

Could we see air and heat, men would have been led to many further discoveries, and many difficult problems in this connection would have been easy for inventors.

Heat exists in all materials as well as in air. If we take a given amount of atmospheric air, say in a bicycle pump, the air has the heat of the atmosphere, which is, say 70 degrees Fahrenheit. Now we push the piston to compress the air. Through compression a large volume of air becomes a small volume; the 70 degrees of heat cannot be squeezed out of the air as water is squeezed out of a sponge. A volume of air has been compressed! Pressure is obtained, but while doing this a large volume of heat also has been made to take a smaller compass. What happens? Air notifies us of its presence through pressure; heat tells us of its presence through degrees. Without pressure there is no air (vacuum); without degree there is no heat (critical temperature).

The compressed air in the bicycle pump gives us more pressure and more heat. It is possible to so compress air and its heat with it that it will make the pump red hot. On the other hand, if the pressure is entirely released to its starting point, it may seem like magic, but both the air and the pump will become instantaneously as cold as when started. By following this principle we will be able to produce artificial cold. Upon this artificial ice making is based. If we again shove the piston down in the bicycle pump and compress the air and thus make the air and the pump hot, and in this state plunge the pump and the compressed air in it into cold water, thus cooling the hot air in the pump to say 70 degrees Fahrenheit, its starting point and then entirely release the pressure on the air, it will be found that the pump will instantly become intensely cold, for the reason that the heat produced through compressing the air has been taken out, and by allowing the air, through the release of pressure, to take up its original volume, there is a lack of heat. Lack of heat is cold. A very easy proof of this can be had by using a "Sparklet" for carbonizing water. A small amount of liquid carbonic acid gas through release of pressure is allowed to become a large volume of gas. The water may be warm, yet by the discharge of the contents of the Sparklet into the bottle, water and bottle become ice cold instantaneously.

Making artificial ice or producing cold, consists of compressing air or a gas, thus making it hot, cooling the gas in its compressed state with water, and allowing this cold and compressed gas to expand back to its original size. The same gas is recompressed, recooled and expanded over and over again for years. By making ice you are making use of the cold produced, but if you do not make this use of the cold, and let the process continue, liquid air, solid air, or something even colder is obtainable.

The air, even at a temperature of freezing, still contains a great deal of heat. All the heat of all the air at the freezing point, if concentrated by compression, is enough to burn the City of New York off the earth in five minutes; it would melt all the iron in the world in a few seconds; it would make steam for all the boilers and engines of the earth for years.

Having satisfied ourselves that there are other ways to produce heat than to have fires, and that there are other ways to produce cold than by means of having ice around, we are now ready to understand the fact that by burning a fire we not only produce heat, but cold as well. Let us see how this happens. Suppose we burn a gallon of oil. The gallon of oil will become, first, vapor, then gas, then finally a product of combustion. In this form it is at least 500 times as large as when it was oil. You have burnt the oil, you have produced heat, but you have allowed it during the process of burning to expand, to become something very large; you have the ice machine in the midst of your fire. The heat-producing qualities of the burning oil are, it is true, greater than the cold produced through its expansion, so the heat wins the contest, but at a very large loss. If this cold-producing quality of a fire could be prevented, there would be no trouble to produce undreamed-of degrees of temperature.

If we could burn the gallon of oil, and instead of allowing it to expand to a volume of 500 gallons of gases in the open air, we could provide a chamber which has a capacity of only 250 gallons, the products of combustion, instead of being at an atmospheric pressure of 15 pounds, would be under a pressure of 30 pounds to the square inch. The heat would be condensed as well as the gases. Now if we make the chamber so small that instead of 30 pounds we create 200 pounds pressure, a correspondingly high degree of temperature would be produced.

Pressure has a great deal to do with heat. Pressure controls the boiling point of all liquids. Water in a vacuum or without pressure on it, boils at a lower temperature. On high mountains, where the pressure of the atmosphere is less than 15 pounds, the mountaineers cannot cook their beans or potatoes, as the water boils away before it gets hot enough to cook with it. With enough pressure and a strong enough vessel to hold it, it is possible to heat water red hot without boiling it. On the other hand, it takes but little heat to raise the temperature of water from freezing to the boiling point, but it then takes a great deal of heat to tear the molecules of the water apart and convert it into steam, yet the steam will have the same temperature as that of the water. The heat goes into expansion, and as steam is 1,700 times as large as water, a great deal of heat is needed to make up for the increased volume.

Heat can be produced slowly or rapidly. The iron that rusts and the food that is digested in our stomachs are both burned slowly. Oil on the fire burns millions of times faster than the iron rusting. Exploding gunpowder burns many times faster than oil on the fire.

It is the oxygen of the air that does the work, but only 21 per cent. of the air is oxygen. The percentage of nitrogen and the percentage of carbonic acid gas do not help. For that reason a great deal of air is needed to make a fire burn, and the largest loss which steam engineers encounter is the heating up of this 79 per cent. of neutral gases to the temperature of the fire and then having to send them off through the chimney. Coal, in burning, consumes two and one-half times its weight of oxygen. The neutral gases are four times as great in volume. The expansion of the gases also absorbs a great deal of heat. For these reasons the engineer looks at the chimney with a sorry eye.

As it is true that nothing leaves the earth, and that there is more carbon in the air than beneath the earth's surface, it does not seem that there ever needs to be a fuel famine. Future inventors will probably find a means to rob the air of its carbon. There are also other fuels than carbon. Water by weight is one part oxygen and eight parts hydrogen. If these two gases are separated and again brought together and ignited, enormous heat is the result. To separate the water into these gases with our present knowledge, costs more than the value of the heat so obtainable, but some day an inventor may discover how to do it for a less cost than the value of the heat so obtainable. Such a discovery would soon make the inventor a billionaire. We are living in a very wonderful age, and for that reason anything may be expected.—JOSEPH MISKO, M. E.—*Electrical World.*

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The Tynan Annealer and Rivet Heating Forge.

Many uses will be found for the Tynan annealer and forge in repair and regular ship work, and also in particular classes of work in boiler, copper and plate shops, steel car work, bridge building and the like. This device has shown its efficiency in railroad repair shops for straightening bent sills and sides of pressed steel cars, straightening damaged steel body and truck bolsters, arch bars, truss rods, etc. The entire outfit is of a strictly portable character, so that it can be used in any desired position or location.

The first engraving shows the annealer applied for annealing the armor plate of a battle ship to receive the armor door hinges. The general arrangement of the parts is illustrated in the drawing, Fig. 2. The oil supply tank may be carried upon a small truck or placed near the work, as shown in Fig. 1. The air pressure is taken from a general or special pneumatic plant, and is allowed to pass through an air pressure reducing device, thus serving the precise amount of air required for economical combustion. Regulating devices are also used for controlling the supply of air and oil at the combustion nozzle. When a pneumatic pressure service is not convenient a small hand pump will serve the purpose equally as well, an auxiliary air receiver of suitable size being the only detail required to form a portable air power plant.

THE TYNAN ANNEALER WORKING ON ARMOR.

The burner can be directed at any point, and the localizer or concentrator, which is composed of a special mixture of nonradiating material, while allowing the flame to be concentrated on the part to be operated on, also protects the surrounding parts from the heat and prevents the spread of flame. The same burner has been applied successfully to a portable forge by the manufacturers, the Chicago Pneumatic Tool Company, Fisher Building, Chicago.—*Iron Age*.

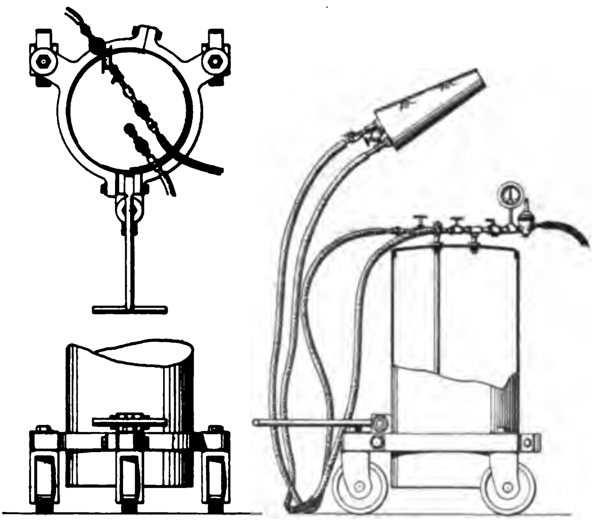


FIG. 2.—ANNEALER AS USED FOR PRESSED STEEL CAR WORKS.

Miners' Phthisis.

ITS CAUSE AND MEANS OF PREVENTION.

The *Cornish Post* gives the following report by Dr. J. C. A. Aymard, of Krugersdorp, on Miners' Phthisis, and will form an appendix to the next half-yearly report of the Government Mining Engineer:

"It is hardly possible to come in contact with the mining community at the present time without realizing the great anxiety which exists as to the prevention of this serious complaint. This apparently was not so before the war, but may possibly lapse into a similar state if the opportunity is not at once grasped.

"In order to properly combat any disease it is of the first importance to become thoroughly acquainted with its pathology (with the conditions found after death microscopically and otherwise). This is particularly true with regard to such a 'mechanically' produced disease as miners' phthisis. We know very little indeed about the actual condition of the lungs; there is no single specimen or record in Johannesburg Hospital, and I fear the whole evidence in the hands of the medical men of the Rand amounts to very little. A natural prejudice exists against post mortem examinations on white men, but it is not too much to say that many opportunities have been lost, especially in the case of blacks. The disease will have to be temporized with until the evidence accumulated by the pathologist of the commission shows us the actual conditions we have to deal with. It is not sufficient to only have evidence with regard to the lungs; every organ of the body must be properly examined, but more especially the heart.

"It is held by some of the highest medical authorities that a preliminary bronchitis lays the foundation for this complaint, and that until the cilia (or minute hair-like bodies lining the air passages) have been destroyed, dust does not enter the lung tissues. It matters little whether this is so or not. The dust may of itself cause bronchitis in the first instance, or, which is much more certain the inhalation of poisonous gases, or again these two causes may both run concurrently.

"It is only necessary for a miner to inhale and retain one grain of dust a day to accumulate ounces in the course of years, and the evidence is wanting to show that a miner's lung becomes a block of cement. It must not be concluded that I look lightly upon the inhalation of dust. I do not. I consider it a very serious factor in the production of this disease. I also think a very small amount permanently retained and lining the lung tissue to be quite sufficient. What I do suggest is, that the amount popularly thought to exist in the lung is greatly in excess of what will be found. The great point which I think most medical men are agreed upon is that damage, permanent and ultimately proving fatal, results from the inhalation of poisonous gases, caused by blasting.

"The dust produced by rock drills, if carefully examined, will be found to largely consist of extremely fine particles, so small that they can easily pass into the bearings of a Theodolite. This dust is described by some as cutting its way into the lungs. I doubt it, and should not be surprised to find that it is actually carried to distant parts in the blood itself.

"Is miners' phthisis produced in Cornwall, America and Australia? Is it similar to the disease on the Rand? I can only say that I have heard such conflicting evidence from men who have lived in all these places that I do not feel disposed at present to risk an opinion. This is a question which the Commission would be wise in investigating.

"We know that nitrous compounds are formed after blasting, but as to their relative quantities, together with other noxious gases we have little to go upon. This indeed is where the Commission can do good work. We want the actual facts; samples of air must be taken in various places after complete and partial explosions, and these must be carefully analyzed. The air should be the ground which gives rise to so much dust and gas disturbance. The results of laboratory experiments do not give us what we want. The conditions are probably very different on the spot.

"Miners should realize that it is not only when bronchitis is caused by gas that damage is done, but that, however, produced, it has its serious influences. Men leave their work in their sodden clothes saturated with perspiration and damp, covered in dust, frequently taking their meals in this condition, and almost always thus returning to their rooms. This should be stopped by law. In some mines an effort is made to counteract this evil, but it should be universal.

"I would suggest that close to every shaft a drying room be erected in charge of a competent man. The moment a man leaves the shaft he hands his overalls to an attendant, whose duties are to place them in a steam drier, a matter of a few minutes; then by exposing them to the air they are fresh and dry when wanted. In this room there should be hot and cold water giving every opportunity for the miner to wash.

"When the above reforms have been carried out it will be possible for doctors to see almost at a glance the condition of these men, and many lives will be saved."

The *Daily Chronicle* writes on this same subject as follows:

"The constitution of the Commission to inquire into and report on miners' phthisis has been very severely criticized here. The predisposing cause of the disease, as is well known, is inhaling the sharp angular dust particles arising from the blasting and drilling of the rock, and also the lack of proper ventilation in the mines. So far, this is comparable with similar diseases at home—for instance, steel-grinders' phthisis, stonemasons' phthisis, and tin-miners' phthisis—but there seems to be considerable difference between the miners' phthisis in the Transvaal and that at home. It appears to be the impression of the people on the mines, firstly that it attacks younger men, and, secondly, that the life of the patient when he is attacked is curtailed to a greater extent than in England. A considerable number of young and healthy men are brought out from Europe to work on the mines, and these, of course, on account of their youth, should have a long span of useful work in front of them. But if the reports are anything like accurate, the number of these men who survive five or ten years' rock drilling seems to be but small. Even if they do not get the disease in a fatal form, they are compelled to turn their attention to other kinds of work, as they become incapacitated for rock drilling. The importance of the existing state of affairs is enormous, firstly to the men themselves, secondly, to the mines, and thirdly to the general community.

"To the men—A rock driller is a skilled laborer; he therefore has had to undergo a training. In the ordinary course of events he expects to obtain a fairly high rate of wage until his working days are over, instead of which he finds after a period of say five years he has two alternatives, either to continue his work of rock drilling and look forward to the inevitable early death at the end of another five years, or he must seek some other occupation, for which he has probably no special training, and which therefore commands a much lower rate of pay.

"To the mines—The result of the men becoming sick is that the mining authorities have constantly to employ new series of less experienced rock drillers, which must necessarily affect their progress.

"To the general community—The mines being the mainstay of the country, and as at the present juncture their progress is retarded, it will naturally follow that South Africa itself will also be retarded. And further, the conversion of the wage-earning young man into an aid-requiring pauper is a very serious consideration to the remainder of the community.

"Miners' phthisis, until proved to the contrary, must be assumed to be a preventable disease, or in any case one that is capable of reduction. However, the amount of our knowledge is inconsiderable when compared with the amount of our ignorance on the subject, and it is only by a very thorough investigation of the disease and the conditions that a sufficiency of knowledge will be gained to enable the miners to work under circumstances which will not render their occupation 'dangerous.' To this end the Commission has been appointed, and it is concerning its constitution that the criticism has been very severe by those having the interest of the mines and the miners at heart. It would seem to be an axiom that whenever a Commission is appointed on a question such as this the list of members should include the name of at least one scientist. On the first Commission on Tuberculosis at home the list of members included Professor German Sims Woodhead and Professor Sydney Martin, and on the second Commission on Tuberculosis Professor John Macfadyen and other scientists were serving. These are especially named because in addition to their general scientific knowledge each had been previously engaged on the investigation of tuberculosis. The Royal Commission on Sewage included amongst its members Professor Boyce and Dr. Houston, both gentlemen of high scientific attainments who had had a considerable experience of the bacteriology of sewage before the Commission was appointed. The list could be very largely extended. These Commissions are mentioned because they were upon questions not dissimilar to the question that will come under discussion in miners' phthisis, both being very scientific in their bearing, and both being of great economic value.

"It is, of course, realized that in an important Commission such as the present, which entails the sifting of so much probably contradictory evidence, and the findings of which may be of such vast communal importance, one, at least of its members should have some legal training. Good as the medical practitioners serving on it undoubtedly are, and however much experience they may have had of the disease from its clinical aspect, it is doubted if any of them would lay claim to any special scientific knowledge, or venture to call themselves scientists. Although the lay mind is not conversant with the various departments of medicine, it has not got the notion that a general practitioner is not quite the same as a pathologist, and a great deal has been heard about the pathology of phthisis. Where, then, is the pathologist? It seems strange that the Government, evidently realizing the gigantic importance of the inquiry, should have constituted the Commission on lines so different from those of other countries, by the omission of the name of a single scientist.

"At present it is unknown what power the Commission have to appoint or invite a scientific man or men to sit with them as assessors, and it is possible that this defect may be remedied. But the opinion remains that such a man should have been appointed by the Government, and not left for the invitation of the Commission. Is there no such man available in the Transvaal? It is believed there is; but if the Government think not, they still have

Natal and the Cape to draw from, and, failing these, the United Kingdom. Certain it is, however, that without the assistance of a scientist the labor of the Commission will almost certainly lack proportion—which is expected when a Commission is appointed on a subject of such vast importance."

The Making of Liquid Air.

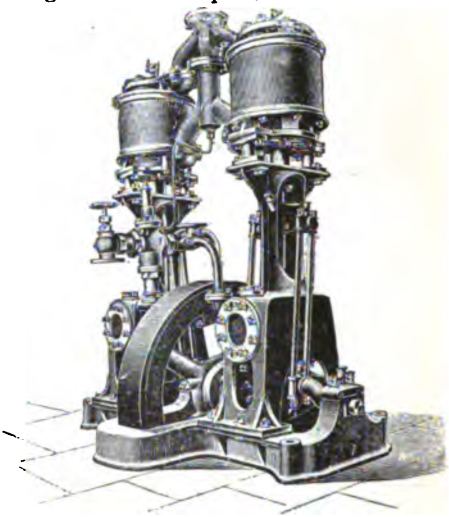
A great deal of nonsense has been written about liquid air, principally in America. It was to be the power of the future. By its means power was to be obtained for nothing, and so on. In the lecture which he gave before the Cold Storage Association recently, Dr. Carl Linde, of Berlin, did good service in clearing away a good many misconceptions. It would not be economical to employ it in cold storage work, he explained, because when you only require a temperature a few degrees below the freezing point of water, it is not economical to produce a temperature 280 deg. F. below. Power has to be expended in producing cold, and the power is roughly proportional to the degree of cold produced. Liquid air in small quantities, the lecturer observed, would be very useful, say, for cooling dining or ball-rooms. In these cases the quantity of liquid air would be so small that the high price at which it was produced would not matter. Drawings were shown of apparatus by which rooms could be cooled in this way.

Liquid air is produced from ordinary atmospheric air, by a continuous process of compression and cooling. Every substance, it is supposed, may exist in one of three states, the solid, the liquid, or the gaseous, according to the surrounding conditions. Each state presupposes the presence of a certain quantity of heat in the substance. Thus in the solid form, a smaller quantity of heat is present, actually in the substance itself, than in the liquid form; and again a smaller quantity of heat is present in the liquid form than in the gaseous. The addition or the subtraction of heat from any substance, in sufficient quantities, will cause the substance to change its state. In addition, the three forms in which substances may exist, mean that the molecules, the very minute parts of the substances, are very much closer together in the solid form than in the liquid form, and in the liquid form they are much closer together than in the gaseous form. So that in order to liquefy a gas, two things are necessary, the closing up, as it were of its molecules, and the extraction of a certain quantity of heat from it. When air is compressed, as in those cases where compressed air is used for mechanical purposes, heat is generated in the air, in the act of compression. It represents a portion of the work done upon the air, by the compressor. And this heat has to be extracted, as well as the heat possessed by the air, in virtue of its condition as a gaseous mixture, before it can be liquefied. And so in the process of making liquid air, the air is continually compressed, by successive stages, and continuously cooled, a very pretty device being made use of in the cooling, by which the air which has been cooled to a certain degree, is made to cool air that has not reached that point, so that the effect is cumulative. When liquefaction is finally reached, the air in its liquid form looks exactly like water, and may be poured out just as water is—with certain precautions. The fact that liquid air is at the extremely low temperature named, makes it dangerous to handle, without precautions similar to those which are taken in handling hot bodies. With very cold bodies, heat passes from the hand, say to the object, at a very rapid rate, just as heat passes from a hot body to the hand, at a rapid rate. It is the rate at which the heat is transferred, either to or from the human body which causes the pain and other troubles. When poured out on a table the liquid air runs about in small globules, just as mercury does, and disappears in a very short time. It has returned to its gaseous form. When allowed to escape into the atmosphere, its presence is shown by clouds of mist, producing the impression that the liquid air is converted into fog. This is not so, however. What really happens is, the aqueous vapor which is always present in the atmosphere, particularly that of rooms in which a number of people are assembled, condenses, and then freezes, or forms a sort of hoar frost, and it is that we see, not the liquid air itself. Liquid air seizes every opportunity of returning to the gaseous condition, but it can only do so by extracting heat from surrounding bodies. When it is allowed to escape into the atmosphere, it extracts the heat from the air into which it passes, the atmospheric air of the room, in the immediate neighborhood of the orifice from which it is escaping. This lowers the temperature of the air at that point, and with lowered temperature it is no longer able to maintain so much aqueous vapor in suspension. The vapor is deposited as water, and then freezes. The same action, in a minor form, may be seen in any cold storage engine house, where the cold pipe is covered with snow.

The method adopted for storing liquid air, devised by Professor Dewar, is one of the most novel arrangements that has been seen in the domain of physics for a long time. The air is stored in glass bottles, each bottle consisting of two distinct bottles, separated by a vacuum, maintained at as high a figure as it is possible to obtain. In addition, the outside of the outer bottle is silvered all over with mercury. The object of the arrangement is to prevent the access of heat to the liquid air inside the inner bottle. The vacuum space offers a very high resistance to the passage of heat waves through, or across it, and the mirror formed by the mercury on the outside of the outer bottle reflects the heat waves away from the bottle. The mouth of the bottle is left open to the atmosphere, and it was stated by Dr. Linde that a charge of liquid air would last for about fourteen days. During this time the charge is slowly disappearing by evaporation, by reconversion to the gaseous form, from the passage of heat to the liquid. Closed bottles cannot be used, as, it being impossible to exclude completely heat from the liquid air, the latter would be slowly changing into the gaseous state, and in so doing, creating a pressure within the bottle which no vessel could withstand, which would also resist the passage of heat through its walls. The final pressure was given by Dr. Linde as 12,000 lbs. per square inch, when all the liquid had returned to the gaseous form. This is the reason why steel bottles cannot be employed as they are for carbonic acid gas, ordinary compressed air, and so on.—*Globe,* London.

Double-Acting Air Compressors.

We illustrate herewith a pair of vertical double-acting air compressors, recently manufactured by the Pulsometer Engineering Company Limited, of Nine Elms Ironworks, Reading, and intended to supply a large volume of air at a small pressure of, say, 25 lbs. The plant consists of two separate compressors, each combined with its own engine, the steam cylinder, with its guide and valve chest, being cast in one piece with the main



DOUBLE-ACTING AIR COMPRESSORS.

frame. The compressor is directly driven, two side rods being used, each coupled up to crank placed below the steam cylinder. The valve gear is driven from a separate crank, and is of a modified "Hackworth" type, which gives a very satisfactory steam distribution. The steam cylinders are each 7 in. in diameter by 9 in. stroke. One plant can be run independently of the other if required. The compressors, which are double-acting, 10 in. in diameter by 9 in. stroke, are placed above the steam cylinders, being carried on two wrought-iron standards. The valves and seats are renewable, and the compressor is water-jacketed. Both engines are mounted on one continuous bed, making the whole plant entirely self-contained. An automatic arrangement is fitted, so that when the required pressure is obtained in the reservoir, the plant stops automatically, starting again as soon as the pressure falls 2 or 3 lbs. The plant is fitted up in the company's usual high-class style, and is a thoroughly mechanical job in every way.
—*Mechanical World, London.*

Dental and Surgical Air Pump.

The accompanying cut shows an electric air compressing outfit for use with atomizing tubes in treating mouth, throat and lung diseases, and which is also adapted for dental purposes, such as cleaning cavities in teeth. The outfit, as shown, consists of a single-action piston air pump with metallic ball valves operated by an electric motor, connected by two feet of pressure hose to a 6-gallon nickel-plated tank, which is supplied with a gauge to show the pressure, and stop-cocks and hose connections for leading off to the atomizing tubes, etc.

pump the 6-gallon tank, as shown, up to 10 lbs. in 2½ minutes; 15 lbs. in 4½ minutes; 20 lbs. in 6½ minutes; 30 lbs. in 10 minutes; 40 lbs. in 15 minutes; 50 lbs. in about 20 minutes.

This style of outfit is not only much more convenient than any water pressure air pump, but in most cases will cost very much less to operate, and has the additional great advantage of being able to get the pressure anywhere that it is desirable, and no permanent fixtures are necessary for fitting up this outfit, as all that is necessary to start it in operation is to plug in the lamp socket the same as an electric lamp or an electric fan motor.

THE "EMERSON DENTAL AND SURGICAL AIR PUMP."

The pump can be started with the maximum pressure in the air tank. A small air valve is furnished at the bottom of the pump, and when it is desired to start pumping when pressure is on the tank, this air cock should be opened until the motor reaches speed. As soon as the motor reaches speed, close this air cock and the air will be delivered into the tank without stopping the motor.

This pump will compress air up to about 50 lbs. pressure, but is more efficient up to about 30 lbs. pressure, which, we understand, is usually sufficient for this class of work.

The pump has a capacity of about 1½ gallons of free air per minute, and will

The cost of operating such an outfit is hardly worth considering, as at the ordinary rates charged for an electric light current of 20 cents per 1,000 watts, it would cost less than one-fourth of a cent to pump this tank of air up to 20 lbs. pressure.

All of the parts of this outfit are extremely simple and durable, the pump having long, heavy bearings, and the valves being metallic, the only part of the pump which might require renewal after a considerable length of time being the leather packing of the piston, but this can be replaced by anyone in a very few minutes, and at a cost of a few cents.

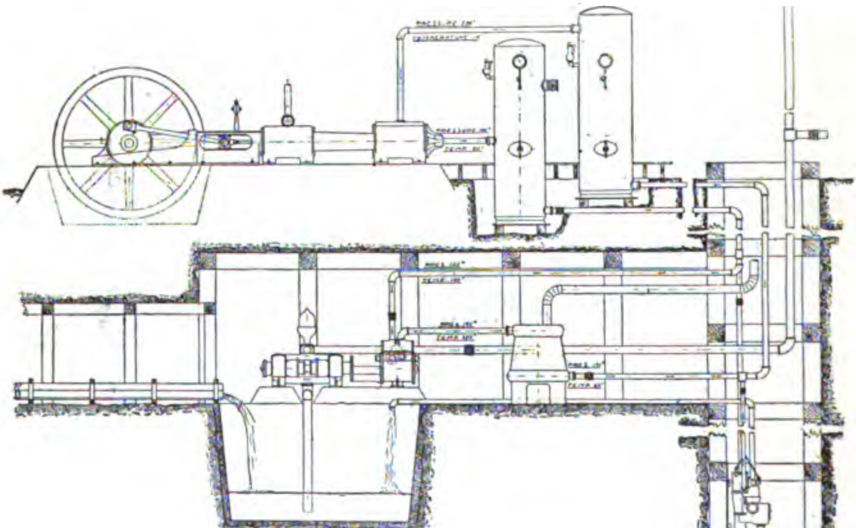
The motor is our regular type of small

power motor, which has a half-inch shaft, and for such a use as this, will practically last forever. In ordering, great care should be taken to give the exact voltage of the current on which it is desired to use it, and in addition to this the number of alternations per minute of the current, if for use on alternating current circuit.

The "Dense Air" System of Power Transmission in Deep Mine Pumping.

There has been recently installed at the Bisbee West Copper Mining Company's shaft No. 1 a pumping plant using air as a means of power transmission. This plant was installed by the John Wigmore & Sons Company, of Los Angeles, Cal., and is operated under patents which they control. They have named the principles of these patents "The Dense Air System of Power Transmission." This dense air system has as its object the use of the difference in pressure between two confind air bodies. A compressing engine is used to maintain the greater pressure by raising that of the low-power body of air and delivering it to the high-power body. In operation the low-pressure air is sufficiently above atmospheric pressure and sufficiently cool to allow of an economic line of compression in reaching the high pressure. The general scheme of the system is shown in the accompanying drawing.

Following is a brief description of the machinery employed in the Bisbee West Plant. Steam is supplied by a 60 horse power horizontal return tubular boiler burning fuel oil. This boiler supplies a 30 horse power hoist, and the air compressor of the pumping plant. The main compressor is one built by the Ingersoll-Sergeant Drill Company, and is one of their standard straight-line type, with the exceptions that the air end was built a little heavier than usual, and that the piston inlet was enclosed in a bracket fitted for pipe connection to the return system. The steam cylinder of this compressor is 16 inches in diameter by 18 inches stroke, and is furnished with an adjustable Meyer cut-off valve. The air



DENSE AIR SYSTEM OF POWER TRANSMISSION.

cylinder is 12¼ inches diameter by 18 inches stroke. The regular poppet inlet and discharge valves supplied by the manufacturer are used. From this compressor two lines of pipe are led to the shaft, about 60 feet distant, and then to the 700-foot level. The high-pressure line is 2½ inches diameter, while the return or low-pressure line is 3 inches diameter. In the high-pressure line is an air receiver 36 inches diameter by 8 feet, and also a reheater of sufficient size to heat the air to 300 degree F., the reheater being on the 700-foot level adjacent to the pump and the receiver on the surface near the compressor.

The low-pressure, or return line, is continuous from the exhaust of the pump to the inlet of the compressor. The pumps used were built by the Cameron Steam Pump Company, and are of their standard station and sinker types. The station pump has an air cylinder 16 inches in diameter by 18 inches stroke, and a center packed plunger 6½ inches diameter by 18 inches stroke. This pump raised the water from a sump on the 700-foot level to a tank 40 feet above the collar of the shaft, giving an average lift of 750 feet. A vertical sinking pump 10 by 5 by 13 inches is also included in this installation, but was not operated during the test given below. Its duty is to lift the water to the sump on the 700-foot level from the shaft bottom. A small compressor 6 by 6 by 6 is connected to the low-pressure return line, its duty being to supply sufficient air to overcome leakage from the pipe lines and stuffing boxes of the machines, in this manner keeping the quantity of air in the system constant. In the following test the reheater was not used. This reheater was designed to burn gasoline, but it was found that it was impossible to do so, as there was not sufficient air in the pumping station, which is very small, to support combustion. If this reheater could have been used the efficiency of the plant would have been at least 20 per cent. better than that shown by test. In the following table will be found the average results of a series of tests of this plant made September 14, 1902:

Duration of tests.......	1 hour each.
Average steam pressure at throttle of compressor	81 lbs.
Total steam used by compressor	802 lbs.
Average R.P.M. of compressor	52.3
Average R.P.M. aux. compressor	20
Average R.P.M. pump..	39.8
Average pressure: inlet to compressor........	83 lbs. gauge.
Average pressure: discharge from compressor	158 lbs. gauge.
Average pressure: inlet to pump	152 lbs. gauge.
Average pressure: exhaust from pump....	92 lbs. gauge.
Average temperature: inlet to compressor....	69° F.
Average temperature: discharge from compressor	162° F.
Average temperature: inlet to pump.........	89° F.
Average temperature: exhaust from pump..	52° F.
Average ft.-lbs. per minute shown by indicator cards, steam end compressor	1,075,300
Average ft.-lbs. per minute steam end aux. compressor	22,300
Total average ft.-lbs. per minute shown on steam end of compressors	1,097,600
Average ft.-lbs. air end compressor, as shown by indicator cards..	1,045,100
Average ft.-lbs. air end auxiliary compressor.	19,500
Total ft.-lbs. air end of compressors	1,064,600
Total water pumped...	833 cu. ft.
Cubic ft. of water pumped per minute..	13.88
Average lift	750 ft.
Total ft.-lbs. per minute in water pumped.	649,584
Efficiency of ratio between ft.-lbs. of work in air cylinder of compressor and air cylinders of pump........	70.6 per cent.
Efficiency or ratio of ft.-lbs. shown by indicator cards on steam end of compressors and ft.-lbs. of work in water actually pumped	59.2 per cent.
Duty or ft.-lbs. of work in water pumped per 1,000 lbs. of steam used, .4............	8,600,000

From this test it is very readily seen that the efficiencies are exceptionally high for a deep mine pumping plant.

One incident in regard to this plant showing its adaptability to deep mining operation occurred September 20. The supply of fuel oil was exhausted, and there being no other fuel obtainable, it was necessary to shut down the plant. Before more fuel oil was secured—a matter of three or four days—the water had risen in the mine almost to the 200-foot level, putting the pump about 500 feet under water. When the boiler was fired up and the compressor started, the pump started with the compressor, as was shown by the water from the discharge pipe. It required about 48 hours of continuous running to pump the water down to the pump level. During this time the pump worked under water at its greatest capacity and continuously.—D. A. McNeill in *The Engineering and Mining Journal.*

Chain Coal Mining Machines Operated by Compressed Air.

The first breast type of coal cutting machine was brought out by the Jeffrey Manufacturing Company, of Columbus, Ohio, and as one now looks back on such early machine and compares it with the chain coal cutter as now manufactured by that company, he is impressed with the great strides that have been made in coal mining machinery during the past twenty years.

The early efforts resulted in a machine having upright engines attached to a moveable carriage or bed-plate, to the front of which was attached a frame, on the extreme outer end of which was supported a round bar, designated as a cutter-bar, the surface of which was covered with small tools steel cutters. This bar was supported in suitable bearings, and power was transmitted from the engine shaft to this bar by means of an endless steel chain. The engine, carriage, moving frame and cutter-bar were all fed forward in an outside stationary frame by means of a screw, the depth of undercut depending upon the length of the frame. On the outside of stationary frame were placed light chains with suitable wings attached for the purpose of bringing back away from the face of the coal the small particles of coal or cuttings which were displaced by the revolving cutter-bar. The width of the cut was about thirty-six inches, the depth of the cut varying from five to seven feet, and the kerf removed about four inches. It would make an interesting chapter in the history of coal mining if the failures, break-downs, and obstacles which were met with by the manufacturers and users of this early machine could be recorded. This first machine was built with the one idea constantly in mind ot keeping the weight down to the minimum, and as a result the machines went to pieces just about as fast as they were put up against the coal.

An amusing incident has been told of a test run which was made in the presence of a prospective buyer of one of these early machines. A miner had been employed to operate one of these machines and to try to make a success of it. His faith in the machine far exceeded the merit of tne machine as shown in actual service. He had been for weeks struggling to make the machine work successfully, and was finally able to make one single undercut. After finishing this one cut he received from his employer a telegram, advising him that one of the largest operators in the country was going to visit the mine to see this machine in operation, with the idea in view of adopting it throughout his properties if an examination satisfied him as to its practicability. The miner was in distress, but finally decided to pack the kerf of the one cut which he had succeeded in making with the fine particles of coal which had been removed, set the machine in the position in which it had made its original cut, and await the visit of the operator. His deceit worked like a charm. The machine buried

AIR CHAIN COAL MACHINE.

its cutting frame in the fine cuttings and finished its run without a mishap. The operator was won over to the great future of the mechanical coal cutter and the necessity for all up-to-date mines to be equipped with the "Iron Miner." It is of interest to note that this same operator has been since that day a constant user of the breast type of machine, and perhaps has been the very largest user of coal cutters in the country.

The Jeffrey Manufacturing Company kept hammering away in the face of almost unsurmountable difficulties, strengthening the parts which proved weak, altering from time to time the different feed and pull back mechanisms as defects developed, lowering the engines down close to the frame of the machine, making it possible to adopt the machine in the thinner veins of coal, and in fact departing very largely indeed from the original idea as to form and construction, until they finally made the most distinct step toward the perfecting of the machine by changing from the cutter-bar type to the chain type. This change, it was found, immediately reduced by over one-half the power required to cut the coal. An illustration is here shown of the chain type of air machine. We regret that we have not been able to get hold of a photograph of one of the very earliest types of cutter-bar machines having the upright engines.

Prior to the change from the cutter-bar type to the chain type of machine, the Jeffrey Manufacturing Company had developed and brought out the electric motor to take the place of the air engines on the machine. There are to-day a number of mines throughout the country where it has been found desirable, on account of gas and other peculiar local conditions, to use the air machine in preference to the electric so that the 16-D air chain machine is still manufactured in large numbers.

Compressed Air as Transportation Agent.

The *Scientific American* contains in its special "Transportation" number an article by Mr. Waldon Fawcett on compressed air locomotives from which the following has been taken:

"With a more extensive use of compressed air for power purposes has come a corresponding broadening of the scope of its employment as a transportation agent, and indeed it has been conclusively proven that pneumatic traction has decided advantages over all other forms of mechanical haulage for a large variety of operations. Prominent among these are the various phases of underground haulage. For coal mines where there is danger from mine gas its utilization is almost essential, whereas the advantages which commend its employment in non-gaseous mines are almost as potent. A rather unique field has been opened by the introduction of compressed air locomotives in railway tunnels, where the smoke vapor and gas from steam locomotives are objectionable.

"For the ordinary compressed-air haulage plant there are five essential features, namely, the locomotives, constructed to carry stored-up energy in the shape of compressed air, a charging station, a stationary reservoir, usually consisting of one or more storage tanks in which the air is compressed, an air compressor capable of compressing any desired number of cubic feet per minute to any pressure desired, and power for operating the compressor, either steam or water power being applicable for this purpose.

"The general machinery of an air locomotive, cylinders, frame, etc., is usually very similar to that of a steam locomotive, save that the weight is greater, the bearings larger and the details of construction stronger than in a steam machine of the same power. The main points of difference are found in the fact that instead of the usual boiler with its fuel and water accessories for developing power, the air locomotive is equipped with one or more strongly constructed main storage tanks, which are charged with compressed air at high pressure, a combination regulator and automatic stop-valve and an auxiliary low-pressure reservoir, in which the air is carried at a uniform working pressure for distribution to the cylinders. The cubic capacity and the pressure of air in the main storage tanks on a motor are determined, of course, by the amount of stored energy required by the length of the run which such a locomotive is to make and the weight of the train which it is called upon to draw. Not infrequently locomotives are built to carry an air pressure of 800 or 1,000 pounds, but relief valves make it impossible to charge the motor tanks to a higher pressure than is required. The initial storage pressure decreases, of course, while the locomotive is working. As illustrating the capabilities of the compressed air motors, it may be mentioned that there are in service in this country a few locomotives which are fitted with seamless, steel tubes and carry a pressure of from 1,500 to 2,500 pounds per square inch.

"For charging the locomotives storage tanks previously referred to, there are provided the charging stations, which are connected with the stationary receiver or reservoir by a pipe. It is customary, when the reservoir or storage system is a pipe line, to have a charging station at each end of the line, so that the motor may take a charge of air at the end of each single trip or each round trip as required. Air locomotives may be charged either direct or by reservoir. However, direct charging is very wasteful, and consequently the method most generally accepted involves the use of the stationary reservoir.

"The reservoir for a compressed-air transportation line usually consists of either a pipe line or one or more storage tanks of construction similar to the locomotive storage tank, although usually designed to carry a somewhat higher pressure. By means of the reservoir system the compressor may be kept in nearly continuous operation at a fairly uniform speed. By an automatic system of governing the compressor, when the work is light, slows down in speed, whereas when the demand for air increases, the speed is quickly brought up to the required capacity."

Priest Snow Flanger.

The flanger is attached between the front truck wheel and the pilot, and is supported directly on the truck. The effect of this is to give a very slight motion to the flanger across the track in passing around curves, thus enabling the flanger to be constructed so as to cut the snow close to the rail, cutting about 2 inches deep on the inside and 1 inch on the outside. The flanger being supported directly by the engine truck does not rise and fall by the movements of the engine on the springs, thus enabling a deep cut to be made, and at the same time maintaining a uniformity.

The knives are placed about 1 inch above the rail, which avoids all friction and wear, and enables the use of torpedoes with no danger of their removal by the flanger.

These knives are strongly built so that they will cut the hardest snow. The knife proper is attached by means of bolts to the wings so that in case of an accident nothing but the knife will be injured, and any engineer can easily remove the knife and replace with a new one.

It is operated by means of an air cylinder controlled in the cab.

This flanger can be used with perfect safety on all trains. It is properly located, gives clean rails for all wheels, leaving no snow to absorb power by contact.

Prevents derailments caused by engine truck wheels mounting hard-packed snow or sand.

Costs nothing to operate; in charge of and controlled by engineer; run by compressed air.

Daily use of flanger prevents formation of hard flanges, making line always passable for hand-cars, facilitating the work of section men instead of increasing it by flanging by hand.

Preserves full tractive power of locomotives, preventing loss caused by intervention of snow and ice between driving wheels and rails.

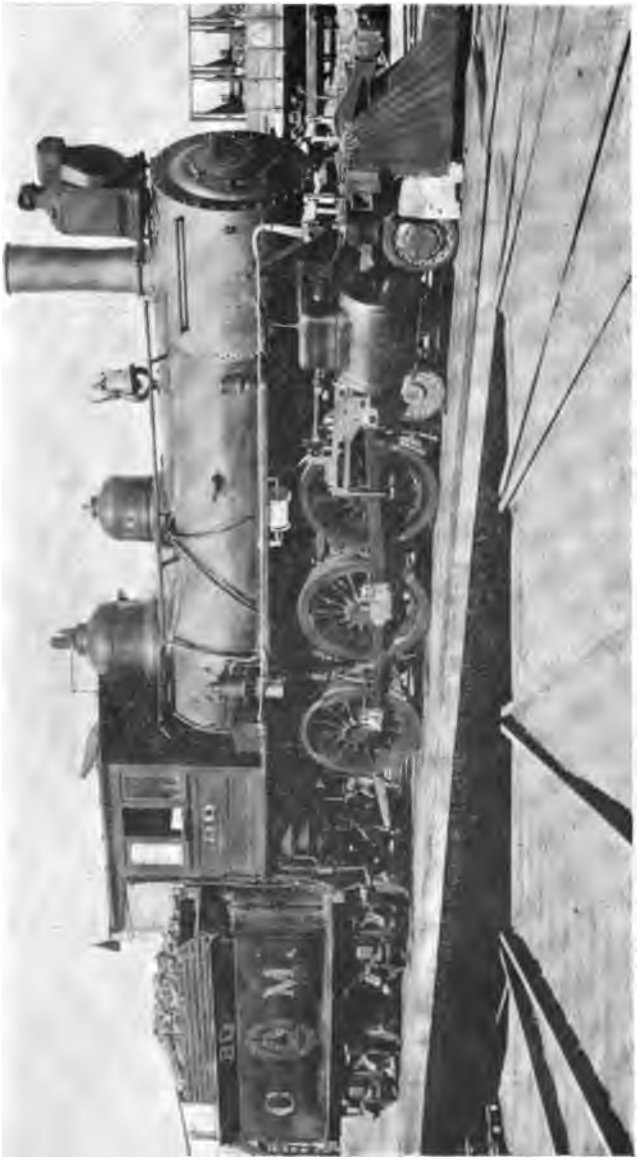
Avoids rail and tire cutting by slipping on snow.

The flanger is not unsightly, being behind the pilot and out of the way.

A pilot plow of any size desired can be carried in the usual manner.

A passenger train equipped with the Q and C-Priest Flanger will readily run through 10 inches to 12 inches of hard-packed snow and sand. A freight engine will pull its usual winter load under same conditions with but slight reduction of cars.

These flangers are now being used on more than thirty railroads in the United States.



LOCOMOTIVE FITTED WITH PRIEST SNOW FLANGER.

Doubling the Efficiency of Compressed Air.

In the volume of the *American Machinist* for the year 1898, at page 219, will be found an article with the above title in which I showed the promise of largely increased economy in compressed air power transmission by the use of the dense air or return pipe system. In this system the same air is used over and over (a small auxiliary compressor making up for the leakage) and the pressure in the exhaust or return pipe is maintained far above the normal atmospheric pressure. In the example which I considered in the article referred to, the assumed working pressure was 200 pounds gage, and the exhaust pressure 100 pounds. Theoretically the system promised a great increase in efficiency, and this has since been realized in practice. Several applications of the system have been made upon the Pacific coast and all have shown most satisfactory results.

I am enabled to present here some data from an installation of this system at the Bisbee West Mine, near Bisbee, Arizona. The plant consists of the following: One Ingersoll-Sergeant Straight-Line air compressor, steam cylinder 16 inches diameter, air cylinder 12¼ inches, stroke 18 inches; one Cameron station pump, air cylinder 16¼ inches diameter, plunger 6½ inches diameter, stroke 18 inches. A 6x6x6-inch auxiliary air compressor is connected to the low-pressure pipe line to supply leakage in pipe line, thus keeping the pressure constant at any desired point. The duration of the test here recorded was 70 minutes:

AVERAGE TEMPERATURES.

	Degrees F.
Inlet to compressor	69½
Receiver	162
Inlet to pump	88.8
Discharge from pump	51.6
Station	72
Engine-room	93

GAGE PRESSURES.

	Pounds.
Inlet to compressor	83
Discharge from compressor	158.3
Inlet to pump	152.6
Discharge from pump	90.9

MEAN EFFECTIVE PRESSURES IN CYLINDERS.

	Pounds.
Compressor	65.6
Pump	61.7

SPEED.

	R. P. M.
Compressor	56.35
Pump	19.9
Auxiliary compressor	98.7

WORK.

Total indicated foot-pounds in air cylinder of compressor per minute	1,268,400
Total indicated foot-pounds in air cylinder of pump, per minute	751,500

The power thus indicated at the pump is 59 per cent. of that of the compressor cylinder, while with the usual compressed air practice in driving a steam pump in this way it is rarely that more than 25 per cent. is realized.

This plant is criticised for its deficiencies by the operator of another dense air plant, where a rock drill is operated instead of a pump. The drill is 1,800 feet from the compressor, and there are two lines of 2-inch pipe 1,300 feet long and two lines of 1½-inch pipe 500 feet long. The working pressure is from 215 to 220 pounds, and the return pressure 95 to 100 pounds. Notwithstanding that it is much more difficult to keep the piping around a drill tight than it is around a pump, the auxiliary compressor to make up the leakage is not run more than a quarter of the time. The compressor in this case, with air cylinder 5 inches diameter by 9 inches stroke, runs 90 to 95 turns per minute, and besides driving the 2¾-inch rock drill in "the hardest rock I have ever seen" it also runs a 5x6-inch slide valve engine eight hours a day to drive a blower, and pumps 8,000 gallons of water 200 feet high. The joints of the pipes in this case were made with shellac, which the engineer claims accounts for the small leakage. He also suggests that the pipes at the Bisbee West mine are too small, being 2½ and 3 inches instead of 3 and 4 inches, the latter of each of course being for the exhaust.

I regret the crudeness of the information here given, but it still seems clearly to show that, both theoretically and practically, there is much to be saved by the adoption of this system wherever there is any permanency of installation. The above data came from Mr. F. H. Wheelan, president of the Pneumatic Power Company, 224 California street, San Francisco, Cal.—Frank Richards in *American Machinist.*

Electrical Equipment Manhattan Elevated Railroad.

In January, 1902, the *Railroad Gazette* described the new electrical equipment on the Manhattan Elevated Railroad, New York City. One year has passed and the system is nearing completion. Difficulties have developed, but most of these have been met and the indications are that within a short time the entire system will be working smoothly.

Compressed Air's interest in this railway rests on the use of the air brakes.

Each of the motor cars on the elevated line is equipped with an electrically-driven air compressor for working the air-brake system. Each compressor consists of a motor, about 5 h. p. direct connected to a two-cylinder direct-acting air pump without gears. Each compressor is controlled by an automatic governor which maintains the proper air pressure in the storage tank. The Westinghouse quick-action automatic brake is used, giving much quicker retardation than the vacuum brake, thus allowing speed to be held longer.

The complete motor and controller equipments, as well as the air compressors and their governors, were designed and built at Schenectady by the General Electric Company, this being the largest single order ever placed for electrical apparatus.

The eight motors on one six-car train weighing with passengers 154 tons will, on a level track, bring the train up to a speed of at least 15 miles an hour 10 seconds after starting from the station, which is over twice the speed that the steam locomotives can reach in the same number of seconds with a five-car train. If allowed to run up to full speed the electric trains will reach 40 to 45 miles an hour on a level track.

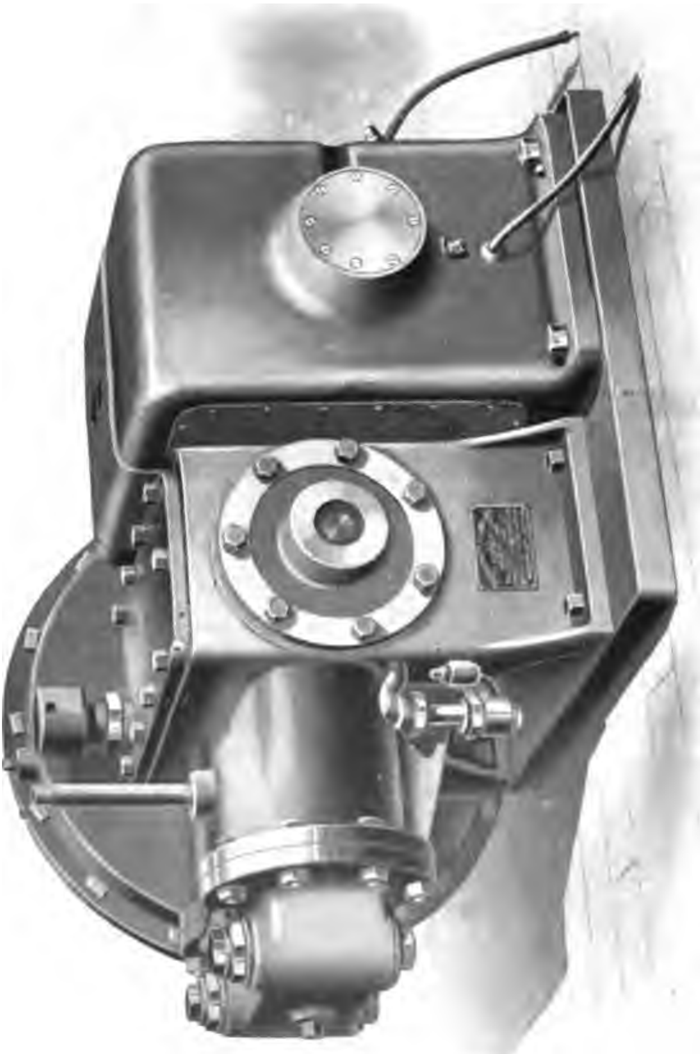
The motorman controls all eight motors on the four motor cars of a complete six-car train with one controller, much smaller than the controller of the ordinary street car. Each of the motor cars is fitted with the General Electric Company's train control. Each motor car is fitted with a master controller at each end, so that a train of any number of cars may be reversed at the end of the route without switching.

The generating station occupies the block bounded by Seventy-fourth, Seventy-fifth, the exterior streets, and the East River. All current is generated there, the plant having a maximum capacity of 80,000 h. p. The main building is divided by a longitudinal wall into two parts; the boiler plant and accessories occupying one-half and the engines and dynamos the other.

Westinghouse Electrically Driven Air Compressor.

A growing demand exists for electrically driven air compressors adapted to supply compressed air for car brakes and train signals as well as for various other industrial uses.

To supply this demand the Westinghouse Air Brake Company has designed a motor-driven air compressor, which consists of a pair of parallel cast-iron cylinders in which are trunk pistons connected to a crank shaft. The cranks are spaced 180 degrees apart, so that as one piston commences its forward stroke the other begins its return; thus the pistons constantly move in opposite directions and produce a continuous and uniform thrust on the shaft. The pistons are single-acting; that is, the air is compressed only on the forward stroke. The axis of the crank shaft is located below a plane through the axes of the two cylinders in such a way as to minimize the angularity of the connecting rod during the forward or working stroke, and by this arrangement the wear of the cylinder and piston is largely decreased. The crank shaft is of cast steel, connected to the motor directly by a gear and pinion. The valves, made of machine steel, are, in form, a successful modification of the



WESTINGHOUSE ELECTRICALLY DRIVEN AIR COMPRESSOR.

simplest check, and, while meeting every demand of the most severe service, requir little or no attention. Placed vertically, they operate without springs, and can be very easily removed or replaced without disturbing any other part. Particular attention has been given to reducing the cylinder clearance to a minimum; and, as a result, this clearance is so small that an unusual efficiency, approximating 80 per cent. of the theoretical displacement, is obtained. The pistons are of cast iron, fitted with improved packing rings which prevent any undue leakage of either air or oil. The cylinder head, including valves, can be easily removed, and ready access to the pistons secured. The teeth on the pinion and gear are of the helical, or "herringbone," type. This style of gearing has proved to be durable and best adapted to operate with the least possible amount of noise.

The Tunnel Hospital.

The strangest hospital known is that which is being maintained to-day in Jersey City for the benefit of the Hudson River tunnel workers.

The "hospital" is fitted up on the tunnel company's grounds for the treatment of those who collapse while working in the compressed air of the long black hole.

The work has to be carried on under atmospheric pressure far exceeding the normal pressure on the earth's surface of fourteen pounds to the square inch. The abnormal pressure is bad for most men and fatal for some. Men working under such conditions are attacked by a strange disease known as "the bends." Many, too, go down with heart failure.

To allow men who collapse to be brought immediately into the normal atmosphere would in most cases be fatal. This explains the company hospital.

It is not a hospital of the ordinary kind. It consists of a huge cylinder, like a locomotive boiler without the tubes. It is fitted with air pipes and valves, by which the atmospheric pressure can be regulated. It is also fitted with a cot, on which the victim of an accident or of the "bends" may be placed.

When a man is overcome he is removed through the various air locks slowly, and then, with a companion, is sent up the shaft and immediately taken to the "hospital." He and the man who accompanies him are admitted and the air is turned on. It is compressed to the proper degree and then the pressure is gradually reduced and the victim allowed to become accustomed to it until it is down to the normal, when he can with safety go out into the open air. This treatment takes hours of time.

Of course, there are other features of the treatment, but the main principle of the hospital is the compressed air.

Dr. A. J. Loomis is in charge of the hospital and he is kept busy with the many cases that come from the black hole each day.

It is said that in the heading at the New York end of the tunnel, the atmospheric pressure is so great that men can work only twelve minutes at a time.

A man stands at the lever that controls the valve with a watch in his hand and on him the lives of the men in the heading are said to be absolutely dependent.

Notwithstanding the hospital, the tunnel is not without its victims. The last was Patrick Garvey, of this city, who died recently of the "bends."

Garvey dropped dead in the ferryhouse of the Erie Railroad while he was on his way home after having undergone nearly twelve hours of most excruciating agony.—*The Chicago, Ill., American.*

Novel Engine, Which Runs by Oiled Air. Is a New Form of Motive Power.

The Diesel Engine does not operate by an explosion, as is the case with the ordinary gas or internal combustion engine or other types. There is no mixture of combustible elements in the cylinder excepting at the moment when the combustion is intended to begin. There is no explosion and there are no ignition devices of any description, the machine being a simple caloric or heat engine, using air as a medium of expansion instead of steam. Steam has received heat from the fuel at the boiler. Air in the Deisel process receives heat direct from the combustion of oil-fuel mixed with the air in the working cylinder.

The engine operates on the Otto cycle or four-stroke principle, the first stroke filling the cylinder full of air at atmospheric density. The second stroke compresses the air to about 35 atmospheres.

At the point of highest compression the air is practically in an incandescent condition. Just at the reversing point in the stroke of the piston a certain quantity of oil is sprayed through an atomizer in the shape of mist, but not vapor. This oil is immediately ignited and burns slowly through a limited portion of the stroke. The expansion of the aid and gases completes the third or working stroke, and the fourth stroke ejects the gaseous products of combustion, clearing the cylinder for a repetition of the cycle.

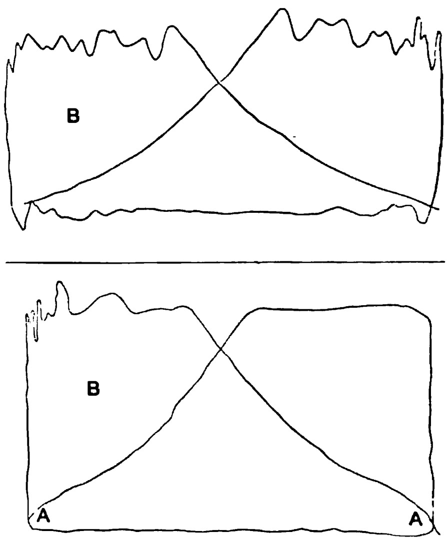
The conditions required in order to make the nearest possible approach to the perfect Carnot cycle seem to be almost ideally met in the Diesel engine, hence the results claimed for it are rational. Where the best steam plants convert only about 10 per cent. of the total heat of the fuel into work, the Diesel engine is said to convert from 25 to 30 per cent.. and this in the smallest sizes as well as larger ones. Furthermore, the range of best economy extends over a large part of the entire power, whereas in the steam engine this range is limited to a very small part of the entire power.

Regardless of the size of the unit, the consumption of fuel will not exceed 0.5 to 0.6 pound per brake horse power per hour, when the engine is running within its economical range; or, more particularly speaking, a 100-brake horse power engine running one hour at its most economical point will use about six and one-half gallons of oil. This same engine, running at 50 horse power for two hours, will use about seven and one-half gallons, and running at 25 horse power for four hours will use about eight and one-half gallons. It will thus be seen that the economical range is a large part of the whole power range, a great contrast to the steam engine in this respect. In adapting a Diesel engine to a widely variable load, are, element of efficiency at different loads may be practically ignored.

The engine is started with compressed air from a storage tank, and ignition is secured during the first revolution. As soon as the engine comes up to speed, the compressed air supply is automatically cut out and the permanent air supply which injects the oil is also automatically thrown into operations. The starting and running are, in all respects, as positive, reliable and free from tricks as is the steam engine. Regulation is effected by ranging the amount of oil fuel introduced at each working stroke under control of a governor, and any number of engine units can be controlled from one governor.—*New York Evening Post.*

Air Compressor Diagrams.

The following illustrations are two diagrams taken from an air compressor driven by a cross-compound engine. The air is first received into the 19-inch cylinder and afterwards compressed to a higher



Power N. Y.

AIR COMPRESSOR DIAGRAMS.

pressure in the 11-inch cylinder. All the valves in connection with the compressor are poppet valves, with the exception of the inlet valves at low-pressure cylinder. These are gridiron and are operated with a positive motion. You will notice at the point *A* on the diagrams taken from the low-pressure cylinder that there is a considerable rise in pressure before the piston moves. The correspondent who contributed these diagrams to "Power" would like to know what causes the rise shown by the diagrams.

Pneumatic Flue Welding Machine.

There is in operation at the Oelwein shops of the Chicago Great Western Ry., a simple but very efficient and rapid flue welding machine. The device was originated by Mr. H. A. Fergusson, assistant superintendent of motive power of the Chicago Great Western Ry., and was built at the Oelwein shops. It will be noted that the welding operation is accomplished through the medium of compressed air, the admission of the same to the cylinder at the top of the machine being effected by a foot lever. The economical feature of the device is displayed in the statement that from 75 to 80 more flues are welded per day than in the method formerly pursued at the Oelwein shops. About 300 flues are now welded per day as against 225 formerly. A weld is made complete in 4 seconds, and the output of the machine is only limited by the number of flues which can be heated in the furnace, while the work done by the apparatus is so perfect that it has been found that it is not necessary to test the flues before placing the same in locomotive boilers, nor are the flues scarfed befor welding. The ordinary water tests to which the flues are subjected after placing in the flue sheets is all that is necessary, practically no imperfect welds having been found, and there are 19,000 flues in service which have been welded on this machine, with no failure reported at the welds up to this time. The welds are so perfect that it is practically impossible to detect the point at which the two parts were joined together, even after the flue has been thoroughly cleaned and subjected to acid treatment.—*Railway and Engineering Review.*

Cylinder Sizes on Air Compressors.

A fine air compressor—a 14x14x24—was in operation in a large railroad plant, supplying air to many kinds of pneumatic tools, portable engines, car cleaning, airbrake testing, yard jacks, and a dozen other kinds of service. This air compressor was not equal to the demands made upon it for air, was often hot—that is, the air delivery was hot, and once exploded the reservoir, 40 inches by 14 feet, one end going through a brick wall and the other out into the yard. This reservoir was replaced and the compressor run afterward just as before the accident. Now remember this air compressor was a real compressor, a fine machine by a reliable builder, and when not hot was practically noiseless compared with some shop air compressors.

In making repairs on the compressor the machinist found that the air cylinder had been reduced to 12 inches by a cast-iron bushing, and that too without any provision being made for water circulation. On his recommendation that the bushing be removed he was gravely informed by those in charge that their air pressure was very high—85 pounds needed at intervals and 75 pounds continually. The steam pressure being only 85 pounds, it was impossible to enlarge the air cylinder by removing the bushing as they could not then obtain the needed 85 pounds air pressure.

It was impossible to tell these people that 85 pounds of steam in a 14-inch cylinder could compress air to 85 pounds in a 14-inch air cylinder; absurd, nonsense. So it was given up as a bad job.

There are many people who know just as much in the matter of air compressing.
—F. Rattek in *Power.*

Notes.

The current market price of liquid air in Berlin, where a company has been formed for its production and sale, is 1s. 6d. per litre, or nearly 1¾ pints.

"A man named John Baumgardner, of Manistee, Mich., went 'daffy' on the subject of compressed air last week. He was given a berth in the county jail until removed by friends."

The Trigg Granite and Marble Works, of Rockford, Ill., has recently installed air compressors and added pneumatic tools to their already large plant for cutting letters on monuments.

By "free air" is meant air at one atmospheric pressure, 14.7 pounds to the square inch. An altitude of 6,000 feet—barometer 28.83—would give an air compressor—theoretical standard 100 per cent. sea level—a comparative efficiency of 82.8 per cent.

If a volume of air at 60 pounds pressure, equivalent to 18,000 cubic feet per hour, at atmospheric pressure be passed through 1,000 feet of pipes, the loss of pressure of air for 2½ inch, 3 inch, 3½ inch pipes would be 5¾ pounds, 2 pounds, 1½ pounds, respectively.

A contract has been completed between the Great Central Railway Company and the British Pneumatic Railway Signal Company of Chippenham, Wilts, for the installation of automatic pneumatic signals through the Woodhead Tunnel, which is over three miles long.

When using compressed air don't install your piping without properly providing for drainage of condensed moisture at regular intervals in the system. The simplest method is to slightly incline the branches leading from the main line and insert drain cocks just before the hose connection is reached.

A little booklet has found its way to us, telling all about the Flinn Defferential Steam Trap, manufactured by Richard J. Flinn, West Roxbury, Mass., and sold by A. Lorge, Jr. & Co., 1019-21 Monadnock Block, Chicago. This device was described in the November issue of COMPRESSED AIR, page 2080.

The efficiency of compressed air can be greatly increased by using air-heating stoves. The efficiency of fuel consumed in heating compressed air is more than six times greater than burning the same fuel under a boiler. The efficiency of the motors is also considerably increased owing to better lubrication and to less danger from freezing up.

To determine the amount of air that can be produced by different size air cylinders, multiply the area of the cylinder by the stroke; multiply result by 2 if it is a straight line compressor; by 4 if a duplex compressor, or by 2 if a compound duplex compressor. Divide this result by 1,728, which will give the amount of air per stroke, then multiply by number of strokes per minute.

A turntable operated by a compressed air engine is in use at the West Oakland shops of the Southern Pacific Ry. The motor in use was designed at the shops. It works at 100 lbs. pressure and uses about 8½ cu. ft. of free air in turning a locomotive. The cost of the device was about $250. It is described and illustrated in *The Railway and Engineering Review* of Dec. 13.

Compressed air can be used in steam engines without any change being made in the construction of the engine if the exhaust be large. A small exhaust will have a tendency to cause the moisture in the air to freeze as it escapes from the the vent, but this may be remedied to some extent by causing the air to exhaust underneath water. A better, but more expensive method, is to reheat the air.

The Chicago & Alton has just put in a system of compressed air appliances which underlies their entire yards. The pipes are equipped with a hose fixture at each of the side tracks on which the trains are placed that are made up here. One end of the pipe is connected to a pipe at the compressed air building. This plan is now used to test the air on all trains before they are connected to an engine to be sent out on the road.

Recent important contracts awarded the air compressor department of the Chicago Pneumatic Tool Co. include five cross compound compressors, of 600 feet capacity each, for the Baltimore & Ohio Railroad; two compressors of 2,000 feet capacity each for the Pressed Steel Car Company; 2,000 foot compressor for the Kawasaki Dockyard, Japan; two 600 foot compressors for the New York Ontario & Western Railroad, and one 700 foot compressor for the signal department of the New York Central & Hudson River Railroad.

The Philadelphia Pneumatic Tool Co. has just completed the equipment of Kaiser Wilhelm's new navy yard at Kiel, Germany, with an outfit of Keller Pneumatic Tools. This is the latest phase of the American commercial invasion of Europe.

Looking in the opposite direction this company reports an increasing trade on the Pacific coast. Mr. O. A. Berger, the representative of the Philadelphia Company in San Francisco, has just visited the home office, bringing with him some large orders from the various ship yards, steel works, etc., on the Pacific coast.

While it is known that air can be made solid as well as liquid, up to the present comparatively few experiments have been made in this direction. A scientist recently converted a certain quantity of liquid air into a small solid mass, and on examining it found it was as transparent as clear ice and as elastic as rubber. To test its elasticity he struck it with a hammer, and the latter immediately rebounded. That solid air may prove to be of commercial value is the opinion of some scientists in Germany, but it is admitted that many more experiments will have to be made before any certainty on this point can be arrived at.

In blasting, the ground has everything to do with the grade and amount of powder used. It is not an unusual thing to drill holes to a depth of ten feet, and in some few instances to a greater depth, but as a rule a hole, say six feet, may be considered about the average. Such a hole will take about ten sticks of giant powder. In the large companies where there is room these drill holes are about two inches in diameter and the sticks of powder are one and one-quarter inch. Every one of the big companies must necessarily carry a large amount of this fearful explosive in the mines, sufficient, no doubt, should it explode all at once, to level the camp.

The Cripple Creek and Pueblo Railroad Company, of Colorado Springs, Colo., with $2,000,000 capitalization, filed articles of incorporation with the El Paso County Clerk on Dec. 10. T. B. Casey, of Boston, is president; J. R. McKay, of Chicago, treasurer. J. T. McAuley, of Chicago, is a director. The object of the company is to build a road from Cripple Creek to Pueblo over a route not to exceed thirty-three miles in length. The proposed road will reduce freight rates and secure Pueblo smelters a share of Cripple Creek business. Electricity or compressed air will furnish the motor power for the road, which will be partly an underground system.

The Fairmount Glass Works, Alexandria, Ind., has made a new application of an old principle which promises to lengthen the life of natural gas fuel and is giving marvelous results in the burning of the fluid. The process is simply the forcing of air into the well at a high pressure which mixes thoroughly with the gas before again coming to the surface, giving off a much greater heat, better combustion and a pressure amply great, where previously there was practically none. The discovery has created much interest over the gas belt.

[If this system proves effectual, as it seems to be doing at present, it will revolutionize the methods now employed in pumping and compressing gas in all sections where gas is to be found.—Ed.]

Drilling and reaming by pneumatic power may now be done in places where it is impossible to work an air motor. This is made possible by the Air Motor Auxiliary, the invention of Joseph A. Humphries, gang foreman of the Chicago Belt Railway. The auxiliary may also be successfully applied in drilling out from bolts through the frame and cylinder wall, beneath the saddle casting.

The Railway Master Mechanic, a well known authority, says: "An improvement on this device would be the application of four handles (similar to those used on an air motor) to the set screw for propelling the drill. In the present form of the device this set screw must be turned with a wrench, which is an inconvenience to the operator."

Compressors can be fitted with automatic controllers which will cause the machine to stop when the air pressure has reached a stated number of pounds per square inch, and to start it up again when the pressure has gone down to a fixed limit. In the hydraulic regulator this is accomplished by the use of two cylinders fitted with pistons, arranged tandem. One piston is subjected to air pressure, the other to water. When the air pressure is greater than the water pressure it forces the water cylinder piston to close the gate on the pipe line, and, the power being cut off, the compressor stops. The air being used in the mine causes the pressure to decrease until the water pressure overcomes it, when the gate is opened and the compressor again starts up. Supplied with a device of this description, a compressor requires little attention.

It is reported that a certain man, named Count Ravelli, is determined not to meet a watery grave as did so many of the other members of his family. Two sisters, two uncles, a brother and the count's father have all been drowned, and he therefore has invented a remarkable suit of pneumatic garments which he wears all the time when in the vicinity of water. He has a hat which in itself is a life preserver. It looks like an ordinary hat, but by means of a tiny valve, generally out of sight, it can be quickly inflated when it will float like a cork. Not only the hat, but everything worn by the count—his coat, vest, even his shoes and umbrella—is inflatable. Whenever the count sees water he blows into one or more tubes and instantly he swells up to enormous proportions and it would be impossible for him to drown. "Isn't he a funny man."

The street car company of Salt Lake City, Utah, has responded quickly to the popular demand for cleaner street car. The air compressor has recently been received at the factory, and it will be installed at the car barn as quickly as the work can be done. The machine cost $2,100. It will be operated by electricity and will work like the compressors used in cleaning railroad coaches.

The officials of the street car company hold that the city authorities are largely to blame for the dirty street cars, and that they could do very much toward keeping them clean by cleaning the street crossings. It is urged that the street sweeper could be used to very good effect in cleaning the crossings in the business part of the city. With the mud on the crossings as deep as it is a great part of the time, Superintendent Read is not sanguine of keeping the cars very clean even with the greatest care.

Perhaps the most unspeakably horrible and atrocious thing which it ever came in the line of our duty to speak of, was the killing of a thirteen-year-old boy by his young shopmates at the American Locomotive Works, South Paterson, N. J., on December 4. The lad was a new employee and was being "initiated," as is a quite common practice, under which the subject is made the victim of any prank the moment may suggest. As in any such establishment, there is a constant supply of compressed air usually maintained at a pressure of 80 to 100 pounds with attached hose and nozzles for blowing away dust and chips and other uses. The boys applied the hose to the body of the victim and turned on the pressure, with the result of rupturing the intestines, and the boy died after lingering in agony for two or three hours. It would seem to be impossible and useless to comment upon the occurrence.

A neat application of compressed air is used at the Toronto Junction shops of the Canadian Pacific, in connection with the wheel press. When the axle is brought to the press, instead of being hung from the horizontal beam of the machine, it is supported on what is practically a permanently placed small air jack, situated two or three feet in front of the press. The axle can be raised to the required height by the operator pressing his foot on a button in the floor very much like that by which a motorman on a street car rings his gong. When the axle is upon the air jack, the wheels are rolled to position and entered. Two iron rack plates on the flood allow the wheels to easily slip in toward the wheel seats when urged thither by pinch bars, whose points engage with the teeth of the rack. When the wheels have been pushed in a sufficient distance by hand, the air jack is lowered and the wheels and axle roll forward to the press, where the operation is completed.

The dingy walls and pillars of the east front of the treasury building at Washington, D. C., have for a long time been the despair of the officials of the department who are charged with the care of the structure, says the *New York Times*. How to clean them has been a problem for many years. Recently Chief Clerk Hill thought of using the compressed air sand blast, and wrote to a Chicago firm that has patents on the process. A few days ago the building was subjected to the new method of cleaning, and the results are wholly satisfactory.

The men who manipulate the machine wear a long hood to keep the particles of sand and grit from the granite out of their eyes and lungs, and with a small engine go over the huge pillars and stones slowly in the same fashion that an atomizer paint machine works. The sand blasts removes the dirt and a thin layer of stone, and leaves the pillars looking practically as well as new.

The Chicago Pneumatic Tool Company, Chicago, are mailing to the trade a four-page circular, designated as Special Circular No. 32, attractively designed in black and red on enamel paper, illustrating the Tynan Patent Annealer and the Tynan Rivet Heating Forge. The company has secured the entire control of these devices and will be the exclusive manufacturers of same in the future. The Annealer and Rivet Forge fit in very nicely with the line of pneumatic appliances which the company manufacture, as they operate by compressed air, using crude oil as a fuel. They are designed for the various classes of repair work incident to shipyards, railroad shops, etc., and repeated demonstrations have proven them to be far superior for this class of work to the various machines of similar character on the market. Both machines are light in weight and therefore easily removed from place to place—an important feature in the class of work for which they are adapted.

H. K. Porter Company, Pittsburgh, builders of light locomotives, report very active business conditions. They have just completed two 24-in. gauge compressed air mine locomotives for a large lead company in Missouri; also a heavy compressed air locomotive for the mines of the Keystone Coal and Coke Company, of Pennsylvania, and additional air locomotives are now building for the McCormick Harvesting Machine Company, to be used at the Chicago works. Another order is being filled for the Ceneral Coal and Iron Company, Alabama. Contracts have recently been closed for similar machines, including the equipment of the Dominion Iron and Steel Company, Sidney, Cape Breton. The shops are now engaged in building a number of steam mine locomotives for West Virginia and Pennsylvania, also a number of logging locomotives for the West and South. Lately there has been an unusual demand for this machinery for steel works and contractors, for switching locomotives, and the books show a large number of orders for export to Mexico, the West Indies, Japan and South America.

A scheme is being promoted in Paris for constructing a system of subterranean pneumatic conduits for the rapid transportation of mail matter and parcel freight and express. The proposition has been brought to the notice of the government, and official trials will be made of models. The system employs electricity as its motive power, and its inventors represent that they can transport cars weighing a ton over any given distance at a speed of 160 miles an hour. The system is styled the "electric postal service." A metal duct is to be constructed, of a width not exceeding 30 ins., which will be wide enough for a double track to accommodate trains going in opposite directions. The cars would be simply sheet iron cases, supported on two or four axles, and carrying the electric motors. The central compartment of each "car," measuring about 20 cu. ft., would be reserved for freight. The total length of each vehicle would be about 22 ft., but it would not exceed 20 ins. in height. To counteract the resistance of the air—naturally of great force in view of the excessive speed attained by the vehicle—the front and rear of each car would be equipped with wind cutters in parabolic form.

The Pneumatic Signal Co., Broad-Exchange, Bldg., New York City, with western offices in the Monadnock Bldg., Chicago, has published an illustrated pamphlet on the "EZ-Pipe" carrier. The construction of this carrier makes it of universal application, and it is unnecessary to carry any number of ways or any special bolts for tying the same together. The carrier stand 27 E. Z. has a thin lip, forming a part of the opening at the top for the purpose of tying the two uprights together with a pin. In installing this form of carrier, the stands are fastened to the foundation with lag screws, the top roller is slipped on to the pin, and this pin with top roller is dropped into the top of the carrier and quickly secured in this position by inserting a cotter. The addition or reduction of a lead of pipe can be accomplished quickly and without the necessity of discarding any of the note that nearly 90 per cent. of all the hot boxes reported are driving boxes. The question naturally arises, why? Taking a modern freight engine, for instance, we find the projected area of the engine truck journals to be 63 sq. ins., and the weight per sq. in. 142.8 lbs., while that of the driving journal is 112 sq. ins., carrying 194 lbs. per sq. in. The travel of engine truck journals, we find, is 1052 ft., while that of the driving journals is 927 ft. per mile.

The thousands of people who pass the big Traction skyscraper, in course of erection at Fifth and Walnut streets, Cincinnati, Ohio, marvel at the rapidity of the work of construction. Modern machinery and equipment make possible the putting up of one of these structures as rapidly as if it were all masonry..

Immense boom cranes swing the iron pillars to the points where they are wanted. A "stiff-leg" derrick then lifts the column to the top of the one beneath it, and intercepting flanges act like a cleat to receive it. The column is bolted on by the iron workers, and they immediately start after another column, while the riveters follow them up.

There is a man to heat the rivets and one to pass them. Another man operates the "woodpecker," as the compressed air riveting machine is called. It makes a noise not much unlike that of a great woodpecker hammering away at a tree, there is a succession of hard raps, and in about seven seconds, often less, the rivet is clinched. The operator of the "woodpecker" can carry his machine to any part of the structure, as the instrument is light and portable, and the air is fed through a long line of hose. The air-compressor is operated by an engine in the cellar. The granite layers, with their "facing," follow the riveters, and, while bricklayers back up the facing, workmen are making ready for the flooring. A hoisting machine dispenses with hodcarriers.

The great Consolidated Pneumatic Tool Trust, which recently amalgamated the leading manufacturing firms in this line, has decided to commence operations in Scotland on a very large scale.

Up to now the making of pneumatic tools has been almost wholly an American industry. Within five years a trade has been built up there employing 5,000 workmen. The British factories, which are to manufacture for all Europe and for the British colonies, will, as a beginning, employ 4,000 men and spend £300,000 a year on wages.

Aberdeenshire has been chosen as the centre for the new factories, with the little town of Fraserburg as the headquarters. The experiment of opening works so far from the established centers of trade has been resolved on for novel reasons.

"We have determined to start there," says Mr. Maconochie, M. P., Chairman of the British Board of Directors, "because of the climate, the kind of labor to be had, and the remoteness from towns. If you have a man in training for athletics you put him in the surroundings where he can develop his best. So it should be with keeping your workmen in good form, if you began on a rational basis. Everything is against the man in a big city. He has a hundred things to distract and tempt him; he breathes vitiated air, rent is high, and many expenses accumulate. I am convinced that the hope of much manufacturing enterprise in the future will lie in getting the works away from cities."

The work of erecting the factories will be begun in Fraserburg in January. The plans are being sent from America. On a basis of granite there will be erected buildings of steel framework with the sides as as far as possible of glass.

"American business methods will be introduced," Mr. Maconochie adds, "and American managers will teach their ways. With American organization and British labor you have the finest industrial combination possible."

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Canton, Stark Co., Ohio, Dec. 27, 1902.

Sirs: I have heard of the excellent teachings through your journal on the application of compressed air. Please send me several sample copies of your journal and let your subscription price be known. Could you furnish me any books treating on compressed air? Yours truly,

GEORGE E. SMITH.

One of our readers writes us as follows:

Sirs: I am a subscriber to both COMPRESSED AIR and the *Cyclopedia of Compressed Air Information*. Can you find the first two volumes of COMPRESSED AIR for me? I was foolish enough not to save them, and now would give anything within reason to get them, bound or unbound.

A. D. FOOTE, Supt. North Star Mines, Grass Valley, Cal.

(Correspondence is solicited on the above subject.)

Index for Vol. II. is very much wanted by COMPRESSED AIR, who will be glad to purchase same if it be possible to obtain it.

Sirs: In your December issue, there is an error in statement, in regard to the d'Auria Air Compressor, which I would like to have corrected if possible—which is, that the machine is built by the I. P. Morris Co., the fact being that I built the machine described in my paper read before the American Institute of Mining Engineers, which you so kindly copied. As I was not writing an advertisement, I naturally refrained from stating that I was the builder.

If the correspondent of the *American Machinist* will apply to the d'Auria Pumping Engine Company, No. 941 Drexel Building, Philadelphia, he will probably be enlightened more fully as to the merits of the machine. Yours very truly,

HENRY G. MORRIS.

Sirs: Can you refer us to any data or papers on separators, mechanical or chemical, for removing water from compressed air?

Thanking you in advance, we are,

Yours truly,

BORTON & TIERNEY CO.

In answer to your letter of Dec. 17, asking if we have any data on the subject of separators, mechanical or chemical, for removing water from compressed air, we are sending you under a seperate cover a copy of COMPRESSED AIR for November, 1902, on page 2080, of which you will find a description of a form of separator which we understand is well adapted for compressed air mains.

You will also find on page 2082 a description of a washer, which will prove of service in cases where dust and oil must be removed. We would also suggest that you correspond with some of our advertisers who manufacture compressed air machinery, as they can probably quote you on special devices for removing the water from compressed air.—ED.

Western Tube Co., Kewanee, Ill., Jan 1, 1903.

COMPRESSED AIR:

We note in your issue of December, you show on page 2104, a pneumatic sand rammer and we should like to know from whom we can get prices and other information in regard to one of these complete, which you specify as weighing about 20 pounds.

We would like to have the information promptly and would consider it a favor if you would let us have an early reply.

Yours truly,

WESTERN TUBE COMPANY,

Purchasing Agent.

INDEX.

U.S. PATENTS GRANTED NOV. 1902

Specially prepared for COMPRESSED AIR.

712,478. PNEUMATIC-DESPATCH-TUBE SYSTEM. Thomas Bemis, Indianapolis, Ind. Filed May 17, 1902. Serial No. 107,-799.

A pneumatic-despatch-tube system, the combination with a pressure-maintaining device, of a non-carrier-receiving trunk-line pipe leading thereto, a plurality of overlapping independent pipe-lines leading into said trunk-line at different points in its length, and cut-outs arranged between and connecting adjacent overlapping portions of independent pipe-lines, each of said cut-outs being provided with means by which carriers may be transferred from one pipe-line to another.

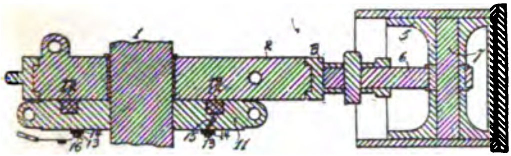
712,479. PNEUMATIC-DESPATCH-TUBE SYSTEM. Thomas Bemis, Indianapolis, Ind. Filed May 17, 1902. Serial No. 107,-800.

A pneumatic-despatch-tube system, the combination with a suction device, of a loop-circuit pipe-line, a supplemental-circuit pipe-line, one end of said supplemental pipe-line being connected to the first arm of the loop, and the other end of the supplemental pipe-line being connected to the second arm of the loop, a cut-out arranged at the point of junction between the first arm of the loop-circuit and the beginning of the supplemental circuit, said cut-out being provided with means for allowing the passage of a carrier therethrough from one circuit to another, a cut-out arranged at the point of junction between the supplemental circuit and the second arm of the loop-circuit and provided with means for allowing the transfer of a carrier from the supplemental circuit to the loop-circuit, and an air-passage between the supplemental pipe-line and the suction device.

712,508. AIR-COMPRESSOR FOR AIR-BRAKES. Burt J. Denman, Toledo, Ohio, assignor to John R. B. Ransom, Toledo, Ohio. Filed Nov. 7, 1901. Serial No. 81,-384.

An air-compressor, the combination of an axle, a cam loosely mounted upon said axle and provided with a cam-strap, a cylinder, a piston connected to said cam-strap, an electromagnetic disk fixed upon the axle and adapted for direct engagement with the loosely-mounted cam, and means for controlling the electric circuit in said disk to cause it to directly engage or disengage said cam.

In combination, an air-compressor, an axle, a cam loosely mounted upon the axle, a cam-strap in engagement with said cam and connected to the air-compressor, a disk fixedly



mounted upon said axle contiguous to the loose cam, an electric coil carried by said disk, a collecting-ring mounted upon and insulated from the disk, connections between the collecting-ring and the coil, and a make-and-break device in circuit with said coil for controlling the electric circuit in said coil.

712,833. ENGINE-BRAKE. Edward Y. Moore, Cleveland, Ohio, assignor, by mesne assignment, to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Oct. 14, 1901. Serial No. 78,542.

An engine having a crank-pin crank and crank-shaft combined with an extra disk journaled axially with the crank-shaft and loosely engaging the crank-pin, and means for moving said disk parallel with the axis of the crank-shaft to cause braking, substantially as described.

The combination with a pneumatic motor, of a break and a pneumatic mechanism for operating it, said brake including a non-rotable member and a co-operating rotatable disk loosely engaging a crank-pin of the motor and located axially with the crank-shaft and movable longitudinally thereof to apply or relieve the brake, substantially as described.

712,843. PNEUMATIC SUGAR-CANE CUTTER. Ralph H. Paul, Brisbane, Queensland, Australia. Filed Aug. 17, 1901. Serial No. 72,394.

A pneumatic sugar-cane cutter, a cylinder, a reciprocating piston therein, a sugar-cane cutter operated by the impacts of said piston, and means pivotally carried by said cylinder for enabling the latter to be secured to and supported from the arm of the user.

A pneumatic sugar-cane cutter, a cylinder, a cutter-holder mounted in the front end thereof, a sugar-cane cutter adapted to be inserted into said holder, a reciprocating piston in said cylinder, a handle on said cylinder, and means pivotally carried by the latter for enabling the cylinder to be supported from the arm of the user

712,902. PNEUMATIC STACKER FOR THRESHING-MACHINES. Oscar O. Bodvig, Velva, N. D. Filed May 13, 1902. Serial No. 107,156.

The combination with a threshing-machine, of a pneumatic stacker mounted thereon and comprising a plurality of sections, one of which is capable of being revolved and moved longitudinally, the movable section having its forward portion hinged to swing in a vertical plane, a spring for controlling said hinged portion, means for revolving the section, and means for moving the section longitudinally.

The combination with a threshing-machine, of a pneumatic stacker mounted thereon and comprising a plurality of sections, one of which is capable of being revolved and moved longitudinally, means for revolving the section, an adjusting-rod for moving the section longitudinally, and means for connecting the adjusting-rod to the movable section whereby it may be revolved independent of the adjusting-rod.

712,915. AIR-BRAKE SIGNALING AND RELEASING DEVICE. Frank H. Dukesmith, Charlestown, W. Va., assignor of one-half to Benjamin F. Ackerman, Palestine, Tex. Filed June 6, 1902. Serial No. 110,490.

An air-brake signaling and releasing device comprising a cylinder arranged at one end for connection with the brake-cylinder, a piston operating in said cylinder and arranged to be actuated by the pressure from the brake-cylinder, a spring for readjusting the said piston to normal position, a hollow piston-rod extending from said piston and arranged to receive pressure from the brake-cylinder, a valve in the piston-rod, and a signal carried thereby substantially as set forth.

713,366. INTERNAL-COMBUSTION ENGINE. Henning F. Wallmann, Chicago, Ill., assignor to the Wallmann Engine Company, a Corporation of Illinois. Filed Feb. 3, 1900. Serial No. 3,842.

An internal-combustion engine, the combination with a combustion-cylinder, of means for supplying a body of compressed air thereto for the combustion of the fuel, means for subsequently injecting a charge of fuel at a higher pressure into said body of compressed air and for firing the mixture, and means for introducing into the hot expanding products of combustion in the combustion-cylinder another body of compressed air commingled with a spray of water or steam, substantially as described.

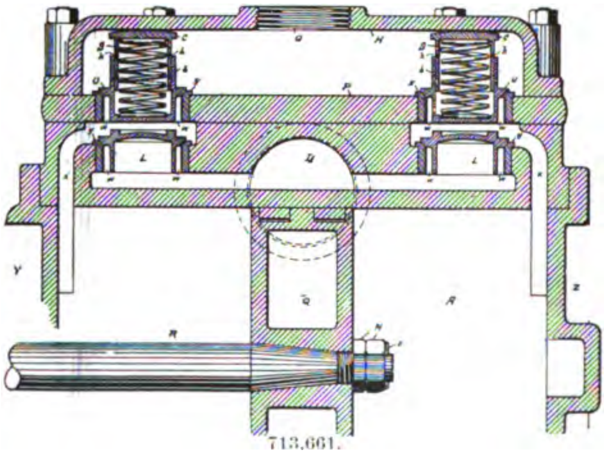
713,367. INTERNAL-COMBUSTION ENGINE. Henning F. Wallmann, Chicago, Ill., assignor to the Wallmann Engine Company, a Corporation of Illinois. Filed Mar. 21, 1900. Serial No. 9,530.

An oil-engine, the combination with a combustion-cylinder having an air-inlet valve, a fuel-inlet valve, and an exhaust-valve, all located in the head of the cylinder of an air-compressor which delivers compressed air to the combustion-cylinder past said air-inlet valve, the initial portion of said compressed air serving as a scavenging-blast and the remainder forming part of the next combustible charge, a second air-compressor whose delivery is connected to the casing of the fuel-inlet valve, and a fuel-pump whose delivery-pipe taps the air-duct between the discharge-port of said second air-compressor and the casing of the fuel-inlet valve, substantially as set forth.

713,631. DISCHARGE-VALVE FOR COMPRESSORS. Frederick W. Gordon, Hartford, Conn. Filed Mar. 17, 1902. Serial No. 98,543.

In discharge-valves for compressors, the combination, substantially as set forth, with a compressor-cylinder, compressor-piston, discharge-chamber, and discharge-valve opening to the discharge-chamber, of a piston and cylinder disposed at the back of the discharge-valve and arranged to detract from the area thereof subject to discharge-pressure, a tappet projecting into the compressor-cylinder and adapted to be engaged by the compressor-piston as it nears the end of its compressive stroke, and connections between said tappet and the valve whereby the movement of the tappet under the influence of the compressor piston causes the practical closure of the valve.

713,661. AIR-COMPRESSOR VALVE. Foster M. Metcalf, Battlecreek, Mich., assignor to American Steam Pump Company, Battlecreek, Mich. Filed Apr. 28, 1902. Serial No. 105,119.



713,661.

An air-compressor valve having an extended sleeve, a cushion-cap embraced within the same, and in sliding engagement therewith, an internal spring acting to separate the valve and cap, and the cap having radial holes communicating with the interior thereof, substantially as shown and described.

713,687. BLOWING-ENGINE. Cyrus Robinson, Pittsburg, Pa., assignor to the Westinghouse Machine Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 19, 1899. Serial No. 734,114.

An air-compressor, the combination of a stationary cylinder, outlet-valve for controlling the escape of compressed air and adapted to yield to the air, springs for holding said valves closed against the pressure of the air, a piston adapted to reciprocate in said stationary cylinder, a piston-rod connected to said piston, power mechanism connected to the said piston-rod to drive it, said rod being provided with an air-duct, a valve in said air-duct, a lever for moving the said valve carried by and movable with the piston-rod, and means for moving said lever independently of the movement of the piston-rod.

713,739. PNEUMATIC STACKER. Chester Bradford, Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed May 17, 1902. Serial No. 107,798.

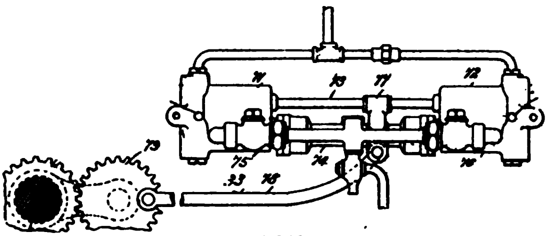
The combination, in a pneumatic stacker, of the delivery-duct, a turn-table carrying the same, a curved rack on said turn-table, a mutilated gear adapted to engage with said rack and thus actuate said turn-table, a mechanism for driving said mutilated gear, and means for reversing said mechanism at the end of a predetermined travel in each direction and arranged to operate after the mutilated gear has passed out of engagement with said curved rack, whereby the latter is permitted to pause at each end of its travel before starting on its return movement.

713,787. PNEUMATIC STACKER. William McKone, Neepawa, Canada, assignor of five-sixths to Daniel Hamilton, William Pringle Johnston, George Arthur Dinwoody, Horatio F. Forrest, and James Henry Howden, Neepawa, Manitoba, Canada. Filed June 13, 1902. Serial No. 111,539.

713,834. AIR-VALVE FOR SHIPS. Theodorus S. Bailey, Elizabeth, N. J. Filed Dec. 28, 1901. Serial No. 87,544.

A device of the character described, a casing having a passage therethrough for air, a pair of valve-seats in said casing, a pair of independent valves for said seats, means for automatically closing one valve against its seat when water attempts to pass in one direction, and similar means for closing the other valve against its seat when water attempts to pass in the opposite direction, both valves normally remaining open for the free passage of air.

713,848. AIR-COMPRESSING DEVICE. James H. Bullard, Springfield, Mass., assignor to the Overman Automobile Company, Chicopee, Mass., a Corporation. Filed Nov. 25, 1901. Serial No. 83,593.



713,848.

A pump consisting of a cylinder, a valve-chest therefor, an induction and an eduction pipe in said chest, a check-valve in the latter for each of said pipes and opening in the same direction, a single port for the cylinder located between the check-valves and serving both for an induction and an eduction port; a passage outside the valve-chest communicating with opposite ends of the latter, and in communication only with the eduction-pipe, and an expansible and retractable sack in proximity to the check-valve for the induction-pipe, adapted to be inflated by back pressure from the eduction-pipe whereby an excess of pressure in the latter will effect the lifting of the check-valve in the induction-pipe from its seat, to render the pump ineffective.

713,924. PNEUMATIC-DESPATCH SYSTEM. Kenneth E. Stuart, Philadelphia, Pa. Filed Jan. 27, 1902. Renewed Oct. 22, 1902. Serial No. 128,241.

In a pneumatic-despatch system the combination with a despatch-tube of a movable barrier extending into the tube in normal position to be struck by and arrest the motion of an advancing carrier, a latching device arranged to lock the carrier in normal position or in the alternative to have it unlocked and free to move out of the way of an impacting carrier and selective latch-actuating mechanism also extending into the tube in the path of the advancing carriers to be acted upon by selective carrier-heads.

In an air-brake system for street-cars, the combination of a brake-cylinder provided with air connections, a piston mounted in said cylinder, a spring bearing on said piston, a piston-rod passing through both heads of said cylinder, a brake-beam bearing two shoes set to engage two of the wheels of the car, a connecting-rod connected to said brake-beam and to one end of said piston-rod, a lever connected to the other end of said piston-rod, a brake-beam bearing brake-shoes, and a connecting-rod connecting said lever and said last-mentioned brake-beam.

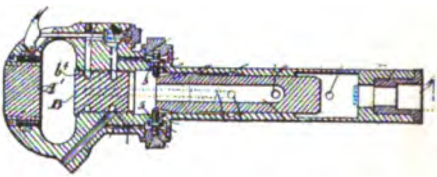
714,273. AIR OR VACUUM MOTOR. Max Arndt, Aix-la-Chapelle, Germany. Filed Jan. 20, 1899. Serial No. 702,855.

A motor, the combination with a smoke-stack of a bell dipping in a sealing liquid and suspended on a counterweighted lever, a main pipe discharging into the interior of the bell and connected with the smoke-stack by a branch pipe of a comparatively small size, a valve to temporarily open and close the main pipe and a controlling-lever actuated by the said counterweighted lever to control the valve.

714,295. RELIEF-VALVE FOR AIR-COMPRESSORS. Arthur Giesler, Dayton, Ohio, assignor to the Stillwell-Bierce & Smith-Vaile Company, Dayton, Ohio, a Corporation of New Jersey. Filed Mar. 27, 1901. Serial No. 53,018.

An air-compressor, two cylindrical valve-casings connected by an air-channel and located one at each end of the compressor-cylinder, ports leading from the lower ends of the casings to the corresponding ends of the cylinder, valves in the casings, commanding the ports and opening outwardly, springs for opening said valves, pistons upon the valve-stems, diaphragms secured to the pistons and to the cylindrical casings, a chamber in the upper ends of said casings above the diaphragms, a valve-casing located at the side of the compressor, and containing two oppositely-facing valve-seats, passages through said seats connecting the ends of the casing with the space between the seats, valves for the passages so arranged that one is seated as the other is unseated, an air-vent in one end of the casing, means for holding the valve commanding the vent normally seated, and the other one open, a pipe connecting the compressor-reservoir with the closed end of the casing, and pipes connecting the space between the valves with the chambers above the diaphragms.

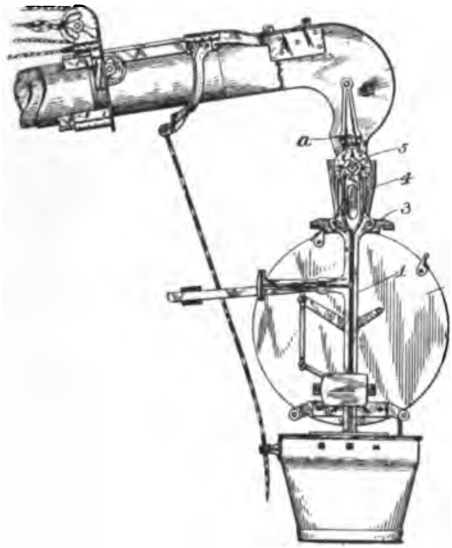
714,321. PNEUMATIC HAMMER. John T. McGrath, Fort Gratiot, Mich. Filed Jan. 11, 1902. Serial No. 89,345.



A pneumatic hammer, the combination with a casing having a supply-passage for air provided with a main controlling-valve, said casing having ports for admitting air in rear of the piston, check-valves controlling said ports and having stems projecting into the casing, a piston within the casing having inclines for contacting with said stems to raise the valves from their seats to admit air and propel the piston, means for admitting air to the opposite side of the piston to return it to initial position, and means whereby the air is exhausted from the chamber, substantially as described.

714,358. PNEUMATIC ELEVATOR AND WEIGHER. Chester Bradford and Ridgely B. Hilleary, Indianapolis, Ind. Filed Dec. 18,1901. Serial No. 86,341.

The combination, in a pneumatic elevator and weigher, with a separating-head changeable in its position, and a weighing-receptacle located therebelow, of an intermediate hopper arranged between said separating-head and said weighing-receptacle and held in substantially unvarying relation to said recep-



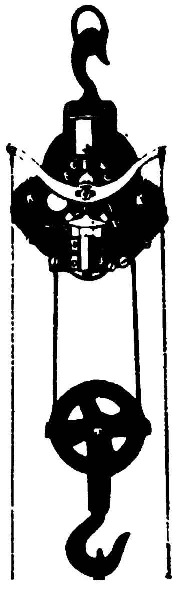
tacle and adapted to receive the discharge from said separating-head and guide it into said weighing-receptacle.

714,497. RAILWAY ELECTRIC-MOTOR-COOLING SYSTEM. Cyprien O. Mailloux and William C. Gotshall, New York, N. Y. Filed Aug. 26, 1902. Serial No. 121,077.

The combination with an electric-railway motor, of a source of compressed air or gas upon the car or train of cars propelled by said motor and means for releasing and discharging the air into or upon the motor to keep the temperature of the same down by the refrigerating or cooling effect due to expansion of the air.

714,631. TRUING DEVICE FOR TRIPLE CYLINDERS OF AIR-BRAKES. Edwin M. Barnes, Sacramento, Cal., assignor of one-half to Robert Graham and Edgar R. M. Pierce, Sacramento, Cal. Filed July 23, 1902. Serial No. 116,750.

A device for truing cylinders of triple valves of air-brakes, the combination of a removable bearing arranged to fit within the slide-valve seat, means for fixedly clamping and centering said bearing in said seat, a device attached to said bearing having an internal thread, a cutter-stem having a threaded end working in said internal thread, a cutter-holder carried by said stem, and cutters carried by said holder.



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Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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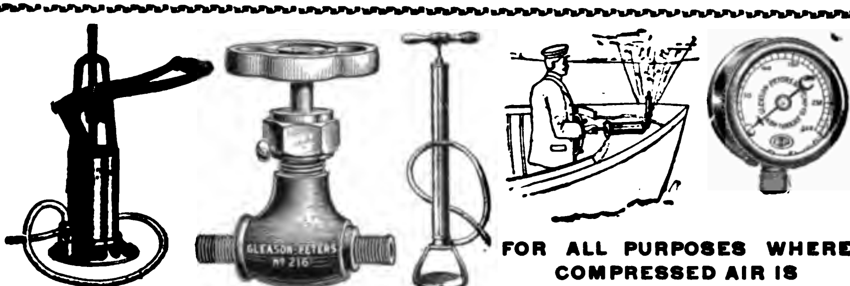
GLEASON-PETERS
Nº 216

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN, }

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Lubrication of Compressors.

COMPRESSED AIR has on various occasions insisted that owners and operators of air compressors do not as a rule give sufficient attention to the question of lubrication.

The subject is one which possesses at the same time interest on the score of economy and also because of the opportunity afforded for accidents.

Elsewhere in this issue we publish a valuable contribution to the subject of compressed air and its production, and while the article is devoted to a discussion of cylinder ratios and the temperatures obtained in compressing to higher pressures, it, at the same time, calls attention to the question of oils and lubrication, which after all is of as great importance as economical compression because improper oil introduces the one dangerous feature of air compression,

That care should be used in selecting a high flash test oil for lubricating the air cylinders of a compressor has long been known, and as positive evidence of this need, we have published from time to time several accounts of explosions, the cause of which can be traced in the majority of cases, directly to the fact that a low grade oil was used for lubrication. Yet in the face of danger and of possible serious accident resulting, it is also as well known that many violations of the above rule are of daily occurrence, and though we believe that it is often due to ignorance, this is hardly a plausable excuse when life is endangered. Every new report of such an accident throws a little more light upon this "not very well understood subject." It is to be regretted that no very accurate data relative to the action of such oils under high pressures and temperatures is known, all values so far determined, such as the flashing and ignition points, being those for atmospheric conditions only. Efforts have been made by some manufacturers to develop high flash test oils, but the difficulty generally met is in the high percentage of carbon contained in these which, for practical results, is about as objectionable as a low flash point. The article which we publish in this issue, gives some very valuable data on the temperatures reached in air compression cylinders, and illustrates the importance attached by at least one of the largest air compressor manufacturers to experimental research along this line. It is hoped that the points brought out will be remembered by users of compressors as well as those engaged in the design of air compressing machinery, for we believe impartial investigation will show that the operator has been at fault in most cases of explosion in compressor cylinders and receivers,

Safe Ratios in Air Compression.

THE DETERMINATION OF THE MAXIMUM RATIO OF COMPRESSION THAT CAN BE USED IN A SINGLE CYLINDER WITH PRACTICAL SAFETY.

In the course of advance in air compressor design, the above question under certain conditions becomes of importance, especially so when the tendency toward higher pressures is considered, an example being in the case of air compressors for furnishing the high pressure air used in pneumatic mine locomotives which sometimes reaches 3,000 pounds per square inch, and in the case of coal mines where the cost of installation of the power plant is of much more importance than that of operation, the fuel used being that which would otherwise be wasted. Any comparatively small loss in the thermal efficiency of the compressor would have far less consideration than the consequent reduction in the cost caused by simplyfying the construction, and for this reason there has been a tendency toward high compression ratios. In the course of certain experimental work carried on by one of the larger compressor manufacturing concerns, namely: The Ingersoll-Sergeant Drill Co., the above question came up and it was decided to carry the experiments further and determine if possible the causes which should limit this, and make deductions sufficiently accurate to be of practical value. For this purpose an experimental air compressor having compound single acting air cylinders of the following dimensions was used. See Figs. 1 and 2.

Low pressure air cylinder, 7" in diameter by 10" stroke.

High pressure air cylinder, 1⅞" diameter by 10" stroke.

In early stages of this work an explosion occurred which eventually led to the solution of the problem. The compressor was running about 150 R. P. M., against a final discharge pressure of about 1,100 pounds per square inch when the accident occurred, which fortunately was accompanied by no more serious result than the bursting of the receiver and a bad scare for the men working close by, though it had sufficient force to blow the larger part of the receiver, weighing approximately 200 lbs., about 40 feet down the shop. An examination of the ruptured parts left no doubt as to there having been an explosion of much more force than that attributable to the stored energy of the air itself. There were two distinct ruptures.

First: One in the 1" extra heavy pipe leading to the receiver, which was torn practically into two equal parts having split down the sides for about 9½" in length, and opened up across the middle over 4". In this pipe, at the end of the rupture nearest the compressor, an oily residue was found, though only in small quantity.

Second: That of the receiver itself bursting the head to which the inlet and outlet pipes were attached, and blowing the parts in every direction (the body of the receiver being blown down the shop as already stated). Whether flaws in the material of the broken head were in any way responsible for its bursting is doubtful, and difficult to determine, though some signs of defects were in evidence. A carbonaceous oily residue was found in the receiver, there being quite an extensive coating all over the inside of the pipe, and the head which remained intact, while on the broken head there was hardly any residue at all, simply a small quantity of hard, black, dry powder having the appearance of a carbonaceous ash. Neither of these residues showed any life when subjected to the hot flame of a Bunsen burner. Another point to be noted is that the discharge valve and air passages in the high pressure cylinder, were covered with a coating of residue very similar to that (second one) mentioned above, which was found in the burst end of receiver; this also showed similar action when subjected to the hot flame, having no life or burning qualities.

Summary of conditions known to exist at the time of the explosion:

Discharge air pressure.. 1,100 lbs. per sq. in.
Intermediate air pressure .... 136 lbs. per sq. in.
Intake air pressure.... Atmospheric.
Compression ratio in the H. P. cyl....... 7·384.

The compressor had just previously been running at a discharge pressure approximately 3,000 lbs. per sq. in., and had been running thus for quite some time, during tests, etc., using a lubricating oil of 388° F. flash test. The quantity being in all probability far in excess of the proper or safe amount to use, though no observations as o this were made.

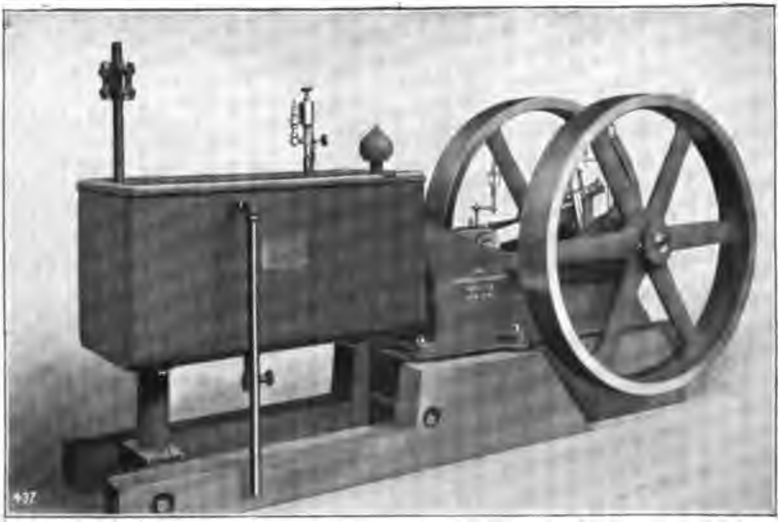


FIG. I—WATER COOLING BOX IN POSITION.

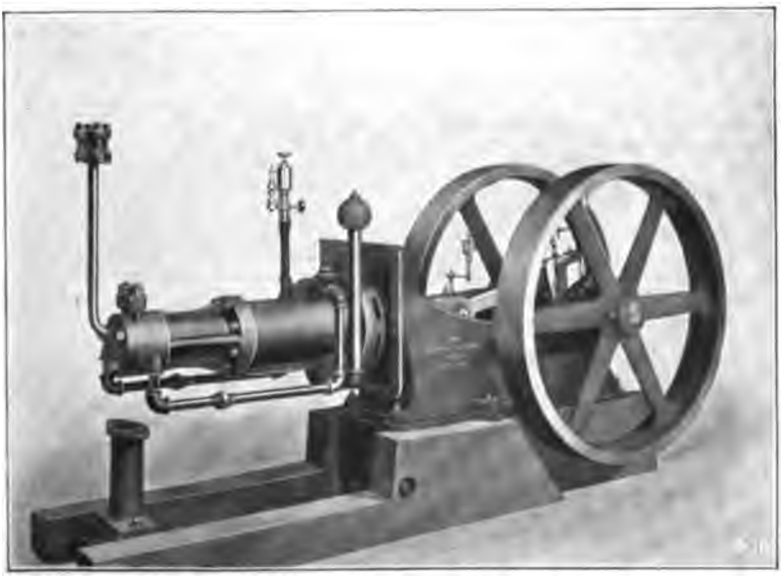


FIG. 2—WATER COOLING BOX REMOVED.

The idea which presented itself at that time in looking for a cause, was that the oil in conjunction with the air must have formed an explosive mixture, which upon being ignited resulted in the accident.

The company supplying the oil was then notified and they immediately sent their expert representative to help throw some light on the subject.

After some consideration of the facts at hand, it was decided to connect up again for running, a new receiver, piping, etc., were supplied, and several test runs made, observations being taken of the different temperatures, etc., as follows:

TABLE I.

No. of Run.	1st.	2nd.	3d.
Speed, r.p.m	150.	150.	120.
H. P. air pressure gauge ...	1100.	3000.	3000.
Int. air pressure gauge.....	136.	136.	136.
Intake pressure gauge	Atmospheric.		
H. P. air temperature	148.°F.	325.°F.	194.°F.
Int. air temperature	135.°F.	165.°F.	125.°F.
Intake air temperature.....	72.°F.	72.°F.	72.°F.

These temperatures were recorded on standard thermometers, that of the low pressure cylinder being placed in a regular cup, inserted in the discharge pipe. For the high pressure observations an improvised cup of asbestos packing was attached on the outside of the discharge pipe.

The first set of these readings it will be noticed, was taken under similar conditions as existed at the time of the accident. The second set maintained the same speed, but the high pressure air pressure was increased to 3,000 lbs. (Note the rise in the high pressure temperature reading.) The third set of conditions was taken at the rated speed of the compressor, and it was while running under these conditions that the special investigation committee arrived. They made a complete examination of the compressor and of the broken parts of the old receiver and piping. The general opinion of the above committee after a long discussion was that much higher temperatures than those recorded by the thermometers were reached in the compressor, and that at these temperatures a gaseous explosive mixture had been formed, which upon being ignited had produced the accident, thus sustaining the first opinion. After these runs were completed, the compressor was taken apart and samples of the oily residue remaining in the cooler tubes and the carbonaceous deposit on the piston and in the high pressure cylinder were taken for further study.

The results ot the examination of some of these residues are as follows:

The sample of carbonaceous deposit from the pistons and cylinder was subjected to the heat of the hot plate about 400° F., at which temperature it became a glowing mass. The exact chemical constituents of this last residue are not known, but it appears to contain iron and carbon. However that may be, here appears to be the igniting medium for which several theories had been advanced, such as the piston striking a spark on a small particle of carbon or other hard deposit. Also the effect of excessive friction from defective lubrication in the high pressure cylinder, which could be caused by the oil being gasified in the low pressure cylinder and carried through the high pressure cylinder as a gas having little, if any, lubricating effect, either of which in connection with the aforesaid residue could account for the ignition. At any rate it is probable that some form of ignition is necessary, though no data or results of tests on the flashing of oils under high pressures of air has come under the writer's notice. There is little question as to the increased violence of the burning of oils, etc., under high pressure, experiments carried on by Mr. F. M. Leavitt (M. E.), A. S. M. E., in connection with the development of the automobile torpedo having shown that burning alcohol, etc., in a heater pot in the air flask of a torpedo under 1,500 lbs. pressure, was accompanied by excessively violent and rapid combustion.

Considering the compressor from a theoretical standpoint, assuming that the adiabatic laws of air compression prevail, the temperatures of compression work out as follows:

First Stage of Compression—Low Pressure Cylinder—

Assume atmospheric intake at 70° Fahr., and compressing to 136 lbs. gauge (the intercooler pressure); the temperature of discharge from the low pressure cylinder would be approximately 576° F., and the ratio of compression equal to $151 \div 15$ equal to 10.06 for the low pressure cylinder. This will remain the same for all variations of load since the cylinder ratio is a constant.

Second Stage of Compression—High Pressure Cylinder—

First: Without any intercooling effect being taken into account the intake temperature into the high pressure cylinder being that of the low pressure discharge, viz., equal to 576° F., compressing from 136 lbs. gauge to 1,100 lbs. gauge, the pressure at which the explosion took place, the final discharge temperature would be approximately equal to 1,391° F., and the ratio of compression 1,115÷151 equal to 7.384. Compressing from 136 lbs. gauge to 3,000 lbs. gauge, the rated pressure for the compressor, the final discharge temperature becomes approximately equal to 2,009° F., and the ratio of compression equal to 3,015÷151 equal to 19.96.

Second: With cooling in intercooler down to 70° F., or that of the intake to the low pressure cylinder, this is approximately correct thougn no exact determination has been made.

Compressing from 136 lbs. to 1,100 lbs. gauge, the final temperature becomes approximately equal to 487° F., ratio of compression as before 7.382. Compressing from 136 lbs. gauge to 3,000 lbs. gauge the final temperature becomes approximately equal to 804° F., ratio of compression as before, 19.96.

No effect on the high temperature point as effected by the cylinder jackets has been taken into account, as any information of value on this point must be determined experimentally for the compressor in question.

Considering the difference between these theoretical temperatures and those heretofore observed, with the opinion prevailing that a pretty high temperature must have been reached, the writer was instructed to carry the experiments far enough to determine if possible the actual temperatures existing. It was then suggested that by inserting small particles of different metals having melting points from 450° F. upwards, into the clearance spaces of the cylinders, and observing the effects on the same, that the highest temperature point could be approximately located. This suggestion relieved the situation considerably, as it was known that the highest temperature lasted only for an instant during each revolution, the cylinder cooling down from the combined effects of the re-expansion of the air in the clearance spaces, and the in-rush of comparatively cold intake air, consequently any thermometric method other than the above which would be able to record this temperature would necessitate considerable delay to install and probably give no more accurate results. The high pressure cylinder head was then fitted with a suitable test plug entering the clearance space, to which were attached the metals used. The preparation of these metals so that they would show the effects of the highest temperature necessitated their being hammered into very thin filaments, approximately 1/1,000 of an inch in thickness, so that the heat could make an impression on them and not be absorbed and conducted away faster than it was supplied. These were arranged in the form of a small semi-spherical rosette, presenting many thin filaments to the air during its passing in and out of the cylinder.

The following are the conditions of running and the results obtained in the high pressure cylinder, no experiments having as yet been tried in the low pressure cylinder.

TABLE II.

No. of Run.	1st.	2nd.	3d.	4th.
Metal used	Tin.	Lead	Zinc	Zinc.
Range of melting temperatures..	442.° —446.°	608.° —618.°	725.° —780.°	725.° —780.°
Speed, r.p.m	102.	100	102.	126.
Time of Run. Min.	15.	15.	15.	25.
H. P. air pressure guage	2230.	2980.	3000.	3000.
Int. air pressure guage	136.	136.	136.	136.
Intake air pressure guage	Atmospheric.			
Temp. observed on H. P. pipe	185.°F.	195.°F.	184.°F.	232.°F.
Temp. observed on Int. pipe	220.°F.	234.°F.	236.°F.	220.°F.
Intake air temp ...	71.°F.	70.°F.	72.°F.	70.°F.
Compression, ratio H. P	15.	19.5	19.96	19.96
Compression, ratio L. P.	10.06	10 06	10.06	10.06
Effect on test metal	Melted.	Melted.	Ox'dzd.	Melted.

No attempt has been made to carry these experiments further, as a suitable metal or alloy having a melting point under the theoretical temperature of compression in this cylinder, viz., 804° F., is lacking, which temperature cannot be exceeded when compressor is working properly.

These experiments with the results obtained form a basis from which a reasonable solution as to the causes which resulted in the explosion can be derived.

It has been shown that the water jackets had little effect on the air in the cylinder during the compression, in consequence of which the actual temperatures reached were very near those figured for adiabetic compression. Considering this in a compressor, which is a striking example of excessive cooling properties, the question arises as to what limit must be placed on the number of compressions allowable in a single cylinder, when the lubricant to be used must be selected from the lists of high grade marketable oils prepared for this purpose.

The United States Navy Department, among other requirements for high pressure air compressors for torpedo boats, includes this; that oil shall not be used as a lubricant in the air cylinders, a mixture of soap and water being substituted.

Following the course of the oil as it passes through the compressor, it is found to come in contact with the successive changes of pressure and temperature summarized below:

First: In the low pressure cylinder a temperature variation from 70° F., to approximately 525° F., accompanied by a pressure variation from atmospheric to 136 lbs., this latter pressure and the high temperature lasting 5 per cent. of each revolution (the discharge period).

As the flash point of the oil in question is 383° F., it is evident that considerable volatilization of the same might occur in this cylinder, and so make a thorough mixture of oil and air and whatever moisture accompanies the air. Now passing into the cooler tubes its temperature is reduced to about 70° F., where some of the oil and water is condensed, coming down in the mixed form of residue already mentioned, which in turn is carried over into the high pressure cylinder, where a pressure variation from 136 lbs. to 3,000 lbs. and a consequent temperature variation from 70° F. to 750° F., occurs every revolution. The discharge period, or that during which the high pressure and temperature exist, being only 2.9 per cent. of each revolution, which at a speed of 120 R. P. M. is .00725 part of a second. It is probable that at this point the ignition occurred which upon reaching the discharge pipe and receiver resulted in the accident, as much of the explosive gas already generated was stored in these places.

The high temperature of discharge in this cylinder is sufficient to account for a gaseous oil and air mixture being continuously generated when running up to pressure.

And in view of the fact, that the sample of the carbonaceous deposit from the high pressure cylinder became a glowing mass at a temperature about 400° F., there seems to be at hand all the necessary adjuncts for an explosion, provided that just the right mixture of air and oil is developed. Professor J. E. Denton in a statement on this point cited some experiments in which gasoline and air under atmospheric conditions were mixed in a closed receptacle in which an electric spark was passed. The results were as follows: When the mixture consisted of 8 milligrammes of gasoline and 2 quarts of air, a violent explosion occurred when sparked, but with a mixture containing one milligramme more or less than the above it simply burned or showed no effect at all.

A similar set of conditions probably exists for all volatile oils, when the necessary temperatures are reached, and the correct mixture is formed. The fact that the mixture to be explosive must not vary except within very narrow limits, and that this mixture is seldom approached in general compressor running, is without doubt the reason that so few explosions of this sort are recorded.

In attempting to answer the question under consideration, that as to what limit should be placed on the number of compressions allowable in a single cylinder, it appears at present to depend on the grade of oil used for lubrication, and if the manufacturers of the same could guarantee to furnish an oil for use in air cylinders, whose flash point exceeded a certain temperature, determined and agreed on after careful experiments, or some other form of lubricant, possibly of a parafine or glycerine nature, is forthcoming to take the place, it is useless to adopt any set limit no matter how low, for there are at present a great many if not a large majority of the compressors running using oils whose flash points are far below the temperatures reached in the cylinders, and quite often crude petroleum from which explosive gases are generated under atmospheric conditions will be found in the cups.

Considering, however, that the highest flash oils sold at present will be used, this would mean that they would not flash under 475° to 500° F.; although claims are made for certain oils having flash tests around 550° F., it is questionable whether at all times they could be unfailingly relied on for this. Taking the former figures as the safer, it would appear that the number of compressions in one cylinder should never exceed (eight), giving a theoretical final temperature when compressing from atmosphere at 70° F. = of 510° F., and in compound compressors (seven) in the high pressure cylinder is a safer figure since intercooling down to 70° F., is counted on, and in many cases this cannot be accomplished (lack of water, etc., being among the conditions which are to be met).

Considering the tendency at present towards higher pressures in both steam and air and the increased cost to purchaser when higher multiple compressors are used, it is to be hoped that experiments for determining the best form of lubricant for use under high pressures and temperatures will be carried on until a successful and determinative issue results.

FRED. V. D. LONGACRE, M. E.

Continuous Power.

The *New York Herald* of January 25th, illustrated and described the new invention of Mr. J. F. Place, for the production of what he aptly terms "Continuous Power." The article referred to touched but lightly on the technical points of the invention, and we give below some extracts from Mr. Place's treatise on the subject.*

"It is a law of physics that whenever any gas, which exists as a gas at ordinary temperatures, is caused to become liquefied, then such liquid gas is, so long as it remains a liquid, at a lower temperature (colder) than the atmosphere, and will constantly boil if exposed to ordinary temperatures—or to the normal heat of the atmosphere. These gases, when liquefied, are called liquid gases, as, for example, liquid air; therefore, a liquid gas is a liquid which boils when subjected to the normal temperature of the atmosphere.

"No matter how much heat runs into a liquid, it gets no warmer. For instance, you cannot raise the temperature of boiling water, the pressure being constant, no matter how fierce the fire, so long as there is any water in the boiler; so, also, the heat of the atmosphere will run into liquid air and keep it boiling under pressure, for the temperature of the atmosphere is 70° F. and that of liquid air is 270° below zero at 125 pounds pressure (or 340° colder); and the pressure being constant, you cannot raise the temperature of boiling liquid air or any other liquid gas so long as there is any liquid left in the boiler.

"The loss of heat due to work done by expansion against resistance carries the temperature theoretically far below the liquefying point, which largely neutralizes the latent heat of condensation, which in air is about one-seventh that of steam, and which disappears entirely at the critical temperature; but provision is also made for a sub-cooler or condenser to absorb the latent heat of such expanded exhaust gas remaining unliquefied, but which is at the point of liquefaction.

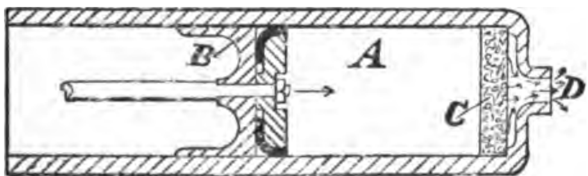


Fig. 2.

"In order to properly explain the system I propose, let me illustrate (well known though it may be) the throttled-nozzle method of making liquid air, which is the process adopted by all who have produced it in quantity—Linde, Hampson, Ostergren, Tripler and others.

"Leading up thereto, I will first show the Joule-Thompson experiment with the porous plug. This well-known experiment is illustrated in Fig. 2.

* Continuous Power the Natural Result of Converting Heat into Work in an Insulated Expansion Engine at Temperatures below the Normal of the Atmosphere. By J. F. Place. New York: The Standard Power Co., 1908.

"In the cylinder A is shown a piston B; at C is fixed a porous diaphragm or plug through which air is forced by moving forward the piston, but the diaphragm C, being made of porous material, the air passes through the same with difficulty. As the piston B is moved forward in direction of the arrow, the air in the cylinder A is compressed and consequently is heated; and the piston can be moved fast or slow, so as to give the air in the cylinder a greater or less tension, or a uniform pressure if desired, the air meanwhile constantly passing through the porous diaphragm C and expanding as it leaves the same at D. After a predetermined pressure of the air in the cylinder A is reached and its temperature has cooled to that of the surrounding atmosphere, if the piston B is continued to be moved forward then just fast enough to maintain that pressure, there will be no increase of temperature of the air in the cylinder A, and the heat generated by the friction of the air in passing through the porous diaphragm C as the piston moves forward (and which represents the work done in overcoming the resistance of the diaphragm) will in a perfect gas exactly equal the heat absorbed for the work done during the expansion of the air as it passes through or leaves the diaphragm at D; and consequently there should be no change of temperature. There is, however, as is claimed, a slight fall of temperature (air being, as is supposed, an imperfect gas) and which is known as the Joule-Thompson effect.

"By changing the foregoing Fig. 2 a trifle, it will be seen that it is practically the same thing as allowing air to escape (from a reservoir in which a constant pressure is maintained) through a throttled nozzle. For instance—

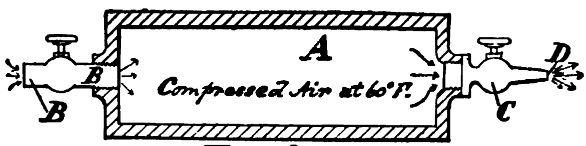


Fig. 3.

"Here A is the cylinder, but instead of a piston a supply pipe B from a compressor or reservoir keeps the air in the cylinder at any uniform predetermined pressure; and, instead of the porous plug or diaphragm shown in Fig. 2, we have in this Fig. 3 the throttled nozzle C delivering at D, by which the air is allowed to escape with difficulty, or is throttled the same as in passing through the porous diaphragm in Fig. 2, so that the pressure in the cylinder A is not lessened, but is kept constant by the supply pipe B from the air compressor or reservoir, and its volume is practically constant. The temperature in the cylinder A is also uniform, the same as the surrounding atmosphere, say, or that of the source of supply (the heat of compression having been removed). The greater the pressure in the cylinder A, the greater will be the friction in passing through the throttled nozzle C, and naturally the greater will be the work of expansion in pushing away the atmosphere in leaving the nozzle; consequently, there will be no change—the temperature of the expanded air at D will be the same as that of the compressed air in the cylinder A. It was long believed that air grew cold as it expanded, but this has been proven to be a fallacy; to be sure it grows cold, and intensely cold, if when it expands it is made to do work; but if no work is done there is no appreciable fall of temperature. This may be easily shown in practice by opening the cock in the compressed-air pipes in any machine shop; the air from the pipes is never even cool, no matter what the pressure may be. But if run through a small engine, and worked expansively by a cut-off valve, the exhaust air is intensely cold.

"The slight fall of temperature, however, owing (if it really exists in practice, as is supposed) to the fact, as claimed, that air is an imperfect gas, and which has been called the Joule-Thompson effect, has been made use of to cool the incoming compressed air in the cylinder A or supply pipe B by passing the expanded air as fast as it is expanded from the nozzle C, back over the nozzle and supply pipe, as shown in Fig. 4.

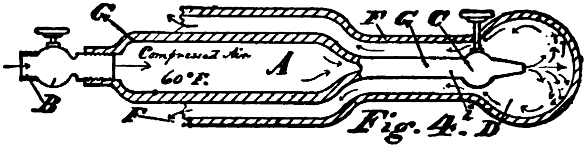


Fig. 4.

"This is the same as Fig. 3, except the expanded air as it leaves the throttled-nozzle C is trapped in the hood or chamber D and the direction of its flow changed, as shown by the arrows, so that it passes back in the outer pipe F (Fig. 4) and is carried back over the inner pipe G in the opposite direction to the flow of the compressed air in that pipe (G). This is the throttled nozzle or regenerative method, so-called, and has been used by all up to this date who have made liquid air in quantity. This method of cooling or production of low temperatures is practically the same as the Siemens' interchanger with the addition of the handicapping device, the nozzle, and it has been known for nearly fifty years. It is crude and wasteful of energy, for, combined with the hood, there is more friction than with the nozzle alone, and the great pressure necessary is costly, not a foot-pound of which is utilized.

"I will here add a rough sketch, shown as Fig. 5, of Prof. Linde's liquid air-making apparatus, which will serve to illustrate also the mechanism of Dr. Hampson and all others who have produced liquid air, and it will be noticed that the method is practically the same as that shown in Fig. 4.

"In this Fig. 5, the throttled nozzle is shown at C, operated by the valve wheel H; the smaller pipe I of the coil shown takes the place of but is practically the same as the cylinder A and pipes B and G of Figs. 3 and 4. This pipe I is supplied with compressed air from the compressor K by the discharge pipe P through the water cooler J and connecting pipe B.

"After the air is expanded from the throttled nozzle C into the chamber D it is passed back over the incoming compressed air supply pipe (I) in the outer pipe F of the coil. The pressure (and practically the volume also) in the pipe I is constant, the nozzle cock C not being opened so wide as to cause a fall of the pressure therein; and the theory claimed is that, however slight the fall of temperature of the expanded air as it leaves the nozzle C, it will absorb a correspondingly small amount of heat from the compressed air in the pipe I, especially from the lower end near the nozzle.

"When the temperature in the chamber D has been reduced to the liquefying point, the liquefied air is gathered in the lower part of the chamber, and is drawn off through a cock as shown. Only about one-twentieth of the air delivered from the nozzle C becomes liquefied, the other nineteen-twentieths passes back through the annular pipe F for the purpose of cooling the incoming compressed air in the pipe I; this unliquefied expanded air is finally delivered to the suction valve of the compressor again through the pipe N. Through the check valve in the pipe O new compressed air is forced from an auxiliary compressor in order to make up for the amount liquefied and drawn from the chamber D.

"The fall of temperature due to the Joule-Thompson effect, as claimed, of the expanded air as it leaves the diaphragm C in Fig. 2 or nozzle C in Fig. 3 has been carefully calculated and amounts to about half a degree Fahrenheit for each drop of one atmosphere of pressure (14.7 pounds). Joule and Thompson (now Lord Kelvin) neither experimented with nor made calculations, so far as I know, for the hooded nozzle with the Siemens' counter-current coil or interchanger (which is the Linde and Hampson method) as shown in Fig. 5. If they had made any such experiments, then we probably should have now before us some calculation as to the effect of the friction in the chamber D, and possibly a new equation entirely for the Joule-

Thompson effect in the nozzle shown in Fig. 4, and perhaps another one for the nozzle with complete interchanger as shown in Fig. 5.

"The figures given as the Joule-Thompson effect from the equation of the authors of the theory by the three authorities, Professors Sloane, Travers and Linde, reduced to Fahrenheit degrees, are respectively .5°, .458° and .497°. Protessor Sloane says that if the compressed air is cooled to 132° F. below zero before it is allowed to escape through the nozzle, then (according to the Joule-Thompson equation) the fall in temperature may be a trifle over one degree Fahrenheit for each atmosphere (14.7 pounds) of pressure released, thus showing that the cumulative cooling effect is relatively greater as the initial temperature (or temperature of the compressed air before release) is reduced. Taking the average cooling effect obtained per atmosphere of pressure released by the nozzle, or .485° F., then if we have 90 pounds constant gauge pressure in the pipe I (Fig. 5) at normal atmospheric temperature, the fall in temperature of the expanded air as it escapes from the nozzle and expands to atmospheric pressure will not exceed in the aggregate 2.9 Fahrenheit degrees. This seems a very trifling fall of temperature, and yet in the apparatus for making liquid air as in Fig. 5, it is very doubtful if even that fall of tem-

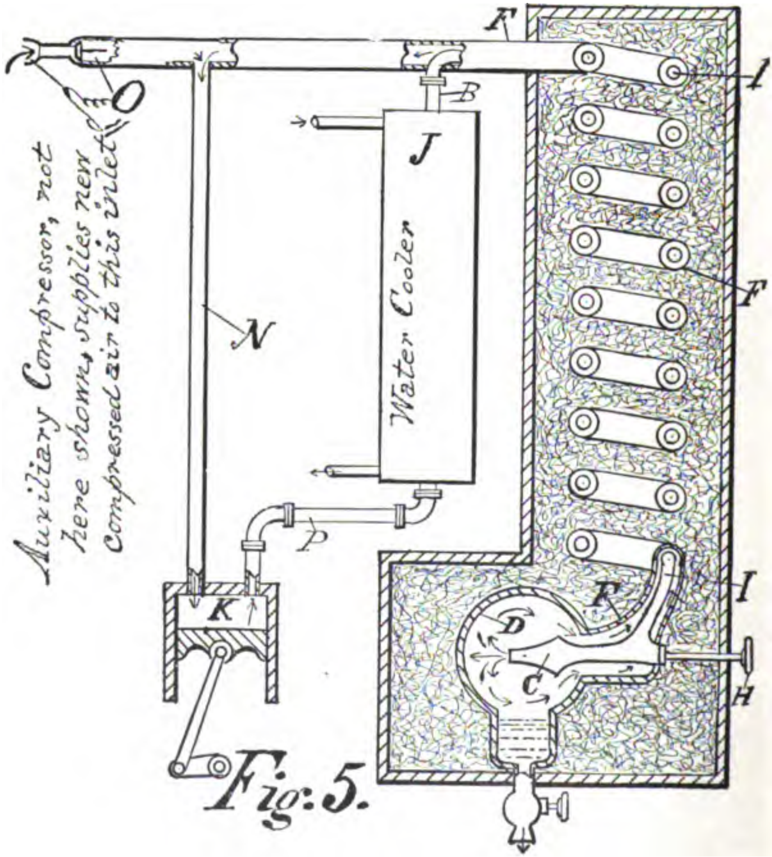


Fig. 5.

perature is realized in practice, for the figures given are based on experiments made with the arrangement as shown in Figs. 2 and 3, and not as constructed in either Figs. 4 or 5. In Fig. 4, and especially in Fig. 5, it is a different proposition, as I have previously stated; for the expanded air as it leaves the nozzle is "corralled" or trapped as it were in chamber D and turned back as shown by the arrows. The friction caused by the expanded air thus striking against the walls inside the chamber D and changing its direction has a tendency no doubt to neutralize more or less of the Joule-Thompson cooling effect; and the higher the pressure used, the greater will be the impact against the walls (in D), and consequently correspondingly greater will be the friction (work or motion converted into heat) which is death to refrigeration.

"It is by no means clear to me that the specific heat of the air in both pipes of a Siemens' interchanger is the same. The conditions are very different, for in pipe I of Fig. 5 the air is under a high tension, practically at constant volume, and the work done seems to be localized to the nozzle C (to the friction right in the nozzle), where it is converted into heat, and this heat is immediately absorbed by the work of the expanding air as it passes through the nozzle; while in the outer pipe F the air is at atmospheric pressure, and is continually doing work and expanding at constant pressure as it takes up the heat from the compressed air in pipe I.

"Whatever importance may be attached to the Joule-Thompson effect, it is very clear that liquefaction is produced by the low temperature, and that that low temperature is due to loss of heat by the air; and as that heat cannot have been transferred by conduction to the environments of the air (as such environments were of a higher temperature), it must have been converted into work somewhere—heat and work being equivalents, and temperature simply the evidence of or by-product due to the transformation; and, therefore, that the liquid air is a by-product of the transformation of heat into work. If the specific heat of the air in each of the two pipes of the interchanger is not the same, then the seeming mystery is easily explained; the ratio of the heat consumed by being converted into work in the outer pipe F to the heat given up by the compressed air in the inner pipe I for equal units of weight of air would doubtless approach the well-known ratio of 1.41 to 1 (or .237 to .168, the specific heat of air at constant pressure to its specific heat at constant volume) which would cause a constant lowering of the temperatures sufficient to produce partial liquefaction in spite of the frictional heat generated in D —which is exactly what happens.

"It is quite clear, also, that the Siemens' interchanger is the prime factor in the transformation, and that the nozzle is a detriment instead of a help, and that the cooling effect is produced in spite of the nozzle rather than otherwise. Air was never liquefied in quantity until apparatus using this method through the Siemens' counter-current interchanger was adopted.

"The very high pressures used by the throttled-nozzle system (shown in Fig. 5), in order to liquefy air (generally from 2,000 pounds to 3,000 pounds), makes the process an expensive one, and especially so as only about 5 per cent. of the air compressed can be liquefied. The General Liquid Air & Refrigerating Co., of New York (using the Ostergren apparatus), used but 1,250 pounds pressure, owing to the fact of probably more perfect insulation of the counter-current coils; and they carried the production of liquid air, two years ago, nearer to a commercial basis (in so far as quantity of output means commercial) than any parties that have ever liquefied air either before or since, for they produced at one time from 400 to 450 gallons in 10 hours' run of the apparatus.

"Linde states in his English Patent (No. 12,528—1895), with a view, probably, of showing that the cost of making liquid air by this throttled-nozzle method is more apparent than real, that a pressure of 3,000 pounds per square inch can be used in the inner coil (I, Fig. 5), and that, if such pressure is dropped to 1,500 pounds through the nozzle in the expansion chamber D, then the return flow for cooling (or the expanded air in the outer coil F) will be delivered to the air compressor through the pipe N at that pressure (1,500 pounds); and, if so, 'then a reduction of about 45° Fahrenheit will be obtained with an expenditure of energy that will not be greater than that required for compressing air from one atmosphere to two atmospheres.' This reasoning might be good provided all the liquid air were evaporated again as fast as produced and carried back to the compressor by the outer coil F, although the reduction in temperature which it is stated would be realized (45 degrees) it is very doubtful; but as for every gallon of liquid air made and drawn from the chamber D. its equivalent or about 800 gallons of new free air must be compressed by the auxiliary compressor up to 200 atmospheres (or 3,000 pounds) and delivered to the apparatus through the pipe O, then the expenditure of energy is clearly not 'from one atmosphere of pressure to two,' but from one atmosphere to two hundred, or from atmospheric pressure to a pressure of 3,000 pounds per square inch. Besides all this power required, there is the power needed to compress the other nineteen-twentieths of the air used in the outflowing or cooling coil F (or 15.200 gallons, in order to make one gallon of the liquid) from a pressure of one atmosphere to two, or 1.500 pounds to 3,000 pounds per square inch. It is also significant that Prof. Linde says in this connection that 'experience has shown that for the mere making good the losses in working, the difference in pressure before and after release (or the drop in pressure in the nozzle), must be greater than 20 atmospheres, (300 pounds).

"Possibly I have taken more space than called for to give these details of liquid-air making; but it has been justly charged that liquid air is costly, and for that reason that it has not met public expectations, and I wish to show, 1st, why it is costly; 2d, that it can be produced at a fraction of its cost hitherto; and 3d, that cheap liquid air means cheap compressed air (which it is, in fact, and in the most concentrated form of compression), and naturally cheap power; moreover, its cheap production leads up to the main object in view—Continuous Power. Other liquid gases, of higher temperature than liquid air, such as carbonic acid, acetylene or ethylene, may be used for continuous power in my system, as the principle of liquefaction applies to all; but liquid air is an ideal substance and represents the best type, the limit as it were, of low temperatures; and the raw material for its production may be had for the taking, everywhere, and is both exhaustless and costless—three good reasons for giving it first a good square test in the system I propose.

"The question here naturally suggests itself to the reader: Why not reduce the cost of liquid air by making the compressed air do work? Why compress air to the enormous tension of 3,000 pounds and then let it escape through a nozzle and thus waste all that energy, when 30 pounds, expanded in an engine, would give a much greater fall of temperature—and the engine be made to do a good part of the work of running the compressor?

"The question is more than pertinent, for the gain in refrigeration or cooling of the air (the by-product) would be very great, and the saving in power required for compressing the air would be enormous, aside from the power utilized from the engine, which would be all 'velvet.' as it were. Let us see how it would look on paper; for instance, referring to Fig. 6:

"Suppose we have an air reservoir A supplied with compressed air at a temperature of 60° F. (the heat of compression having been removed by a cooler), and an expansion engine B, which is belted to a dynamo H. The reservoir A has an outlet valve J and a main pipe E, which is connected by a branch pipe F to the engine through the throttled valve G. The pipe E also has a branch pipe I. which is supplied with a throttled valve C and a nozzle D—the valve C when opened having an orifice of exactly same size as the valve G. (This nozzle D is practically the same as the nozzle D in Fig. 3.) We will say that the valve J is opened at a certain point and locked, and that the pressure in the reservoir A is 91 pounds gauge. By opening the throttle G the engine B will run 200 revolutions, and will develop 10 horse-power in driving the dynamo, and will take all the air that can pass through the valve J; and the pressure in the pipes E and F will show 90 pounds, or one pound less than in the tank A, and the engine will not be run so fast but that the pressure will be maintained constant at that tension (90 pounds)—it being understood that the engine has a cut-off inlet valve, and that it is set so as to cut off at a point of the stroke so that the air will be expanded down (adiabatically) from 90 pounds to exactly atmospheric pressure at every stroke. Now, we will shut off the throttle G and open the throttled-nozzle valve C, and the orifice in valve C being exactly the same as in valve G, the pressure in the pipes E and I is 90 pounds, same as when the engine was running, thus showing that exactly the same number of cubic feet of free air per minute is being delivered from the nozzle D as was delivered from the exhaust K of the engine when it was running—the main valve J not being disturbed, but being fixed and locked at the same point as when the engine was running. Now, what will be the temperature of the expanded air at each respective discharge—D and K?

"The writer has submitted this sketch and this question to more than one mechanical engineer, and has received the startling answer that the temperature would be very cold, but the same in each case; and he has replied, if that is the case, then from whence comes the ten horse power of work?

"If the authorities on the fall of temperature due to the Joule-Thompson effect (which has been fully explained herein) are correct, then the temperature of the air as it expands from 60° F. and 90 pounds gauge after leaving the nozzle D, will be 57.1° F., which is a cooling effect or reduction of 2.9° F. from the temperature (60°) of the air in the pipes E and I. The temperature of the expanded exhaust air at K, from the engine (if the engine cylinder is thoroughly insulated, so that no heat can pass through its walls), will be found to be about 165° F. below zero, which is a fall of temperature of 225° F., or nearly 100 times as much as the theoretical fall at the nozzle D, and probably 200 times as much as the actual reduction in temperature realized in practice.

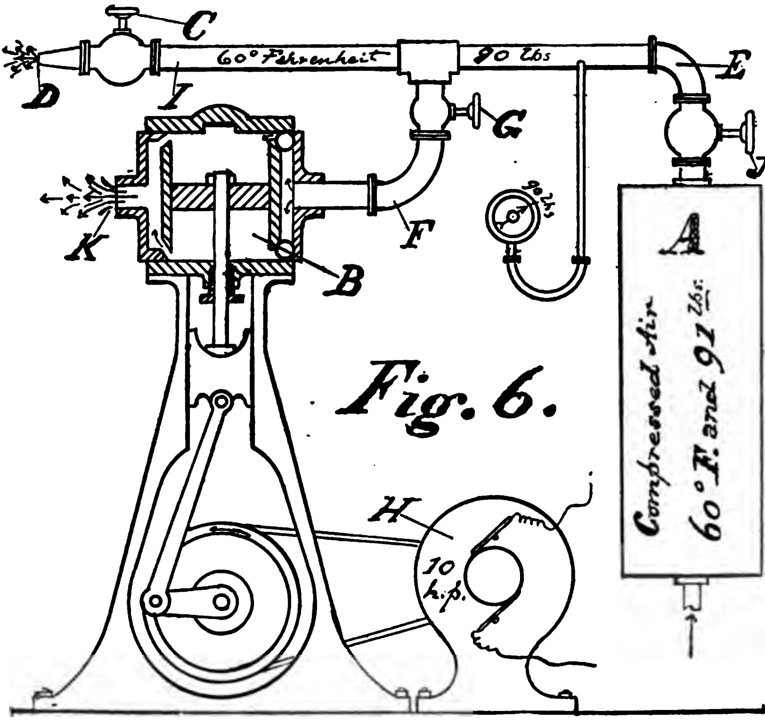


Fig. 6.

"The nozzle D in Fig. 6 is practically the same as used in making liquid air, with the addition of the hood or expansion chamber D, shown in Fig. 5. Now, if we take the engine B (Fig. 6) and muzzle the exhaust K, by adding to it the chamber D of Fig. 5, and the counter-current or Siemens' interchanger coils I and F, (Fig. 5), we ought to get all the advantages of the throttled-nozzle method (by which liquid air has been produced in quantity) besides the advantage of the total gain of the work of the engine, which should be 60 to 80 per cent. of the power required to compress the air used, and the further immense gain of probably 200 times the reduction in temperature of the expanded air, and no frictional heat in chamber D.

"The illustration (Fig. 8) will show the arrangement proposed, wherein is shown the expansion engine having the Siemens' interchanger (same as shown in Fig. 5), and thoroughly insulated from the heat of the outside atmosphere by a vacuum jacket (V) and inclosed in hair felt (H) with also an insulating expansion chamber inclosing the engine and its exhaust ports, and connected with the counter-current or

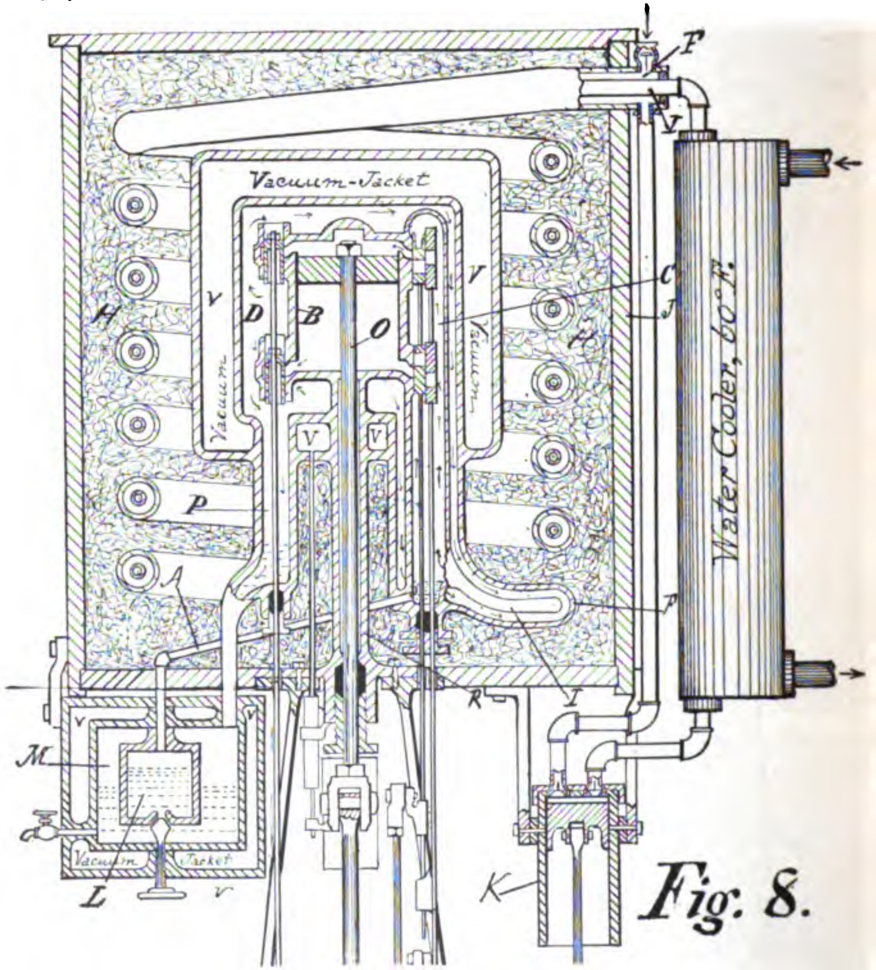


Fig. 8.

return flow cold-air pipe F (same as the pipe F, in Fig. 5) for cooling the compressed air before delivery to the engine.

"In Fig. 8 the expansion engine is shown at B, having a cut-off inlet valve gear and ordinary exhaust valves; at I and F is shown the interchanger, the high-pressure pipe of which (I) is connected with the discharge of the compressor K at one end and with the inlet valve chamber C of the engine at the other end—a branch pipe A connecting with the liquid air receptacle L, which receptacle is to catch the liquefied air which drips down from the inner pipe I of the interchanger, and which is jacketed by an outer receptacle M to catch the liquid discharged from the insulating exhaust chamber D of the engine—the latter liquid being colder than the former, owing to its less pressure. At V is shown an insulating vacuum-jacket inclosing the engine, and at *v* a similar jacket inclosing the liquid receptacles. The compressor is provided with a water-cooler, as shown, and is driven by an outside source of power from the wheel N, the engine, of course, doing a good part of the work, the moisture being absorbed from the air by passing same through a calcium chloride drum (not shown).

"Now, if the air is compressed to 125 pounds gauge pressure, and it is expanded in the engine to atmospheric pressure from a temperature of 60° F., the temperature of the exhaust will be 190° F. below zero, so that, instead of expanded air at a temperature of 57° F. above zero to flow back in the outer pipe F of the interchanger (as in the nozzle operation) the return flow or cooling current of expanded air in the pipe F will be at a temperature of 190° below zero, or a fall of 250 degrees instead of less than 3 degrees, and the expenditure of power for compressing the air is for 125 pounds only instead of 3,000 pounds. As that cold-expanded air passes through the exhaust chamber D and the outer pipe F of the interchanger, the next following charges of compressed air delivered to the engine from pipe I will naturally be at or near that temperature also; and if expanded against resistance from that temperature (190° below) will fall theoretically to 320° F. below zero—thus with but two strokes of the piston, or one revolution of the engine crank, we get a fall of 380 degrees and have reached a temperature actually below the point of liquefaction. It must also be noted that the compressed air in the inner pipe I, near the engine cylinder, being under a pressure of 125 pounds, will liquefy at or below its condensation point, which is 270° below zero; whereas the temperature of the expanded air in the chamber D after the machine is running will be the same as the temperature of liquefaction, or that of saturated vapor at atmospheric pressure, 312° below zero, or 42 degrees colder.

"A less compression may be used, and still satisfactory results be obtained. For instance, with 90 pounds gauge pressure and an initial temperature of 60° F., the temperature of the exhaust expanded air will be 165° below zero; with 60 pounds gauge pressure, the exhaust temperature will be 133° F. below zero; and with 30 pounds gauge pressure the exhaust (from an initial temperature of 60° above) will be 103° below zero—giving a fall in temperature even at that very light compression, of 163 degrees.

"The fall of temperature, or increased refrigeration over and above that of nozzle expansion, if the air is expanded against resistance in an engine, will be exactly equivalent to the work done by the engine; thus, besides having at the engine exhaust all the advantages of the nozzle without its friction, and with probably a much greater cooling effect, we realize in addition a positive gain at both ends—for we gain the power, and the air loses its heat exactly equivalent to that power, is just that much colder, the cold being simply a resultant effect or by-product of the transformation; and cold is what we are after, for by the loss of its heat air becomes liquefied.

"Having produced liquid air with our expansion engine and the interchanger, as shown in Fig. 8 (and trapped it in insulation where the heat of the atmosphere cannot get at it), let us see what results would be obtained if we should use this liquid air over and over again in the same engine—exposing it to and absorbing heat from the atmosphere to evaporate it under a pressure, and then converting that heat into work by expanding against resistance in the engine, thus re-liquefying the air; and then completing the cycle of Carnot's function by returning it to the same condition as to pressure, volume and temperature that it was found in.

"The declaration by Carnot is here worth repeating: 'Wherever there exists a difference of temperature, motive power can be produced.' We have the difference, and it is ample—382° F. But suppose we boil the liquid air, by exposing it to the atmosphere, until 125 pounds gauge pressure is indicated, and use its vapor (air) as fast as it boils at that pressure. Olszewski (and he is good authority) gives as the boiling point of liquid air, under a tension of 125 pounds gauge pressure, as about 270° F. below zero. With the initial temperature at that point, 270° F. minus, the temperature of the exhaust from the engine will be theoretically at 362° F. below zero, which is 50° below the temperature of liquefaction at atmospheric pressure; and the difference of temperature between 270° below and the normal of the atmosphere (70° above) is 340 degrees.

"The critical temperature of air is 220° F. below zero, above which it will not liquefy; and the critical pressure (or pressure required for liquefaction at that temperature) is 39 atmospheres, or 559 pounds gauge, at which critical point latent heat becomes nil. By compounding the expansion engine and working from that or higher initial pressures, or from an initial temperature of slightly above the critical (220° below) the final temperature of the exhaust would be theoretically 370° F. below zero, or 58 degrees below the temperature of liquefaction.

"In the improved form of expansion engine for continuous power, being built by me," says Mr. Place, "provision is made for compound-expansion cylinders, the high-pressure cylinder being supplied from a boiler, and the low-pressure cylinder alone being supplied by a compressor, the latter cylinder exhausting into a partial vacuum in a separate interchanger attached to the exhaust of the high-pressure cylinder as a surface condenser. In this way the temperature of liquefaction of the exhaust of the high-pressure cylinder is raised to about 100 degrees above the temperature of that of the low-pressure exhaust, and the latent heat almost entirely eliminated; this method largely increases the effective power of the engine, and insures absolute and total liquefaction of every exhaust charge, the exhaust chamber being practically also a condenser.

"In Fig. 9 this form of engine is shown in a conventional way, the cylinders being inclosed in the insulating case J, two liquid-air boilers, W, being shown, provided with air flues, S, for supplying same with large quantities of free atmospheric air at normal temperature, from which the moisture has been absorbed by calcium chloride.

"The boilers are supplied with large quantities of free dry air at normal temperature, which is forced through a calcium chloride drum and the flues S by a fan-blower. This air passes up through the tubes in the boilers same as hot air through an automobile steam boiler, and then is carried off through the large insulated cold air flues X, and may be used for cooling or ventilating purposes—the refrigeration thereof being a by-product. The dry free air as it passes through the liquid gas boilers gives up its heat to the liquid (air or other gas) and causes it to rapidly boil (evaporate), and when sufficient pressure is generated a relief valve is forced open and this evaporated liquid gas under tension (cold compressed air or other gas) is delivered to the engine again, and thus the heat which has been absorbed from the atmosphere through the liquid gas boilers is also converted into mechanical work, and the cold expanded gas, thereby losing its heat again, becomes liquefied and is delivered to the insulated receptacle (L, Fig. 9). Practically all of the evaporated gas (with the aid of the condenser), will be liquefied this time, for it is a law of physics that the vapor, gas or steam from a liquid is always of the same temperature as that of the liquid from which it evaporates; therefore the vapor from the boilers (W), under such pressure as desired, will be delivered to and expanded in the engine at the same low temperature as the boiling liquid gas in the boilers. Meanwhile the compressor having stopped working (being arranged as is the common practice to automatically stop when a certain pressure is attained), the power of the engine, derived entirely now from the heat taken from the atmosphere, may be utilized for other work, its speed being limited the same as with a steam engine by the heating capacity of the boiler.

Mr. Place declares that "temperature is not power; it is simply a resultant manifestation—the evidence of the change from heat to power or power to heat. That in the transformation of heat to work in an expansion engine, the fall of the temperature of the expanding air is a by-product of the operation; and that refrigeration being a by-product, necessarily liquid air is also a by-product of the conversion of heat into work in an insulated expansion engine. That heat and power alone are the equivalents, one of the other—not temperature. Nature deals in equivalents, it is true, and its laws are most exacting; but there can only be two equivalents—one of the other; there cannot be a third. The temperature, the refrigeration, or liquid

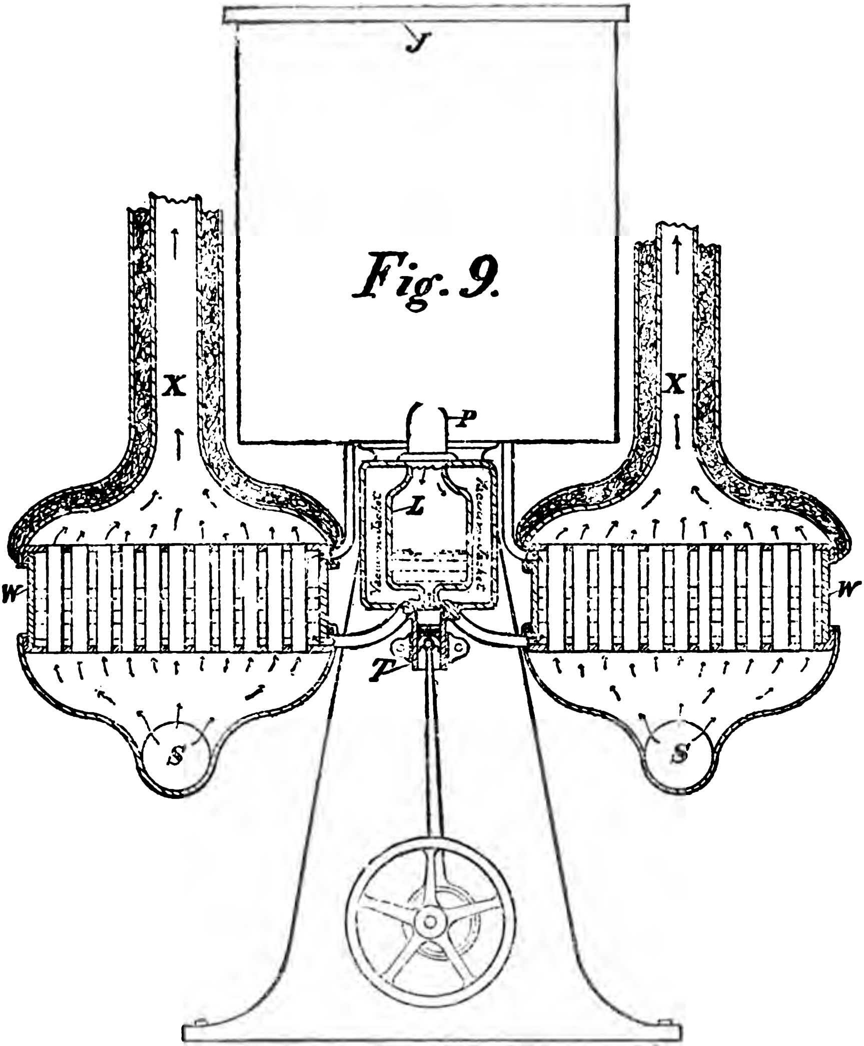


Fig. 9.

air, if you please, has cost no energy; the work recovered is the mechanical equivalent of and has cost (if such a term may be used) all the energy (heat) expended; therefore the temperature, refrigeration or liquid air is simply the evidence of the loss or disappearance of the heat transformed, and is consequently a by-product of the operation of the conversion of such heat into work.

"I have disproved by actual experiments at least three theories which had become through popular fallacy 'bogies' of the first magnitude, namely—1st, that an engine cannot be run without lubrication; 2d, that thorough insulation cannot be maintained, and 3d, that the moisture in air cannot be removed.

"Experience shows that an engine can be run without lubrication, and that it runs better cold than hot: that thorough insulation of an engine cylinder is as easy of attainment as the insulation of a steam pipe from the normal temperature of its surroundings; and that by the passage of compressed air through a drum filled with calcium chloride the moisture thereof may be thoroughly absorbed therefrom."

The Substructure for the 1,800 Ft. Cantilever Bridge at Quebec, Canada.

The longest span bridge in the world is now in process of construction across the St. Lawrence River, about seven miles west of Quebec, Canada.

The substructure of the Quebec Bridge consists of three masonry structures on each side of the river as follows: An abutment on the top of the rocky cliff, an anchor pier at the foot of the cliff and 210 ft. from the abutment, and a main pier near the margin of low tide and 500 ft. from the anchor pier. The two main piers, as before stated, are 1,800 ft. apart. Those on the north shore were exactly similar in all respects, except the volume of masonry contained. The same statement is true with respect to the main piers. The masonry is granite face work with concrete backing, except the coping courses of the abutments and anchor piers and the upper 19 ft. of the main piers, which are solid granite masonry throughout.

The most interesting features of the foundation work are the construction, equipment and method of sinking the caissons and the contractor's plant and equipment for performing the construction work of the main piers. Since all these features were the same, except in minor details, for both piers, a description of the south pier work alone is sufficient to explain clearly all the work.

The caissons for the two main piers were identical in construction and dimensions, and were 49 x 150 ft. in plan and 25 ft. high. The timber used was yellow pine from Georgia, and all main timbers were 12 x 12 ins. in section after dressing. The outside sheathing consisted of two layers of crossed diagonal planking spiked to the sidewalls. A single layer of planking was employed to sheath the ceiling and walls of the working chamber and both sides of the dividing bulkheads. This chamber was 6¼ ft. high in the clear and was divided into six compartments by the transverse bulkheads 2½ ft. thick, just mentioned. The sidewalls at the bottom are beveled at a very flat angle to make a cutting edge 9 ins. wide, which is shod with a ¾-in. x 6-in. x 6-in. steel angle. Generally speaking, the construction of the caissons involves no new features other than the method employed to avoid annoying leaks of water into the shafts due to the wide variation of tide level, and their construction requires no further description than is given in the plans.

The trouble from leakage and the method of remedying it may be described as follows, premising first that the six compartments of the air chamber were each made accessible by means of a material shaft 3 ft. in diameter. It was found that the rising tide would fill the shaft wells with water and that, aided by the leaks of air from the chamber, this water would reach a height somewhat above the river level. No trouble was experienced from the leakage of this water into the shafts until the tide began to fall and the air pressure was correspondingly reduced, when the water in the shaft well escaping less rapidly than it had come in would soon exceed the chamber air pressure, and thus force an entrance into the shafts at the deck line and into the chamber at the ceiling by loosening the oakum in the seams. But for the fact that the air chamber was double-calked with four threads of oakum, this excessive inward pressure would have caused very serious trouble by entirely dislodging the oakum. As an indication of the pressure encountered it may be noted that on one occasion during extreme high tide alarm was given that the roof of the caisson was caving in, when, upon investigation, it was found that this excess water pressure was great enough to draw the ½-in. x 7-in. spikes with which the 3-in. lining was spiked to the roof timbers near a shaft, and force several planks downward, giving the appearance of the roof giving away. The leakage mentioned was greatest and most annoying where the shafts passed through the deck, and profiting by the first experience, rubber gaskets in the horizontal seams and stopwaters in the vertical seams were employed around each shaft opening, as shown by Fig. 1. These devices proved to be an effective remedy for the trouble.

The equipment of the caisson for sinking comprised air and water pipes, material shafts, air locks and accessories. Described in more detail, each compartment of the working chamber was provided with a material shaft, a blow-out pipe, an air signal pipe and a water pipe. The main air supply pipe entered through the roof of one of the center compartments. The longitudinal sectional elevation, Fig. 2, shows the arrangement of the water and blow-out pipes.

The six working shafts were built of 8-ft. sections of 36-in. wrought-iron cylinder bolted together with gaskets and outside flanges, and connected to the deck with 24 ¾-in. bolts passing through a special cast deck flange, and the three courses of deck timbers, as shown by Fig. 1. There were two plain shafts used for materials only and four ladder shafts used for both material and workmen. The cross-section of the ladder shafts in each case consisted of 300° of a circular cylinder, and for the remainder of the perimeter of a bent plate offset beyond the circle. The space afforded by this off-set accommodated a ladder, and thus left a 36-in. diameter space clear for the passage of material, as shown by Fig. 3. The two plain shafts were complete cylinders 36 ins. in diameter, and were the only ones provided with material locks.

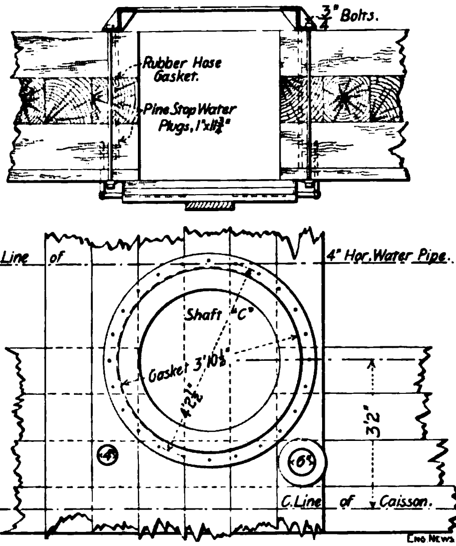


FIG. 1—DETAILS OF AIR-SHAFT OPENING IN DECK OF MAIN PIER CAISSONS.

The two material locks were adapted to

work on top of any of the six shafts, but during the process of sinking the caisson were kept on the two plain shafts, and material which would not pass the blow pipes was accumulated at the foot of these

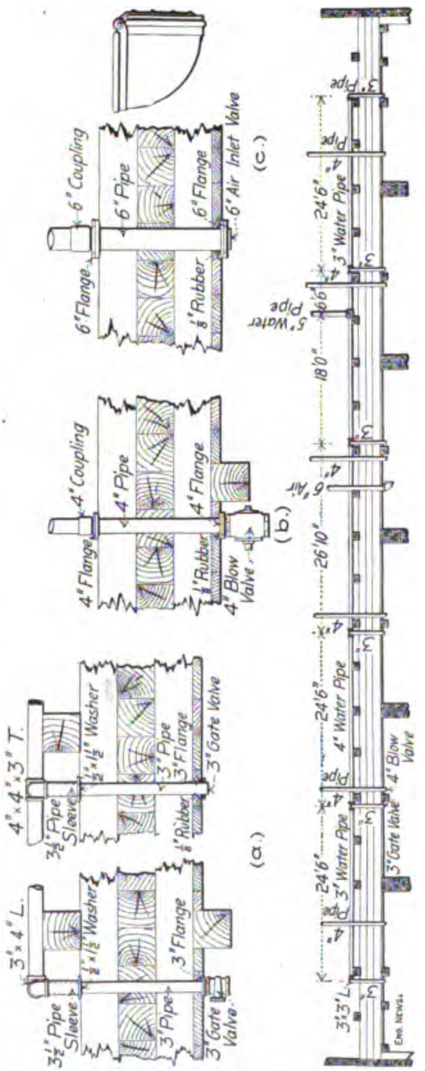


FIG. 2—GENERAL DETAILS OF PIPE OPENINGS IN DECK OF MAIN PIER CAISSONS.

shafts by passing it from the adjacent chambers. When sealing the chamber, the locks were transferred from shaft to shaft as each compartment was filled with concrete. A portable platform was built level with the top of each lock and skips filled with concrete were landed thereon and dumped directly into the locks, and when the latter were equalized the charge of concrete would drop through the shaft into the air chamber, where it was shoveled into place and rammed.

The ladder shafts were all converted into man locks by inserting between the sections of the shaft a diaphragm containing a door. Each ladder shaft was

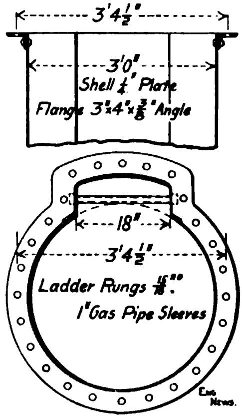


FIG. 3—DETAILS OF MATERIAL SHAFTS FOR MAIN PIER CAISSONS.

provided with two of these and they were raised as new sections of shaft were added. Before using any of these shafts for concreting, the top diaphragm and door was removed and a Moran lock put its place. The lower of the two diaphragms was made up of two plates, the smaller one containing the door being slightly smaller than the shaft was unbolted from the larger plate and lowered into the air chamber, thus leaving a circular opening 2 ft. 7½ ins. in diameter through which the concrete could readily drop when released from the lock. By the use of these diaphragms it will be seen that man locks of varying capacity could easily and quickly be made. After sealing the chamber, all the shafts were unbolted from the cast-iron Z-bar shoe and lifted out in one piece and the several sections afterwards unbolted, thus preserving the shafts unhurt.

The material locks used were Moran locks and were attached to the tops of the two plain shafts. The construction of one of these locks is shown in detail by Fig. 4. As will be seen, the lock chamber is about 12 ft. long and 5½ ft. in diameter, and is provided with upper and lower doors. The lower door is circular and double-hinged so that it swings entirely clear of the opening. The upper door is made of two halves hinged to links, which work in guides carrying them away from the opening. Both doors close on rubber gaskets and are operated by counterbalanced shafts. To permit the working of the hoisting rope through the upper door when closed a semicircular groove is cut in the closing edge of each half which form a circular hole when the door is closed. A stuffing box carried by the rope closes this hole against the escape of air while allowing the rope to pass freely through it. Fig 4 shows the construction of this stuffing box, and of all other details of the air locks.

The two locks described were used continuously in sinking the caissons, and proved to be very valuable machines. They were capable of passing iron buckets 34 ins. in diameter and 48 ins. deep, these buckets being filled with excavated material and hoisted directly from the air chamber by a ⅝-in. wire rope operated by a hoisting engine located on the working platform. With the aid of these two locks in passing the concrete to the working chambers, perhaps the quickest work in sealing an air chamber of such size was done in sealing the chamber of the north caisson. The work was begun at 7 a. m., Oct. 31, and contiuously prosecuted until 7 a. m., Nov. 6, when the work was completed. During the 144 hours of actual work about 1,500 cu. yds. of concrete were passed into the air chamber, the largest record being 250 cu. yds. in twelve hours of the night of Nov. 3.

Referring to Fig.2, it will be seen that a 4-in. water pipe is run along the deck of the caisson near the longitudinal center line, which has six vertical 3-in. pipes extending into the six compartments of the working chamber. There are also six blow-out pipes 4 ins. in diameter, one extending into each compartment. The water pipes having gate valves and the blow-out pipes have special cast-iron plug valves, giving a 4-in. clear way for the passage of mud, sand and small stones. The connections of the water and blow-off pipes to the caisson deck are shown at (a) and (b) in Fig. 2. The air pipe is 6 ins. in diameter. It passes through the caisson deck and terminates in an elbow, the horizontal open end of which is closed by a hinged iron disk faced with leather. The details of this pipe are shown at (c) in Fig. 2.

The caissons were constructed on the north bank of the river, at a point about 4,000 ft. below the site of the bridge. They were built ready to sink before launching, and weighed about 1,600 tons each. The launching ways were four in number, each 30 ins. wide and about 300 ft. long, and having an inclination of 1 in. per foot. The running ways were 32 ins. wide and 60 ft. long, and had an effective bearing area of about 550 sq. ft. in the aggregate, thus making a load of about three tons per square foot at the time of launching. Owing to this great pressure some difficulty in launching was apprehended, but by the use of a superior beef tallow thoroughly and freshly applied, the friction was so reduced that the effort down the ways was great enough to split four 12 x 12-in. yellow pine sticks with the grain through a length of 12 ins., and release four 1½-in. screw bolts with which the two end sliding ways were bolted to the fixed ways. The launch was made broadside on, and without accident in case of either caisson.

The north caisson was launched on June 20, 1901, and the south caisson on May 26th, 1902. Prior to launching each caisson a timber working platform having an area of about 12,000 sq. ft., was built on piles around the corresponding pier site. The piles for these platforms were shod, the better to penetrate the boulder formation.

At the site of the piers the water had a depth of about 10 ft. at low tide and 29 ft. at high tide. As the caissons unloaded drew about 12 ft. of water they grounded at low tide and floated at high tide. The widely varying tidal range occasioned no trouble or inconvenience in handling the caisson while afloat, but when it would barely float at high tide care was required to have it grounded in correct position. Before the next high tide, 12 hours later, sufficient concrete would be added to prevent the caisson from floating again. Therefore as soon as the caissons were in position the work of loading them with concrete was begun and prosecuted continuously until the crib-work above the deck was entirely filled ready to start the pier masonry.

cutting edges of the caissons as much as 4 ft. without any difficulty, thus greatly facilitating the removal of boulders.

All boulders too large to enter the 34 x 48-in. iron buckets used in removing the excavated material were drilled and broken by dynamite, 3,000 lbs. of this explosive being used in sinking the south caisson, and without a single case of injury from this cause and without the men suffering from the gases evolved. The air chamber was lighted by 16-c. p. in-

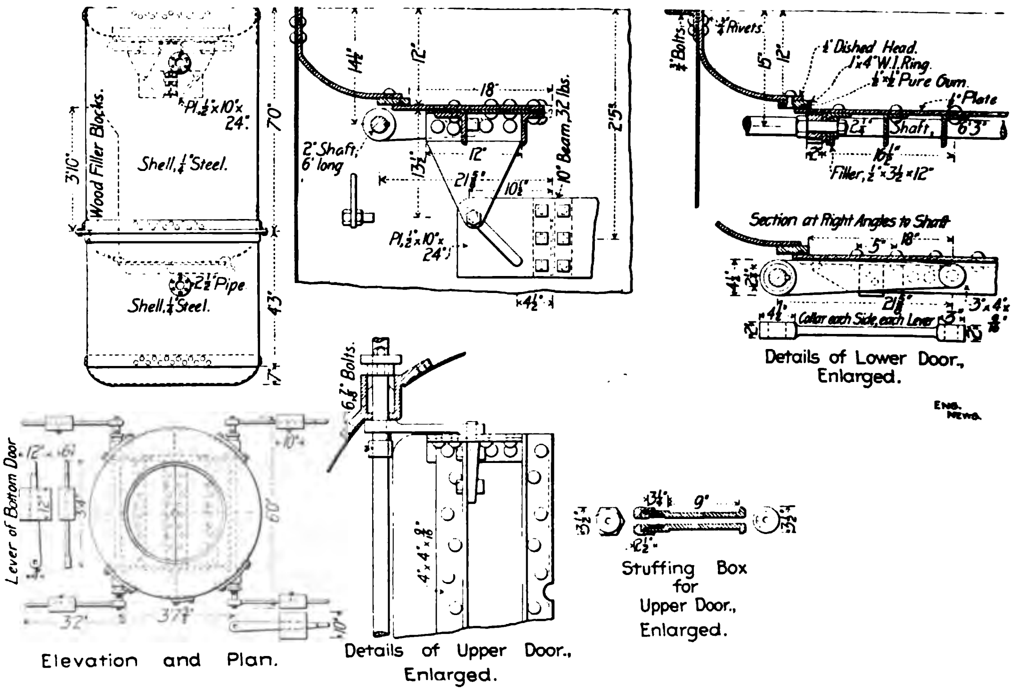


FIG. 4—DETAILS OF MORAN AIR LOCK FOR MAIN PIER CAISSONS.

Simultaneously groups of men were put at work in the chamber excavating and removing the boulders constituting the river bed. There were no unusual features in sinking the caissons other than the material to be penetrated, which consisted of sand, gravel and boulders, some of which were many tons in weight, so compacted as to be impervious to compressed air. Due to this latter fact it was possible to keep the excavation below the

candescent electric lamps, about 100 being used in the six chambers. The current which supplied the lamps was also used to fire the dynamite charges by attaching the leading wires to a lamp socket. When a blast was to be fired the most convenient lamp was unscrewed and the socket attached to the leading wires was inserted and as soon as contact was made the shot was fired. This proved to be quicker, more reliable and more economical than the blasting battery generally used for such purpose.

The sinking of the south caisson was begun on June 7, 1902, and finished on Oct. 17, thus requiring 131 days to sink 59 ft., or at an average sinking of 5.4 ins. per day, varying from a minimum of 2 ins. to a maximum of 10 ins. The number of men employed at the bridge site varied from 500 to 600, and at the quarry at Riviere a Pierre from 100 to 300. The number employed in the air chamber of the south caisson varied from 225 to 300, divided in the beginning into three shifts of eight hours each. This continued until a depth of 50 ft. was reached, when four gangs were employed, working six hours each. When a depth of 65 ft. was reached, six gangs were used, working four hours each, until a depth of 75 ft. was reached, when eight gangs were employed, working three hours each until the final depth of 80 ft. was reached. The maximum air pressure used in sinking the south caisson was 36 lbs., and was endured by the men with little inconvenience and without developing any serious case of "bends."

It is impossible to determine with any exactness the percentage of materials removed through the blow pipes, as no means were used to gauge the volume, but it is believed that this percentage did not exceed 10 per cent. in the case of the north caisson or 25 per cent. in the case of the south caisson. The north caisson was sunk to a depth of 60 ft. below high water, but owing to the existence of a widely extended pocket of sand at this depth on the south shore, the south caisson passes through this sand and to a depth of about 80 ft. below high tide, giving it a penetration of 59 ft. into the boulder formation.

The compressed air power plant which supplied all the power for the work, consisted of three duplex compressors, with 16 x 18 x 18-in. cylinders; one 16 x 10 x 10-in. duplex high pressure pump; one 18 x 10 x 12-in. duplex high pressure

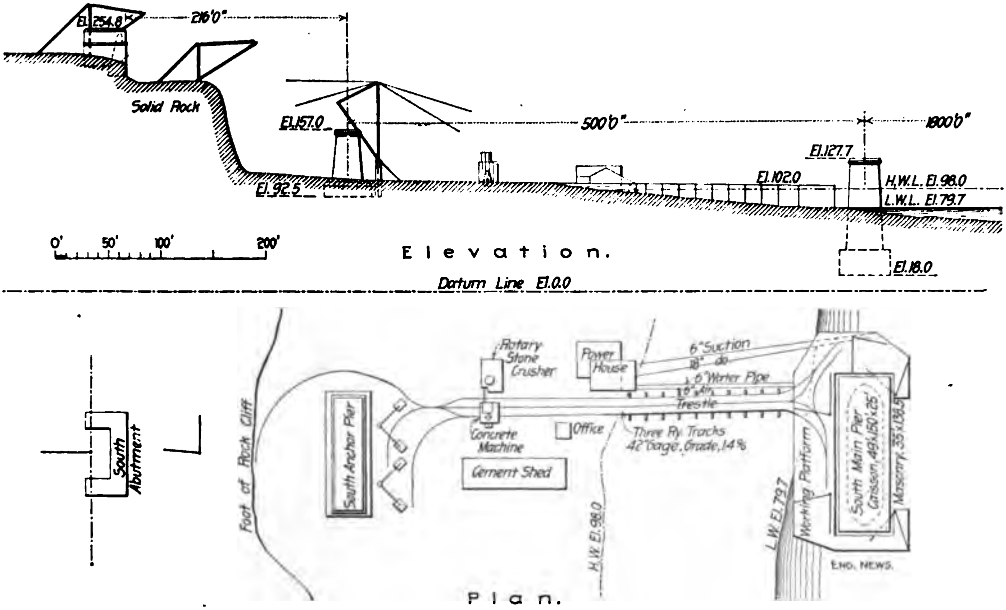


FIG. 5—PLAN AND ELEVATION OF CONTRACTOR'S PLANT FOR SOUTH SHORE ABUTMENT AND PIERS.

pump; one 18 x 10 x 10-in. duplex high pressure compound pump; one 10 x 18 x 18-in. single jet condenser; one 10 x 6 x 10-in. duplex boiler feed pump; two 6 x 4 x 6-in. duplex boiler feed pumps; two 7½-KW. electric light generators, and two Moran air locks. This machinery and all the hoisting engines were supplied with steam by a battery of six 100-HP. boilers working under forced draft and supplied with hot water through a feed water heater. The power house and machinery, including the boilers, was set on a heavy concrete foundation. The water supply was taken from the river through one 18-in. suction pipe, a 6-in. pipe also being laid for use in feeding the boilers in event of accident to the 18-in. pipe.

The contractor for the substructure of the Quebec Bridge was Mr. M. P. Davis, of Ottawa, Ontario, whose staff consisted of Mr. A. A. Stuart, M. Am. Soc. C. E., Resident Manager; Mr. W. L. Scott, Mechanical Engineer; Mr. Henry Barnes, Day Superintendent, and Mr. Charles George, Night Superintendent of Pneumatic Work. Mr. Stuart states that the substructure work will involve a cost in treasure of about $1,200,000.—*Engineering News.*

Pneumatic Jack.

Our attention has been called to a new form of Pneumatic Jack, which is the invention of Mr. Jas. Macbeth, Supt. of the car shops of the New York Central R. R., at Buffalo, N. Y. This jack consists of a large and small cylinder placed side by side, both mounted on a single base having two wheels and a suitable handle for moving about. The larger cylinder is about 15½" in diameter and has inside a piston rod with two large pistons properly packed. The lower end of the piston rod is enlarged and works in a small oil or hydraulic pump cylinder. This connects with the outside or jack cylinder. The lower portion of the large cylinder is used as an oil reservoir to supply the pump cylinder.

In operation air is admitted to the upper sides of both of the large pistons, this exciting a double pressure on the piston rod which is forced down into the pump cylinder, and forcing the oil over into the jack cylinder. The pump cylinder being only 4" in diameter the pressure is largely multiplied. Each full stroke of the large combined piston of about 7" forces the jack plunger out the same distance. A check valve is placed at the bottom of the jack cylinder so that the plunger cannot slip back. A two-way valve is provided to admit air to the top of both working pistons or to the bottom of the upper piston to make the return stroke. A by-pass valve also allows the oil to flow back from the jack cylinder to the reservoir. The usual hose coupling and length of flexible hose is also provided for. It is claimed that with 100 lbs. air pressure this jack will lift 37,252 lbs. Referring to the device, Mr. E. P. Mooney says:

"I have seen this jack in operation from time to time and will candidly say it is about the only appliance on the market to-day, that will raise these 100,000 lb. cars without using a double set of hydro jacks.

"I have also seen this jack tested when the car has been raised, and the air hose disconnected, and must say it is an impossibility to have an accident occur by having any part of the jack or hose give way, in other words, if the hose, air pipe or any part of the jack should give out, the air is locked in the jack in such a manner that it is impossible for the load to come down.

"Another important feature of this jack is that the left piston is so offset from the center line of the cylinder of jack that they can be placed under steel cars at the body bolster and not interfere with the moving of the truck under car when it is jacked up, as is the case with all other air and hydro jacks."

Port Huron Air Motors and Drills.

The illustrations show a line of pneumatic apparatus recently designed and manufactured by the Port Huron Air Tool Co., Ltd., of Port Huron, Mich. The firm is a comparatively recent organization and has been formed with the intention of bringing out special designs in air driven mechanism and practically applying them to jib cranes, stationary motors, traveling cranes, etc.

The Port Huron motor consists of a couple of oscillating cylinders, each double acting and set at right angles in an air tight case as shown in the interior view of the motor seen in Fig. 1. There is no movable valve mechanism as the oscillation of the cylinders opens and closes the ports and causes a sharp cut-off. A small quantity of oil is kept in the case so that the crank splashes the lubricant upon the valve seats and the air carries it through the inlet ports to the pistons. All motors are reversible and those of the same size and type are interchangeable. It will be noticed that the cylinders oscillate from the extreme end. There are eight ports to each engine. When the engine is on the dead center the air is shut off. Four of the ports of each cylinder head operate at the same time, two feeding and two exhausting so that when the engine turns off the dead center the feed and exhaust ports open and when the engines are on half stroke the ports are wide open and then gradually close until the dead center is reached and the cycle of operations commences anew.

FIG. 1—INTERIOR VIEW OF THE PORT HURON MOTOR.

The cylinder head is a bronze casting and the cover is cast iron on all motors. The cylinder heads in the drills are

FIG. 2—FRONT VIEW OF STATIONARY AIR HOIST.

bronze castings whilst the covers are made of aluminum with steel bushings. The two wearing surfaces are thus of different metals and are scraped to a surface plate and the engines are all tested under pressure and sent out perfectly tight. The cylinder rocks on a trunnion which is stationary with a spring under the lock nuts on the cover. The spring is made strong enough to take up all wear that may come on the two faces. The bearing fits on the pin for the full width of the box and the oscillation is so small that it takes proportionately about six turns of the crank shaft for one turn on the trunnion. Every bearing is bronze bushed and the shafting is made of high grade steel.

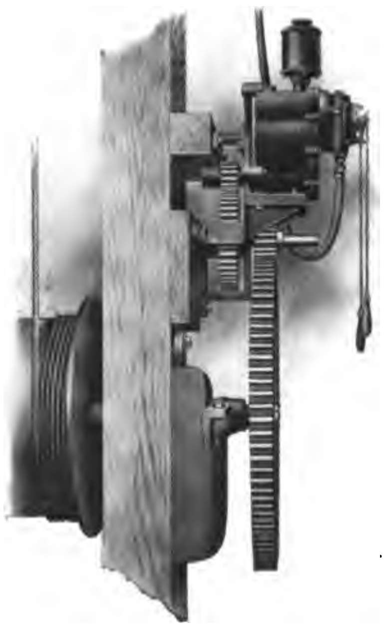


FIG. 3—STATIONARY MOTOR APPLIED TO JIB CRANE.

The drills are made with aluminum cases. The drill is readily reversed by a three-way valve. When the tool is employed in boiler tube work, the reverse movement is of great convenience in contracting the expander for the next operation. The gear box is interchangeable so that the tool can be made to tap holes up to 1½ inches by a variation in the gearing ratio, the spindle speed being from 30 to 40 turns per minute.

The motor illustrated in Figure 3 is gearing for attachment to a jib crane or derrick and may be applied in a similar manner to locomotive turntables or the running of any individual machine. A 4-ton air motor hoist is shown in Figure 4. The motor handles the load through straight line gearing at the rate of 12 feet per minute. The company claims that the hoists will lift as much again as the catalogued capacity and that the hose may be disconnected and the load held indefinitely without the use of any additional brake. The valve is operated by two chains reaching to within four feet of the ground and by this means the motor may be instantly stopped, started or reversed. The valve is self closing when the chains are released. The hoist is made with a winding drum and equipped with a wire rope, with double or triple sheaves and will lift from one to ten tons. Twenty-four of these stationary motor hoists are in use by the Bass Foundry & Machine Co., of Fort Wayne. Ind.—*Iron Trade Review.*

Various Methods of Conveying Power to the Interior of Mines.*

One of the most useful methods of transmitting power to a distance, and one of the best adapted to the requirements of mining, consists in the employment of compressed air as the medium of transmission. It is worth while taking note of the fact that this method was introduced as early as 1849 for driving an underground winding engine at Govan Colliery by Messrs. Randolph and Elder—the predecessors of the present Fairfield Shipbuilding and Engineering Company. But the greatest impetus to the employment of compressed air in mining operations was given when the first long railway tunnels through the Alps were being driven. The Mont Cenis and St. Gothard tunnels—respectively seven and nine miles in length, without intermediate shafts—would have

*A paper read before the Glasgow University Engineering Society, by Mr. T. Linsey Galloway, December 4, 1902.

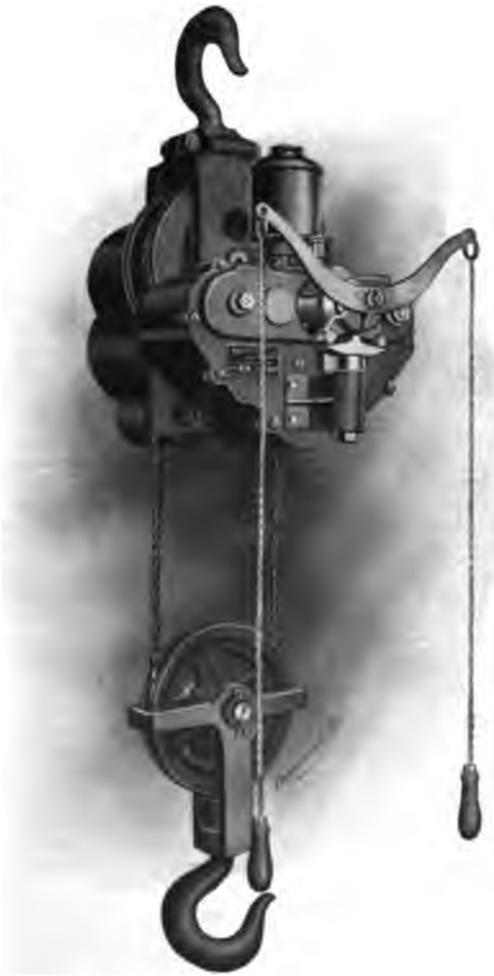


FIG. 4—PORT HURON 4-TON AIR MOTOR HOIST.

been a financial impossibility without the use of mechanical rock drills which enabled the work to be completed within a reasonable time. The drills were driven by means of compressed air, which was conveyed by a line of pipes from compressors near the entrances to the tunnels. The compressors were actuated by water power obtained from the mountain streams. M. Sommeiller, the engineer who had charge of the Mont Cenis Tunnel, demonstrated the practicability of conveying power by compressed air, without serious loss, for a distance of four or five miles; and the experience gained at the Mont Cenis Tunnel and in subsequent undertakings, led to great advances in the construction and design of rock drills and air-compressors. It was a remarkable achievement in those days when electric transmission was still unthought of, that the impetuous Alpine torrents should have been harnessed in the service of man, generating power which could be conveyed far into the interior of the mountains, and making it possible eventually to pierce those rocky barriers from side to side. Compressed air is well adapted to driving all the various classes of machines, which are usually required in the interior of mines. The machines themselves do not essentially differ from ordinary steam engines, except that the exhaust passages should be as short as possible, and of ample area in order to prevent them from becoming choked with ice. In coal mines which are liable to the dangers arising from explosive gas and dust, compressed air is specially prized as a means of driving drills and mining machines. Its absolute safety constitutes one great recommendation. Another advantage, which applies to mines of all classes, is that the low temperature of the exhaust helps to cool the mine and assists the ventilation. One of the difficulties of deep mining arises from the ever-increasing temperature of the earth's crust. The rate at which the natural temperature of the rocks increases has been the subject of much investigation. Many observations have been made in all parts of the world, from which it appears that no uniform rate can be established which will be applicable to all cases. A rock temperature of 80 to 90 degrees, however, is by no means unusual in deep mines, and it will readily be understood that the cooling effects arising from the use of compressed air are much appreciated under such circumstances. In the gold-mines of the Transvaal it is customary, when work is suspended at meal hours, to open up the mains and allow the compressors to run full speed, with a view to cooling and improving the ventilation, a circumstance which the manufacturers of compressors require to take into account in designing machines well governed and of sufficient strength to withstand the extra strain so brought upon them. The chief defect of compressed air as a medium for transmitting power arises from the waste of energy which generally takes place. When air is compressed, a great amount of heat is developed in the process. This heat is rapidly lost as the air passes along the pipes. When it arrives at the motor it has attained practically the same temperature as the atmosphere of the mine. After it has done its work, and is exhausted from the motor, it falls to a low temperature in expanding to the atmospheric pressure. The latter circumstance is a positive advantage from a sanitary point of view, as already stated. But the heating of the air during compression entails a positive loss of power by dissipation of energy, and is therefore to be avoided as much as possible. Formerly several devices were introduced for keeping the air cool. The compressing cylinder was enveloped in a cold water jacket—a jet or spray of cold water was injected into the cylinder—or the cylinder was completely filled with water, as in Sommeiller's compressor, and the air was compressed in vertical chambers at each end of the cylinder in which the water rose and fell with the reciprocating motion of the piston. Most of these devices have now disappeared in favor of the system which is known as stage compression. In this system the air is first of all raised to a certain intermediate pressure. The heat which it has developed is then extracted by causing it to pass through a cooler. It then passes on to a second compressing cylinder in which it undergoes further compression. It may be again cooled and the same process continued to higher stages, but only two stages are generally employed in the case of pressures not exceeding 100 lbs. An instance may be given by some particulars of a pair of air-compressing engines by Messrs. Walker Brothers, of Wigan. The steam cylinders are on the Corliss principle. The engine frames are of the trunk type. The Corliss valves are controlled by a governor. The air cylinders are on the double stage system of compression, with cylindrical water jackets. The intermediate cooling apparatus consists of a large number of brass tubes enveloped in water, which is made to circulate by means of a pump. The steam cylinders are 33 in. and 57 in. in diameter respectively; the air cylinders are 29 in. and 48 in. in diameter respectively. Length of stroke. 5 ft. The approximate air pressure is 100 lbs. per square inch.

In order to exhibit the advantage of double-stage compression, we shall make a calculation of the amount of energy required to compress air under various suppositions. If air could be compressed without any rise of temperature, its pressure would vary inversely as its volume, in accordance with Boyle's law. This would be the case if the heat due to compression could be abstracted as quickly as it is produced. Under these circumstances it is easy to prove that the number of foot pounds necessary to compress a mass of air from pressure p_a to pressure p_b would be

$$W_1 = p_a v_a \log_e \frac{p_b}{p_a}$$

This is the ideal towards which actual compressors should approximate, but to which none ever attains. On the other hand, if there were no abstraction of heat at all during the process of compression, the ratio of pressure and volume would follow the law of non-transmission of heat, according to which

$$v = v_a \left(\frac{p_a}{p}\right)^{\frac{1}{\gamma}}$$

where γ is the number 1·41 which expresses the ratio of the specific heat of air at constant pressure to its specific heat at constant volume. On this supposition, the energy required would be

$$W_2 = \frac{\gamma}{\gamma-1} p_a v_a \left\{\left(\frac{p_b}{p_a}\right)^{\frac{\gamma-1}{\gamma}} - 1\right\}$$

In practice, however, neither this nor Boyle's law expresses what actually takes place, because there is always some cooling effect produced during compression by radiation and conduction of heat from the compressing cylinder, even if no special means of cooling are adopted. Under these circumstances the law of variation of pressure and volume may be assumed to lie between the two extremes, and to be of the form

$$v = v_a \left(\frac{p_a}{p}\right)^{\frac{1}{n}}$$

where n is the number greater than unity but less than 1·41. On this supposition, the energy required would be

$$W_3 = \frac{n}{n-1} p_a v_a \left\{\left(\frac{p_b}{p_a}\right)^{\frac{n-1}{n}} - 1\right\}$$

Now, if the air, instead of being compressed in one stage, from p_a to p_b, is first compressed to an intermediate pressure, which we shall denote by p_m, and is then cooled to its original temperature, and afterwards compressed from p_m to p_b in another cylinder, as in the compressing engine just described, the amount of energy expended will be expressed by two terms similar to the last, viz.:—

$$W_4 = \frac{n}{n-1} p_a v_a \left\{\left[\left(\frac{p_m}{p_a}\right)^{\frac{n-1}{n}} - 1\right] + \left[\left(\frac{p_b}{p_m}\right)^{\frac{n-1}{n}} - 1\right]\right\}$$

But in this formula p_m is indeterminate. In order to obtain the best results from two-stage compression, however, it is evident that this expression ought to have its minimum value, and adopting the usual process of the differential calculus, we find that this will be the case when—

$$p_m^2 = p_a\, p_b.$$

Accordingly, the best result of two-stage compression is obtained when we substitute the value of p_m thus determined, and the final result is—

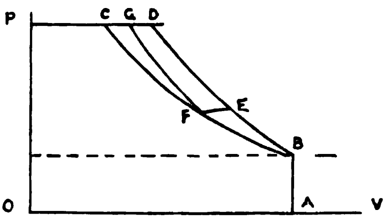
$$W_5 = \frac{2n}{n-1} p_a v_a \left\{\left(\frac{p_b}{p_a}\right)^{\frac{n-1}{2n}} - 1\right\}$$

It is easy to deduce also what the relative diameters of the two compressing cylinders ought to be, supposing they have the same stroke, as is usual; the result is as follows:—

$$\frac{D}{d} = \left(\frac{p_b}{p_a}\right)^{\frac{1}{4}}.$$

For example, if the final pressure is to be 100 lbs. above atmospheric pressure, the diameter of the larger cylinder ought to be one and two-thirds that of the smaller, a result which agrees exactly with the practice of the best makers.

All the foregoing formulæ are illustrated by the accompanying diagram. O V is the direction in which volumes are measured; O P is the direction in which pressures are measured; the dotted line indicates the atmospheric pressure; O A is the initial volume; B F C is the curve of isothermal compression; B E D is the curve of singe-stage compression; B E represents the first stage in two-stage com-



pression; E F is the shrinkage of volume in the passage of the air through the cooler; F G is the second stage of compression. The area D E F G represents the saving effected by double stage as compared with single-stage compression. In order to illustrate these results, let us take a numerical example. We shall assume the index n to have the value 1·25, a value which agrees with actual experiment, and let it be required to compress air from atmospheric pressure to 100 pounds per square inch above atmospheric pressure. Using these data, and remembering that the pressures in the formulæ are absolute, so that $p_a = 14·7$ and $p_b = 114·7$, we obtain the following results, expressing the number of foot-pounds of work required to compress one pound of air under each of our three suppositions:—

	Foot-pounds.
1. Isothermal compression....	56,927
2. Single-stage	70,383
3. Two-stage	63,179

In other words, compared with the ideal of isothermal compression, the work expended in single-stage compression is 23 per cent. more, and in two-stage compression only 11 per cent. more, a clear saving of 12 per cent. There is no doubt an additional saving in two-stage compression, arising from the fact that the average temperature of each of the cylinders must be lower than when all the work is done in one cylinder. The author does not know that this saving has been calculated, or taken note of; but it is evident that as the range of pressures is less, so must be the range of temperatures, and therefore, also, *cæteris paribus*, the average temperature. This saving is in a certain way analogous to the advantage gained in steam engines by expanding the steam in two separate cylinders, and so preserving the average temperature of each as nearly constant as possible, with this difference, that in the present case we wish to keep both cylinders as near the lower temperature as possible. In order to prevent jar, and at the same time to enable compressors to be run at a much higher speed, mechanically controlled valves are used by several inventors, notably by Professor Riedler, of Berlin, in whose compressors the air valves open automatically, but are closed by mechanism. Professor Riedler's large compressors at Paris have been made the subject of elaborate experiment, from which it appears that with two stage compressors, an efficiency of 89 per cent. can be obtained. In one case of a Riedler two-stage compressor, the steam cylinders are 23 and 37 inches diameter, and the air cylinders 23 and 36 inches diameter. The stroke is 48 in., and the capacity, at 75 revolutions, 4,230 cubic feet per minute.

The conveyance of the air from the compressor to the interior of the mine does not require any special description. If moderately large pipes are used, so that the velocity of the air does not exceed 20 to 30 feet per second, the air may be conveyed to long distances, even several miles, with very little loss of pressure. There ought also to be no trouble from leakage if the joints have been carefully made in the first instance; for the temperature of a mine is so uniform that there is no appreciable expansion and contraction of the pipes. Compressed air is *par excellence* the medium for driving reciprocating tools, such as rock drills and coal-cutters of the percussive type. A high degree of efficiency is not expected in machines of this class. They are made as small and light as possible, and work with a low grade of expansion. But compressed air has also long been used for driving hauling engines and pumps, especially when these are of an auxiliary character only, and placed at long distances from the shafts. Whether electricity will eventually supplant compressed air is a question which it is impossible to answer at present. Attempts to improve the efficiency of compressed air by using stoves to heat the air have proved successful in applications above ground, but the additional complication and risk have hitherto prevented similar appliances from finding favor in mines. Expansion of the air in two stages is another way in which its efficiency can be improved, but very few applications of this method have yet been tried.

The electric transmission of power differs in one respect from the system already described. No serious damage is done to a hydraulic or compressed-air engine, if through any cause the load or work to be done suddenly becomes greater than the normal amount. But an electric motor, unless proper provision has been made, becomes unduly heated and is liable to be rendered unserviceable. The obvious way of preventing such a mishap is to insert a fuse or magnetic cut-out in the circuit. But when such safeguards come too readily into action, great inconvenience may arise from frequent interruption of the work. When, however, a motor is considerably larger than is actually required for the normal amount of work, it will not be injured so readily by overloading, and it will not be necessary that the cut-out appliance should come so readily into action. Accordingly, the most up-to-date makers recommend an ample margin between the power of a motor and its normal work. As an example of this we may cite the following recently-erected plant at Ashington, Northumberland. It is entirely a pumping installation, and we give, in the case of three different sizes of three-throw pumps, the effective horse-power of the electric motor, and the actual horse-power required to lift the water.

Motor.	Pump.
120	70
25	14
11½	3

But although it is expedient to allow a margin of 50 per cent., or even 100 per cent., between the effective horse-power of a motor and the work which it is intended to do, this does not imply any such discrepancy between the power expended and the power utilized. The efficiency of a well-designed continuous-current plant for pumping may be judged from the following figures founded on the experience of an expert and manufacturer of such machinery. Starting with a steam engine of 100 indicated horse-power, the generator will develop 87. The loss in the cable of course depends on the distance, but under ordinary circumstances we should have 82½ horse power delivered at the motor, and the motor ought to yield 70 horse power in useful work. Thus the aggregate efficiency of the whole installation may be taken at 70 per cent., a result which compares favorably with either of the two systems described above. Electricity has not up to the present been so successfully employed for driving percussive tools, and it remains to be seen whether it will eventually supplant compressed air for this class of work.

The advisability of introducing any form of electric transmission into the inner workings of collieries which give off explosive gas or are largely permeated by explosive dust, is a question which has engaged the anxious attention of mining engineers. It is here that the induction motor possesses a distinct advantage in consequence of its entirely sparkless character. No doubt many continuous-current motors are in use which are wholly enclosed within an airtight casing. Such motors require to be made of about 30 per cent. larger size than open running motors designed for the same work, in order to make allowance for the extra amount of heating which the absence of ventilation entails. As a protection against injury from dust the closing of the motor may be excellent; but we doubt whether it can be considered a sufficient remedy against the risk of a possible accident in the case of a motor running in an explosive atmosphere. It is sometimes said that an explosive atmosphere ought not to exist in any mine, but those who make this observation may not be aware that there are many mines which are liable to sudden outbursts of gas which, for a time, render the whole mine explosive. A derangement of the ventilating machinery is another cause which may render the best ventilated mine dangerous for a time. In addition to the danger from sparks at the commutator of a continuous-current motor, there are other possibilities of danger which apply to both the continuous current and to the three-phase system of transmission. These arise from the burning out of the insulation, or the rupture of a cable. Heavy falls of the roof are matters of the most ordinary occurrence in mines, and it is at least conceivable that such an accident might rupture the cable and produce sparking. This risk is perhaps preventible by proper precautions, and appears more remote than those previously mentioned.

It has been proposed that for the class of mines of which we have been speaking, electrically driven air compressors might be established in parts of the mine where there is hardly any risk of the atmosphere ever becoming explosive, in order that power might be transmitted safely into the more dangerous inner workings. Where the distance of transmission is exceptionally long, or where electric current is already available, this arrangement may be quite feasible. But the principal losses incurred in the employment of compressed air occur at the compressor and at the motor, and not in the course of transmission along the pipes. It therefore would seem an unnecessary complication to convert the energy of a steam engine first into electric energy, then to transform it into the energy of compressed air, when the air might just as well be compressed by the steam engine, and conveyed with hardly any more loss from thence to the point at which it is required.—*The Colliery Guardian.*

Efficiency Test of a Nordberg Air Compressor at the Burra Burra Mine of the Tennessee Copper Company.*

BY J. PARKE CHANNING.

This compressor, which is of the cross-compound two-stage type, is located in a brick power house, together with a first motion hoisting engine and an independent jet-condenser. An adjoining brick boiler-house contains two 150 horse-power National water tube boilers, which furnish steam for the above-mentioned engines as well as a 9 and 18 by 12-inch crusher house engine. The compressor and the crusher house engine run condensing while the exhaust from the condenser itself as well as part of the intermittent exhaust from the hoisting engine are carried to a large Hoppes open feed-water heater. The balance of the exhaust steam from the hoisting engine is discharged into the atmosphere. Steam has never been off the jackets of the hoisting engine cylinders since first turned on. These cylinders are jacketed, not from motives of economy, but to make the hoisting engine quick to respond to the throttle. All the auxiliary cylinders of the hoisting engine are steam-jacketed.

The test was made on Sunday. During this time, the boilers, which could not be separated, furnished steam for the hoisting engine jackets and the independent jet-condenser as well as the compressor. The crusher engine was not running nor was the hoisting engine.

The makers' guarantee was that the steam consumption would be 14 lbs. per indicated horse-power when running at full speed, 92 revols. per min., and that the ratio of 1 h. p. between the steam and air cylinders would be as 115 to 100, or 87 per cent. No guarantee as to efficiency of the air end as a compressing mechanism was given.

In determining the feed-water consumption the engine was to be charged with all water fed to the boilers during the test, including that used in the steam-jackets. The engine was to be credited with all water trapped from the steam

* Paper presented at the annual meeting of the Lake Superior Mining Institute, 1902.

separators and indicated by the calorimeter test of the steam from the separator into the cylinder. The engine was further to be credited with whatever heat was contained in the water formed by condensation in the steam-jackets and reheaters.

The test was made under the supervision of Mr. C. H. Glasser, the mechanical engineer in charge of the construction of the Tennessee Copper Company's mine and smelter plant. Feed-water was taken by feed-pump from a square wooden tank in the boiler-house and water supplied to the tank from two barrels placed on scales set over the tank. No allowance was made for the small amount of steam necessary to operate this pump. Condensation from steam-jackets and reheater of the compressor was drawn off continuously into two barrels partly filled with cold water and set on scales, one barrel filling while the other was discharging. The height of water in the piping system was regulated throughout the test by a gauge glass inserted in an enlarged chamber of 6-inch pipe and thermometer attached, to record the proper temperature of the water. The thermometer reading was taken always when the barrel was nearly full or when the circulation had been continuous for the longest possible period of time. The condensed water from the hoisting engine jackets passed through a steam trap to a barrel partly filled with water and set on scales. The discharge was intermittent with the working of the trap. The steam used for running the condenser was exhausted through coils of pipe laid in a shallow wooden tank and constant circulation of cold water maintained in the tank, thus condensing all the exhaust steam, which was led into barrels and measured. Each barrel being always filled to an exact height, the capacity of the barrels to that height was found by weighing before and after the test. The slip of air was calculated from the relation of the total length of indicator card to the length of card on the atmospheric line.

The theoretical horse-power required to compress and deliver the actual delivery of air by adiabatic compression was calculated from the formula on page 501 of Kent:

$$W = 3.463\, p_1\, v_1 \left\{ \left(\frac{p_2}{p_1}\right)^{0.29} - 1 \right\}$$

in which p_1 is 14 lbs., p_2 is $79.3 + 14 = 93.3$ lbs. and v_1 equals 1,976.7 cubic feet.

The theoretical horse-power by isothermal compression was calculated by the formula,

$$W = p_1\, v_1 \left\{ 1 + \text{Nap. log. } \frac{p_2}{p_1} \right\}$$

The results of the test are given in the accompanying tables. The governor pulley was not the right size, and so the speed maintained was only 90 instead of 92 revols. per min. The inter-efficiency between the steam and air cylinders—95.1 per cent.—is high, and this figure was borne out in another test of the compressor. The efficiency of the machine—78.1 per cent.—is also remarkably good.

It may be interesting to reduce the figures of this compressor as well as two other Nordberg machines to the basis of pounds of feed water used per 100 cubic feet of free air compressed and delivered at 80 lbs. gauge pressure.

Newport Mine, compound, two-stage .... 3.87 lbs.
Leonard Shaft, triple, three-stage . 3.10 lbs.
Burra Burra Mine, compound, two-stage .... 3.68 lbs.

The above figures are reduced to a basis of 80 lbs. gauge pressure, as the Newport compressor was tested at 100 lbs. and the Leonard at 90 lbs.

Particular attention is called to the efficiency of the cooling arrangements and the relatively low temperature of the finally discharged air. All the air valves of the compressor are positively operated, being in construction and connection similar to the exhaust valves of an ordinary Corliss engine, there being no trip or release on any of them. The discharge valves of the compressing cylinder are provided with auxiliary poppet valves, which would open in case the receiver pressure was lower than that at which the main valve would begin to discharge. The governor for this compressor is one especially designed by Mr. Nordberg for work of this class, and consists essentially of a floating lever. The three forces which operate upon it are the steam pressure, the air pressure and the speed of the machine. This governor is so designed that it maintains a constant

EFFICIENCY TEST OF NORDBERG CROSS COMPOUND TWO STAGE AIR COMPRESSOR. BURRA BURRA MINE.

Results of Indicator Cards.

			Mean Effective Pressures.				Indicated Horse Powers.					
Indicator Card.	Time Taken.	Revs. per Minute.	H. P. Steam.	L. P. Steam.	L. P. Air.	H. P. Air.	L. P. Steam.	H. P. Steam.	Both Steam Cylinders.	L. P. Air.	H. P. Air.	Both Air Cylinders.
1	10.45 a.m.	90	45.74	13.26	16.26	38.24	155.14	136.52	291.66	144.76	131.40	276.16
2	11.45 a.m.	91	48.90	12.64	16.16	40.70	149.53	147.51	297.04	145.06	140.41	285.47
3	12.45 p.m.	90	47.17	12.64	16.18	38.18	147.89	140.78	288.67	144.05	131.39	275.44
4	1.45 p.m.	90	48.0	13.04	16.33	39.94	152.56	143.26	295.82	145.21	137.24	282.45
5	2.45 p.m.	87	48.04	12.86	16.16	39.45	145.44	133.86	279.30	138.90	131.04	269.94
6	3.45 p.m.	91	48.92	12.97	16.18	39.35	153.43	147.58	301.01	145.24	136.72	281.96
7	4.45 p.m.	91	47.88	13.82	16.34	40.81	163.49	144.44	307.93	146.68	141.78	288.46
8	5.45 p.m.	88	45.04	13.70	16.15	38.75	156.73	127.01	283.74	140.41	130.19	270.60
Averages							153.03	140.12	293.15	143.79	135.02	278.81

air pressure in the receiver, permitting the variation of the steam pressure as well as the speed of the engine. In other words, whether there be ten or twenty drills running, the air pressure in the receiver will remain practically constant and the speed of the engine will vary to suit the demand for air. This variation of speed is, of course, made by varying the cut-off point on the high-pressure steam cylinder. In practice this governor has been found to be entirely satisfactory, and is a great improvement over the older types which were more or less intermittent in their action, even if otherwise satisfactory.

RESULTS OF CALORIMETER TESTS WITH PEABODY'S THROTTLING CALORIMETER.

Readings Taken.	Temperature Fahr.	Calorimeter Gauge.	Steam Pipe Gauge.	Per cent. Moisture Calculated.
4.30 p. m.	294	11	145	1.23
4.35 p. m.	294	11	145	1.23
4.40 p. m.	296	15	145	1.34
4.45 p. m.	296	15	145	1.34
4.50 p. m.	296	14	145	1.35
Average				1.3

TEST NO. 3, NORDBERG TWO STAGE AIR COMPRESSOR AT BURRA BURRA MINE. ALTITUDE 1,800 FEET.

1	Date of Test	Feb. 16, 1902.	
2	Duration of Test	8	hours.
3	Diam. of High Pressure Steam Cylinder (Steam Jacketed)	14	inches.
4	Diam. of Low Pressure Steam Cylinder (Steam Jacketed)	28	inches.
5	Diam. of Low Pressure Air Cylinder	24½	inches.
6	Diam. of High Pressure Air Cylinder	15⅝	inches.
7	Stroke of All Pistons	42	inches.
8	Diam. of Piston Rods	2¼	inches.
9	Revolutions of Engine, Average per Minute	90	
10	Piston Speed per Minute	630	ft.
11	Steam Gauge Pressure, Average	145.9	lbs.
12	Temp. of Steam in Steam Pipe, Average	364	°F.
13	Steam Pressure in Reheating Receiver, Aver.	8	lbs.
14	Vacuum in Condenser, Average	25.66	inches.
15	Air Pressure in Intercooler, Average	22.63	lbs.
16	Air Pressure in Receiver, Average	79.3	lbs.
17	Temperature of Air at Intake, Average	65	°F.
18	Temperature of Air Leaving Low Pressure Cylder, Average	211.5	°F.
19	Temperature of Air Leaving Intercooler, Average	78.5	°F.
20	Temperature of Air Leaving High Pressure Cylinder, Average	240	°F
21	Indicated Horse Power in High Pressure Steam Cylinder, Average	140.12	
22	Indicated Horse Power in Low Pressure Steam Cylinder, Average	153.03	
23	Indicated Horse Power in Both Steam Cylinders, Average	293.15	
24	Indicated Horse Power in Low Pressure Air Cylinder, Average	143.79	
25	Indicated Horse Power in High Pressure Air Cylinder, Average	135.02	
26	Indicated Horse Power in Both Air Cylinders, Average	278.81	
27	Feed Water Weighed to Boilers	43,343	lbs.

28	Reheater and Jacket Water from Compressor, Weighed	4,081	lbs.
29	Average Temperature of Reheater and Jacket Water	356.7	°F.
30	Total heat in 1 pound of Steam at 356.7 deg. F.	1,190.7	H.U.
31	Total Heat in 1 pound of Water at 356.7 deg. F.	328.9	H.U
32	Equivalent Credit for Reheater and Jacket Water	1,127	lbs.
33	Water Weighed from Condensation in Hoisting Engine Jackets	1,781	lbs.
34	Steam Used to Run Condenser	4,320	lbs.
35	Total Credits to Feed Water	7,228	lbs.
36	Total Feed Water charged to Engine	36,115	lbs.
37	Moisture in Steam Shown by Peabody Calorimeter.	1.30	%
38	Credit for Moisture in Steam	473	lbs.
39	Total Steam Charged to Engine	35,642	lbs.
40	Dry Steam per Hour Charged to Engine	4,455	lbs.
41	Steam Consumption per Indicated Horse Power per Hour	15.19	lbs.
42	Guaranteed Steam Consumption per Indicated Horse Power per Hour, at 92 rev. per min.	14.00	lbs.
43	Excess of Steam Consumption per Indicated Horse Power per hour over Guarantee	1.19	lbs.
44	Theoretical Delivery of Free Air per Minute at 90 Revolutions	2,037.8	cu.ft.
45	Slip of Air (Percentage).	3.0	%
46	Actual Slip of Air per Minute	61.1	cu.ft.
47	Actual Delivery of Free Air per Minute, Average	1,976.7	cu.ft.
48	Theoretical Horse Power Required to Compress and Deliver Actual Delivery of Air at Receiver Pressure by Adiabatic Compression	306.53	
49	Theoretical Horse Power Required to Compress and Deliver Actual Delivery of Air at Receiver Pressure, by Isothermal Compression	229.0	
50	Actual H. P. Shown by Air Indicator Cards	278.81	
51	Actual H. P. Shown by Steam Indicator Cards.	293.15	
52	Actual H. P. Consumed by Friction of Engine.	14.34	
53	Efficiency Ratio Between Steam and Air Cylinders	95.1	%
54	Efficiency Ratio Between Steam and Air Cylinders Guaranteed by Builder.	87	%
55	Efficiency of Machine, or Ratio of Steam I. H. P. to Theoretical Air I. H. P. Isothermal Compression	078.1	%

Building a Tube.

IN THE SUB-AQUEOUS SECTION OF THE BAKER ST. LINE, LONDON.

With the appearance of the tuppenny tube most people are familiar, though there are some folks who still pride themselves on refusing to travel by the electric railway, whose developments are being so closely watched by all sorts and conditions of men whose avocations make rapidity of transit and an easy method of going to and from their places of business an imperative necessity.

The tube, however, in its incomplete stage is a subject with which few people can in the nature of things have a personal acquaintance, for the work has to be done unhampered by the presence of curious sightseers. Still, as a special favor a representative of the *Morning Leader* was recently allowed through that section of the Waterloo and Baker St. railway which is building.

Access to the tube is gained from the landing stage in the middle of the river by Hungerford bridge, under the shadow of Charing cross. There one enters an iron cage to be hoisted many feet and swung round the arc of a circle, over the circular opening down which one is lowered, to the accompaniment of the rattle of the engine, the sixty or seventy feet which intervent between the outer air and the road-bed through which, in the course of perhaps a couple of years, there will roll an unceasing line of traffic.

The work is at present being conducted under two different systems. One of these is under ordinary conditions of atmospheric pressure, while the other is "in the air," to use the term the men themselves apply to it. This is under an additional pressure of ten pounds to the square inch, and it is obtained by pumping compressed air into the works. It need hardly be said that in order to obtain this additional pressure the air has to be confined within a certain area. This is done by the construction of a lock which acts in exactly the same way as the familiar locks on the river. A lock is in a brick wall some eight feet thick, with a door at each end. That at the farther end opens out of the lock into the tunnel, while the inner door opens the other way. They are so arranged, however, that both cannot be opened at once. If workmen have to go "into the air" the lock is filled with air, and when the required pressure is obtained the far door opens and allows them to enter the works; while, when they desire to leave, the process is reversed, the pressure is removed, and the inner door opens.

No visitor is allowed in any part of the works being conducted under this additional atmospheric pressure without having previously undergone a thorough medical examination, and the same precautions are taken with the workmen. On first going "into the air" one can hear the air rushing into one's ears, and some people feel the pressure against the ear-drum, but there is no oppression on the chest, and no difficulty in breathing. Occasionally, however, the pressure on the ear becomes quite a pain, and men have been known to cry aloud from it, while another effect is to take away their appetite. The men who work under this increased atmospheric pressure have only an eight hours day, while the other laborers work twelve hours.

The compressed air is brought down in a pipe running along one of the walls of the tube, and by its side is a smaller pipe for conveying water which is needed for mixing the cement with which the iron skin of the tube is filled to a depth of six or seven inches. A section of the tube would show in addition to the two pipes at the side two wires which run over head suspended by means of transverse wires. One of these carries the current for the lamps with which the tunnel is lighted throughout its whole length at equal distances of about seventy feet, while the other carries the current for propelling the little electric engines which draw a train of metal boxes. Into these the earth is loaded as it is dug out, that it may be taken down to the river, where it is hoisted out, loaded into barges and taken out to sea and thrown away. On the return journey the same boxes convey sacks of cement and other building materials to the places where the men are working.

The rails on which the engines run are close together, perhaps between twelve and eighteen inches apart. By the side of them is a narrow footpath formed, for the most part, of three ordinary boards laid side by side so that though two men could hardly walk abreast they may easily pass one another. Lighted though it is by electricity, the tube can scarcely be said to be brilliantly illuminated, and as the little engines run rapidly and smoothly along, the play of blue fire from the wire above and the rails below gives a distinctly uncanny suggestion to the twilight gloom which fills the tunnel, for it is not a bit like lightning flashing through the storm-driven, clouded sky, but suggests rather the "ineffectual fires" of some unknown inferno. As one pauses in the tube one begins to appreciate the meaning of the word silence, the dread soundlessness that might exist in a city of the dead, intensified by the feeling of having been cut off, as it were, from all the rest of the world. Yet, ever and anon, at certain places on the way the distant sounds of traffic come mumbling and rumbling down as if to assure the passer-by in these unfrequented regions that life still takes its hurrying way along the street some sixty feet above his head.

Occasionally, as one tramps along the narrow pathway, one comes upon a hole left in the side of the tube to enable the platelayers to go from one tunnel to the other, for in the tunnel now building, as is the case in the familiar tuppenny tube, the down trains will run in a different compartment from the up trains, so that the possibility of a collision is removed. These tunnels are, in some cases, extraordinarily close together, being separated, at a junction, by perhaps not more than an inch and a half of material, though they diverge until they may be as much as five feet apart. At intervals along them, too, one comes upon ledges on which the engineers may place their instruments while they are making observations, while here and there from the iron roof depend little stalactites formed by water percolating, from the clay through which the tubes are run, through the partition between two of the iron segments of the tube, after having dissolved the layer of cement which is pumped in between the earth and the metal skin of the tube. Here and there, too, one notices sleepers, which have been removed from the track because the damp has rotted them. These damp places, however, are only noticed by their contrast with the general dryness of the tube, and it will be quite easy to completely eradicate them when the time comes, even though it were possible for the moisture to make its presence felt through the layer of encaustic tiles with which the tube will be lined from end to end. At present, however, that work has not been begun, though it has been thought of, for at one spot between Picadilly-circus and Oxford St. several different sorts of tiles have been put in order to try their effect.

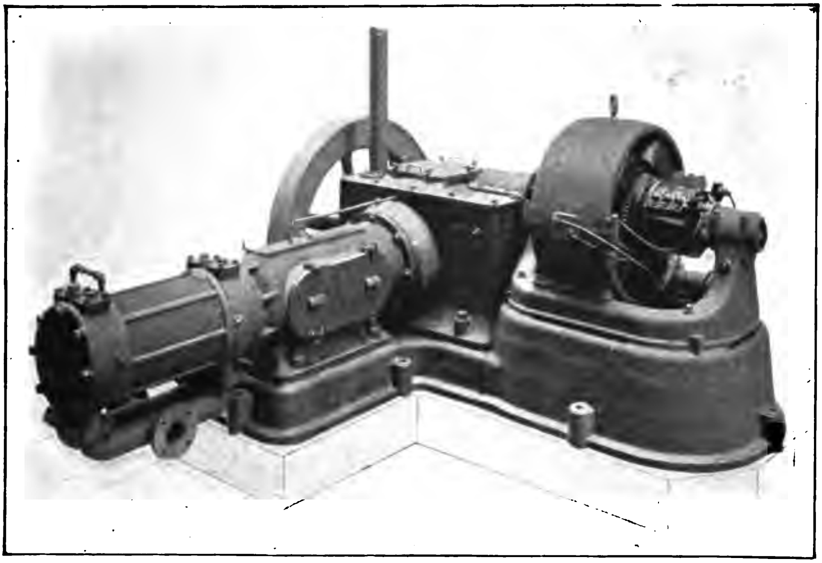
At Oxford-circus the same sort of cage is to be found as at the river stage with a cable chain and a donkey engine to run it. The engine, however, is not kept working all night and day, though laborers are engaged in the tube every hour of the twenty-four. That they may leave at Oxford St. instead of having to go back all the way to Charing cross when their work is finished, ladders lead from the tube to the level of Oxford St. To prevent the possibility of any accident there is not one long ladder, but four short ones set against platforms which form convenient resting-places, so that even the least skilled climber may go from tier to tier without fear and with perfect safety.—*Morning Leader,* London.

Rock Boring Machinery.

Exactly 50 years ago Piatti proposed the use of compressed air in the construction of the Mont Cenis tunnel, and it is interesting to consider the far-reaching effects on the mining industry of this suggestion, which at the time was received with indifference. Undoubtedly the most important result has been the introduction of boring or drilling machines as substitutes for the older method of hand boring. for although the merit of devising and using the first machine for drilling rocks belongs to Richard Trevithick, his invention was forgotten until the Mont Cenis experiments showed that compressed air was more suitable than steam as motive power for such machines. Since then inventions have followed one another with rapidity, and there has been an astonishing development of this class of machanism. Bartlett's rock drill was tried at Mont Cenis in 1854, and in the same year Schumann invented his percussion power drill. Sommeiller's drill was invented in 1857. In 1861 Lisbet applied his boring machine in soft rock. The Sachs drill was invented in 1863; the Burleigh drill in 1866; the Doering drill in 1867; the Dubois and Francois drill in the same year; the diamond drill in 1870; the Ferroux drill in 1873; and the Darlington drill in 1873. Since that time to the present inventors throughout the world have applied themselves to the production of modifications which should accomplish more easily the intended object. In the earlier forms the machines were exceedingly heavy, especially in the supporting arrangements, which were planned for keeping two or more machines at work simultaneously. The adoption of smaller and lighter forms, of which the Little Vixen, the Little Hercules, the Ingersoll-Sergeant, Schram, Champion, Holman, and Larmuth drills are typical modern examples, has done much towards popularizing their use in mines. The advantage of a machine driven by compressed air for ventilating workings is so obvious that the use of hydraulic power, which has been successfully applied in the Brandt rotary drill, has met with but little favor in mines. On the other hand, electricity is now beginning seriously to compete with compressed air for transmitting power to drills, and after the 50 years' sway of compressed air it is a matter of no little difficulty for a mining engineer in the year 1903 to say which of the numerous admirable rock drills on the market it would be best to adopt in a mine entrusted to his charge. The Brandt drill, with which remarkably fast work can be done, is very costly to install. Its consumption of power in enormous, and the necessary repairs expensive. This machine is consequently only suitable for use in tunnels of the highest class. Electric drills have met with great favor in the Cleveland iron ore mines. and the electric drill described by Mr. Edward Dane (*Mining Journal,* 1902. p. 187) and that used for stopping at the Battery Reef Mine of the Lancaster Gold Mining Company described last year (*Mining Journal,* 1902, p. 516) appear to present distinct advantages. Indeed, in view of the advantages of electricity over compressed air as a medium for transmitting power, there are many who believe that the days of the compressed air drill are numbered. Apart from the loss of power, the long rubber hose is an undoubted inconvenience. No such drawbacks are presented by electric transmission. All local difficulties can be overcome and the cable occupies hardly any space and can be laid with ease and rapidity. On the other hand the percussive electric drill necessitates frequent and costly repairs, and the mechanism is of a complicated character. In an account of his experience with electric drilling at the Raibl mines, the eminent Austrian mining engineer Von Posch notes that the drill used consisted of 330 distinct parts, as compared with 40 or 50 in a compressed air drill, and that during the period from March to November, about three-quarters of a year, there were 186 breakages, or about one a day, whilst Mr. T. Giller records that four compressed air drills working simultaneously at the end of a crosscut were used for many weeks without the expenditure of a penny for repairs. The solenoid drill, although requiring much more power, is far more portable and lighter than the electric percussive drill. A solenoid, it will be remembered, consists of insulated copper wire coiled in the form of a spiral, with an iron core movable, not fixed as in an ordinary electro-magnet. When a current passes it has the same power of attraction as a magnet, and the iron core is drawn up. In a solenoid drill two solenoids are placed against each other, and the electric current imparts a reciprocating motion to a magnet to which the drill piston is fixed. This machine necessitates a special primary motor. The most serious drawback presented by the solenoid machine is the objectionable heating. This not only means loss of efficiency, but the heating is often so intense as to make the drill unpleasant in a narrow level or to cause risk of accidents from burns. Large quantities of air are necessary for ventilation and the loss by friction is high as the lubricants are volatilised. In short, practical experience tends to show that electricity has as yet hardly fulfilled the expectations as regards the transmission of power to rock drills. The chief reproach to which the compressed air drill is liable is its high consumption of power. Published figures show that the indirect-acting percussive electric drill requires 1½ to 2 horse power, the solenoid drill 4 to 5, and the compressed air drill 5 to 11 horse power, according to the size of the compressor. Apart from this drawback, which after all is not so serious to the miner, to whom speed of driving is frequently the first consideration, as might at first appear, all the advantages are on the side of compressed air. The question which type of rock drill (electric, hydraulic or pneumatic) is best to use is nothing more than a question of power transmission, which depends upon the natural resources and local conditions and upon the physical properties of the medium of power transmission. Probably the best solution of the whole question is to be found in a combination of electric power transmission with the compressed air percussive drill. This combined system, as was evident from the display at the recent Düsseldorf Exhibition, is meeting with great favor in Germany. The system consists in conveying by cables to the vicinity of the working place electric energy generated at a convenient spot. The electrically-driven high speed compressor is placed at the mouth of the tunnel, or is made movable and brought within 100 yards of the mine working. An installation of this kind was put in operation in the spring of 1902 at the Friedrich Wilhelm mine in Upper Silesia. In the first month, with two light drills (2½ inches in diameter), 1620 feet were bored in 5700 minutes (including time of seting up), or in other words 1 yard in 10½ minutes. The ground consisted of sandstone and shale with ironstone nodules. The electro-motor was of 13 horse power, and the two drills, at six atmospheres pressure, required only 5 horse power, or at five atmospheres only 4½ horse power. A Meyer high speed compressor was used, so arranged that a 25 horse power air compressor with motor and accessories could be placed within the cross section of a mine wagon. The length of the whole was only 7¼ feet, the height 3¼ feet and the width 37½ inches. A whole series of such high speed portable compressors was shown at the Düsseldorf Exhibition, and the conclusion impressed on the observer was that in a rational combination of electricity and compressed air the future of rock boring installations is to be sought.—*Mining Journal,* London.

Motor Compressor.

The accompanying illustration represents a type of motor compressor used by the American Compressed Air Cleaning Co., in connection with their work, built in sizes from 50 cubic feet of free air per minute and upwards. In the design of this compressor is embodied the desirability of having all the working parts enclosed so as to exclude dirt and grit. The chamber so formed contains oil with which all the working parts are automatically and continuously lubricated, including the cylinder, which is connected with the oil chamber in such a manner that the proper quantity of oil for lubricating the surface between the cylinder and piston is automatically supplied, so that no sight feed lubricator is required. The machine will remain lubricated as long as the main supply of oil in the well is maintained up to a level determined by a filling plug on the side of the crank chamber. The piston rod passes through a specially constructed metallic packing box, which is self-adjusting and will last for many years without attention or renewal, on account of the perfect lubrication of the piston rod, as well as its superior mechanical construction. The piston is provided with an improved form of packing rings, which are carefully fitted in place, both in the piston and against the surface of the cylinder so as to form a nearly perfect sliding joint. The cylinder is of extra quality close grained cast iron, accurately and smoothly bored, free from blow holes and defects, and is together with the valve heads, thoroughly water jacketed.



The extended end of the crank shaft is provided with a gear which meshes with a pinion arranged on the armature shaft immediately above. The gear chamber and the crank chamber are connected in such a way that the gear as well as the pinion are operated in a bath of oil, which oil is also supplied automatically to the bearings at the pinion end of the motor. The gear and pinion are of the helical herring-bone type, with teeth cut by special machinery in the most perfect manner, thereby reducing the noise of operation to such an extent that it can hardly be noticed alongside of the ordinary operation of the compressor valves. The motor is of the series wound type with formed coils of the most improved pattern, the insulation and other material being of the very highest grade of their respective kind. The material and labor of this motor are of such excellent quality that we are able to start the compressor without using resistance in the motor circuit, by simply closing the motor circuit in the same manner as with a knife switch.

House Cleaning with Air.

In Fig. 1 we see dust laden hangings, shaking off their accumulations at every breeze or touch, and polluting the air about them. Heretofore, it has been necessary to take them down when cleaned, and this with the rehanging and redraping often cost more than the cleaning, besides incurring more or less worry and bother. With compressed air they may be cleaned where they hang, without material disarrangement of their folds, with absolutely no wear to the fabric and with little expense—therefore cleaned often.

FIG. 1.

Chalk is a difficult thing to remove from billiard cloths; and, besides, it is wearing to the fabric. Fig. 2 illustrates a stiff brush in the hands of a strong boy, and the cleaning is accomplished within a few minutes.

The Portable Compressed Air Cleaning

Apparatus used in this work by the American Compressed Air Cleaning Co., consists of a strong well built wagon upon which is mounted a gasoline engine, air compressor, air reservoirs, cooling tank, hose, nozzles, cleaning machines, etc.

Two styles of wagons are built: i. e., self-propelling and draught, both being equally efficient except that a team is required to move the latter from house to house.

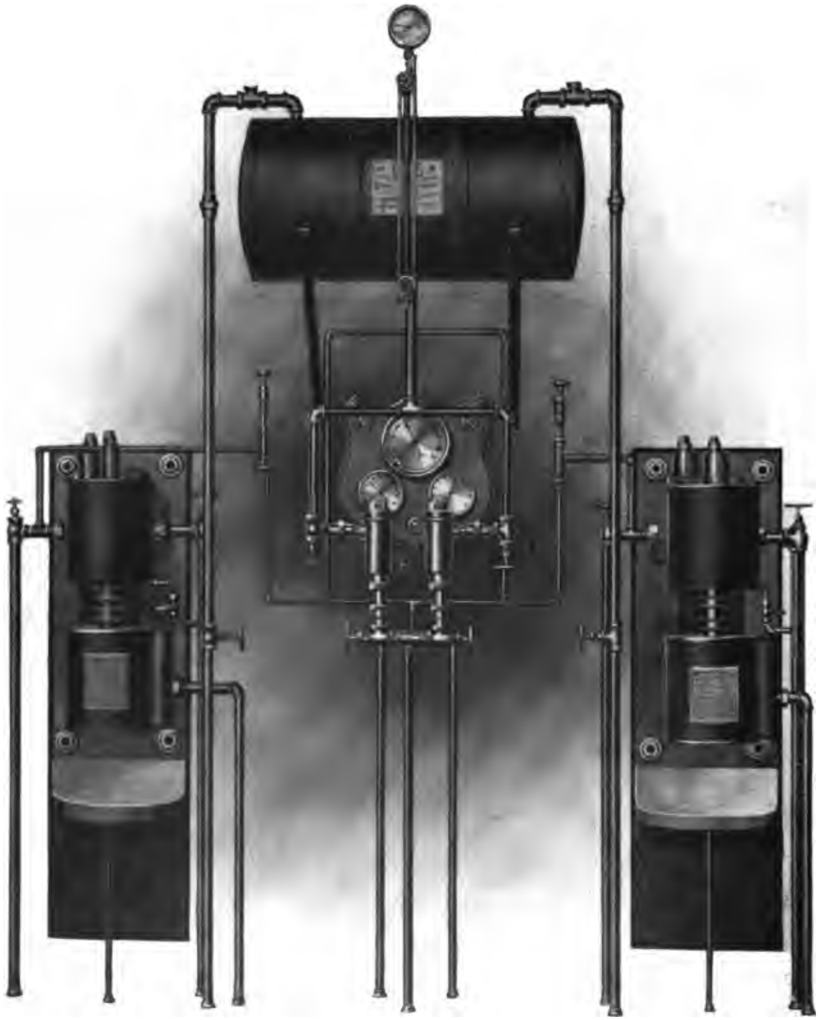
FIG. 2—COMPRESSED AIR BILLIARD CLOTH CLEANER IN OPERATION.

These wagons are admirably adapted for cleaning residences and other buildings too small to require a stationary plant.

One wagon manned by two competent workmen and an apprentice will clean a ten room residence in a day.

Pneumatic Lubricator.

The accompanying illustration shows the plant as it appears above the floor line. Beneath the floor there is a ten-barrel receiving tank into which the oil is run in the first place. In connection with the system there is an air receiver, located beneath the engine room into which air to operate the system is compressed, as for example, up to 60 lbs. From the receiver to the original tank there is a pipe line which admits air pressure to force the oil up into the tank above the engine room floor. On top of the original receiving tank a filter is connected up to said tank with a check valve between. The return oil from the sole plates of the engine is conveyed to the filter through piping and percolates through the same by gravity into the original receiving tank. The filter is protected from any pressure by the check valve before mentioned. An equalizing valve between the receiving and distrbuting tank as illustrated shows that any desired pressure can be kept thereon beneath the distributing tank. There are two filters, one can be cleaned while the other is in operation, and two Westinghouse or similar air compressors, one or both can be used according to requirements for such purposes as cleaning of switch board dynamo, or as is often done whitewashing the basement, pipes for which are taken from the receiver to any desired point of the plant. It is a well known fact that in many places an elevated tank is used for a gravity system. The oil must be pumped up from below to those tanks and the gravity system is intermittent regardless of the head. With the present system, no matter how slight,



the feed is constant, a system, such as this, will take care of every bearing on any job regardless of how extensive the case may be. The saving of the oil is not taken into consideration, that is thrown in as a bonus. Mr. Young, who installed the B. & O. tunnel electrical generating plant, writes that he is saving $300.00 a month on labor alone.

This pneumatic lubricating system is the invention of Mr. J. F. Pilling, general manager for the Port Huron Air Tool Co., Ltd.

Dake Pneumatic Chain Hoists and Air Motors.

Descriptive Circular No. 6, received from the Dake Engine Co. of Grand Haven, Michigan, illustrates their Pneumatic Chain Hoists and Air Motors.

We show in Fig 1 the pneumatic chain hoists manufactured by this company. This hoist is made along the line of the standard hand chain block, to which is attached the Dake reversing air motor. The hoist is simple in construction, durable and efficient. It is operated by pendent hand chains as shown in illustration, and will sustain the load at any point. This class of pneumatic motor hoist is meeting with a very favorable reception from manufacturers of heavy machinery, and is especially adapted for serving heavy machine tools and in places where it is necessary to sustain the work in one position for machine operations.

The air motor used with this hoist (Fig. 2) is of the double reciprocating square piston type, and is favorably known to the trade as a desirable motor for direct-connected work where small, compact and high speed motors are desired.

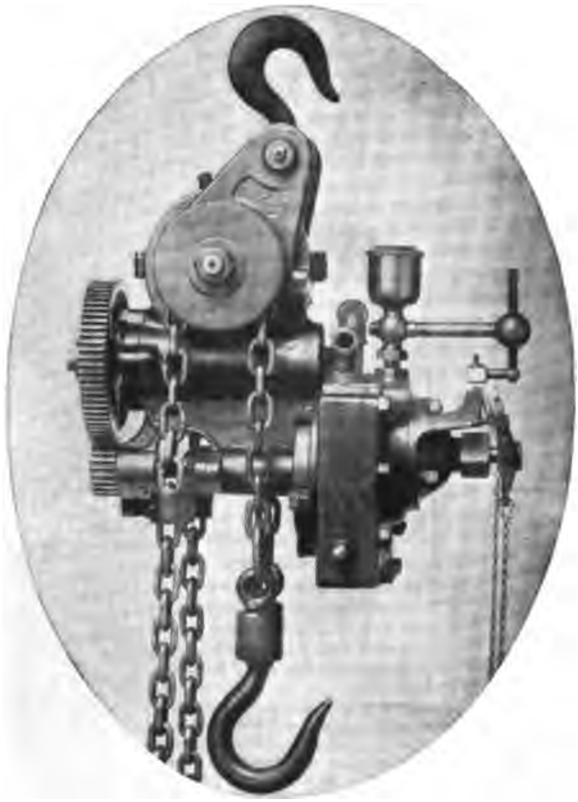


FIG. 1.

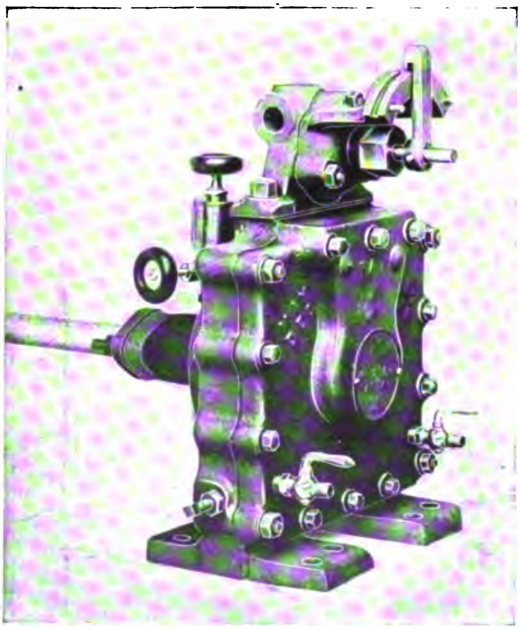


FIG. 2.

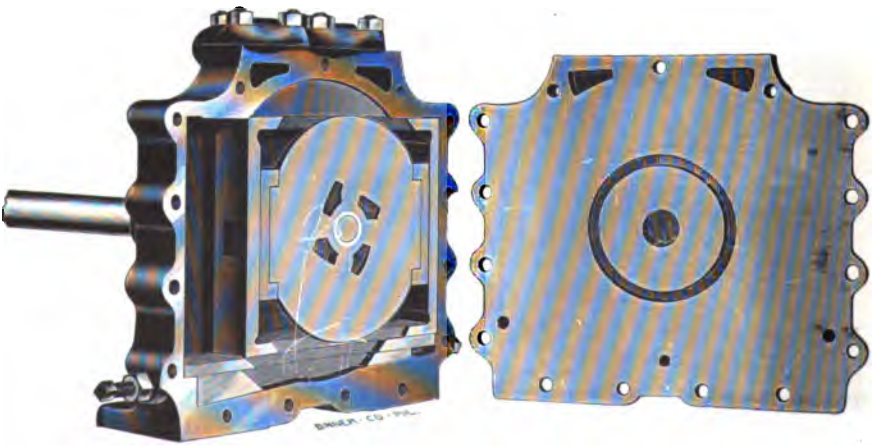


FIG. 3.

We also give in Fig. 3 the working parts of the motor. They consist of only two movable pieces, one sliding inside the other and guided in their movements by the crank on the end of the driven shaft.

FIG. 4.

The inner piston has cored through its body four ports, leading to the four sides or ends of pistons, and which communicate with the two ports cut in cover or cylinder head of engine. In the reversing engine the air passes through the center and exhausts through the circular aperture; or when throttle is reversed, air is taken through the circular ring and exhausted through the center port. The engine can be reversed instanly by the valve lever shown on the reversing air motor.

The engine operates either with compressed air or steam, and is used for changing hand to power cranes, for direct connection to fans, blowers, centrifugal pumps, and for general hoisting engine purposes.

Low Pressure Pneumatic Signaling at Salisbury.

The above plant, on the London & South Western, which is the first large low-pressure installation in England, was put into service on Sunday, November 2. At each end of the station there is situated a cabin known respectively as the east and west boxes. These two cabins and a ground frame do all the work which formerly was done by four mechanical machines, thus saving the service of six signalmen. The ground frame is only used during the time that shunting is going on at that point, and has been rendered necessary, not on account of the distance from the east cabin, as these switches could easily be operated from there, but to meet the requirements of the Board of Trade, which demands that a man must be on the ground to attend switching operations carried out at such a distance, i. e., about 1,200 ft. from the cabin. The interlocking between the east box and the ground frame is carried out as follows: When shunting is to be done a man is sent to the ground frame, all the levers of which he finds locked in the normal position. He asks cabin No. 2 for an "unlock," which is given by pulling over the lock lever provided for the purpose and which, on being reversed, frees the king lever in the ground frame and locks up all conflicting signals and points in the east cabin. On obtaining this release the signalman at the ground frame is able to operate any of his points or signals, and when the shunting is finished and his king lever has been replaced by him to its normal position, then, and not till then, can the signalman in the east box replace his lock lever, get his indication and free his signals and switches controlled by it.

The west cabin contains a 64 lever frame of the usual type made by the British Pneumatic Railway Signal Co. Twenty-two of these levers work 30 signals, 19 are for switches and five for bolt locks between the Great Western and west box; in addition to these there are two special lock levers controlling signals operated from the east cabin similar to those for the east box and ground frame; and 16 spare spaces. The east cabin also contains a 64 lever frame, 27 of which work 32 signals, 17 are for switches, three special lock levers and 17 spare spaces.

The compressed air for working the whole of the switches and signals is obtained from one power house situated near the east cabin. There are provided here two compressors, each more than sufficient to do the work of the whole station; and one is kept as a stand-by while the other is working. A further precaution is taken by having two separate powers to drive the compressors, one compressor being driven by an electric motor run from the mains of the Electric Company at Salisbury, the other by steam from a boiler in the boiler-house adjoining. The air is compressed to 30 lbs. per sq. in. and conducted through a galvanized pipe to a receiver of 250 c. f. capacity. From thence, having been reduced in pressure to 20 lbs., to two more receivers of the same capacity situated one at each cabin, and from these latter receivers, to the cabins, switches and signals, by means of galvanized pipes. The main pipe is 2 in. in diam. and the various branches run from 1 in. down to ¼ in. diam.

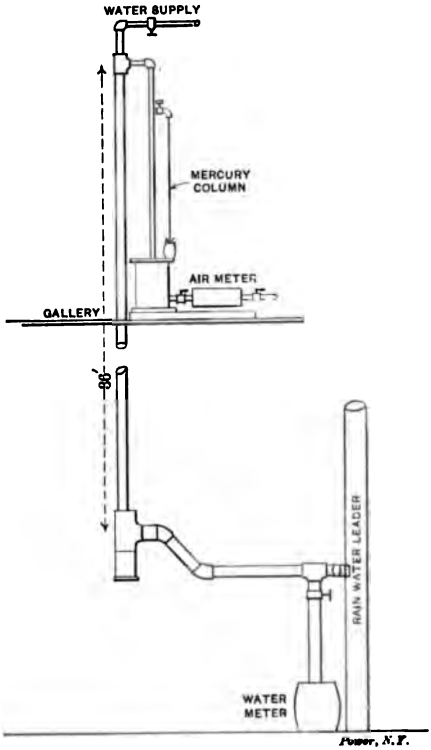
A novelty, so far as English practice is concerned, is that all the levers operating the running signals are replaced in the normal position electro-pneumatically by a valve actuated by the relay of the track circuit, with which all the running lines of the station are provided.

In several cases in this station one lever will operate one of two signals, which one depending on the position of the switch leading to the track for which these signals give permission to run on. The method of doing this is as follows: The indicator selector valve which is placed at the switches and worked by the motion plate is similar to the ordinary switch indicator valve with the exception that it is provided with extra ports. In one position of the motion plate the low pressure operating pipe A is connected, by means of these extra ports, with the low pressure pipe operating the diaphragm for signal No. 1; but when the points are moved over, the pipe A will be connected to the low pressure pipe operating diaphragm for signal No. 2.—*Railroad Gazette.*

Air Enmeshed in Falling Water.

Water, when falling freely through air or other gas, enmeshes and carries in suspension, practically, its own volume of such gas, the volume of air so carried depending somewhat upon the viscidity of the water.

That the foregoing statement is approximately true with air at atmospheric pressure is demonstrated every time a pitcher of ordinary shape is filled at a strong-



AIR ENMESHED IN FALLING WATER.

flowing hydrant. When the rising water-level approaches the relatively narrow throat, foam overflows at the brim of the pitcher and the water level remains stationary. This status continues, until the flow of water is checked to such an extent that the reduced volume of air entering in the decreased flow of water can find room enough to escape again without commotion, when the pitcher can be filled to the brim.

The accompanying sketch shows a small experimental aspirator fastened to the wall of a building. It is provided with an air meter, consisting of a piece of pipe between stop-cocks having an internal capacity of a convenient fraction of a cubic foot. A marked barrel is placed on the ground, where it can, when required, receive and measure the descending water, while a mercury column, placed where shown, indicates the density of the air inside.

With an internal density of about one-half the atmospheric, I found that, for every cubic foot of free air entering, two cubic feet of water were measured into the barrel.

It was by no means easy to so manipulate the air admission stop-cock as to prevent the mercury column from fluctuating, but repeated trials showed the foregoing statement to be approximately correct.

Similarly, with a density of about one-quarter the atmospheric, four cubic feet of water descended; with one-eighth the atmospheric density, eight cubic feet of water descended, and so on.

With the air entirely shut off, the mercury column crawled up to 28.25 inches, which, as the temperature of the water was 80° Fahr. and the local barometer indicated 29.30 inches, was practically the water vacuum.

ARTHUR PENNELL,
in *Power*.

The Koerting Gas Engine.

The discovery of the fact that gases of low heating capacity, such as the waste gases from blast furnaces, could be used effectively, gave a great impetus to the construction of such engines, especially of large capacity. One type of engine which is now extensively used in the Koerting, which is manufactured in this country by the De La Vergne Refrigerating Machine Company, of New York. The makers claim substantial advantages for the two-cycle type, of which the Koerting engine is a representative, in comparative simplicity of construction.

This engine is the result of five years of tests and experiments on the part of Mr. Ernst Koerting, a well-known expert on all subjects relating to the gas engine. After a number of models had been constructed a 400-horse-power gas engine was built in the Koerting shops, and when it was found that this complied with all the requirements, the new engines were immediately placed upon the market, and proved very successful. The makers have already sold in the United States engines of this type, representing 41,800 horse-power.

The engine is of the two-cycle type, and is double-acting, like a steam engine, hence the crank end and head end of the lower cylinder are similar, the admission valves being located in the valve boxes, which are bolted to the cylinder heads. There are no exhaust valves required, the products of combustion escaping through slots in the middle of the cylinder from which the exhaust pipe leads. These slots are covered by the long motor piston.

The combustion mixture is admitted through two double-acting pumps, the one for gas, the other for air. The crank ends of the air pump and gas pump discharge into the crank end of the power cylinder, and the head ends of the pumps discharge into the head end of the power cylinder. The gas and air are compressed to about 9 pounds per square inch by the pumps.

The combustible mixture of gas and air is produced only at the inlet of the cylinder. There is no storing of it. The mingling of the air first introduced with the burnt residue gases, or with the succeeding charge of combustible mixture, is avoided by the construction of the admission device. For the same reason there is no loss of mixture through the exhaust ports.

The pump is provided with piston valves, with the valve gear so arranged that its maximum capacity cannot exceed 50 or 60 per cent. of its total displacement. For after the pump has completed the suction stroke, the gas suction port is left open during a portion of the succeeding (compression) stroke, so that the gas can return without increase in pressure until the suction port is closed, when the gas is compressed and passed out through the compression port. The amount of gas thus furnished corresponds to the maximum power of the engine.

The engine is started with compressed air. Engines to which blowing cylinders are attached are easily started with air under 150 pounds pressure. For those without such cylinders 90 to 120 pounds pressure is sufficient. These engines are built in sizes ranging from 400 to 2,000 horse-power.—*Engineering and Mining Journal.*

Compressed Air or Steam Hammer.

The American Engineering Works of Chicago, are building post hammers which are particularly well adapted for railroad, mining, blacksmith and general machine shops. They are designed to be driven either by steam or by air. A special valve movement and treadle for handling these hammers has been patented. It is so arranged that a slight movement of the treadle causes the ram to rise to top of its stroke and remain there for any length of time desired, thus enabling the operator to adjust work or tools on the lower die. If the treadle is then pressed down to the limit the ram will give a hard, full blow, the same as a drop hammer; or the treadle can be pressed down part way, when the hammer will give repeated hard or light blows, as may be required. This special valve gear permits one man to easily handle the hammer for drawing or regular forge work, or for die work. The change from one kind of blow to the other is made instantly and smoothly.

The cylinder and frame are cast in one piece from best quality, close grained gray iron. The exhaust ports are so arranged as to keep the cylinders always drained. The piston is forged solid with the piston rod from the best quality of O. H. steel.

The ram is a steel forging square in form where it passes through the lower part of the frame which acts as a guide. The lower end of the ram is aranged to receive the upper die in such a position that it stands at an angle of 45 degrees to the post supporting the hammer, thus enabling long pieces to be worked either way of the die without coming in contact with the post.

The upper and lower dies are steel forgings fastened by means of dovetail and wedges so that they can be easily removed.

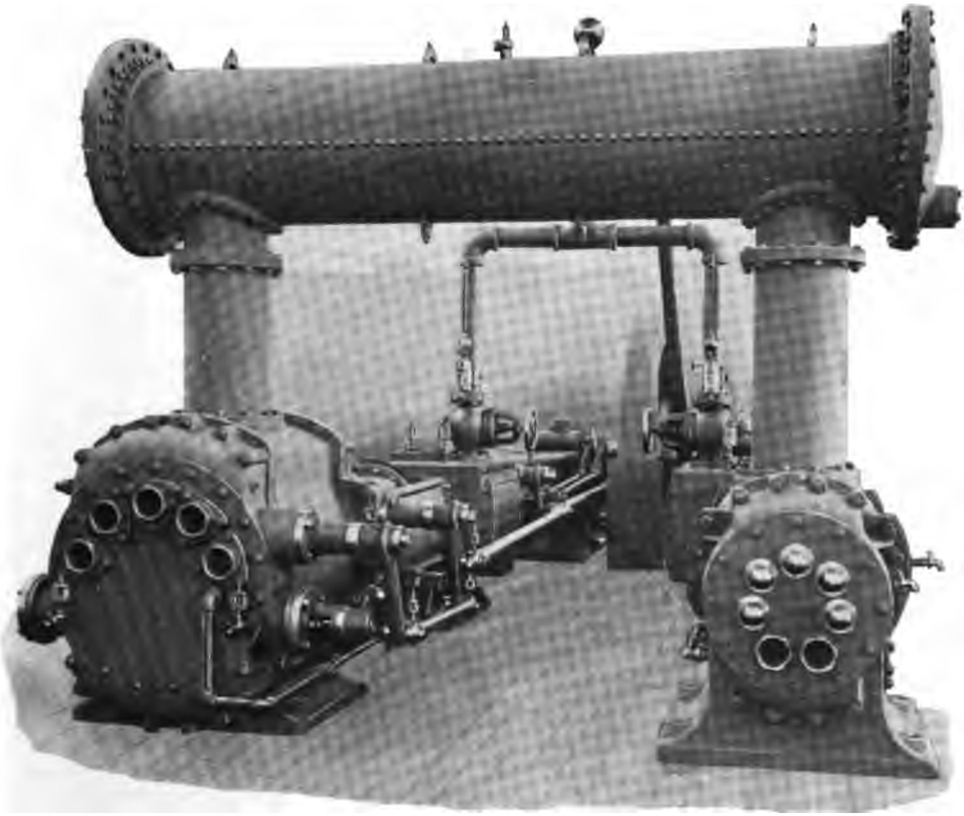
The anvil is designed to be secured to a wooden block set on end, the anvil being bolted to the block with lag screws.

The weight of the falling parts (the piston, piston rod, ram and die) designates the size of the hammer.

The hammer is usually arranged for bolting to a wooden post. Special attachments will be furnished when so ordered for bolting to a wrought steel column, or where preferred a steel column made of extra heavy wrought pipe will be furnished, together with the necessary clamps for properly clamping frame of the hammer.

Compressors at the Canadian Niagara Falls Power Co.

The entire work of the excavating plant at the above company's works is being accomplished by rock drills run by compressed air, which power is supplied by two large steam driven compressors, built and installed by the Canadian Rand Drill Co. We show herewith a picture of one of the compressors. These machines are of the duplex steam, cross compound air type, and indicate 300 h. p. each. Entering a conduit leading from the open air to the compressor, the air is admitted at atmospheric pressure to the low pressure air cylinder through Corliss valves, actuated from the main shaft by eccentrics. Here it is compressed to 30 lbs. per square inch, the temperature of the air being kept as low as possible by means of the circulating water with which the water jacket surrounding the cylinder is kept filled. The air is then discharged into the intercooler, which is of the Rand water tube type, so well and favorably known to the Canadian engineering world on account of the excellent results that have been obtained from machines installed by this firm in British Columbia, Cape Breton and other parts of Canada. This intercooler practically consists of a large cylinder. made of steel plate, and filled with pipes in which cold water in circulated. An ar-



rangement of internal plates forces the air to pass transversely across the pipes, thus removing a large proportion of the heat of compression. After passing through the intercooler, the air enters the high pressure cylinder, and is there compressed to 100 lbs. per square inch. The compressors discharge the air into the air receiver, which takes up the air pulsations, thereby equalizing the pressure. From the air receiver the air passes into the pipe line, from which it is taken off by the different machines. The general dimensions of the compressors are: Steam cylinders, 18 inches in diameter; high pressure air cylinder, 18 inches in diameter; low pressure air cylinder, 28 inches in diameter; stroke, 24 inches. The compressors run at a speed of 100 revolutions per minute, and each machine has a capacity of 1,700 cubic feet of free air per minute.

Mail Tubes for Chicago.

Contracts for about nine miles of pneumatic tube service in Chicago, taking in a number of the depots and postal stations, were let Jan. 24, by the postoffice authorities at Washington, to the Chicago Pneumatic Tube Co. An annual rental of $13,750 per mile is paid by the government. At least three miles of the pneumatic tubes must be in operation within a year, and the entire system contracted for must be completed within three years. The tubes will center in the new postoffice building, and if the three miles to be completed within a year are to be used in the service the temporary postoffice will either be abandoned within that time for the new site, or connections will be made with the structure on the lake front. Three separate tube lines are provided for in the contract. The longest one is to cover the principal South Side stations. It will start from Adams and Dearborn and run east in Adams street to the lake front, where a turn south is to be made, the tubes continuing through the park to the Twelfth street station of the Illinois Central R. R. A new postal station will be established at Twelfth street to handle local business in addition to the railway mail service. From Twelfth street the tubes will run south in Indiana avenue to Twenty-second street, where the Twenty-second street postal station is located. They will continue south to Thirty-second street, where the Armour station is situated, and further south to the stock yards station. Forty-second and Halsted streets, which is the terminus of the south tube system. The west tube system will run from the new Federal building west to the board of trade postal station in the Rand-McNally building, and from there west to the Union depot. This line will handle railway mail as well as the business of the Union depot postal station. The north system will run beside the south system to the Lake Front park, thence north to the temporarry postoffice, or to a new postal station to be established nearby when the temporary postoffice is abandoned. The tubes will extend to the South Water station at 15 La Salle street and under the river to the Northwestern depot, which will be the terminus. A new postal station will be established either inside of or near the depot. All the tubes will be 8 ins. diameter, inside measurement, and of uniformity, so that the carriers can be interchanged. It is left to the successful bidders to make arrangements with the city for the use of the streets which the tubes will traverse.—*Railway and Engineering Review.*

Tunnel Construction for the Cables of the Illinois Telephone & Telegraph Co.

Quite in contrast with much of the work connected with the subway construction in New York City, is the building of the tunnels in Chicago for the cables of the Illinois Telephone & Telegraph Co. This work has been carried on so quietly, with practically no plant on the surface to attract unusual attention, that very few of the people that frequented the busy thoroughfares of the business district of Chicago were aware of, the magnitude of the work until some 12 miles of tunnels had been completed. It is really remarkable that a work of this magnitude should have been constructed without a single complaint from a taxpayer or a pedestrian on the streets, or a complaint from any department of the City Hall. The Department of Public Works in the city of

Chicago, during the construction of the 12 miles of conduit, saw that the work was done in such a manner that there would be no possible chance of any unfavorable criticism from taxpayers, they keeping almost hourly reports of the work as it progressed. *Mines and Minerals* in their January issue describes the sinking of the shafts as follows:

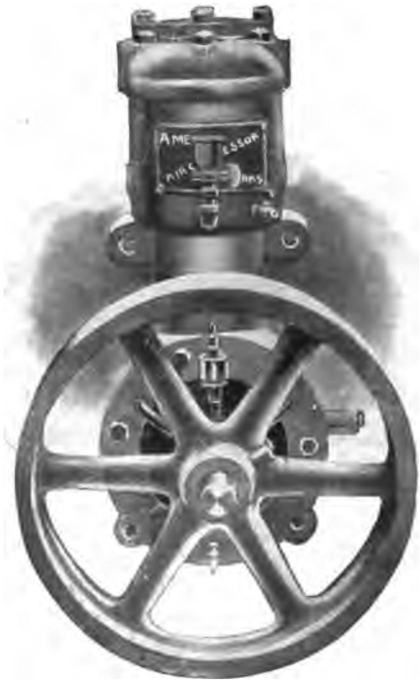
"A steel caisson was used, made of No. 12 steel plate with a 3-inch angle iron riveted to the plate at the top and bottom. These steel plates were made in sections 18 inches deep, and divided in proper lengths to fit a semicircle 9 feet in diameter. The sections of steel plates and lagging were bolted together as the excavation was being done, or, in other words, the depth of the section being 18 inches, only about 18 inches at a time were excavated in depth, and as the individual plate sections were about 5 feet long, pockets about 18 inches deep, 2 feet wide, and 6 feet long were excavated, which excavation allowed the placing of one of the sections to a completed upper section. By this method of closely following the excavation with the plate lining, any chance of settlement in the ground or caving in was obviated. After the shafts had been sunk to the proper depth, a 7-inch wall of concrete was constructed inside of the caisson.

"After satisfying themselves as to the nature of the subsoil, the company settled upon the method for carrying out the work, and the pneumatic system was adopted, as experience dictated that it was the most economical and safest. While it was not altogether necessary to use this system, as the nature of the soil gone through was such that it would stand without caving or swelling, the pneumatic system was introduced more for the purpose of protection in case it was necessary that the work should be left for a time in an uncompleted state. In installing the pneumatic system, air locks were placed just outside the several shafts."

A small Vertical Belt Air Compressor.

This compressor is manufactured by the American Air Compressor Works and is built in three sizes, namely, No. 4, No. 6 and No. 7, having a capacity of 6, 16 and 25 cubic feet per minute, and suitable for any pressure up to 100 lbs. per square inch.

These machines work on the double acting or compound principle, that is they partially compress the air on the down stroke, then passes on into the other side of piston where it is again compressed to the pressure desired.



A SMALL VERTICAL BELT AIR COMPRESSOR.

These machines are built with improved metallic (Poppet valves), water jackets around air cylinder, fly wheel pulley, lubricator, oil cups, and all other mountings complete. The machines are particularly adapted for experimental and laboratory work, No. 7 size being used quite extensively for operating three stone hammers. They are also adaptable for operating moulding machines and air hoists.

Notes.

At a meeting of the Board of Directors of the Allis-Chalmers Company held January 15th, 1903, regular quarterly dividend was declared on preferred stock.

Steel cars are being cleaned by the Pittsburg & Lake Erie with compressed air, and the Pennsylvania is giving the subject attention with a view to improving methods it has employed.

The generating plant of the Northern California Power Company at Cow Creek in the high Sierras, furnishes current from that and another station for ore smelting, for operating air compressors, for town lighting, for water works and for the irrigation of land.

The Empire Engine and Hoist Co. report that they have just completed the filling of an order for 24 Empire air drills to the U. S. Navy Yard, at Brooklyn, N. Y., at which place they have had in operation for the past few years not only many other Empire air drills, but numerous Empire air hoists as well.

Mr. A. C. Amos, of 20 Bucklersbury, London, E. C., announces that he has been appointed sole London agent to the Consolidated Pneumatic Tool Company, Limited, which is an amalgamation of the New Taite Howard Pneumatic Tool Company, Limited, and the International Pneumatic Tool Company, Limited.

It is reported that the British Schuckert Electric Co., Ltd., Surrey Street, London, W. C., have sent out a blue print showing the results of rock drilling tests at the Düsseldorf Exhibition. This indicates that the combined Meyer-Schuckert electrically-driven compressed air percussion drill achieved results nearly 33 per cent. better than the second best competitor.

The International Correspondence Schools of Scranton, Pa., have issued a little booklet called "One Thousand and One Stories of Success," which they intend sending to all prospective students. This publication proves beyond a doubt the genuineness of the International School's prosperity, and we especially wish to congratulate them on the well gotten up little booklet.

In the machine shops of the Hydraulic Installation at the Panuco Mines in Mexico, many pneumatic tools are in use; the steam hammers in the smiths' shops are run by compressed air in place of steam; the largest hoisting plant is run direct by a water-power motor, and the general existing circumstances seem to point in favor of compressed air being used for general underground purposes; and this, after the fullest consideration, has been finally adopted, and the general results obtained after its installation fully justify its adoption.

Ottoffy & Williams of St. Louis, Mo., sent a communication to Jacksonville, Fla., calling attention to their new invention, consisting of a van for the purpose of washing and sprinkling streets by means of compressed air. The street board considered it wise to investigate this device and get further data and information in regard to the subject, and Superintendent of Streets, S. L. Earle, will communicate with the inventors and manufacturers and report as soon as he has definite information. There have been numerous complaints regarding the bad condition of the streets.

The directors of the American Pneumatic Service Company, in a circular letter to stockholders, outline the work of the company, the development of the pneumatic tube system, the plans for the extension of the business of the company, the needs of the company for ready cash, and say:

"For these reasons your directors have unanimously voted to defer action upon the payment of any dividend on the preferred stock for the present, and they are advised that by so doing the rights of the preferred stockholders to share in dividends out of the past year, as well as out of earnings during the period in which earnings are thus employed, are preserved and protected."

An estimate of $10,000 has been transmitted to the House at Washington, D. C., to pay the annual rental of a pneumatic tube service proposed to be established in the treasury building. The letter of transmittal contains a statement from Supervising Architect Taylor, which states that under the direction of the Secretary various proposals have been received for a pneumatic tube service in the treasury building, and also between that building and the various executive buildings, said proposals being much in detail, one of which is for the rental of a pneumatic tube service in the treasury building, the department to furnish the power therefor, for which rental and expenses incident thereto an annual expense of $10,000 will be involved.

Within the last month, before the Birmingham Students' Engineering and Metallurgical Society, England, Mr. A. Craven read a paper on "Pneumatic Tools, their Construction and Uses." The author having briefly indicated the great expansion in the use of these tools in British works, described very fully the construction of the chief types of those in general use, and also of some of their prototypes. In this description he included chipping and caulking tools, drills, hoists, hammers, rivetters, etc., and afterwards showed by means of lantern slides, the many and varied uses to which these may be adapted, and compared the work done with them to hand work, actual examples of such work being shown for comparison.

The efficiency of compressed air plants can be greatly increased by reheating. The gains are both direct and indirect. The chief direct gain is in the greatly increased efficiency of fuel used in the heating stoves as compared with the effect when coal is burned under boilers. It is commonly stated, and the statement is fairly correct, that when one pound of coal is burned in a reheater stove the commercial effect is as great as when three pounds are burned under a boiler. The increase in commercial efficiency when reheating air from 60° to 400° F. may be put at 35 per cent. The indirect gains are: 1. Better lubrication of the compressed air engine. 2. Less investment required as a smaller plant will be required. 3. Reduction of compressor engine friction as compared with the useful work done. In the next few years we hope to see all mines using compressed air have reheater stoves.

It seems rather pathetic nowadays when a leading railroad reports that the air brakes on a fast freight train must wait for test until the locomotive is backed down from the shops and coupled to the train, and when a full hour is consumed in the testing. Yet this is the situation on some of the railroads which otherwise have a claim to greatness. The time of testing will be largely reduced if the yards are equipped with testing plants where an important train may be tested while it is being made up, or immediately after, thus doing away with the necessity of waiting for the engine and consuming valuable time after the crews have been called and are ready to start.

This old-time method, which should be immediately regulated as exceedingly costly and behind the times, should be replaced by a more modern one of yard testing plant, which will greatly facilitate the air-brake service.

The physiological effects of working in compressed air have been studied during the placing of foundations for a lock in the Danube at Vienna. The work required nearly three years, and in this time 675 men were employed for an average of 553 hours under pressures of one to five atmospheres above the normal. Each working shift of four hours was followed by eight hours off duty. Included in the working time were the rests in the air-locks to become gradually accustomed to the pressure changes, from 5 to 35 minutes being necessary on entering and a longer period up to 20 minutes for each atmosphere on leaving. The results have led to the conclusion that carefully-selected men may work under pressures up to 75 pounds to the square inch without serious risk. Yet of these men nearly one-half were obliged to go to the hospital, two dying and six being permanently injured, and it was found that sufferers from nasal catarrh, ear troubles or bad digestion were specially unfit for employment.

When using the term motor, one should not always have in mind an electric motor, as we believe that a great deal of the economy which has been arrived at by the use of individual electric motors can be very closely approximated by the use of individual steam or compressed air motors. There are quite a number of small steam motors which are quite efficient, and it is very noticeable in factories abroad how the use of small steam engines driving different parts of factories, instead of their being coupled to one main engine, has been adopted. In Paris the use of individual air motors is a very common practice, and in Germany the use of individual gas engines is nearly as well developed.

Recent developments in the direct compression of air by falling water, from which a very much larger net effect can be obtained by means of preheating and premoistening before using in motors, and the possibilities of distributing perfectly dry, cold compressed air long distances without serious losses will in the near future bring the use of individual air-driven motors into greater prominence.

The Morning Mining & Milling Co., Idaho, employs in exploitation a well planned power system, most of which is used for making compressed air. The water is gathered from various streams high up on the mountains above the compressor site, and conveyed to the wheels by three pipe lines of 1400, 1200 and 140 feet head, respectively. The 1400 and 1200-foot heads are delivered by separate nozzles on a Pelton wheel 32½ feet in diameter. The 140-foot head is used to drive two 11-foot Pelton wheels, one on each side of the big one and on the same shaft. There are two compressors, one on each end of the water wheel shaft. They have 18 x 32½ x 42-inch cylinders, with intercoolers. The air is compressed to 28 pounds in the low-pressure cylinder, and delivered by the high-pressure cylinder at 90 pounds. Running at full speed these machines compress about 6000 cubic feet of free air per minute. The pipes which convey this air to the mine cost more than the machinery. They comprise 9200 feet of 12½-inch pipe to No. 6 tunnel, at which point the air is divided into two lines of 9-inch pipe, one entering No. 6 tunnel, which will be 2 miles long, and another leading 4½ miles to No. 5 tunnel.

The beneficient results of keeping electrical or other particularly vulnerable machines clean are very generally realized, but the flexibility and efficacy of compressed air as a cleaner of such machines are not appreciated as universally as they might be, judging from the relatively limited number of such applications. One, and possibly the chief advantage derivable from the use of compressed air to clean dynamos, motors, etc., is the ability to remove collections of foreign material without touching the parts of a machine on which they are lodged. By no other means is it possible to remove oil-soaked copper or carbon dust, for example, without either wiping or scraping the coated part. Perfect cleaning by wiping is almost impossible, to say nothing of the liability of making matters worse by the use of dirty waste or pieces of cloth; the serious objection to the scraping process is obvious. Another advantage of a compressed air cleaning system is that an outlet may be (and usually is) provided near each piece of machinery or apparatus, so that in many cases each one can be at least partially cleaned while in operation. In the worst cases, except those of enclosed machines, a shut-down of only very short duration is necessary for effecting complete cleaning.

The Krupp Colleries of Essen, Rhenish Prussia, are three in number, namely Hannover, Hannibal and Sälzer and Neuack, all in Westphalia. These have seven working-shafts altogether, furnishing the entire coal supply of the Essen Works and also the greater part of the coal and coke supply for the remaining Krupp Works.

The plant at the Hannover and Hannibal United Collieries comprises seven shafts, of which five are winding shafts. Another winding shaft is being constructed. The greatest depth is 550 yards. The various plants work 30 seams with a total thickness of 111 ft. The "Hannover" and "Hannibal United" Collieries have, among other machinery, three surface and six underground pumping engines with a total delivery per minute of 529 cubic feet of water to an average height of 448 yards; six hydraulic air compressors which take in per hour 353,000 cubic feet of air at atmospheric pressure for the working of underground compressed air engines;

three fans (and one spare ventilator) acting by suction with a total delivery per minute of 350,000 cubic feet; and four coal-separation and three washing plants with an output of 200 tons per hour.

The total output in 1901 of the Krupp mines amounted to 1,479,334 metrical tons of coal.

The ordinary gasoline blow torch commonly used in paint shops for removing old paint from cars and trucks preparatory to repainting, says the *Automobile Review*, is not only an inconvenient thing to handle, but is constantly a menace to property and requires the strictest attention to prevent fires.

Mr. J. Millar, superintendent of rolling stock for the International Ry., of Buffalo, has abandoned the use of blow torches entirely in this work and now uses a home-made sand blast consisting of a sand tank, a few feet of 3/4-inch iron pipe, and a nozzle made by flattening out a piece of 3/4-inch iron pipe. Compressed air is taken through the iron pipe from an air compressor in the main shops. The sand which must be of fine clean quality is fed from the tank into the air pipe in the manner indicated in the diagram, the force of air combined with gravity, being sufficient to draw the sand down into the pipe in a good steady stream. By means of the flexible connection and nozzle one man directs the sand against the surface to be cleaned, exactly in the same way as he would handle a blow torch of any kind. Mr. Millar states that with an air pressure of approximately 90 lbs. and a good quality of sand every particle of old paint is removed and a cleaner surface is secured than could be obtained with a blow-pipe flame, and in just one-half the time, inasmuch as one man now does the work formerly requiring the services of two men.

Electricity is not being largely adopted in Australian mining so far; the real reason for this does not arise from want of appreciation of the advantages as much as from the difficulty of obtaining immediate deliveries. German and American motors are in places obtainable, but there is absolutely no chance of obtaining British plant subject to any reasonable date of delivery. In large mines, like the Broken Hill Proprietory, where the tonnage is large, 10,000 tons per week, electric haulage has been adopted, and all trucking is done by electric motors instead of horses at considerable reduction in cost. In most large mines throughout the colonies also the lighting is electric, but electric winding engines and drills are not in use. Even at the Kolar mines, India, where water power is available and there is an electric supply, the hoists and drills are worked by compressed air. Apart from the advantages as regards ventilation by the use of compressed air, compressors can be very cheaply run where electric power is available, as the motor and compressor can be run always at high efficiency. Receiver capacity of sufficient volume can always be provided, and by reheating the air both drills and hoist can be run continuously, as the compressor will recharge the receiver between the skips, the demand of the drills being comparatively lignt. The fuel required for 150 horse-power for reheating will only average about a cord a day, and the hoisting charges, where electric power costs, say, £10 per horse power per annum, would not, for ordinary depths, amount to more than 1s. per ton milled.

We take the liberty of reprinting a note found in the *Daily News*, London, reading as follows:

"Compressed air (writes an enthusiastic correspondent) is one of the few natural forces which has not as yet received its due share of attention in the Press. It has, however, a journal of its own, published in America, and printed in the most luxurious style. Many of us scarcely realize the importance of compressed air. It may therefore be described as the inspiration of a football or a Dunlop tire. It is, moreover, compressed air which breathes manifold music from the souls of organs, and which lends rotundity to the cheeks of Sousa's performance on the trombone.

"It is compressed air (he continues) which causes lovers to sigh and steam whistles to shriek. It boos from the fog-horn and catcalls through the siren. And recently it was to be found opposite the

National Liberal Club, where it was being carried about in a kind of red vehicle—a cross between a motor-car and a water-cart.

"A pipe led from it through the windows of a hotel, where something must have been going on inside. But what? Were people having a little ozone in the drawing room? I rather suspect that the furniture was being cleaned by means of the syringe, through which the air is directed whenever there is dust. It is far more efficacious than brushing or beating the poor armchairs, and compressed air is frequently used to cleanse railway carriages. It is the regular agency for stamping glass mugs. Air mixed with sand is driven through a stencil, and eats its way into the vessel in a very few minutes—as may be seen at any London County Council laboratory for testing such measures.

A more or less new shaft sinking system has been recently introduced by Mr. Charles Walker, of Doncaster, England, and two 24 ft. 6 in. pits are now being sunk with it by him at the Sherwood Collieries, Mansfield, Notts., with great success. The power adopted has been compressed air, combined with hand-boring, and the whole of the plant has been manufactured by the Hardy Patent Pick Co., Ltd., Sheffield. The sinking frame proper consists of an iron or steel ring, in this case 8 ft. in diameter, with a tee-slot annular groove. Upon this ring are mounted eight arms, each telescopic, and provided with jack screws, the end-mounting on the ring being secured by suitable clamps, held down by tee-bolts in the annular slot. The frame is also provided with telescopic legs, which adjust themselves to any irregularity in the pit bottom, and on the telescopic arms the boring machines are mounted in any desired position. The circumference of the frame is indexed with figures showing the position the arms must be in to drill any desired number of holes. For example, let us suppose that it is desired to drill a round of 16 side holes. Each of the eight arms must be over the arrow marked 16. These holes are then put down the desired depth, and one moving of each arm to the next arrow marked 16 completes the round. Following on these, 14 sumpers may be required. The machines must be worked back on the arms to the mark thereon for the proper diameter of the ring for sumpers, and the drilling in each case commenced and finished over the arrow marked 14, and so on; so that it will be readily seen that there is no loss of time in marking out, but the mathematical accuracy of the drilling enables the chargeman to reap the full advantage of his firing.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

COMPRESSED AIR:

Gentlemen—We note in your issue of December, Volume 7, No. 10, you show on page 2104, a pneumatic sand rammer, and we should like to know from whom we can get prices and other information in regard to one of these complete, which you specify as weighing about 20 lbs.

We would like to have the information promptly, and would consider it a favor if you would favor us with an early reply.

Yours truly,

WESTERN TUBE COMPANY.

WESTERN TUBE CO.,
Kewanee, Ills.

Gentlemen:

We find on looking into the matter that the Pneumatic Rammer, shown on page 2104, of the December number, is manufactured by the Philadelphia Pneumatic Tool Co., 1038 Ridge Ave., Philadelphia, Pa., and we believe they publish a special pamphlet describing this rammer and suggest that you write to them. We are sending a copy of your letter to this Company and trust that you will approve of our action.

Yours very truly,

COMPRESSED AIR.

INDEX.

U.S. PATENTS GRANTED DEC. 1902

Specially prepared for COMPRESSED AIR.

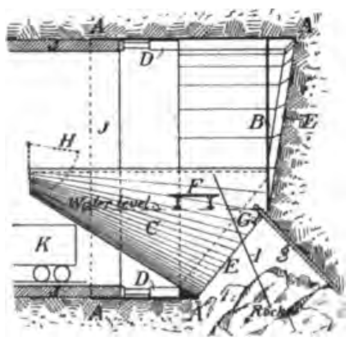
714,662. DOOR FOR HOUSING OF PNEUMATIC ELEVATORS. Chester Bradford, Indianapolis, Ind. Filed May 17, 1902. Serial No. 107,797.

The combination, in a boot or housing for pneumatic elevators having an opening in the bottom thereof, of a door for closing said opening consisting of a piece adapted to fit therein, a frame carrying said piece formed at one end to engage with a supporting device carried by the sides of the housing and having ears at the other end, locking-bolts engaging with said ears, and the housing sides provided with lugs with which said locking-bolts may also engage.

714,873. PNEUMATIC CARRIER SYSTEM. Wilbur G. Davis, Newton, Mass. Filed Dec. 2, 1901. Serial No. 84,297.

A pneumatic-carrier system comprising a carrier, a normally dead transmitting-tube therefor, a reservoir containing air at a pressure at variance with the pressure in said tube, means to place said reservoir in communication with the end of said tube, to cause the difference in pressure between the air in said reservoir and that in said tube to establish propelling movement of air through said tube, a closure for the opposite end of said tube and automatic means for holding said closure withdrawn from the end of said tube during flight of a carrier toward it through said tube.

715,244. PNEUMATIC TUNNELING SHIELD. Theodore Cooper, New York, N. Y. Filed May 31, 1902. Serial No. 109,648.



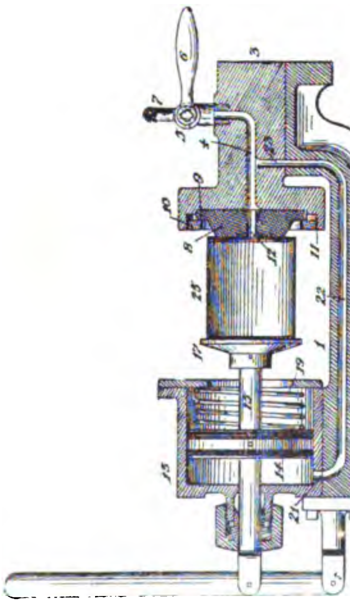
The combination with a tunneling-shield of an after bulkhead therein comprising a conically-shaped trough having its axis parallel with the axis of the shield and extending rearwardly from the cutting edge of the shield at or near which its forward edges attach.

714,874. PRESSURE-CREATING DEVICE FOR CASH CARRIER SYSTEMS. Wilbur G. Davis, Newton, Mass. Filed Dec. 9, 1901. Serial No. 85,144.

A pneumatic propelling device comprising a segmental inclosing case having one or more flat faces, a rotary reciprocatory member in said case and treadle means for reciprocating it, inlet and outlet openings in said flat face at each side of the axis of said reciprocatory member, valves for said openings and means to support said case in position with its said flat face or faces and said inlet-openings uppermost.

715,324. CAN-TESTING MACHINE. Newton B. Wachhorst and Maurice J. Ross, San Francisco, Cal. Filed September 4, 1902. Serial No. 122,104.

In a can-testing machine, a can-clamp, means for admitting air to the can while in

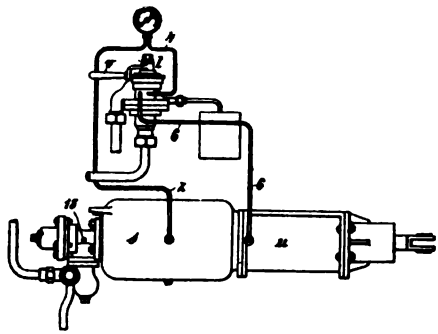


the clamp, means for pneumatically maintaining the clamp, and means for releasing the clamp at a break in the air-pressure.

715,349. PNEUMATIC STRAW-STACKER FOR THRESHING MACHINES. Robert Christie and Thomas B. Christie, Hamilton, Canada. Filed June 9, 1902. Serial No. 110,712.

715,585. COMPRESSED-AIR BRAKE F· RAILWAYS. Leon Kirchner, Mulhouse, Germany, assignor of one-half to Johannes Handschen, Basle, Switzerland. Filed Oct. 7, 1902. Serial No. 126,307.

In compressed air-brakes for railways, the combination with an auxiliary air-reservoir and its brake-cylinder of a differential elastic-tube manometer permanently connected by one



of its elastic tubes with the said auxiliary air-reservoir and means controlled by the brake-operating valve for connecting the other manometer-tube to the brake-cylinder on an ordinary service braking so as to indicate then the difference or equality of pressure both in the auxiliary air-reservoir and in the brake-cylinder.

715,723. PNEUMATIC SPRING FOR VEHICLES. William C. Wood, Wetumpka, Ala. Filed April 19, 1902. Serial No. 103,832.

715,760. PNEUMATIC STACKER FOR STALK-SHREDDING MACHINES. Charles E. Curtiss, Chicago, Ill., assignor to International Harvester Company, Chicago, Ill., a Corporation of New Jersey. Filed June 28, 1902. Serial No. 113,602.

715,800. AIR AND GAS MIXER. Charles W. Hinman, Boston, Mass. Filed April 15, 1902. Serial No. 103,018.

In a gas-lighting and heating apparatus, a holder for holding a variable volume of mixed air and gas under constant pressure, a delivery pipe leading from it to the burner, a pump connected with said holder for simultaneously delivering measured volumes of air and gas thereto, air and gas inlets to said pump, means controlled by the volume of mixed air and gas in said holder for regulating the delivery of air and gas thereto, and a motor for operating said pump.

716,031. PNEUMATIC TIRE. Henry N. B. Good, London, England. Filed Mar. 17, 1902. Serial No. 98,574.

716,196. COMBINED AIR-BRAKE AND SLACK-ADJUSTING MECHANISM. James M. Craig and William H. Buck, Denver, Colo. Filed Feb. 27, 1902. Serial No. 95,932.

The combination with brake devices, of a cylinder, two pistons therein, means for introducing air to the cylinder between the pistons, stems connected with the pistons and protruding from the opposite extremities of the cylinder, levers connected with the protruding piston-stems and suitably fulcrumed, a stationary frame suitably mounted, ratchet-bars slidable in the frame, dogs mounted in the frame and engaging said bars, and a suitable connection between the ratchet-bars and the piston-stem levers, and between the said levers and the brake-levers of the car-trucks, for taking up slack in the brake-rigging, substantially as described.

716,212. PNEUMATIC-DESPATCH-TUBE-SYSTEM. Edmond A. Fordyce, Chicago, Ill. Filed Aug. 4, 1902. Serial No. 118,-267.

In a pneumatic-despatch-tube system, the combination with a trunk-tube and a blower connected therewith, of a series of pairs of tubes tapping said trunk-tube and leading respectively to outlying stations, and cut-out valves interposed in said trunk-tube between the individual tubes of each pair of the series, respectively, substantially as described.

716,213. CARRIER FOR PNEUMATIC-DESPATCH TUBES. Edmund A. Fordyce, Chicago, Ill. Filed Aug. 4, 1902. Serial No. 118,268.

716,251. PNEUMATIC HAT-BLOCK. Robert Lamont and Charles E. Weatherhead, Denver, Colo. Filed June 3, 1902. Serial No. 110,104.

As an improved article of manufacture, a pneumatic hat-block comprising a base, an inflatable portion attached to the base, and a flexible air-escape conduit extending through the block, substantially as described and for the purpose set forth.

716,323. PNEUMATIC SIPHON. Andrew J. Weekley, East Pittsburg, Pa. Filed April 4, 1902. Serial No. 101,379.

In a pneumatic siphon, the combination of a body portion, an air-inlet, a refuse-inlet and a common outlet formed therein, said body portion being provided with an inclined side between said refuse-inlet and said outlet-port, and means provided in said air-inlet for deflecting the injected air against said inclined side, substantially as described.

716,498. SUBBASS FOR SELF-PLAYING ORGANS. Charles Warren, Guelph, Canada, assignor to the Bell Organ and Piano Company, Limited, Guelph, Ontario, Canada, a Corporation. Filed May 10, 1901. Serial No. 59,675.

In pneumatic-organs, the combination with the upper and lower vacuum-chambers, diaphragms, tubes and tracker-board and pneumatics coacting with same, of a subbass-chamber having a mute opening and pneumatics located therein beneath the top of the same, tubes connecting such pneumatics with the passage-ways leading to the upper portion of the vacuum-chamber, the reed-box and reeds located in chambers therein, such reeds extending downwardly through the main or lower vacuum-chamber into the exhaust-bellows and the pallets extending over the top of the reed-box chambers and connections between the pallets and pneumatics as specified.

716,499. MOTOR FOR SELF-PLAYING ORGANS. Charles Warren, Guelph, Canada, assignor to the Bell Organ and Piano Company, Limited, Guelph, Ontario, Canada. Filed Oct. 11, 1901. Serial No. 78,324.

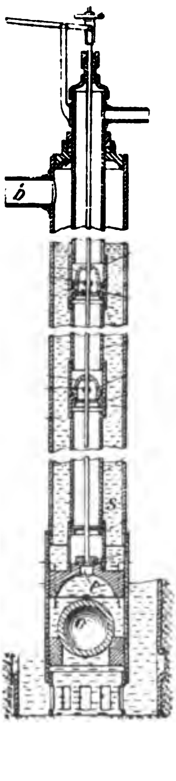
In a pneumatic organ, the combination with the motor and spindle thereof and the music-sheet and driving-drum therefor, and gear-wheel on the spindle of the driving-drum, of the supplemental spindle provided with a gear-pinion at one end meshing with the gear-wheel on the driving-drum, a sleeve secured on the opposite end provided with longitudinal slots extending lengthwise over the end of the motor-spindle, and a pin extending through the motor-spindle and the slots whereby the supplemental spindle may be moved longitudinally to throw the pinion in and out of gear without disturbing the operative relation between the two spindles, as specified.

716,693. PNEUMATIC INNER TUBE FOR TIRES. Charles E. A. Esse, Ormskirk, England, assignor of one-half to James Hamilton Cobley, London England. Filed May 16, 1902. Serial No. 107,670.

716,783. PNEUMATICALLY-ACTUATED CAR DOOR. Albert W. Sullivan and William Renshaw, Chicago, Ill. Filed April 13, 1901. Serial No. 55,638.

In combination with a sliding door, means for actuating the same including an abutment on the door, a reciprocatory member, a collet carried by said member and adapted to contact with the abutment on the door, a guide supported by the framework of the door and engaging said collet, and means for shifting the reciprocatory member, substantially as described.

716,839. AIR OR STEAM OPERATED PUMP. Franklin Heil, Santa Ana, Cal. Filed Feb. 20, 1901. Serial No. 48,176.

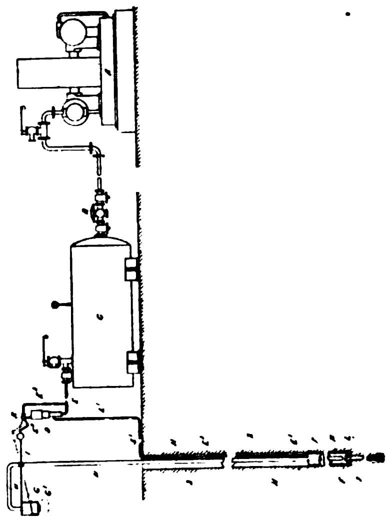


A pump comprising a lifting-pipe; a check-valve at the lower end thereof; an air or steam pipe furnished at its lower end with an outlet directly above the check-valve; a valve for said outlet; means for supplying air or steam under pressure to the air or steam pipe; and means for periodically operating the valve for the outlet of said air or steam pipe.

717,046. SOUNDING MECHANISM FOR TELEGRAPH-OFFICES. John C. Stewart, U. S. Army, assignor of one-half to Andrew S. Burt. U. S. Army. Filed March 18, 1902. Serial No. 98,807.

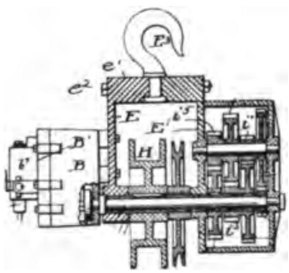
The combination with a relay-magnet and a sounder of a telegraph-station plant, of a pneumatically-operated motor mechanism for the sounder, a valve for controlling said pneumatically-operated motor mechanism and an armature for the relay-magnet supported directly by said valve; substantially as described.

717,048. APPARATUS FOR RAISING LIQUIDS SUCH AS OIL, FROM OIL-WELLS BY DIRECT AIR-PRESSURE. Robert Stirling, Baku, Russia. Filed July 10, 1902. Serial No. 115,096.



An apparatus for raising liquid from deep wells by air-pressure, the combination of a closed chamber located in the well and fitted with a non-return inlet-valve for the admission thereinto of the liquid to be raised, a pipe for discharging said liquid out of said chamber, an air-pipe connected to said chamber, a piston-valve having a smaller end piston normally exposed to the compressed air and an opposite larger end piston, a three-way valve opening communication between said larger piston and the atmosphere to permit said valve to be opened and a supply of compressed air to be conducted through said air pipe to said chamber to expel and raise the liquid therefrom and alternately opening communication between said larger piston and the compressed-air supply to move said valve to cut off the supply of compressed air to said chamber, and an automatic device exterior to said chamber and operated by the discharge therefrom for alternately opening and closing said three-way valve.

717,243. HOIST. Edward Y. Moore, Cleveland, Ohio, assignor, by mesne assignments, to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed May 15, 1901. Serial No. 60,322.



In a hoist, the combination of a pneumatic motor, a direct-acting elevating-drum, straight-line reduction-gearing connecting said drum to said motor, and a governing-valve for said motor adapted on one position to positively entrap the air in the engine whereby the air alone blocks the pistons and sustains the load on the straight-line reduction-gearing, substantially as described.

717,264. PNEUMATIC TIRE. Herbert R. Palmer, Cleveland, Ohio, assignor of one-half to Omar Stoppel, Cleveland, Ohio. Filed Oct. 11, 1902. Serial No. 126,862.

717,312. PNEUMATIC STACKER. Edward P. Alsted, Truesdell, Wis. Filed May 8, 1902. Serial No. 106,379.

717,465. PNEUMATIC STACKER. Albert A. Stelting, Madison, Wis. Filed Aug. 6, 1902. Serial No. 118,675.

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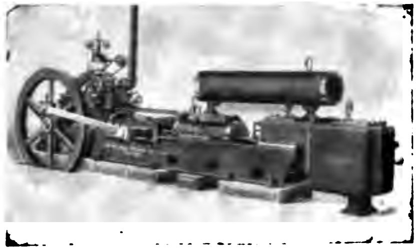

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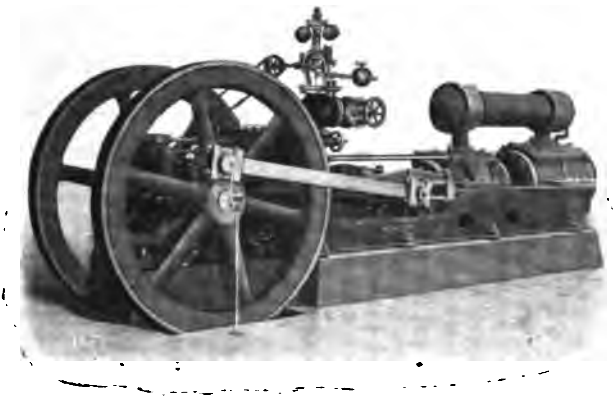

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Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, MARCH, 1903. No. 1.

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EDITED BY

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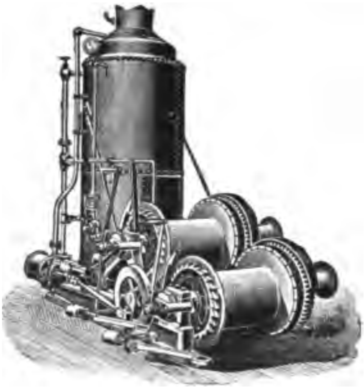

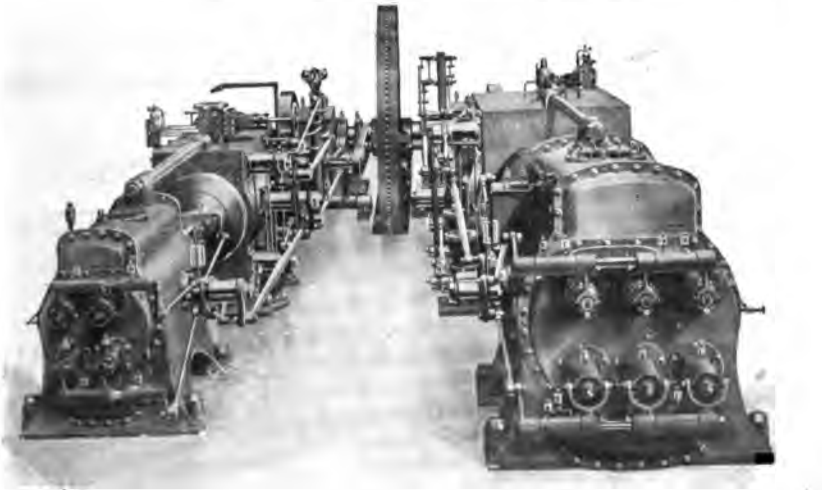

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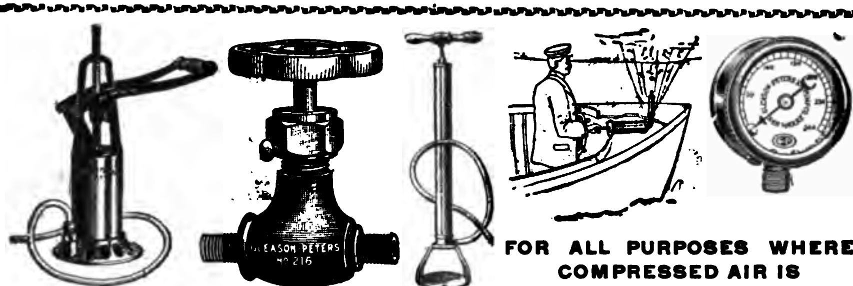

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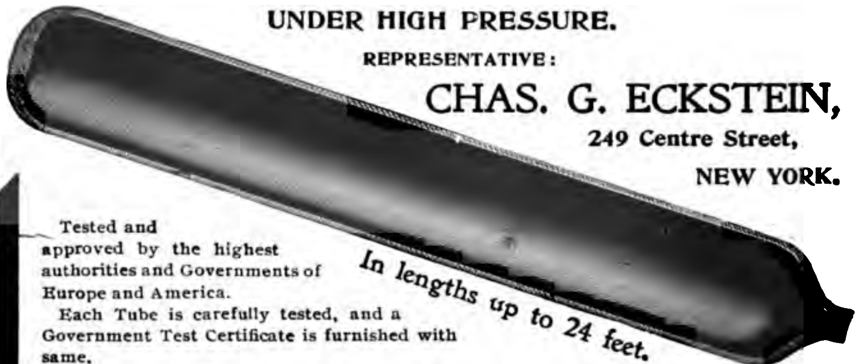

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VOL. VIII. MARCH, 1903. NO. 1

Another Year for Compressed Air.

With this number we begin the eighth volume of COMPRESSED AIR. Previous volumes are completed and speak for themselves and it is hoped to make the coming volume more complete and valuable than those already issued. Starting at a time when the possibilities of air under pressure were beginning to be appreciated, COMPRESSED AIR has endeavored to chronicle each step in advance.

Important as the general subject is, it does not warrant a large publication. For this reason COMPRESSED AIR has purposely refrained from an expansion which would mean the publication of a large amount of matter more or less foreign to the subject. It makes no attempt to occupy a position other than the mouthpiece of those manufacturing or using compressed air machinery in one manner or another.

Since its first issue an earnest effort has been made to report the discoveries and advances in the science of compressing and using air, and the practical application of this medium in the shop, factory and elsewhere. To do this it has been necessary to abstract material from other general technical journals, from papers read before Engineering Societies and from all sources where suitable material or anything likely to be of practical value or of especial interest could be obtained. To this has been added contributions from papers, discussions and correspondence from subscribers and others, the whole being supplemented by timely editorials purposely made brief and intended only to call attention to the salient features of more practical articles.

The first five years have recently been printed in one volume of about 1200 pages, entitled "Compressed Air Information," and this has enabled us to supply a complete file to many of the new subscribers, who in this way have had at hand for reference, practically all of the important contributions to the branch of science and engineering included under the term of compressed air.

For all articles from contemporary publications we have at the time of publication given credit, but we take this occasion to thank our friends among the technical journals for the courtesies extended to us. Throughout the ensuing year the same policy will be maintained and an effort will be made to collate everything bearing on the subject, that our subscribers may have a cyclopedia of compressed air information.

Power Transmission Using Belt and Rope.

BELT DRIVES.

From time immemorial belts have been the most common form of transmitting power from shaft to shaft. In spite of this fact, the principles of belt driving are but rarely thoroughly understood today. The transmitting power of any belt is dependent upon the following points:

1st—The number of feet per minute travel.

2d—The tension under which it is run.

3d—The number of degrees of contact which it has with both the driving and driven pulleys.

4th—The width and thickness of material used in its manufacture.

In addition to these points a number of varing conditions enter many drives that must be taken into account for the particular drive to be considered.

Possibly the most common error of engineers is their failure to appreciate the importance of speed or feet per minute travel of belts. By this statement I do not mean necessarily the high rotation of shafting; although slow speeds can often be profitably increased, I suggest a simple way of obtaining the same result, the speed of the shaft remaining the same. If we double the speed of a belt we double its transmitting power, or a belt of one-half the width will deliver the same power at the increased speeds.

The principle expense in belt driving is the belts themselves. If by simply increasing the diameter of the pulleys, the width of the belt and therefore its cost, can be halved, a considerable saving has been affected. The cost of the increased diameters of pulleys is partially offset by their reduced widths of face and the total saving made is large or small in accordance with the size of belt required.

It should be borne in mind that while increase in speed is advantageous, a point is eventually reached beyond which it is a dead loss to venture. Above 5,500 feet per minute centrifugal force increases to such an extent that it tends to throw the belt away from pulleys and it is not practical to place a sufficient strain on the belts to resist this force. Belts are often run at higher speeds than I have noted, but other considerations enter the case, and no increase of power results after exceeding the maximum figure named.

The usual running tensions in ordinary mill practice for first quality single, double and heavy double leather belts are 60, 80, and 100 pounds per running inch of width.

A few rules that experience has taught and with which every engineer should be thoroughly conversant follow:

Always place a tightener upon the slack side of the belt.

Run the slack side of the belt on top if possible.

Keep belts clean.

Treat with some approved dressing as often as required to keep soft and pliable.

Place grain side of belts next to pulleys.

Place idler pulleys on slack side of belts so far as practicable.

The smaller the pulley over which a belt runs the shorter its life; the constant sharp bending of the fibres wears it quickly.

Avoid single belts of great width. Doubling the thickness of belts does not double the power they transmit.

Do not run light double belts over pulleys less than 18 inches diameter, heavy double over less than 36 inches diameter, and triple over less than 60 inches diameter, if possible.

Make belts endless if practicable and provide means for taking up slack.

Avoid belt hooks; they are particularly hard on wood pulleys, as well as belts.

Never forget the loss from slippage by belts.

In accurately figuring speeds of pulleys belt slip should be considered. It amounts in general practice of from two to three per cent.

Belt drives with as nearly even diameters of pulleys as practicable give best results. Use wider double belts in preference to triple belts. A belt invariably climbs to high side of pulley.

ROPE DRIVES.

There are two systems of rope driving in use at the present time. One, having a separate rope for each groove in the drying and driven sheaves and known as the English system, and the other having one continuous rope for any number of grooves and known as the American system. A fair and just comparison of its merits with the English system, and belts, is interesting and of value to every engineer. Taking up the English system we find that each rope is separate and distinct from every other rope on the drive. Each rope requires its own splice. No two ropes can be spliced either in or out of the grooves under an equal tension. This may be verified by noting the different points to which the various ropes sag. Beside this primary tension due to splicing on tightly, and which amounts to nothing as soon as the ropes stretch, each and every rope is dependent for its tension upon the weight of the rope between the driving and driven sheaves. To partially overcome this difficulty a steeper and sharper angle for the sides of the grooves is adopted. The grooves are also made very deep in order that the ropes may not jump out. Owing to the uneven tension on all the ropes it is evident that a few of the tightest must do the work for which the whole number were first considered necessary. The few ropes are largely overloaded while the balance are not doing their share of the work. The overloaded driving ropes thereupon quickly stretch out and as soon as they do so the remaining ropes take their share of the load, but having stretched to practically no extent before, they now stretch to a great extent under the increased load imposed, and the load is thus shifted back onto the few originally light and overloaded ropes. As a consequence of this severe strain they soon wear out and new ropes must be spliced in place. The new ropes, of course, easily stretch, and the load must then be borne by the tightest of the old remaining ropes. Thus we see the same cycle of events continually recurring and the majority of the work being done by a few ropes alone. Owing to the unevenness and lack of tension a large number of ropes are needed for any given amount of power. This means heavier sheaves and heavier shafts, couplings and bearings for their support. These heavier shafts and sheaves mean increased friction upon the bearings, and, therefore, more power to overcome the friction load alone.

English rope transmissions are only successful for straight open drives. They do not permit of complicated turns and angles. They are not successful with small diameters of rope, and, therefore, large diameter sheaves must always be used.

As compared with this style of rope driving the American system has the following points of advantage. It has but one rope, and, therefore, one splice for any number of grooves within good engineering practice. The ends of the rope which stop on opposite sides of a sheave when a drive is completely wound, are brought together by means of a single groove tightener sheave set in an automatic take-up carriage. This tightener is set at an angle equal to the cross or distance between the two outer grooves of the driving and driven sheaves on any drive. By means of weights attached to the tension carriage the slack is automatically removed from the rope, and an even and known amount of tension is kept upon all the ropes at all times.

The carriage automatically adjusts itself to the amount of power to be transmitted at any given time, and as the amount of tension is controlled by the amount of weight used, it can at all times be adjusted to the requirements of the drive. Having a fixed, even, and known tension upon each wrap of rope the amount of power that one or more wraps will transmit can be readily determined.

As compared with belt drives the rope required is many times cheaper than belting and the sheaves cost somewhat more than pulleys. There is no slippage, however, and for cotton and woolen mills requiring a steady, even load and a uniform speed the American system is superior to belts. The friction load, as numerous tests have proven, is less with this rope method than with belting, and the amount of space required is only 60 per cent. of the width of belting required for an equal amount of power. Belts are under only such tension as the experience of the operator deems best to put on the tightener, if any tightener be fitted to the outfit, while the ropes are a tension at all times automatically adjusted.

The life of the average rope is about two and one-half to three and one-half years; under exceptionally favorable conditions it will last longer. Its small cost, however, makes it but a small item as compared with belts, and the amount of capital required for the purchase of rope is not tied up as in the case of the large first cost of the belt. A separate belt is usually required for each line of shaft to be driven. By means of the vertical and horizontal drop-off system a single rope will drive a number of shafts upon different floors or upon the same floor. The total space required by this method is extremely small and is many times less than that occupied by belts. In this connection it is usually cheaper then belts. For transmitting power to long distances the rope drive stands alone. It runs out of doors and by means of idler towers can be carried for long distances.

As compared with an electrical outfit the American system of rope transmission is at the present time far more economical. The use of motors is claimed to give a steadier and more even speed. This is not proved by experience. The rope drive has always shown that it will transmit power in an absolutely even and steady manner. This can easily be explained by the fact that the ropes absorb vibration and load variations, since they are not a rigid connection and the slip is inappreciable.

The cost of a rope drive and an electrical outfit, each to transmit the same amount of power, is about in the ratio of three to one in favor of the rope.

A rope drive is the easiest transmission known, upon an engine. Engine manufacturers who have tested the matter thoroughly admit this fact, and advise this form of connection. It is as easy to use a grooved fly-wheel as a band fly-wheel, and, as already noted, the space occupied by the grooved wheel is much less. The loss of power transmitted in simple belt drives amounts to from six to fifteen per cent. when the belts are under ordinary tension. When they are tightened excessively, the friction loss on bearings, etc., is much greater. The English system of rope transmission has the same friction losses as belting and is figured upon this basis. In the American system the loss is less than with either the English system or belts, and as nearly as can be estimated amounts to from three to eight per cent. in accordance with the design of the drive.

The average friction load of cotton and woolen mills varies between twenty-five and thirty-five per cent. Upon a basis of twenty-five per cent. this would be divided up as follows:

Six per cent. for the engine.

Eleven per cent. for shafting and main belts.

Eight per cent. for shifting belts, tight and loose pulleys and machine connections.

This is upon the basis that the mill is belt driven throughout. For an electrical outfit the percentage of loss is as follows: If engine loss is six per cent. in any case ninety-four per cent. of the indicated horse power remains for driving the generators. Under very best conditions the generator has an efficiency of ninety per cent., or 84.6 per cent. horse power of each one hundred indicated horse power would be delivered to the line wire, and, in addition, the friction for a direct connected engine would be greater than for a mill engine, owing to the increased weight on engine shaft; larger shaft and greater distance between bearings. Mill loss between generator and motor would be about two per cent. This gives us 83.9 per cent. indicated horse power delivered to motor. The motor loss would be so great if not more than generator loss. Upon this basis the motors deliver to line shafting 75.51 per cent. of the indicated horse power. In other words, in the substitution of motors and generators for belts or ropes and main head-shafts in a mill, we have a greater loss than occurs in ordinary cotton or woolen mill practice. We have still ignored the friction loss by shifting belts, line shafting, and other machine belts.

Taking our above figures we find that 62.51 per cent. of the indicated horse power is delivered to machines as compared with the 75 per cent. of the indicated horse power with belts or ropes. Losses in transformers, etc., have not been considered, but an appreciable loss occurs through their use. The cost of operation is also greater, as an electrician must be employed. The repairs on electrical apparatus are the most expensive of any class of machinery. If individual motors are used for each machine the above cost would be so great as to be totally impracticable. The above figures are based upon the use of an independent motor for each or every two line shafts and belting or direct connecting to these shafts.—F. H. Underwood, M. E., in *Power and Transmission*.

Graphite as an Air-Brake Lubricant.

Quite exhaustive experiments have been conducted at Purdue University, under the direction of Prof. Goss, to determine the effects of lubricants on the sensitiveness of triple valves. The experiments were conducted on an airbrake rack which embraces a full equipment for two trains of fifty cars each. All piping, valves, fixtures, etc., which would be used on an actual train of cars, has a place upon this rack. The rack was designed and is now maintained for the purpose of determining the action of triple valves used on freight cars which are interchanged from one road to another. Accessory to the rack is a chronograph, and all necessary gauges for determining the precise time of action of every brake.

The controlling mechanism of the air-brake system is the triple-valve, of which there is one for each car composing the train. It is the triple-valve which, responding to a reduction of pressure in the train-pipe, brought about by the engineer, permits air from the auxiliary reservoir to pass into the brake cylinder, thereby applying the brakes. It is the triple-valve, also, that responds to an increase of pressure in the train-pipe, and in so doing exhausts the brake cylinder and re-establishes connection between the auxiliary reservoir and the train line releasing the brakes. The mechanism of the triple valve is necessarily delicate and nicely adjusted. Its wearing parts are of brass, and as the pressure imposed upon its rubbing surface is light, it was thought that all conditions were favorable to the use of graphite alone as a lubricant.

A test of triples, showing well their responsiveness to changes in pressure, is one which has come to be known as the "skipping test." It is well known by those familiar with air-brake performance that the brakes upon certain cars of a train may be cut out of action without interfering with the action of the remaining brakes. If, however, too large a number of brakes are cut out, or if they are grouped too closely together, then it becomes impossible to secure an emergency application on those brakes which, counting from the engine, are beyond the cut-out group. For example, in the rack under consideration, it is found that when triple valves are lubricated with vaseline, it is always possible in a thirty-car train to cut out alternate groups of two throughout the length of the train, without interfering with the emergency action in those brakes which are left in service. When the valves are in good condition, and if the three following the engine are left in service, it is possible to cut out alternate groups of three; the exact number of cut-outs in any train always depending on their grouping. It is by means of this delicate test that it was proposed to test the value of graphite.

The process of conducting the experiments under consideration consists in cutting out brakes in certain well-defined groups, and in making application; after which an additional brake or two will be cut out, the application repeated, and so on until a limit is found for which an emergency application fails on the brakes in the rear of the train. In preparation for the test, all triple-valves in the rack were taken apart, wiped and thoroughly cleaned, lubricated with dry flake graphite, and restored to their places in the rack.

On starting the air pump in preparation for the test it was found impossible to secure a pressure on the train line of more than forty pounds. It was found also that there was a constant blow of air from the exhaust of every triple on the rack. This was thought to be due to the presence of graphite between the slide-valve of the triple and its seat, which would raise the valve a sufficient amount to cause the leakage to be observed. Believing that a few movements of the slide-valve would bring it to its seat and thus stop the leak, repeated emergency applications were made. On first trial only the one brake nearest the engine went into quick action, but after repeated trials all ten brakes involving a ten-car train were made to work successfully. After this, other brakes were added by twos until an emergency could be had on a thirty-car train, and after six applications were effected by exhausting the train line from the valve of the fiftieth car at the rear of the train, a full fifty-car train would respond in an emergency application. This preliminary work involved fifty or sixty applications for those brakes which were near the forward end of the train, and not less than fifteen for those triples which were subjected to the fewest number of applications.

The valves having in this manner been made tight, the formal skipping test was undertaken, first on a fifty-car train, next upon a thirty-car train. Alternate twos could be cut out either with the first two in or out, but in the thirty-car train, action could not be depended upon if the first two were cut out. With alternate threes cut out, the first three being in, the emergency was obtained upon the sixth car of the fifty-car train, but no emergency could be obtained on the thirty-car train.

The attempt to cut out alternate fours, the first four being in, gave emergency on the first four only, both in the fifty and thirty-car train.

Repeated experiments served to show that two consecutive brakes could be skipped with certainty at any place upon the train, both when fifty cars and thirty cars composed the train. Three cars could be skipped in the middle of fifty; two in the middle of thirty and one in the middle of a fifteen-car train.

The time record, as obtained for each test, shows the valves to have been slower in action with graphite than under normal conditions. For example, the time lapse between the application of the brake on the first car and that of the last car of the fifty-car train was three and one-half seconds longer when graphite was employed than under the usual conditions with vaseline, the facts in this record being as follows:

	Graphite.	Vaseline.
Seconds between time of action on first car and time of action on the last car of twenty-five car train	13.5	12
Seconds between time of action on first car and time of action on the last car of fifty-car train..	28.5	25

Upon the conclusion of the tests with graphite, as described in the preceding paragraph, the triples were again taken apart. In this process it was discovered that the slide-valve of some of the triples was so firmly held to its seat that it could only be moved by the use of a lever of considerable length. The usual freedom of motion which characterizes several parts of the triple had in many cases quite disappeared. No evidence of damage appeared in any valve, and no surplus graphite was found. Having been thus taken down, the several parts of the triples were well vaselined and, having been re-assembled, the triples were restored to their position on the rack. Following the restoration of the triples, the schedule of tests previously run was in part repeated, whereupon it was found that the action of the triples was more delicate than has ever been shown to be before. The record shows that they were more responsive to skipping tests and the time of action was shorter than in any previous tests made upon them. The important conclusions of the test may be stated as follows:

1. Graphite alone is not a sufficient lubricant for triple valves.

2. After graphite has been well rubbed into the working surfaces of the valves, and after this process has been followed by thorough oiling with vaseline, the action of the triple valves is more delicate and more rapid than with vaseline alone, prior to the use of graphite.

3. The presence of the graphite on the metal surfaces of the valves, when operated with vaseline as a normal lubricant, serves to improve their action in a marked degree.—*Graphite.*

Rand Deep Level Temperatures.

When discussing the increased cost which deep level mining involves, the liability of encountering temperatures detrimental to economical working is one of the fair factors which demand consideration. It is, of course, included in the more general problem of the amount of ventilation required; but, on the other hand, if it be known definitely wnat temperature would be encountered at a given depth one more factor of uncertaintv is eliminated, and the amount of air necessary for the ventilation, apart from the refrigeration of the mines, would alone remain to be determined. It seems the more desirable to determine this question, owing to the wide varieties of opinion which have from time to time been expressed as to the range of geothermal gradient in different parts of the world and the failure to substantiate exceptional results in the face of accurate investigation. Temperatures are, of course, investigated under conditions which differ widely, both as regards the practicability of close observation and the experience of the observer. Naturally, the data taken from boreholes is more reliable than what is obtained in shafts—observations which can hardly be of more than relative value, depending greatly on the amount of ventilation, machinery, exhaust from condensers, explosives, lights, the temperature of the air delivered into the mine, and many other conclusions which render observations conducted in shafts practically valueless for anything like general and exact conclusions. In the case of bores, on the other hand, the smallness of the aperture renders the thermal disturbance from above improbable, and the possibility of plugging the bore itself makes it possible to isolate each temperature level from the influence of those above and below it. Again, in the case of boreholes, not only have we the possibility of accurate observations at great depth by means of an overflow thermometer, but also the fact that such observations have been actually made at depths practically double those reached in any mine. In any general estimate of temperature, therefore, for future workings such as is now necessary in the case of the Rand, it would be well not to rely on shaft observations. What, then, may be taken as the ordinary increment of temperature with increasing depth? Professor J. D. Everett, Chairman of the Standing Committee appointed to investigate the rate of increase of underground temperature, in a lecture delivered some two years ago, states that "the gradients of temperature vary between 1° F. in 40 ft. and 1° F. in 80 ft., the best average being about 1° F. in 60 ft. Gradients steeper than 1° in 40 ft., or less steep than 1° in 80 ft. are sometimes met with, but are very rare." The three deepest as well as the most carefully conducted series of experiments to determine temperature were made at the boreholes, at Paruschowitz, in 1893, when an observation was obtained at a depth of 6,427 feet, at Schladebach, where a depth of 5,630 ft. was observed, and at Sperenberg, where the depth observed was 4,172 ft. The gradient observed in these three cases, when the surface temperature had been corrected, was: At Paruschowitz 1° F. in 58.3 ft., at Schladebach 1° F. in 65 ft.; while in the third instance the gradient is variously given as identical with that of Schladebach and as 1° F. in 51½ ft. Other well-known bores which may be mentioned are an oil well of 4,800 ft. at Wheeling, in Virginia, which gave 1° F. in 74 ft.; a well of 2,733 ft. in Sydney harbour, 1° F. in 80 ft.; and the Rand Victoria borehole, 1° F. in 82 ft. In Victoria, according to Mr. Jenkins, late Government Metallurgist, the rate of increase is 1° F. in 80 ft. Though these observations extend over localities widely separated as well as geologically distinct, their general agreement makes it difficult to accept without reserve the highly favorable estimates which have been put forward for deep level working on the Rand, especially since the highly exceptional figures at one time advanced for the Calumet and Hecla, the deepest mine in the world, have been withdrawn in favor of a figure more or less in consonance with the foregoing results. The most recent instance of such an estimate was that put forward by Mr. Leggett, in the discussion of the paper of which he and Dr. Hatch were the joint authors, and which was recently reported in these columns ("M. J.," 1902, p. 1581). Mr. Leggett there spoke as if the rate of increment had been definitely observed at 1° F. in 206 ft., and it may be that opportunity has been taken of some of the recent deep bores to make observations of which this is the result. But if this is the case, the results will certainly come as a surprise to scientific observers in this department, and it is remarkable that no authority was given for the statement. The opportunities which present activity in boring presents should not be lost. Some doubt has been thrown on the exactness of the Rand Victoria results, but if they are inaccurate this emphasizes the necessity for obtaining reliable data, and in any case confirmation of single observations is always desirable. Until such observations are obtained, however, the conservative will prefer to accept the results arrived at by Mr. Hamilton Smith at the Rand Victoria borehole, which, allowing for the higher surface temperature of the Transvaal, assumed to be about 70° F. compared with that in Germany, gave results not incommensurate with these more extensive experiments. The difference in working conditions involved by the estimates of the two authorities at 5,000 ft. would be something like 130° F. as compared with 94° F. Of course, it is not suggested that the higher figure would prove in any way insurmountable, but it would undoubtedly sensibly affect the question of expense. If the best results are to be obtained from miners, that is to say, if highly paid labor is to be economized as much as possible, the temperature should be kept down at least to 80°, and that means that the allowance necessary for ventilation alone must be greatly increased if the higher rather than the lower estimated temperature should prove correct. Now the amount of ventilation requisite will determine the size of the shafts which have to be sunk, and it would be interesting to know to what extent provision has been made to meet this unknown quantity of possibly high temperature, the existence of which Mr. Jennings has so definitely pointed out. There can be little doubt that at the present time the ventilation of many of the Transvaal mines is, judged by English standards, defective, and in the recently issued report of the Transvaal Mines Department it is pointed out that the miners are dependent for their supply of fresh air required by the mining regulations on the exhaust from rock drills, and that "in many cases no precautions are taken to insure that pure air shall be supplied to the drills. On the contrary, many of the cylinders of the compressors are lubricated with oils of low flash point, which, under the combined influence of heat and pressure, take fire. The result is that the products of this combustion are forced into the mine, and thus, instead of the ventilation being increased, it becomes impossible for the miner to work his drill in a confined place, owing to the suffocating gases emitted." The lamentable amount of disease prevalent among the miners, both black and white, comprising phthisis, pneumonia, enteric, dysentery, scurvy, and recently leprosy, are proof that a disregard of the laws of health cannot be persisted in with impunity; and with labor comparatively scarce, as it now is, this fact will have to be recognized. De Beers mines, with some 12,000 employes, have apparently not experienced the same difficulty as the Transvaal in maintaining a full complement, which looks as if native labor would be forthcoming if conditions were sufficiently attractive. To quote the words of the manager of the Crown Deep with reference to the general comfort of the boys, "If bread was given with coffee in the morning and more money spent in housing, feeding and clothing the boys, I think it would prove the most sensible way of settling the native wage question." Unless every forethought is exercised in making the conditions of employment as tolerable and healthy in deep level mines as in outcrops, it appears likely that new propositions will always have the call of labor, while the great deep level propositions will be continually in want.—*Mining Journal,* London.

The Production of Low Temperatures.

It was not very long ago when the experiment of freezing mercury, as performed in physical laboratories, was considered quite remarkable. To-day, however, it is not so looked upon; and the physicists have shown us that by the judicious use of liquefied gases extremely low temperatures in the neighborhood of 200 deg. Centigrade (392 deg. Fahrenheit) below zero can be obtained without very much trouble.

If, however, theoretically, no man of science ignores the fact that such extreme intensity of cold can be produced, many, on the other hand, practically, find it materially impossible to produce them.

Contrary to what one would suppose, nevertheless, it is not extremely difficult to obtain very low temperatures with apparatus easy to procure.

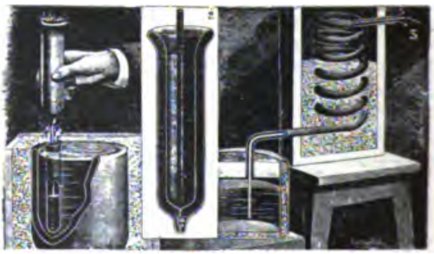


FIG. 1—1. FREEZING GASOLINE BY LIQUID AIR.
2.—TUBE OF LIQUID AIR.
3.—APPARATUS FOR VOLATILIZING CARBONIC ACID DISSOLVED IN ACETONE.

As Prof. d'Arsonval demonstrated recently at the Academy of Sciences, with certain judicious precautions, one can easily produce temperatures between —60 deg. C. and —195 deg. C. (—140 deg. F. and —383 deg. F.).

Thus, if some chloride of methyl be placed in a porous receptacle, by its simple and natural evaporation through the sides of the vessel, the temperature will reach 60 deg. C. below zero. With carbonic acid or acetylene, it is easy to obtain temperatures ranging from —112 deg. C. to —115 deg. C. (—233.6 deg. F. to 239 deg. F.) To do this, acetone which has been previously cooled is made to absorb carbonic acid or acetylene snow, either of which may be easily obtained at ordinary temperatures and varying pressures by opening a cylinder containing liquid carbonic acid or acetylene. The cold produced by the sudden evaporation of a part of the liquid mass, lowers the temperature sufficiently to transform the rest of this mass into a snow which, left to itself, then slowly melts. The snow is caught in a napkin, rolled up in the shape of a cone, into which the jet of carbonic acid or acetylene is directed from the cylinder containing the liquefied gas. This snow, especially that derived from acetylene, is very soluble in acetone. At—80 deg. C. (—176 deg. F.) acetone will dissolve more than 2,500 times its volume of acetylene. The snow, in dissolving, will lower the temperature 20 deg. C. further, and, if the acetone has been sufficiently cooled beforehand, this will bring the final temperature down to —115 deg. C.

The method pursued by M. d'Arsonval for obtaining by this process the lowering of the temperature to —115 deg. C. is as simple as it is ingenious. It consists in hastening the evaporation of the carbonic acid or acetylène snow, by a suitably cooled current of air. For this purpose, he makes use of a double coil of tin pipe obtained by inserting in a piece of pipe 10 millimeters in diameter and 10 meters long another pipe of the same length, but only half the diameter, and then rolling the two into a spiral, after which they are packed in a wood box stuffed with wool to prevent exterior radiation.

The upper end of the small pipe is connected to a blower and the lower end is introduced into the bottom of the solution of snow-acetone, while the upper end of the large pipe opens into the air and the lower end passes in through the stopper of the vessel containing the solution. The air that is blown in through the small pipe passes through the volatile liquid and produces very rapid evaporation—evaporation which is accompanied, naturally, by an enormous absorption of heat. As a result of this, the gases that are disengaged are at a very low temperature. But these cold gases must make their exit through the large pipe which incloses the small, thin, tin one through which the air was drawn in. Therefore the entering air is cooled economically by the gases of evaporation before it reaches the mixture of snow-acetone.

For temperatures still lower than 115 deg. C. below the melting point of ice, recourse must be had to liquid air, which can now be easily produced by the Linde process. The following is the method pursued in obtaining these intense degrees of cold that it is possible, moreover, to maintain perfectly constant.

The liquid air is placed, in order to avoid its rapid loss by evaporation when exposed to the air, in a closed vessel that is as impermeable as possible to heat—a vessel consisting, as is generally known, of a double casing of silvered glass in a wool lined box.

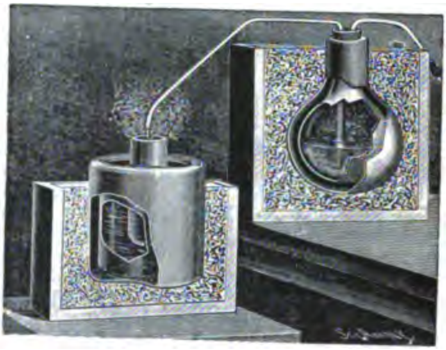


FIG. 2—ANOTHER METHOD OF FREEZING GASOLINE BY LIQUID AIR.

In another silvered, double walled vessel, likewise packed in a box in wool, some gasolene is placed. This liquid, if it has been made in the usual way, is capable of resisting without congealing a temperature as low as —194 deg. C. (—317.2 deg. F.), which is that of ebullition of liquid air under the normal pressure. Into this bath of ether, which constitutes the medium to be cooled and to be maintained at a constant temperature, a sort of test tube of thin copper is introduced. If the experimenter then forces the liquid air through this tube and causes it to fall drop by drop into the vessel surrounding it, by the evaporation of this air he will obtain a cooling of the gasoline which may be maintained constant if the flow of liquid air is suitably regulated. For this, M. d'Arsonval uses two different arrangements which are equally simple. The first consists in employing as a reservoir for the liquid air a double walled flask closed by a cork through which two tubes pass. One of them goes to the bottom of the flask, so that its end is below the surface of the liquid air. The other, which merely passes through the stopper, terminates in a rubber bulb. By squeezing the bulb, and thus exerting a pressure on the volatile liquid air in the flask, the latter is forced in small quantities through the outlet tube which leads to the small metal cup inside of the vessel contaning gasoline. The apparatus is nothing more or less than an application of the pipette of the chemist.

The other arrangement, which is perhaps even more commodious, consists of a double walled glass tube terminating at the bottom in a small pipe, the flow of liquid air through which can be regulated by a vertical glass needle.

By following the above described methods of M. d'Arsonval, great intensities of cold can be obtained without using an excessive amount of liquid air. "With cylindrical silvered vessels of about a liter in capacity," says the illustrious physicist, "the loss of heat by exterior radiation at —194 deg. C. can be reduced to 20 grammes of liquid air per hour—a very small quantity, as will readily be seen, and one that will make the employment of liquid air quite practical." —Translated for the *Scientific American* from *La Nature*.

A Small Hydraulic Installation.

For some processes of manufacture, nothing is superior to hydraulic transmission, but the cost of installing it deters many from using it who should do so.

Where I am employed they put in a hydraulic press operated by a direct-acting steam pump which pumped the operating fluid directly into the press cylinder without an accumulator. Of course, in time it became necessary to put in additional presses, and as the direct-acting method of operating had not been fully satisfactory, it was decided to put in a complete hydraulic system with an accumulator. The cost of a pump of suitable capacity was moderate, but an accumulator of sufficient size, of the weighted type, with its safety valves, etc., was expensive and objectionable on account of the space required and the expense of keeping it in good operating order.

The steam-hydraulic accumulator was duly considered, but it also was expensive, and seemingly costly to operate on account of loss by condensation and wear of packings. The variety of work done on the presses was such that it was desirable to use pressures from 500 to 2,000 pounds per square inch at will, and if the system would permit of easy adjustment to the pressure needed there would be considerable economy in operation. One very favorable feature was that a 10 per cent. variation in pressure from the desired point was permissible.

All this pointed to an air accumulator as being the ideal thing for the conditions, but I was unable to learn of any precedent of use with such heavy pressure as 2,000 pounds. Yet there seemed to be no particular reason why it would not work successfully.

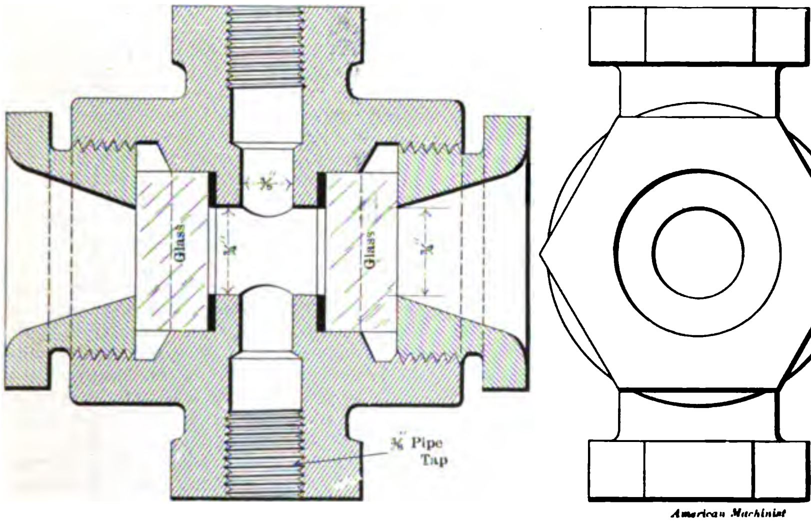
For the accumulator a steel bottle 14 inches diameter and 7 feet long was ordered, but for some reason the firm who took the order, after a long delay, offered as a substitute a bottle 9 inches diameter, 10 feet long. As one of this size was too small, it was necessary to get two of them. They were set vertically, close together and connected top and bottom so that they acted as a single one.

In this kind of accumulator, it is necessary to have some means of showing how much, or at least when there is enough water in it; for if the water is all drawn out and air escapes into the presses, it is a permanent loss of pressure which requires special means of restoration. Of course, a sight gauge was the thing wanted, but a sight gauge that will stand 2,000 pounds per square inch is not a common article. Various substitutes, magnetic and mechanical indicators, were thought of, but none of them seemed practical or reliable, so it was decided to make peep sight gauges.

The accompanying drawing shows the construction of one of them. The sights are plate glass 11-16 inch thick and the metal is brass. It has frequently stood a pressure of 2,500 pounds per square inch without failure. One glass was broken, but that was not due to the working pressure, it being caused by improper setting of the glass in the gauge.

It is important to have both surfaces of the glass flat, smooth and parallel. It is also safer to have a tough paper ring between the screw gland and the glass, so that when screwing down tight it will prevent the metal from grinding on the glass. This packing ring under the glass is leather.

Two of these gauges were used, connected by ⅜ inch heavy pipe with the top and bottom of the accumulator, one being located in the pipe 4 feet below the top and the other 5 feet below that. When working the water is supposed to be kept between them and especially not allowed to get below the lower one. Just below the lower sight is the connection to a pressure gauge. At the top and bottom of the vertical gauge pipe angle stop valves are placed, the upper one having a chain wheel on it with the chain coming down to a



WATER SIGHT GAUGE FOR HYDRAULIC ACCUMULATOR.

convenient height so that the valve can be shut quickly should a gauge fail under pressure. The two bottles are connected at the bottom by 1½-inch pipe and to this the pump pipe and press pipes are connected.

A triplex single-acting belt-driven pump 1¼x5 inches was installed for operating the system. It was necessary to charge the accumulator with air pressure of 300 to 500 pounds when the water stood at the lower gauge. The tank from which the pump drew its supply of water was placed so that the fluid would flow into the pump by gravity. Into the suction pipe an air pipe was tapped having on it a throttle valve.

To pump air the air pipe was left open and the water suction pipe was throttled to allow enough water to go with the air to seal the valves. It was found that 300 pounds was the highest air pressure that could be obtained by this method. To get a higher pressure an air pump 3 inches diameter and 6 inches stroke, single-acting, was mounted and driven by a crank on the end of the pump shaft. This pump had a suction pipe to the tank and the air pipe was placed in it, and the discharge pipe was run into the suction pipe of the triplex, making a compound air pump. The mixture of air and water is pumped till the accumulator is filled to the upper gauge, when the water is drawn down to the lower gauge. This is repeated until there is enough air to produce the required pressure when at the lower gauge.

With the pump running 100 revolutions per minute, it takes 3½ to 4 hours to get up 500 pounds air pressure. It requires some experience to find how much water must be let in with the air to get up the pressure in the least time. In operation there is a gradual loss of air, probably partly from leakage and partly from absorption by the water, and this loss is supplied usually whenever the system is idle.

To get automatic control of the pump when in regular operation a belt-shifter was used, which was operated by a plunger actuated by the pressure in the system, which stopped the pump when the pressure got too high. The plunger was 3/8 inch diameter and was weighted with removable weights, which were changed to suit the pressure required.

This is not a satisfactory plan of control, and it is better to have the pump run continuously and control the pressure by having a switch valve in the pump discharge pipe, operated by the controller plunger, so that when the pressure reaches the maximum point it will lift the valve and allow the water to discharge back into the supply tank or the pump suction pipe. It is of course necessary to have a check valve between the switch valve and the accumulator, so that the pressure will not force water back through the switch valve.

More pumping capacity was soon required, and a duplex, direct-acting steam pump, 14—2x10 inches, was put in. To control this pump it was decided to put a throttle controller on the steam pipe to be actuated by pressure from the accumulator; but it was discovered, when corresponding with makers of pump regulators, that a Mason differential pressure regulator would give complete control, the pump itself serving as part of the controller. The standard Mason regulator was used and the screw adjustment of it proved to be sufficient to get any pressure from 500 to 2,500 pounds in the accumulator, and it is so sensitive that a fall of 20 to 30 pounds in the accumulator starts the pump. This pump will not pump air, and the air charging is still done with the triplex pump. It will be observed that the accumulator is in fact nothing but a large air chamber for the pump, provided with a means of charging it with air. It is very interesting to watch how promptly the steam pump responds to the demands of the presses, and where some variation in the working pressure is allowable this system is so good that it may be adopted with entire confidence in the results. In operation there has been found no need for safety valves on the pipe lines, as they are all comparatively short, and of course the accumulator does not need one, as the air pressure is perfectly elastic and without inertia.

I have spoken of water being used in the system, but a partly refined grade of petroleum is really used instead of water. This, however, is a possible source of danger, and it was with some doubt that I watched the first charging of the accumulator, because an air pressure of 2,000 pounds on top of oil, and at a sufficient temperature, would be a combination for producing a first-class gas explosion. However, the air pressure accumulated so slowly that the heat had time to radiate.

When the pressure is changed from 500 to 2,000 pounds it is done very quickly, but it does not increase the heat enough to seem near the danger point. In case of a fire there is no doubt that a very bad explosion would result as soon as the heat reached the right point, and where oil is used it would no doubt be best to have a valve on top of the accumulator, which would let off the air when the heat reached a given point; something like the automatic sprinklers used in buildings to put out incipient fires.

In hydraulic systems it is an advantage to keep the working fluid free from all matter large enough to lodge in the pump valves and cause trouble, and we tried to do this by putting a strainer on the suction pipe inside the tank, but this was frequently troublesome, on account of getting clogged so that the pump could not get its supply. To overcome this a special tank was made, of a rectangular shape and of a width one-half the length. Across this, in the middle, is a partition which reaches from the top to within an inch of the bottom.

About 1½ inches above the bottom, in one end, a brass cloth screen is located, which is easily removed, as it rests on angle-irons around the inside of the walls. All the discharge pipes from the presses project just through a cover on this end of the tank. The discharge from the pipe keeps the oil in rapid circulation above the screen and prevents it from clogging, and as it is easily removed for cleaning when required, it has proven a success.

The pump suction pipe is attached to the other half of the tank in the center of the bottom. The partition in the tank prevents air bubbles from getting into the suction half of the tank, as all the fluid has to pass down under the partition to get there, and this compels nearly all the air bubbles to be liberated in the first half.

This is important, because all the air which goes into the duplex pump collects in the valve chambers and produces irregular motion with pounding.

The weak point in this system now is the operating valves at the presses. A valve is needed which is easily operated, reliable and durable, but we have no such one yet.

With valves as satisfactory as the rest of the system is, there would be no cause for complaint, and if any of your readers know of such a valve, I would be pleased to see some account of it in your columns. —Mr. BELL CRANK, in *American Machinist.*

Air Testing in Tunnel Construction.*

The frequent resort to tunneling in modern engineering construction involves the necessity of furnishing by artificial means a pure, cool, and abundant supply of air for the men engaged in carring on the work. The fumes arising from the use of explosives, the possible presence of inflammable gases, and the exhalations of the workmen, all tend to vitiate the atmosphere of the tunnel headings. These conditions require that effective methods of ventilation shall be employed to insure the safety and health of the workmen. In nearly all underground excavations carbon dioxide, marsh gas, and sometimes hydrogen may be present in greater or less amounts. Sulphuretted hydrogen occures occasionally, and carbon monoxide may be present as the result of the combustion of inflammable gases and from the use of certain explosives. Some of these gases, such as marsh gas and hydrogen are dangerous because of their inflammable and explosive character when mixed with air; some are poisonous to inhale, such as carbon monoxide and sulphuretted hydrogen; and others like carbon dioxide and nitrogen cause asphyxiation. Excepting the combustion of inflammable gases, the exhalations of the workmen form the chief source of carbon dioxide, and ordinarily the ventilation of a tunnel has largely to do with the removal of the vitiated air thus produced.

* A paper presented by Joseph W. Ellms to the Laboratory Section, American Public Health Association, at the New Orleans meeting, December, 1902.

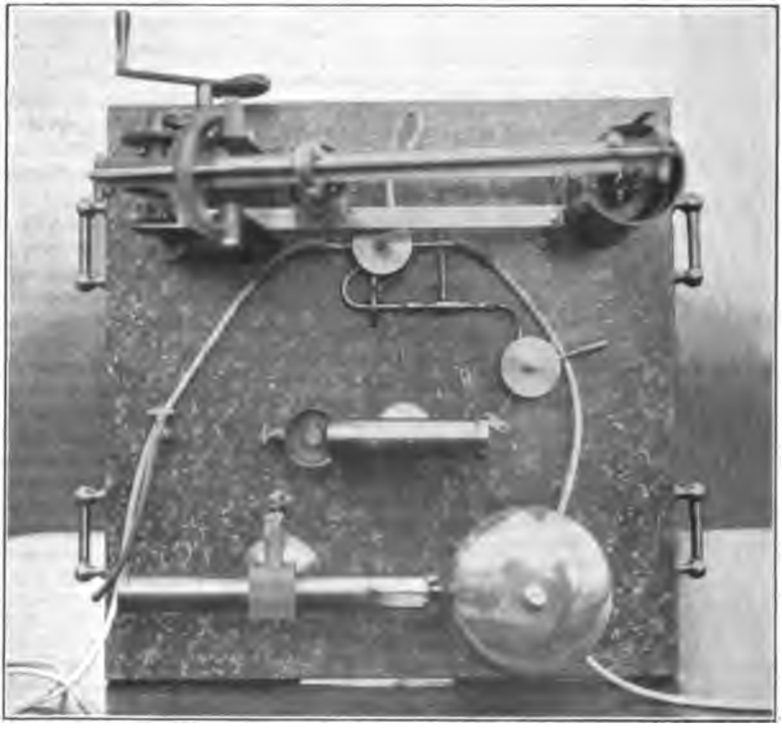
Ventilation is commonly effected by means of exhaust fans, blowers, and compressors; the latter also supplying air for operating drills at the face of the excavation and for other purposes.

A part of the new system of water works being built for Cincinnati, Ohio, is a tunnel 4 1-5 miles long, which is to convey the water from the reservoirs and filter plant to a distributing pumping station situated at the eastern end of the city. The tunnel lies about 120 feet below the surface of the ground, and has a diameter of 7 feet in the finished brickwork. The diameter of the excavation averages between 9½ and 10 feet. The portion of the tunnel thus far excavated passes through a limestone and shale formation. From the first more or less gas of an inflammable and explosive character was encountered and several explosions occurred. It was therefore decided by Mr. G. Bouscaren, the chief engineer of the Commissioners of Water Works, to test the air of the various headings daily in order to detect inflammable and explosive gases, and also to determine the efficiency of the ventilation of the headings. The writer has had charge of this testing.

It was apparent from the first that the ordinary methods of chemical gas analysis were not well suited to detect gases of an explosive character in the air of the tunnel with the rapidity that was necessary to make the tests of any immediate value. The use of miners' testing lamps of the Davy type by inspectors was considered unsafe and for certain reasons inadvisable. Our attention was called at this time to a mechanical device known as "Shaw's Gas Tester," which seemed to be able to give the necessary information, and which after some investigation was purchased. The machine is capable of detecting quite small quantities of gases of an inflammable character, although it is not able to differentiate between them as a chemical analysis would do. It determines quantitatively the amount of explosive gas present and is sensitive to differences as small as 0.1 to 0.2 per cent. With this device samples of air can be tested very rapidly and it has proven to be well adapted to the case in hand.

The machine consists of two cylinders fitted with air-tight pistons attached by rods to one side of a beam which oscillates on a pivot. The larger of the two cylinders is situated at the extreme end of the beam; the other cylinder is movable and can be placed close to the larger cylinder or next to the pivot on which the beam turns. The beam is moved by means of a winch, which actuates gears connected by a rod to the end of the beam opposite from that to which the piston rod of the larger cylinder is attached. From the lower ends of the cylinders tubes lead to a two-way valve, which is turned automatically by the movement of the beam. From this valve tubes, so arranged as to mix the air and the inflammable gas pumped respectively through the large and small cylinders, lead to an explosion gun. This gun consists of a long, narrow cylinder having at one end a movable head and at the other a cap provided with a small hole. A small tube projects from the side of this cylinder and connects with it through a small flap valve. The outer end of the projecting tube is immediately over the top of a Bunsen burner. Near the movable head of the gun is a gong, which is rung whenever an explosion in the gun is of sufficient force to drive out the movable head far enough to hit the gong.

A scale on the side of the beam, to which the piston rods of the cylinders are attached, is so graduated that when the piston rod of the movable cylinder is set to coincide with any division of the scale, the number corresponding represents the percentage by volume which the displacement produced by the piston of the small cylinder is of that produced by the piston of the large cylinder. As the position of the large cylinder is fixed and the movement of the piston always the same, the air which it pumps is a constant quantity. The piston of the



THE SHAW GAS TESTER.*

* We are indebted to the American Public Health Asso., for the illustrations.

movable cylinder, however, moves a longer or shorter distance, depending on its nearness to the large cylinder or to the pivot on which the beam is oscillating. It is evident, therefore, that by changing the position of the small cylinder varying proportions of any inflammable gas may be mixed with a constant volume of air, and may then be forced into the gun to determine whether the mixture is explosive or not.

The method of operating the machine is as follows: A 5-gallon rubber bag is filled with illuminating gas and attached to the tube leading to the movable cylinder. The piston rod of the cylinder is set at about nine on the scale on the beam. The Bunsen burner is lighted in front of the ignition hole of the gun. By turning the winch the beam is made to oscillate. On the up stroke of the beam the air from the room is drawn into the large cylinder, and illuminating gas into the small or movable cylinder. The two-way valve is automatically changed at the end of the up stroke so that the ports open to the tubes leading to the explosion gun. On the down stroke the air from the large cylinder and the illuminating gas from the small cylinder pass into the gun well mixed, and the mixture is gently forced through the gun. A portion of the mixture passes out the side tube of the gun over the top of the flame of the Bunsen burner and is ignited. At the end of the down stroke the ignited gas and the flame of the burner suck back into the main portion of the gun and ignite the mixture in the gun proper. If the mixture is of such proportions as to be explosive an explosion occurs, which drives out the movable head of the gun, causing it to strike the gong.

By gradually decreasing the percentage of illuminating gas added to the air, a mixture can be obtained of such proportions that the force of the explosion is not quite sufficient to cause the bell to be rung. Such a mixture is termed a "standard ringing mixture," and is determined for each set of tests made. It is obvious that, if now in place of the pure air of the room a sample of air containing gas of an inflammable character be pumped through the large cylinder, the gas contained in this air added to the known quantity of illuminating gas being used to form the "standard mixture," will cause a sufficient strong explosion to ring the bell. By further decreasing the percentage of illuminating gas a point is again found where the force of the explosion is insufficient to cause the bell to be rung. If, for example, it was found that a standard mixture of air and illuminating gas, in which the latter formed 8 per cent. of the whole, was barely sufficient to cause the bell to ring, and that when air containing inflammable gas was substituted for the pure air used in the "standard mixture," the force of the explosion was hardly great enough to cause the bell to ring with the addition of only 6 per cent. of illuminating gas, then it would be assumed that the difference between 8 and 6 or 2 was the percentage of inflammable gas present in the sample of air being tested.

The samples of air from the various headings are collected in four-gallon pear-shaped rubber bags, fitted with stopcocks. When empty their sides lie flat together. A small brass air-pump is used to inflate the bags when taking samples of air in the headings. The suction pipe of the pump can be placed at the roof, middle, or bottom of the excavation so as to obtain samples from these different positions. The sample is usually taken near the top of the excavation so as to obtain the inflammable gases, which because of their less specific gravity lie near the roof of the tunnel. These samples are brought to the laboratory daily to be tested for explosive gases and for carbon dioxide.

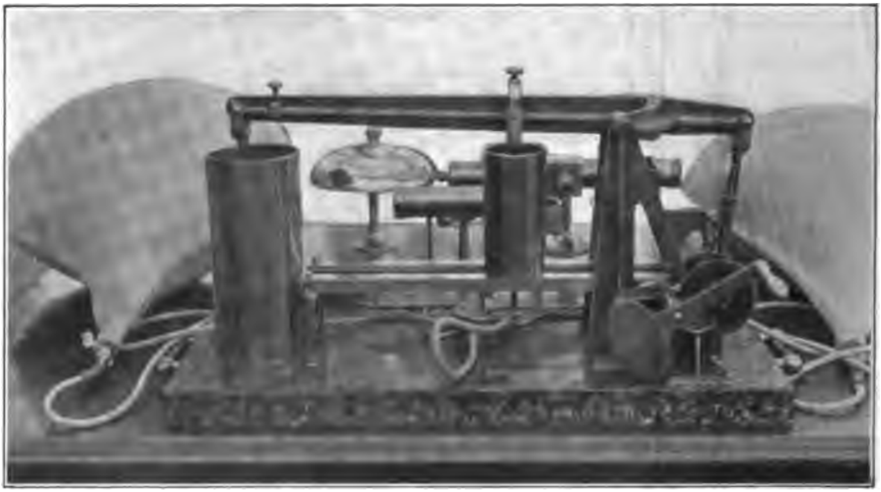
The testing for carbon dioxide is carried out by the usual method of absorption of the gas in a barium hydrate solution. The air from the sample bags is transferred to calibrated bottles of about one liter capacity. Ten cubic centimeters of a standard solution of barium hydrate are run into the bottle, which is then closed with a rubber stopper. The bottle is then shaken several times to permit the carbon dioxide in the air to be absorbed by the barium hydrate. After standing from five to ten minutes the excess of barium hydrate is titrated with a standard oxalic acid solution. Corrections are applied for temperature and barometric pressure, and the results are stated in parts per hundred for standard conditions of temperature and pressure.

The present method of ventilating the various tunnel headings is by means of air compressors, which supply air for operating drills and for other purposes. The air passes from the compressors to a receiver and thence is conveyed by a 4-inch pipe to the bottom of the working shafts, where the pipe is reduced to 3 inches. This 3-inch line is laid along the bottom of the tunnel to the face of the excavation. The exhaust from the drills forms the source of the fresh air supply when the latter are in operation. When the drills are not in use the air is permitted to escape at intervals along the line as well as from the end of the pipe.

The explosive gases thus far encountered have generally entered the excavation at points where the water was leaking into the heading in considerable quantity. It may occur in pockets and be liberated in the course of blasting; or it may permeate the rock in places and leak into the excavation because it is under a slight pressure. An approximate analysis was made of the gas bubbling up through the water in one of the headings. It was found to contain 31.0 per cent. of hydrogen, 45.7 per cent. of marsh gas (methane), 2.2 per cent. of carbon dioxide, beside oxygen and nitrogen. The two latter gases were very likely of atmospheric origin, although the oxygen was in excess. There were also some indications of other hydrocarbons being present beside methane. In general the gas is similar in composition to the natural gas found in the Ohio and Indiana fields. It owes its explosive properties to the marsh gas and hydrogen which it contains. The so-called "explosive limits" for mixtures of methane and air and hydrogen and air, as recently determined by Bunte and Eitner, are as follows:

	Lower limit. Per cent.	Upper limit. Per cent.
Marsh gas (methane)	6.1	12.8
Hydrogen	9.4	66.4

It will thus be seen that the mixtures containing between 6.1 per cent. and 12.8 per cent. of marsh gas, and 9.4 per cent. and 66.4 per cent. of hydrogen, will form explosive mixtures with air. Other investigators vary these limits somewhat, and all state that the manner of igniting the mixture affects the results obtained. Below the "lower limit" of explosion mixtures will not explode, and above the "upper limit" no explosions occur, but the mixture burns freely where it lies in immediate contact with a layer of air which will furnish the necessary oxygen to support combustion . The chief danger from the presence of these gases in any quantity lies in their rapid diffusion through the air with the consequent formation of mixtures of such proportions as will explode if accidentally ignited.



GAS TESTER, SHOWING BAG FOR COLLECTING SAMPLES.

It was found that the "lower limit" of explosion of as pure a sample of the gas as could be obtained from one of the tunnel headings, was about 7.0 per cent. The "upper limit" was not definitely ascertained, but it appeared to be less than 20.0 per cent. These figures refer to tests made with the Shaw gas tester and to conditions such as exist in using this machine. This should be borne in mind if comparisons are made with figures obtained in more exact experiments. Moreover, it must be remembered that the explosive gas occurring in the headings is a mixture of gases and that its composition is probably variable. In the course of the daily testing, samples of air containing as high as 67.0 per cent. of explosive gas has been found. Such samples could not be exploded directly, but burned freely when ignited. In order to obtain an explosive mixture in such cases dilution with air was necessary.

Traces of inflammable gas are not infrequently found. If present at all, however, it usually is in amounts of less than 1.0 per cent. The larger part of the time these gases are absent from the majority of the headings. But since it has been shown that inflammable gases are liable to be encountered at any time, the only safety lies in a continuous testing of the air in order to detect dangerous conditions immediately. About 1,800 tests for explosive gases and 1,700 tests for carbon dioxide have been made during the past year.—*The Engineering Record.*

Pneumatic Tools and their Uses.

THE NEW INDUSTRY AT FRASERBURGH.

The negotiations, which are proceeding in connection with the establishment at Fraserburgh of works for the manufacture of machine tools, now give so much promise of a successful issue that some account may be given of this important branch of engineering industry. Considerable surprise has been expressed at the proposed location of works of this character in the northest of Scotland, but it may be pointed out that in America the chief centres of the machine tool industry are not, as might be supposed, in Pennsylvania and Ohio, in close proximity to the great iron and coal regions of the United States, but in New England, hundreds of miles from what might be imagined to be the more favorably situated places. The Pratt and Whitney Company of Hartford, Connecticut; the Fitchburg Machine Works of Fitchburg, Massachusetts; the Becker-Brainard Milling Machine Company, Hyde Park, Massachusetts, and the Brown & Sharpe Manufacturing Company of Providence, Rhode Island, are a few instances in point. A person familiar with American industrial methods might point to many similar examples in other branches of manufacture. It is to be remembered also that the quantities of material to be handled in the machine tool business are not large proportionately to the amount of labor involved in their manufacture. Pneumatic tools are highly finished pieces of mechanism; at the same time they are comparatively small, and proximity to the raw material is not therefore of such importance as in shipbuilding or foundry work, where great masses of steel and iron have to be dealt with, though, as a matter of fact, the case of Messrs. Harland & Wolff, of Belfast, who have to import from England or Scotland every atom of metal they use, shows that even in shipbuilding juxtaposition to iron and coal is not a supreme factor. Nevertheless, should the consolidated Pneumatic Tool Company erect its British Works at Fraserburgh, the people of the northeast of Scotland will have good reason to congratulate themselves upon the advent of an industry which will be as valuable as it will be unexpected, and there will be the warmest appreciation of the enterprise of Mr. Maconochie, to whom, as is well understood, belongs the credit for pushing forward this scheme so full of possibilities for this part of the country.

The use of compressed air for the operation of tools is one of the more recent developments of engineering, and it is in America that it has made most progress. The Westinghouse air brake, with which we are familiar on our railways, may be said to have been the first practical application of pneumatic pressure. Now a complete compressed air installation is part of the equipment of many foundries and workshops, consisting of the central air compressor, the pipes and tubing, which convey the air to the various departments, and the actual pneumatic tools. In granite work, in which Aberdeen is particularly interested, pneumatic tools have become an essential feature of every well-furnished establishment, and their application to dressing, chiselling and carving has opened up new possibilities for this local industry. The earliest compressors were simply pumps such as are used in locomotives in connection with the Westinghouse and automatic brakes. They were of low efficiency, and they have now been replaced for stationary purposes by special air compressors, designed to meet the necessities of different establishments. Pneumatic appliances may be roughly divided into small portable tools such as hammers and drills and larger pieces of mechanism like hoists and cranes, which necessitate a greater expenditure of power. The work done by pneumatic tools is generally such as has previously been done by hand, and except in the case of hoists, it does not appear that compressed air can vie with electricity as a motive power for heavier machinery, such as planing and milling machines. But to work such as hammering, electricity cannot be applied. A current of either steam, water or air is necessary, and of these three air has the deciding advantages, that it can be easily conveyed in tubing, and that the exhaust gives no trouble. The experience of American workshops has shown that the increase of output of a workman and his pneumatic tool over that of a workman using the old hand tools is so much greater than the increased cost due to the added expense of maintaining and operating the pneumatic plant that the work is done at far less cost per unit. The saving in boiler rivetting, for instance, when done by pneumatic tools, is 66 per cent. in cost, and 50 per cent. in time. In other kinds of work it is even greater.

Of the numerous pneumatic tools now in use a few may be mentioned. The simplest perhaps is the hammer. It has a handle like that of a saw, and it is connected by a length of flexible rubber tubing with the fixed air mains. The head of the hammer is the piston, which is operated directly by the air current, and which in some designs strikes from 10.000 to 15,000 blows per minute. These high-speed hammers are used for chipping and caulking. For rivetting work, in which a heavier blow, is required, valve hammers delivering from 1500 to 2000 blows per minute are employed. In boiler-making and in the erection of bridges and steel work, machines of this kind are particularly applicable, and these pneumatic hammers have even been used by divers working on a sunken wreck. In the same category may be included the pneumatic sand rammers, which, according to an interesting article on compressed air and its uses in the current issue of "Cassier's Magazine," enter largely into foundry practice in America. These rammers vary from small hand ones to large pieces of apparatus swung from a crane, and their application has not been confined to foundries, but has been extended to the ramming of concrete in building work. Of almost as much importance as the pneumatic hammer is the pneumatic drill. Instead of taking a heavy piece of metal to a stationary drilling machine, the newer method is to take the pneumatic drill to the piece of work to be done. The rubber tubing can be bent in any direction, and a pneumatic drill can be set to work in out-of-the-way corners which it would be difficult to reach with stationary drills on hand ratchets. By the use of such drills, holes may be put in at a rate many times that possible by hand. Rock drills driven by compressed air are used extensively in mining and tunnelling. Other purposes for which pneumatic tools are now commonly employed are reaming and expanding boiler tubes, grinding steam joints and driving a special tool for the removal of flues from old boilers, an operation that was formerly very tedious and costly. Many pneumatic tools, like those employed in the granite trade, are provided with taper sockets, so that a variety of tools may be used, and to quote the writer in "Cassier's," "once installed, they constantly suggest new uses and prove their value from the start."

Pneumatic sand rammers for foundries have been mentioned. Other foundry devices are pneumatic sand sifters, sand blast tumble-barrels and pneumatic brushes for cleaning castings, and air blasts, something like a powerful water-hose, for cleaning the cores of castings. The buildings at the Chicago World's Fair were painted by pneumatic machines, which blow the paint on in the form of a spray. Compressed air has also been applied to the burning off of old paint; to the operation of small presses, where the work to be done is not sufficient to require great hydraulic presses; to cleaning machines for use in railway carriages, and to a variety of other purposes. Pneumatic hoists and pneumatic overhead trolleys, for conveying materials from one part of a work-shop to another, are in use. They are stated to have this advantage over electrical apparatus of the same kind that dust and grit cannot hurt them beyond increasing the frictional wear. It is evident that the field for pneumatic tools is a large one, and that the possible uses for these convenient and economical appliances have not by any means been exhausted. A notable instance of compressed air equipment is at the Baldwin Locomotive Works at Philadelphia, where there is a generating plant of ten compressors, and where over 100 pneumatic drills are employed, in addition to pneumatic rivetters, hammers, moulding machines, and so on. The Passaic Rolling Mills in New Jersey are similarly equipped, having 40 pneumatic hoists alone. Hitherto the demands of engineers on this side of the Atlantic have been mainly met by imported apparatus. Like other great American concerns, such as the Westinghouse and the Thomson-Houston electrical firms, the Pneumatic Tool Company is now going to commence manufacturing operations in this country, and, unless some unforeseen difficulty occurs, Fraserburgh will be the scene of its new enterprise.—*Aberdeen Press.*

Sinking a Shaft by Compressed Air.*

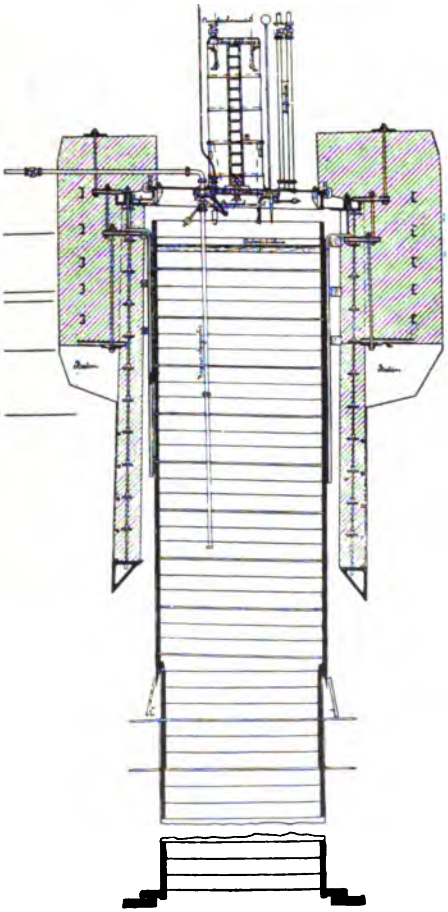
When the necessity arose of sinking a second shaft at the Recklinghausen I. Colliery last year, it was hoped, from the experience gained in adjacent properties, that no great difficulty would be encountered in passing through the known 45 to 50 feet of quicksand by means of a sinking shaft and wall. Work was therefore commenced with an iron sinking shoe to form a shaft measuring 20 ft. diameter when lined, but after traversing the first 30 ft. of quicksand—which, moreover, was very wet, probably through infiltration from the adjoining river Emscher—a number of fragments of rock impeded the advance of the shoe and tilted the sinking shaft out of the vertical. At the same time serious subsidences were discovered round the shaft, and as these extended close up to the air culvert of the neighboring shaft, the work was suspended and the sinking of a 16 ft. iron shaft within the lined sinking shaft was decided upon. While the iron shaft was being cast, eight guide rails were fastened in position inside the bricked shaft, to guide the former, leaving a play of just over an inch between the rails and the outer wall of the iron shaft; and a 4 in. flange was arranged on the inside of the sinking shoe, to facilitate the fitting of the lower tubbings to the sinking shaft.

The iron shaft was first mounted on a firm stage above the water level, and suspended from the aforesaid flange by twenty rods. By the time the seven rings of tubbing had been assembled, the cutting edge of the shoe had reached the level of the quicksand in the lined shaft; but as it was found impossible to get the shaft down beyond about 3 ft. further, eight 60-ton hydraulic presses were mounted between the upper tubbing and the pressure ring, and the effect of these presses was assisted by excavating at the shaft floor. Notwithstanding these measures, the influx of quicksand could not be kept back, nor could the shaft be forced lower than about 45 ft.; whilst the increasing subsidences round about the periphery necessitated continual filling up and levelling at the surface. At the same time the air culvert sustained some damage and the sinking shaft began to tilt owing to the fact that part of the cutting edge of the shoe was already resting on the underlying marl.

To overcome these difficulties it was resolved to resort to the use of compressed air, in preference to the alternative congelation process or the introduction of a smaller sinking shaft, the reason for this choice being that the adoption of the last method would too greatly reduce the diameter of the shaft, the congelation process would be too costly for the small distance to be traversed, and it was highly problematical whether the boreholes could be sunk perpendicularly, in view of the presence of stony fragments in the sand; finally, because the colliery was already provided with two powerful air compressors. The pressure ring was therefore surmounted by an air lock, consisting of an iron cover 0·4 in. thick and an old boiler attached to the cover by rivets, the dimensions of the boiler being 64 in. in diameter and 14¾ ft. high. Assuming the pressure required to be 2 atmospheres, the surface of this lock would have to

*Bergassessor Lüthgen. *Glückauf.*

stand a total pressure of nearly 400 tons, only a portion of which would be taken up by the sinking screws. The cover having been packed close, it was therefore topped with a number of double-T girders set close together, and these in turn were loaded with tubbings, curbs, &c., to a total



TUBE FOR SHAFT SINKING IN SOFT GROUND.

weight of about 350 tons. The cover was fastened to the pressure ring by means of 120 set screws, the joint being packed with nearly ½ in. of sheet lead, and ⅞ in. screw bolts were inserted in the holes previously serving for the reception of the anchor rods for the iron shaft. Flaps of 0·4 in. iron plate covered with 2 in. boards, and arranged to open downwards, were provided in the cover and bottom of the boiler, the joints being closed by leathern strips resting against wooden frames. These flaps weighed nearly 2 cwt. and were fitted with counterpoises to facilitate closing, and the upper halves of each were provided with split bushes of red brass for the passage of the skip cable. Five orifices were drilled through the cover, two of them for the passage of the compressed air pipes (3¼ in. diameter), one of similar size for the water discharge pipe, one for an electric signalling wire, and the fifth for a ⅝-in. gas-pipe to which were attached the two pressure gauges; the first three pipes were fitted with valves above bank, in order that they might be opened or closed at any time.

In order to produce the excess pressure in the airlock, a 3½-in. iron pipe was employed to connect the interior of the lock with the space below the shaft cover, the valve of which pipe could be controlled both from within the lock and from the working stage about 3 ft. below the shaft cover. Ordinary safety lamps were used for lighting, but were turned down lower than usual owing to the elongating effect of compressed air on the flame cone. To enable the sinking shaft to stand the high internal pressure, it was surrounded with a strong outer wall of masonry (about 3 ft. thick) down as far as the water level, where it rested on a concrete foundation. On testing the arrangement, it was found that an excess pressure of as little as 0·6 atmosphere caused the water to recede, the level sinking nearly 18 in. in the first half hour, without the valve in the discharge pipe being opened. At the same time the wall began to exude water, and to show a few cracks on one side, as well as sundry leaks around the shaft. Consequently, it was decided to strengthen the wall by a further thickness of three to four bricks and insert channel-iron rings, the weaker side being made four bricks thicker, and the rest three bricks; and in addition the wall was raised about 6 ft. above the pressure ring and fastened with anchor ties.

At the time of commencing work the shaft had sifted up with over 10 ft. of quicksand, surmounted by about 22 ft.

of water. On admitting air under a pressure of 0·6 atmosphere, the water was expelled through the discharge pipe, and at the end of eight hours the shaft was sufficiently drained for work to be commenced on the floor. On admitting the shift of eight men, who entered by means of two wooden ladders, the rope hole in the upper flap was closed by a wooden plug; and pressure was then turned on in the lock by gradually opening the air-pipe valve from the shaft, so that, the pressure becoming equalized, the lower flap could be opened and the working stage easily reached, whence access to the shaft floor could be gained by several flap doors. Owing to the comparatively rapid retirement of the water under the influence of the compressed air, the wet sand soon became dry enough to dig out into the skips, which were first raised into the air lock, and after closing the lower flaps and the equalizing valve, could be drawn through the upper flaps to bank, emptied, and returned in the reverse way. In twenty-four hours the sand was all excavated down to the level of the iron shoe, fifty-five skip loads, equal to thirty tub-loads, being raised in the six-hours shift. The iron shoe was found to be resting on the marl in one place, but, even after excavating under it for about 2 ft., the shaft could not be forced down any lower, and therefore a channel-iron ring, 18 ft. in outside diameter, was set in position at a depth of 2 ft. below the level of the marl, the intervening space between this ring and the shoe being then filled with a lining of 2 in. planks. After backing this wall tightly with hay, the air pressure was reduced and water run into the shaft through a main, the sinking being thereafter continued by ordinary means.

Altogether the compressed-air method was in use for about sixty hours The chief inconveniences experienced were from the considerably-increased temperature, and the noise of the incoming and outflowing air which made hearing difficult at the shaft floor. Although a pressure of as much as 1½ atmospheres were employed some of the time, none of the men were unfavorably affected, except two who had probably taken more alcoholic stimulants that was advisable; in fact, one of the officials remained for eleven hours in succession, of his own accord, at the bottom. On issuing from the shaft most of the men experienced a singing in the ears, accompanied by slight headache, and in two cases with bleeding at the nose. It is therefore considered advisable, in future cases, to shorten the shifts, lengthen the intervals of rest, and employ a larger staff of men.

After removing the air lock and draining the shaft, the hay stopping proved effectual in keeping back the quicksand, only a little water leaking through; so the shaft was deepened about 3 ft. through the marl, and a ring of tubbing was suspended from the inner flange by means of strong iron hooks, the deviation from the vertical being compensated by inserting boards of unequal thickness in the horizontal joint. Owing to the presence of the sinking shoe, it was impossible to lower the closing ring in one piece, and the latter had, therefore, to be made in two unequal segments, the smaller being fitted with a straight vertical flange. On deepening the shaft, to allow of the insertion of a second ring of tubbing, a slight subsidence of the sinking shaft occurred after three segments had been put in position, and—probably by crushing one of the boards behind the sinking shoe—opened a path for the quicksand to flow into the shaft again. To dam this back below the first ring of tubbing, oaken planks, 1½ in. thick, 40 in. long, and about 6 in. wide, were driven into the marl, the width being a little greater on the sides next the shaft wall. One end of these boards was fastened below the ring of tubbing, the other finding sufficient support against the marl. At the part where the ring rested on the three segments of the second ring, the boards were replaced by iron wedges, but this work was not begun until after the space between the sinking cylinder and the wall had been filled with concrete, to prevent the further descent of the sinking shaft, and to form a solid layer behind the shoe. The pressure of the column of water was reduced by drilling a hole through a segment in the lower part of the sinking shaft, which done, the inflowing sand, &c., was cleared out and the second ring of tubbing completed. After driving a second curb of planks below this ring, the space at the back was filled up with concrete. From this point onward to the more solid marl, at a depth of 88 ft., the sinking was continued in the ordinary manner, with provisional timbering, and then a double wedge curb was put in, no further difficulties being thereafter encountered in erecting the additional tubbings.—*Colliery Guardian*, London.

Some Records of Sand Pounding with Pneumatic Rammers.

With the exception of a few inches of sand next to the pattern, by far the greater volume of sand necessary for a large mold may be rammed up by anyone who has sufficient muscle to drive this together, so that it will withstand the pressure of the iron. In green sand molding that part of the ramming requiring skill and delicate touch is done in the six inches of sand immediately surrounding the pattern. When we enter the dry-sand branch of the trade the problem of ramming a mold properly disappears nearly altogether, because with the right kind of a sand mixture and proper drying of the mold it is almost impossible to lose a casting, no matter how careless the ramming has been done, so long as the mold is of sufficient density. That practically no skill is required in ramming up molds which are dried is shown by the fact that when molders, who have never worked on any other class of work, attempt to do green sand molding, they all without exception prove a failure at the start and have to learn a part of the trade over again.

RAMMING UP A COPE WITH PNEUMATIC RAMMERS.

The ramming of the larger class of

molds by pneumatic machines is growing in favor and there is no reason why this method should not steadily gain ground. In the first place, with the exception of green sand molding, there is nothing mechanical about pounding a lot of sand together, proof of which is given in the ramming up of many kinds of molds, from those for water and gas pipes to molds for cylinders, by common laborers. If pneumatic rammers will take away much of the hard work done in connection with ramming up molds, the molder ought to be thankful, for even under the best of circumstances he will do enough of a laborer's work. Just how effective a power rammer will be in green sand molding will, of course, depend upon the skill of the operator, yet, as stated before, there is nothing to prevent the greater part of the mold from being rammed up by this method. Certainly after the first course of sand has been rammed in a large cope, the balance may be pounded down good and hard, and if pneumatic power will do this in less time than it can be accomplished by hand, there can be but little use in offering objections.

The Philadelphia Pneumatic Tool Co., of Philadelphia, have for a long time devoted special attention to pneumatic tools for ramming sand, claiming the honor of having made the first hand power rammer and at the present being the only firm manufacturing a power foundry rammer. They say that founders in general are beginning to realize the value of the pneumatic rammer and that the molders, once they learn that these tools remove most of their hardest work, take kindly to their use. To show the advantages of these rammers the Philadelphia Pneumatic Tool Co. quote some of their performances, from which it is learned that at the plant of the Dodge Mfg. Co., Mishawaka, Ind., a split bevel gear of 5 ft. diamater, was rammed up complete by one man with a pneumatic rammer in six hours against 14 hours by the old method. The Buckeye Malleable Iron & Coupler Co., of Columbus, Ohio, have with a pneumatic rammer obtained 150 drawbars in 10 hours against 48 by hand ramming. At the foundry of the Atlas Engine Works, Indianapolis, Ind., copes and drags, 4 ft. 6 inches square and 8 inches deep, were rammed up in 5½ minutes each, while in the shop of the George H. Smith Steel Casting Co., Milwaukee, Wis., a cope, 8 feet square and 12 inches deep, was rammed up in 55 minutes. Other examples of the efficiency of the pneumatic rammer are mentioned by the Philadelphia Pneumatic Tool Co., the above being a fair average of these performances.—*The Foundry.*

A Novel Jib Crane.

In the new foundry of the Gruson Iron Works, at Eddystone, Pa., David Townsend, who is general manager of the plant and was the engineer in charge of its construction, has devised a series of jib cranes which prove interesting features. The cranes are built up of channels, angles and plates, and are so constructed that they revolve completely around an ordinary I-beam column, to which their bearings are fastened. The cranes are mounted on steel balls, so that even when loaded to their full capacity they can be revolved by hand with ease.

Each crane is of 3,000 pounds capacity, being provided with a Pedrick & Ayer pneumatic hoist, supported by trunnions resting on grooves in the top of the frame of a four-wheel trolley, which is moved by hand.

The general construction is shown in Fig. 1. The trolley, it will be observed, travels on the steel channels, which provide the horizontal beam or jib. These are 6-inch channels, 15 feet 7 inches long, and weigh 13 pounds per foot. They are located 20 inches apart, being connected at the forward end by two pieces of angle iron and riveted to a ¼-inch plate forming part of the frame or box surrounding the column. The supports to the jib are also of 6-inch channels. In addition to the end fastening, the channels forming the support and jib are connected by angle iron braces, as shown in Fig. 1.

The upright frame or box, which serves as a mast, is built of 2½x2½x¼ inch angles and ¼-inch plates. The top of this frame is 15 feet 9 inches above the floor. The bottom of it is elevated 18½ inches. The sides are 33½ inches wide. This frame is bolted around two halved cast iron plates, each having a circular opening in the center sufficiently large to revolve around the column. One of these plates is located at the bottom of the frame and the other is within 3 feet 7 inches of the top, or directly behind the jib. At

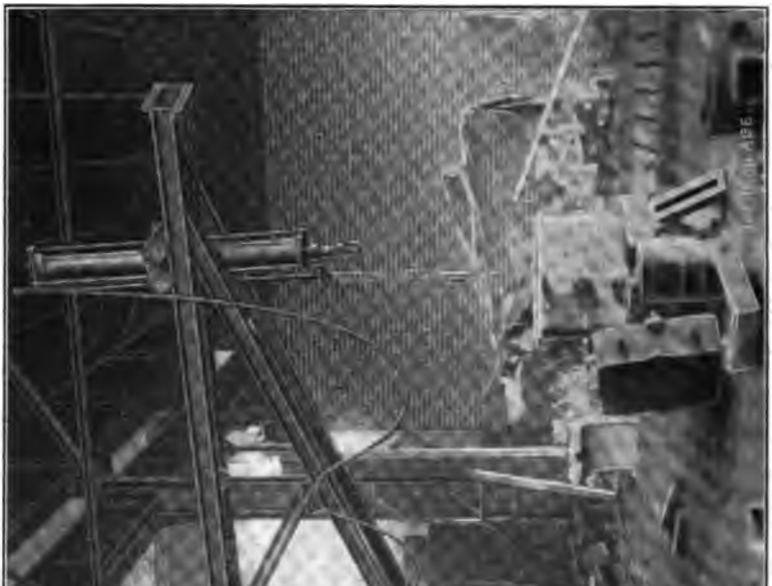


FIG. 1.—SHOWING GENERAL APPEARANCE OF CRANE.

suitable points on the column the bearings are fastened. These consist of divided cast iron circular plates, Fig. 3, bolted to the column. They are provided bolted to the column thus bear the weight of the crane and its load, and furnish a circular track, allowing the crane to perform a complete circle about the col-

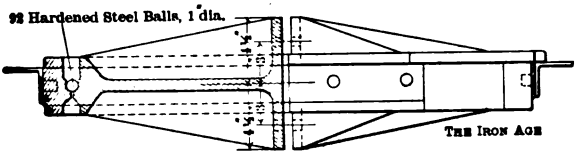


FIG. 2—SECTION OF UPPER BALL BEARING.

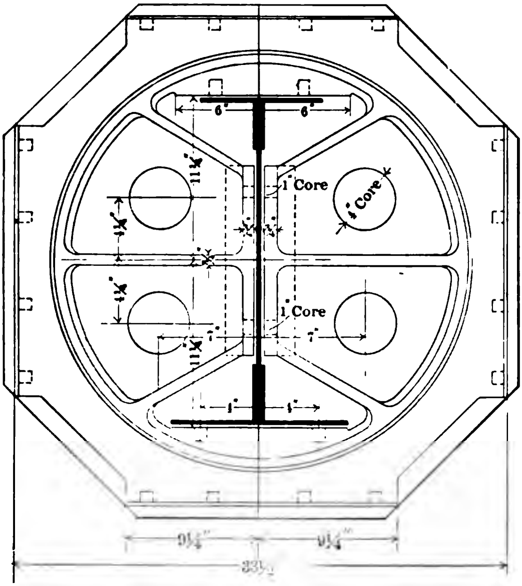


FIG. 3—PLAN OF BEARINGS.

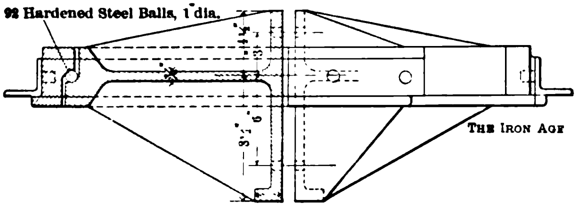


FIG. 4—SECTION OF LOWER BALL BEARINGS.

with grooves, Figs. 3 and 4, as are also the plates joined to the frame, making a runway for the steel balls. The segments umn. In attaching the crane to the column 1-inch holes are drilled through the latter in the positions to be occupied by the bearings. The segments are provided with 1-inch cores to correspond, and they are bolted to the column.

The crane being completely assembled, with the exception of the rear half of each of the grooved plates, the angle iron back of the frame is then placed in position, the balls being properly placed in their grooves. The assembling is then completed around the column.

As will be noted by the illustration, Fig. 1, the cranes can be used very advantageously in swinging materials from the bays to the central span of the building, and *vice versa*. One of them is conveniently located on a column near the core room, which is located in one of the bays. Heavy cores can be swung by this crane from the core room to the trucks of the core ovens without further handling.—*Iron Age.*

Oiling System for Power Plants.*

A good oiling system, that is, one that can be depended upon at all times—in fact, be more reliable than the ordinary oil cups and filters would be, and is a valuable addition to any power plant; the reason they are not in more constant use is their seeming unreliability as well as first cost.

The first thing to be considered in connection with a good oiling system is drainage pipes and tank. All oil should be trapped in the neatest manner possible —that is, at the closest point at which it leaves the bearing. I have found for side-crank engines where a circular shield is used for same, a complete housing between shield and crosshead, covering connecting rod, is a great saver of oil. It seems to look odd at first, but when considered in connection with engines that are completely housed up the looks improve somewhat.

It is also absolutely necessary to make tight joints at all places where oil is led off from engine bed, as any amount of oil, however small, that leaks by and has to be wiped up is clearly wasted. This is especially true of joints of shields on both sides of main bearing, which usually catches the oil from main bearing, crank and eccentrics. After considerable experience with different methods and ways of packing same, which is usually a difficult task, as they are hard to get at, I have found this a very good as well as inexpensive method.

Wipe thoroughly clean of oil and grease, then at point where shield and bed plate meet put on a coat of shellac by tieing a small brush or, what is just as good, a piece of cloth on end of stick, by which you will be able to get under and around crank disk; when this is partially set take ordinary friction tape and lap same over joint, over which add several coats of shellac. This is practically indestructible and will remain until joint is broken by removing shield.

I have seen quite a number of oiling systems, both of the gravity and air pressure or force pump styles, most of them were more or less unsatisfactory, the one kind due to the high pressures that are maintained, in which case it is necessary to flood the engine with oil, for if throttling down the sight feeds is tried it will soon be found that any small particles of foreign matter or even the viscosity of the oil itself will cause them to stop feeding, thereby causing constant attention.

The other, or gravity style, has some advantages over the pressure style, as the tank can be placed at a slight elevation so that sight feeds can be set nearer full opening, but even in this case the diffierence in pressure, due to the various heights of oil on tank, would be considerable, causing oil to drop very much slower when tank was nearly empty than it would when full. This will be more readily seen when it is noted that an ordinary oil cup two or three inches high feeds very much the faster when it is full.

The secret, then, of a successful oiling system lies in keeping the oil which supplies the sight feeds at a constant level regardless of whether the supply tank is full or nearly empty.

Now it will be seen that when tank is filled the oil will rise in the stand pipe a corresponding height, valve at top of tank now being closed; the oil in stand pipe will readily feed down to level of sight feeds or to a point where air will be let into bottom of tank, thereby causing oil to run out, and this point will be the constant oil level, which in my opinion, should not be more than six inches above the level of sight feed oilers.

*Paper read by P. E. Moock before the Ohio Society Electrical, Mechanical and Steam Engineers, Warren, Ohio, Feb. 14, 1903.

Referring again to the ordinary oil cup, it will be seen that not much fall is needed. The sight feeds should all be on the same level and once properly set need never be shut off, as a valve is placed in branch to each engine, so that all that is necessary when starting or stopping an engine is to open or shut this valve. I would recommend that oil cups be left on the important bearings, such as main bearing, crank and eccentrics. As before stated, they should all be on the same level. It will be seen that a common level will be maintained in all the cups at all times, no matter whether feed is on full or shut entirely off. Cups can be connected by bending one-fourth inch tubing as shown, drilling holes in bottom of cups and soldering same, thus connecting them in series. The supply pipe coming to center of bank cups and feeding both ways. At other places, such as outer bearings, crossheads and guides, sight feeds could be used, both methods being given. This may be arranged as individually desired. Each will work equally well, conditions being right, the cup arrangements having the advantage that if, from any cause, the oil supply from main tank was cut off the cups, being nearly full, would act as a reservoir, and as they would keep on feeding, thereby lowering the oil level, which would be quickly noticed by the attendent and the supply replenished by hand with oil can until the trouble was remedied. While the danger of this happening is very remote, yet it should be provided for, and in the case of sight feeds being used throughout a small auxilliary tank could be placed between shut-off valve and feeders. This need not be left on, it being necessary, of course, to have it fitted up so that it can be quickly applied. Main supply tank should be tapped several inches from bottom to allow for sediment, and also have a good screen over drain and supply pipes, thereby keeping out all foreign matter as well as helping to purify the oil.

The matter of oil filtration, however, is not of so great importance as some seem to think, for if an engine bearing is in proper shape and well taken care of there is no nicer, cleaner, smoother place to be found, and in passing through such a bearing oil will not be harmed. The way to get it nearest to its original color is to let it stand in a closed vessel for several weeks. Indeed, this is an ideal way of filtering oil and all that is necessary is a small oil house in which can be stored several hundred gallons of oil. I would recommend in this connection a small filter, principally for removing entrained water from the oil, and as the best results are obtained by slow filtration, this part of the system should be so arranged that the oil would be passing through the filter regularly drop by drop as it leaves the engine, drawing off the water at bottom and adding sufficient new oil to maintain a constant level.

I have not given near all details, as that would be tiresome, and, at any rate, there are a number of different ways of doing the same thing. However, I have given sufficient outline so that any one interested will have no trouble in working out same to their entire satisfaction.

This system is what I would term a home-grown one, such as any engineer during leisure hours could install, and it is inexpensive. The cost, other than labor and oil house, for a thousand horse power plant need not exceed sixty dollars, and in a plant of this size will save its cost in oil in six months.

Compressed Air Crane Hose Support.

We show herewith an extremely ingenious method of supporting the hose for supplying compressed air to traveling cranes. The method which has been used more than any other for this purpose consists of stringing the hose by ring hangers on a taut wire, the hose hanging in loops when the crane is at one end of its run-way and being straightened out under the opposite condition. This method involves the use of a hose of a length equal to the shop, and the fact that it lies in loops most of the time, while these loops always bend the hose at the same places, is undoubtedly detrimental to the life of the hose.

A hose of half the length of the shop, with a weighted carrying sheave, has been used in some cases, but the extent of rise and fall of the counterweight makes this plan undesirable. The present plan uses a hose of but half the length of the shop in combination with a carrying sheave, and by an extremely ingenious arrangement of sash cord the hose is kept in position

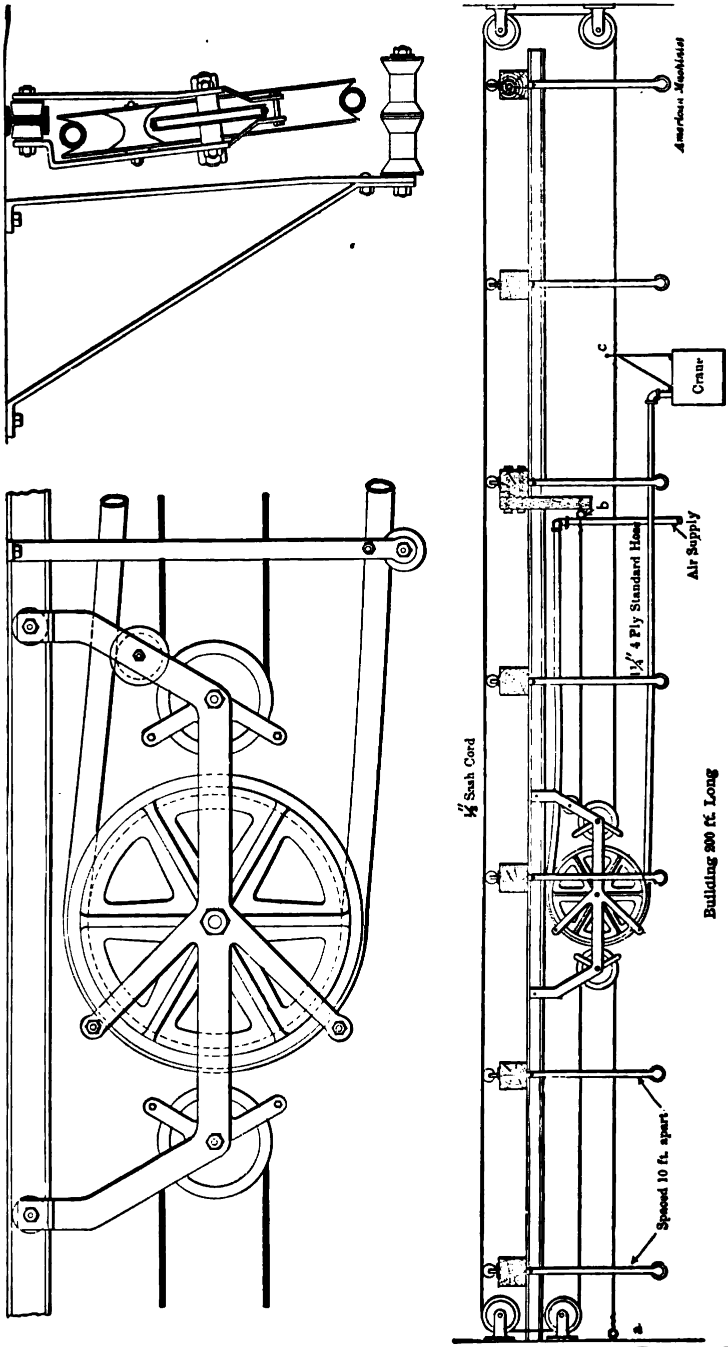


FIG. 1—COMPRESSED AIR CRANE HOSE SUPPORT.

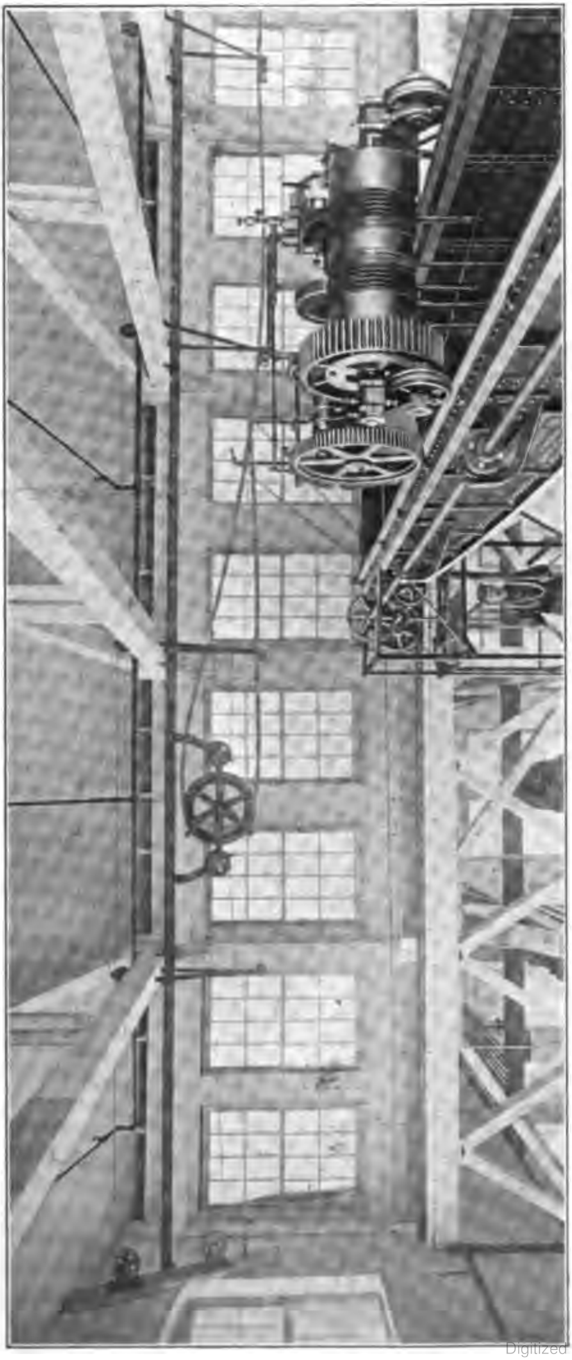


FIG. 2—COMPRESSED AIR CRANE HOSE SUPPORT.

without the use of a rising and falling weight.

Fig. 1 shows the arrangement diagrammatically, the crane being indicated only. The ends of the cord are secured at *a* and *b*, and the cord is again attached to the crane at *c*. During the movement of the crane toward the left it is clear that the action of the cord will be to carry the sheave in the same direction at one-half the speed of the crane, and so take up the slack of the hose. The upper views show the arrangement of the sheave in greater detail. Permanent changes in the length of the rope due to use are taken up from time to time by re-tying the rope at the crane end, and, except in extra long runways, we doubt if temporary changes in length, due to changes in the moisture in the air, would cause any annoyance. If found to be so, they could be easily provided for by carrying the end *a* over a sheave and hanging a weight, slightly greater than the tension on the rope, to it. This weight would not, of course, rise and fall with the movements of the crane, but would gradually settle with the stretching of the rope.

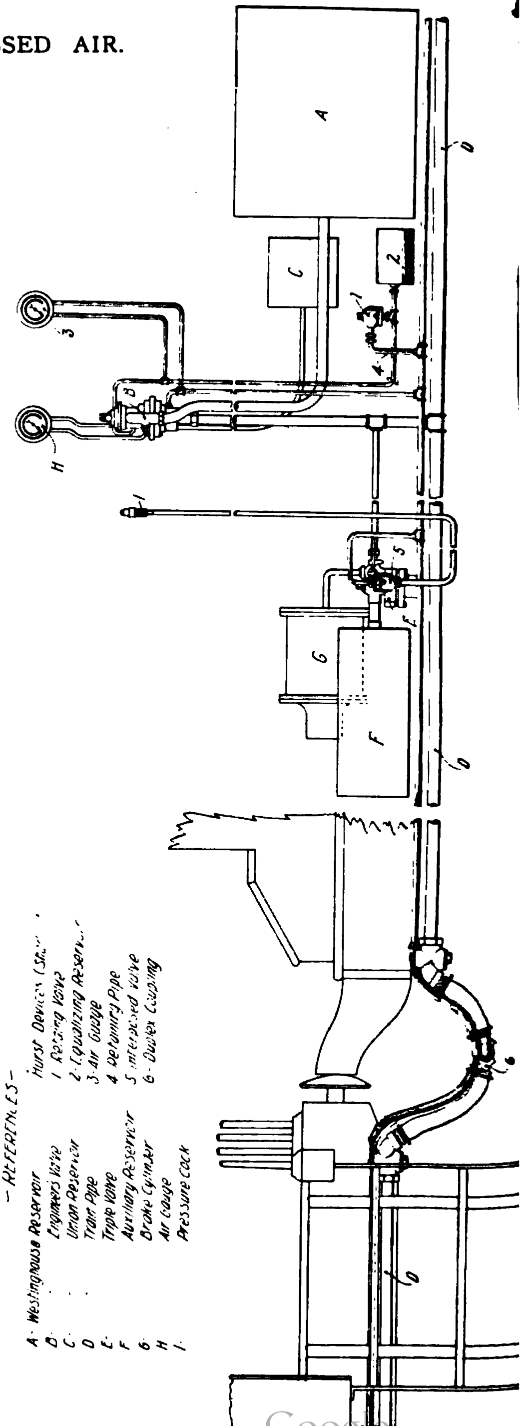
We must say we fail to see the need of the portion of sash cord between *b* and *c*. The hose itself would seem to be able to do the work of this part of the sash cord.

Fig. 2 is from a photograph, and shows the arrangement as it appears in use.—*American Machinist.*

Hurst Air-Brake Improvement.

In the air-brake room of the Rio Grande Western shops at Salt Lake City, and on the engines of that road some interesting experiments and road trials have lately been made with the Hurst improvement for automatic air brakes, the results of which evidenced in a satisfactory manner the value and practicability of the apparatus. This device was invented and patented in 1895 and 1896, by the late John M. Hurst, master mechanic of the Salt Lake and Ogden road, and previously an engineer on several Utah lines, who died before the improvement was fully developed. The patents then passed into possession of others and after the appliance was further perfected, a corporation known as the Hurst Air-Brake Co., was organized for exploiting it.

The Hurst improvement is an automatic retainer, designed for the purpose of holding the brakes set while recharging, and the trials above mentioned were carried



on especially for the purpose of proving the efficiency of the attachment on steep grades and under the conditions of a mountain road.

The apparatus is intended to avoid the present waste of air, to make quicker and smoother stops possible on rapidly moving trains, to keep auxiliaries always charged and ready for emergencies, to avoid the flattening of wheels by placing control of the brakes entirely in the hands of the engineer, and finally effecting an economy in the consumption of air. It is especially adapted to rapidly moving trains which have to make frequent stops: and to long and heavy freight trains on extreme grades.

The accompanying illustration shows the regular Westinghouse air-brake apparatus, and the Hurst improvement (parts shaded) in which the parts of the former are designated by letters A, B, C, etc., and the latter by the numbers 1, 2, 3, etc., the drawing represents the arrangement of the apparatus on the engine, tender and first car. The air from the engineer's brake valve reservoir (C) controls the retaining valve on the engine (No. 1) and the air from the train-pipe (D) controls the interposed valve on the car (No. 5). The gauge (No. 3) shows the pressure retained in the brake cylinder and retaining valves. The retaining reservoir (No. 2) is made about one-half the size, or less, than the engineer's brake-valve reservoir, thereby retaining 2 to 2½ lbs. for every pound exhausted from the brake-valve reservoir. The pressure goes into retaining valve (No. 1) which is divided by a diaphram having a stem, in the center which seats on an exhaust port on the opposite end of the valve. On the other end of the valve the air comes from the train-pipe and being unable to get out flows back through the retaining pipe (No. 4), passing to the interposed valves, closing them the same as the retaining valve.

The retaining valve allows the engineer to make a gradual release of the air from the brake cylinders in much the same way that a gradual application of the air is made in the first place—an interesting feature of the improvement. It is believed that this will do away to a large extent with the parting of trains and insure smooth handling of trains on a down grade. The retaining valve also lets the excessive pressure out of a brake cylinder having a short travel, making it correspond with a 7 or 8-in. piston travel.—*Railway and Engineering Review.*

Test of New Automatic Gun.

H. A. Rademacher and Franklin J. Jewett, of Brooklyn, and William C. Stone, of Utica, N. Y., are arranging for the second test of a new automatic gun, the patents for which are pending. The new gun, which is now being perfected, will be operated by compressed air. A departure in its scheme is that the bullet will not be closed in a shell as in other automatic guns. It is the joint invention of Mr. Stone, who is a civil engineer, and Mr. Rodemacher, a Brooklyn chemist. Mr. Jewett is simply interested in the new arm.

The gun is of automatic type. Heretofore a portion of gas resulting from the explosion of cartridges has been used as a means for opening the mechanism of such guns. Experience has shown this to be objectionable, and in the gun which is now being perfected the recoil of the barrel is utilized to compress a certain amount of air, which is used as the motive power of operation.

The gun complete weighs about 280 pounds, and has no single piece weighing over 20 pounds. Its most important feature is the character of the ammunition used. Heretofore all the fixed ammunition consisted of a metallic shell, containing explosive material and primer, in the outer end of which the bullet has been concealed. In this new cartridge the metallic shell or casing is entirely disposed of. The new explosive is a secret compound of the nitro-gelatine type, a sufficient quantity of which is secured to the base of the bullet. This material is nearly as hard as the lead of the bullet. It is water and concussion proof, and can only be exploded by the use of a special primer, which has been especially designed for this purpose. The material is inflammable and can be ignited with an ordinary alcohol lamp. The total amount of explosive used for the cartridge is small in a 45-calibre bullet, being only one-quarter of an inch thick. When exploded it leaves a very small residue in the barrel of the gun.

It is intended by the owners of the gun

to locate their plant in Utica and manufacture both the gun and ammunition in that city. An effort will be made to organize a stock company, and with any support whatever the venture should attain success.—*Utica Press.*

Mine Fires.

An underground conflagration is one of the most dreaded catastrophies with which mines are visited. Outside, on the surface, a fire can generally be attacked from a number of vantage points by the firemen; but in the cramped and narrow mine workings it is usually most difficult for a man to work his way through the smoke and deadly gases given off by the fire to a point from which to attack the flames. Prompt, energetic action may extinguish the blaze or confine it to a small section, but when once a mine fire gains headway it may be necessary to flood the workings to put it out. In many instances destruction of valuable property nas been averted and lives have been saved by men provided with the Vajen-Bader head protector. The wearer of this helmet was thereby enabled to work in an atmosphere in which a man ordinarily could not live, and successfully fight fire, restore doors and brattice after an explosion, and by prompt removal to fresh, pure air, save lives that would have been lost in the deadly mine gases, Fig. 1.

FIG. I—RESCUE WORK WITH VAJEN-BADER HEAD PROTECTOR.

This helmet is made in two sizes, the larger of which supplies a man with fresh air for several hours; it encloses the head as shown in Fig. 2. It is about the same weight as that of a thick overcoat and is supported in a similar manner when worn; it rests on the shoulders and is held firmly in place by two straps passing under the arms. It is constructed of a double thickness of leather, the outer layer being horse hide chemically treated to render it fireproof and waterproof. At the rear is shown an air cylinder from which leads a tube ending in front of the nostrils. Fresh air is supplied to the wearer, at about the natural pressure, from the reservoir, which can easily be recharged in a short time, by the special air pump included in the outfit.

After the helmet has been adjusted to the body, the wearer turns on the air by the valve shown on the right side of the gauge, which indicates the amount of air in the reservoir. The cylinder on the larger size protector carries air at 150 pounds pressure when full. The fresh air being constantly forced into the helmet, creates an outward pressure, and the foul air escapes through the neck gear and around the bottom, which is lined with absorbent lamb's wool. The two lookouts are constructed of double plates of clear mica with revolving cleaners, and are protected by four cross-wires. The side or ear pieces have special sounding diaphragms so as to render the hearing distinct. The whistle attached in front is used for a call and is a convenient means of signaling. The helmet furnishes full protection to the head from falling debris or on striking top rock or timber, as it is padded on top and reinforced with four ribs.

The setscrew between the gauge and the valve is regulated by a screwdriver and should be tested as to adjustment, from time to time, to see that the air is delivered to the helmet at the right speed. When the device is needed there will be no time to look after this detail. This setscrew provides a very delicate adjustment, and is heavily gold-plated to avoid corrosion.

This head protector is manufactured by the Vajen-Bader Co., 120 North Penn St., Indianapolis, Ind., who suggest that mine owners among others take up the question of securing this very important part of every mine equipment before it is actually needed, similar to the advisability of carrying a revolver in Texas—it is not always necessary, but when a man needs it, he needs it bad.—*Mines and Minerals.*

FIG. 2.

Starting Large Gas Engines.

A somewhat daring system is employed at the Snow Steam Pump Works, in starting the 1,000 and 4,000 horse-power gas engine gas-compressors in Cleveland, Ohio, U. S. A. It cannot be better described than in the Works Manager's own words: "An auxiliary power-house is provided, containing small auxiliary gas engines, which, during the night, operate electric generators to supply light for the plant, and supply the storage-battery used for furnishing current for the electric igniters during the day and night. These auxiliary gas engines are also connected to mixture compressors, which compress the proper proportion of natural gas and air (in the proportion of about 1 to 12) into a large tank. Connection is made from this tank to the ends of the cylinders, which are used for starting. The engineer turns this mixture under about 100 lbs. pressure into one end of one power cylinder, which causes the piston to move to the other end. The pressure is then allowed to escape from this end, leaving the cylinder full of mixture at about atmospheric pressure. He then goes to the other end of one of the other cylinders, and admitting mixture pressure to this end, forces the pistons back again to the other extreme position, compressing the mixture in the end of the first cylinder to which it was admitted. He then trips the igniter on this cylinder, which causes an explosion and starts the machine, and upon compression and ignition in the second cylinder to which the mixture is admitted, the reverse stroke is made under power, by which time the other cylinders have been rendered operative on account of drawing in their own gas and compressing same and exploding. Very little trouble is experienced in starting the engines in this way. The mixture tank and its connections are designed to stand easily an explosion-pressure of about 600 lbs.; while, in addition to this precaution, a number of large relief valves are applied to the tank for the purpose of partially relieving internal pressure, should an explosion of this mixture take place in the tank. We question as to whether this method of starting would be permitted by insurance companies within the city limits; but, as we have before remarked, all our work in the gas engine line has been confined to the building of gas engine compressors, which are always located back in the country, and always some distance from cities or populous communities."—*Proceedings British Association*, 1902.

Notes.

Good steam coal will not contain more than eight per cent. or ten per cent. ash. It will take 10⅛ pounds air to burn one pound ordinary coal.

The patented compressed air sweeper now used at the Washington Hotel at Portsmouth, O., excites much favorable comment. The Washington is strictly up-to-date in all respects.

At Claridge's Hotel, in London, on the night of January 9th, Mr. George Westinghouse entertained at dinner a large company of British railway managers, financiers and scientists.

The Pneumatic Signal Co., New York, has been awarded the contract for installing an interlocking plant at Grand Forks, B. C., being a crossing of the G. N. and G. F. and K. R. Railroads.

The Norwalk Mfg. Co., of Norwalk, O., have been incorporated to succeed the Norwalk Foundry & Machine Co. Capital stock, $50,000. Incorporators: W. H. Price, E. A. Stevens and A. M. Beatty.

To calculate the horse power of a windmill, approximately, multiply the area of the slats in the plane of revolution by the cube of the velocity of the wind in feet per second, and divide product by 4,000,000.

To determine the approximate horse power necessary to pump water to a given height by steam, multiply the total weight of water in pounds by height in feet and divide by 16,500. This allows for friction and steam loss.

The Philadelphia Pneumatic Tool Co., of Philadelphia, have issued a pamphlet dealing with "The Care and Use of Pneumatic Tools," of which a copy will be mailed upon application. It is of general interest to the trade.

The air compressor plant of the Castle Creek Mining Co. of Mystic, S. Dak., was totally destroyed by fire. The plant consisted of boilers and engine, as well as air compressor and pump. The loss is $7,000. The machinery will be replaced.

The British gallon of water contains 277.274 cubic inches; the United States gallon of water, 231. There are 7.48 United States gallons in a cubic foot, 6.23 British. A British gallon of water weighs 10.01 pounds; a United States gallon 8.35 pounds.

The Naval Magazine at Iona Island, N. Y., have had a $14,000 appropriation made them for a new compressed air charging station, with pipes and fitting, machine tools for the machine shop and the carpenter shop, and improvements to the old dock.

To keep machinery from rusting dissolve one ounce camphor in one pound melted lard; remove the scum; mix as much black lead with the lard and camphor as will give it an iron color; clean the machinery well; smear with the mixture; after twenty-four hours rub off; clean and polish with soft cloth.

Handsome new cars for the electric railway between Lansing and St. Johns, Mich., have been received in that city, and electric transportation will be furnished shortly. The cars are said to be the finest ever brought into the state, and they are equipped with compressed air reservoirs for propelling them along the streets of the city.

A telescope ladder capable of being extended to a length of 85 feet and worked by means of compressed air was tested recently in Pittsburg, Pa. The ladder can be directed at a particular window in a burning building; a fireman lashed to the end of the ladder is shot up with it, and rescued persons need not clamber down, as the ladder can be quickly lowered with them on it.

Notice is given steamboat and sailing vessel masters that the machinery operating the compressed air siren at the Thimble shoal light station, in Chesapeake Bay, Delaware, was disabled during a fog recently and cannot now be sounded. Repairs will be made to siren as soon as possible, but until they are made fog bells will be struck by machinery in thick and foggy weather to warn vessels of their approach to the shoals.

The New Jersey Pneumatic Crane Company, with a capital stock of $100,000, which it is said will later be increased to several millions, have been organized and papers of incorporation filed in New Jersey through the Corporation Trust Company. The charter of the company is very broad and enables the company to manufacture, buy, sell and deal in pneumatic cranes, air compressors, tool and machinery of all kinds operated by air, electricity, steam and water power.

The Havana Bridge Company, of Montour Falls, has been reincorporated under the name of the General Pneumatic Company, and the capital stock increased to $75,000. The stockholders have elected the following officers:

President, Robert T. Turner; vice-president, C. F. Carrier; secretary, James A. Shepard; treasurer, Frank A. Hatch. The articles to be manufactured are motor hoists and cranes, air compressors, pneumatic hammers and compression riveting machines.

A non-slipping tread for pneumatic motor car tires has been introduced by the Dunlop Company. The thickness of the ordinary tread is somewhat increased. The thickened tread is cut transversely with segmental grooves about ½ in. deep by ¾ in. wide, the grooves occurring at center to center distances of 1¾ in. all round the tread. Although efficient while comparatively new, it remains to be seen how the device will work when worn. It will also probably be found that the tire is not so resilient when fitted with the non-slipping covers.

At the new shop of the Allis-Chalmers Co., near Milwaukee, Wis., the boilers are fed from cisterns outside the room, supplied by artesian wells. The wells are operated by air lifts, 1½ in. air pipes and 6 in. water pipes serving to lift 385 gallons of water per minute through a height of 108 ft. Air pressure of 105 lb. per sq. in. is required to start the flow, which then continues under 80 lb. air supply.

A cross-compound two-stage air compressor supplies air at 100 lb. per sq. in. for driving air tools, hoists, etc., and for the air lifts in the artesian wells as already noted. Its capacity is 1,000 cu. ft. of free air per minute.

The Philadelphia Pneumatic Tool Company has arranged to double the size of its offices in New York by renting additional room in the Singer Building, corner Broadway and Liberty streets.

This is made necessary by the greatly increasing business of this company in and around New York City. An electrically-driven air compressor and a complete plant for testing and exhibiting pneumatic tools of all kinds in operation will be installed.

The New York offices will continue under the management of Mr. W. A. Battey, assisted by Mr. James H. Beaubien.

Air Compressors can not be satisfactorily utilized to operate power drills, running the air direct from the compressor through the pipe line to the drills. A receiver should always be provided at an intermediate point, and, if the line be long, two receivers are advisable, one near the compressor and one at the nearest point available to the drills. At some mines having auxilliary steam power plants, when the boilers are not in use as steam generators the air lines are connected with the boilers, thus largely increasing the storage capacity and rendering more uniform efficiency. When steam boilers are used in this manner the air may be re-heated by keeping a moderate fire underneath the boilers, greatly increasing the expansive force of the air thereby.

The Public Health Committee of the London County Council have just issued a report giving the results of chemical and bacteriological examinations of the atmosphere in the stations, lifts, passages, and tunnels of the Central London Railway, England.

In concluding their report, the committee state that they have been informed that the Central London Railway Company are taking steps to improve the ventilation of the tunnels by installing a large rotary fan at the Shepherd's-bush end, which will be powerful enough to draw out all the tunnel air three times in the three hours during which the traffic is stopped at night. They also state that the company are installing at the Bank station an air compressor which will force compressed air drawn from the street level into the extreme end of the Bank sidings while the trains are in motion and thus purify that part.

A smart and simple instrument is the Evelyn patent bubble clinometer, which consists of a curved tube or vessel, fitted with water or diluted spirits in which floats a small bubble of compressed air. Adjacent to the tube and concentric with its outer edge is the graduated arc of a circle. When the air bubble is at the zero point of the graduated arc, the base of the instrument is horizontal or level, and any deviation from the level is marked in degrees by the position of the bubble on the graduated arc. These instruments are invaluable to yachts, especially racing yachts, as they afford the means of ascertaining the comparative stiffness of different vessels. The Hughes "X.Y." station pointer also will be of interest to yachtsmen. This pointer, in addition to the usual three metal arms, possesses the great advantage of having a transparent disc of xylonite, through which all the details of the chart are clearly seen. It is very simple in construction, and less than half the price of the regular station pointer.

William M. Myers, of St. Joseph, Mo., an inventor of that city who has a shop and residence at 2817 Dewey avenue, believes he has studied out a process for making compressed air and liquid air that will reduce their cost and make them available in many more ways than at present dreamed of. W. T. Van Brunt, the newly elected president of the St. Joseph & Grand Island Railway, has become interested in the invention of Mr. Myers and in turn has financially interested E. H. Harriman, the railway magnate, who is enthusiastic over the possibilities.

The new compressor is a simple appliance, a plain, simple air pump, either single or double acting, as desired, by which water is injected at each stroke, thus cooling the interior and water packing the piston, thereby avoiding back leakage and reducing the heat vibrations. By this simple process air can be compressed from ordinary atmospheric pressure up to any desired compaction, even to thousands of pounds per square inch at one stroke in a simple pump without heat.

Mr. H. J. Lake, of Grand Marias, Mich., has received the sole agency, with authority to appoint in Alger, Luce and Schoolcraft counties for the new "Kant Clog" nozzle and Compressed Air Sprayer. The new invention is practical in every way and can be brought into a number of uses, the principal one being that of spraying plants, vegetables and fruit trees with solutions. In this alone the farmer will have found a prize, as the sprayer works automatic when once filled with compressed air, is light to handle and can be operated by a child. Besides the above, the sprayer can be used to whitewash the interior of buildings, wash windows and carriages or in fact anything where a stream of water or solution is demanded. The cost of the sprayer is small when its usefulness is considered, as no farm is complete without one or more, and they cost but $5 each. They are the most complete outfit for spraying paris green that has ever been placed on the market.

The Kenefick-Hammond contracting company has opened headquarters at Aurora, Mo., and have a large force of men and horses to start the construction work on the White River road from there south.

About fifty expert men have arrived in Aurora and are awaiting orders to leave for the south, where they are to begin work on the two great tunnels on the line of the White River road, the first near Reed's Spring, about four and one-half miles southeast of Galena, and the other not far south of White River.

An electric light and compressed air plant is to be established at the mouth of each tunnel for furnishing air for the drills and light for the workmen. A large number of Ingersoll-Sergeant air drills are to be used on the contract, and tons of dynamite.

Work will also be commenced as soon as possible upon the big steel bridge to be built across White River, the structure to be 1,300 feet in length and eighty feet above the water level.

The *Scientific American* writes that a number of tiny engines have been constructed at different times, but doubtless the smallest which has yet been built which is actually operated was recently completed by Mr. A. G. Root, of Danbury, Conn. It stands on a piece of metal just the size of an American 10-cent piece, the materials of which it is made being gold, silver, brass and steel. The largest part of the engine is less than a half-inch in length, the fly-wheel being 7-64 of an inch in diameter, while the main shaft of steel is but 5-16 of an inch in length. The band of the fly-wheel is of gold. The total weight of the engine without the base is but three pennyweights, and its total height is less than a half-inch. In making the various parts and putting them together it was necessary to use a magnifying glass on account of the delicacy of the work, yet the engine runs perfectly, compressed air being used for power applied through a tiny tube. As long as the air supply is maintained, it continues in motion. The horse power developed is so small that it cannot be estimated.

At a meeting of the Yorkshire College Engineering Society, Leeds, England, on Monday, Feb. 9th, a paper on "Pneumatic Tools" was read by Mr. J. R. Kelly, who dealt with this recent and important development of engineering principally from a practical standpoint. He claimed the advantages of portability, absence of skilled labor for operating, absence of risk, increase of output as compared with manual labor, and low cost as compared with fixed tools doing the same work. He explained the construction and action of pneumatic hammers and drills, and gave particulars of remarkably good work performed by these tools, citing the repair of the steamship Etruria as an instance of time and labor saved by their use. He was careful to explain that he did not consider pneumatic riveters would displace fixed hydraulic riveters where work could be taken to the machines. The lecture was illustrated by slides and tools in operation. The paper was warmly applauded, and at the close of a discussion which followed a hearty vote of thanks was accorded to Mr. Kelly.

The *Brooklyn Times* writes that the Brooklyn tunnel is still in an incipient stage. The only work done thus far has been the sinking of a shaft at the Battery, Manhattan, but the excavating will not begin until the necessary steel has arrived. The Rapid Transit Commission at the last meeting gave the contractor permission to sink two shafts in Brooklyn, one at the foot of Joralemon street and the other near Henry street. Compressed air drills will be installed and the work of completing the Brooklyn end of the tunnel to Flatbush avenue will be rapidly pushed.

Principal Assistant Engineer Rice, of the Rapid Transit Commission, said that the work of tunnelling under the river will not commence until the early spring. Most of this will be through solid rock according to the soundings made by the engineers. This work will require special machinery and drills, which are now being manufactured and will not be ready until some time in May.

The work on this part of the tunnel will start simultaneously from both sides of the river. The men will work toward one another and it is expected that they will meet and the tunnel will be joined in the center of the river. This work, the engineers say, will take about two years. The burrowing of the land ends of the tunnel will be accomplished in less than half that time, as there will be no difficult engineering problems to solve and the work is simply that of excavating.

Allis-Chalmers Company will on May 1st, 1903, remove their general offices from the present location in the Home Insurance Building to the New York Life Building, corner of La Salle and Monroe streets, Chicago.

This move is only another indication of the progressive spirit which prevails in the management of this strong indutstrial. The Allis-Chalmers Company has for the past two years been expending enormous sums of money in betterments at their various works in Milwaukee, Scranton, and Chicago, so as to give their customers the best possible service in point of economy and quick deliveries.

The new offices of the Allis-Chalmers Company will provide ample space for the various sales departments and general business offices, which will be inducive of the best possible service to their trade.

To give a fair idea of the scope of the business enjoyed by the Allis-Chalmers Company, will mention that during the past two months orders for either engines, mining machinery, rock crushing machinery, saw mill machinery and flour mill machinery were booked from every State in the Union, besides the following foreign countries: England, South Africa, Mexico, Canada, Chile, Central America, Brazil, West Australia, Turkey, Finland, Yukon Territory, Belgium, British Columbia, Bolivia, Hawaiian Islands, Peru, Alaska, China, Philippine Islands.

The Chicago Pneumatic Tool Co., of Chicago, state that if the amount of business transacted for the month of February is any indication, the year 1903 will indeed be the banner year of the pneumatic tool business in their experience. They state that the orders received for the month show an increase of over 50 per cent. over those received for the same month in the preceding year, and this immense influx of business has necessitated the removal of their plant at Aurora, Ill., to Cleveland, and its consolidation with the plant there in order to adequately fulfill requirements. Even with this increase in facilities they are obliged to work both night and day forces at their factories.

The following are a few of the installations of pneumatic machinery made during the week ending Feb. 28th:

Moran Bros. Co., Seattle, Wash.

Wm. Cramp & Sons' Ship and Engine Building Co., Philadelphia, Pa.

International & Great Northern Ry., Palestine, Tex.

Messrs. J. A. Yates & Co., of Birmingham, Ala., writes COMPRESSED AIR as follows:

"We notice in some of the articles referring to explosions in "Air Receivers" that in nearly every case the cause is attributable to the use of low grade volatile oils for lubricating the air cylinders, and presuming that all such cases brought to your attention will prove of interest to you, we wish to cite an instance which was brought to our notice very recently in this county. In this case we found that common, unrefined black oil was used in the air cylinder, and that the compressor was being run at a high speed and sustaining a steady pressure in the air receiver of something over 80 pounds. This imprudence resulted in an explosion taking place in the air receiver, blowing it to atoms and killing the engineer in charge of the plant. We do not think that you can put too much stress on the condemnation of this practice of using low test oils, and we note with pleasure that they are frequently calling attention to such errors in the columns of your paper. COMPRESSED AIR, anything which may arise in our work here, and which will be of any interest to you, we will gladly bring to your attention."

INDEX.

U.S. PATENTS GRANTED JAN. 1903.

Specially prepared for COMPRESSED AIR.

717,642. AUTOMATIC RELIEF-VALVE FOR PNEUMATIC SEED-COTTON DISTRIBUTERS. George W. Wade, Oakforest, Tex. Filed Jan. 6, 1902. Serial No. 88,653.

A pneumatic flue of the class described having an air-inlet opening, in combination with a valve to open and close said opening, a weight, a flexible element connecting the weight to the valve, to normally maintain the valve in a closed position, and an eccentrically-mounted revoluble direction element engaged by said flexible connecting element, for the purpose set forth.

717,688. GAS AND AIR REGULATING VALVE. Elmer E. Kerns, Bradford, Pa. Filed May 10, 1902. Serial No. 107,992.

The combination with a valve-casing provided with an inlet and an outlet opening, and a valve-plug rotatably mounted within said casing and provided with graduated openings adapted to be brought into register with the outlet-opening of the valve-casing; of a mixing-chamber communicating with the outlet-opening of the valve-casing and provided with an air-inlet opening, an air regulating valve for said mixing-chamber, and a connection between the air-regulating valve and the valve-plug, whereby when the latter is operated to regulate the flow of gas through the outlet-opening, the air-regulating valve will also be operated to control the admission of air to the mixing-chamber.

717,760. AIR-PUMP. Abner A. Phipps, New York, N. Y. Filed Feb. 1, 1902. Serial No. 92,115.

The combination with the pump having the usual piston and discharge, a valve-seat in the receiving end of said discharge, of a valve carried by the piston to fit the seat, and means as the threaded parts in the discharge and on the valve-stem to secure the valve in closed position.

The combination with the pump having the customary piston provided with a valve, a valve-seat in the receiving end of the discharge, of a limiting device to prevent the valve parts from coming together during the reciprocation of the piston.

717,926. PNEUMATIC GRAIN-ELEVATOR. Julius C. Rieth, Sandwich, Ill. Filed Aug. 5, 1902. Serial No. 118,478.

A device of the kind described comprising a winged revoluble cylinder, a passage arranged adjacent to and parallel with the cylinder, the spaces between the outer edges of the wings corresponding to the width of the passage, and the wings being adapted to register with the sides of the passage to form a closed conduit.

717,965. PNEUMATIC DRIVER AND CUSHION FOR LOOM-SHUTTLES. John C. Blundell, Boston, Mass., assignor to Pneumatic Textile Machinery Company, Jersey City, N. J., a Corporation of New Jersey. Filed Nov. 30, 1901. Renewed Dec. 13, 1902. Serial No. 135,164.

An apparatus of the character described, a cylinder, a source of compressed air, an inlet for the compressed air to the cylinder, a valve controlling said inlet, mechanism operated by compressed air for driving the shuttle, and means independent of said air-inlet-controlling valve for regulating the escape of air from the cylinder and thereby cushioning said driving mechanism on its return stroke.

717,996. RAILWAY-BRAKE. Georges Houplain, Paris, France. Filed June 30, 1902. Serial No. 113,801.

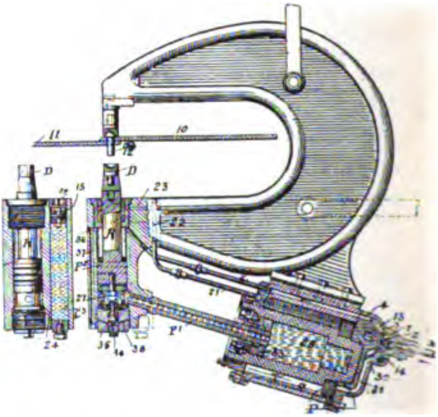
An air-brake, the combination of a piston and its rod, a lever for controlling the brake, two levers and one end of the lever being pivoted to the lever and one end of the lever being pivoted to the rod and the other ends of said levers being pivoted to each other and cheeks having recesses to normally receive one end of the lever and hold the same perpendicular to the rod when the piston is in its idle position and also to put said lever into alignment with the rod when the same is operated to thereby multiply the movement of the rod at the commencement of the brake action and bring the brake-blocks into contact with the wheels by a very slight movement of the piston.

718,395. PNEUMATIC STACKER. Thomas W. Slutz, Crowley, La. Filed April 11, 1902. Serial No. 102,341.

718,424. HYDRAULIC APPARATUS. Alexander S. Cardella, Chicago, Ill., assignor of one-half to William H. Wallis, Chicago, Ill. Filed Jan. 17, 1902. Serial No. 90,117.

A hydraulic apparatus, the combination with a siphon, of a reservoir into which the longer end of the siphon empties, an elevated tank connected to said reservoir, a pump connected to the larger end of the siphon and to the reservoir, operating to create suction upon the longer end of said siphon, and to force air into the reservoir, and suitable means for closing the communication between the pump and the siphon and the pump and the reservoir.

718,365. RIVETING-MACHINE. George E. Martin, Philadelphia, Pa., assignor to the Pedrick & Ayer Company, Philadelphia, Pa. Filed Dec. 21, 1901. Serial No. 86,734.



A riveting-machine, the combination of a power-cylinder provided with a differential power-piston constructed with a hollow trunk for containing a liquid, a fixed hollow spindle communicating therewith and with the riveting piston-cylinder; a minor piston-cylinder communicating independently with the air-pressure and with the riveting-cylinder, and a check-valve device with means for operating the same located between the riveting and the minor cylinder, for the purpose set forth.

718,450. SUBMARINE BOAT. Clarence B. Gillette, Winsted, Conn. Filed Aug. 6, 1901. Renewed Nov. 24, 1902. Serial No. 132,578.

A submarine boat having suitable propelling means, means for regulating the reserve buoyancy, wings on opposite sides connected at their forward ends to a horizontal shaft that extends transversely near the middle of the boat, and pneumatic mechanisms for rotating the shaft and giving the wings a vertically-rotative movement to such positions that they will, as the boat moves, counteract the reserve buoyancy, substantially as specified.

718,533. INSTANTANEOUS RELEASE FOR THE AIR-BRAKE CYLINDERS OF ENGINES AND TENDERS. Thomas A. Seery, Keene, N. H. Filed April 4, 1902. Serial No. 101,326.

An air-brake system, the combination with the brake-cylinders for the engine-driver brakes, a main reservoir, an auxiliary reservoir, a triple valve, of means to instantly release the pressure in the said brake-cylinders, independently of the operation of the brakes on the cars, said means comprising a supplemental release-valve connected to the said brake-cylinders, and means carried entirely by the engine and under the control of the engineer to operate said release valve by the main-reservoir pressure.

718,657. AIR-INLET VALVE. Herbet S. Renton, Brooklyn, N.Y., assignor of one-half to Jacob Manneschmidt, Jr., Brooklyn, N. Y. Filed Aug. 4, 1902. Serial No. 118,228.

An air-inlet device comprising a casing having an air-inlet opening and a valve-seat, and a valve pivoted on an axis intermediate of the length of its valve-faces and having a greater area in the portion of the valve which moves outwardly to close the valve than in the portion of the valve which moves inwardly to close the valve and having its weight disposed so that it will normally assume an open position and being so balanced in open normal position that the portion of greater area extends inwardly away from the air-inlet opening and the portion of lesser area extends outwardly toward the air-inlet opening, to provide in normal position of the valve an opening through the valve-seat which is practically free and unobstructed.

718,740. PNEUMATIC-TUBE SYSTEM. Kenneth E. Stuart, Philadelphia, Pa. Filed May 31, 1902. Serial No. 109,603.

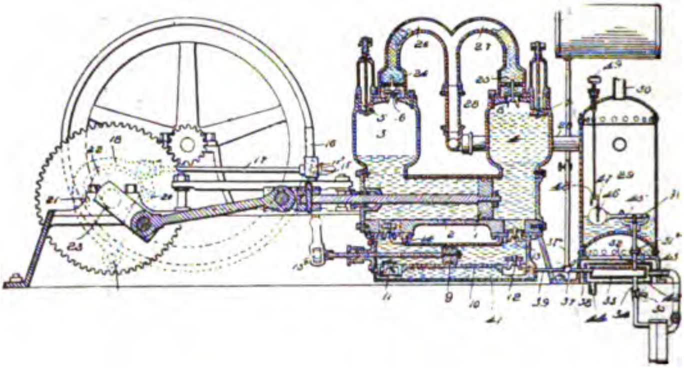
A pneumatic-tube system consisting of a series of station-heads provided with selective discharge appliances whereby an incoming carrier is automatically delivered at the station or shunted into the conduit leading to the next station in accordance with the character of selective appliances on such carrier, in combination with a series of tube-conduits connecting the series of stations in an endless circuit, means for inserting carriers at the respective stations, a suction-conduit connected with one of the tubes, an opening into the tube for admission of air adjacent to the suction-conduit connection and a flap-valve in the conduit between the suction and air-admission connections adapted to open under the impact of a carrier.

718,911. TRIPLE VALVE FOR AIR-BRAKES. Niels A. Christensen, Milwaukee, Wis. Filed April 15, 1901. Serial No. 55,842.

719,027. PNEUMATIC HAMMER. William T. McCook, Richmond, Va. Filed Jan. 30, 1902. Serial No. 91,825.

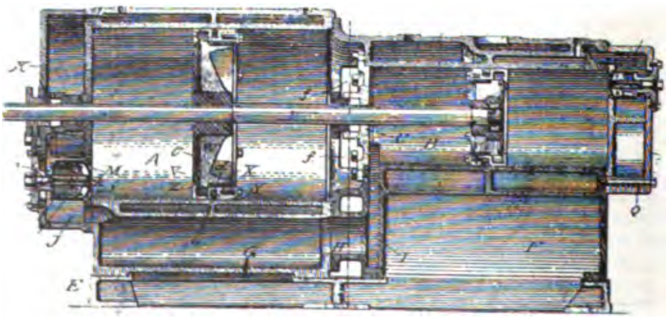
An automatic hammer having an inlet-passage for the admission of the motive fluid, a pressure-chamber, a hammer in the pressure-chamber, a valve-chamber intermediate and in communication with the inlet-passage and the pressure-chamber, a valve in the valve-chamber to control the flow of the motive fluid between the valve-chamber and the pressure-chamber, and an intermediate chamber in communication with the valve-chamber and connected with the pressure-chamber by a series of ports or passages which enter the pressure-chamber at points along its length, a check-valve controlling the connection between the intermediate chamber and the valve-chamber, and adjustable means located in the intermediate chamber whereby the check-valve may be put in communication with the pressure-chamber through any one of the series of ports or passages entering the latter.

719,127. AIR-COMPRESSOR. William M. Myers, St. Joseph, Mo. Filed Dec. 14, 1901. Serial No. 85,953.



An air-compressor, the combination with two vertically-arranged compression-chambers in which liquid is adapted to be reciprocated, a horizontal chamber in communication with said chambers, a horizontal reciprocating piston in said chamber, a smaller horizontal chamber below the said chamber and in communication therewith to supply liquid to the compression-chamber, a piston mounted so as to reciprocate in said smaller horizontal chamber to force the liquid into the pump-chamber, an adjustable reciprocating lever connected with said last-mentioned piston, a rod operated by an eccentric adjustably connected with said lever so as to limit the throw of the piston, and a motive power for operating the lever and the horizontal reciprocating piston, of a tank to receive the compressed air and means to cool the liquid before it is supplied to the small horizontal chamber.

719,142. COMPRESSOR AND VALVE FOR SAME. Edwin Reynolds and Cyrus Robinson, Milwaukee, Wis. Filed April 1, 1899. Serial No. 711,458.



An air-compressor or the like, the combination of a low-pressure cylinder, provided with a suitable air-intake; a head secured to said cylinder and formed with an air-receiving chamber; eduction-valves mounted within said chamber and closing ports leading into the cylinder; a high-pressure cylinder; a receiver connecting the said air-receiving chamber with the intake end of the high-pressure cylinder; a chambered head for the opposite end of said high-pressure cylinder; eduction-valves mounted therein for controlling the ports communicating with the high-pressure cylinder; a piston-rod working in said cylinders; a piston mounted in each of said cylinders, and connected to the rod; and induction-valves carried by said pistons.

719,279. PNEUMATIC TRANSFERRING MECHANISM FOR CIGAR-MACHINES. Oluf Tyberg, New York, N. Y., assignor to Rufus L. Patterson and George Arents, Jr., New York, N. Y. Filed Aug. 1, 1901. Serial No. 70,467.

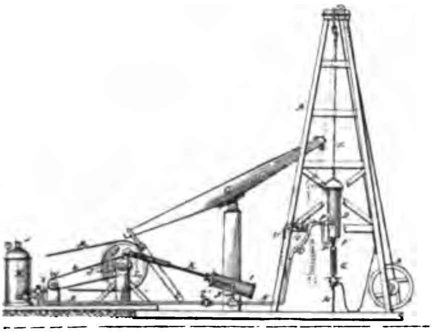
719,308. PNEUMATIC STRAW-STACKER. Charles F. Dammeier, Metz, Iowa. Filed June 6, 1902. Serial No. 110,439.

719,370. PNEUMATIC BALANCING ROPE-TENSION ATTACHMENT. Harry W. Rank, McDonald, Pa. Filed June 29, 1901. Serial No. 66,559.

A well-drilling apparatus, the combination with a drill-rope, and an oscillating beam, of a pneumatic cylinder on said beam, a piston sliding in said cylinder and having a rod, means for connection with a drill-rope, the cylinder being filled with air on the front side of the piston, whereby the latter reciprocates as the beam oscillates and the drill-rope slackens and tightens.

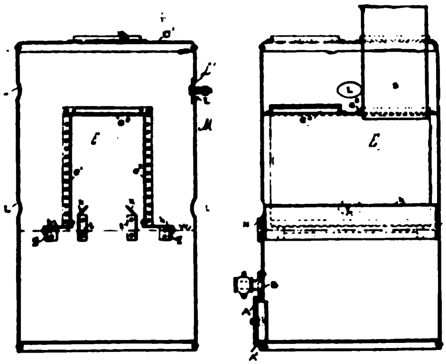
719,371. PNEUMATIC WELL-DRILLING APPARATUS. Harry W. Rank, McDonald, Pa. Filed July 6, 1901. Serial No. 67,288.

A pneumatic well-drilling apparatus, the combination, with a suspended drill-cylinder having an air-port at bottom and another near the bottom, said ports being provided



with valves seating in opposite directions, as specified, of a slidable piston arranged in such cylinder and whose rod is adapted for connection with drilling mechanism proper, an air forcing and suction apparatus including a cylinder and a piston reciprocating therein, and a pipe which connects the last-named cylinder with the first-named or drill cylinder and is branched to connect with the two ports of the latter, and means for reciprocating the piston of the cylinder of the forcing and suction apparatus.

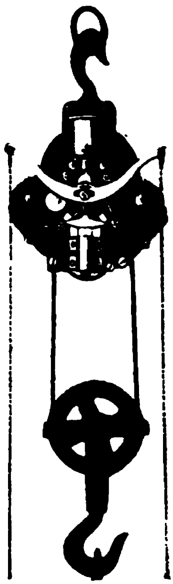
719,395. WASHER FOR SAND-BLAST APPARATUS. Ambrose G. Warren, Philadelphia, Pa., assignor of one-half to J. W. Paxson Company, Philadelphia, Pa., a Corporation. Filed Mar. 30, 1901. Serial No. 53,665.

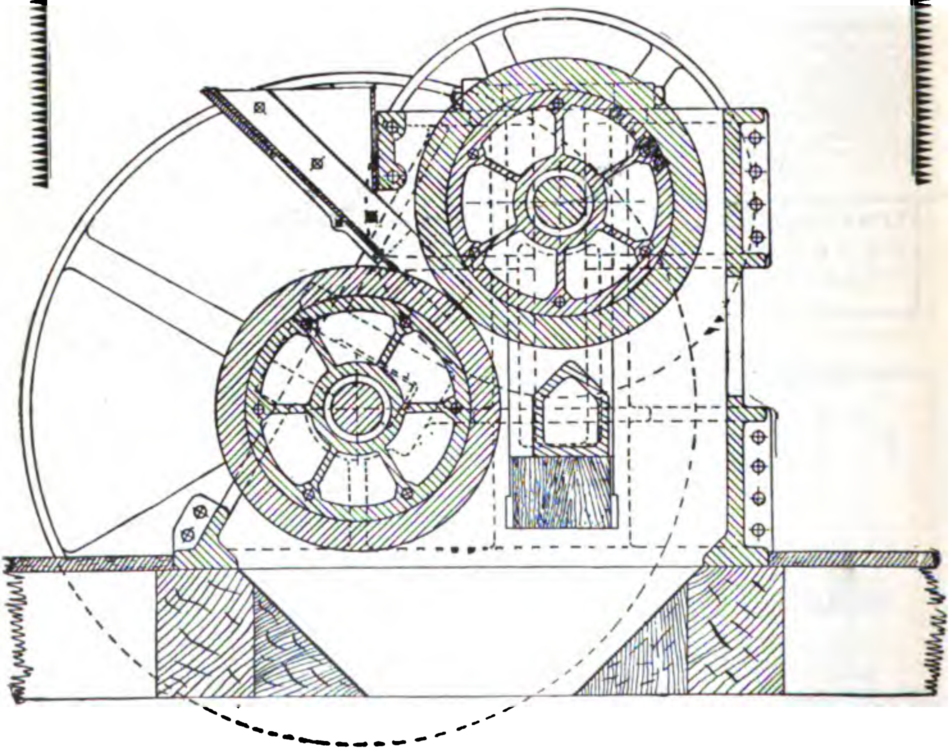


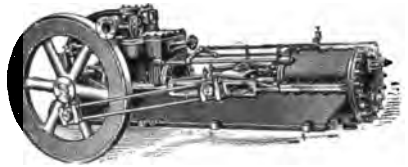
An apparatus for separating dust from air, consisting of a suitable closed casing having air inlet and discharge openings at or near the top thereof, laterally-disposed partition-walls e^1 e^2, with a cover-plate e^3 forming a central chamber into which dust-laden air is conveyed, a tubular inlet-pipe S forming a conduit or passage-way between the air-inlet and said partition-chamber, a laterally-arranged perforated plate at the base of each partition-wall, and vertically-arranged deflecting-plates within said chamber, extending below the perforated plates.

719,397. DRY ORE-SEPARATOR. Robert E. Waugh and Eugene Waugh, Denver, Colo., assignors of four-sevenths to James H. McShane, Felix J. McShane, Henry J. Paschel, and Clemont L. West, Omaha, Neb. Filed Sept. 21, 1901. Renewed May 27, 1902. Serial No. 109,199.

A dry ore-separator, the combination with a main frame, of an apron-frame mounted thereon and provided with an air-chamber, an endless traveling apron mounted on the apron-frame and provided with electromagnets located adjacent the inner surface of the apron which is arranged to close the air-chamber, and means for introducing air under pressure to the air-chamber, the apron fabric being such as to allow the air from the chamber to pass therethrough for the purpose set forth.





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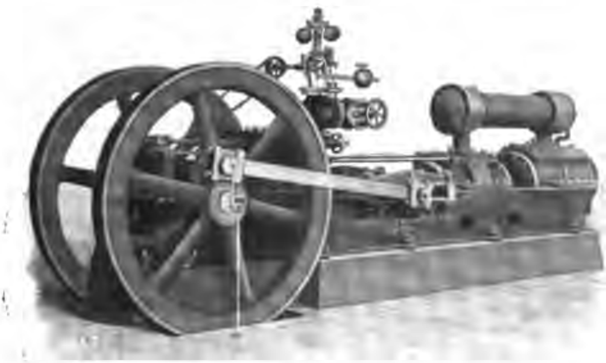

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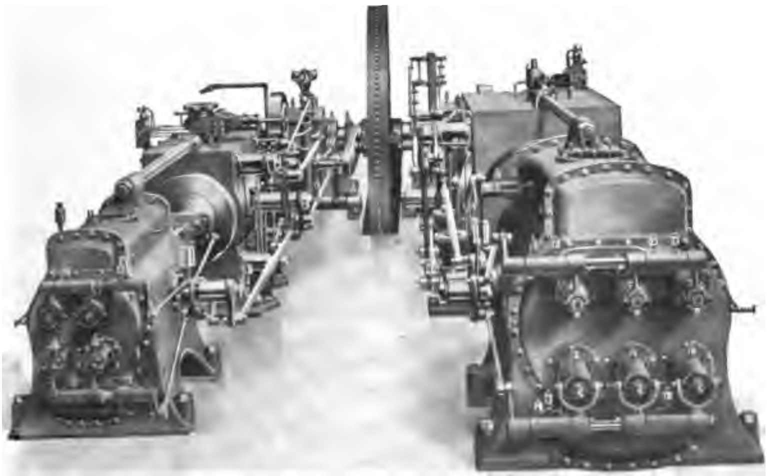

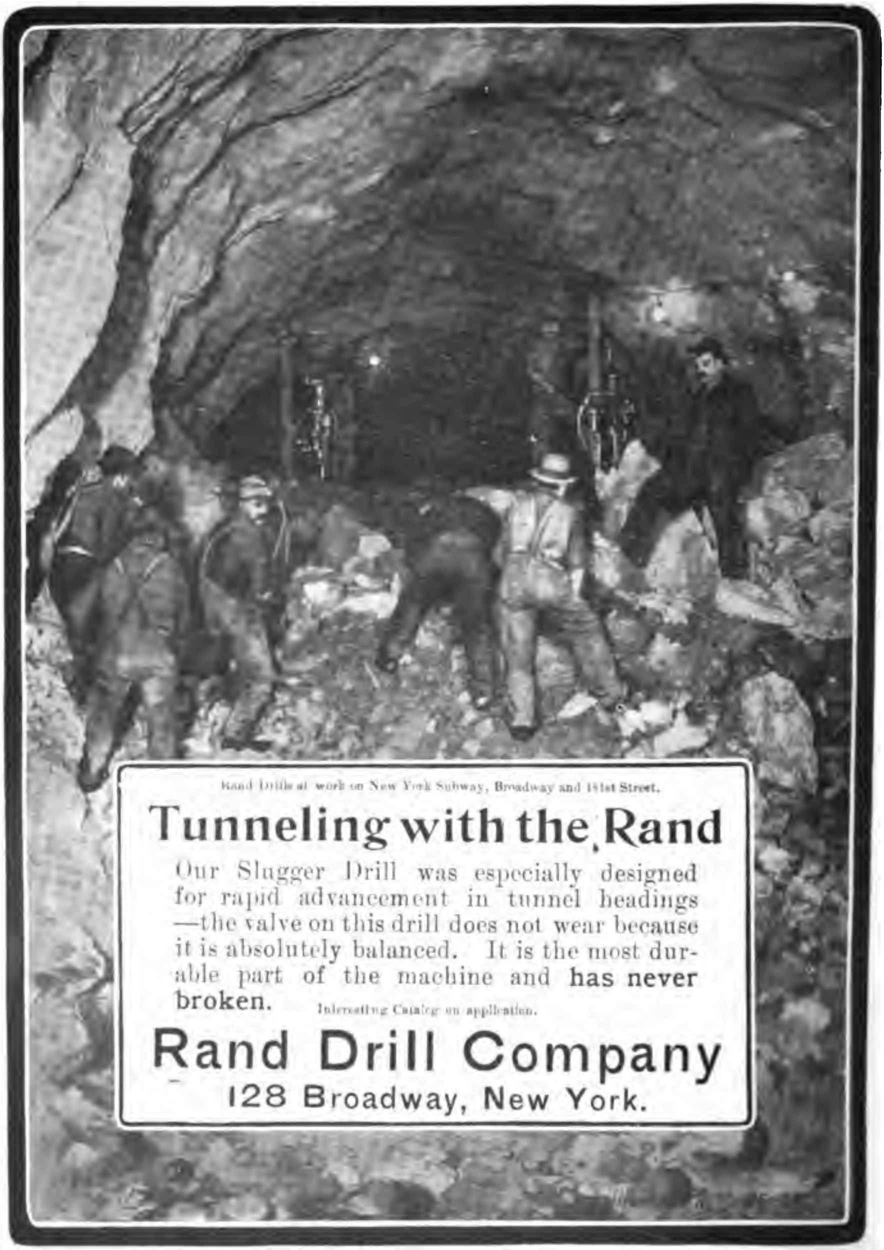
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VOL. VIII. APRIL, 1903. NO. 2

Oil and Dust from Rock Drill Use in Mines.

It is an encouraging sign of the times that the question of the health of the miners should receive such serious consideration as is recently being given it in connection with work in mines. In South Africa a commission has been appointed and it is alleged that laws are to be passed specifying certain regulations by which the lives of the miners will be prolonged. Opinions differ as to what causes the trouble, but no one doubts the fact that the lives of miners have been shortened by some of the conditions that exist in mines, and particularly in the African mines. It is well known that ventilation is an important auxiliary to men working in mines. Bad ventilation in mines is just as hurtful as bad ventilation anywhere else, and unless the miners have good air to breathe they are liable to be affected by diseases, especially so as the damp atmosphere in the mine and the changing degrees of temperature cannot be considered as favorable conditions. Some think that oil either from the air compressor or from the rock drill is responsible for the miners diseases, and cases have been cited where asphyxiation and even death have resulted from the discharge of "bad air" into the mine through the pipe leading from the engine room. We have a record of perhaps the most serious case of this kind, one which occurred several years ago in a western mining field and which resulted in the death of more than a dozen men, the direct cause being a fire in the engine room, and as the air compressor throttle had not been closed the machine continued to work while the building was burning all around it; hence the products of combustion were sucked into the compressor and forced into the mine, the miners being ignorant of the existence of a fire on the surface and having no means by which to discover the trouble until it was too late to prevent serious consequences. Here is an accident which cannot be compared with normal conditions and yet it has a bearing on the case, because it points to unforeseen possibilities and also to the importance of discharging only pure air through the line pipe into the mine. Pure air is not always compressed by air compressors. This is due sometimes to defects in design and at other times to negligence. A properly designed air compressor when used to pump air into a mine should have compound air cylinders, with intercoolers and aftercoolers. To compress air up to pressures from 75 to 100 pounds in one stage by a single blow, as it were, is to heat it beyond reasonable temperatures and to burn the air to such an extent as to produce unhealthy conditions. Stage compression means a gradual piling up of pressure with a gradual increase of temperature and no smell from burnt oil or other particles, which are often taken in with the air and heated to excessive temperatures during compression. By stage compression not only are lower maximum temperatures produced, but the air is brought down to atmospheric temperatures when passing through the intercoolers and aftercoolers, and in this way less power is consumed in compressing the same volume of air to the same pressure, and such things as oil, smoke, water and dust are collected by the cooling devices and blown off just as sediment may be blown off from a boiler.

It is said that oil when discharged from the exhaust of rock drills is hurtful to the miners and that it interferes with the amalgamation process. As to its being hurtful to the miners, we can scarcely agree to the possibility of this, as when the oil is discharged from the exhaust it is at such low temperatures as to be condensed into a liquid which drops to the floor or is blown against the walls of the mine. In other words, it is not in the condition of a vapor or gas. As to its interfering with the amalgamation process, the late Mr. Collins, of the Smuggler Union Mine, at Telluride, Colo., who was an acknowledged expert in all that pertains to mines, made some exhaustive experiments to determine the effect of oil upon the amalgamation plates, the results being uniform in each case and showing no effect whatever. Oil floats on the surface of water, while the particles of gold sink to the bottom. Oil being lighter than water, it is not at all likely that it will carry particles of gold with it. But whether oil, when used in rock drills, is hurtful or not, it is plain that too much oil is used and too little attention is given to the wastefulness of oil. When a rock drill becomes worn, its efficiency is much improved by frequent doses of oil. This is especially true of rock drills that have independent valves; that is, valves that are not moved by direct mechanical connection with the piston. The oil fills up loose spaces and with the aid of lubrication the machine works more like a new one. Of course, the proper plan to pursue when a rock drill is worn is to take it out of the mine and repair it, because a loose piston and a loose valve waste air, and in most mines they are wasteful also in oil. However this may be, a runner usually keeps the machine at work until it breaks down or will not work any longer, so that it becomes important to recognize this situation and endeavor to save in some other direction. It is bad enough to waste air, but when so much oil is thrown away, this wastefulness becomes important and even serious. A little soap and water will save money and accomplish the same results when fed into a worn rock drill, and nobody will claim that soap and water interferes in any way with either the health of the men or with the amalgamation process. It is cheaper than oil, it is a fair lubricant and in the cold passages of the rock drill it becomes thickened and serves an excellent purpose in filling up loose spaces. It cannot injure the machine, provided it is not allowed to remain in the machine when it is idle, as in such a case as this it might produce rust. Just before shutting down the rock drill oil should be run through, and in this way the soap and water will be neutralized by the oil and the machine made free from rust.

The real cause of the so-called miner's consumption is, in our judgment, due to the fine particles of dust that permeate the atmosphere and become impregnated in the lungs of the miners. This dust is only excessive in dry hole work or in raises where it is difficult to introduce water into the hole in the process of drilling, but it is quite possible to prevent this entirely by the injection of water through the drill steel, or by forcing it through a tube which is placed alongside of the steel and which is connected to a common bicycle foot pump. The trouble is that too little attention is given to matters of this kind, because dry hole work in mines is not general and the miners do not care to change to any special appliances when engaged in this work. It is quite likely, however, that agitation of the subject will result in the introduction of practical appliances by the use of which excessive dust in the mine may be absolutely prevented.

Sand Blast Cleaning of Structural Steel.*

It is intended to set forth, in this paper, some of the results which have been attained in the use of the sand-blast in cleaning steel plates and structural steel. Some data as to the cost and other elements which enter into its application will be presented, in the hope that possibly something may be added to the facility of making approximately accurate estimates of the cost of any sand-blast cleaning which may be in contemplation hereafter. Some of the work heretofore done has been referred to in a paper, published in *Engineering News* of April 24th, 1902; and in it the cost of cleaning 12,600 sq. ft. of the Front Street Viaduct over the Little Miami Railroad, in Columbus, Ohio, was stated. In presenting the experience gained in the continuance of the work during the season of 1902, giving results in cleaning a total area of 135,500 sq. ft. on viaducts in that city, which have been repainted since the early part of November, 1901, it is hoped to add a record of at least some value.

If it leads to a thorough discussion, and if members of the society add to the record, the most important part of the purpose in presenting this paper will have been realized.

During the past few years some attention has been given to attempts to secure thorough cleaning of structural steel before the application of the preservative coating; but, unfortunately, we are still far from the realization of the kind of work which should be required. Much has been written relative to the kind of paint which will best preserve the steel and iron used so extensively in a great variety of structures. In the discussion, which has been going on for many years, many have argued very strenuously against, and many just as earnestly in favor of, perhaps every kind of paint now used largely as preservatives of ferric structures from the ravages of rust and corrosion. But, in the discussion, they have, often lost sight of the very important matter of cleaning the steel properly. On account of the great deterioration of such structures, in the past, whether by reason of exposure to the weather on land or at sea, or to the action of acids, or the gases and moisture of coal combustion, in combination with the oxygen of the atmosphere, this is a question of vital interest to all engineers and others concerned in their erection or maintenance. Nevertheless, comparatively little has been done thus far toward securing such cleaning as will insure a much longer life for, as well as economy in the maintenance of, such structures. The dawn of a better day seems to have appeared, in the application of better methods, in some instances, on new work, and, in more cases, on the old; and it is to be hoped that the full light of that day may soon be seen, in the results on new work in the shop—as a provision for the future—and on old structures—to undo, as far as possible, the neglect of the past.

It has often been observed that mill marks made with paint of a very inferior quality have afforded good protection to steel, while other portions, covered with a much better paint, have been much affected by rust, the latter even extending under paint which, for the most part, has still retained its continuity and elastic qualities. The explanation is found in the facts that the mill marks were made when the metal was clean, and that the paint applied subsequently was spread upon the mill scale, rust and grease which had accumulated upon it before the shop work was finished. However excellent may be its qualities, it is absurd to expect any paint to preserve steel to which it is applied, unless the mill scale, rust, dirt and grease have been first removed. This observation applies with equal, or, it may be said, with even greater force, to the repainting of old structures which have been neglected, and upon which rust and corrosion have proceeded so far that it

*Paper presented before American Society of Civil Engineers by Mr. Geo. W. Lilly, Asso. M. Am Soc. C. E., and published in the society's proceedings for February, 1903.

is impossible to secure good preservation by ordinary methods of cleaning. Having this knowledge in mind, it is proper to determine, from the conditions met in any case, what is necessary to be done in order to insure that the preservative coating shall be applied only after the surface of the metal is clean and in proper condition to receive it. To accomplish this, there is no doubt that much of the new as well as old steel will be required to be cleaned by means of the sand-blast, as the only practicable and effective method. Much of the steel, after leaving the mills, is stored out-of-doors and exposed to the weather for a considerable length of time before the shop work is done. Thus its rusting often progresses to such an extent that the ordinary process of cleaning with wire brushes, even if that be attempted, is not sufficient to permit the paint to come into immediate contact with and become firmly adherent to the metal. The quality of the paint used, on new structures as well as old, is an important matter; but that cannot be discussed in this paper.

The effectiveness of the sand-blast process depends upon the ability of sand, used as a projectile, to break up, wear away and remove the substances against which it is directed, when actuated by a current of compressed air. All the machines, often called mixers, for the application of this process, are intended to secure the introduction of the proper proportion of sand into a current of compressed air, passing through a pipe. This current of compressed air, bearing with it the sand thus introduced, is then directed into and through rubber hose, preferably 2¼ or 2½ ins. in diameter, and a steel or iron nozzle of suitable size, and against the surface to be cleaned. Sometimes the air-blast alone may be used to remove dust and soot. Such an appliance was first invented and patented by General Benjamin C. Tilghman, the patent being issued on October 18th, 1870. This appliance, as improved by Mathewson, is still on the market. In this apparatus, a slotted slide, operated by a lever, regulates the quantity of sand introduced into the current of air. This is shown by the sectional drawing, Fig. 1.

In the Paxson-Warren machine, Fig. 2, the feed of the sand is regulated by a revolving piece, or valve, which covers the opening in the bottom of the hopper to the extent desired to let the proper quantity of sand fall through it and into the air pipe.

In the machine patented by J. M. Newhouse, of Columbus, Ohio, shown in Fig. 3, the sand passes from the hopper at the bottom through an annular opening around the end of a nozzle-shaped steel piece, which decreases in its outer circumference toward the end; and by raising or lowering it, this annular opening may be increased or diminished in size. The distinguishing feature of this appliance is the use of this nozzle as a

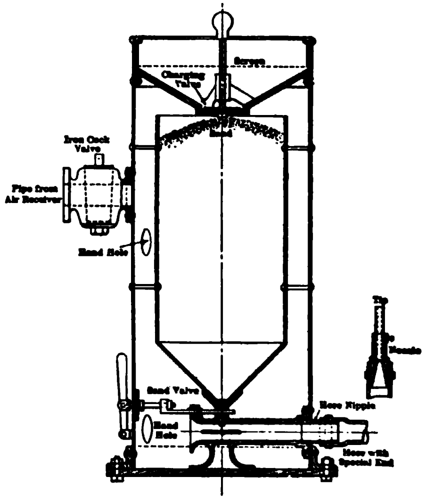


FIG. 1.

MATHEWSON'S SAND-BLAST.

siphon, with its perforations as shown. The small holes permit part of the air which flows through the small pipe and the siphon to escape outwardly through the surrounding sand, thus stirring it up and preventing it from clogging at the opening. A similar siphon, without the perforations, is placed in the air pipe.

Possibly there are other machines, but the writer is not familiar with them. Any of the sand-mixers may be made with two chambers, with valves arranged so as to lock the sand through the upper one into the lower one while the sand-blast is in operation.

The greatest merit of the sand-blast is that it removes from the surface of the metal every trace of dirt, scale, rust and grease, and the bright, metallic surface is everywhere exposed and perfectly clean. This is an ideal condition to secure the strong adhesion of the paint, so that, so far as it is possible, it will protect the metal. The thoroughness of the cleaning effected by the sand-blast is noted especially upon the metal surfaces which have been pitted by rust and corrosion to a considerable degree. The pits are thus cleaned as thoroughly as other places.

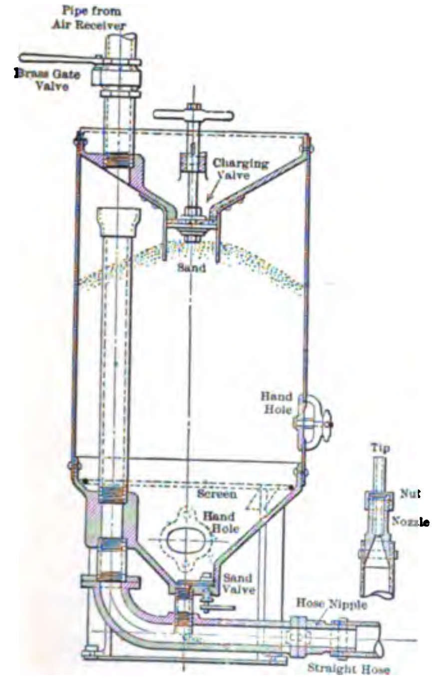
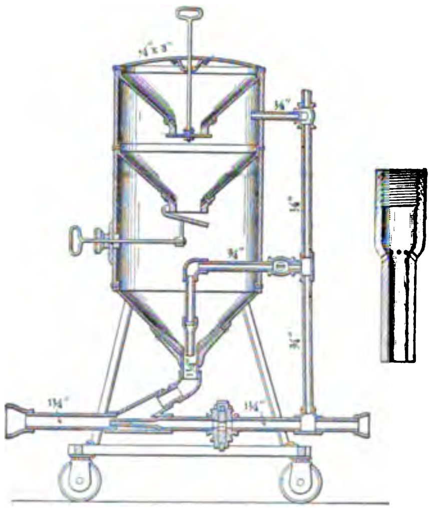


FIG. 2.

PAXSON-WARREN'S SAND-BLAST.

It also reaches and cleans effectually every portion, in re-entrant angles and on the edges of the different sections of a beam, girder or post, on and around rivet heads, and in many other places either entirely inaccessible to the wire-brush or steel-scraper, or on which they are used with great difficulty and little effect.

Such places cannot be cleaned thoroughly by hand, even with the most diligent effort. Even plane surfaces of considerable area, on old structures requiring re-painting, especially where covered largely with scales and rust, can not be thus cleaned so as to remove all the dirt, rust, scale and disintegrating paint. There will still remain sufficient rust and scale to separate slightly the paint from the metal, so that there is not the intermate contact and firm adhesion necessary to prevent the rusting process. The continuity of the coat of paint will soon be broken at places, and moisture and gases in the atmosphere coming in contact with the metal, rust will be formed even under places where the paint remains intact.



THE NEWHOUSE SAND-BLAST.
FIG. 1.

Paint applied to such surfaces can often be stripped off like the peel of an orange, and still remains tough and elastic. Good paint it may be, but it has never taken a good hold on the steel. On the other hand, the writer has seen a piece of old steel, which was cleaned and painted with red lead in 1899, on which the paint will not peel off at all, but may be cut away, still leaving the under portion tightly adhering to the steel.

The sand-blast has been found serviceable and economical for other purposes than the cleaning of steel plates and structural steel.' It is used in cleaning iron and brass castings, either by the direct application of the blast, or by introducing the sand-blast through the hollow trunnion of the tumbling barrel in which the castings are placed. The inner, as well as the outer, surfaces of castings are thus cleaned, and the sharp lines of the edges preserved, while the cleaning effected by the tunbling barrel without the sand-blast tends to round off the corners. Its use to clean street railway rails and fish-plates, for cast and electric welding, is familiar to all. It is also quite effective in cleaning cut-stone work. One of the ice-manufacturing companies of Columbus, Ohio, has recently purchased a sand-blast machine for use in removing from its condenser pipes the lime scale formed from the hard water used.

The Columbus Railway Company has made use of it in cleaning about 18 ins. in length of a large number of its iron trolley poles, just above and below the surface of the ground. At this point the poles had rusted to such an extent as to weaken them materially, and it would soon have been necessary to replace many of them. After cleaning in this way, a coat of paint was immediately applied, and soon afterward each pole was encased in a cylinder of cement mortar tamped into removable form.

The sand-blast has also been used at the shops of the Pan Handle Railway, and in other railroad shops, in cleansing the tenders of locomotives before repainting. A great saving of expense is thus realized and superior work is obtained. It would be attempting too much to take up the methods and relative costs in these various lines of sand-blast work.

It seems that, beyond a few scattered experiments, only during the past six or seven years may be found any published record of the application of this process to the cleaning of structural steel. And, even in these recent years, no very great amount of such cleaning has been done. Most of the trials heretofore made have been upon a somewhat experimental basis, and yet something may be learned from them. It is still rather problematical as to how cheaply the mill scale, rust and grease could be cleaned from new steel plates and structural steel, if an efficient permanent plant were provided for the purpose. Some new plates for the bilge keels of the Massachusetts were cleaned at the United States Navy Yard, Brooklyn, in April, 1897. With one nozzle, 3,155 sq. ft. of surface were cleaned in 11 hours. This is at the rate of 286.8 sq. ft. per hour. The cost of the work was 0.56 cent per square foot. Upon this basis the writer estimated that the sand-blast cleaning of new steel plates, I-beams and other sections, would cost from 50 cents per ton, for very heavy sections, to $1.75 per ton, for light sections. This would not be a very large additional expenditure upon steel structures, considering the longer life which it would, no doubt, insure for the steel thus treated. The rapid deterioration and wasting away which has been observed on bridges and other structures may well cause builders of steel-framed buildings to consider the advisability of cleaning the steel in this way, before painting it and hiding it from inspection in the walls. The safety as well as the durability of such buildings may depend upon better provision against the rusting out of these steel frames. Who knows?

The steel for the anchorages of the cables of the New East River Bridge were cleaned by the sand-blast, under the direction of L. L. Buck, M. Am. Soc. C. E., Chief Engineer. This was done for the special reason that it would be "buried in the masonry, and would be totally inaccessible for all time." This process was also used on some of the steel in the Boston subways, Howard A. Carson, M. Am. Soc. C. E., Chief Engineer. The writer has no figures as to the cost in these cases.

Much of the expense of repainting in the future would be saved if greater care were taken in securing thorough cleaning at the shops before applying the first coat of paint to new work. If this is to be accomplished, it will in many cases be found necessary to use the sand-blast; but this will not be done until the purchaser is willing to pay for it; and he must be convinced of its necessity and ultimate economy before he will be willing to do so. When there is a demand for it, the shops will be equipped with the necessary machinery, and will be able to do it more cheaply. At present, one shop has to bid against the other, and, none of them being required to make bids with such cleaning as a part of the specifications, the bids are such that the shops probably cannot afford to clean the steel properly, in some instances at least. They are averse to this process because of the expense of fitting up for it, the delay in getting the work out, and the cost of handling. Therefore the purchaser must be the prime mover in securing such work.

In the cleaning of old structures for repainting, this process has been more extensively applied, and, therefore, there are better data relative to such work than as to the cost of cleaning new steel at the shops. The necessity of its use to preserve old structures requiring repainting is more apparent than the more remote future saving of the expense of its application for repainting, by a much smaller outlay to secure thorough cleaning before erection.

During the latter part of March and the first two days of April, 1897, the bottom of the United States steamship Atlanta was cleaned at the United States Navy Yard, Brooklyn, by means of the sand-blast, the plant used being furnished by Ward & Nash, of 26 Whitehall street, New York City, who had the contract for the work. Its cost was 4.24 cents per square foot; but the work was done on a more or less experimental basis, and, with the added experience of the past six years, and a more perfect plant, it could probably be done for much less.

The work done on the One Hundred and Fifty-fifth Street Viaduct, in New York City, under the direction of E. P. North, M. Am. Soc. C. E., Consulting Engineer, during the year 1897, is familiar to all.* The cost of this work was reported as averaging about 13 cents per square foot, ranging from 20 cents, at the first, down to a little less than 10 cents, in the latter part of the work of cleaning 50,000 sq. ft. of surface. The pressure of compressed air then used was only about 20 lbs. at the sand-blast apparatus, which is without doubt too low a pressure for the efficient removal of scale such as had accumulated there. It would seem, from recent experience, that a pressure of 35 lbs. would have been much more effective. This is true, because the viaduct was covered to a considerable extent with heavy rust scale and four layers of old paint, and a pressure of 35 lbs. would have made the sand projectiles much more efficient in breaking up and throwing off such scale.

M. E. Evans, Assoc. M. Am. Soc. C. E., who was in immediate charge, estimated that the 600,000 sq. ft. of the painting surface of the viaduct could be cleaned for about 7.5 cents per square foot. It is quite probable that this could be done now at half that estimate, at least on all portions of the viaduct except the members having a very small extent of surface, where much sand and air are wasted in missing the steel along the edges.

The next work of this kind reported upon was the cleaning of the iron lock-gates and a portion of the aqueduct of the Muscle Shoals Canal, during the years 1898 and 1899, under the engineers of the United States War Department. The first report of this, made before its completion, is found in the House Documents for 1898-9.* This covers the work done to June 30th, 1898; and, on page 1926, Major Kingman states that the cost for cleaning was about 2.3 cents per square foot. In the report† of Sydney B. Williamson, M. Am. Soc. C. E., made after the completion of the work in 1899, the cost of cleaning 49,664 sq. ft., and painting it with red lead, is stated to be $0.0588 per square foot. Allowing a reasonable amount for the painting, it is probable that 3 cents per square foot would be very near the cost of the cleaning alone. In this case the plant was erected on a barge, roofed over, and was very well arranged to accomplish the work. The cost of the plant was included in this statement, and the same plant could be used for continuing such work. This cost was about one-third of the whole cost of cleaning and painting.

During the year 1899 the Pittsburg, Cincinnati, Chicago and St. Louis Railway Company used the sand-blast for cleaning the columns and girders supporting its buildings over the railroad tracks, along the east side of the High Street Viaduct, in Columbus, Ohio. The girders support brick arches, and there are no buckle plates. They are subjected to the blast, gases and steam from the large number of locomotives passing to and from the Union Depot, and freight and switch engines passing under them at frequent intervals. This company also cleaned part or all of a bridge at Akron, Ohio. No accurate account was kept of

* *Engineering News*, September 23d, 1897, p. 198; *The Engineering Record*, September 25th, 1897, p. 356; and other engineering periodicals.

* War Department Reports, Engineers, Part 3, p. 1925 *et seq.*

† Engineer's Report, Part 3, p 2289, House Doc. for 1899 to 1900.

the cost and the area cleaned; but, from the best available information, it is estimated to have been about 3 cents per square foot. J. M. Newhouse, the inventor and patentee of the Newhouse Sandblast, is foreman for this company, and his apparatus was used in doing the work.

The city of Columbus, Ohio, has six viaducts in the vicinity of the Union Station, by which the streets pass over the railroad tracks. All the railroads passing through the city, except one, enter and leave the Union Station under the Fourth Street Viaduct near the east end, and the High Street Viaduct near the west end; and some of them pass under each of the other viaducts, one to the west and three to the southwest from the High Street Viaduct. Besides the freight and passenger trains passing under them, much switching is done under each by the yard engines. Hence, all these viaducts have been attacked seriously by rust and corrosion; and, on the portions most exposed to the blast, steam and gases from the locomotives, nearly all the paint has been destroyed and the metal consumed to a considerable extent. The Fourth Street Viaduct has been injured most, and two years ago it was cleaned by hand and repainted. This viaduct was erected in 1891, and was repainted in June, 1894, in September, 1896, and again, at the time above mentioned, in the fall of 1900. When the last repainting was progressing it was found necessary to replace with new ones, seventeen of the 7-in. I-beams supporting the plank floors of the sidewalks over the tracks most used by freight trains and yard engines. The viaduct was painted under a contract, and considerable care was taken in trying to clean it as thoroughly as possible with steel scrapers, brushes, chisels and hammers. The hammers were often vigorously used to jar the scales loose by blows against the steel, and then scrapers, chisels and wire brushes used to complete the work.

At that time the sand-blast was suggested by the Engineering Department, but was not used. With as thorough work as could be done, many scales, so tighly cemented to the steel that they could not be detached, were loosened, upon the application of the first coat of paint, by the softening effect of the oil acting upon the cementing rust. The paint then applied began to scale in places within six months thereafter, partly due to the inferior quality of the first coat of paint and partly to the rust, soot and scale left upon the steel when repainted. The flange-angles of the floor stringers continued to waste away, and, in the summer of 1902, it was found necessary to replace, by new ones, the two angles of the lower flange on each of ninety floor stringers.

The new angles were surrounded with a covering of Portland cement mortar, 1 to 2 mixture, about ¾ to 1 in. thick. This was rammed under the lower surface of each beam, between it and a plank form, which was left to hold it against the steel until it had set for 48 hours. A wire netting, four meshes to the inch, secured by sheet-iron fasteners placed on the rivets as they were driven, was placed so as to surround the lower flange-angles before the cement mortar was applied. The cement covers the angles and netting completely, and is expected to protect them from rust. After seven months the cement is still intact, and shows no sign of cracking.

In view of the rapid deterioration of the viaducts of the city, and the prospect of having to replace them in a few years unless something were done to arrest it, the city authorities were induced to adopt the sand-blast as a means of cleaning them before repainting. Julian Griggs, M. Am. Soc. C. E., Chief Engineer of the Department of Public Improvements, had been very earnest in the advocacy of this course, believing it to be the only one that would be effective. Accordingly, in November, 1901, the work was commenced on the Front Street Viaduct, over the Little Miami Railroad, and 12,600 sq. ft. were cleaned and repainted, under the supervision of the writer as engineer in charge. When the weather became suitable for it, in April, 1902, the work was resumed and continued on this and the other viaducts named until the middle of November. The cleaning done amounted, in all, to 135,500 sq. ft. of surface. The cost and other data relative thereto are shown in Table No. 1. Four viaducts and the south span of the High Street Viaduct were completed. It is likely that the other three spans of the High Street Viaduct, and the Fourth Street Viaduct, will be cleaned and repainted during the coming season of 1903.

It was impracticable to secure good contract work at a reasonable price, and all the sand-blast cleaning, as well as the painting, was done by men hired by the day. Two Newhouse sand-blast machines, mounted on light trucks, so that they could be moved about and placed where convenient for the work, were used in cleaning the viaducts named in Table No. 1. A wire-bound, 1½ in., rubber air-hose, 50 ft. in length, connected each machine with the 2-in. air pipe. Old rubber hose, which was much cheaper than new, was used for the sand hose, part of it being 2¼ and part 2½ ins. in diameter. The nozzles used were ½-in., extra heavy, gas pipe, of various lengths, from 12 to 24 ins. A length of at least 12 ins. seems to direct the blast with more effect than a shorter one. This was used instead of tool steel or other hard pipe because it was believed that it would last nearly as long and cost much less. The average length of time one nozzle lasted was about 5 hours, as shown by the length of pipe used and the total hours run. The nozzle was connected to the sand hose by a heavy, special cast reducer, about ¾ in. thick. This reducer was made thick, to sustain the wear caused by the deflection of the sand into the small nozzle pipe. The most severe wear of the nozzles is at a point 3 ins. from the connection with the reducer.

It will be noted that the sand, in passing from the large sand hose to the small nozzle, is deflected so as to produce a cross-fire, striking with greatest force against the sides of the small pipe near the reducer end. A like wear upon the rubber sand hose occurs near its connection with the pipe from the machine, which is a 1¼-in. pipe, and the spreading out of the sand to form the larger stream causes it to strike against the sides and then deflect to follow the direction of the hose. One foot in length, or sometimes a little more, cut from this end of the hose occasionally, fitted it for further use. The length of sand hose used varied from 25 to 65 ft., being regulated by the distance of the work from the place where the machine had to be placed. As the machines could not be placed upon scaffolding, in this work, at least 35 ft. of hose were required on nearly all the work, so as to reach from the ground to the floor system, from 16 to 20 ft. above the tracks, and in some places out over the tracks as far as 30 to 40 ft.

The nozzlemen should be men of some judgment and intelligence, so that they will understand how to manage the nozzle to make the blast most effective. When ready for work the nozzleman wore a helmet of tin, with cloth curtains hanging to the shoulders to keep out the dust, as far as possible. Instead of using wire gauze in the helmet, two pieces of glass were used for the nozzleman to see through, because it excluded the dust more effectually. When frosted over by rebounding sand, the glasses were removed and new ones inserted. After a little experience, a good nozzleman will learn how to hold the nozzle in any given case, varying its distance from the working point according to the manner in which he finds it is operating. Heavy scale requires him to hold the nozzle close, and light cleaning can be done more rapidly by holding it farther away and permitting the blast to spread somewhat and thus cut a wider swath. On moderately hard places about 5 to 6 ins. is the proper distance. To make it clean most rapidly he must also direct the blast so as to cut a swath clean as he goes, passing first in one direction and then in the other, across the member being cleaned, so as to leave no spots to which he must go back and thus waste the force of the blast on clean metal around them. The nozzle should generally be directed so as to strike the surface at a slight inclination from the normal, say 20 to 30° away from the nozzleman, thus blowing the dust and sand away. The cleaning should be carried forward from the nozzlemen, so that the blast will always act upon the exposed edge of scales, rust, or old paint, and, by getting under any loose portions, throw them off without first having to break them up.

The compressed air was supplied by the Union Depot Company, from a compressor with an air cylinder of 14 ins. diameter and a stroke of 12 ins., compressing the air to a gauge pressure of 50 to 60 lbs. The number of strokes was regulated automatically so as to keep the pressure nearly constant. The air was led from the compressor to a large receiver, and then, by a line of 2-in. steel pipe, to a small receiver at the viaduct where the work was to be done. From this receiver (having a capacity of about 9½ cu. ft.) the air was conducted to the sand-blast machines. The pressure at the machines was usually from 30 to 40 lbs. The requisite length of 2-in. pipe varied from about 1,250 to 2,200 ft. The small receiver had a pet-cock in the bottom to let out accumulated water, and it removed much of the moisture from the air used.

The compressed air was paid for by the city, at the rate of 40 and 45 cents per hour for one machine, and 60 cents per hour for two machines in operation. For 18 per cent. of the time only one machine was in operation. This made the work cost more, because two machines could have been operated for about one and one-half times what one would cost. A foreman, two nozzlemen and three laborers could operate two machines and dry the sand for them. The foreman was paid 35 cents, nozzlemen 25 cents, and laborers 15 cents during one-half of the time, and after that 17½ cents per hour.

The sand used was from Lake Erie. An attempt was made to secure rather coarse, clean and sharp sand; but it was at times impossible to do this without some delay, and some of the sand used was too fine and made much dust on account of the silt it contained. The sand was at first dried in two old locomotive ash pans, with old ties for fuel. This required almost constant attendance by one man, to stir it up and keep it from becoming so hot as to make the grains brittle and ineffective.

About May 1, 1902, the dryer was made by fitting a sheet-steel hopper on an old cast-iron stove. The wet sand would not fall through the ¾-in. holes in the lower part of the hopper, but would as soon as dry. The sand was permitted to cool for a few hours before being used, as hot sand caused steam and was likely to choke the small opening in the bottom of the hopper, around the end of the siphon nozzle. The objection to this kind of a dryer is that the fire-pot, being surrounded by sand in contact with it, burns out in a short time. Two fire pots were required in six months' service.

All the viaducts named in Table No. 1 have buckle-plate floor systems, exposing a large amount of steel surface to the action of rust and corrosion. It may be well to state the conditions under which the work of cleaning had to be done, in order to give a better understanding of the items making up the cost. The data here given may then be better analyzed and applied to any other proposed sand-blast cleaning. The first four viaducts named were erected during 1893 and 1894, and all were repainted during August and September, 1896, and none of them had been repainted since that time. High Street Viaduct was erected in the latter part of 1893, repainted in August, 1896, and again in October, 1899. The cleaning done before repainting, in each of these cases, was only hand-cleaning. All appearances indicate that the steel of the Front Street Viaduct over the Pittsburg, Cincinnati, Chicago & St. Louis and the Cleveland, Cincinnati, Chicago & St. Louis Railways, must have been in better condition than that of any of the other viaducts, and a better quality of paint must have been applied at the time of its erection. This is judged largely from the condition of the portions of the viaducts above the level of the street pavement and protected by it from the direct action of the blast and gases from the locomotives. The portion below the pavement, on all the others, are subjected to greater wear by the locomotive blast on account of their small clearance above the stacks, their clearance above the level of the railroad tracks being only 16.33 to 16.75 ft., while this viaduct has a clearance of 20.33 ft. In cleaning them, therefore, it was impossible to swing any staging below the clearance elevation, in the case of four of them. The Front Street and the Naghten Street Viaducts do not afford sufficient space above the lower surface of the plate girders in which a man can work, and it was necessary to work from movable trestles, about 12 ft. high, made as light as possible, so that they could be moved off the tracks whenever a train or an engine was about to pass, and be replaced and the work continued when the track was clear.

Under the first three viaducts mentioned in Table No. 1, there are two main tracks and one side track, with a spur track from the middle of the first, making four tracks under the east half of it.

Movable trestles were also used, part of the time, in cleaning the cover plates on the bottoms of the girders and the portion of the work along the abutments of the Maple Street Viaduct; but a large portion of the cleaning was done from staging resting upon the lower cover plates and angles of the plate girders.

TABLE No. 1.

Cost, etc., of Sand-Blast Cleaning of Viaducts at Columbus, Ohio.

Location of Viaduct.	Cost of labor.	Cost of flagmen.	Cost of compressed air.	Sand Used. Cubic yards.	Sand Used. Cost.	Dryer, sand blast, scaffolding, etc.	Total cost.	Number of square feet cleaned.	Cost per square foot.	Square feet cleaned with 1 cu. ft. of sand.	Square feet cleaned per hour by one sand-blast.	Average pressure at sand-blast, in pounds per square inch.
Front St., over Little Miami Railroad	$385.80	$45.15	$139.40	54.00	$78.55	$56.68	$705.08	24 900	$0.0288	17.1	64	85
Naghten St., " " " "	140.74	17.85	56.40	28.44	42.41	32.52	289 92	8 000	0.0362	10.4	49	37
Maple " " " " "	228.00	11.90	94.80	34.50	58.08	58.70	446.48	17 000	0.0263	18.2	66	35
Front St., over Pittsburg, Cincinnati, Chicago & St. Louis and Cleveland, Cincinnati, Chicago & St. Louis Railways	670.66	....	229.80	92.65	107.43	87.18	1 095.07	63 000	0.0174	25.2	89	30
High St. (South Span)........................	951.20	....	319.94	129.91	161.47	122.46	1 555.07	22 600	0.0688	6.1	23	38
Totals and Averages	$2 370.90	$74.90	$840.34	339.50	$447.94	$357.54	$4 091.62	135 500	$0.0302	14.8	54	33
Excluding High St. Viaduct	....	....	....	....	....	....	2 536.55	112 900	0.0225	20.0	74	33

To secure the safety of the men while at work on these three viaducts, when using the trestles over the tracks, it was necessary to have flagmen to give warning of the approach of trains, so that the trestles could be removed in time to avoid the danger. On the Maple Street Viaduct flagmen were not needed for so large a proportion of the time as on the other two viaducts. The cost of flagmen alone amounts to about 0.2 cent per square foot on the first two in Table No. 1, and 0.07 cent on the Maple Street Viaduct. The time lost on account of trains and switch engines sometimes amounted to one-fourth of the working time. If there had been no interruption by trains, and if flagmen had not been required, a fair estimate, from approximate calculations, based on records of the time lost each day and the cost of flagmen would reduce the cost for the work to about the following figures: Front Street Viaduct, 2.3 cents; Naghten Street Viaduct, 3 cents, and Maple Street Viaduct, 2.45 cents, per square foot. Matched flooring screens, fastened with copper nails, were placed immediately over the main tracks and under the floors of these three viaducts, to protect them from the blast from locomotives.

In the Front Street Viaduct, over the Pittsburg, Cincinnati, Chicago & St. Louis and the Cleveland, Cincinnati, Chicago & St. Louis Railways, in which the clearance was 20.33 ft., the staging was supported on iron hangers which reached 2 ft. below the lower flanges of the floor beams. This space, with the 29 ins. more to the buckle-plates, gave room enough for the work, and the staging still gave about 2 ft. more clearance than the High Street Viaduct, just east of it and over the same tracks. The portion of the three heavy trusses above the pavement was in very fair condition, and it was not thought necessary to clean it with the sand-blast. This saved the cleaning of 36,000 sq. ft. of metal surface on this viaduct, while, on the others, practically all was cleaned. Some of the paint was still good, and it was not all taken off. This, together with the fact that there was not much interruption to the work, made the cost of cleaning, on this viaduct, less than on any other, all the others being much affected with rust, scale and corrosion upon nearly all parts of them, even above the level of the pavement, where protected from the direct action of the gases.

The south span of the High Street Viaduct, the portion already cleaned, is over the main freight and passenger tracks, and yard engines pass under it frequently. The other spans can be cleaned for very much less than this one. It has been estimated by men who are in the employ of the Pennsylvania Railway Company that an average of from 250 to 300 engines pass under this span every 24 hours. The girders and buckle-plates were in very bad condition, and very heavy and exceedingly firm scale had been formed over large portions of them. This scale was firmly cemented to the steel by the rust and carbonates which had formed. As a consequence, the sand-blast did not blow off much of it, nor did it work under the scale and throw it off, as on the other viaducts. Therefore, it cost nearly twice as much as the highest of the others, and nearly four times as much per square foot as the large Front Street Viaduct. The floor system is similar to that of the Maple Street Viaduct, the pavement being supported by seventeen plate girders. Immediately east of this is the structure under the roadway to the Union Station, also having seventeen plate girders. The distance over both is about 165 ft., and this, with the girders extending 3.5 ft. below the floor, causes the smoke to hang a long time between the girders after an engine has passed beneath. Often, it does not clear away before another engine comes along and again fills all the spaces with dense smoke. The smoke, and the dust from the sand-blast work, therefore, caused a great deal of trouble. It was very difficult, and part of the time impossible, to get nozzlemen to keep both blasts in operation. To get rid of the smoke and dust, an electric fan was tried for a short time, it being placed near the abutment between the girders where the work was progressing. This kept the smoke from rising, and cleared away the dust quite well; but the bearings were injured very much by the dust and fine sand. Then the blower was made. This was connected with the air pipe by a ½-in. rubber hose, and a jet of compressed air, passing through an opening of about 1-32 in., and into and through a section of 5-in. sheet-iron pipe, about 2 ft. long, set up a current of air, which, being directed along between the girders, was quite effective. One of these was made for each sand-blast, and they were used for a considerable portion of the time. Smoke and dust, however, would gather behind the blower and be drawn through it at times, and it was not a complete success. It was effective for a distance of about 20 ft.

Another cause of the high cost of this work was the low pressure secured at the sand-blast machine during much of the time. The operation of the blowers tended to reduce it, and the compressor was worked beyond its intended capacity, and was not at the time doing as good work as earlier. The average pressure, at this viaduct, as stated in Table No. 1, is partly an estimate, as the gauge was broken and for a portion of the time was not in use. When at 30 lbs. or less, the sand-blast was very slow in cutting the scale here encountered; but when at 38 to 40 lbs., it was much more efficient. Occasionally, when only one blast was in operation for a short time, the pressure would run up to 45 lbs., and then the effect was still better.

From the experience in sand-blast cleaning here given it may be stated safely that, for heavy scale and corrosion, in situations such as this High Street Viaduct, a pressure of from 35 to 45 lbs. per square inch is not any too high. On the other hand, very efficient work is done at a pressure of about 25 lbs., where only light scale, rust spots and disintegrating paint are to be cleaned off. The labor costs approximately twice as much as the power, and increase of power is advisable where needed.

On all the cleaning done, the bright surface of the steel, having almost the appearance of frosted silver, was exposed to view by the removal of every vestige of rust, scale and old paint. The pitted portions, with a little more brushing, were as well covered with the paint as the others, and, after one year, it still holds on them as firmly, to all appearances, as when it first dried, after being put on.

The paint was applied very soon after the sand-blast, and sometimes curtains of heavy muslin were stretched between the painters and the sand-blast to prevent the dust and sand from interfering with the painting. All surfaces cleaned were painted before night, and rarely was it necessary for the painters to work more than half an hour after the sand-blast was discontinued for the day. It is best to work with the wind, so that it will carry the dust and sand away from the painters and nozzlemen.

Some records of actual results are shown in Table No. 2, both in the ordinary work of cleaning, and on tests in which an accurate account was taken for all the data presented therein. In some of these records there are omissions because all the elements were not noted. The long-time records give only the surface cleaned, and not the sand used or the horse-power necessary; and the two, showing results as to the whole work, are included for the sake of comparison. In these two are given some other results of calculations, from known quantities and records, which represent rates for one sand-blast, although two were running about 82 per cent. of the time. The number of hours stated is obtained by adding together the number of hours run by each machine. The tests of October 16th and 31st, 1902, were made in order to determine the relative effectiveness of nozzles of different diameters, from ¼ to ¾-in. in size. The sizes of pipe given are the nominal sizes of gas pipe, with "Ex. H." added where extra heavy gas pipe was used, which, of course, is smaller in interior diameter than standard gas pipe. The last one noted was with a nozzle, made from three ¼-in. gas pipes, one end of each being inserted in a 1¼ × 1-in. bushing, and babbitt metal poured in to secure them there. While only made for an experiment, this nozzle gave very good results, it having the highest rate of cleaning, in square feet per hour. It used considerable sand, about the same as the ¾-in. pipe, but cleaned nearly one-half more.

All these tests were made on the High Street Viaduct, where, for all of them, the corrosion was, as nearly as possible, of the same character. The rates of cleaning are low, because, on this viaduct, the scale was so hard. These tests of nozzles were made with a sand hose 65 ft. in length. All the nozzles for these eight tests were 12 ins. long. It will be seen from the results that the ½-in. extra heavy pipe, which is ¾ in. when worn out, is about the proper size for this kind of work.

Improvements can certainly be made in this apparatus. Some of the appliances were made as experiments, and are rather

TABLE No. 2.

DATA AS TO THE OPERATION OF THE SAND-BLAST, AND TESTS OF NOZZLES OF DIFFERENT DIAMETERS, AT COLUMBUS, OHIO.

Date.	Duration. Hours.	Duration. Minutes.	Nominal size of gas pipe nozzle.	Air Pressure. At compressor.	Air Pressure. At sand-blast.	Cubic feet of free air per minute.	Horse power required.	Cubic feet of sand used.	Area cleaned, in square feet.	Square feet cleaned per cubic foot of sand.	Rates per Hour. Cubic feet of sand	Rates per Hour. Square feet cleaned.	Remarks.
1899. Sept. 27......	....	29	¼"	..	35	170	20.4	1.52	110	72.5	3.14	227.6	Pittsburg, Cincinnati, Chicago and St. Louis Railway work.
1901. Nov. 14	....	55	½" Ex. H.	50	35	170	20.4	6.60	144	21.8	7.20	157.1	Plate girder, considerably rusted.
" 16......	....	26	¼" Ex. H.	50	36	..	....	2.20	77	35.0	5.10	177.7	Plate girder, paint nearly destroyed.
" 14......	4	45	¼" Ex. H.	50	35	170	20.4	....	375	....	....	79.0	Plate girder (includes lost time).
" 16......	8	..	¼" Ex. H.	50	36	...	....	....	322	....	...	107.8	Plate girder, paint nearly destroyed (includes lost time).
" 18......	7	50	¼" Ex. H.	50	36	...	....	....	655	....	...	83.6	Plate girder, paint nearly destroyed (includes lost time).
" 19......	7	30	¼" Ex. H.	50	35	...	....	....	825	....	....	110.0	Plate girder, paint nearly destroyed (includes lost time).
" 20.....	7	30	¼" Ex. H.	40	25	...	....	....	1,227	....	....	164.0	About 10% of paint good and not removed (includes lost time).
Dec. 7.	13	30	¼" Ex. H	48	33	...	....	....	1,000	....	....	74.1	Floor system over railroad tracks (includes lost time).
Nov. 14th, 1901, to Aug. 13th, 1902..	1 519	..	¼" Ex. H.	..	33	...	....	5,658.9	112,900	20.0	3.72	74.3	First four viaducts in Table No. 1.
1902. Aug. to Nov.	990	..	¼" Ex H.	..	33	...	.	3,507.6	22,600	6.4	3.54	22.8	High Street Viaduct, see Table No. 1.
Oct. 16	....	18	¼" Ex. H.	55	37	156	18 7	1.40	11.80	8.4	4.67	39.33	High Street Viaduct. test run.
" 16......	....	24	⅜"	55	37	140	16 8	1.31	6.65	5.1	3.28	16.63	High Street Viaduct, test run.
" 16......	....	27½	¼"	55	39	108	18.0	1 20	2.42	2.0	2.62	5.28	High Street Viaduct, test run.
" 20...	...	27	¼" Ex. H.	..	35	...	....	3.30	18.70	5.4	7.67	41.60	High Street Viaduct (another blast running).
" 31......	...	7½	⅜"	55	40	200	24.0	1.10	4.25	3.9	9.10	35 20	High Street Viaduct, test run.
" 31......	....	18	¼" Ex. H	55	41	170	20 4	2.20	14.00	6.4	7 33	46 67	High Street Viaduct, test run.
" 31	....	9	⅜"	55	42	156	18.7	1.10	6.60	6.0	7.33	44.00	High Street Viaduct, test run.
" 31	....	24	¼"	55	43	130	15.6	1.00	4.75	4.7	2 50	11.88	High Street Viaduct, test run.
" 31......	. .	7	⅜"	55	41	176	21.1	1.10	6 00	5.4	9.43	51.40	High Street Viaduct, test run.

crude. One observation may be made which will occur to all, that more sand-blasts might be added with advantage, if sufficient power to run them were provided. The work at Columbus was limited to two machines, on account of the small capacity of the compressor. Perhaps a larger pipe to convey the air would have added to the pressure at the machines, and to the effectiveness of the sand-blast. For ordinary cleaning of bridges and other structures, not subjected to such hard treatment as viaducts situated where much exposed to the blast and gases from locomotives, it is safe to say that, with a more perfect equipment, sand-blast cleaning can be done at from 1¼ to 2 cents per square foot. The advantages anticipated for this kind of cleaning, especially where almost a necessity, because nothing else will do the work thoroughly, are to be gained by a careful inspection at intervals after it is done, and the repainting, with ordinary, good hand-cleaning, before the paint has been worn off so as to set up the vigorous rusting process which comes when air and moisture get to the metal. In such locations as the viaducts in Columbus it seems to be the only thing that will do the work. For future construction in similar locations let every engineer beware of the use of steel exposed to locomotive blasts, as these will wear out any paint. The life of those structures already in existence, and others which may be built in the future, should be extended as long as possible by the use of the best means that can be commanded.

Notes on the Design of Riveter Yokes.*

There are three principal methods of driving rivets—by hammering by hand and finishing with a set or "snap;" by hammering with a pneumatic hammer, a device having a rapidly moving piston, striking several hundred blows a minute on a suitable die, or snap, inserted in the end of the cylinder; this is a quite recent method, but for field work is rapidly superseding hand riveting. The large majority of rivets for structural, boiler and plate work, however, are driven by machines, which squeeze or upset the blank rivet end to form a head. Compression riveters are of several distinct types; the oldest form is the hydraulic riveter, consisting of a cylinder and piston or plunger, operated by high pressure, carrying a suitable die. The work to be riveted is placed between the jaws of the machine, the made head resting in a suitable die, attached rigidly to the jaw or stake of the machine. Other machines are of the same general type, differing in the means for applying the power and the kind of motor fluid, as, for instance, direct steam-driven or air-driven. Toggle joint devices, actuated by air, steam, electricity or belts. A late design uses an air cylinder, acting as a hydraulic intensifier, with provision to give a considerable travel at low pressure, followed by a short travel at high pressure.

In all of the compression riveters, of whatever type, the moving die is on one leg or jaw, and the pressure reaction is taken up by an opposed jaw. In general, the form resembles a letter U, the two legs being either in one piece or united by bolts.

This paper will discuss the design of a pneumatic toggle joint riveter, of 12-foot gap, made in one steel casting, of sufficient stiffness to drive rivets 1¾ inches in diameter.

The pressure required to close hot soft steel rivets has been determined quite accurately by Sellers & Co., of Philadelphia, by means of experiments with a hydraulic press, with pressure-recording attachment. These tests have been fully described in the technical press in the past.

The net working result is that to close ordinary soft steel rivets, at bright red heat, with a round or button head, a pressure of 150,000 pounds per square inch of rivet section is required. For large rivets used in boiler work it is customary to heat the rivets as hot as possible, without burning them, in order that the material shall flow easily and completely fill the rivet holes. Under these conditions less power is required to close them, and a pressure of 129,000 pounds per square inch, rivet section, has been found ample.

The pressure required to drive a 1¾-inch diameter rivet, with round heads, is, therefore, the area 2 and 4-10 square inch by 129,000 pounds, or 309,600—say, in round numbers, about 300,000 pounds.

With the type of toggle joint used, assuming a cylinder 18 inches diameter, 12-inch stroke, with air at 80 pounds pressure, we have a total cylinder pressure of

* Written by Chester B. Albree, for the "Proceedings of Engineers' Society of Western Pennsylvania, January, 1903.

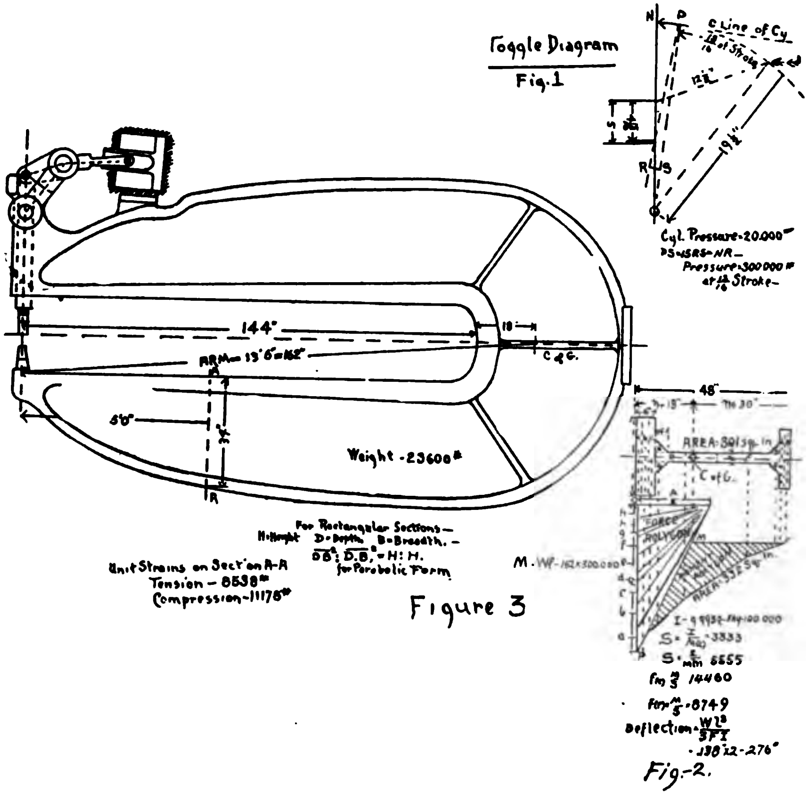
20,320 pounds, or, in round numbers, 20,000 pounds.

In the force diagram of the toggle used (as per the diagram, Fig. 1) we note that the strain, when upper end of the side links have traveled 13-16 of the total distance, is about 15 times the cylinder pressure, or 300,000 pounds—the required amount.

Observing the corresponding travel of the ram, we see that it has traveled to within 1-16 inch of its total travel of 5 inches, or practically the whole distance, hence the rivet head is practically finished at this point. In toggle joints the final pressure becomes theoretically infinite and the plunger travel zero.

The actual pressure on the rivet, however, is measured by the stiffness of the yoke, which yields somewhat under the stress.

In designing the yoke we aim to get the required stiffness with the least weight, and assume that with yokes of well-annealed O. H. steel castings, we may safely use unit strains of 10,000 pounds tensile and 14,000 pounds compressive. Castings, pulling 60,000 to 65,000 pounds, with elastic limit of 30,000 to 35,000 pounds, are used. The gap being 12 feet, or 144 inches, the depth at back of yoke was taken as 1-3 of the gap, or 48 inches. This proportion can be varied by changing the proportions of cross section, but experience has shown this proportion to give economical results.



The section was made an irregular I-beam form, having a tension head much larger than the compression end. We assume a section that looks about right, and by the well-known principles of graphic statics, divide it in layers (see

Fig. 2), determine area and center of gravity of each, and lay off the areas to some convenient scale and construct the force diagram, making the pole distance one-half the length of the load or area line.

This forms always a right-angled triangle, of which particular construction further mention will be made later. We then construct the equilibrium diagram, finding the resultant and locating the center of gravity of our section.

I have assumed that if the arm of the bending moment were taken as the diagonal from the end or nose of the jaw to center of gravity of the median section at the center of the curve, then the increase in length over the straight gap of the machine would compensate for the curvature and actual results in practice, as well as comparison with the mathematical solution, seem to justify the assumption.

Having determined approximately the length of the moment arm, we then have

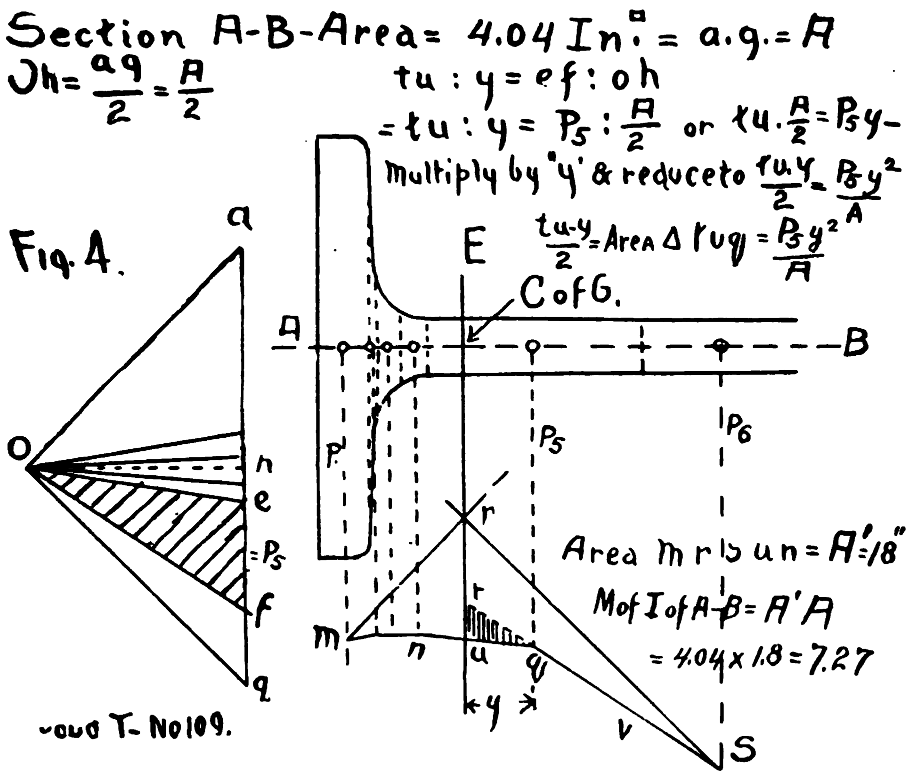


Fig. 4.

In Fig. 3 is shown an outline of the yoke, which you will notice is curved where the two arms or jaws join. The exact mathematical determination of the strains in a curved beam of this shape are very complex. The problem has been studied by several mathematicians, including an exhaustive article published last year in the transactions of the Deutches Eisenhuttenleute Verein; but in practice our bending moment, which for a beam loaded at one end and fixed at the other, is simply Wl— or 300,000 x 162 inches.

Next determine the moment of inertia of the assumed cross section, which may be done analytically, arithmetically or graphically.

The graphic method is simplest, and we use a method shown in Molesworth's handbook, 1889 edition, which is simpler than any other. Although most of you are probably familiar with it, yet for the benefit of those who have not used it I give the proof from Merriman and Jacoby's treatise on Bridges and Roofs—Part II, Graphic Statics, 1902 edition:

"We assume in Fig. 4 a standard T section, divide into convenient sections, letting areas be represented by force lines P^1 P^2—P^5.

Let oh be the altitude of triangle oag and y the altitude of triangle qtu; hence —tu:y=equals ef:oh—but ef=P^5 and oh=½A. or tu:y=P^5:A-2. Multiplying this equation by y and reducing, we have ½tu.y=P^5 Y^2-A, but ½tu.y=area of triangle qtu.

If the area P^5 were of the width dy its moment of inertia would be P^5 Y^2. In like manner, the moments of inertia of

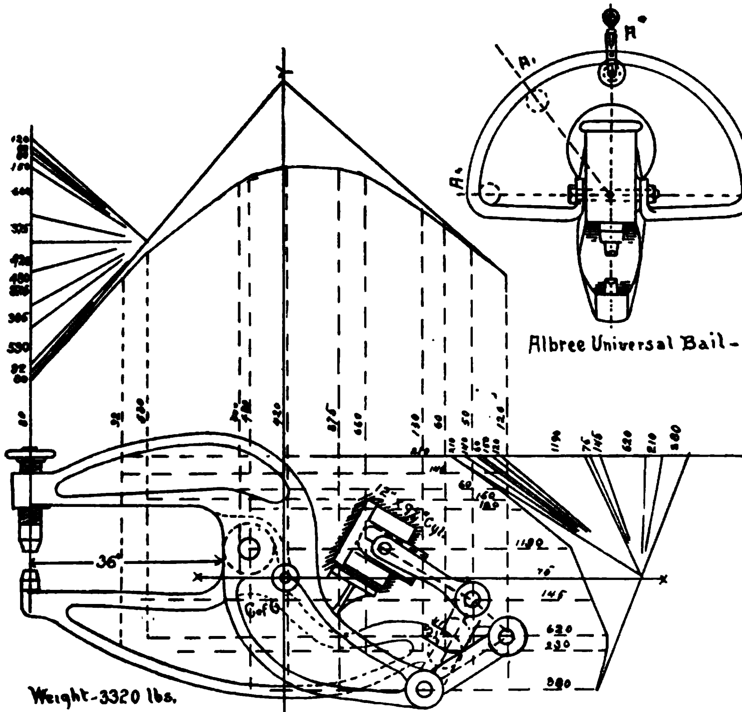


Fig. 5
36" Tipper Riveter—
for 1⅛" Rivets—

"Lay off the load line—ag—parallel to forces P^1—P^5 and proportional thereto, to some convenient scale; make the pole distance oh=½ ag=A2, and construct the force polygon—oag—which by construction is a right angle triangle.

Construct the equilibrium polygon m r s and determine the center of gravity of the Section A—B. Produce sq. to meet axis E at t—. Then triangles qtu and ofe are similar, as sides are parallel by construction.

each force P^1 P^2— — P^6 can be determined, and also the corresponding triangles and their sum, the moment of inertia of the whole section A—B would therefore be the total area of section multiplied by the area of the equilibrium polygon. This latter area, denoted by A_1, can be determined by a planimeter or otherwise, and we have—I=A^1A. Q. E. D.

Referring again to Fig. 2 and using the method just explained, we see the area of the section is 301 s. in. and of the moment polygon, 332 sq. in., and their product about 100,000 as the M. of I.

In the well-known formula for the section modulus—S=I/N—and for extreme fibre strains—f=M/S—we find for tension 8,749 lbs. and compression 14,460 lbs., which are safe, and as a check, and to determine the deflection we use the formula $\frac{Wl^3}{3EI}$ =deflection, using E as 29,000,000, and find the deflection of the beam, supposing the section uniform throughout, to be .138 inches. As there are two arms, equally strained, the total deflection is .276, or a little over ¼ inch. In actual test the measured deflection was 7-16 inch, probably due to the tapering ends being designed a trifle light to keep outer stake small enough for certain work to be done. As this machine has been in constant use for over two years, and no permanent set has taken place, we feel assured of the results and methods.

Having fixed the median section, we design each arm to be a beam of uniform strength. Such beams may be various shapes, but the design chosen is a beam of I-beam section, in general similar to the median section, varying in size according to the parabolic curve, but having the inner edge on a straight line.

The exact proportion of depth, width, thickness of flanges and web might be figured exactly by a more expert mathematician than the writer, but the method adopted was to use the parabolic form for a rectangular cross section, and then finding the unit strains for different points and modifying the cross sections until these unit strains were practically the same as found for the median section.

In large castings blow holes or other defects sometimes occur, and often exist inside, but by omitting as far as possible cross webs and irregularities, fairly good castings can generally be obtained. In several hundred yokes that we have had, but two or three have failed under pressure, and then from blow holes at critical points.

This particular riveter is used for riveting marine boilers 10 to 16 feet diameter, having plates from 1 to 1¼ inches thick, and practically no rivets have had to be caulked to prevent leakage. For large diameter rivets it is best to allow the pressure to remain on the rivet until the steel is black, for if the pressure is taken off while rivet is still red hot the spring of the heavy plates will often stretch the rivet and a leak will be the result.

In small portable riveters it is often desirable to be able to use them in other than vertical planes, for crooked work. This has been generally accomplished by a double worm gear attachment forcibly holding the yoke in any desired position. The writer devised a special form of bail, called the universal bail, to accomplish this result in a simpler manner, permitting of more rapid adjustment.

In mechanics we read that a body will be in equilibrium if supported from above or below, from its center of gravity. Hence if a riveter were suspended from trunnions passing through the absolute center of gravity of the machine it would be in equilibrium, in a vertical plane, if the axis were parallel to the horizon. If the bail, instead of having the usual straight sides, is made in the form of a semi-circle, whose center is the center of gravity of the machine, then if the bail be suspended from any point of the arc, the machine would still be in equilibrium.

By suspending the bail on a trolley attached to a swivel above, the bail can be rolled around and the riveter worked at any angle in any plane.

To determine the exact center of gravity in advance of actually building a machine is necessary in order to locate the trunnion axis on the body of the machine in a convenient place and to provide bosses for trunnions on the pattern.

After designing the general layout of a machine, as in Fig. 5, bearing in mind the probable location of the center of gravity, we mark off on the plan various convenient parts whose weight can be determined, and ascertain as nearly as possible the center of gravity of each such portion. We then construct the force diagram and determine a line containing the center of gravity for one position. We then go through the same process, but for a position at right angles to the first, finding the center of gravity line for this position. The intersection of the two lines locates the absolute center of gravity, and as the machines are symmetrical as regards a median plane lengthways of the yoke, the determination in the third plane is unnecessary.

It is obvious that for machines having deep throats the center of gravity tends to come more nearly to a middle position between the arms. As this location does not permit of placing the trunnions without interfering with the gap of the riveter, it is necessary to add weight to the upper side, at as great a distance from the jaw opening as possible in order to locate the trunnions on the body of the machine. In practice we find that for riveters over 48-inch gap, the extra weight and bulk are so great as to make such machines impracticable.

Compressed Air.*

Reference has been made to the use of compressed air and its facility of adaptation to various requirements; but it is evident, from an inspection of some of the devices in use, that enthusiasm for new methods, rather than good judgment, has prevailed in many of its applications. For some years compressed air was used only in mines, where it produced marked economies. Later, it was introduced into manufacturing lines, and to-day its use in railway and other machine shops, boiler shops, foundries, and bridge works is being widely extended.

The air is used to operate riveting machines, punches, staybolt breakers, staybolt cutters, rotary tapping and drilling machines, fine rollers, rotary grinders, rotary saws, pneumatic hammers, chisels, and caulking tools, flue welders, boring and valve-facing machines, rail saws, machines for revolving driving wheels for setting valves, pneumatic painting and whitewashing machines, dusters for car seats, and the operation of switching engines about the yard. It is also used in the foundry for pressing and ramming moulds and for cleaning castings by the sand blast; but its greatest field of usefulness is its application to hoisting and lifting operations in and about the works.

New applications of compressed air are constantly being made, and each new use suggests another. This has a tendency to increase the number of applications which are intended to be labor-saving devices, but in many cases the work could be done just as well and much more cheaply by hand.

A case in point is seen in an apparatus which was at one time in use on one of the more prominent railways. It was a sort of portable crane hoist which could be fastened to the smokestack of a locomotive whereby one man could lift off the steam chest casings. The hoisting apparatus weighed about twice as much as the steam chest and took three men to put it up. When piece-work was adopted two men easily lifted off the steam chest, and this "time and labor-saving device" was relegated to the scrap heap.

While compressed air has been used, to some extent, for inducing draught in forge fires, it is unquestionably a very expensive agent for such work. Tests have shown that it costs twenty-five times as much to produce blast in that way as it would with a fan.

The success and economy which have attended the use of compressed air in so many lines of work have led to its adoption in fields which are much better covered by electrically operated machines. While compressed air has been used very satisfactorily under certain conditions to operate pumps and engines, printing presses, individual motors for lathes, planers, slotters, dynamos and other work, it does not follow that it is always an economical agent for these various uses, or that other methods could not be used even more satisfactorily in the majority of cases.

It has been proposed to use individual air motors in machine shops and do away with all line shafting, except possibly for some of the heavier machinery. This use of compressed air seems entirely outside the pale of its legitimate field. General experience thus far indicates that rotary air motors are not at all economical, and generally are not as satisfactory as electric motors. Exceptions are to be found in the small portable motors for drilling and similar operations to which electricity is not well adapted. The saving obtained by the use of such portable air drills, as compared with a hand ratchet drill, is very marked.

Although these tools are very successful, they are still rotary motors, not exempt from some of the objectionable features which seem to be inseparable from them. It is not surprising, therefore, to find a tendency to employ reciprocating pistons and cranks in these portable machines, and there are such tools weighing

*An abstract from Professor Flather's article on the "Modern Power Problem," written for *Cassier's Magazine*.

only forty pounds, capable of drilling up to $2\frac{1}{2}$ inches diameter.

In most cases no attempt has been made to use the air efficiently; its great convenience and the economy produced by its displacement of hand labor have until recently been accepted as sufficient, and greater economies have not been sought.

In the matter of compression we still occasionally find very inefficient pumps in use, but manufacturers generally have learned that it pays to use high-grade, economical compressors. The greatest loss is that in the air motor itself. In a large number of cases it is impracticable, or, at most, inconvenient to employ reheaters, and we find very generally that the air is used at normal temperatures for the various purposes to which it is applied.

To obtain the most satisfactory results, the air must be used expansively; but usually where the demand for power is intermittent, no attempt has been made to reheat the air, and as a result the combined efficiency of compressor and motor is quite low, varying in general from 20 to 50 per cent.. While low working pressures are more efficient than high, the use of such pressures would demand larger and heavier motors and other apparatus which is undesirable. The advantages of higher pressures in reducing cost of transmission are also well recognized, and the present tendency is to use air at 100 to 150 pounds instead of the 60 or 70 pounds of a few years ago.

By reheating the air to a temperature of about 300 degrees F., which may often be accomplished at small expense, the efficiency is greatly increased; in some cases the increase has been found to be as high as 80 per cent. While the lower pressures are yet more efficient, the loss due to higher compression is not serious.

If air be used without expansion, there is a material loss in efficiency; but, on the other hand, if it be used expansively without reheating, trouble may be experienced from drop in temperature below the freezing point. With moisture present, this drop will cause the formation of ice, which may clog the passages if proper precautions are not taken to prevent it. The low temperature will not in itself cause trouble; if, therefore, the moisture which the compressed air holds in suspension be allowed to settle in a receiving tank, placed near the motor or other air apparatus, and frequently drained, trouble from this cause will be largely avoided.

While it may be impracticable to reheat the air in certain cases, yet there are many situations where a study of means to overcome the losses referred to would result in marked economies.

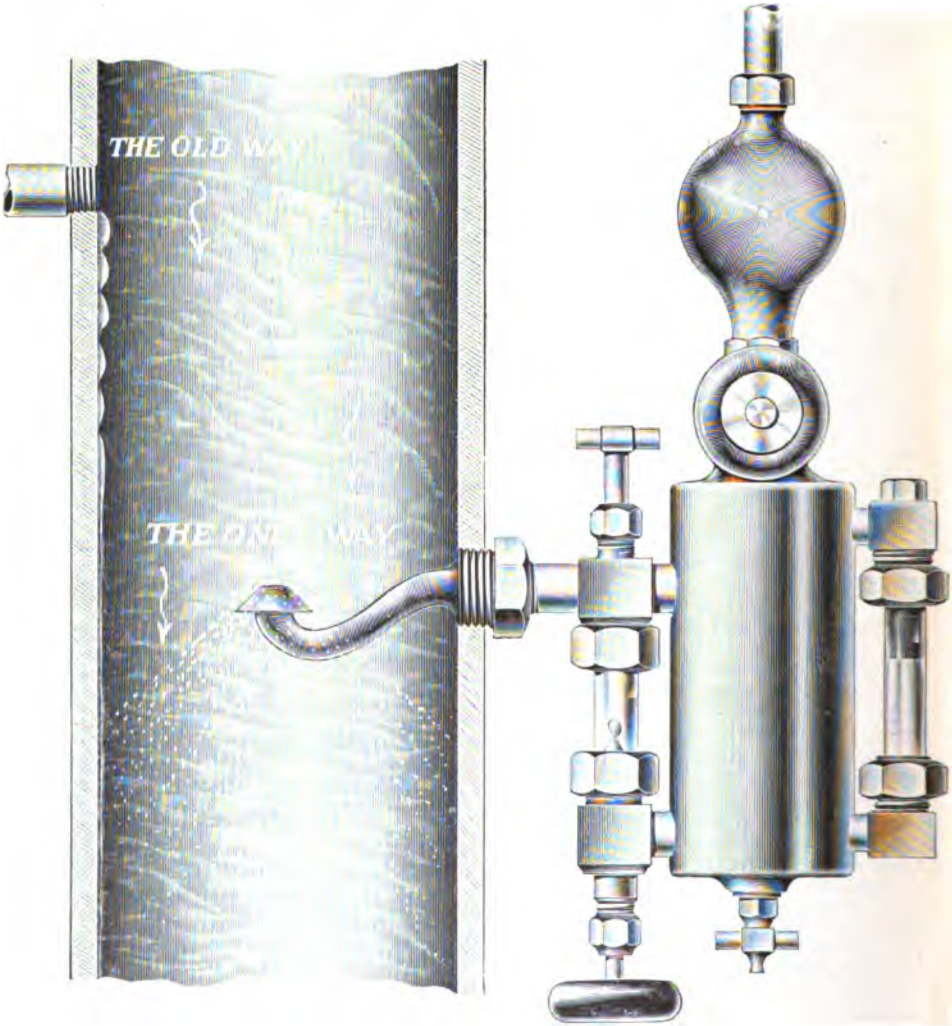
The greater adaptability of compressed air to various purposes causes its use to increase along with that of the electric motor, for it has a different field of usefulness, independent of power transmission; at the same time, when the requirements are properly observed in its production and use, its economy as a motive power in special cases compares favorably with that of other systems. With a better knowledge of the principles involved, we may expect much better results than have yet been attained.

New Cylinder Oil Atomizer.

When cylinder oil is fed to a steam engine cylinder by means of the ordinary pump or sight feed lubricator, the outlets of which are merely tapped into the steam pipe, it is not carried by the current of steam to all parts of the cylinder and valves but tends to run along the inside of the pipe, working through gaskets and stuffing boxes and passing through the engine without being atomized and thereby oiling all rubbing parts of the cylinder, piston and valves. Of course by feeding a large quantity of oil the cylinder may be satisfactorily lubricated, but if it can be lubricated better with less than half the oil ordinarily used by atomizing it, so that the steam will carry it to all parts, then a saving of oil is accomplished, a perfect lubrication is maintained and less oil must be extracted from the exhaust in order to use the condensed steam again.

The device herewith illustrated delivers the oil in a thin sheet to the steam having the greatest velocity, thoroughly distributing the oil in a vapor through the steam and delivering same to all parts of the cylinder, oiling the upper part as well as the sides, and so effectually that one half the oil ordinarily used will, with this device, oil the cylinder better than the amount usually required.

This cylinder oil vaporizer consists of a bronze casting (see cut) so shaped that the outlet is on a level with the inlet opening, one end of which is tapped into the steam pipe, as shown in cut. This end is tapped for lubricator or oil pump; and the action of the device is as follows:



NEW CYLINDER OIL ATOMIZER.

Oil flows in from the lubricator and, passing through the body of the vaporizer heated to the temperature of the steam and by the time it reaches the outlet at the top of cone is sufficiently thin and limpid to spread out over the surface in a thin film, and as it reaches the lower edge of the cone is carried along with the steam. This cone is always small enough to go through the opening in steam pipe and all the work necessary to put same on is to unscrew the lubricator connection, tap the pipe for atomizer screw into place, then screw the lubricator back into the atomizer.

The manufacturers of this device claim

that it is especially adapted for the heavy oils used with superheated steam, as the particles are thoroughly atomized and distributed where the lubrication is needed.

This atomizer is the invention of Mr. C. E. Sargent, Chicago, and is manufactured and for sale by the North Chicago Machine Co., North Chicago, Ill.

Railroad Car Braking.*

The advantage of the use of power, under the control of the engineer, for promptly applying brakes upon all the wheels of a train, early became recognized and the special advantages of compressed air for the transmission of the power throughout trains of considerable length, established the air-brake in a pre-eminent position. At first, the compressed air was stored in a reservoir upon the locomotive and, by means of a line of iron pipe, extending throughout the length of the train, with flexible hose and couplings between vehicles and an operating valve upon the locomotive, it was conducted to the brake-cylinder upon each car, by which the brakes were applied to the wheels, through the intervention of suitable rods and levers. The time required to convey the necessary volume of compressed air from the storage reservoir upon the locomotive to all the brake-cylinders of even a comparatively short train, and the total disability resulting from rupture at any point of the air-conduit, caused by this form of air-brake to be supplanted by the automatic air-brake, in which an auxiliary storage reservoir, of sufficient capacity to operate a single brake cylinder, was added upon each car. Through the operation of a triple-valve device, which connects the train-pipe or air-conduit, the auxiliary reservoir and the brake-cylinder upon each car, admission of compressed air into the train-pipe causes each auxiliary reservoir to become charged to operate the brakes, and discharge of air from the train-pipe, from any cause, causes communication with the auxiliary reservoir to be transferred from the train-pipe to the brake-cylinder, whereby a corresponding quantity of compressed air is discharged from the auxiliary reservoir into the brake-cylinder. By defining the reduction of pressure of air in the train-pipe, the pressure of the brake-shoes upon the wheels may be graduated to any desired degree within the limit established by the ultimate equalization of air-pressure in the auxiliary reservoir and the brake-cylinder, and accidental rupture of the tran-pipe instantly operates to stop the train and to prevent further progress without effective repair. In any case, restoration of the air-pressure in the train-pipe actuates the triple valve to re-establish access to the auxiliary reservoir, whereby it is recharged with air-pressure, and to transfer communication with the brake-cylinder from the auxiliary reservoir to the atmosphere, through which the brakes are released.

When the automatic air-brake became employed upon freight-trains, it was discovered that in making a quick stop by venting the train-pipe at the locomotive, the interval of time required to cause an operative reduction of the air-pressure in the train-pipe at the rear end of the train was so considerable that effective application of the brakes upon the rear cars was delayed until sufficient retardation of the forward portion of the train had become effected to cause collision with the rear cars that damaged and often disabled the cars and did violence to the lading. To remove this obstacle, the automatic air-brake, became superseded by the quick-action automatic air-brake, in which, when a quick stop is desired, each triple-valve opens a vent in the train-pipe, in addition to the vent upon the locomotive. By this means, an operative reduction of the air-pressure progresses throughout the train-pipe, of the longest trains, with nearly the velocity of sound, and damage from the serial character of the application of brakes by compressed air becomes practically eliminated. Incidentally, also, in the local venting of the train-pipe air at each succeeding triple-valve, the utilization of this source of power, formerly wasted at the engineer's operating valve, was accomplished by conducting the vented air into the adjacent empty brake-cylinder, before it receives the ordinary supply provided by the auxiliary reservoir. Thereby, the ultimate air-pressure in the brake-cylinder is augmented about 20 per cent., and the character of the application of the brakes in disaster-threatening emergencies is further distin-

*Abstracts from a paper read at the 171st meeting of the American Institute of Electrical Engineers, New York, Dec. 19, 1902.

guished from that in ordinary service, where neither the violence nor the power of the emergency application is desirable or even tolerable.

While the character of the development of the compressed air brake has thus been chiefly dictated by conditions rendered conspicuous by increased length of trains, and would hardly have been suggested under the conditions to which electric railroad operation appears best adapted, the high operative efficiency and other advantages thereby acquired are participated in by short as well as long trains, and are therefore of interest in dealing with the question of braking in electric service. Where even only two cars are operated together as a train, the automatic feature of the air-brake is still essential, in precisely the same way, if not in the same degree, as in longer trains, and, except where cars are always operated singly, the same is true of the increased efficiency secured through the quick-action feature of the automatic brake.

To enter into the detail of the air-brake apparatus employed to furnish the braking force, in a paper of this character, would unduly extend it and would also be a work of supererogation. The compressed-air supply generally implies a suitable compressor upon the car, or, if operated in trains, one or more upon each train. Storage of the compressed air in sufficient quantity has, however, been satisfactorily accomplished in some cases and possesses certain advantages. The air is usually stored at a comparatively high pressure (generally 150 pounds) in large reservoirs secured beneath the car, or in any other convenient place. It is delivered through a reducing valve into the "main reservoir" of brake operation, at the desired pressure, where it is handled in the ordinary manner. In such a system, a single air compressor, of large capacity and high efficiency, compresses the air at a station, where it is stored and charged into the car storage-reservoir from time to time. The advantages lie in avoiding the cost of installing and maintaining compressors upon all the cars, and in cheapness of operation. The disadvantages consist of the bulkiness of the storage-reservoirs and the time required to stop and charge them, and also the limited distance that may be transversed during the intervals. Where the air is compressed upon the car, the compressor must be accessibly constructed and placed upon the car, and supplied with clean, dry air. It may be operated by steam, by a separate electric motor, or by the car-motor, through suitable connection with the car-axle, as circumstances render it expedient. Its operation should be so controlled by a governor that it shall cease whenever the maximum storage-pressure has been attained in the main reservoir, and shall be renewed when operation of the brakes has reduced the storage-pressure to the inferior limit.

Upon the motorman's operating valve, the satisfactory operation of the brake-system in large measure depends. It must not only present the means of accurately gauging the force of brake-application and of promptly releasing the brakes, but must also define, with precision, the pressure of the air with which the auxiliary reservoirs are charged, to insure the full efficiency of braking without exceeding it to the injury of wheels and detriment of efficiency; while, at the same time, it must provide a superior pressure—that may vary considerably under different conditions—in the main storage reservoir, to insure prompt release of the brakes and restoration of pressure in the auxiliary reservoirs, without any variation of the working pressure in the latter—an exacting combination of conditions not easy of realization, but of capital importance.

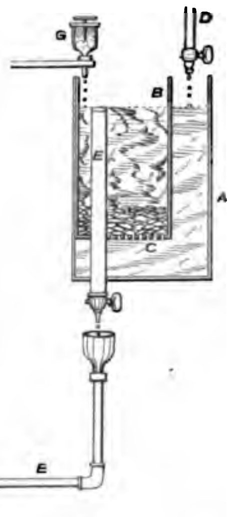
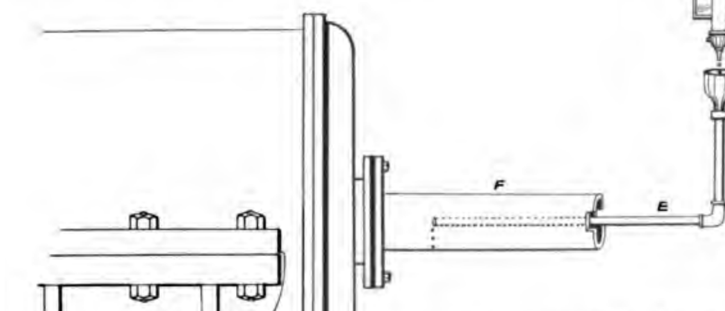
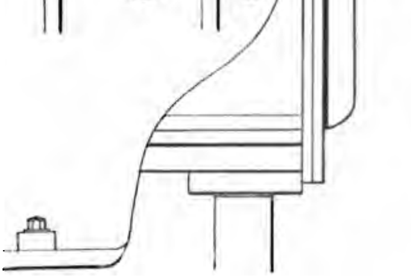
Of the apparatus for the immediate application of the brakes to the wheels, sufficient has already been said, it having been indicated that, in the single case where the unit invariably consists of a single car, simply an air-cylinder, in communication with the motorman's valve, meets all the requirements, while the conditions of every other case justify nothing short of the efficiency of the quick-acting automatic apparatus, and, where characterized by high speeds and frequent stops, the superior efficiency of the high-speed brake is essential to high efficiency of service.

Lubricator for Feeding Soap Suds to Compressors.

In compressing air to 90 and 100 pounds gauge pressure with a single stage air compressor, the temperature of the air after compression frequently reaches 450° to 500° F. This high temperature results in more or less carbon being deposited on the discharge valves and passages, and trouble is often experienced in properly lubricating the air cylinder.

Especially is this the case where compressors are run at high speed and the temperature of intake air exceeds 80 degrees, or where an inferior grade of oil is used. To overcome this trouble, soap suds has frequently been used as a lubricant instead of oil with good results.

The illustration shown herewith shows a novel way of feeding soap suds into a cylinder provided with piston inlet valve, and will, no doubt, be of interest to engineers who are using machines of this kind, who have experienced the trouble referred to above. The device consists of a small galvanized iron water tank (A) about 7 in. long, 6 in. wide and 12 in. deep. Inside of this tank is a smaller

DEVICE FOR FEEDING SOAP SUDS TO A COMPRESSOR.

one (B), which is soldered to the large tank, and the bottom of which is about 2 ins. above the bottom of large tank. In the bottom of small tank are a number of holes ⅛ in. in diameter, shown at (C). Soft brown soap (cut up in small pieces) is put into tank (B). Water is then fed into large tank through a ¼ in. pipe (D) and passes through small holes at (C), dissolves some of the soap and raises to top of ¼ in. pipe (E), through which it passes down into inlet of compressor. The water is regulated at (D), the small cock under tank being left wide open. Just before shutting down compressor the water is turned off at (D) and oil is fed into the small tank (B) from cup (G). The compressor is then run with oil for half an hour in order to prevent rust. It is important to use soap that will sink in water, otherwise small chips of soap will float to top of tank (B) and pass down through pipe (E).

This device is used on an Ingersoll-Sergeant compressor having a steam cylinder 14 in. diameter by 18 in. stroke, and when running at 120 R. P. M. with air pressure at 90 pounds, the water is fed through (D) at about 45 drops per minute. Soap suds has been used in this cylinder for the past four years and no trouble whatever has been experienced in properly lubricating it. The engineer reports the walls of cylinder in perfect condition.

The arrangement shown has been used with much success at the power plant of the Terminal Railroad Association in St. Louis, and was made by the chief engineer at that plant, Mr. E. A. Kolbe.

Springfield Air Lift Plant, Elizabethtown Water Co., Springfield, N. J.

This plant covers about 107 acres, over which are scattered 53 driven wells, connected to a reservoir centrally placed and nearby the power house, where the boilers, pump and air compressors are located. These wells vary in size, some being 6 inches, others 8 inches and 10 inches in diameter, all being cased to rock at a depth of 100 to 150 feet. The total depth of the wells vary from 250 to 750 feet, all in rock, the rock portion being uncased.

The air lift system using a central tube is employed, the water pipes being 4 inches and 3 inches in diameter, and the interior air pipe 3/4 inch in diameter. The average depth of air pipe is 150 feet. To distribute the air to these different wells, 4½ to 5 miles of wrought iron pipe is used, varying in diameter from 10 inches at the power station to 8 inches, 5 inches and finally 3 inches, the larger pipe being flanged coupled, the smaller pipes having screw couplings.

The system of collecting mains consisting of cast iron water pipe with caulked joints and leads from the most remote wells to the reservoir. These collection pipes vary from 4 inches all the way up to 30 inches in diameter, water being returned by gravity flow. The reservoir is "L" shaped, built of concrete and cement lined and has a total length of 150 feet, a depth of 15 feet and a width of 10 feet. One arm of the "L" shaped reservoir is extended out towards the well and the other is just back of the power house, arranged so that when additional machinery is installed the pump suction is kept the same.

The power house (Fig. 1) consists of two separate buildings, one being used for the boiler house, the other containing the pump and compressor. The pump is a Worthington Duplex, with triple expansion steam cylinders, having a 24-hour capacity of 6,000,000 gallons, taking steam at 80 lbs. and delivering water at 50 lbs.

The compressor (Figs. 2 and 3) is an Ingersoll-Sergeant compound steam, duplex air, Corliss semitangye type, of about 240 H. P., with steam cylinders 14 in. and 26 in. by 36 in. stroke and two air cylinders 20¼ in. x 36 in. stroke; rated speed, 78 R. P. M.

FIG. 1—POWER HOUSE SPRINGFIELD PLANT ELIZABETHTOWN WATER CO.

This compressor has a capacity of 1993 cubic feet free air per minute, the air being delivered through a 10-inch discharge pipe into a vertical receiver 54 inches diameter by 12 feet high, placed just outside of the building. The final maximum air pressure employed is 95 pounds, and the boiler house contains two Babcock & Wilcox boilers of 125 H. P., capable of carrying 110 lbs. steam, and two Hughes & Phillips 100 H. P. boilers, delivering steam at 80 pounds pressure.

We are indebted to the Elizabethtown Water Co. for the information above given.

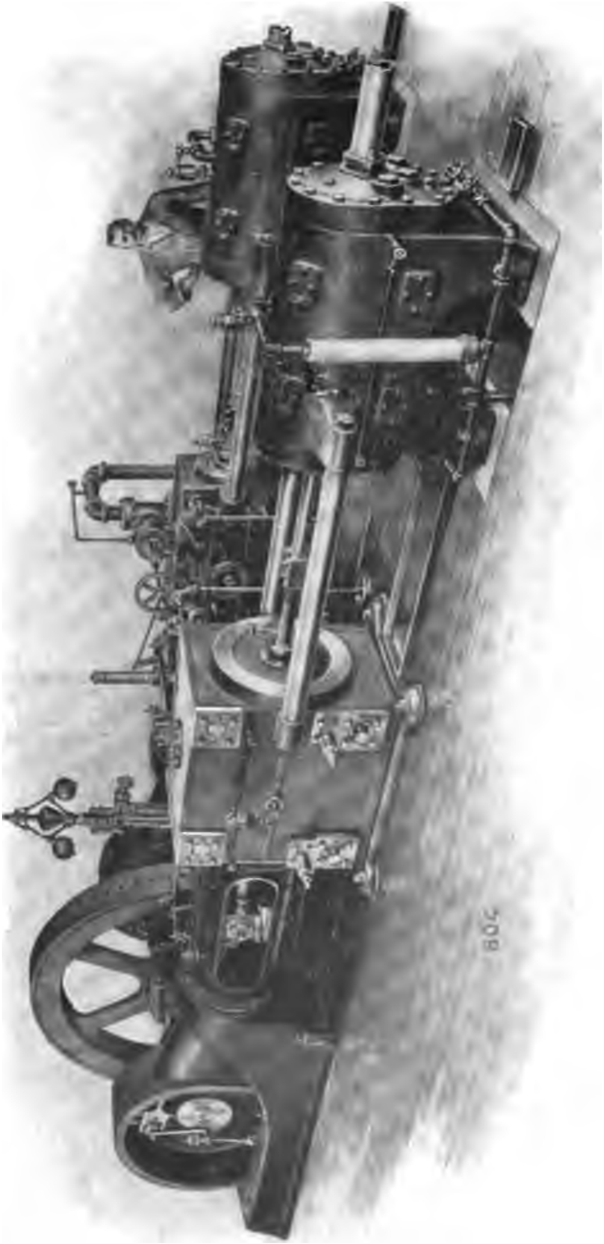


FIG. 2—INGERSOLL-SERGEANT COMPOUND CORLISS AIR COMPRESSOR, SPRINGFIELD, N. J.

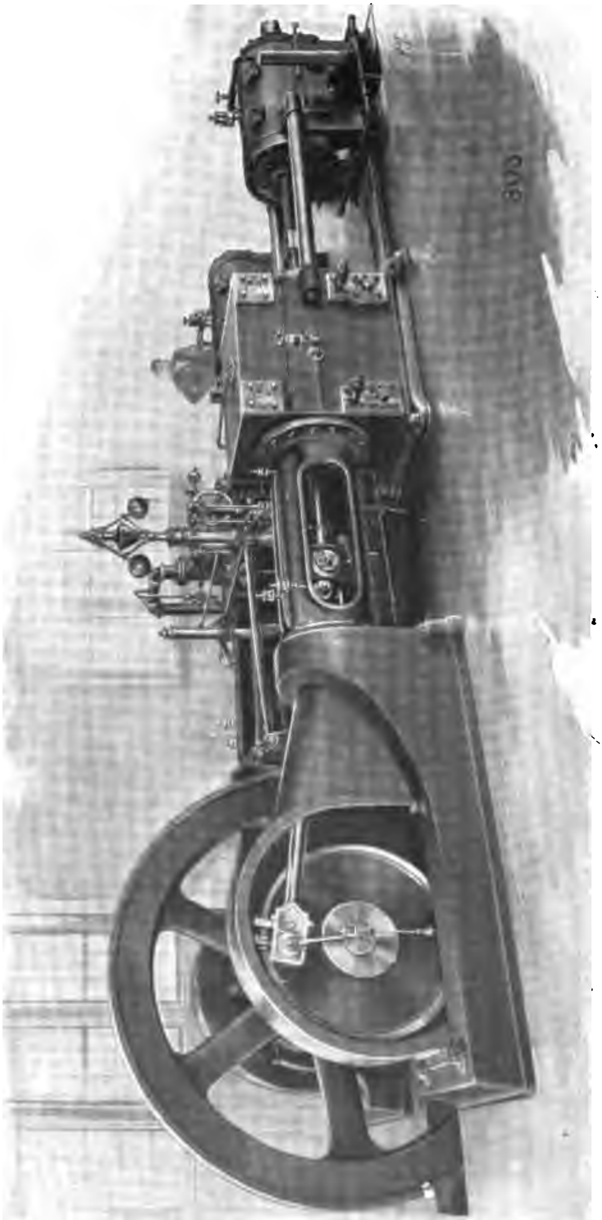


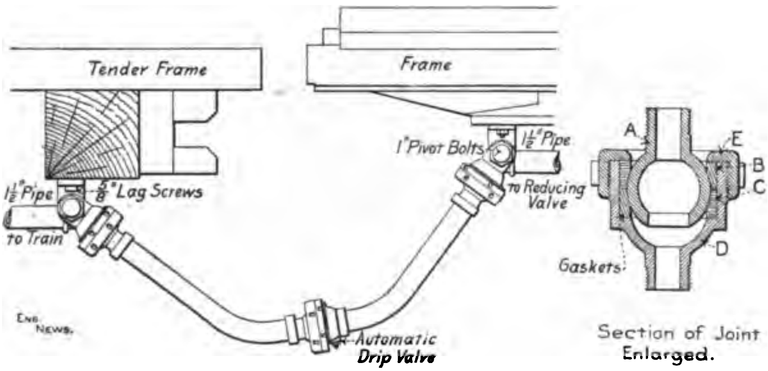
FIG. 3—INGERSOLL-SERGEANT CORLISS AIR COMPRESSOR. STEAM CYLINDERS, 14 x 26 x 36. TWO AIR CYLINDERS, 20¼ x 36.

A New Flexible Metallic Joint.

We illustrate herewith a new flexible metallic joint which is said to be steam, air, water and oil tight, and to ensure positively tight connection wherever movement or vibration occurs between the parts connected. The joint is the invention of Mr. J. C. Martin, Jr., Vice-President of the Holland Co., 77 Jackson Boulevard, Chicago, which company is handling the joint as one of its specialties.

The joint is of the ball and socket type, but does not depend upon internal pressure or the fit of ground surfaces for tightness, the metallic surfaces not being in contact. The end of one of the pipes to be connected is screwed to the bronze ball casting A, upon which are fitted two gaskets, B and C. These are of a special hard, non-metallic material, and their inner faces are moulded to fit the ball and form its seat. The gaskets fit within the head of the bronze socket D (which is attached to the other pipe to be connected), and when the joint is put together the gaskets are held in place by a flanged ring E, screwed upon the socket head. The wear is taken by the front gasket, as the pressure forces the ball forward. When this gasket becomes worn, the ball may be disconnected, the flange ring unscrewed, and the rear gasket put in the place of the forward one. The old front gasket or a new one may then be used for the rear gasket.

So far the joints have been used only for steam-pipe connections between engines and tenders, and they are in experimental use for this particular purpose on several western railways. The arrangement is shown in the accompanying cut. Three joints are used in the connection, the two end joints giving a bend to the pipe and being attached to the engine and tender frames by special malleable iron fittings, which give flexibility and prevent any strain from coming upon the pipe. At the center joint, the pipes are bent so as to give a straight passage, and in all the joints the diameter of the opening is greater than that of the pipe. They are steam tight under pressure, and are fitted with automatic drip valves to prevent the accumulation of any moisture in the joint. This drip is a flat composition seated valve, held up by a light spring of about 5 lbs. pressure.

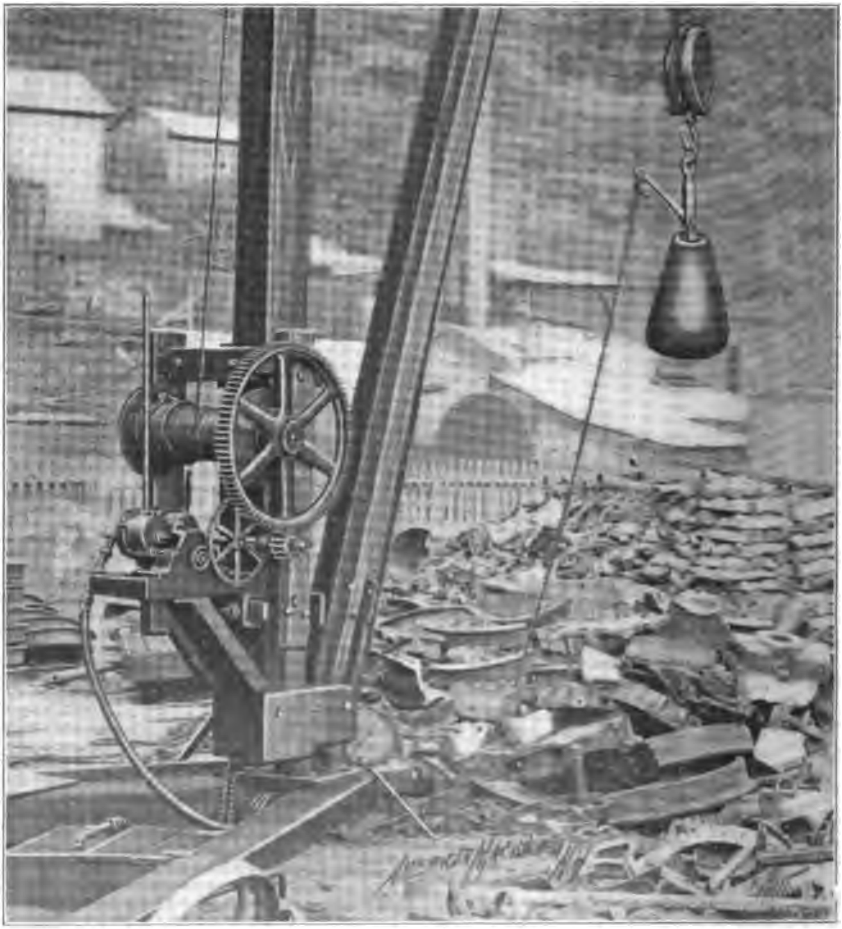


THE MARTIN FLEXIBLE METALLIC PIPE JOINT. THE HOLLAND CO., CHICAGO, MAKERS.

The metallic connections are said to occupy no more space than the ordinary rubber hose connections, and to be as readily applied as the latter. Experiments are now being made for the purpose of applying this metal pipe and flexible joint between railway cars, with straight port couplers interchangeable with the present equipment. The metal pipe and flexible joint may also be adopted as a substitute for lengths of 25 to 50 ft. of hose, three or more joints being used to give the required freedom of movement.

An Air Driven Crane.

The accompanying photograph shows the application of an air motor to an ordinary foundry yard crane which had been operated by hand for years. This crane is used for unloading heavy scrap from cars and also for a "drop" or casting breaker. With this improvement two men will break more than twice as much scrap, and do it easier, than six men could operating the crane by hand. The motor is placed on a braced shelf made of 3½-inch plank. The gear on the motor spindle and the one into which it runs are a couple of odd change gears from an old lathe in the machine shop. The labor of applying the motor was an hour or so for the carpenter and five hours for a machinist, the gears and plank being the only extra material used.



CRANE WITH AIR MOTOR.

An incidental advantage of this arrangement is that scrap comes to the cupola in smaller pieces, resulting in a better mix. "Winding" the weight up by hand was so laborious that men preferred any job around the foundry to that of breaking scrap, but with the motor attachment all the irksomeness of the job has been removed.—ANTHONY STAFFORD, in *American Machinist.*

Ventilation in Cornish Mines.

Supplementing the report of the special committee appointed by the South African Government to investigate the cause of miners' disease, an abstract of which was published on page 2193 in COMPRESSED AIR, we find the following in the London *Morning Post*:

"For some time Dr. J. S. Haldane, F. R. S., has been engaged, along with Mr. J. S. Martin, his Majesty s Inspector of Mines, in an inquiry undertaken at the instance of the Home Office as to the ventilation of Cornish mines. Of these the largest and most important is Dolcoath, and for some years the men working there have suffered from a disease to which the name "Dolcoath Anæmia" was given. They paled as to the face and the lips, and if they exerted themselves they suffered from palpitation. They were liable to become dizzy and faint and were suspected of having heart disease. Almost the whole of the patients from Dolcoath had an itching of the skin, with pustular eruptions which they called "bunches." Neglected cases became gravely complicated, and there was a danger of heart failure. Death might occur, the immediate cause being some intercurrent disease, such as pneumonia or phthisis. Dropsy might also supervene.

Most of the cases occurred in one particular shaft; indeed, everybody who worked there was affected in greater or less degree. Generally they were soon incapacitated from work underground, and it was found that they improved rapidly when they had been employed for a little while at the surface, where daily reinfection was impossible. In some instances this beneficial change was effected simply by shifting them to another shaft.

On investigation Dr. Haldane came to the conclusion that the men were suffering from ankylostomiasis. This is a disease which is caused by a worm that lives and multiplies in the upper part of the small intestine. This worm is about half an inch in length, and has a "suctorial" mouth with four teeth. In 1854 it was recognized as being the cause of a disease then common in Egypt and known as "Egyptian chlorosis." Soon afterwards it was found to be common in Brazil, and since then it has been recognized as a frequent and a troublesome cause of disease in tropical and sub-tropical countries all over the world. The disease has occurred on the Continent—it broke out among the workmen engaged in making the St. Gothard tunnel—but in England it has only been observed by Dr. Manson among Lascars at the docks.

Some three or four years ago it had occurred to the manager of Dolcoath that the disease might have some connection with a certain lack of cleanliness underground. He improved the ventilation, and he had large quantities of chloride of lime and permanganate of potash used in the infected parts of the mine. Dr. Haldane has no doubt that by taking this step he checked the progress of the disease. Cornish miners are constantly going abroad, but they frequently return after a short time, and sooner or later they go back to their old employment. Thus, it is supposed, Dolcoath was infected. The conditions were favorable; among other things the temperature was high. In one of the levels Dr. Haldane found it to be 79 deg. The disease, once it has been recognized, can be treated without difficulty, except in advanced cases, for the worms are expelled from the system immediately on the administration of thymol. At the time when this report was written one patient was so ill that it was not thought that he could recover. Dr. Haldane states in an interim report to the Home Office, which has just been published, that steps have been taken to disinfect the dangerous parts of the mine, and to make the conditions such that the worm, even if it should be reintroduced by some one coming from abroad, will find life impossible. The precautions are all in the direction of securing cleanliness and good ventilation."

South Tacoma Air Lift Plant.

The illustration on the following page represents a test well at South Tacoma, Wash., and affords an excellent idea of the discharge from an air lift well.

The test in question was made on January 21, 1903, the well flowing 800,000 gallons in twenty-four hours. Air for this was furnished by a 12¼x14 inch Class B compressor, manufactured by the Ingersoll-Sergeant Drill Co., and the well was piped according to the Pohlé Air Lift Systems, patents for which are controlled by the above company. The tests were made by L. Forrest McConihe, M. E., to whom we are indebted for the illustration.

SOUTH TACOMA AIR LIFT PLANT.

Telescoping Air Jack.

The air jack recently built by the Hicks Locomotive Works, Chicago Heights, works on the same principle as the hydraulic jack, but moves quicker. The *Iron and Machinery World* says:

"The jack consists practically of two cylinders, one operating within the other, and a piston traveling within the inner cylinder. The outer cylinder is a section of 24-inch wrought iron pipe and the inner cylinder is of 20-inch pipe. The cylinder heads and piston are cast iron and the piston rod is a piece of 6-inch pipe. The inner cylinder and piston are packed with leather to prevent leakage of air while in operation. A check valve is to be attached to the air distributing pipe between the globe valve and drain cock to maintain pressure in the cylinder in case of accident to the hose after pressure has been applied. The piston travels 14 inches within the inner cylinder, the inner cylinder in turn traveling 12 inches within the outer cylinder, giving a total travel of 26 inches. Around the top of the outer cylinder is a steel band, held in position by tap bolts, supporting two journals which are designed to fit in bearings on a truck constructed to transport the jack to any desired point about the shop."

Book Review.

"Dies, Their Construction and Use for the Modern Working of Sheet Metals," by Joseph V. Woodworth, 505 illustrations, 384 pages, size 6x9 inches. Publishers: Norman W. Henley & Co., 132 Nassau street, New York City.

A treatise on the design, construction and use of dies, punches, tools, fixtures and devices, together with the manner in which they should be used in the power press, for the cheap and rapid production of sheet metal, parts and articles, comprising fundamental designs and practical points by which sheet metal parts may be produced at the minimum of cost to the maximum of output; with special reference to the hardening and tempering of press tools, the use of files, and to the classes of work which may be produced to the best advantage by the use of dies in the power press.

"Hardening, Tempering, Annealing and Forging of Steel." A Treatise on the Practical Treatment and Working of High and Low Grade Steel, by Joseph V. Woodworth; 201 illustrations, 288 pages, size 6x9 inches. Publisher: Norman W. Henley & Co., 132 Nassau street, New York.

This book comprises the selection and identification of steel, the most modern and approved heating, hardening, tempering, annealing and forging processes, the use of gas blast forges, heating machines and furnaces, the annealing and manufacturing of malleable iron, the treatment and use of self-hardening steel, with special reference to case hardening processes, the hardening and tempering of milling cutters and press tools, the use of machinery steel for cutting tools, forging and welding, high grade steel forgings in America, forging of hollow shafts, rock forgings, and grinding processes for tools and machine parts.

Notes.

At a meeting of the Compressed Air Company, H. Monkhouse was elected president, to succeed Henry Cooke, and Chauncey Truax vice-president, in place of Mr. Monkhouse. No financial statement was made.

Dornfield Pneumatic Malting Construction Company, Chicago, with a capital of $50,000; manufacturing machines and devices for brewing and malting, has been licensed recently, the incorporators being John F. Dornfield, Henry Ed Northcomb, Frank Little.

The Westler Young Compressed Air Pruning Co. has just been organized, with its principal place of business in San Francisco, Cal. Capital stock, $500,000, The directors are Westley Young, R. H. Hoilt, J. P. Harlon, T. A. Perkins, of San Francisco, and A. J. Newton, of Portland.

The steam turbine has lately been used in the reversed direction for compressing air, an ordinary steam turbine being coupled direct to the air turbine. This air turbine is very similar to the steam turbine, and consists, as usual, of alternate rows of moving blades and guide blades, and is driven at a high speed, each row of blades increasing the pressure, and giving a steady blast.

Elmer F. Woodbury, of the Hotel Cadillac, New York City, has outdistanced the builders of the new hotels that are being constructed on Broadway and Fifth avenue and inaugurated a new era in the hotel and restaurant business by the establishment of a pneumatic tube service between the dining room and kitchen. All of the new and modern hotels now in course of construction are making this great improvement.

A scheme is on foot for the purpose of connecting Montreal and Longueuil, Quebec, by means of a tunnel under the St. Lawrence. Plans have been submitted to the Department of Railways, providing for a double-track tunnel from the south shore to the heart of Montreal, where a central station will be placed. The structure, which will be of concrete and stone masonry, lined with enamel brick, will have a width of 27 ft. and a height of 21 ft.

William E. Nichols & Co. are receiving subscriptions to the $200,000 bond issue of the Compressed Air Company, $120,000 having been subscribed to date. These bonds are issued to liquidate the floating indebtedness, amounting to $47,000; improve the Rome Locomotive Works, the entire capital stock of which is owned by the Compressed Air Company, and to further the development of the compressed air machines. A bonus of 100 per cent. stock is given with the subscriptions to the bonds.

The Great Central Railway Co., of England, in order to accelerate main line traffic, have just completed a contract with the British Pneumatic Railway Signalling Company for the installation of automatic pneumatic signalling through Woodhead Tunnel. Owing to the impossibility of manning a signal-box in so unfavorable an underground position, main line expresses are greatly impeded at this point. The underground installation, the first of its kind in Great Britain, will be, a northern contemporary says, a conclusive test of the trustworthiness of the electric track system under the most unfavorable atmospheric conditions.

Announcement has been made recently that the contract to construct a compressed air plant at the Cleveland Stone Co.'s No. 6 quarry, at North Amherst, O., has been let to the Ingersoll-Sergeant Drill Co. The building as planned is a structure 80x130 and the entire plant complete will cost $130,000. Engines and other machinery used in the compressing of air are now being constructed at the factories of the bidders in Cleveland and New York. The stone company intends to use this power in operating the drills, channellers, derricks and other machinery outside the big mill and they hope to have the plant in running order by August 1. The company claims this new power will be a great saving in time and will enable them to get out more stone and give employment to more men.

A correspondent writes *Modern Machinery*:

"In air valves commonly used on heating radiators of what substance is that portion composed which is so very sensitive to a change of temperature? What is its expansion per foot in variation of 100 deg. temperature?"

"The substance used in air valves," replied the editor, "which is supposed to be affected by changes of temperature, is common vulcanite, or hard rubber. It is known under the technical name of Ebonite."

"The expansion per foot is .000513246 of an inch for 1 deg. Fahr. For a variation in temperature of 100 degs. it would be 100x.000513246 or .0513246 in. per ft. of length."

In the lubrication of air compressors, where the air is sent underground, the use of vegetable oils, or any oils that will decompose easily, should be carefully avoided. For as the air is compressed, its temperature rises, causing a decomposition of all unstable oils, and the formation of carbon monoxide, which is a most deadly gas. This goes into the receiver with the air, and, escaping with the latter from the machines under ground, is liable to cause asphyxiation and death to the operators. A disaster of this kind recently occurred in a German iron mine. The usual supply of mineral oil had run out, and some rape seed oil was temporarily used. The pressure in the receiver was maintained at 80 pounds, and the temperature in parts of the compressor rose as high as 555° Fah. An analysis of the air escaping from the drills under these conditions showed that it contained nearly 6 per cent. of the deadly gas.

One of the great difficulties to overcome with gas engines of great power is the starting. In the case of the 400 H. P. Mono-Triplex gas engine invented by Mr. Letombe, it is remarkably easy and ingenious. The division of power greatly facilitates it, for up to 50 H. P. it can be effected by one man turning the fly-wheel. For greater powers, an automatic starting air reservoir is used. Compressed air from this reservoir is admitted behind the piston, and, driving it forward, causes it to make a compression stroke, followed by an explosion, the motor being thus started. When stopping, two out of the three combined engines are employed to work the third, in which the admission of gas has been stopped. The latter draws in and delivers air to the compressed air reservoir, where an arrangement of valves allows the air to be compressed to 7 or 8 atmospheres. The capacity of the reservoir suffices for three or four startings without requiring recharging.

The report of the directors of the Edwards Air Pump Syndicate (Ltd.) for the year 1902 states that during 1902 the royalties amounted to £4,792, as compared with £4,734 for 1901, while the ordinary expenditure was £2,565, a slight decrease on the previous year. The number of pumps for electrical and other land installations shows a satisfactory increase, and for the first time has exceeded the number of marine pumps; the former representing 52 per cent., and the latter 48 per cent. of the total number of pumps booked. Additional pumps have been ordered by the British Admiralty and War Office, and the Edwards pump has now been adopted for five of the most modern battleships. It has also been fitted at Woolwich Arsenal (three sets). Chatham and Haulbowline Dockyards, and the Government Gunpowder Factory at Waltham. The foreign business of the syndicate is steadily expanding. The directors propose to apply to sinking fund account for redemption of cost of acquiring patents £1,000, and to pay a dividend of 6 per cent., leaving to be carried forward £165.

The beneficent results of keeping electrical or other particularly vulnerable machines clean are very generally realized, but the flexibility and efficacy of compressed air as a cleaner of such machines are not appreciated as universally as they might be, judging from the relatively limited number of such applications. One, and possibly the chief, advantage derivable from the use of compressed air to clean dynamos, motors, etc., is the ability to remove collections of foreign material without touching the parts of a machine on which they are lodged. By no other means is it possible to remove oil-soaked copper or carbon dust, for example, without either wiping or scraping the coated part. Perfect cleaning by wiping is almost impossible, to say nothing of the liability of making matters worse by the use of dirty waste or pieces of cloth; the serious objection to the scraping process is obvious. Another advantage of a compressed air cleaning system is that an outlet may be (and usually is) provided near each piece of machinery or apparatus, so that in many cases each one can be at least partially cleaned while in operation. In the worst cases, except those of enclosed machines, a shut-down of only very short duration is necessary for effecting complete cleaning.

No better evidence of the extraordinary growth of the Pennsylvania Railroad Company's business could be found than the fact that the big trainshed at Broad Street Station, Philadelphia, has become too small for the comfort of the thousands of persons using it every hour of the day and night. Radical improvements, including the extension of the trainshed proper and the enlarging of the space fronting the gates, are to be made at once in consequence.

Plans have been drawn by the engineering force of the company and actual work will be commenced in a few weeks. The train shed, already the largest in the world, will be extended something like 300 feet, bringing its western end to 17th street. As the trainshed begins only a few yards west of 15th street, the improved structure will be nearly two blocks in length.

The extension of the trainshed will make necessary a general reorganization of the pipes supplying compressed air to the trains. The whole system will have to be torn out and moved further west. The vaults for ice and the baggage lifts will also be moved. The signals guarding the tracks within the shed and governing the outer switches must also be changed. The work, it is said, cannot be done in less than a month's time, although big gangs of men will be busy night and day.

Results of tests by students at Cornell University upon the economy derived by re-heating air was recently published by the *Engineering and Mining Journal.* Gas was used as fuel for re-heating and was also metered, thus making very accurate testing possible. The motor was a two horse power vertical engine with a shaft governor, and was provided with a Prony brake and an indicator. The series of tests was made with several one-hour runs, gauge pressure varying from 57 to 82 pounds, and pressure of air raised by re-heating from 90 degrees to 320 degrees, the results being carefully recorded and tabulated. The following summary of the tests is from the *Engineering News.* For general purposes we need only give the following summary of results: (1) The net gain in economy was greatest for the lower gauge pressure of 57 pounds; (2) The curve of efficiency indicates that there would be no further gain by heating the air above 450 degrees F., and with the engine used 400 degrees F. was the maximum temperature consistent with smooth running, on account of the ill effects of a higher temperature upon packing and lubricant; (3) Re-heating the air relieves the engine from difficulties due to freezing of the moisture in the exhaust passages, with resultant choking; (4) The economic advantages of re-heating were conclusively proved. A compressor able to supply 100 horse power of cold air to the motor, could supply 178 horse power by the use of re-heaters.

At a meeting of the North of England Institute of Mining and Mechanical Engineers, Mr. J. B. Atkinson (H.M. inspector of mines) said he had an opportunity before he left Scotland of seeing the first pit at Musselburgh, England, and was in the shaft two or three times during the sinking. It was no doubt a very sucessful operation, and the only difficulties they had were with regard to the brickwork and surrounding cylinder getting slightly out of plumb, and also when they had got so far down they neglected to add brickwork at the top, and the portion of it was caulked by wood lining and held while the rest of it went down; the difficulty, however, was overcome. In another case of sinking through alluvium, further to the north, near Larget, they had about 43 fathoms to go under the sea, and about half of this was alluvium. They first of all started the pit by forcing steel sheaths down the sides on end; that was not successful. They then tried cast iron, and that was not successful. Then steel cylinders were adopted, following much the same plan that was adopted at Olive Bank, but after they got so far down they would not move owing to boulders, and eventually they had to enclose the whole pit and use compressed air. They were two or three years getting through that twenty fathoms of alluvium. He thought in both these cases—certainly in the case near Larget—the freezing process would have been more successful. There was certainly less risk about it, but in connection with that method there did not seem to be sufficient details of costs given in the papers which had been read before the institute to enable them to judge which would be the best system to adopt. If the forcing down of cylinders was cheaper than the freezing process they might be inclined to take a certain amount of risk in using the cylinders, but if there was little difference in the cost, no doubt the freezing process would in almost all these cases be the best.

A very efficient method of watering the main roads is to conduct water under a considerable pressure through pipes laid along the side of the roads. These pipes may be from 1½ to 2 inches in diameter, and may be either fixed to timber set on the side of the roadway or laid along the floor with vertical branch pipes about ½-inch diameter fixed to it at intervals of every 25 yards, and about 3 or 4 feet in height. Suitable nozzles, jets, or sprays are fixed at the end of the vertical pipes, through which a thin spray of water issues into the air. A stop cock is attached to every pipe so that the water can be turned on and off at pleasure. The required pressure of water may be obtained from a pump column, or from an accumulation of water in an upper seam or on the surface. This method may be made more efficient by using compressed air in conjunction with water pressure. If this arrangement is used for this purpose alone it would, however, involve a considerable outlay for air-compressing machinery together with the main and branch pipes required for the purpose, but if the compressed air be used for doing other useful work so as to make the watering of the roads a secondary object, the water and air-pipe connections may be so arranged that the air and water can be brought together at the point of outlet.

The compressed air pipe may be laid along the main road parallel with the water pipe.

At each spray producer a small ½-inch branch pipe leads out from the main compressed air pipe parallel to the branch water pipe, and is connected to it by a nozzle in the interior of an ordinary T pipe, which forms the conjunction of air and water. Suitable valves are placed in the air and water pipes, which prevent the water from passing into the air pipes. When in action the water and air act simultaneously, and the water is spread in such a manner as to have the appearance of dew. In this way the air becomes throughly saturated, and the roof, floor, and sides of the roadways become damped. If this is done at suitable intervals the danger arising from accumulated dust will be obviated.

The transmission of power in mines constitutes, says Professor Courist, in a review of mine progress in 1902, compiled for the Société des Ingenieurs Civils de France, the most remarkable part of the transformation that has been effected in mine working; and it is under the most various forms that energy has been transmitted and applied for supplementing the hard work of the miner. Compressed air especially has met with the most gratifying success. The results obtained in compressors tend by water cooling and injection, to effect an isothermic compression by the use of hydraulic pistons or by compensation, to lessen the influence of dead spaces; and lastly, thanks to the spring-loaded valves, to avoid the issue of compressed air on the inlet side with trepidation of the valves upon their seats. Compression in stages, chiefly recommendable for the storage of compressed air to be utilized in movable motors such as locomotives, or for producing the high pressures necessary to liquefy the gases in cold-producing machines for freezing water-bearing measures, has also been applied in mine working. The applications of electricity have become numerous for various purposes, such as working winches, haulage plants, fans and pumps. Electricity is, indeed, the most practical agent for transmitting power underground. Its conductors easily follow sinuous workings, while occupying less room than other methods of power transmission, and being more easily shifted from place to place. The useful effect of electricity is greatly superior to that of compressed air; and for the numerous appliances that only require rotary motion, the dynamo is the rotary motor "par excellence." Reserves must, however, still be made as to the use of electricity in working places impregnated with fire-damp, or that may become so; while dynamos, interrupters, and cut-outs should be enclosed in hermetically-sealed casings, and placed in situations where there is ample ventilation.

We note in one of the London papers the following:

In reference to the compressed air installation supplied to the Mysore (India) authorities in connection with the working of the Kolar goldfield, we are informed that the pressure used is mostly 45 lb., but all the 11 new compressors which are being installed in connection with the electric power plant are designed for 60 lb. pressure. The installation consists of:—Five 150 h. p. duplex air compressors, each cylinder 16¼ in. in diameter, 18 in. stroke, speed 110 revolutions, capacity to compress 910 cubic feet of air per minute to 60 lb. per square inch pressure. The driving pulley is 10 ft. in diameter, and grooved to receive nine ropes 1¼ in. diameter. The air receivers are 48 in. in diameter, and 12 ft. long. Four 200 h. p. duplex air compressors, each cylinder 18¼ in. in diameter, 24 in. stroke, speed 94 revolutions, capacity to compress 1,314 cubic feet of free air per minute to a pressure of 60 lb. per square inch. Driving pulley is 13 ft. diameter, and grooved to receive 12 ropes 1¼ in. in diameter. Air receiver 54 in. by 12 ft. long. One 300 h. p. duplex air compressor, each cylinder 22½ in. in diameter, 24 in. stroke, speed 94 revolutions. Capacity to compress 1,920 cubic feet of free air per minute to a pressure of 60 lb. per square inch. Driving pulley 13 ft. diameter, grooved to receive 12 ropes 1 1-12 in. diameter. Air receiver 54 in. by 12 ft. long. One 400 h. p. duplex air compressor, each cylinder 25¼ in. diameter, 30 in. stroke, speed 80 revolutions per minute, at which speed the capacity is 2,600 cubic feet of free air per minute at a pressure of 60 lb. per square inch. Driving pulley is 16 ft. in diameter, and grooved for 16 ropes 1½ in. diameter. All compressors have piston inlet air cylinders, with water jacket all round the walls and through all heads, and are provided with automatic sight feed lubricators for air cylinder jackets, automatic air pressure regulators, piping, and all other necessary details which form part of a complete installation. All compressors hitherto used on the field have been steam driven, carrying a small fly-wheel to equalize the angular velocity. In the case of the new compressors, these are driven by a large pulley through the elastic medium of ropes, which have proved so eminently successful in many large motor-driven installations. The compressors and air-tanks are manufactured by the Ingersoll-Sergeant Drill Company, of Queen Victoria street, London, this company being subcontractors for this section of the work to the General Electric Company of New York.

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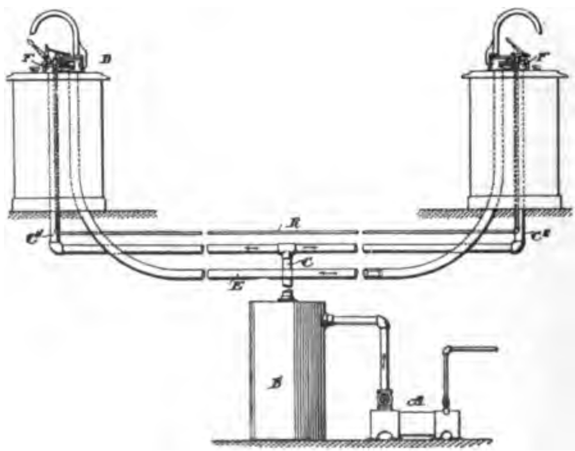
U. S. PATENTS GRANTED FEB. 1903.

Specially prepared for COMPRESSED AIR.

719,421. PNEUMATIC - DESPATCH - TUBE APPARATUS. Birney C. Batcheller, Philadelphia, Pa. Filed June 14, 1900. Serial No. 20,220.

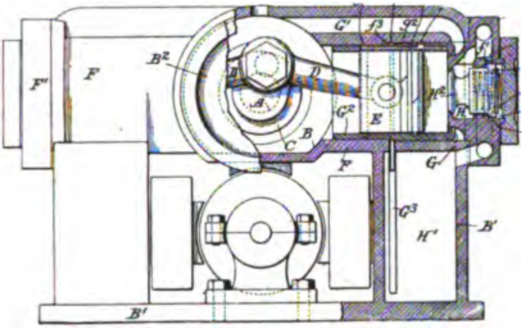


A pneumatic-despatch-tube system, a despatch-tube connecting two stations in combination with a compressed-air conduit or conduits connected to each end of said tube, a normally closed valve in the connection between each tube end and the compressed-air conduit, a gate for closing each end of the tube at will, valve-actuating mechanism whereby the closing of each gate opens the valve admitting compressed air to the closed end of the tube and the opening of the gate causes said valve to close, a latch arranged at each end of the tube to hold the gate closed and gate-retracting mechanism tending to open it, a pneumatic unlatching device at each end of the tube, a pneumatic conduit leading from each station to the unlatching device in the other station, a connection in each station between said pneumatic conduit and the compressed-air conduit, a valve normally closing said connection and means actuated by a carrier arriving at said station for opening said valve and thereby unlatching the gate and shutting off the air-supply in the other station.

719,454. COMPRESSOR. William J. Francke, New Brunswick, N. J., assignor to the Brunswick Refrigerating Company, New Brunswick, N. J., a Corporation of New Jersey. Filed Nov. 23, 1901. Serial No. 83,379.

said plunger, of the tubular valve working within the plunger, and cup-leathers on opposite ends of said valve, of an air-cylinder surmounting said casing and having an outlet-opening in its upper portion, a weighted piston in said air-cylinder having a central under side socket, a rod extending through the upper side of said casing into said piston-socket and within said casing and valve and projections carried on said rod.

719,454



A compressor, the combination with a cylinder, a piston, a suction-valve, and a discharge-valve, of a chamber forming an oil-cushion behind the suction valve, a chamber in front of the piston, a conduit to deliver oil from the chamber in front of the piston to the first-named chamber, and a conduit to receive the oil escaping from the first-named chamber, prevent its escape behind the piston and return it to the second-named chamber through the discharge-valve, whereby the oil in the first-named chamber is under the discharge pressure.

719,709. AIR-PUMP. Charles L. Wilkins, Columbus, Ohio, assignor to the Ohio Pump & Brass Company, Columbus, Ohio, a Corporation of Ohio. Filed Feb. 17, 1902. Serial No. 94,429.

An air-pump, the combination with the casing having a water-inlet, an exhaust-outlet below said water-inlet and a passage leading through the upper end of said casing and connecting with the latter by a port, a hollow plunger within the casing having an enlarged lower end portion, cup-leathers carried on opposite ends of said plunger, the lower end of the plunger having passages adapted to communicate with the interior of the plunger and an outlet-port formed in

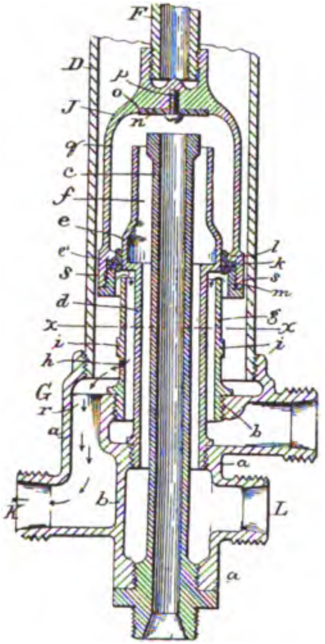
720,083. PNEUMATIC RENOVATOR. John S. Thurman, St. Louis, Mo. Filed Feb. 24, 1902. Serial No. 95,364.

The combination with the casing of a pneumatic renovator, of a handle therefor, a connection between said handle and said casing whereby the latter is movable with respect to the handle, and a duct or passage formed through the handle for compressed air entering said casing through the pivoted connection of the handle.

720,395. TERMINAL FOR PNEUMATIC-DESPATCH SYSTEMS. Hugo Ash and August Woltman, Chicago, Ill., assignors to National Pneumatic Service Company, Chicago, Ill., a Corporation of Illinois. Filed Mar. 17, 1902. Serial No. 98,459.

A device of the class described, the combination with a pneumatic-despatch tube, of a coupling attached thereto, a tube, connected to said coupling, said tube being oval in cross-section, and curved in a reverse curve, so that the end thereof farthest removed from said tube shall be substantially parallel thereto and nearer thereto than the main sweep of the curve formed by said tube, an exhaust-tube, suitably connected to said tube, a valve closing the bottom of said tube, and a consecutive-delivery hopper and chute below said valve and in line with the lower portion of said tube.

720,022. ANTIFREEZING COMPRESSION-VALVE. Philip Haas, Dayton, Ohio. Filed Aug. 5, 1901. Serial No. 70,933.



A device of the character described, the combination with means for receiving water from the source of supply; of a bell-shaped valve constructed to form a chamber or reservoir for receiving and retaining air and water; a supply-valve carried by said bell-shaped valve; an annular tubular stem communicating with the flush pipe and hopper or bowl when said supply-valve is closed, said stem being normally open to the outer air; and mechanism actuated by the closet-seat for moving said supply-valve to a closed position until the air and water in said valve-chamber have passed into the flush-pipe and flushed the bowl.

720,325. COMBINED STREET-CAR AND AIR-BRAKE COUPLING. Lewis. C. Cary, St. Louis, Mo., assignor of one-half to Julia Caldwell, El Paso, Tex. Filed Nov. 24, 1902. Serial No. 132,702.

A combination street-car and air-brake coupler, comprising a flaring half-bell-shaped guide portion; a head within which is formed a bifurcated air-passage; a circular neck opposite said half-bell-shaped guide portion; and a yielding locking-arm pivotally attached to the said head and adapted to lock the same to an opposing head.

720,376. SAFETY BRAKE APPARATUS FOR MOTOR-CARS. Charles F. Peel, Jr., New York, N. Y. Filed Sept. 11, 1902. Serial No. 122,912.

An air-brake-operating apparatus, a vertically-movable spring-operated rod, and air-valve connected with the lower end of said rod, said air-valve being in operative connection with the brakes, said rod being provided with a handle and foot-bracket and said spring-operated rod operating to open said air-valve and set the brakes.

720,486. PNEUMATIC STRAW-STACKER. William C. Robby and William M. Rumely, Laporte, Ind., assignors, by direct and mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed June 21, 1902. Serial No. 112,610.

The combination in pneumatic straw-stacking apparatus, of a straw-collecting chamber having a tipping adjustable lower portion, a fan drawing its air with the straw from said chamber and located under said lower portion and tipping therewith, and a stacker-tube projecting from the fan-casing.

720,639. PNEUMATIC TIRE. Francesco Toni, London, England. Filed Sept. 8, 1902. Serial No. 122,580.

720,697. PNEUMATIC STACKER. Claus P. Jensen, Clarks Grove, Minn. Filed July 10, 1902. Serial No. 115,058.

The combination with a separator involving the straw-delivery rake and screens of the primary blower made up of the case and fan, and the secondary blower made up of the case and fan, said case being opened at its inner side and provided with the hood receiving from said rake, and said case having the hood receiving from said screens, the said two fan-cases being set vertically in approximately the same plane and having straw-delivery stacks or tubes delivering to different places exterior of the machine.

720,786. HOLDER-ON FOR PNEUMATIC TOOLS. Herbert S. Covey, Chicago, Ill., assignor to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Filed Dec. 13, 1902. Serial No. 135-075.

A holder-on for percussion-tools, consisting of a split ring formed with inturned lips or flanges upon its edges and having two finger-pieces crossing each other from the split portions of the ring, whereby the ring may be spread and opened by pressing together upon the finger-pieces.

720-804. PNEUMATIC - DESPATCH - TUBE SYSTEM. Henry J. Hert, Indianapolis, Ind., assignor of part of his right to Thomas Bemis, Indianapolis, Ind., and Major Collins, Brazil, Ind. Filed Aug. 18, 1902. Serial No. 120,105.

A junction for pneumatic-despatch-tube systems, the combination with a pair of converging carrier-channels, of a stop-arm normally but yieldingly projected into one channel, a finger carried by said arm, a second stop-arm adapted to be projected into the other channel, and a finger carried by the second stop-arm and engaging the finger of the first stop-arm, for the purpose set forth.

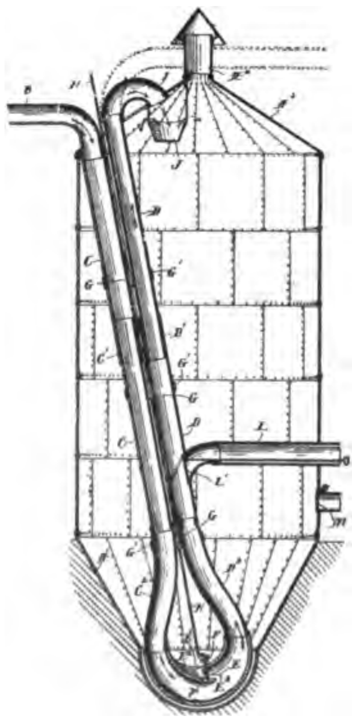
720,865. PNEUMATIC MASSAGE APPARATUS. Robert Watson, Washington, D. C., assignor of one-half to Charles A. Kram, Washington, D. C. Filed May 26, 1902. Serial No. 108,967.

An apparatus for the local treatment of disease by air pressure or vacuum, comprising a laterally-inclosed air-chamber having an opening adapted to be closed by the part of the body to be treated, and having an air-port, a reciprocative plunger for compressing or rarefying the air within the chamber and means connected with said parts for automatically opening and then closing said port during the stroke of the plunger.

720,872. GAS-COMPRESSOR. Stephen E. Alley, Glasgow, Scotland. Filed Nov. 18, 1902. Serial No. 131,872.

A "stage" gas-compressor the combination of a differential trunk reciprocating piston, a cylinder containing it and divided by the piston into two compression-chambers, a crank-shaft operatively connected with that piston, an inlet-valve chest, an outlet-valve chest, both chests extending along one side of the cylinder, an intercooler comprising a series of connected gas-tight pipes, an inlet-conduit from a source of gas-supply to the inlet-valve chest and thence to one of the two said compression-chambers, an outlet-conduit from that chamber to the outlet-valve chest and thence to the intercooler, an inlet-conduit from the intercooler to the inlet-valve chest and thence to the other of said compression-chambers, an outlet-conduit from that other chamber to the outlet-valve chest, two piston sliding valves one in the inlet-valve chest and in the inlet-conduits of that chest and constituting a gas-tight partition between them, and the other in the outlet-valve chest and in the outlet-conduits of that chest and constituting a gas-tight partition between them, and two eccentrics on the crank-shaft one operatively connected to the inlet-valve and the other to the outlet-valve.

721,145. PNEUMATIC CONVEYOR. James R. Burgess, Port Huron, Mich. Filed Oct. 13, 1902. Serial No. 127,072.



In a conveyor, an air-tube having straight parallel portions and a return-bend connecting said portions, said bend being provided with a throat and mouth in its concave side, vertical ways in the throat, a gate movable in said ways to close the mouth, and a rod to operate said gate secured thereto.

In a conveyor, the combination with a storage-tank for grain, of an air-tube extending downward within said tank to the bottom thereof and provided with a return-bend and extended upward through the top of the tank, said return-bend being provided with an opening or mouth, and a semicircular-shaped pipe detachably secured at one end to the end of the air-tube which extends upward through the top of the tank and having its opposite end projecting through the top of the tank to discharge the grain back into said tank.

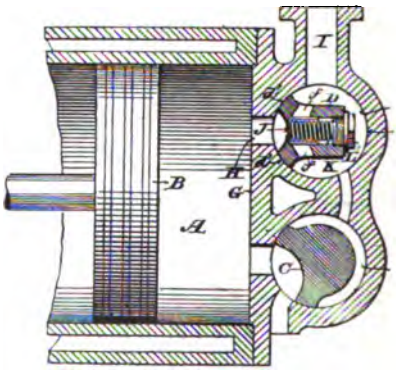
720,997. ART OF ESTABLISHING SUBAQUEOUS FOUNDATIONS. Edmund Becker, Washington, D. C. Filed Oct. 7, 1902. Serial No. 126,272.

A subaqueous foundation comprising an extended base and bulkheads projecting downwardly from the periphery and from intermediate parts of the said base to form separate air-chambers open below and adapted to be operated independently on the plenum system and other vertical but open partitions in each of said chambers to equalize the air-pressure in each chamber and serving with the intermediate bulkheads to prevent the contained water from rushing bodily about within the structure.

721,243. PNEUMATIC STACKER. Joseph K. Sharpe, Jr., Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed June 13, 1902. Serial No. 111,449.

The combination, with a threshing-machine, of a pneumatic stacker, comprising a straw-chamber, one end whereof is fitted to the upper portion of the rear end of the threshing machine and covers the straw-delivery opening therein, and the other end of which is reduced to the size of the next section of the straw-delivery trunk or duct, and the sides whereof converge from one end to the other, a delivery trunk or duct connected to the smaller end, two fans, suitable housings therefor, and air-ducts leading tangentially from the peripheries of said housings to the lower and outer sides of the straw-chamber and adapted to discharge the air along the sides of said chamber whereby the straw is subjected to the action of the air currents at the sides of the mass, and friction between said straw and the straw-chamber walls thus minimized.

721,221. DISCHARGE-VALVE FOR COMPRESSORS. Bruno V. Nordberg, Milwaukee, Wis., assignor to Nordberg Manufacturing Company, Milwaukee, Wis., a Corporation of Wisconsin. Filed Mar. 8, 1899. Serial No. 708,236.



A pump or compressor the combination with a cylindrical valve-chamber communicating with the pump-chamber through the discharge-port thereof and having an outlet-port, of an oscillatory discharge-valve having cylindrical bearings at the ends fitted in said chamber, and a longitudinal working face spanning the cylinder exhaust-port when the valve is closed, said valve being cut away outside of its working face between its end bearings so as to leave a space between it and the inner wall of the valve-chamber, and formed with passages leading through its working face into said space, and outwardly-opening spring-closed relief-valve seated in said passages, substantially as and for the purposes set forth.

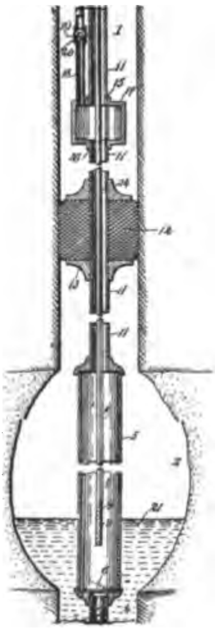
721,324. DIAPHRAGM FOR PUMPS, AIR-BRAKES, COMPRESSORS, OR THE LIKE. Edwin B. Rayner, Piqua, Ohio, assignor of one-half to William H. Rayner, Springfield, Ohio. Filed May 2, 1902. Serial No. 105,-699.

In combination with the distensible diaphragm of a pump, compressor or the like, a reinforcement applied to and covering a side thereof and consisting of a series of sector-shaped plates, substantially as set forth.

721,417. BLAST-FURNACE. Rudolf Berg, Pittsburg, Pa., assignor of one-half to Ferdinand Wenig, Pittsburg, Pa. Filed Oct. 2, 1902. Serial No. 125,613.

A blast-furnace, the combination with the boshes and twyers of the same, of means for supplying compressed and cooled air to the boshes and twyers, and through the same to the interior of the blast-furnace.

721,594. DEVICE FOR RAISING LIQUIDS FROM WELLS. Thomas F. Moran, De Young, Pa., assignor of one-half to Fred. J. Moser, Kane, Pa. Filed July 5, 1902. Serial No. 114,508.



A device for raising liquids from wells, comprising a pipe for conducting said liquids, a casing connected with said pipe and provided with inducts for admitting said liquids, a packing for preventing the escape of gases around said pipe, means for forcing air into said pipe, and for connecting said pipe with a reservoir for storing a quantity of liquid, thereby virtually increasing the capacity of said pipe.

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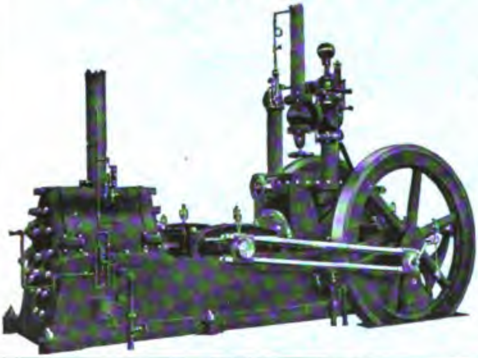

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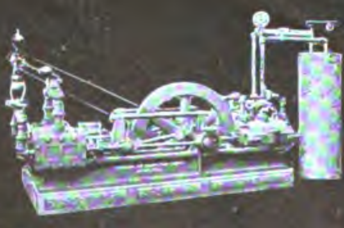

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VOL. VIII. NEW YORK, MAY, 1903. No. 3.

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN,

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VOL. VIII. MAY, 1903. NO. 3

Remarks made by W. L. SAUNDERS in discussing the paper entitled:

"**Electrical Apparatus for Coal Mining,**"

by W. B. CLARKE, Schenectady, N. Y.,

at the Albany Meeting of the American Institute of Mining Engineers, February, 1903.

Notwithstanding the sweeping statements made by Mr. Clarke in this paper the friends of compressed air are not dismayed. There is no war between electricity and compressed air. Each one has its field of usefulness and in that field each is supreme. In spite of commercial interests, in spite of prejudices and the enthusiasm of the inventor, the thing that is best will survive and flourish.

At least ten years ago, our engineering papers contained large advertisements and pages of reading matter about the application of electricity to mines, recording the introduction of numerous rock-drilling plants, and claiming that the problem had been solved greatly to the advantage of the miner and with promise of large profits to the manufacturers of electrical apparatus. Edison and Thomson labored to apply electricity to mines and each believed that the probabilities of success were great. This was the period of the solenoid rock drill, which was admirably suited, theoretically, to the percussive principle and in the development of which hundreds of thousands of dollars have been spent without satisfactory result. I have searched in vain for a standard mining equipment where electric rock drills are in constant, commercial operation. During a recent trip made from New York to California I visited most of the important mines of the West and failed to discover a single electric equipment, so far as this class of mining work is concerned. If any one will inform me where there exists to-day an electric drilling equipment in constant service in mines in the United States, I shall be glad to receive the information.

Mr. Clarke has been for some years an active and intelligent writer on the subject of electricity for mining. Whenever his papers have appeared we have read them with interest; for in many cases his arguments in regard to the operation of electric motors have been used effectively as arguments in favor of compressed air, especially in connection with mechanical haulage. Mr. Clarke mentions the adaptability of electric apparatus to coal-mines and the high efficiency of the electric system. There is no place where the pneumatic engineer has an easier time when competing for the introduction of machinery than in a coal mine. Air is exactly what is wanted in such a mine and electricity is what is not wanted. The one is safe and healthful, the other dangerous and destructive. The following extracts are taken from the Report of the Pennsylvania Department of Internal Affairs for 1899, Part V of the Report of Bureau of Mines:

"Besides the increase in danger from ex-"plosive gases, other elements of danger "have been introduced into the mines by "the use of mining machines and elec-"tricity. These have been introduced dur-"ing the past ten years, and it is the "opinion of the writer that the use of "electricity in any form in coal mines is a "menace to life, limb and property."

This report, for 1901, says:

"Electricity is one cause of fatalities in "the bituminous mines (seven having lost "their lives through it during 1901), that "so far has not proved fatal to any per-"son in the anthracite mines. Electricity "in various forms has been the cause of "many deaths in the soft coal mines, either "from the men coming in contact with the "electric trolley wire, or with the electric "wire that carries the power to the elec-"tric cutting machines. In my opinion, "separate traveling ways should be pro-"vided for the workmen when the haulage "is done by electricity, unless the wires can "be raised to a distance of at least six "feet from the rail, and even then there "should be sufficient room for passing on "the main haulage roads at all points as "men cannot always reach the 'safety "holes' in time. In every case where elec-"tric machines are used for cutting coal, "the wires should be made absolutely safe, "as men in the hurry of their work forget "about the 'deadly wire,' touch it, and all "is over, and the report follows 'killed by "an electric shock.' Humanity demands "protection for the workingmen from this "most deadly agent recently introduced "and employed in coal mines. I hope the "time will come when 'compressed air,' " 'liquid air,' or some other agent will sup-"plant electricity in coal mines.

"In gaseous mines, electric cutting "machines or other electric motors should "never be permitted in use, as otherwise "sooner or later they will be the cause of "a great catastrophe."

It cannot but be of interest to the members of this Institute to read the following statement of "The Difficulties Which Must Necessarily be Met, and Some Means of Reducing the Dangers of Faulty Insulation," which has formed the subject of an admirable paper by Mr. Alton D. Adams in the November, 1900, issue of *Mines and Minerals:*

"In but few other places are so many "conflicting requirements to be met, as to "electric wiring, as in mines. Distances "over which the electric energy must be "distributed are often so great that com-"paratively high voltages are necessary to "economy in the copper conductors. The "higher the voltage of circuits, the greater "the necessity for a high degree of in-"sulation, and yet the conditions in mines "are such that most wires must be run "bare. If wires of comparatively high "voltage must be used without an insulat-"ing covering, it is desirable that they be "erected beyond the easy reach of men and "horses, but the head room in mines is "often such that this precaution cannot be "taken. The large amount of moisture "present in a mine renders it very diffi-"cult to maintain any high degree of in-"sulation on wires unless they have a "covering of rubber, and the sulphur pres-"ent in the moisture of many mines, espe-"cially those of coal, rapidly ruins rubber "insulation. The result is that circuits of "comparatively low pressure are frequently "run with bare wire. A moderate amount "of insulation from the earth is obtained at "the points of support, by using only large "porcelain or glass insulators for the at-"tachment of the wire. Care should be "taken to have the wires touch nothing "save their insulating supports, and porce-"lain tubes are convenient in some cases "for this purpose, where the sides or ceil-"ings of passages are uneven. Such tubes "should also be used in every case where "wires go through partitions. With bare "copper circuits, in mines where there is "much moisture, the most careful work "will not ensure a high resistance to earth, "because of the films of moisture that col-"lect on the surfaces of the porcelain and "glass. While this moisture on insulators "is not usually sufficient in amount to "cause any serious loss of power, it may "well cause a severe shock to one who "makes a single contact with the circuit, if "his body is also in electrical connection "with the ground. The existence of these "conditions points to the conclusion that "all distribution circuits in mines should "be operated at a voltage that is not ordi-"narily dangerous to the life of man or "beast, so far as possible.

"Three kinds of electric service must "usually be provided for in mines, light-"ing, stationary motive power, and hauling.

"The voltages of circuits for these pur-"poses are apt to vary somewhat accord-"ing to the kind of electrical supply "adopted. The only satisfactory motors "available for traction purposes are those "of the direct current type. Such motors "may be operated at any voltage within "wide limits, but the prevailing pressures "for railways in mines are 250 and 500 "volts. Stationary motors of the direct "current type are usually operated at 220 "or 500 volts to correspond with generators "for incandescent lighting or with the trac-"tion system. Satisfactory induction mo-"tors operated by two or three phase alter-"nating currents, are now in use. These "motors are usually supplied by trans-"formers distant not more than a few "hundred feet, and there is therefore, no "reason for a voltage higher than 250 on "their local circuits. If incandescent lamps "are supplied with direct current, the vol-"tage on the two wire system must be "about 125 or 250 to correspond with those "of lamps. In case the three wire system "of distribution is employed for the cir-"cuits, their maximum pressures will be "twice those just named, or 250 and 500 "volts, according to the pressure required "at lamps. Lamps on alternating current "circuits are usually supplied by compara-"tively near transformers, and there is "slight incentive to use maximum pres-"sures greater than 125 volts on the two "wire or 250 volts on the three-wire sys-"tem.

"With these facts, as to the general re-"quirements and limits for electric pres-"sures in mine work, in mind, expedients "for greater safety and convenience of "operation may be considered. The stand-"ard pressure for electric street railway "lines all over the country is 500 to 600 "volts. The Edison three-wire system of "distribution, as extensively used by cen-"tral stations has very generally employed "a pressure of about 250 volts between its "outside wires. Experience, gained from "these two extensive classes of circuits, has "demonstrated that 500 volts is sufficient "pressure to readily kill a horse and even "a man, when a good contact with both "sides of a circuit is made. On the other "hand it has been equally well demon-"strated that 250 volts will not kill a man "under any conditions as to contact that "are at all likely to exist in practice, but "this conclusion does not follow as to a "horse. In mines, where both men and "mules are liable to make contacts with "live circuits of bare wire, it seems highly "desirable that their voltages be limited if "possible to 250, and especially that the "difference of pressure between either "side of any circuit and the ground be not "greater than this amount. As above "pointed out, there is seldom any good "reason for a pressure of more than 250 "volts on the alternating current circuits "for incandescent lamps and motors in "mines. Direct current distribution to "both incandescent lamps and stationary "motors may be carried on in mines at "maximum pressures of either 250 or 500 "volts, with corresponding possible differ-"ences of pressure between any wire and "the earth of 125 or 250 volts respectively. "This result is reached by the expedient, "very generally adopted in Edison city "systems, of grounding the third or so "called neutral wire of the three-wire sys-"tem. Accidental contact is seldom made "with more than one electric wire at the "same time, and a shock, from one side of "a three-wire system with a grounded neu-"tral, is given with only one-half of the "maximum voltage. The conditions as to "the insulation of circuits in mines, as "pointed out, are such that the maker of "contact with one side of an electric cir-"cuit is quite apt to receive the maximum "pressure of the circuit unless it has a "grounded neutral. The moderate pres-"sures necessary on transformer circuits "and the grounded neutral of three-wire "systems thus greatly reduce the dangers "from circuits for lighting and stationary "motors in mines.

"Most dangerous among electric systems "in mines are the trolley or railway cir-"cuits. The wires leading to lamps and "stationary motors may be grounded, so "that a person touching either wire will re-"ceive the maximum pressure, though this "is not usually as much as 500 volts. "There is, however, some chance of "escape without injury from accidental "contact, since the ground connections on "the lamp or stationary motor circuit may "be slight, or the electric pressure of the "circuit may be low. One side of the "street railway system of electric conduc-"tors is, however, permanently and se-"curely grounded by the use of the track "as all or a part of the return circuit. Any "one touching the trolley or the uninsu-

"lated feed wires is therefore subject to the "full difference of pressure between the "two sides of the system, if they are in "electrical connection with the ground or "rails. In places where the pressure on "the electric traction system in mines is "kept at about 220 volts the probable dam- "age to men or animals is very slight, but "repeated and serious injuries have oc- "curred in mines where 500 volts are em- "ployed. The very material incentive to "the use of the 500-volt traction system is "the fact that, compared with a system "having 220 volts as a maximum, it saves "75 per cent. of the necessary copper in "conductors, all other factors remaining "constant. This consideration is of espe- "cial weight in those instances where dis- "tances are so great that the relative "amount of the investment for copper is in "any case large. Fortunately, however, "there is a means, though it has not been "generally employed for the purpose, by "which the advantages of the 500-volt "traction system in mines can be retained "and at the same time the pressure be- "tween the trolley or any of its feeders "and the earth or rails limited to 250 volts. "This result is reached by applying the "three-wire system, long successfully used "for lamp and stationary motor circuits, to "traction circuits in mines. For this pur- "pose two trolley wires should be used, "one connected to each side of the trac- "tion generator, or to the free sides of two "generators in series. If only one gener- "ator is used, the conductors from the "rails to the power station should be con- "nected to a small dynamotor, designed to "keep the rail pressure halfway between "that of the main terminals. If two "generators are used in series for the trac- "tion lines, then the rail conductors should "be taken to their common connection. "On a double track road, one trolley wire, "representing one side of the system, "should be erected over the center of each "track, but for a single track road one "trolley may be located about over each "rail. In this latter case trolley poles "should be mounted near one side instead "of on the center of cars or locomotives "and about one-half of them take current "from each trolley. This arrangement "evidently makes the rails the third or "neutral wire of a three-wire system, and "any accidental contact between either "trolley wire and the rail or ground is ex- "posed to a pressure of 250 volts, when the "voltage between the two trolley wires is "500. Contact through accident with both "trolley wires at the same instant is im- "probable, and the three-wire thus offers a "decided increase of safety over the two- "wire system with 500 volts between trol- "ley and rails. While the low pressure "circuits for lamps and stationary motors "are quite safe as to their own voltages, "there is danger from another source in "those cases where these circuits run from "alternating current transformers that are "supplied by high pressure lines. This "danger arises from the fact that a ground "connection at any point on the high "pressure circuit and a cross between the "high and low pressure circuits inside the "transformer or elsewhere, exposes one "who makes contact from the low pressure "to the earth at any point to the voltage of "the high pressure circuit. Such an acci- "dent would probably result fatally, as the "primary alternating lines usually oper- "ate at pressures as great as 2,000 or "3,000 volts. This danger can be very "largely averted by a substantial and per- "manent connection between one wire of "every secondary circuit and the ground.

"If the secondary circuits from trans- "former are on the two-wire plan, either "side may be connected to earth, but if "they are run three-wire the neutral should "be so connected. The connection to "ground when properly made is of much "lower electrical resistance than the body "of a man or animal and the only damage "likely to result from a cross between the "primary and secondary circuits is a blow- "ing of fuses. The high pressure primary "lines to transformers should be kept out "of the parts of mines in which work is "going on, as far as possible. Rubber "covered wires, cotton braided and with a "sheath of lead on the outside seem to be "the best material for the primary cir- "cuits. Where high pressure wires are "exposed to mechanical injury, as in ver- "tical shafts, the rubber and lead covering "just mentioned should be used and a "substantial iron pipe erected, into which "the leaded wire is subsequently drawn. "It is not necessary to have any lining of "insulation for the iron pipes, or to supply "insulating supports for it."

These are but a few of the many state- ments made from time to time by men of practical experience in coal mines. Electricity, with all its usefulness and value to mankind, is not the best power to be taken down into a mine where gases and dust are liable to accumulate and where human life is endangered by the electric spark. In cases of this kind the question of efficiency is of little or no importance when compared with greater and more serious questions, and in face of the facts with which the members of this Institute are familiar, I deny Mr. Clarke's statement that the coal mine is "a field to which the electric motor seems to be especially adapted."

As to the pneumatic mine-locomotive, the statement is made that it "is not an unqualified success," and among the reasons stated are that "its radius of operation is restricted." A mine-locomotive which is absolutely restricted to the limits of a trolley-wire would seem to have a more limited radius than one which is independent of any wire or connection, which carries its own power stored in tanks and which might go anywhere and on any track to the extent of its storage-capacity. Such is the pneumatic locomotive, the first of which for mining purposes was built in the late eighties and early nineties, and of which probably not more than six or seven were in use in 1895, while to-day there are at least 150 of these locomotives in successful operation in mines, 125 of them having been built during the last three years. This record will, I think, compare favorably with that which can be shown by the manufacturers of electric mine-locomotives. For a more detailed study of this subject I beg to refer to a very practical paper by Mr. J. H. Bowden, Chief Engineer of the Susquehanna Coal Company, entitled "Compressed Air Haulage Plant," at No. 6 Colliery of the Susquehanna Coal Co., published in the transactions of the American Institute of Mining Engineers in the year 1900. In this paper Mr. Bowden shows that by the use of air-haulage as against mule-haulage the total saving in two years was almost equal to the total cost of the air-haulage plant; and he goes on to say that "at the average rate of saving for 1897 and 1898, the entire cost of the plant would be saved in 361 working days." I am indebted to Mr. E. P. Lord, General Manager and Superintendent of the H. K. Porter Company, of Pittsburg, for the following comparison of cost of haulage in coal mines by means of compressed air and electricity:

"Figures for compressed air haulage "taken from a paper read by J. H. Bow-"den, Chief Engineer of the Susquehanna "Coal Co.

"Figures for electricity taken from the "catalog of the General Electric Co., No. "1030, entitled 'Electric Mine Locomo-"tives,' published August 6, 1901.

"The compressed air haulage plant is "located at Glen Lyon, Pa., No. 6 Shaft "and No. 6 Slope of the Susquehanna "Coal Co.

"The electric haulage plant is located at "Forest City, Pa., No. 2 Shaft of the Hill-"side Coal & Iron Co.; Mr. W. A. May, "Superintendent.

"The compressed air haulage plant was "installed 1895 and 1896: One locomotive, "one compressor and the pipe line for the "shaft locomotive, September, 1895; the "slope locomotive and the pipe in May, "1896. A second compressor was ordered "April 7, 1900, to provide sufficient air for "the increasing length of haul and output. "The figures given are for the year 1898.

"For the electric haulage plant I do not "know the date it was installed or the "year for which the published figures are "given.

"Both plants used two locomotives.

"Column 1 is taken from Mr. Bowden's "paper, with the exception of the cost per "ton, which was calculated by the writer. "Mr. Bowden reduces the cost to the ton-"mile unit. The cost per ton-mile given by "Mr. Bowden is 1-93/100 cents. The aver-"age length of haul was less than one mile, "hence the cost per ton hauled is less than "the cost per ton-mile. The other costs "per ton were taken direct from the cata-"log of the General Electric Co.

ITEMS.	1 Cost of Compressed Air.	2 Cost of Electricity.	3	REMARKS.
"Number of working days "per year..............	160	200+	141¼ =	(+) Estimated for (=) Actual time.
"Output per day, tons....	2362½	989	989	Mr. Bowden in his paper figures 1245 ton-miles per day. Figure in Column 1 is tons of coal hauled.
"Engineer, power house..	$1.16	$1.20	$2.84	
"Motorman	4.20	4.23	9.31	
"Helpers (brakemen)	3.20	3.20	3.61	
"Electrician	——	1.67	3.68	
"Repairs to motors.......	.74	5.95	8.42	
"Repairs to line..........	——	——	.46	
"Repairs to generator.....	.57		.61	
"Fireman			2.50	
"Depreciation at 5%......	4.74	5.20	8.17	
"Interest	4.73		4.41	Compressed air, 5%. Electricity, 3%.
"Interest, repairs and de- "preciation, 174 H. P. "boiler	1.63	——	——	
"Oil and waste for motor.	.25	.22	.35	
"Do. for generator........	.47		.74	
"Steam (fuel and firing)..	2.32			
"Totals	$24.01	$21.67	$45.10	
"Cost per ton............	.01015	.02192	.0456	

"Conditions unknown to the writer "might have a tendency to compensate "partially for the great difference in cost; "but it would be hard to find conditions "sufficiently unfavorable to the electrical "haulage to entirely equalize them.

"The ton-mile basis is not a fair basis "of comparison, as the delay at terminals "forms so large a part of the entire time "consumed by the locomotives. The time "lost in this way would remain a fixed "quantity regardless of the length of haul, "and therefore if the haul were longer the "locomotives would make a better show- "ing on the ton-mile basis.

"The compressed air locomotives under "consideration were respectively the fourth "and fifth ever built by the H. K. Porter "Company, and were crude in many ways "when compared with the compressed air "locomotives now being built. We have "no doubt that the electric locomotives "built for the Hillside Coal & Iron Com- "pany were also inferior in many ways "when compared with the present product "of the General Electric Co. But why "should one type improve more than the "other?"

As to efficiency, it is not denied that the efficiency of an air locomotive, like the efficiency of all locomotives, is low. Probably 20 to 30 per cent. is correct when applied to air-locomotives which do not reheat the air before use. It must be denied, however, that the efficiency of an electric locomotive is 55 per cent. In figuring on haulage-plants for mines we have been told by reputable men that the estimates of boiler-capacity for the pneumatic plant were substantially the same as those furnished by bidders of electrical apparatus. In a paper written by Mr. Clarke for "Mines and Minerals," in July, 1901. entitled "Electricity *vs.* Compressed Air—A Comparison of the Efficiencies and Relative Cost of Installation of the Two Systems," he makes the statement that 150 H. P. of boilers will be required to operate his supposed electrical installation and that in the case of compressed air the steam engine driving the compressor was actually indicating 150 H. P. Mr. Bowden makes the statement, in connection with the paper which Mr. Clarke is criticising, that he estimates the steam consumption at 174 H. P., and further, that a second compressor is being installed, from which Mr. Clarke infers that the final steam consumption will be 300 H. P. This cannot be the case, as the present compressor is doing the work, and the installation of the second compressor will simply allow the original machine to be operated at below its normal capacity without any increase in the steam consumption. But in no case would one be led to believe that there was a difference in efficiency of 20 per cent. for compressed air and 55 per cent. for electricity.

As to the relative cost of an air and an electric plant, Mr. Clarke makes the statement that a compressed-air plant "costs from two to three times as much as an equivalent electric mine-haulage system." With all due respect for Mr. Clarke, I must maintain that this statement is incorrect. The relative cost of any two systems would vary with conditions. The facts are that in putting in bids for pneumatic installations we have found that at times the difference in cost has been from 50 per cent. in favor of compressed air to 50 per cent. against compressed air, according to the conditions; and we may say in a general way that the cost of an electric installation is lowest when operating on a single entry, involving the minimum amount of wiring, whereas, when a number of diverging roads occur, the independent nature of the compressed-air locomotive, which allows it to operate over lines without any previous preparation or expense places it in the most advantageous position.

In the early part of Mr. Clarke's paper he alludes to "weaknesses" which have developed in the use of electricity in mines, and goes on to say that this matter has received attention, and improvements have been made which have facilitated "the repairs and renewals." Later on in his paper, when comparing the pneumatic with the electric locomotives, he speaks of the former as "relatively complicated" and "subject to very frequent repairs." This is rather rough on my friends in the air line, especially so as it is a fact that an air locomotive is a simple machine differing little from the well known perfected mechanism of the common locomotive, and that it is very much more simple in its construction and very much less liable to repairs than an electric locomotive. We have no better authority on this point than Mr. Clarke himself, who in his paper in "Mines and Minerals" of July, 1901, previously cited, says:

"The operating expenses of the electric "haulage system would not be much less "than those of the compressed air sys- "tem."

It may be added that the H. K. Porter Company, in a number of cases, although local conditions have made the initial cost relatively high, have received orders solely because an unprejudiced investigation made by disinterested parties has shown that the operating expenses of the air plant, particularly in the question of repairs, have been so much less than those of the electric haulage system that the difference would pay a handsome return upon the initial investment. Furthermore, I desire to call attention to a discussion in *Mines and Minerals* of Mr. Clarke's paper of July, 1901, in which the following correspondence occurs:

"(In order that the above discussion "may be fully understood, and since Mr. "Bowden, who prepared the paper which "is used as the basis of Mr. Clarke's fig- "ures, has died since his paper was printed, "we have submitted Mr. Clarke's figures "to Mr. Bowden's successor as chief en- "gineer of the coal companies of the Penn- "sylvania Railroad Co., Mr. R. Van A. "Norris, whose answer is appended.)"

"Mr. H. H. Stoek, Editor *Mines and Min- "erals*, Scranton, Pa.:

"Dear Sir:—I return to you herewith "the article 'Mine Locomotives, Electricity "*vs.* Compressed Air,' by Mr. W. B. "Clarke. I have made calculations simi- "lar to those made by Mr. Clarke, and "believe his conclusions to be practi- "cally correct as far as they go. But "there are other conditions besides econ- "omy which have decided us in favor of "compressed air haulage; the principal "ones being the gaseous character of the "mines, in which the possible sparking of "an electric machine would be a source of "grave danger; the simple character of the "mechanism of a compressed-air locomo- "tive, which is within the capabilities of a "colliery plant to keep in order and re- "pair; the advantage of having consider- "able radius of action beyond the charging "stations, and the beneficial effect of the "air on the ventilation of the mine.

"As was shown in Mr. Bowden's paper, "the cost of power is but a small fraction "of the total cost of operation, the saving "for even a 50 per cent. decrease in the "steam used being but .09 of a cent. per "gross-ton mile.

"As an evidence of our entire satisfac- "tion with this method of haulage, I "might add that we have just ordered an- "other compressed-air haulage plant com- "plete for our No. 1 shaft, Nanticoke, Pa.

"Yours very truly,
"R. V. Norris,
"Chief Engineer."

The foregoing statement made by Mr. Norris refutes the argument that the pneumatic locomotive is complicated. Mr. Norris' experience and knowledge of this subject are beyond dispute. In connection with the matter of repairs it may be well again to quote Mr. Clarke, who wrote as follows in *Mines and Minerals* in April, 1901:

"'Electric Mine Locomotives—Things "to be Observed in Choosing, Operating "and Caring for Mine Locomotives to "Secure Greatest Economy."

"Annoying delays are often experienced "at mine-haulage plants, where there are "several locomotives, due to the frequent "'blowing' of the circuit breakers. It is "proper, of course, that the circuits should "be automatically opened, when the gen- "erator is called upon to deliver a current "beyond its safe capacity, but it is annoy- "ing if the service is interrupted with too "great frequency. The remedy for this "trouble also lies, to a very great extent, "in the hands of the motorman, as the "intelligent use of the controller will "minimize the demand upon the generator. "This trouble is aggravated by the simul- "taneous starting of all of the locomotives "when the circuit breaker is reset by the "engineer at the power house, since each "locomotive requires a comparatively large "current when starting, and the sum of "their starting currents is often sufficient "to immediately blow the circuit breaker "again. In this way it often happens that "the circuit breaker is thrown out several "times in rapid succession, and the entire "haulage system may be interrupted for a "half hour or more. The engineer occa- "sionally becomes righteously indignant, "allows the circuit breaker to remain out "a few moments before resetting it; and "the relations between the employes of the "power house and the motormen become "strained, with no good results to the "company."

In this paper also Mr. Clarke advocates, where a number of electrical locomotives are employed, the establishment of an inspecting force, which shall work all night in cleaning and hunting for defects and making repairs; and further, that a spare armature or two should always be carried in stock, together with other repairs, and that this is necessary in order to avoid the delay and expense due to the loss of the use of the locomotive, the consequent reduction of the output, the express and telegram charges, not to mention the annoyance that can be avoided if the locomotive is regularly inspected, and if extra parts are carried in stock at the mine.

His summary at the end of this article (the seventh clause) reads:

"Last and most important, establish a "rigid system of inspection and carry *a* "*liberal stock of repair-parts.*"

We might add to this a little advice to anyone who contemplates an electric installation, that he be prepared to take care of all repairs promptly, that he employ an experienced electrician and that he have a shop sufficiently equipped to provide for such repairs as will be inevitable. It is a well known fact that in the mines of the Pittsburgh Coal Company there are several shops located at central points in which they constantly employ a number of skilled mechanics for making repairs to electrical equipment used in their mines, and that in the large syndicate of mines controlled by the Pittsburgh Coal Co., comprising 70 or 80 different mines, only two are equipped with air haulage plants; one of the air haulage plants having been installed thirteen years, yet it is stated by experts familiar with the operation of these mines, that in the matter of cost of repairs and safe, uniform service, these air plants have given less trouble and have cost less than any of the electric plants at other mines. There are, of course, places where electricity is particularly well adapted for mine-haulage and where it is to be preferred possibly to any other means, but those places do not exist everywhere, and it is unfair to state the broad principle, that electricity is better suited for mine-haulage than compressed air.

It is a common thing to hear from electrical sources that compressed air gives a low efficiency. A restricted definition of the word efficiency is, the proportion of the power generated by the coal consumed under the boiler which is delivered by the machine in question. But in the broad, practical sense, namely, that of capacity to accomplish work in the best manner consistent with all conditions, the advocates of compressed air claim that, as compared with all other powers, it is supreme in mines. It is common to criticise the efficiency of a percussive rock-drill. The catalogs of electric-drill manufacturers have invariably stated comparisons showing that an electric-drill consumes from two to three H. P. as compared with 8 to 10 H. P. in an air-drill. But in the first place, the figures of electrical power consumption are largely theoretical, while those of the air-drill are based on an experience of forty years. There is no doubt about the fact that an air-drill when doing good service in a mine will consume from 8 to 10 H. P., but in doing this it does its work; it gets the hole in; it makes progress; it costs the minimum amount in repairs when compared with the number of linear feet of hole drilled. In these respects the air-drill is the most efficient machine at work in a mine to-day. Think for a moment of the hard work done by this "pounder." Here is a machine light enough for two men to handle and yet containing within itself the capacity to make a hole in a piece of hard granite or trap rock at the rate of from 2 to 5 inches a minute. The machine consists of little more than a piston, a valve and a cylinder, as these are the principal moving parts. The power is led through a piece of hose which in itself is certainly a simple piece of mechanism, and the compressed air is conducted alternately to one end of the cylinder and the other, thus causing the piston to strike its blows. Unless some one discovers a better way to drill rock than by the hammer-blow it is likely that the air-drill will stand supreme for a great many years to come. No electric drill that has thus far been devised has equalled it in simplicity; and it is certain that no electric drill has ever equalled it in drilling-capacity, which is really the measure of efficiency.

The little air-compressor which is mounted on the hip of a locomotive is another example of efficiency in air-apparatus. This Westinghouse pump has been pointed to as a wasteful machine, and if it were used to drive the shafting of a shop it would be wasteful; but when applied to the air-brake, taking its power from the boiler of the locomotive, storing it in tanks along the train and using it at the proper time to throttle the wheels and bring to a standstill within a few hundred feet a train weighing many tons, and moving at the rate of a mile a minute, it is the most efficient device known to mankind. There is another little air-device used to move switches, known as the electro-pneumatic system of switching. This is an admirable illustration of efficiency and it also illustrates the point which I referred to in the beginning, namely, that there is no war between electricity and compressed air and that each has its field of usefulness. This electro-pneumatic system which controls the great Pennsylvania Railroad in its line between New York and Philadelphia, and which may be found in all large railway terminals, represents a community of interests between compressed air and electricity. Wires and air-pipes run side by side, the one to act as the trigger and the other as the power to move the switch and direct the train safely, expeditiously and economically. The air-part of this system, so far as the little cylinder in which is a piston moved by air is concerned would not be an efficient engine if applied to common purposes for which power is used, but when doing its work on the switch of the railroad it is one of the most efficient known. Were this not so, some other means would be employed; and we have in this instance electricity by its side ready to serve the purpose, were it able to do so with equal efficiency.

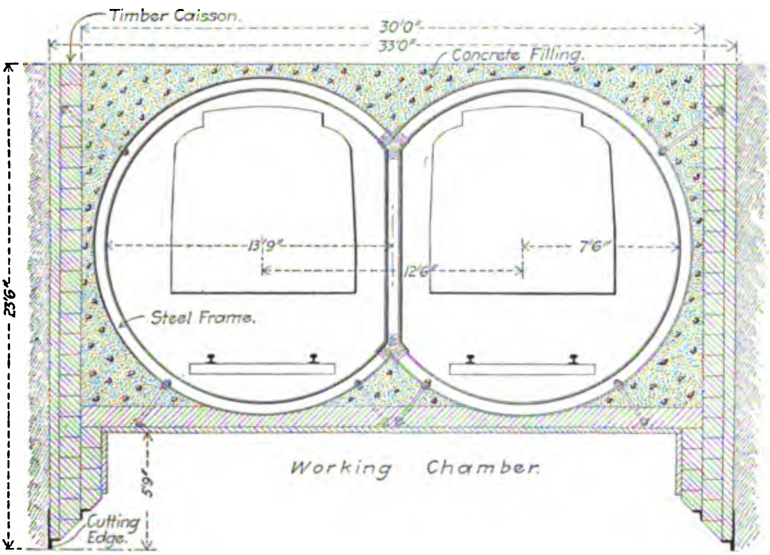
Improved Methods for Difficult Sub-aqueous Tunneling.

The new transit systems planned for Greater New York involve the construction of a number of very important tunnels under the East and North Rivers, which will have lengths of several thousand feet and dimensions sufficient for one or two railroad trains. These tunnels must be placed at a considerable depth in the ground, involving in some cases great difficulties in construction. In various places they will have to be driven through rock, hard pan, clay, gravel, boulders, sand, mud and very soft silt, and sometimes very dissimilar strata, like rock and silt, will be intersected by the tunnel at the same point. No material obstruction to navigation can be permitted at any time. Where the tunnels cross the rivers the tide has a range of several feet and a maximum current of more than four miles an hour. The ordinary methods of construction will not satisfactorily meet these difficulties.

Recognizing these facts, prominent engineers and contractors have devoted special effort to devising new and improved solutions for the problems of design and construction, which will be applicable to difficult tunnel work in general and, in most cases, suited to the assumed requirements of one or more of the tunnels projected for New York. Several of these plans have had their essential features patented, and have been submitted for consideration in connection with the different projects. While it has not been officially announced that any scheme has been accepted, it is probable that some of the methods suggested may be adopted in the near future, and, as they represent the most advanced thought and careful design of engineers experienced and successful in important constructions, the *Engineering Record* has prepared the following concise descriptions of those plans which have come under its notice.

The system proposed by Mr. John F. O'Rourke, contracting engineer, provides for a finished structure consisting of piers, sunk below the bottom of the river, connected by submerged tubular spans supported uniformly throughout the whole lower surface on the solid bottom, with no projections above the river bottom or obstructions to navigation. The construction will comprise four principal processes:

the construction of temporary working shafts about 500 feet apart in the line of the tunnel; the building on shore, launching and floating to position of sections of the tunnel which will reach from shaft to shaft; the sinking of these sections to sub-grade between the shafts; the alignment and connection of the sections in final position, the removal of the shafts or piers above them, and such back-filling as may be required. The method is a new and ingenious combination of operations and principles which have for years been standard in pneumatic caisson work for chamber for use in sinking the tunnel. These sections will normally be about 500 feet long, but other lengths may be used when circumstances permit. They will be fully or partly constructed on shore at any convenient place, launched, concreted and towed to position. On the line of the tunnel a trench will be dredged wide enough to receive the tube and extending down to sub-grade, or the sections may be sunk to place by doing all the excavating from the air chamber. Along the center line pneumatic timber caissons about 50x72 feet will be sunk by ordinary methods



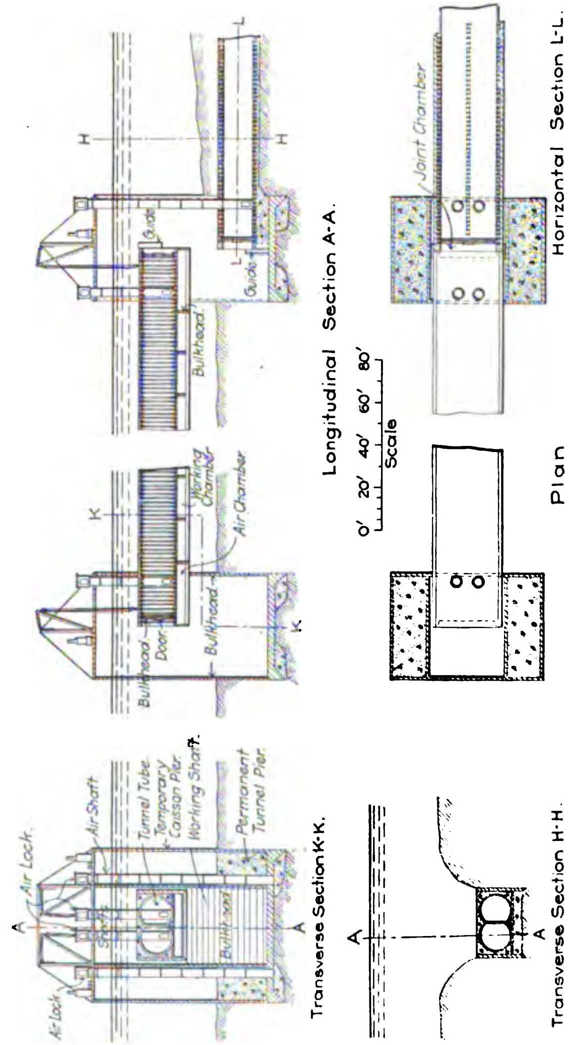
Cross-Section of Finished Tunnel.

bridge piers, is believed to be conservative and positive, and to permit minimum depths and grades and rapid execution.

The tunnel shown is designed to be a twin structure having a cross-section composed of two intersecting circles, each having clearance for a train of steam cars. The tunnel shell will have a steel framework of transverse bents of curved I-beams covered with a riveted steel plate and enclosed in a monolithic protecting mass of concrete filled between the steel work and a timber caisson, as shown in the general cross-section. The lower part of the caisson will be decked over solid, and the walls will be extended a few feet below to form the sides of an air-tight working until their cutting edges are sufficiently below sub-grade of the tunnel. Then the working chambers will be sealed and concreted and the caissons, being thoroughly fixed to a considerable depth in the river bottom, will afford sufficient stability to resist the force of the current and the pressure from the tunnel sections; but will be so far apart and of such moderate dimensions that they will not seriously obstruct navigation. The sides of the caissons, which are transverse to the tunnel axis, will be removable bulkheads easily displaced to allow the ends of the tunnel sections to be inserted through them, as shown in the general plan and elevation.

Two adjacent pier caissons having been

sunk and a tunnel section inserted between them, the ends of the tubes will be temporarily closed by bulkheads and the end compartments at least of the working cut away under pneumatic pressure, so as to let the ends of the tubes, which rest between them, sink rapidly under control, the ends being carried on jacks while the



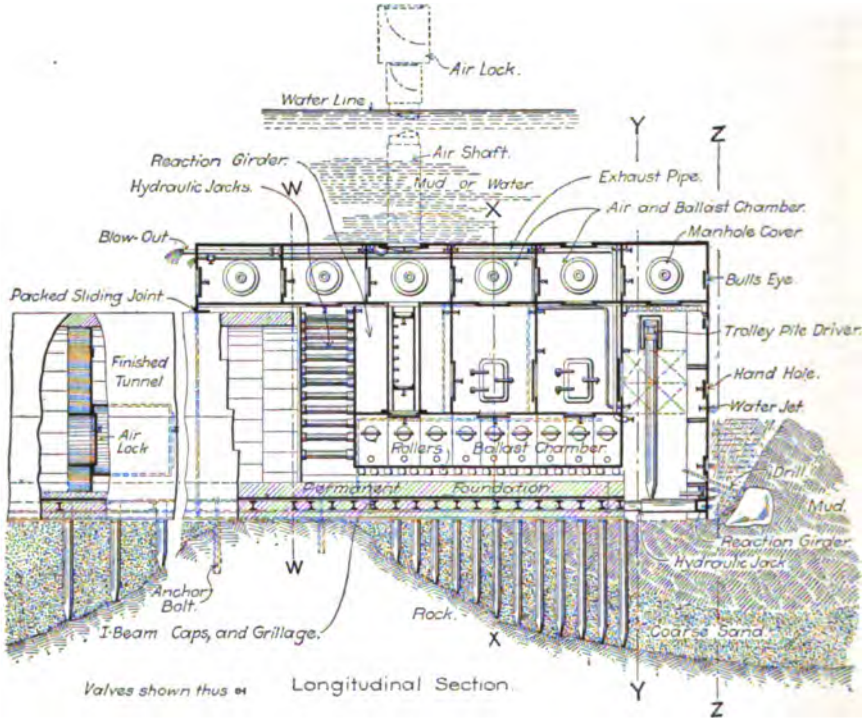
Method of Sinking Caisson Tunnel Sections.

chamber underneath will be filled with air. The buoyancy of the tunnel section will be overcome by admitting sufficient water to the tubes to sink them, and the bulkheads in the sides of the pier caissons will be cutting of the timber proceeds and then lowered at will. When the cutting edge of the tube caisson reaches the bottom of the river, the excavating will be carried on as in ordinary caisson work, and the tubes will descend under perfect control to their required level or grade, after which the working chamber will be sealed and concreted solid to the deck of the pier caisson and to the bottom of the excavation between piers. A third caisson pier having been placed, another tunnel tube will be floated into position and entered in it and in the second pier, and sunk as already described. Guide pieces will probably be attached to the ends of the tubes so that the second tube will engage the first and be guided to its approximate alignment, where it can easily be closely adjusted by hydraulic jacks or other devices which can move it in any direction while the weight to be overcome will be reduced by the approximate equilibrium between the ballast and the buoyancy. The tube caissons will be fitted with air shafts and air locks at both ends, and the end bulkheads of adjacent sections will be separated a few feet so as to leave small chambers between them which can be pumped out and made accessible for caulking and splicing. In this way the successive lengths of the tunnel between piers can be put in position and finished, after which those portions of the caisson piers which are above the tunnel roof will be detached and removed.

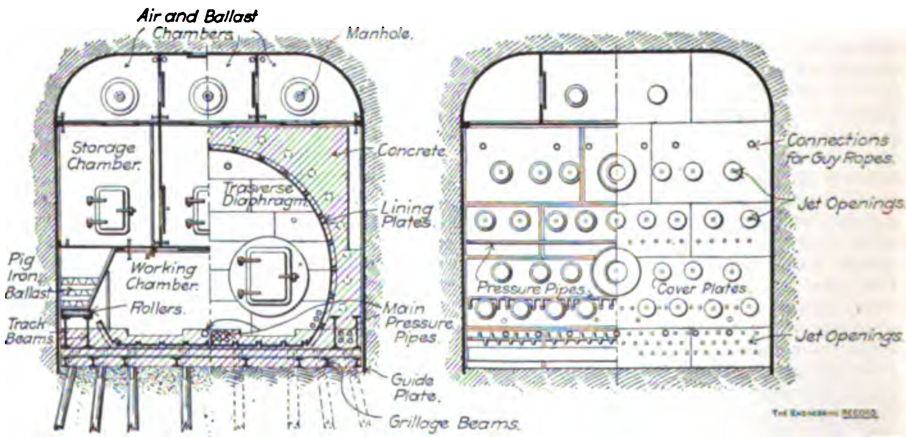
Calculations have been made which, on an assumption of a current of four miles an hour, give an hydraulic pressure of 375 tons against one tunnel section and of 86 tons against one of the caisson piers, making a total transverse pressure of about 460 tons against one pier, which will have a stability due to its own dead weight of 2,500 tons, besides being embedded to a considerable depth in the hard bottom, thus giving it a large factor of safety against overturning under the worst circumstances, when the tunnel tubes are floating at the surface of the river. After completion, the tunnel tubes will have continuous bearings over wide bases, so as to be thoroughly supported and not be in danger of sinking, even on soft material. The steel and concrete construction will have great transverse and longitudinal strength so as to distribute concentrated loads over large areas of the supporting ground, which, it is believed, will have ample bearing power, even if of silt, which, however, is not the case to the same degree in ordinary driven tunnels with cast iron or masonry lining.

A large part of the construction work will be done on shore where the tubes can be made as strong as desired and perfectly water-tight. The sinking will be unrestricted and simple, and air pressure will be used to exclude mud and water in the only perfect way, on horizontal planes. As the construction is independent of a natural roof, the depth and the attendant peril is diminished and the conditions of working are comparatively safe. This method is adapted to construction of pile foundations, where necessary, and provides for separate tunnels, although switches can be arranged to transfer trains if necessary from one tube to the other, and doors can be placed at intervals between the two tubes so that in case of accident, particularly fire in a train, the passengers can escape the flames and deadly fumes by entering the other tube and closing the door. It is not thought that this method will differ much in cost from driven tunnels where conditions are favorable to the latter method. In cases of mixed rock and earth in the same cross-section it is much cheaper, while the time required is less than in either case. The material advantage, however, lies in the stronger tunnel and better grades.

The method of tunnel construction proposed by Mr. Jules Breuchaud, C. E., provides for the preliminary construction of a pile foundation or solid footing in successive portions made just in advance of the tunnel walls and roof and all built within the protection of a shield. This shield, which may be considered as a movable pneumatic caisson, is designed to be sunk at any point in the alignment of the tunnel and to move forward on the natural or artificial bottom of any trench or tunnel, excavating the material in advance. Several shields may be placed at intermediate points, be simultaneously operated so as to construct adjacent sections at the same time, and thus greatly diminish the duration of the work. The shields may move through water, silt or mud while the excavation of soft or hard material progresses on the under side, and are primarily adapted to the construction of tunnels without natural roofs; but they may be modified for the construction of submerged foundations, piers, pipe lines or conduits. The shields are rectangular with vertical sides and ends, horizontal top and rounded corners, and are made with double walls enclosing space around the sides and roof, which is divided into numerous air-tight chambers by transverse vertical and horizontal partition plates. These chambers



Longitudinal Section.



Half Section X-X. Half Section W-W. Half Section Y-Y. Half Elevation Z-Z.
Shield Constructing Permanent Tunnel Foundation in Advance.

are connected and are accessible from the interior of the shield by covered manholes and doors, as shown in the sections.

The shield has only four sides, being open at the rear and bottom, and is braced by the interior solid plate diaphragms between the air chambers. Its lower part is an unobstructed working chamber corresponding to that of an ordinary pneumatic caisson. There is a transverse vertical bulkhead near the forward end enclosing a chamber reaching to the roof and affording an unobstructed space for the driving of foundation piles, which may be supported in a traveling carriage, handling also the driving apparatus. The front end of the shield is a solid plate diaphragm, which may be stiffened by longitudinal bracing to the transverse bulkhead, as indicated by dotted lines. It is pierced with horizontal rows of small holes through which pneumatic and hydraulic jets can be played to loosen the material in front. There are other small holes, provided with stuffing boxes, for the insertion of drills to attack rock, boulders, hardpan, etc. Larger holes are also provided and covered with water-tight inside plates, which may be removed to reach external objects.

The excavating jets are supplied by nozzles or flexible connections branched to horizontal pipes running across the inner face of the end of the shield, connected with large mains permanently built into the concrete floor of the tunnel. The compartments in the roof and sides are independent and can be filled with water ballast or emptied by a system of pressure pipes operated from the power plant in the shaft or on shore. The lower chambers in the sides are tapered at the bottom to give more space in the working chamber, and can receive pig iron ballast to increase the stability of the shield. One of the interior center chambers is provided with vertical, telescopic, cylindrical shafts which may be projected through the roof and carried above the surface of the water, so as to terminate there with an air lock and afford independent access. The shield is seated on horizontal transverse rollers under its parallel sides, which take bearing on the tops of special pairs of deep I-beams permanently embedded in the concrete footing of the tunnel. The side plates of the tunnel project below the rollers and enclose the full depth of the sides of the concrete footing, thus guiding the tunnel in its alignment and serving to prevent the escape of compressed air, excepting under the higher front edge where its action would be beneficial rather than harmful in loosening the material about to be excavated.

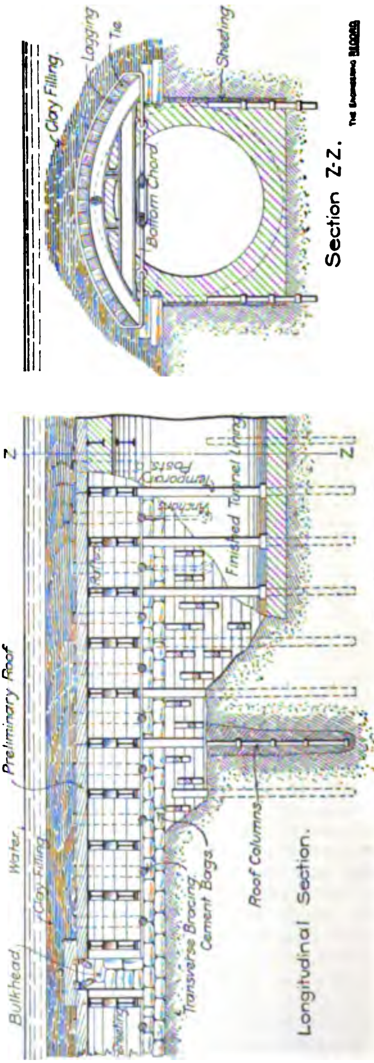
The longitudinal movement of the shield is effected in the usual way by means of hydraulic jacks placed horizontally to bear between the forward end of the last finished section of tunnel lining and a girder of corresponding outline in the rear of the shield. Besides, there is a horizontal row of jacks in the lower part of the front end of the shield which bear between a girder across the lower edge of the front diaphragm and the end of the completed floor platform. This latter set of screws, not ordinarily used in shields, is designed to give a balanced pressure and provide more regular and positive motion. The rear end of the shield is made to overhang the completed tunnel lining for a considerable distance and to slide upon it with a close joint. In operation the shield may be constructed at any convenient place on shore with a temporary air-tight bulkhead closing the rear end. It may be launched, floated to position and sunk as required, adjusted like a foundation caisson and connected to the end of the tunnel before removing the bulkhead, or the bulkhead may be attached to the walls of a tunnel lining built inside the shield and left to close it while the shield moves forward constructing a section of the tunnel.

In operation, at any given position, several rows of piles will first be driven inside the shield and capped with a grillage of longitudinal and transverse I-beams filled in with a solid bed of concrete, or the surface of the rock will be prepared to receive the tunnel floor which may be anchor-bolted to it, or the invert may be laid on a bed excavated in hard material. Then a section of the lining for the walls and roof will be built in the rear end of the shield and the material in front excavated through the orifices for that purpose. The jacks will then force the shield forward, another section of the floor and walls will be built, and so on.

Important features of this method are the ability to construct the foundation in advance from within the shield, to use the shield as a pneumatic caisson, and to build sections of the tunnel at intermediate points, and the safety for the workmen afforded by the closed forward end of the shield, which prevents any possible caving in or entrance of water while the air pressure is maintained. The framework of the shield is rigidly braced with heavy trusses, stiffened by deep flange plates and provided with lateral connections for outside guy lines which may be used to anchor it. The front end is provided with suction pipes through which soft material may be drawn into the shield and with bulls-eyes through which the character of the material in advance may be observed.

A process for building submerged tunnels in open trench through soft earth has been designed by Mr. Jas. C. Meem, who proposes to use a pitched or arched timber roof, built on shore in long sections, launched, floated to position and sunk on to longitudinal foundations previously laid in a dredged trench parallel to the side walls. Underneath this roof the excavation will be made in open trench, suitable foundations constructed and the invert, walls and roof of the tunnel built. The essentials of the process are the special roof and the method of supporting it and excavating and building beneath it. Two types of roof are proposed—one having double pitched I-beam rafters and horizontal cross-beams forming A-shaped trusses, and the other having segmental arch-shaped I-beams with horizontal ties connecting their lower ends, both types being covered with longitudinal timber lagging secured by straps on the upper side which are bent around the lower ends of the rafters and securely joined by tension bars with tightening adjustments. The roof sections are sunk so that their edges rest on the longitudinal walls, preferably built with concrete bags placed by divers. The abutting joints at the adjacent ends are covered with felt or steel aprons and the entire shield is well covered with a bed of clay and sand to exclude water from above and prevent the escape of compressed air from below. At intervals of several sections, short spaces may be left between the ends of the roofs and filled in with solid bulkheads to divide the tunnel into shorter sections, if necessary, for excavation and construction.

If additional stability is required, the roof may be temporarily secured by sinking on it loaded barges. After the roof is in position, excavation is commenced under it and, if necessary, air pressure is used there. The excavation is made in open trench with sheeting and bracing for the sides if necessary. In very soft material, short transverse drifts may be made in advance of the main excavation and sectional pipes sunk in them and filled with concrete to the roof, after which the excavation can be completed in short

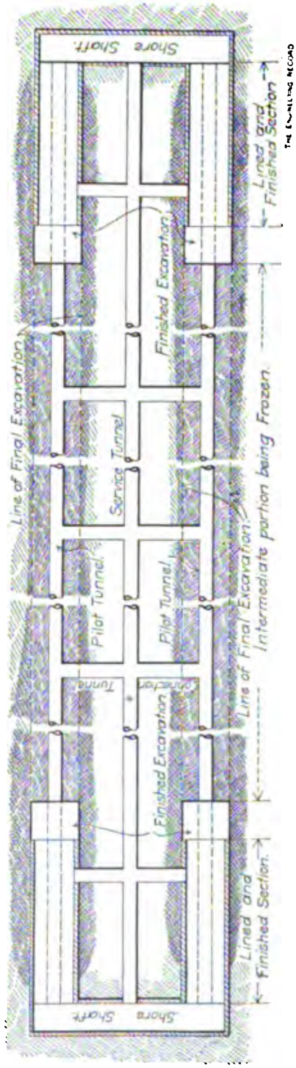


Tunneling under Sectional Roof

sections and the concrete invert laid and vertical posts set upon it, to which the weight of the roof may be transferred. It is designed to complete the permanent masonry roof arch underneath the roof shield and to leave the latter permanently above it. In order to anchor the buoyant wooden shield to the heavy tunnel masonry, the middle sections of the horizontal tie-bars may be revolved into vertical positions and built into the side walls, as indicated in the drawings. The method provides for preliminary roof protection, and, while it would be less economical than a shield for sub-aqueous tunneling in ordinary soft ground, the inventor believes that it will be especially suitable where the rock is overlaid with soft material and the tunnel cross-section is intersected by both strata. It is claimed that in a tunnel built by this method the approach grades could be materially lightened because the roof of the tunnel would not have to be depressed below the bottom of the river.

In continuation of the above subject, descriptions of other methods and apparatus which have been designed for such work and are considered applicable to the transit problems similar to those in Greater New York are here presented. Brief reference is made to some important tunnels of recent construction, the descriptions of which it is desired to supplement with others of similar interest and importance. A discussion of such engineering designs and operations is valuable, and fair-minded criticisms are helpful to their projectors. The columns of the *Engineering Record* are open to communications and suggestions concerning them or to descriptions of difficulties and devices developed in similar work.

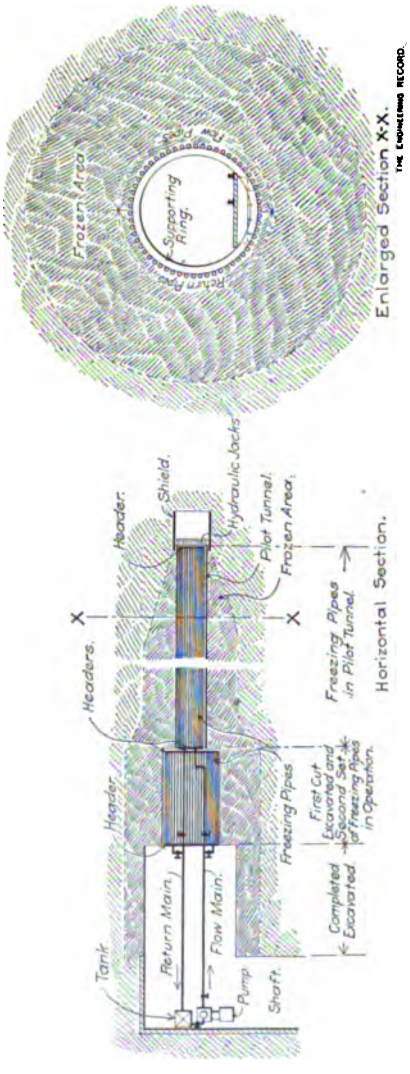
The method proposed by Mr. Charles Sooysmith, C. E., provides for a foundation of piles driven through deep water to support two or more separate or joined parallel tunnels, excavated in very soft, wet material from headings driven from the bottoms of shafts, wholly under the river bed and always retaining a roof of the natural earth above them. Novel features are involved in the driving of the piles to a great depth under water, and in the combination of the freezing method and pilot tunnels for the difficult excavation. The preliminary drawings show a special pile driver carried by two barges held by frames at a fixed distance apart. The multiple leads or guides in the space between the two barges are adjustable in both directions, so that when the barges are anchored in position several rows of piles can be driven without changing their location. Braced guides extend below the barges and through them spuds may be put down to hold the barges in position, and yet leave them free to rise and fall with the tide. Anchors and lines may



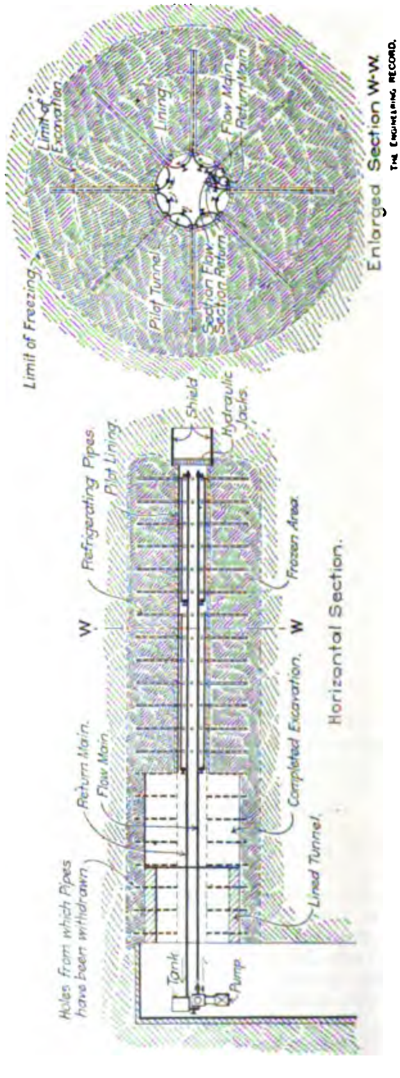
ARRANGEMENT OF PILOT TUNNELS AND SHAFTS.

be employed as usual, in addition, and the pile leads or guides are so constructed that they may be supported directly on spuds and lifted free from the barges, which would then have no connection with them and would serve only as a means of moving the leads to any position as required. Enough leads will be provided to drive several bents of piles without relocation.

Before driving each pile, a steel tube somewhat larger than the pile will be driven by hammer or water jet until its bottom is at the level of the bottom of the proposed tunnel; the pile will then be driven through this tube, the length of the pile selected being such as to make it drive to the desired resistance at the bottom of the tube. The pile within the tube will be driven by a Nasmyth steam hammer



LONGITUDINAL REFRIGERATING PIPES.



RADIAL REFRIGERATING PIPES.

METHOD WITH PILOT TUNNELS AND REFRIGERATION.

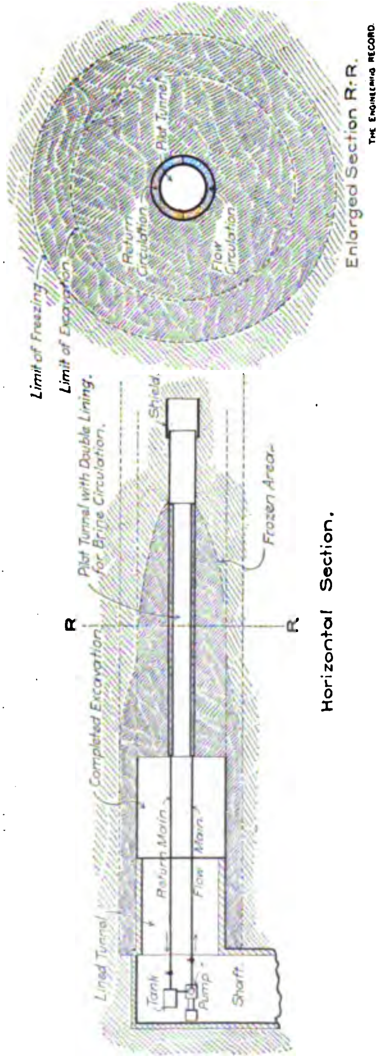
pile driver, preferably run by compressed air. This will rest upon the pile and be enclosed in an air-tight shell attached to it, open at the bottom and extending a little below the top of the pile. Air will be kept in this shell to exclude water from it so that the hammer will work as in a diving bell. The use of the guide tube, subsequently withdrawn, will avoid much of the difficulty and friction of driving piles to great depths under water and is intended to promote the rapidity, economy and accuracy of the work.

After a foundation has thus been constructed to carry the tunnel and its loads, without danger of settlement or distortion in the soft and treacherous silt, it is proposed to drive a small heading about 7 feet in diameter on the axis of each of the required tunnels. These small headings can be driven without difficulty in the usual way by compressed air, at an estimated speed of 10 feet a day or more and will serve first as refrigeration chambers and afterwards as pilot headings which will be enlarged to the full sized excavation required for the permanent tunnel. As fast as built, the temperature within the pilot tunnels will be reduced to about 10 degrees below zero, by means of pipes laid directly against the soil. Through these pipes there will be a circulation of chloride of calcium brine, cooled by an ice machine outside, precisely as is done in cold storage warehouses. The freezing will continue until the earth is frozen to such thickness that the full sized tunnel can be excavated within the protection of the temporarily hardened walls, or where the time available will not permit the freezing to be done at one operation from the original heading, which would require several months, an enlargement of the pilot tunnel will be made in the frozen material and pipes laid against the new surface so made and the freezing continued. By reason of the increased freezing surface so obtained this will result in an economy in time from freezing the necessary distance outward. Or radial pipes can be pushed outward from the pilot tunnel before freezing and a circulation of cold brine maintained in them. In any event, the working face of the main tunnel would be bulkheaded off from the finished section by a rolling partition, which would prevent circulation of warm air to the pilot tunnel.

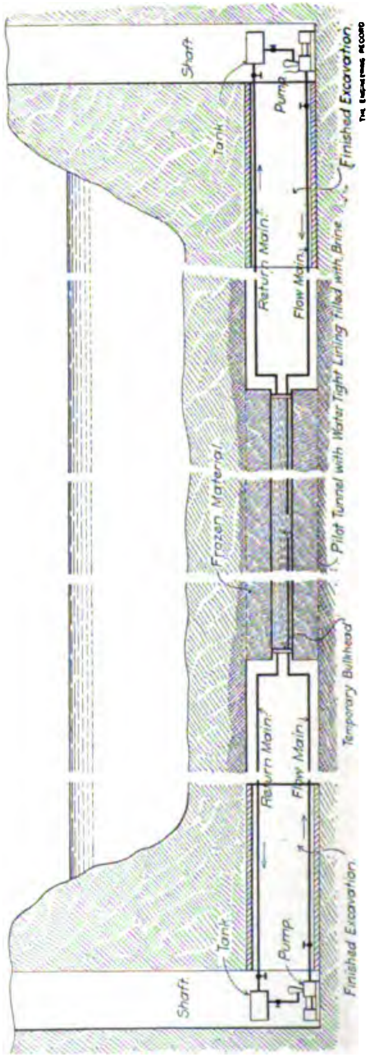
Experience has shown that soil so frozen is impervious to water and has great strength. It resembles a dense sandstone and can be worked in much the same manner by blasting or chipping. Tests of frozen silt from the bottom of the Hudson River show it to have a compressive strength of from 400 to 600 pounds per square inch. It is estimated that the walls should be frozen 5 feet outside the line of excavation and that for a 10,000-foot tunnel a refrigerating machine, with a capacity of 525 tons a day, would be required to accomplish the necessary freezing in one year. One of the principal advantages of the freezing method as applied to tunnels is that when the pilot tunnels are constructed and the freezing done the work of constructing the main tunnels can progress rapidly without compressed air, and in a manner permitting the most elaborate supervision and inspection. This is difficult to obtain by any other method. Another advantage claimed is that after it is once established the freezing will be progressive for some time should the refrigerating medium be withdrawn, and that an accident disabling the entire plant for several days would not necessarily cause a disaster to the work.

Mr. Sooysmith bases some of his calculations on data afforded by his use of the Poetsch system for sinking difficult shafts by the freezing method at Iron Mountain, as described in the *Engineering Record* of June 14, 1890. These data and other knowledge and experience gained by sinking vertical shafts and excavations by the freezing process enable preliminary estimates to be made which are claimed to be more accurate and less contingent as to time and cost than for other methods, and it is interesting to note that while there is no record of the application of the combination of this system with pilot tunnels, the freezing process has been successfully applied to difficult tunneling as described in the *Engineering Record* of May 6, 1886, where the foot way tunnel in Stockholm was driven with the aid of cold air supplied to the heading.

The general plan of operations includes the initial construction of three parallel 7-foot pilot tunnels in a plane through the axes of the required tunnels. The two outer pilot tunnels will be used for refrigerating galleries and subsequently enlarged to the required cross-section for the permanent tunnels. They will be connected by transverse tunnels about 500 feet apart, so that the center pilot tunnel may be used as a service gallery to expedite the construction of the main tunnels, after which it may be abandoned or retained for conduits. The pilot tunnel will be driven from shafts at each end, which will be long enough to serve both of the main tunnels, and from these shafts the excavation of the full width will be commenced on both sides of the river while freezing is in progress in the pilot tunnels, as indicated in the general diagram. It is proposed to provide the pilot tunnels with a system of longitudinal pipes laid together around the circumference of the tunnel and supported at suitable intervals on circular ribs. These pipes will be connected at both ends by circular headers in such a manner that half of them will be used for flow and the other half for return pipes, and a constant flow of brine



REFRIGERATING SHELL.



REFRIGERATING TUNNEL.

METHOD WITH PILOT TUNNELS AND REFRIGERATION.

will be maintained through them by means of circulation mains from the shore header to the pump and refrigerating machine. The pipes will be so close together that they will serve as skeleton lagging which, with the air pressure, is expected to exclude the mud; but may be reinforced, if necessary, by inserting short strips of wood between them until the mud is frozen stiff enough to be stable independent of the air pressure.

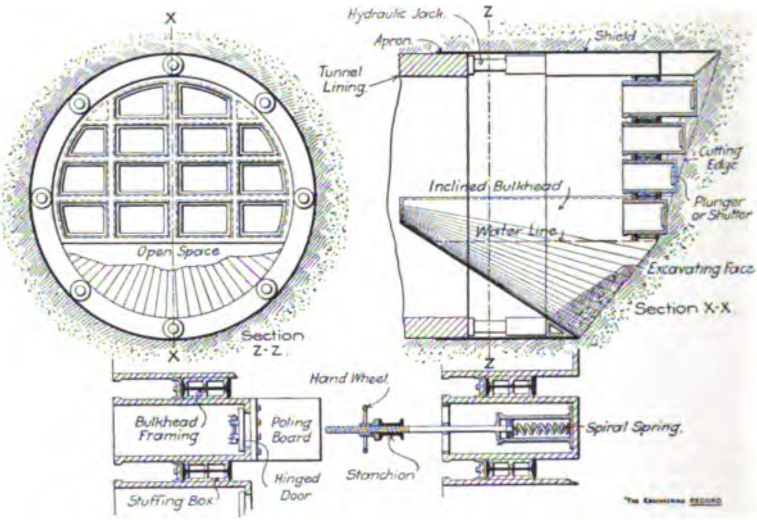
At the ends of the tunnel close to the shaft, it may be desirable to remove these pipes and make a circular excavation about 16 feet in diameter before the ground is frozen to the final limits. In this excavation another set of longitudinal pipes and headers will be placed to freeze the ground to a distance of about 5 feet beyond the limits of the final excavation, about 25 feet in diameter, which can thus be made much more quickly, but less economically, than if the freezing there was entirely accomplished from the original pilot tunnel. This method of successive cuts will only be employed at the beginning of the tunnel to expedite the construction.

As there will be four working headings, the conditions in them may vary, and another system of piping has been devised for use near the shafts where it is necessary to accelerate the freezing as much as possible, so as to be able to commence the construction of the finished tunnel without waiting a long time for freezing to be completed throughout. It is proposed in this case to line the pilot tunnels and to lay in them large longitudinal flow and return mains controlled by gate valves dividing them into sections of perhaps 1,000 feet. From each of these sections several smaller secondary parallel mains, about 100 feet long, will be valved, and from each of them connections will be made with series of radial pipes 11 or 12 feet long driven in sets about 6 feet apart. These pipes will be closed at both ends and will contain a small inner pipe connected with the brine supply and open at the outer end, the return flowing back through the large pipe. These pipes will be connected to each other and to the secondary mains in series by valved lead branches, so that the brine will flow successively through all of them from the supply to the return main, as indicated in the cross-sectional diagram. By this method freezing will be very rapid and can be controlled absolutely or varied at every point, but a very large and costly pipe installation is required. After the materials are satisfactorily frozen, the pipes can be easily withdrawn by first injecting steam, and the holes which remain, and which are shown in the diagram by dotted lines, will be useful for blasting the frozen material.

The most economical method of freezing the main part of the tunnels under the center of the river is believed to be by means of converting the pilot tunnel itself into a single large refrigerating tube, which will effect great economy of pipes and pumping, but will be slower than the process above described and will preclude any extension of the pilot tunnel which is being refrigerated. It is, therefore, proposed to treat only the central part of the tunnel in this manner, while the shore ends are being excavated and lined by methods already described. For this process the pilot tunnel will have a watertight lining closed at both ends with bulkheads through each of which there will be made connections to flow and return mains, the former being extended nearly to the center of the tunnel. The refrigeration plants will be installed at both ends of the tunnel and will, therefore, be enabled to work together on the center section after the headings of the pilot tunnels have met. When the time available is sufficient, as when the pilots have been completed a long distance ahead of the main tunnel construction, the pilot tunnel may be lined with a double shell divided into two parts by radial diaphragms so that the flow and return mains connected at the shore ends would insure a circulation of brine to the inner end and back as indicated in the diagram.

In order to prevent any danger of leakage out of the pipes, the brine will be circulated by pumps located at the foot of the shaft, thus avoiding the head that would be incurred if the mains rose to the surface of the river. The pipes would be subjected externally to the full hydrostatic head of the ground water, so that if there were any leaks in them the flow would tend inwards instead of outwards and no damage would be occasioned. These methods have all been studied and analyzed with great care in reference to the practical results which have been obtained in successful application of the freezing process to very difficult work in this country and abroad, and it is believed by Mr. Sooysmith that the systems here described may, any or all of them, be employed under the conditions obtaining for the tunnels that they were designed for, and that they will afford the most safe and desirable method of construction for them. The accompanying illustrations of this process are conventional diagrams intended only to indicate general principles and arrangement, and are in no way definite plans for actual construction. They help explain the methods of application of the freezing process for excavation only; they omit the important pile foundation and all details of design and construction.

tical transverse bulkhead. The lower part of the cutting edge is inclined backwards and is open, a conical bulkhead being carried from its circumference to a level with the axis of the tunnel and affording a sort of inclined scoop through which access can be had from above to the lower part of the working face, and in which water may rise above the lower edge of the vertical transverse bulkhead in the front of the shield, but will be retained at that level by an adequate pneumatic pressure



Automatic Plunger. Plunger with Pressure Device.
Improved Head for Tunnel Excavating Shield

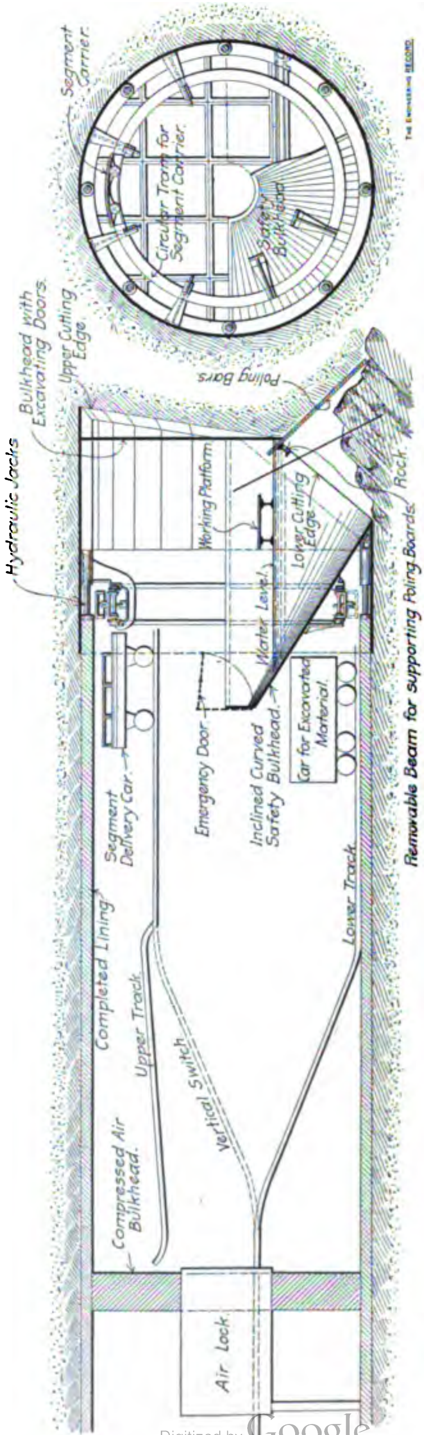
SHIELD METHOD.

The plan proposed by Mr. Theodore Cooper, C. E., is based on the use of a special pneumatic shield designed to be efficient in any combination of rock, earth, silt and water. The shield can be used under very different conditions ranging from the construction of a tunnel in water without any solid excavation, to that of its construction in silt, clay or rock or the construction with the upper and lower parts in different materials. This shield is a pilot of a full cross section of the tunnel, having the usual apron plates which project backwards over the finished tunnel lining and make a close joint with it. The front of the shield is provided with the ordinary slightly inclined cutting edge, and the upper part of it can be entirely closed by removable doors in a vertical transverse bulkhead

inside the shield. This arrangement, which is clearly shown in the vertical and horizontal cross sections, provides, if necessary, absolute tightness to retain the air in the upper part of the shield and leaves the bottom of the tunnel exposed and accessible through the open lower end of the shield, so that excavation may be carried on there in the dry under ordinary conditions or at the very worst, if it is impossible to wholly exclude the water, it can only rise to a limited height and excavation may be carried on below its surface. If the material is firm, the doors in the forward bulkhead may be opened and excavation made through the whole face of the shield. If it is very soft, these doors may be closed and the shield may be forced ahead into the unexcavated mass, causing the latter to flow inward and upward at the bottom through the conical apron around the lower part of the cutting edge, and even deliver itself through its apex into the material cars on the tunnel floor. If excavation is required in the bottom of the tunnel only, inclined poling boards may be driven under the lower edge of the main diaphragm as indicated in the cross section, and rock and other material removed under their shelter, so as to permit the shield to advance. In other cases these temporary poling boards may be driven, leaving the bottom accessible under the inclined cutting edge, so that if necessary sectional piles can be forced down to make a foundation under the tunnel. With the diaphragm doors all closed and the water seal maintained above the lower edge of the main diaphragm, the shield can be pushed forward on the bottom of the river and the tunnel lining built behind it in the usual manner without any excavation or the protection of any natural roof above it.

The design provides for high level and low level tracks connected by a vertical switch. The high level track will be used for bringing segments of the cast iron lining to the crown of the tunnel where they would be delivered to a car operating on a circular track to assemble them in position. The lower track would be used to remove the soil and muck. The connection of the circular track to the moving shield saves a great deal of labor and time in handling the lining segments and enables them to be put in place without interfering in any way with the operations of excavation, thus greatly expediting construction and materially reducing the total expense.

For tunneling through very wet or soft material Mr. Cooper has designed an improvement especially adapted to the shield already described, which is intended to reduce the excavation absolutely to the amount of displacement of the finished tunnel, and thus prevent disturbance of the material pierced or subsidence of the surface and consequent danger to structures above; to facilitate the alignment and diminish the force necessary for driving the shield, to prevent material from caving in and to decrease the danger to workmen. This improvement avoids the necessity of having workmen stationed in advance of the forward bulkhead, or of using a long and unwieldy projecting hood. It consists essentially of forming the forward



Pneumatic Tunnel Shield with Water Seal.

SHIELD METHOD.

bulkhead of independent horizontal hollow plungers. Their outer ends receive most of the horizontal thrust against the end of the shield, and can be set so as to resist the pressure of the earth and water and confine its slope to a required angle.

These plungers are units with dimensions suitable for their convenient operation, and enable the pressures against the outer surface to be advantageously differentiated in accordance with the conditions which vary with their positions. They virtually constitute a series of springs covering the solid face of the end of the shield, which is exposed to unequal pressures, and maintain equilibrium over that portion of the heading which is above the point of excavation. They provide for a constant and regular flow of material into the lower part of the shield where it can be handled and controlled, and permit the intermittent or continuous advance of the shield with a constant regulated pressure on the upper part. As the air pressure in the pneumatic shield is constant, while the external pressure decreases upwards, they can only be balanced at one point and the former is in excess by an amount of 60 pounds per square foot for each foot in height above the level of the water seal. This unbalanced pressure will enable the plungers to be automatically operated in the upper part of the shield, and the lower ones may be provided with special devices for overcoming the friction and increased outside pressure.

The patent drawings show the forward bulkhead extending in a vertical transverse plane to below the seal of the water line in the inclined bulkhead, and composed of a framework of vertical and horizontal I-beams with the spaces between them entirely filled by rectangular plungers working in stuffing boxes. Each of these serves as a movable shutter which is pushed out against the soft earth, and maintained there wholly or in part by the pneumatic pressure in the shield. They may be used with or without pneumatic pressure and with or without water seal and the conical interior bulkhead. In a dry tunnel they may be used to reduce the amount of excavation, and it is believed that in either wet or dry earth they will advantageously replace ordinary poling boards.

The plungers may be open at the inner ends and closed at the outer ends by hinged and latched doors through which material can be removed if necessary, and they may be provided with projecting flaps or fixed iron poling boards to diminish the inward flow when the doors are opened in very soft material. They may also be made, as shown in the detail, with open inner ends and closed outer ends provided with spiral springs enclosed in cylinders which receive a piston head that compresses the spring by a rod commanded by a nut and hand wheel arranged inside the shield, so as to enable the plunger to be set in any required position and adjust itself to the variable pressure.

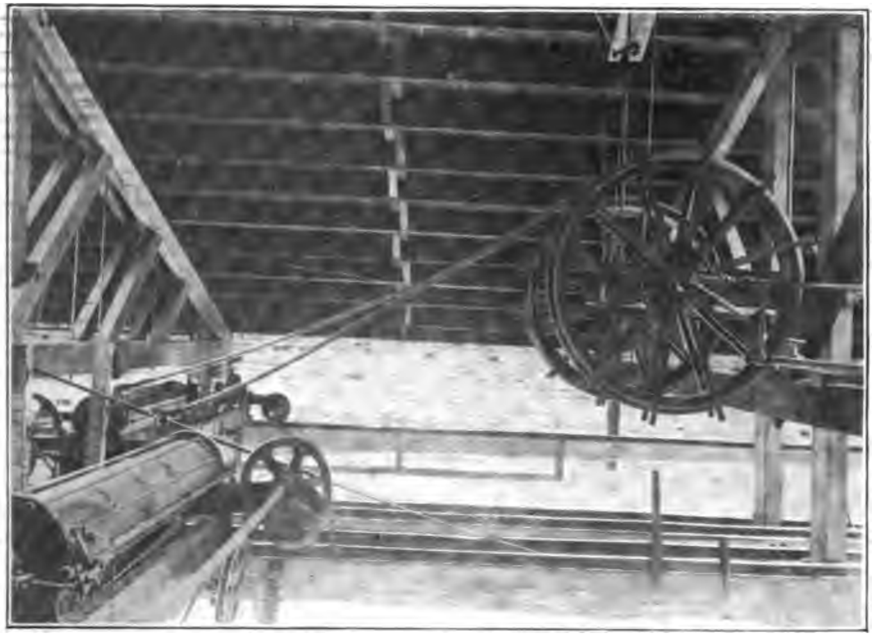
The plungers may be advanced with the shield or independently of it, or may be allowed to recede or remain stationary when the shield is advanced by the usual method, thus materially facilitating the manipulation of the shield and permitting its cutting edge to penetrate the soil with decreased expenditure of force. They afford an elastic resistance to the soil and enable any portion of it to be separately treated and all portions of it to be put under special or automatic uniform or varied pressure, while the excavation may be absolutely confined to the lower part of the shield under the water seal and governed to correspond with the definite slope of the material for the actual displacement of the shield.—*Engineering Record*.

Hose-Reel for Pneumatic Cranes.

The object of this device is to provide a means for properly paying out the hose as the crane moves toward either end of its track and automatically rewinding the hose as the crane moves from either end of the track toward a point about midway the length of the same.

In its preferred form the invention consists of a reel, journaled at a suitable point above the rails of the crane and at a suitable point, preferably midway, between the opposite ends of the track. Wound on this reel is the supply-hose, one end of which is passed through an opening in the periphery of the reel and connected to a nipple of the coupling connecting the hose to the stationary supply-pipe. The nipple is connected to a tube, which is nicely fitted on the projecting end of the reel-shaft, said shaft being hollowed out axially at this axial chamber being in constant communication with an annular chamber, formed interiorly of the tube about midway its ends and in communication with the lateral branch or nipple by means of a series of radial passages. Packing-rings and glands, screwed on the ends of tube, form stuffing-boxes which prevent the escape of air at the ends of said tube. This coupling permits the inner end of the hose to revolve with the reel and at all times in communication with the supply-pipe, as is evident. The other end of the hose is connected to the inlet-pipe of the crane-cylinder by a similar coupling. The hose is connected to a nipple, which is formed integral with a tube, surrounding the perforated horizontal portion of the inlet-pipe, this tube being internally chambered and having its end portions nicely fitted on said tube. A cap is fitted on the end of the tube, this cap fitting in a socket formed in the end of the tube and being held therein by means of a screw-cap. Another screw-cap is screwed on the other end of tube, and a suitable packing may be incased by this cap to form an air-tight joint. With a coupling of this sort it will be observed that the end of the tube will have a swivel-like connection to the supply-tube.

It will be observed that as the crane moves out toward either end of its track the hose will automatically unwind, and to prevent the hose sagging below the track-beams journal on posts rising at intervals along the same, above the rails, supporting rollers or pulleys, on which the hose will rest as the crane moves outward and from which the hose will be picked up as the crane moves toward the reel. To automatically thus pick up the surplus hose as the crane moves toward the reel, a weight is provided, which is connected to a rope or cable, extending up through pulleys, depending from suitable beams above the reel, and then down to and around a small drum, attached to the reel at the side opposite the coupling. This counterweight is of just sufficient weight to automatically rewind the surplus hose as the crane-carriage moves toward the reel from either end of the track, but not sufficient to exert a pull upon the carriage.



HOSE-REEL FOR PNEUMATIC CRANES.

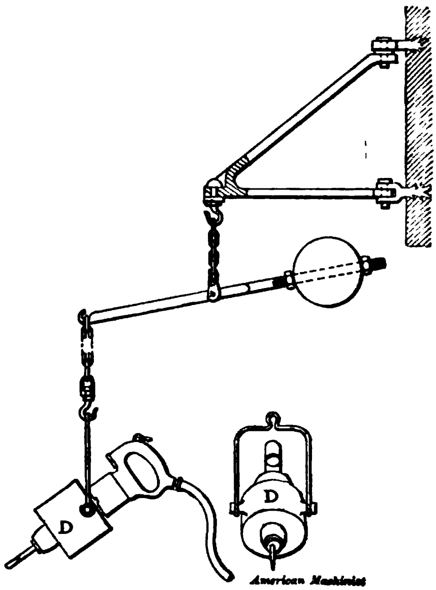
The rollers or pulleys are supported slightly below the line of travel of the horizontal part of the inlet-pipe, so that as the carriage moves away from the reel the hose will be deposited on the rollers and be thereby prevented from unduly sagging, and when the carriage moves toward the reel the hose will be lifted off the rollers in succession. To the left of the reel a roller or pulley is journaled just above the line of travel of the hose, so that when the carriage moves out on the track to the left of the reel the hose will engage under this pulley and be held down on the rollers without impeding the free passage of the hose.

It will be observed that the swivel connection between the hose and the inlet-pipe of the crane permits the crane to move freely backward and forward under the reel without twisting the hose, and it will also be observed that by locating the reel above the track and at a point midway of the ends of the same it will be necessary to employ hose of a length simply equal to half the length of the travel of the crane.

It is obvious that this device is not confined to compressed-air cranes, but is applicable to any apparatus where a flexible tubing may be employed to supply fluid to a movable carriage and where it is desirable that the tubing shall be automatically paid out and rewound as the carriage moves away from or toward the reel, which device has been patented by Mr. Henry H. Sullings, of Huntington, West Virginia.

Something New.

The cut herewith, from a recent patent by F. M. Leavitt, of Brooklyn, N. Y., combines two suggested improvements in the use of pneumatic hammers, riveters, caulkers and tools of that type. Those familiar with these tools need not be told that the jar or vibration of the tool is a very serious matter to the workman who manipulates it for a considerable time, and the device of Mr. Leavitt is primarily to minimize this objectionable feature. This is done by increasing the mass of the hammer case, a heavy weight *D* being attached to or made integral with the normal case of the tool. It goes without saying that this increase of weight must and does reduce the jar. The increase of weight necessitates some means of supporting it, and this has led to the suspension device here shown, by which the weight is perfectly balanced, enabling the tool to be moved about with great ease. Instead of the fixed



A PNEUMATIC TOOL IMPROVEMENT.

bracket, the device may of course be suspended from any crane, overhead rail or other convenience of the shop.—*American Machinist.*

Haeseler Axial Valve Hammers.

We call attention to a new form of Pneumatic Hammer recently introduced by The Ingersoll-Sergeant Drill Co. It is claimed that the highest degree of excellence yet attained in pneumatic hammers is represented by these tools. The features of marked improvement, as compared with other pneumatic hammers, are the valve mechanism for reciprocating the piston, a locking device for taking up wear and securely locking the handle, valve box and cylinder of the tool together, and a simple arrangement of throttle valve for controlling the admission of the air supply.

The valve is a radical departure from the various forms of straight-line reciprocating valves ordinarily used. Its strength of construction, steadiness in action and freedom from wear over-

AXIAL VALVE.

comes the recognized defects in valves heretofore employed in connection with other pneumatic hammers. As its name, "AXIAL VALVE," implies, its movement is around a fixed axis or trunnion, the travel forward and back, to alternately open and close the admission and exhaust ports, being caused by a constant air pressure upon the short wing or projection of the valve and intermittent air pressure upon the long wing.

INTERIOR OF VALVE BOX.

The ports in the valve, as well as those in the valve box, are relatively of equal areas, and are located diametrically opposite to each other, so that any pressure against either side of the valve is equalized by a corresponding pressure upon the other side, resulting in a balanced valve and consequent absence of friction and wear on the trunnion or axis about which the valve moves.

As the movement of the valve is transverse to the direction of the travel of the hammer or piston, the vibration of the entire tool is lessened in operation, and the action of the valve is not disturbed when the hammer blow is struck, but is quick, steady and uniform, and entirely free from fluttering or incomplete travel common with valves moving in line with the piston.

The valve is steel, drop forged from selected stock, is hardened, accurately ground to gauges, interchangeable, and guaranteed against any breakage from service.

The valve box is also made of steel throughout, with all surfaces ground.

The efficiency of a pneumatic hammer is seriously impaired if the joints between

THROTTLE VALVE—CLOSED.

the faces of the cylinder, valve box and handle are not kept tight. See A and B on cut.

To insure keeping these joints tight, by securely locking the parts together, we have provided a simple and strong construction, consisting of a number of slots in the collar of the cylinder and a different number of notches in the end of the handle, the one number not being a multiple of the other. This arrangement permits a fine adjustment to be made when it is desired to take up the wear of the parts, as a notch in the handle will always be in line with one of the slots in the cylinder, without regard to any required position of the handle being necessary.

SECTION OF CHIPPING HAMMER.

When the handle is screwed up tight, the parts are locked together by a key being inserted in the registering slot and notch referred to, and this key is held in place by a spring band being snapped over it and around the collar of the cylinder.

Haeseler-Ingersoll Chipping Hammers are made in five standard sizes with the symbols 1-H, 2-H, 3-H, 4-H and 5-H, the figures in each instance referring to the length of stroke. The Long Stroke Riveting Hammers are built in sizes 6-H, 8-H and 9-H.

CHIPPING HAMMER.

RIVETING HAMMER.

A Suspended Tunnel.

Mr. J. S. Parmenter, of Woodstock, Ontario, Canada, writes the *Scientific American* as follows:

Three methods have been suggested lately in many of the scientific papers for the support or foundations of the proposed North and East River tunnels of the Pennsylvania Railroad Company. In my opinion, there are serious objections to each of these plans.

The one proposed by Mr. Jacobs, the railroad company's engineer, is, if I understand it correctly, simply a girder bridge of several spans incased in a tunnel with foundations at each span reaching down to bed-rock The inclosing of these girders inside the tunnel makes it necessary to build the tunnel of very large outside diameter, which fact makes it very difficult of construction and *very costly*.

Mr. Sooysmith's plan of freezing the silt is, I believe, too much of an experimental nature, as yet, for tunneling to warrant its adoption in an undertaking of this magnitude. The adoption of Mr. Sooysmith's plan of driving piles throughout the whole length of the tunnel would certainly disturb the silt through which the tunnel would have to be pushed, to such an extent that in all probability it would be of the consistency of builder's mortar, and consequently very difficult to tunnel through.

As to Mr. Reno's plan of pushing the tunnel in the usual way by means of a shield, and the use of compressed air, I believe it to be the correct way; but as to his method of providing a foundation for the tunnel, I cannot approve, for the reason that the solidity of the concrete foundation would depend entirely upon the solidity of the silt or other material upon which the concrete rested. Consequently, it seems to me it would be quite unsafe to rely upon a foundation of this nature.

With your permission, I will suggest a plan for supporting these tunnels, entirely different from either of the above named. I would suggest that the tunnels be built in the usual way, as Mr. Reno suggests, by the use of a shield and compressed air, and that at each end of the tunnels, as close to the water's edge as possible, a substantial foundation be built upon the bedrock, and of sufficient height to reach about half way up the tunnels at each side. These foundations are for the purpose of supporting wire cables, which would run through the inside of the tunnels, one at each side, and securely fastened thereto and anchored at each end, as in those of any large suspension bridge. From these two cables the car tracks would be suspended. This method of suspending the tunnels on wire cables would effect a very large saving, as the diameter of the tunnel could be much less than those containing bridge girders. It could also be built in much less time than either of the three plans above mentioned, as the tunnel and the cable foundations could be proceeded with simultaneously.

Gold Mining in Wales.*

Five miles northwesterly from Dolgelley, Wales, the gold mine Colgan, or St. David, is situated. Mining in the Colgan Mountains is supposed to have been carried on by the Romans, if not, indeed, started by them. It is now managed by a company formed in "Barmouth," whose mill buildings are modern framed corrugated iron structures, neat and sufficient—not extravagant.

In seasonable weather, which means wet weather to the gold miller, all the plant is run by water power, with a Pelton wheel of 190 H. P. under a head of 200 feet of water, piped from a distant reservoir. In the absence of sufficient water, a Tangye producer gas plant is used.

There is also a compound steam engine to drive compound air compressors when water is short. These were supplied by the Tuckingmill Foundry Company, of Camborne. Air is compressed to eighty pounds pressure for rock drills and air winches, the former supplied by the Tuckingmill Company and the latter by Holmans, of Camborne.

Ore is obtained by means of compressed air rock drills, which drill holes to a depth of about five feet in the working face. In each hole are placed one to six dynamite cartridges, and each explosion brings down from five to six hundredweight of quartz. The firing of a shot in a mine sets the air in the galleries into vibration, as though the gallery were a long organ pipe, extinguishing lights and giving, in addition

* Abstract from an article by W. H. Booth, in *Cassier's Magazine*.

to the sharp report of the explosion, a low note, which is very startling, as it comes unexpectedly.

At the Voel Mine, near by, a compound air compressor and compound steam engine to drive sixteen rock drills was installed by the Tuckingmill and Foundry Co., who also furnished the rock drills.

The compressor house is some distance from the mill, and air is carried round to the mine by pipes, with a second large air receiver at a considerable distance from the compressor. This helps to maintain the pressure at the more distant points and equalizes the flow of air in the pipes.

The third of these gold mines is the "Gwyn-Fynydd," on the Mawddach. The air compressor used there is of single-cylinder type, and is driven by a turbine, to which water is piped from a point about half a mile away at a head of 170 feet. Failing water, there is a steam engine as a reserve.

Powerful Air Compressors.

"During a recent visit to Messrs. Walker Bros.' works at Wigan, England," the *Iron and Coal Trade Review* writes, "we inspected large air compressors approaching completion for collieries and mines at home and abroad. One installation, for South Africa, was composed of two complete pairs of compressors. In this case the low pressure steam cylinders were 64 in. diameter, and the air cylinders 58 in. diameter. Steam pressure was 140 lb. per square inch. Air pressure 100 lb. per square inch.

"We saw many other large compressors in course of construction. Messrs. Walker informed us that they had recently supplied to the Cordova Exploration Company for a mine in Canada, compound-compressors driven by a turbine of 1,000 horse power.

"The power from the turbine, in this case, is transmitted to the drum on the crank shaft of the compressors by 30 cotton ropes, 1¾ in. diameter. The compressed air is led for a distance of about three miles in wrought steel pipes, 12 in. diameter.

"The loss in transmission, so far as at present ascertained, is not more than 3 per cent. One important feature of this installation is the employment of an 'After Cooler,' which is placed near the compressors for extracting the moisture from the air before it enters the main pipe line.

"The compressed air is delivered at the mine in a very dry condition, and very free from moisture. Re-heaters are used at the mine for heating the air before being used. The whole plant, consisting of hoisting engines, pumps, stationary engines for driving the stamp mill, machine shops, etc., as well as the rock drills, are entirely operated by compressed air. The capacity of the compressors is about 5,600 cubic feet of free air per minute, compressed to 100 lb. (about) per square inch."

The Weiss Valve for Air Compressors.

The Weiss valve was patented by Mr. F. J. Weiss in 1893, and is suitable for use for air compressors, vacuum pumps, and is applicable to distributing valves for steam engines. It is more especially largely used for the first, or air compressors, on the continent.

The Weiss valve is chiefly designed to give in a rapid manner a large port opening to the suction. It acts in a manner somewhat similar to that of a "trick" slide valve, that is to say, two passages are provided for the air. There are also two cut-off suction edges which close simultaneously. The internal lap of the outer casing of the valve is not quite sufficient to cover the outer ports, at such time as the valve is in its central position. From the above it will be obvious that both ends of the cylinder will be simultaneously in communication the one with the other, for a short time, as the slide valve is at that time moving at its highest rate of speed.

The above action is necessary owing to the fact that the clearance space in air compressors is reduced to a minimum so as to give the highest possible displacement capacity, which latter in some cases is as high as 95 per cent. of the theoretical displacement, and, directly the slide valve closes or shuts off the delivery of compressed air, the occurrence of an excessive amount of compression, is prevented by the air passing, as above mentioned, to the other side of the piston.

It is claimed by makers as an advantage of the slide valve for air compressors that they can be run at a greater speed than is the case with spring-actuated closing valves, but there are, nevertheless, some compressors in the market which are intended to run at as high a speed as 400 revolutions per minute in the case of those of small size, although they are fitted with spring-actuated closing valves.—*The Refrigerating Engineer.*

Compressed Air in House Heating.

A young man in Virginia has patented and capitalized an invention in house heating which, if it works to his expectation, will be revolutionary. He proposes to heat buildings by means of compressed air, and subsequently use this compressed air to cool the refrigerator and perform other functions for which ice is now required. That he can do all he promises is undoubtedly true, but some doubt is natural in the circumstances that he can do it profitably with present facilities. The best net result in fuel utilization with boiler, engine and compressor is to account for about 9 per cent. of the British thermal units in coal, which would seem to be far below the efficiency of the ordinary stove. To give out the amount of heat which could be had by the direct combustion of 12 tons of coal probably 125 tons would be required if the medium was compressed air. Evidently the inventor has been told this or something like it, for he proposes to compress the air by hand and has included a pump in his patent combination. This, however, does not seem to help the matter any. A man can develop the greatest number of foot pounds of which he is capable in the treadmill, consequently the treadmill would seem to be the most effective mechanism for actuating the pump. By this means an average man can develop an energy equivalent to 2,000,000 foot pounds per day. One heat unit is equivalent to 778 foot pounds. A pound of anthracite yields in complete combustion about 13,000 British thermal units, or the equivalent of 10,000,000 foot pounds. From this it would appear that 1 pound of coal contains as much energy available in heating as five men can exert in a day on a treadmill. Twelve tons of coal distributed over six months of cold weather when heating is necessary would be an allowance of 5½ pounds per hour, which would be equivalent to the continuous work of 275 men on a treadmill. This is confusing.

We should also take account of occasional "cold snaps," when comfort might require the consumption of say 12 pounds of coal per hour to keep the house warm. To develop the equivalent of this we should have to keep 600 men on the treadmill.

It would probably be necessary to square things with the union by conceding the eight-hour day; and as the work must be continuous we should need three shifts, employing altogether 1,800 men. This would involve a considerable pay roll. The difficulty is not insuperable, of course, but it may operate to discourage the adoption of the compressed air heating method. The possibility of a strike is always imminent, and treadmill wages would need to be well up to the prevailing rate to be attractive. Everything considered, perhaps power compression would be cheaper and more generally satisfactory.

Another opportunity for captious objection is found in what would appear to be the difficulty in expanding the air again without lowering the temperature of the whole county and inviting restraint by injunction. In conjunction with an ice factory or a cold storage warehouse it might work very well, but such an establishment could scarcely be considered practical as an adjunct to a domestic heating plant.—*Metal Worker.*

Cleaning Carpets with Compressed Air.

The Denver Compressed Air Carpet and Mattress Renovating Works in 1880 brought to Denver from the East the first

FIG. 1—CARPET BEING CLEANED OUT IN THE OPEN AIR.

carpet-cleaning machine. This was a beater and brush machine. Several years afterward they adopted the now commonly used and so-called tumbler machines (carpet cleaners), of which they had three in use.

Experience combined with careful study has brought about evolution in the line

FIG. 2—AFTER CARPET HAS BEEN CLEANED OF MOST OF THE DUST.

of renovating work as it does in all other things. After much investigation and many trials they came to the conclusion that there is nothing so harmless and at the same time effective as compressed air in extracting dust and renovating of carpets and hair mattresses (see Figs. 1, 2, 3).

FIG. 3—CLEANING WITH OPEN NOZZLEMAN.

This company does not think that carpets can be as thoroughly cleaned while on the floor as they can be if taken up and sent to a cleaning establishment. They compare it to the laundrying of one's clothes, and assert that a "man's shirt cannot be cleaned satisfactorily while it is still on his back."

The cuts give a fair idea of the process as employed in this case. Fig. 1 shows the carpet being cleaned out in the open air; Fig. 2 after it has been cleaned of most of the dust. In Fig. 3 an open nozzleman is used, on a screen floor lifted about five feet from the flat roof, thus giving the air a chance to take off the dust above and below while cleaning. In addition to the open roof is a room with two large Blackman fans, also provided with a screen floor, which is used in bad weather. In this work it has been found that air at from 100 to 120 pounds pressure and a 1-64-inch nozzle gives the best results.

Pneumatic Appliances.

The Northern Engineering Works, Detroit, Mich., are manufacturers of the Champion air hoist shown in Fig. 1. They

FIG. 1.

claim that this air hoist is the most advanced and practical for all classes cf service to which air hoists are suitable, from the most delicate to the most severe. They claim that its special features are all of real and practical value in actual service, and are not simply theoretical. It is economical in air consumption. It is accessible and simple. It is automatic both in lifting and in closing valve. It is safe. It is self-cleaning and self-oiling. It is adjustable both as to speed and lift. It is cushioned. It is high-grade throughout.

This hoist has an improved adjustable valve, combining in one body the inlet and exhaust functions, the speed adjustment, cut-off and the safety check.

FIG. 2.

Fig. 2 illustrates the compressed air jack for short lifting around car and repair shops, as well as in general manufacturing shops. These appliances are in extensive use, and are of great convenience. An extra large piston rod or plunger is used. The standard lift is one foot, but this may be readily increased or decreased to suit conditions.

The Northern Engineering Works build a variety of these, including truck jacks and pull down jacks. They also make a pit truck jack for lifting wheels and axles in car shops.

Notes.

A locomotive on the Chicago, Burlington & Quincy Railway has been fitted with a device for shaking the grates by pneumatic means.

On the Bessemer and Lake Erie Railroad, near Greenville, Pa., an air blast track tamping apparatus is being used on a section of track laid with steel ties.

A Pneumatic Separator Company has been organized at Elgin, Ill., with a capital of $115,000, the incorporators of which are Henry Schmitt, Raymond Schlager and Edward Keogh.

The Pennsylvania Railroad is making trial of a new air brake device in the nature of a pressure retaining system, which is the invention of a New York man and which is said to be giving good results on Altoona mountain.

The Rand Drill Co., 128 Broadway, N. Y., have recently issued the *Imperial Pneumatic Tool Circular No.* 2, describing their chipping hammer, long stroke riveters, piston air drill, air motor hoist, drift bolt driver and all their many different types of air appliances.

Through the recent death of her father, Miss E. F. Jones has assumed active charge of the Preble Machine Works in Chicago. The shop does considerable marine and contract work. Miss Jones recently completed a two years' course in mechanical engineering, and assumed charge of the shop six weeks ago.

The Lidgerwood Manufacturing Company, of New York City, which has large contracts for Brazil, has let an order for an electric-lighting outfit for Manaos, Brazil, to include an engine built by the Harrisburg Foundry and Machine Works, of Harrisburg, Pa. The generator will be of Westinghouse manufacture.

It is with much pleasure and interest that we read carefully the little bulletin just received from the University of Wisconsin, Madison, Wis., describing in full their six weeks' summer school for artisans, the entire cost of which schooling and living combined seem very reasonable.

Catalogues will be sent on application describing in detail the various branches of study, which comprise, among others, courses in heat, steam, gas and other heat engines; also courses in electricity, fuels, lubricants, etc.

The applications of electricity in mines have hitherto been limited for the most part to the distribution of energy to machines in the mines, the necessity in such cases for a power transmission of some kind making electric transmission, with its high economy and its ease of installation, extremely desirable. Its introduction for this purpose has, however, been hindered by fear of utilizing it in fiery mines and by the good work done by compressed-air motors, which have often rendered possible the employment of existing compression plant.

The Philadelphia Pneumatic Tool Company has secured a contract from the Lake Shore and Michigan Southern Railway Company to supply them with all the pneumatic hammers which they will use in the new Collinwood shops and on the entire system for a period of one year. This contract is awarded after a competitive test of all the different makes of pneumatic tools. This company has also received large orders for chipping and riveting hammers and drills from the Wabash, the Delaware and Hudson and the Central of New Jersey railroads.

The Carbon Limestone Co. have recently made initial tests of a new Ingersoll-Sergeant air-compressor drilling machine, capable of operating twenty-five drills. At the company's quarries is being installed a third crushing plant, which will increase the daily capacity of concrete limestone railroad ballast to 1,200 tons of material, ranging from ½-inch to 2½-inch ballast. This in addition to 2,000 tons of furnace stone. The Carbon Company is now filling an order for 100,000 tons of such ballast for the P. & L. E. for use on the four-track system between Pittsburg and the Valleys.

It is reported that Secretary Shaw is figuring with the owners of a pneumatic tube system, who propose to connect the Treasury Department at Washington with its various branches, including the bureau of engraving and printing. Secretary Shaw recognizes the possible value of such a system, and has requested that estimates be furnished him of the cost of a system connecting the Treasury and the bureau. If the estimate is not too high Secretary Shaw may submit it to Congress with a recommendation that an appropriation be made to install a system. In the meantime he is going to consider the practicability of the plan and all the questions arising out of it.

Should Calais, France, and Dover, England, be joined together by a pneumatic postal tube beneath the channel, then a new service may be added to the twentieth century wonders in the form of little trains each carrying, say, twenty people, who will begin traveling through the tubes between Calais and Dover.

These passengers will lie luxuriously extended on "sofa-cars," so as not to bump their heads against the ceiling of the great tubes. They will cross the channel comfortably in twenty minutes, without the slightest fear of sea sickness.

It is anticipated that English patriotism will make no effective objection, if the splendid innovation be brought about by degrees.

Our attention is again called to an explosion in an Illinois coal mine, killing six men and injuring five others. We have no doubt whatever but what this accident was caused by an insufficient amount of air being in the mine at the time of this explosion.

People persist in using electricity for operating machinery in mines when it is a well-known fact that fire damp and other gases prevail in coal mines. Compressed air can be used to do the same work (with the exception of lighting), never at a greater cost and in most cases reducing the expense considerably and at the same time furnishing a large amount of pure air in the mines.

Freezing treacherous earth by artificial process in order to cut tunnels through it is a development of modern engineering that should excite popular interest to an unusual degree. This freezing process is said to have been employed successfully in numerous difficult excavations in Europe. It was applied to the sinking of a shaft at the Chapin iron mine at Iron Mountain, Michigan, where a cylinder of water-bearing strata fifty-four feet in diameter and extending 100 feet below water level was first frozen, and the perpendicular tunnel then excavated through it. The freezing was accomplished by sinking vertical pipes arranged in a circle around the site of the shaft. Through a smaller pipe in each of these was circulated brine, cooled in an ice machine to zero temperature until the mass was frozen.

One of the unique uses to which the compressed air is put at the Brightwood shops of the Cleveland, Cincinnati, Chicago and St. Louis Railroad is in the operation of the letter presses. Those presses are surely the materialization of the dreams of a lazy man. All that is necessary is to place the copying-book in the press, turn the handle of a stop-cock and the bottom of the press raises leisurely and squeezes that book like no other power on earth could. The mechanism is simple—just a cylinder beneath the press, equipped with a close-fitting piston. When the air is admitted to the cylinder the piston is raised, the bottom of the press is pushed up and something has to give.

The farthest point to which the compressed air is sent from its engine is about 900 feet, but even at that distance it loses only three or four pounds of its pressure.

The efficiency of compressed-air plants can be greatly increased by reheating. The gains are both direct and indirect. The chief direct gain is in the greatly increased efficiency of fuel used in the heating stoves as compared with the effect when coal is burned under boilers. It is commonly stated, and the statement is fairly correct, that when one pound of coal is burned in a reheater stove the commercial effect is as great as when three pounds are burned under a boiler. The increase in commercial efficiency when reheating air from 60° to 400° F. may be put at 35 per cent. The indirect gains are: 1. Better lubrication of the compressed-air engine. 2. Less investment required as a smaller plant will be required. 3. Reduction of compressor-engine friction as compared with the useful work done. In the next few years we hope to see all mines using compressed air have reheater stoves.

An exhibition of a new invention for providing a means of escape from high buildings when on fire was given by John Connett in San Francisco, Cal., the other day. In the short space of two minutes and forty-one seconds the inventor succeeded in throwing three lines from the street on to the roof of the Chief Secretary's office, a height of 101 feet. The lines are wound round a "messenger" and inclosed in a paper wrappage. This constitutes a charge, which is placed in a narrow brass tube about 10 feet long and is fired from it by means of compressed air. The "messenger" ascends into the air, and one end of the line drops to the ground while the other goes to the roof. A heavier line can then be attached and made fast by the people on the top of the building. The inventor claims that he can fire his lines to a height of 200 feet. In order that the end of the line that drops to the ground could be readily found at night, he proposes to illuminate it with phosphorus.

An application for the Pneumatic Cotton Harvester Co., capitalized at $250,000, and backed by Memphis and St. Louis capitalists, has been filed with the register of Shelby County, Mo. The company will manufacture and sell a pneumatic tube cotton picker.

The mechanism of the machine consists of a four horse-power gasoline engine, rotary fan, and a number of rubber tubes. The engine will be geared to the fan, which will be revolved at great speed, creating a vacuum in the air chest with which it has connection. This vacuum will be communicated to the rubber tubes which are to be applied to the cotton bolls, sucking the cotton from them by pneumatic force. The apparatus is to be placed in an ordinary farm wagon.

The machine is operated by men who will fit the tubes to the bolls. It is claimed one man, with one of these tubes, can gather as much cotton as four or five pickers.

A pneumatic system of sewage disposal on the Liernur principle at Stansted, England, is described as follows in a recent issue of *The Surveyor:* Stansted is a scattered village in a hilly country, but the pneumatic system seems to have worked well since it came into operation a few months ago. The pumping station, containing a receiver, vacuum pump and gas engine, is in the lowest part of the village, the sewage being conveyed there by a network of 4-inch iron pipe about one mile long, with another mile of house connections. The receiver and pipes are kept in a constant state of partial vacuum, so that there is a steady flow, but the full vacuum (about one-fifth of an atmosphere) is applied for ten minutes every morning, which completely clears the house receptacles and sewer-pipes, leaving them clean and dry. There is no need for special flushing, disinfecting the manholes or ventilating shafts. The work of laying the sewers was carried out by Mr. E. T. Watts, surveyor to Stansted Rural District Council.

The Haeseler-Ingersoll Pneumatic Tool Company, No. 26 Cortlandt street, New York, have issued a pamphlet describing their axial valve hammers. In this the valve is a radical departure from the various forms of straight line reciprocating valves ordinarily used. As its name implies its movement is around a fixed axis, the travel forward and back, to alternately open and close the admission and exhaust ports, being caused by a constant air pressure upon the short wing of the valve and intermittent air pressure upon the long wing. The ports in the valve, as well as those in the valve box, are relatively of equal areas, and are located diametrically opposite to each other, so that any pressure against either side of the valve is equalized by a corresponding pressure upon the other side, resulting in a perfectly balanced valve and a consequent absence of friction.

Much of the delay in the adoption of compressed air for cleaning machinery has probably been caused by the cumbersome and complicated compressing appliances that were employed for a long time; but this objection no longer exists, as simple, durable and compact air compressors suitable for this purpose are now obtainable. The electrically-driven compressor is by far the simplest and most desirable for railway shops, and it is always available by simply closing a knife switch. The operator does not need to know anything whatever about the compressor, and as skilled attendance is not required, pneumatic appliances may be intrusted to ordinary laborers about the car shops and power houses, and the same class of help can be utilized for using many pneumatic tools. There are many little things about a shop that can be done when compressed air is available, and which effect small economies in themselves, but aggregate a considerable sum in the course of a year.

It would be an instructive inquiry for a committee of English engineers, who might be appointed, why the bulk of the air-compressors on the Rand are either American or German, and only the few of British make. Certainly one of the answers would not be that the trade is not worth having. Apparently, also, in the matter of quality, English manufacturers have little to learn, their machines being universally conceded to be superior to those made in other countries. This statement, however, seems to require some qualification, for one observer states that the only British air-compressor which he saw on the Rand was said to cost 30 per cent. of its total value in yearly repairs. Price, possibly, accounts for the preference being accorded the foreigner; an any case, the engineers' committee suggested would be able to discover the cause, and it might even pay the makers of these machines to engage the salaried services of such a committee, who could complete their labors by an inquiry on the spot. According to trustworthy accounts, only a little energy is needed to secure a much larger share of the trade than now falls to British firms. A hint that has been thrown out for the improvement of these appliances is worth repeating here, viz., that the compressor cylinders should be made of greater capacity than the normal size to allow for the rarefied atmosphere on the Rand and Rhodesian mining fields.

Italy has discovered an original method of combining business and matrimony. On the occasion of the great exhibition which is to be held at Milan to celebrate the opening of the Simplon Tunnel the committee is organizing a beauty show among girls from eighteen to twenty-six. The number of these graces must not exceed eighty-three. In connection with this competition a lottery has been established, the money from the sale of the tickets being awarded to the prize beauties as a marriage portion. Thus he who wins the first prize ticket in the lottery gains the prize Venus and 1,000,000 lire, four second prizes will assure the four next beautiful girls and 500,000 lire, eight thirds secure pretty partners for the gainers and 250,000 lire, twenty fourth prizes take a good-looking girl and 100,000 lire, while the remaining fifty competitors in the beauty show go to those who win with 50,000 lire. A million lottery tickets at ten lire each will, it is expected, be sold, while the entry money of the rival beauties will help to raise the 10,000,000 lire required for the prizes. According to the number of tickets sold to each buyer he will receive so many photographs of the eighty-three different beauties; thus he can make up his mind beforehand which he would rather win. Every ticket will be accompanied by a small pamphlet giving the biography of each girl. If the winner refuses to marry his prize or if she should refuse the winner the amount of the fortune will be divided between the two.

The braking of high-powered cars is one of the most important problems in automobiling. The presence at the recent Chicago show of what is probably the first motor vehicle to be equipped with air brakes is therefore interesting. The machine in question has a small air pump, driven by a cam on the crank shaft, which forces air into a tank. The pump is provided with automatic mechanism that can be adjusted to throw it into action when the pressure in the tank falls below a given point, say 60 pounds, and out of action when it reaches 80 pounds per inch. Connected with the air tank by a tube is a small cylinder on the rear axle having two oppositely acting pistons that when pushed outwardly expand friction shoes in brake drums on the rear wheel hubs. Each stop of the car uses about two pounds of pressure, so that if the pressure is up to 80 pounds, ten stops can be made before it falls to 60 and the pump is put into action again.

The compressed air is also used for blowing a whistle and for forcing gasoline from a large tank under the rear of the body into a smaller tank on the dash, which is provided with a gauge glass so that the operator can always see how much gasoline is in the small tank, which feeds the carbureter. By connecting a hose direct to the air pump the tires can be inflated to 150 pounds pressure.

On the dash is a double gauge that shows the air pressure in the tank and the pressure in the water circulatory system, whereby, if there is any stoppage of the circulation, the driver will be promptly made aware of it.

A number of mining engineers recently visited the works of Messrs. E. Scott & Mountain, Ltd., at Newcastle-on-Tyne, England, in order to inspect a combined "Reavell" air compressor and "Scott & Mountain" continuous-current electric motor, which has been designed for use in collieries, where it is not possible to take electricity to the face. In collieries, where much gas accumulates in the face, and where it is advisable to have coal-cutting, rock-drilling and other machinery, it is safer, and, in some cases, more satisfactory to use compressed air than electricity, and the above-mentioned compressor is specially designed for such positions. The motor and compressor may be placed in the in-take, or as close to the position where the power is required as possible. The compressor is of the single-ended type (they are also made double-ended, *i. e.*, with the motor between the two compressors), the power being transmitted direct to the compressor shaft, which runs at a speed of 275 revolutions per minute. The compressor is of the double-stage pattern, and will deliver 150 cubic feet of air per minute at a pressure of from 80 to 100 pounds per square inch. The motor is an 88 horse-power Scott & Mountain continuous-current machine, but three-phase motors can be used if desired. The same type of compressor is also suitable for driving drifts in collieries where compressed-air drills are used. The compressor which was on view was to the order of Messrs. Walter Scott & Middleton, Ltd., and is to be used in connection with the excavations for the Great Northern and Strand Railway.

An important invention in connection with trolley arms used on electric cars to take the current from overhead wires is credited to C. V. Greenameyer, mechanical engineer of the Pacific Electric Company. Under the high speed that is sometimes attained, especially in the suburbs of cities, it has been noticed that the trolley wheel is in contact with the wire only part of the time. Much power is in this way undoubtedly lost, through the formation of arcs in the circuit, thereby transforming into light and heat the energy that should be used for propulsion of the cars. In his investigations as to the cause of this trouble, Mr. Greenameyer concluded that it is due to the spring used at the base of the trolley arm, and he has originated a device by which the spring is supplanted by compressed air, which not only keeps the trolley wheel closer to the wire, but also prevents any damage to the overhead construction in case there is a jump of the wheel from the wire.

The trolley arm swings on a swivel on top of the car, with the rope dangling from its end, as is now the construction. Through pressure exerted by an air cylinder attached to the trolley arm the wheel is pressed against the wire. Should the wheel be forced from the wire on a trip the air pressure is released automatically and the arm falls to a point out of range of cross wires, instead of flying upward, as is now the case, to the destruction of the supporting wires sometimes, and also of the arm itself. The new trolley arm may be replaced in position by the turning of a lever at the hand of the motorman, the conductor at the same time using the guide rope, as at present used. One peculiarity pointed out is that the greater the speed the more surely does the wheel remain on the power wire.

Two "champing jaws" do the trick for the W. J. Clark's Quick As Wink Hose Coupling. A single push forces them over the shouldered groove of the companion piece—the other half of the coupling—and in an instant you have a joint that is absolutely air-tight. A spring holds the jaws together, but when the pressure is on no amount of rough handling could make them release their grip, even if the spring were not there.

The Quick As Wink Coupling will not come apart until you want it to—till you separate the jaws, with the thumb-levers or with the small flat key (whichever style you prefer). In either case connection is broken *in an instant.*

The Engineering Agency, 1208-9-10-11 Monadnock Block, Chicago, was started in 1893 by Mr. F. A. Peckham, at that time Western Manager of the *Engineering News.* Mr. Peckham found in traveling about the country that he was constantly asked by manufacturers where they could find certain competent help. On the other hand, his office was visited every day by those who thought his paper might be able to assist them to positions.

The agency has grown steadily, and during the past ten years has secured positions for over 5,000 technical men. The registrations during the past two years have exceeded 3,000, and yet to-day the agency has difficulty in securing enough competent men to supply all of the demands made upon it by companies that wish high-grade help. It is therefore using the "want" columns of some fifty leading papers throughout the country. Every person who registers in the "Engineering Agency" is obliged to give a complete record of his past experience, and if the agency thinks that the experience is not satisfactory it refuses to permit the applicant to register; if it does accept the registration fee, but finds upon investigating the references that he is not such a man as the agency wishes to recommend, it returns to him promptly the registration fee. The care taken to register only competent men and to recommend always the right man for the right place, together with an experience of ten years with the leading railways, manufacturing and industrial companies, enables the agency to secure positions promptly for almost any high-grade technical man who can furnish a good record and references.

Mr. F. A. Peckham, President of the agency, was for twelve years with the *Engineering News;* Mr. A. B. Gilbert, Treasurer, has recently completed over eleven years' work for the same paper, during six of which he was Assistant Manager; Mr. A. G. Frost, Secretary, has been connected with the agency for several years.

The summer plans for the F. F. Proctor circuit of theatres, New York city, have been practically completed, and steady employment is promised to the large number of actors in Mr. Proctor's employ, and, best of all, a gay season of highly entertaining shows for the public at large. Later on there will be a revival of several of last season's biggest hits, and then there will be produced in quick succession half a dozen gay pieces never before seen in New York. All those productions will be as carefully made as though the season were at its height, for it is never Mr. Proctor's idea to curtail expenses, be the season early or late. At his Twenty-third street theatre the plan of presenting all vaudeville shows will be continued throughout the summer, the bills being made up with special reference to the warm weather. At his One Hundred and Twenty-fifth street house, Fifth avenue and Fifty-eighth street theatres the favorite stock companies will continue their excellent work.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

THE NORTH STAR MINES,
GRASS VALLEY, CAL.

Editor of COMPRESSED AIR,
New York City:

DEAR SIR—In your February number Mr. Place seems to think that there can be no appreciable drop in temperature of compressed air escaping through an orifice into the atmosphere (only about one degree F. for each atmosphere). By using an engine to pass his air through he claims getting a loss in heat precisely equivalent to the work by the engine.

If he will take his engine cylinder and fill it with air compressed to, say, ninety pounds, shutting off the supply, open the pet cock and hold his thermometer in the escaping air he will get a temperature of thirty or more below in the few seconds it takes to empty the cylinder. In other words, if he will keep his piston in his cylinder still and let the compressed air in and out of it, taking care to cut off the supply during the exhaust, he will get the same low temperature, or loss of heat, and the air will have done no work, as I understand it.

Very truly yours,

ARTHUR DEWITT FOOTE.

[That work of some kind is done when air is expanded and that the equivalent is the cold evidenced, we think is a general axiom which should be accepted. It is not necessary, of course, to do this work in pushing the piston of an engine, as it might be done in the shape of internal work; that is molecular work.

We should be very glad to have you send us any report you may care to make of your experiments for measuring compressed air under pressure and by means of the flow from orifices.

The subject of metering or measuring volumes of compressed air is a very important one, and, so far as we know, there is no device at the present time which can be relied upon for this purpose.—ED.]

Editor Compressed Air:

Sir—We have noticed quite a number of articles in your book about the use of oil for lubricating air compressors and would esteem it a great favor if you would give us some information as to what is the best oil for this purpose. We have two stage compressors, and our terminal pressure is from 100 to 120 pounds. So far we have been using what is called * * *, and we have been told that it was rather a bad oil to use for that purpose and that we ought to use "Renown" engine oil, and feed it into the air cylinders the same as we have been doing with the * * * oil. Kindly advise us your opinion of either of the above-mentioned oils and whether there is another make of oil that you can recommend. The party who recommends "Renown" oil claims that the Ingersoll-Sergeant people, after a good deal of experimenting, found the "Renown" to be the best all-around oil for use in air compressor cylinders.

Thanking you in advance for any information you may give us, we remain,

Very truly yours,

Heine Safety Boiler Co.

[We acknowledge receipt of your letter of April 1 relative to the use of oils for lubricating air compressors. This is a subject which has aroused a great deal of interest lately, and we are glad to see that it is receiving the attention which its importance warrants.

Owing to the frequent inquiries which we have received from various sources, we recently published a brief article on the general subject of lubrication, and we have from time to time published reports of accidents resulting from the use of inferior grades of oil, rich in volatile matters.

We also refer you to Compressed Air for November, 1902, where you will find an article containing some very valuable information on the subject.

Relative to the * * * oil, we frankly say that we do not know anything about it other than it is an oil largely used for machine lubrication. The "Renown" engine oil we know to be a good oil for air cylinders, and a great many compressor operators are partial to it, and we think that you should have no trouble if you use "Renown" oil. We also refer you to our advertisers, some of whom handle high-grade oils.

We would, however, advise against the use of too much oil, no matter what the make. The air cylinder lubricators should be adjusted to feed regularly a smaller quantity than is necessary in the case of a steam cylinder. They should also be watched carefully to see that they do not get to feeding faster than necessary or that they do not clog up.—Ed.]

Hamilton, Ont., April 24, 1903.

Editor Compressed Air:

Dear Sir—I received your book, *Compressed Air Information,* and prize it highly.

I notice an article on "Hydraulic Plant for Compressing Air," by H. D. Pearsall, of London, Eng., on page 173, and read the same with some interest.

I would like if you could give me any further information on the particular appliance he writes of. Have you any drawings showing how the water is controlled by the valve, or can you inform me where I can see any drawings of it on this side of the Atlantic?

Your favor will much oblige,

Yours truly,

Walter Anderson.

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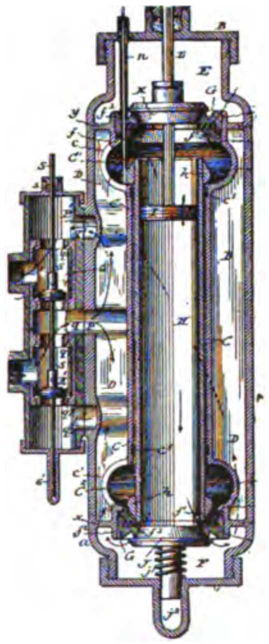
U. S. PATENTS GRANTED MAR. 1903.

Specially prepared for COMPRESSED AIR.

721,662. AIR-PUMPING APPARATUS. Byron B. Bower, Bainbridge, Ga. Filed Aug. 21, 1900. Serial No. 27,607.

The combination with a frame or casing having a chamber at each end formed by internal flanges, a cylinder-guide extending between such flanges and formed with an enlarged chamber adjacent each such flange and provided at its open ends with internal and external valve-seats, of an endwise-movable cylinder entirely open at its ends which extend



into said enlarged chambers and is formed with a valve at each end adapted to seat against said internal valve-seats, automatically-acting valves seating against said external valve-seats, a piston reciprocating in said cylinder, its piston-rod passing through one of said automatically-acting valves and ports and passages for admission and expulsion of air.

721,743. PNEUMATIC COTTON-CONVEYOR. George E. Richmond, Houston, Tex. Filed Nov. 21, 1902. Serial No. 132,263.

721,752. COMPRESSED-AIR SPRAY. Lloyd Scruggs, Omaha, Nebr. Filed July 22, 1901. Serial No. 69,170.

721,877. RAILWAY-MOTOR-VENTILATING SYSTEM. John H. Fedeler, Schenectady, N. Y. Filed Dec. 6, 1902. Serial No. 134,175.

The combination of a railway-car, an electric motor thereon, a source of compressed air, pipes leading from said source to the motor and pipes from the motor to the interior of said car.

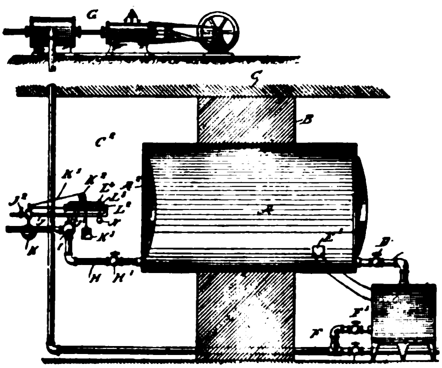
The combination with a railway-car and an electric motor thereon, of means for passing air over said motor, and a passage for the air thus heated from the motor to the interior of the car.

721,960. MEANS FOR REMOVING SLEET, SNOW AND ICE FROM THIRD RAILS. Peter Lindemann, Westchester, N. Y. Filed Jan. 7, 1903. Serial No. 138,118.

A third-rail electric railway, a sand-blast nozzle connected with a car or motor adjacent to the contact-shoe and adapted to discharge a blast onto the contact-surface of the rail, substantially as shown and described.

A third-rail electric railway, a sand-blast nozzle connected with a car or motor adjacent to the contact-shoe and adapted to discharge a blast onto the contact-surface of the rail, said sand-blast nozzle being under the control of the motorman, substantially as shown and described.

721,991. SAFETY AIR-LOCK. Walton I. Aims, New York, N. Y. Filed Dec. 17, 1902. Serial No. 135,494.

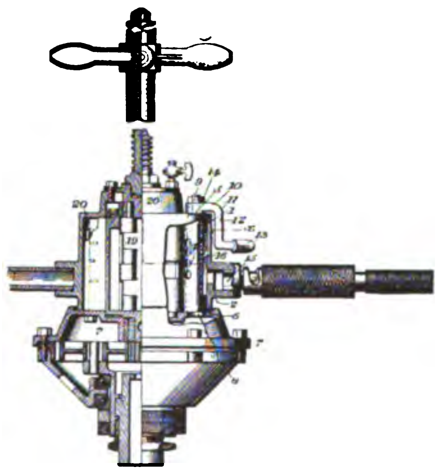


An air-lock having means for regulating the exhaustion of air from the lock, and means for simultaneously supplying heated air to the lock, as set forth.

An air-lock having an air-escape, a time-controlled device for the said air-escape, to cause a gradual reduction of pressure in the air-lock, an air-supply for the said air-lock, and heating means for heating the air previous to its entrance into the lock, as set forth.

722,179. REVERSING-VALVE FOR COMPRESSED-AIR MOTORS. Julius Keller, Philadelphia, Pa., assignor to Philadelphia Pneumatic Tool Company, a Corporation of New Jersey. Original application filed Aug. 13, 1902, Serial No. 119,479. Divided and this application filed Sept. 4, 1902. Serial No. 122,021.

A reversing-valve, consisting of a cylinder, a passage therethrough, open at its bottom and closed at its top, a longitudinally-extending



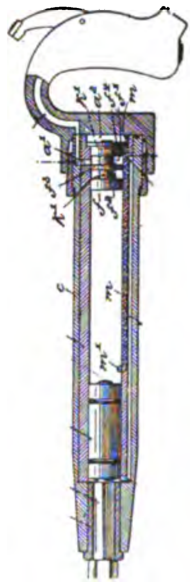
external groove on one side of said valve, and ports on the opposite side of said valve, whereby the latter is adapted to permit the entrance and exhaust of the motive fluid, the latter initially passing around said groove, in combination with an engine-cylinder in which said valve is mounted, handles therefor, one of said handles serving as an inlet-pipe, said valve being located in said cylinder between the rotary engine and said handle.

722,369. PNEUMATIC STACKER. Charles N. Leonard, Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Apr. 14, 1902. Serial No. 102,722.

722,403. AIR-BRAKE. Joseph Farrar, Montreal, Canada. Filed Mar. 18, 1902. Serial No. 98,837.

722,614. PNEUMATIC HAMMER. Samuel Oldham and John J. Padbury, Philadelphia, Pa., assignors to George Oldham and Samuel Oldham, trading as George Oldham & Son, Frankford, Philadelphia, Pa. Filed Apr. 12, 1901. Serial No. 55,462.

In a pneumatic tool or hammer, a cylinder, a piston or hammer adapted to reciprocate in a portion of said cylinder, a valve adapted to reciprocate in the remaining portion of said cylinder and means controlled by the move-



ment of both piston and valve for admitting live air or fluid to the cylinder above the piston on its down stroke in varying volume, so that the downward movement of the piston is accelerated after it has begun to travel.

723,230. PNEUMATIC BRANDING AND HEATING IRON. John H. Belz, St. Louis, Mo., assignor of one-half to Ben Steyermark, St. Louis, Mo. Filed May 26, 1902. Serial No. 108,944.

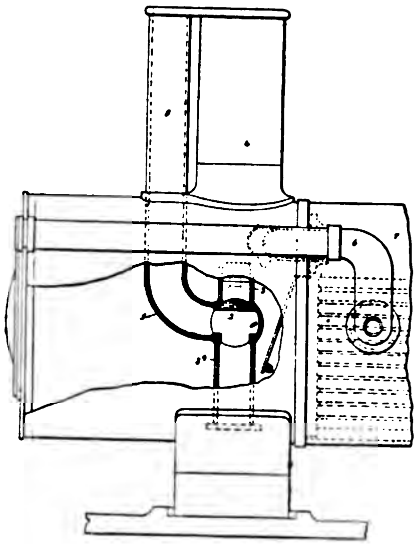
723,297. DUPLEX AIR-BRAKE SYSTEM. William H. Nightingale, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed May 20, 1902. Serial No. 108,157.

723,457. PNEUMATIC-DESPATCH RECEPTACLE. Emanuel C. Gipe, Chicago, Ill. Filed Jan. 6, 1902. Renewed Jan. 22, 1903. Serial No. 140,178.

723,870. PNEUMATIC STACKER. John Henry, Grand Forks, N. D. Filed Nov. 2, 1901. Serial No. 80,924.

724,183. COMBINED STEAM AND COMPRESSED-AIR LOCOMOTIVE. Ebenezer Hill, South Norwalk, Conn. Filed Apr. 1, 1902. Serial No. 100,908.

A combined steam and compressed-air locomotive, the combination with a boiler, of a

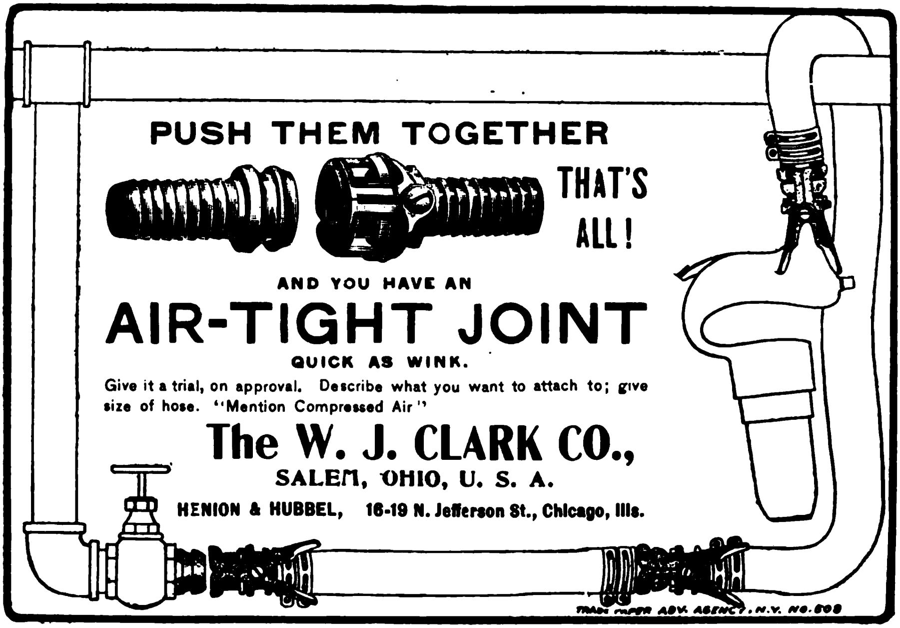


steam cylinder, means for distributing steam in the said cylinder, a compressed-air reservoir, means for supplying the said boiler and hence the said cylinder, with compressed air, and means for relieving the fire of the locomotive from the suction of its exhaust.

724,180. PNEUMATIC SWITCH APPARATUS AND VALVE THEREFOR. Lawrence Griffith, Yonkers, N. Y. Filed Apr. 18, 1902. Serial No. 103,523.

In a pneumatic apparatus, a slide-valve comprising a seat having inlet and outlet ports, an under slide adapted to slide on said seat and having ports adapted to be put into registry with the ports of said seat, a top slide adapted to slide on said under slide and having ports adapted to be put into registry with the ports of said under slide and therethrough with the ports of said seat, and means for moving the top slide in two directions whereby it must make a complete stroke in either of said directions before commencing the stroke in the other direction, and for carrying with it said under slide for a part only of such complete stroke.

724,302. ENGINEER'S AIR-BRAKE-CONTROLLING VALVE. Joseph Lipkowski, Paris, France, assignor to Societe Generale des Freins Lipkowski, Paris, France. Filed Jan. 31, 1903. Serial No. 141,317.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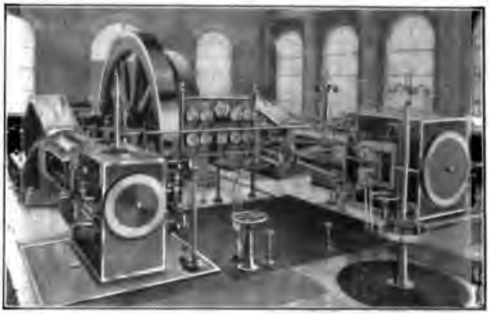

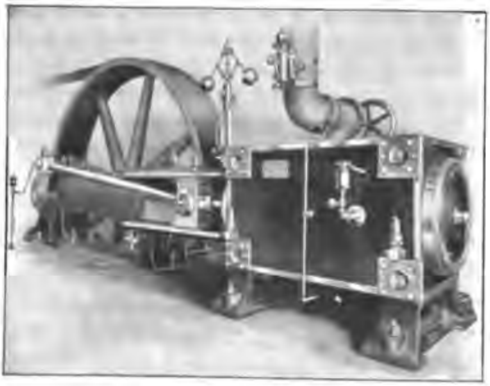

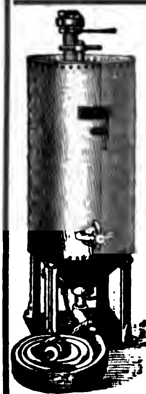

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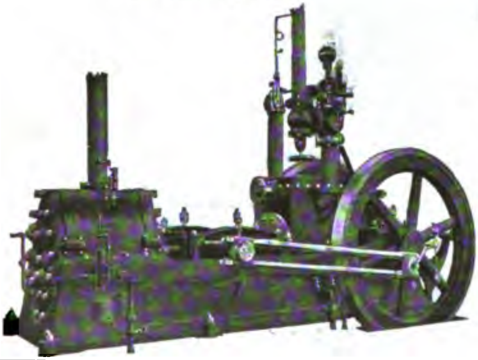

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VOL. VIII. NEW YORK, JUNE, 1903. No. 4.

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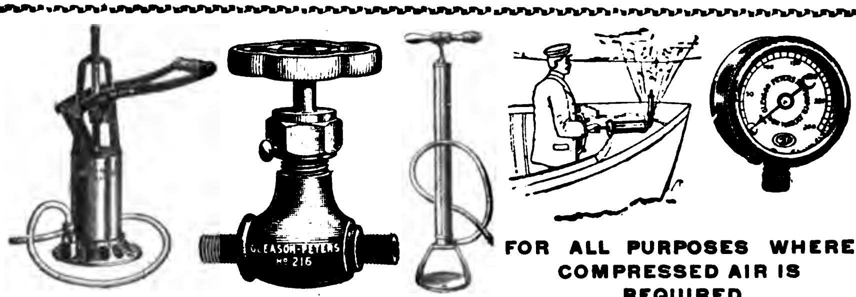
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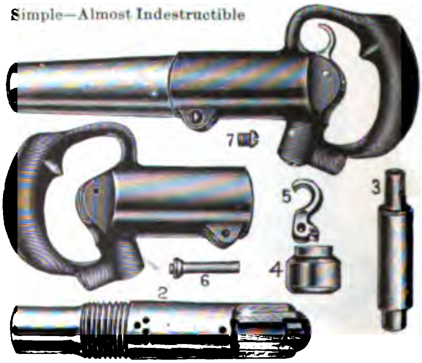
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"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - Editor and Proprietor
J. E. QUINTERO, - } Associates
M. E. VARIAN,

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Accidents due to Combustion within Air Compressors.

Dr. Ledoux, in a paper read before the American Institute of Mining Engineers, gives an interesting account of a serious accident which might occur in almost any common mining plant, provided due precautions are not observed. In the first place, it is very likely, though not stated, that the air compressor in question was not a compound machine; that is, the air was not compressed in stages. This is the first point to consider when equipping a mine with an air compressor, and where the purchaser wishes to be insured against a similar occurrence. By compressing the air in stages, that is, by the use of compound cylinders, the maximum temperature during compression is very much reduced and the liability to "flaming" is less. Having an air compressor with compound cylinders, the next thing to do is to provide a high grade of oil to be used in the cylinders. This should be an oil with a high flashing point and of a non-coking nature. In other words, when the oil is placed on a shovel and held over a fire there should be little or no carbon deposit left after it has been volatized. The third point to be observed is to caution the engineer not to use much oil in the air cylinders. A drop every five minutes is sufficient in a cylinder of ordinary size, and every engineer should feed soapsuds into his cylinders for at least one day in the week in order to wash away any deposit which may have accumulated through the use of oil which has been acted upon by high temperatures in air. These soapsuds may be fed through the regular oil cup. Care should be taken not to let the machine lie idle with soapsuds remaining in it; that is, shortly before quitting time the feeding of soapsuds should be stopped and oil feeding substituted.

Another point is that every engineer should look into his discharge valves, air-receiver and other places where deposits are liable to accumulate, and keep them clean. A discharge valve which sticks, either through defective construction or through the accumulation of carbon around it, is liable to admit hot compressed air from the receiver back into the cylinder to increase the temperature of the air before compression to so high a point that it is quite possible to reach the flashing point of the oil. In connection with this, it is well, also, to bear in mind that the intake air should come from the outside and not from the inside of the engine room. This is important, because a cold intake gives a higher volumetric efficiency to the compressor and also because it results in a lower maximum temperature during compression, which not only means safety against "flaming," but economy of power. The hotter the air is during compression the greater is the resistance to compression. Another reason for an outside intake is that bad air in the engine room, or smoke or fumes from a fire, will not be sucked into the compressor and discharged into the mine.

This case also illustrates the value of intercoolers and aftercoolers in a compressed-air plant. These coolers are surface condensers, the intercooler being placed between the high and low-pressure air cylinders and serving to reduce the temperature between the two stages of compression. The aftercooler reduces the temperature after the last stage and condenses and collects all such foreign matter as oil, moisture, dust, etc., sending pure, dry air down into the mine.

Utilizing Tidal Action.

While many minds have labored vainly to find some practical means of bringing about the conversion of the tidal action into mechanical energy for general transmission and use, the day may come when this apparent wholesale waste of energy will be ended and the power of the tides brought into control becoming a prominent factor in the generation of power for the commercial and mechanical world. Various methods to accomplish this end have been devised in past years, but, while some of them have actually been shown to work successfully in fact as well as in theory, there has always been some unsurmountable barrier, as exceptional conditions or prohibitive cost, which prevents their general use.

Most inventors have confined their efforts to some mechanical device which will transform the action of the tides into some form, generally electricity, that may be easily transmitted. It remains for an engineer of Mons, Belgium, Chas. Eugene Ongley by name, to devise a method of compressing air directly by the rise of the tides. His idea is to construct a tunnel or reservoir with a comparatively small opening at the low-water mark. As the tide rises the water flows into the tunnel or reservoir covering the opening and gradually compressing the air in the top of the receptacle from which, with the aid of a proper outlet valve and piping, it can be conveyed under pressure to another reservoir. While the inventor admits that the pressure thus obtained would not be very great, 25 to 30 pounds at best, he believes that his idea could be profitably utilized along the Atlantic sea board.

While we do not doubt the practical working of this method, yet we believe that it would not pay to install it generally, because its application is very limited. There are only a few places where it could be put into operation, and in all places both the pressure and the volume would be small. Furthermore, there is no special commercial advantage in a compressed air plant which is located down at the seashore some miles away from the point of consumption. As the rise and fall of tide takes place only twice in 24 hours, the volume of compressed air which might be produced by this process would be small in proportion to the expense involved. In other words it would be necessary to confine large volumes and to construct expensive works, which from a commercial standpoint would hardly be likely to compare favorably with the production of compressed air by means of engines of high duty, working directly at the point where the air is utilized.

A more extended description of Mr. Ongley's invention, with illustrations, will be published in the July number of COMPRESSED AIR.

Notes on Accidents due to Combustion within Air Compressors.*

With the improvements in design and efficiency of machinery the element of danger in its use is becoming less, but it is a question whether the strain involved in operating modern plants is not increasing somewhat the danger of accident due to human fallibility.

I propose to describe a somewhat uncommon casualty resulting from a not infrequent incident in the use of air-compressors. It is not necessary to state the location of the mine in which the accident occurred nor the makers of the compressor, and the object of this brief paper is more to draw out suggestions from members more familiar than am I with the practical handling of mining machinery than to point a moral.

The compressor in question was a three-drill machine of standard make. At the time of the accident it was furnishing air to a single drill working in an upraise from a well-ventilated tunnel, and giving ventilation to a winze below the tunnel where two men were hand-drilling. The compressor also furnished power to a small hoist in the winze, but the hoist was only operated occasionally, and never while the drills were working. The drills were located about 1,200 feet from the compressor. The engineer testified that he never had been short of air and that there had been no complaints that the machine was inefficient. The engineer testified, further, that the water used in cooling the air-cylinder had never become greatly heated, but that he used a mixture of good cylinder-oil and of a lighter grade known as "Atlantic Red." The valve of the compressor was set to blow off at 80 pounds. He was eating his luncheon in the boiler-room when he heard a "crack like a pistol," and, going into the engine-room, found water spurting out of the jacket about two feet from the end of the compressor. He tightened the jacket and stopped the leak, and found that the jacket was perfectly cool. He next noticed that "grease began to fry on the pipe and receiver."

He next saw that the air-pipe had become red-hot, the heat extending to a point where the pipe went through a wooden partition, setting fire to it. Then he noticed that the pressure was going down "just as quick as if some one had opened a valve outside," which, in fact, is what happened. He stopped the engine, but, getting the signal for more air, started up again. It is well to note at this point that the intake of the compressor was in the engine-room, the temperature of which usually stood at 115° F.

Let us now see what occurred in the mine. What happened at the bottom of the winze cannot be better told than in the testimony of one of the miners at the Coroner's inquest: "I was turning a hole and my partner was striking the drill; he says, 'We ain't got much air here this morning; I will ring for some more air.' He rang, started to strike again, and struck two or three blows; straightened up and took a couple of breaths of air, and started in to strike again, and then quit. I had been joshing him, and says, 'You ain't as tough as you used to be.' I stood up, picked up a pick, struck two or three blows and felt that the air was bad. Just then the air stopped, and the hoist-tender hollered to us that there was no air and we had better come up. I looked around and seen my partner standing in the corner. He was all trembling, and I caught him as he fell over."

These two men were gotten up by heroic work on the part of comrades, and their lives were saved. But not so fortunate were the men in the upraise. There were four of them here, and when they felt the air getting bad they opened the valve full—of course, only increasing the difficulty. They were experienced miners, and at first could not understand what was the matter with them, because their candles continued to burn as usual. This was due, undoubtedly, to the fact that they were working in an upraise, and that the heavy carbonic-acid gas sank, and perhaps to the fact that carbonic oxide may have been generated through incomplete combustion or the reduction of the carbonic acid, first formed, by the glowing carbon in the pipe.

Two men were killed and four others barely escaped with their lives as a result of the combustion of the oil, deposited carbon and organic dust accumulated in the compressor, receiver and pipe. Explosions of air-compressors due to this cause have been frequent, and lives have been lost thereby; and what is known as the "flam-

* By Albert R. Ledoux, for the Albany Meeting, February, 1903, of the American Institute of Mining Engineers.

ing" of compressors or cylinders is an every-day experience, and in some cases the rupture of the air-pipes, but, so far as I can ascertain, without the serious consequences described in the present case.

I shall leave to those better qualified than I the discussion of the best means of preventing such catastrophies. Among those which suggest themselves are the taking in of the air from a point where its temperature is as low as possible, the introduction of auxiliary coolers, the use of as heavy oil as possible—yet never in excess—the cleaning out of cylinders, receivers and pipes, and especially a warning to the engineer to be very sure, when he receives a signal for more air, that the actual shutting-down of the compressor may not be more essential. In this case, had he shut down it is probable that no lives would have been lost, for with the stopping of the air the miners would have at once returned to the tunnel level.

Sand-Blast Cleaning of Structural Steel.*

CHARLES EVAN FOWLER, M. Am. Soc. C. E. (by letter).—This paper is certainly one of the most important that has ever been presented before the Society. The failure to clean the metal of steel structures properly before they are painted is the principal cause of their deterioration, and, practically, is the only cause which exists as a prejudice against them. While the bridge shops have, in most instances, endeavored to clean the steel properly before paint is applied, it has never been done satisfactorily, in the majority of cases, owing to the character of the plant used, and owing to the character of the help which it is necessary to employ on work of this kind. The laborers ordinarily employed as painters about bridge works are not possessed of a very high order of intelligence, and soon fall into the rut of glossing over and slighting their work. When they are discharged, and new ones put in their places, there is always a length of time for breaking them in, during which the work is not done properly, so that the writer believes that, necessarily, it must come to some such method as sand-blast cleaning at the bridge shops before painting is done, or else follow the lead of some European railroads, where the bridges are not painted until some time after erection.

The specifications of the Sheffield and Lincolnshire Railway Company for 1889 require that no portion of a structure shall be painted before erection, except such parts as are not accessible for painting afterward. Some time after the structure is erected, and the scale has all disappeared by rusting off, the metal is cleaned thoroughly and painted. Should this be done by the sand-blast process, and paint at once applied, there would be some surety of a proper protection from future rusting.

Many engineers seem to object to allowing rust to appear upon the steel at all, preferring to have the metal kept under cover from the time it is rolled until it is fabricated and painted, but any one who has had experience with raw steel plates and shapes stored in a yard will know that the mill scale, which very often is not removed otherwise, is rusted off, and the solid metal, although coated with rust, can be gotten at so as to be cleaned thoroughly and painted; whereas, if the metal is kept under cover, much of this scale remains on and is painted over, and in a few years flakes away from the metal, or rusting between the scale and the body of the metal goes on unseen.

In the writer's opinion, particular parts of bridges should be galvanized, in a great many cases, or protected by Barffing, so as to give them a protection once for all; but, in lieu of this, the thorough cleaning of existing structures by a method similar to that used by Mr. Lilly should be followed, and the coating applied directly afterward to protect the steel thoroughly. In such cases it will be possible soon to arrive at some definite idea as to which paint is really the best to use on bridges and steel structures.

While not directly a feature of Mr. Lilly's paper, it certainly is one which comes up in studying it, as to what kind of paint is really the best. The writer is not prepared to change his opinion, formed during many years as chief engineer of one of the large Eastern

*Abstract from *Proceedings* American Society of Civil Engineers for April, 1903.

This is a discussion of the paper by George W. Lilly, Assoc. M. Am. Soc. C. E., printed in *Proceedings* for February, 1903, and also reprinted in April, 1903, "COMPRESSED AIR."

bridge companies, that red-lead paint is the best that can be applied, regardless of the numerous paints which are advertised so loudly as the best for protecting steelwork. Red lead, used according to the Baltimore and Ohio specifications of 1896, by the addition of 10 oz. of lampblack to every 12 lbs. of red lead, can be handled as easily as any other paint. Next to this, for first-class work, are the various carbon paints put on the market by the standard paint companies.

While the writer has no data of his own as to the cost of sand-blast cleaning, it appears from the paper that the cost can be reduced to a reasonable figure, and one which would warrant the use of the method whenever there is a large amount of cleaning to be done.

If this paper shall have served no other purpose than to have called attention in a forcible way to the need of thorough cleaning of steelwork before painting, it will have proved itself to be one of the most valuable papers ever presented for the consideration of engineers having to do with steel structures.

William Anderson Polk, Assoc. Am. Soc. C. E. (by letter).—The writer has read this paper with much interest, especially that part relative to cleaning the One Hundred and Fifty-fifth Street Viaduct, in New York City. During this operation the writer had the pleasure of devoting about one month's time to observation of the workings of the sand-blast, and found that it was the only power capable of removing the accumulated rust scale with despatch and economy. Moreover, it was the only method that was thoroughly efficient in preparing the surface for the tests of paints, that being the object for which the sand-blast was used on the viaduct.

To understand how thoroughly the machine did its work, it may be stated that on days in which the humidity was great (such days were frequent, the humidity registering often from 90° to 98°), the metal was no sooner cleaned than the gray color was changed by oxidation to a rusty brown. It was deemed expedient to apply the paint as soon as possible after a sufficient number of square feet (about 200) had been cleaned. This surface would comprise two buckle-plates, one on each side of the girder, and the section of the girder supporting these buckle-plates. The cleaned surface was protected from sand by a screen of sail cloth while the machine was being operated.

Notwithstanding this protection, a great deal of fine dust settled on the cleaned portion. This dust was readily taken up by the paint, however, and, in the writer's opinion, did no harm. One painter could finish in two hours the portion which had been cleaned by one nozzle-man in eight hours, under favorable conditions, viz., in dry weather and with dry sand. Four nozzle-men could keep one painter busy, but, to accomplish this, the sail-cloth screen had to be moved frequently to places where protection might be necessary. On bridges at other places the writer has noticed that a screen was not needed.

The expense of cleaning the One Hundred and Fifty-fifth Street Viaduct was necessarily much greater than it would be to-day. The cost and the time of cleaning could be reduced very much by the addition of more machines.

For the purpose of preparing metal surfaces for painting, nothing has come under the writer's observation, during a period of ten years, that can approach the efficiency of the sand-blast machine. In order to have the best results from painting, it is expedient, nay, it is necessary, to have the surface absolutely free from rust, mill scale and grease; therefore the sand-blast will more than pay for itself in decreased maintenance and in furthering the lasting qualities of metal coatings.

J. P. Snow, M. Am. Soc. C. E. (by letter.—The Boston and Maine Railroad (with which the writer is connected) has used a sand-blast outfit for four seasons, but from its experience little can be added to the testimony given by the author. The mixers used are of the Tilghman pattern, with a second hopper, so that sand may be fed continuously while the blast is operating.

The air is furnished by a Fairbanks-Morse gasoline compressor, with an 11-inch engine cylinder and a 14½-inch pump having an 18-inch stroke. Two, and sometimes three, open-topped galvanized-iron tanks, of 600 gallons capacity, each containing circulating water for cooling the cylinders, are used; these, and a small galvanized-iron gasoline holder, a boiler-iron air-reservoir, a sand-dryer, and pipes, hose, etc., complete the outfit.

The air pressure with this plant is from 15 to 18 pounds, which is very effective on weather rust not heavily scaled. Where the scale is caused by engine gases or by brine from refrigerator cars it is removed with hammers, chisels, etc., before applying the blast. It is thought that a greater pressure, as advocated by Mr. Lilly, would be more effective where the rust is heavy and the metal pitted. The pressure can be increased by exchanging the pump cylinder for a smaller one.

Usually this outfit is loaded and unloaded by a car derrick. It is set up near the bridge to be operated upon, the water tanks are filled from the locomotive tender, a detachable shanty is put over the engine, sand is unloaded, the pipes are connected, and work is commenced. It requires only a few hours to set up the plant at a given bridge. It is desirable to have the sand-dryer as near the bridge as possible, but the engine should be 100 feet away or further, to get it somewhat out of the dust.

The sand should be clean and hard. For the highest efficiency, its fineness should depend on the kind of rust to be attacked. For simple weather rust, fine sand is the best. If the rust is heavy, the metal pitted and the surface hard to get at, coarse sand should be used. Where the work is over dry land, the sand can be used again several times. It gets finer each time it is used, but as the impact against the metal breaks the grains of sand, they are sharp, and, until it becomes too fine, its effectiveness is rather greater than at first.

For drying sand a so-called Chicago dryer is used. The dry sand escapes through an annular opening against the fire-box, which prevents, in a measure, the overheating mentioned in the paper. This method of drying sand is very unscientific, however, inasmuch as the mass of sand in the hopper acts as a blanket to prevent the escape of steam from the lower portion next to the fire-pot, where there is the greatest heat. In fact, it is a good deal like trying to drive moisture out of a steam-tight box. A dryer arranged so that the sand could fall over a series of inclined baffle-plates in a furnace, where the heated gases from the fire could pass over a thin moving sheet of sand and absorb its moisture, is a desideratum. The waste heat from the engine exhaust is enough to dry the sand in a properly arranged dryer, but there are practical difficulties in using it. The exhaust from an explosion engine should be free and close to the engine, to obviate back pressure; but, to save the running parts, the engine should be at some considerable distance from the sand. Again, it is frequently desirable to dry sand when the engine is not running; therefore, on the whole, it seems best to use an independent dryer.

Some difficulty is experienced from moisture carried by the condensed air. A very little dampness will cause the sand to clog at the lower valve, as mentioned in the paper; but, with drips at the air reservoir and no sags in the lines of air pipes, the trouble is not great.

In cleaning a long bridge the air has been carried as far as 900 feet from the reservoir. A 3-inch pipe is used, and there is very little reduction in the pressure from the reservoir to the mixers.

The operation of painting is similar to that described by Mr. Lilly. On overhead bridges, which suffer from the blast action of the locomotive smokestacks, it is not considered a disadvantage to have the sand get into the raw paint. Two coats are applied, and the portion directly over the centres of the tracks receives three coats. If the first is well filled with sand the result is a thick, gritty coat, which has considerable power to withstand the blast of hot sparks from the stacks.

With the engine described, three mixers and nozzles are used. The force required is generally a foreman and six men—three on the nozzles and three drying sand and feeding it to the mixers. The writer has no reliable statistics as to cost. The figures given in the paper are fairly comparable with average results obtained, but many jobs cost more on account of the difficulty of getting at the parts to be cleaned. The question simply resolves itself into a choice between letting the metal waste away at its own rate or paying the cost of cleaning it with the sand-blast. Where iron has become heavily scaled by locomotive gases, brine from beef cars, or sea water, it is simply impracticable to stop corrosion by any method known to the writer other than the sand-blast.

THEODORE BELZNER, Jun. Am. Soc. C. E.—In this paper Mr. Lilly has carefully covered the ground, and has left little to be added except practical experiences in the same line. A number of his recommendations should be carried out, and if criticism were to be made, it would have to be said that he does not place sufficient emphasis on some of his recommendations.

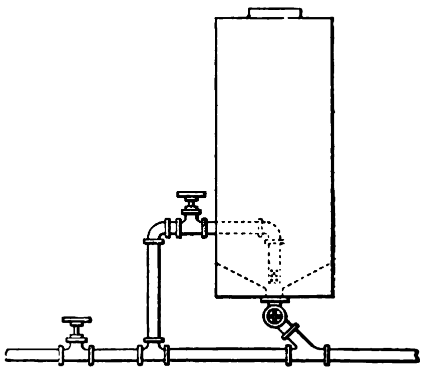
The speaker will endeavor to relate the experience gained in the sand-blast cleaning of steel on the Rapid Transit Subway, in New York City.

Owing to the magnitude of the Rapid Transit Subway work, steel had to be ordered largely in advance from the manufacturers, who in this case were the American Bridge Company. Such steel as columns and girders of standard size and design were ordered, so as to facilitate the output at the mills. Large quantities were received, and lay for from eighteen months to two years, piled high in the streets and at the yard at the foot of Forty-second street, East river. This steel was exposed to the inclemency of the weather for that period. When the sub-contractors were ready to use the steel it was found that the paint had worn off considerably and a part of the steel was corroded. It was determined to clean and repaint before erection such parts as were to be exposed in the structure, and all abutting and connecting parts which were not to be embedded in concrete. S. L. F. Deyo, M. Am. Soc. C. E., Chief Engineer for the Rapid Transit Subway Construction Company, acting on the recommendation of William Barclay Parsons, M. Am. Soc. C. E., Chief Engineer for the Rapid Transit Commission, then gave the order to the sub-contractors to clean the steel with the sand-blast.

Before taking up the work in detail it should be stated that the various sub-contractors had established air-compressing plants on their various sections, thus having their line covered with compressed-air pipes.

A large quantity of steel was piled at Canal and Elm streets, and work was commenced there, but was found to be such a nuisance to the tenants of surrounding buildings and to traffic that it was moved down into the partly finished subway. Here the dirt and sand became a hindrance to the workmen, and the work was moved to Bond and Elm streets. Here, again, it proved to be such a nuisance to the public and to traffic that the operation of the blast was confined to night hours. Work was then carried on at this point for a long time, until the street was cleared for paving. The plant was then moved to Forty-second street and the East river, where again work during the day was found to be objectionable to the neighborhood, and the work is now being done at night.

The plant, after being moved to Forty-second street and East river, was



SECTION OF SAND-BLAST TANK.

entirely rearranged, and in such a way as to obtain much better results than those obtained previously. The size of the pipe from the condenser to the blasts was increased to 1½ inches, and a much greater pressure was obtained, thereby largely increasing the quantity cleaned. The tanks were about 200 feet from the power-house. The arrangements for drying and storing sand ready for use were also improved, and the handling was facilitated considerably by the use of the crane in lifting and piling the steel.

Two plants are at work. That for The Degnon-McLean Contracting Company consists of four tanks of double-row, riveted, extra heavy, ordinary kitchen boiler, 14 inches in diameter and 4 feet

10 inches long, the interior arrangement of which is shown in the illustration on page 2419. The plant in use by the Holbrook, Cabot & Daly Contracting Company consists of two tanks having a similar interior arrangement.

Although four tanks were erected for The Degnon-McLean Contracting Company, only two are in use, as a rule, the extra tanks being kept in reserve in case of any trouble, thereby preventing any interruption of the work.

The simplicity of the design of these sand tanks should recommend itself to engineers, because any mechanic can look after them, thus avoiding the use of patented devices such as described by Mr. Lilly.

Great care has been taken in the selection of the sand. That coming from the shores of Long Island Sound has proved to be the best for the purpose desired. The arrangements made for drying the sand consist of an open brick flue, about 3 feet wide and 20 inches high, on which are placed two iron trays. These trays are of ¼-inch iron, and each is 6 inches deep, 3 feet 6 inches wide and 4 feet long.

Great care should be taken in drying the sand. It should be turned over continually, which in this case had to be done by hand. When dry it should be removed from the pans at once, and not allowed to burn or bake, for in that case when it came into impact with the steel it would be brittle, and, battering into fine dust, would not remove the rust. Sand dried properly and carefully can be used two or three times with good results. In a permanent plant a rotary dryer, over a fire, or supplied with a hot blast, could be used very economically, and the drying would be more uniform.

A section, about 6 inches in diameter, was cut out of the crown of each blast tank and a screw cap fitted to the opening. This is removed while the tanks are being filled. The sand is passed through a fine wire mesh before being poured into the tanks, so that nothing can pass through that will tend to choke or obstruct the valves and fittings.

The outlet for the sand is at the bottom and centre of the tank, and is of 1½-inch pipe, connecting below with the air-pipe at an angle of about 45 degrees. About 6 inches above the outlet another connection is made through the side of the tank by a 1-inch pipe extending to the centre of the tank, with an elbow, the end looking down into the outlet. This pipe and elbow are perforated with small holes, and air under pressure and controlled by a valve is admitted, so as to keep the sand slightly agitated, thereby facilitating its flow through the outlet.

The sand flows from the tanks through a flexible rubber hose of 2½ inches internal diameter, to the end of which is attached an ordinary pipe reducer to receive the nozzle; it passes out at a uniform pressure of 65 pounds per square inch. This pressure is furnished from the power-house erected for the purpose of supplying power for the work being done on Park avenue and Forty-second street.

In front of the tank a platform of 2-inch timber, 25 by 50 feet, was built. On this the pieces of steel are placed side by side, and when the upper sides are cleaned, the pieces are turned over and the opposite sides cleaned. When cleaned, the steel is painted, and then removed and piled by the crane.

Nozzles of extra heavy ½-inch gas pipe, varying from 7 to 18 inches in length, have been used, but it has been found that the 12-inch lengths are most effective. The life of the nozzles varied with the sharpness of the sand, the temper of the pipe material and the air pressure, but, on the average, lasted 1½ hours. The nozzles were generally worn through about 2 to 3 inches from the reducer, owing to the deflection of the sand leaving the large hose, passing through the reducer and then striking the nozzle at that point. This condition would suggest that a special, graduated coupling from hose to reducer be devised, so that the sand would pass through at a uniform rate without meeting a break, thus avoiding the deflection.

The force consists of a foreman, who regulates the valves controlling air and sand, two nozzle-men who direct the blast (these men had to wear goggles to protect their eyes), two men to dry the sand, attend to the fire and keep the tanks filled, and also one laborer, who assists the nozzle-men in handling the hose.

As the yard covered a large area and the steel was distributed all over it, it was a question whether it would be more economical to have a portable blasting machine or to make it stationary and use the crane and traveler for the purpose of handling materials. It was finally decided to make the plant stationary and use the crane for collecting and subsequently piling the steel.

The material cleaned consists principally of bulb angle-columns, I-beams for wall-columns, roof I-beams, knee-braces, rivets, plate-girders, splice-plates, grillage-beams and angles.

The question of the advisability of cleaning the steel before it leaves the shops could well be taken up. Were the mill scale and dirt removed before the steel is painted, the protective coating given it at the shops would undoubtedly prove more effective in the prevention of corrosion than by the present methods.

Such an adjunct to the manufacturing plants, if properly laid out, could resolve itself into practically first cost. If automatic devices for drying the sand and then feeding it to the blast were devised, much labor and time would be saved. Still more, the nozzles of the blast could be in a fixed position, and a rolling table provided for the steel. An automatic device for spraying the paint on the steel might also prove an advantage.

In preparing this discussion the speaker had the assistance of Mr. R. S. Fowler, Junior Assistant Resident Engineer, who also furnished the data, photographs and drawings. The speaker's thanks are also due to Mr. J. J. Shannon, Inspector for the Rapid Transit Subway Construction Company, for useful suggestions.

Theodore Paschke, M. Am. Soc. C. E.—Before giving any figures which can serve as a basis for comparison with those given by Mr. Lilly, as to the cost of cleaning some of the structural steel for the New York Rapid Transit Subway, as described by Mr. Belzner, it will be necessary to state briefly and as nearly as possible the actual conditions, rather adverse in some cases, under which the work had to be done.

When it became evident that the shop coat of paint had been practically destroyed by long exposure, and that it was necessary to arrest the destructive work of corrosion which had set in, the Subway Construction Company, in obedience to orders from the Rapid Transit Commission, assumed the responsibility of the work, and arranged with its sub-contractors on Sections Nos. 2 and 3 to perform the work of cleaning the steel and replacing the shop coat of paint, as an extra, at cost plus the usual percentage allowance customary in such cases. The sub-contractors for Section No. 2 (comprising the Elm street section) are the Degnon-McLean Contracting Company; for Section No. 3 (comprising Lafayette place and Fourth avenue) the Holbrook, Cabot & Daly Contracting Company. The work was done by them subject to the inspection of the engineers of the Rapid Transit Commission.

The work was started by hand cleaning, that is, by hammer, scraper and wire brush. This did not prove satisfactory, either in point of cost or in efficiency, and involved the sub-contractors in an almost continuous controversy with the inspectors. It was suggested that the sand-blast process be used, and in view of the fact that the sub-contractors had compressed-air pipes along the line of their work, thus facilitating the installation of such process, Mr. Deyo, Chief Engineer of the Subway Construction Company, readily assented.

On the Elm street section the steel to be cleaned was piled at various points along the street. Mr. Belzner has described the attempts made to locate the sand-blast at the various piles of steel. Thus, the operation of the blast had to be confined to one point and carried on during night hours. The steel had to be brought to the sand-blast and there manipulated by hand entirely. The arrangements for drying the sand were primitive, owing to the temporary conditions of the work. The first cost of installation of the blasts, their various removals and transfers from one point to another, was added to the cost, tending to increase this abnormally.

At the Forty-second street yard, where the Fourth avenue steel was piled, the conditions were somewhat different. The yard is 200 feet wide and 700 feet long, and is provided with a network of tracks and a traveling crane with a flat car for the handling of the steel. Here a plant on a little more permanent basis was erected, and the steel handled and brought to it from the various points of the yard by the traveling crane. Although these conditions were more favorable than on Elm street, they may be considered rather exceptional for such work.

In the work on Elm street and at the Forty-second street yard about 5,000 tons of steel have been cleaned by this process.

But all this steel was not cleaned over its entire surface; only about one-half being cleaned entirely, one-quarter had 75 per cent. of its surface cleaned, and on the other quarter about 50 per cent. of its surface underwent the sand-blast process, for the reason that on the remaining surface the shop coat was found to be in good condition.

In the case of the work at the Forty-second street yard, the total cost, including the repainting, amounted to from $3.50 to $6.50 per ton, the higher cost being due to the greater adversities experienced during the winter months. In the case of the work done on Elm street, the cost ranged about $1.50 per ton higher. It should be stated that the eight-hour basis for a day's work is in vogue throughout the subway work, and that the entire work of cleaning and painting had to be conducted in the open, exposed to all the vicissitudes of the weather, resulting often in the necessity of reblasting the steel before being able to paint it.

It would seem from these figures that, in the case under consideration, the use of the sand-blast did not result in any direct economy over hand cleaning. However, the results obtained were infinitely superior. The steel, after emerging from the sand-blast, presented a beautiful appearance, in fact, being fit to go into an electro-plating bath.

The experience had here with the usual customary shop coat as a protection for the steel against corrosion before erection seems to confirm Mr. Lilly's contention for the desirability of applying the sand-blast to structural steel at the works, after manufacture and before the application of the shop coat. Notwithstanding the high cost of the work performed in the present instance, which was due to exceptional and rather abnormal conditions, the speaker fully believes that the sand-blast process can be used at the works to advantage, and at a cost not exceeding that given by Mr. Lilly.

A. H. Sabin, Assoc. M. Soc. C. E.—Although the speaker has never actually conducted any sand-blast work, he believes that it was at his suggestion that the sand-blast was used upon the One Hundred and Fifty-fifth Street Viaduct some years ago. He has, however, been interested for years in this matter of the proper cleaning of structural steel before painting and can agree fully with what Mr. Lilly says about its great importance. It is a waste of money to buy even the best of paint and spend a large sum for labor in applying it to a rusty surface.

More than a hundred years ago, one of the great early English engineers—Smeaton—remarked that he had observed that if rust had once started on the surface of the iron, it made no difference what varnish or paint was applied to the surface, the rusting would continue to go on progressively under the paint. That conclusion has been reached by every man who has investigated the subject honestly and disinterestedly.

Mr. Paschke has stated when the steel had been cleaned with the sand-blast it was fit to go into an electro-plating bath. That is right. It will be observed that it is assumed that if a piece of metal is to be electro-plated it has to be clean, down to the surface of the metal; none of the oxide or scale must be left on the surface. It is equally true that to apply a vitreous enamel, such as on granite earthenware, etc., in the first place the surface of the metal must be obtained on which to put the enamel. All such ironwork is cleaned usually by pickling. To apply a varnish enamel, as in the case of a bicycle frame, it is absolutely necessary to do the same thing; otherwise the enamel, or the electro-plate, will come off in time, because the rate of expansion of the scale is always a little different from that of the iron, and in time the scale will loosen up.

Now, the speaker is a paint man, and has had an experience of a good many years. He believes that paint sticks on iron in exactly the same way that anything else does, and the conditions which favor the adhesion of other things favor the adhesion of paint. If it is necessary, if it is absolutely indispensable, as all agree, to have all these other coatings applied to the actual surface of the metal, and not to any scale or rust, or anything of that sort, it is also desirable to apply paint directly on the iron.

There are plenty of people who think —no doubt many who think honestly— that the oil and paint will mix up with the iron rust and keep out the air, and in that way the corrosion will be stopped. The trouble with that theory is that the paint and varnish are not absolutely non-porous. If they were it would be all right. Neither is cement or concrete non-porous, and when the corrosion gets under way its action is very rapid. That is a chemical question which is not worth while discussing now, as it has been beaten over a good many times, and probably most of those who are interested in the subject are thoroughly familiar with the theory of the matter.

It is comparatively easy to keep iron free from rust when it is clean, but, after the rust has started, it is very difficult to stop it or to clean it away from the metal.

The speaker had hoped that this paper might bring out a discussion from somebody who had had experience in cleaning iron by dipping it in acids, or "pickling." Of course, that is not sand-blasting, but the result is what is desired. The speaker is not aware that, in this country, any structural metal-work has been cleaned by pickling, but a great deal has been cleaned in Europe, some of it many years ago, and it is being done now, with most excellent results. Of course, the result of a first-class job of pickling is just the same as the result of sand-blasting.

One of the advantages of the sand-blast, not mentioned by Mr. Lilly, is that it leaves the iron not only clean, but dry. The process of pickling leaves the surface of the iron wet, and it has to be dried. It would be difficult to apply the process of pickling to structural work in place, such as an erected bridge, or anything of that sort, but it would have been extremely interesting to have had an idea of the comparative cost of cleaning the steel for the rapid transit work by pickling as compared with the sand-blast.

There is probably a thousand times as much iron and steel cleaned by pickling as is cleaned by the sand-blast. There is an immense amount of it done. Those who are not familiar with the subject have no idea of the extent to which it is practiced, but, in this country, it has not been applied to structural steel.

There is a feature which did not appear in Mr. Snow's admirable discussion. Mr. Snow has really had a great deal of experience in the use of the sand-blast on bridges, and has told the speaker that, usually, he did not clean the whole of a bridge with the sand-blast, as that is regarded as rather expensive. Such parts of the bridge as are specially liable to corrosion are cleaned by the sand-blast, and other portions, which are not so subject to deterioration, are cleaned in a less thorough and less expensive manner, for the reason that those portions which are most liable to corrosion will, in spite of the greatest care that can be taken, probably rust out as rapidly as the other portions with somewhat less care, although, of course, a man who is sufficiently interested in the matter to do sand-blasting is not going to have any poor work done. This feature, however, is worth remembering.

It may be regarded in another way. If a man sets up a sand-blast plant to clean a bridge, and has all his apparatus and his gang of men to do it, and only cleans, say, one-quarter or one-third of the bridge, he cannot do that quarter or third of the bridge as cheaply per square foot as he could clean the whole bridge, so that the cost per square foot is a great deal higher than it would be if he were cleaning the whole work, and for that reason any figures that he gets must be taken with regard to that fact.

In reference to the possible danger of cutting away the iron: Mr. Lilly observed that it was immensely more difficult, and required a great deal more power, to remove a hard compact scale than to remove ordinary rust. Now, the difficulty of cutting away tough, hard steel is immensely greater than that of cutting away the hardest kind of rust, and the speaker was told— this was not his own experience—by the manager of the Wolff Bicycle Company, some years ago, when they were using the sand-blast for cleaning the frames of bicycles, that before they purchased their sand-blast apparatus they were apprehensive about cutting away the metal, because the tubing they used was very thin; and to test the matter they held a piece of tubing in the current from the sand-blast machine for twenty minutes continuously, and then, with a micrometer scale caliper, which would show a thousandth of an inch, were not able to find any diminution in the diameter of the tube. Consequently, they thought that they were safe in using it; and if that is the case, there should not be very much apprehension as to cutting away the steel.

H. B. SEAMAN, M. Am. Soc. C. E.—There seems to be little to add to the discussion which has already taken place, except, possibly, to mention the dangers of the misuse of the sand-blast. It is undoubtedly a most efficient method of cleaning iron, especially where the rust is badly caked, or is in inaccessible corners and cannot be reached by hand; but where the rust is slight, and especially where surrounded by elastic paint, the excessive use of the sand-blast may prove more injurious than the rust which it removes. The sand-blast will remove the rust quickly, but if continued long enough to remove the elastic paint, which requires considerably more time, the parts which were rusted will be worn deep and pitted, and when the whole surface is bright and smooth, and acceptable to an enthusiastic inspector, more metallic iron may have been removed than would be the case after several ordinary coats of rust. Furthermore, the naked iron, as left by the sand-blast, will rust much more quickly than when the mill finish is left.

An illustration of the danger of overdoing the sand-blast occurred recently, under the supervision of an ardent, but well-meaning inspector. Four columns, which had been similarly exposed to the weather while stored in the same pile awaiting erection, were brought out and laid side by side to be cleaned by the sand-blast. After 3½ hours of the sand-blast two of these columns were stripped absolutely clean of rust and paint, and of all sign of the original mill surface; finished, in fact, clean enough for electroplating. The work could not have been done more thoroughly if performed in a laboratory for experimental purposes. The remaining two columns were then cleaned of rust and dirt, but all good paint was left on. This required 45 minutes, and the columns were left in better condition than the first two, at about one-fourth of the expense.

The theory that iron must be cleaned to a white surface before being painted does not seem tenable. The thin coat of black oxide formed after rolling is of itself a valuable protection, being the most permananet form of iron oxide, and even when the iron is tinted brown with rust it is not clear why the paint which would protect the iron from rusting will not in like manner prevent the rust from progressing, excepting, of course, where the rust is so thick as to prevent adhesion of the paint to the iron. Where the sand-blast is used it is necessary to paint at once to prevent corrosion.

Aside from the commercial or scientific value of sand-blasting, there is a very serious question of its effect upon the eyes and lungs of the operator. Its use in connection with bridge shops would seem not only objectionable on account of its disturbing effect upon the other operations, but, as already mentioned, would remove the black oxide of manufacture, which is its natural protection. Any scale which may be formed after rolling is quite thoroughly removed in punching and handling through the shops.

E. A. H. TAYS, M. Am. Soc. C. E. (by letter).—The writer has noticed that the means of drying the sand, as described by Mr. Lilly, were very crude, and the idea suggested itself that they could be improved.

The following suggestions may be of service in enabling those of the profession engaged in that work to improve upon the present practice in that line:

Where temporary plants are required, a sheet-iron bed, 8 feet long, 4 feet wide, or wider, made hollow, about 4 inches high, or, with sufficient room for a 2-inch steam coil, or line, of pipes, set on a frame 3 feet high, would do the work; the steam coil being used to pass the exhaust steam through; or, the exhaust could be turned directly into the hollow bed. This bed can be made of the thinnest sheet or galvanized iron, and should have a 2-inch flange on the sides, but none at the ends; and it might be set with a slight fall, to facilitate drawing off the sand with a hoe or rake at the lower end.

In large stationary plants a cylindrical dryer, on the lines of the Howell-White roaster, or of the type of the ordinary ore-dryer used in dry-crushing mills, would seem to be just about the thing. It could be made of much lighter material than the ore-dryer and much smaller in size.

This dryer is a revolving cylinder, larger at one end than at the other, and is heated by wood or coal, the heat passing down the cylinder. The sand is fed into a hopper at the small end, and the revolutions of the cylinder, say five per minute, gradually pass it out at the other, thoroughly dried.

These observations may enable some of those who are working in this line to devise an economical as well as efficient sand-dryer; if so, the object of these remarks will have been attained.

George W. Lilly, Assoc. M. Am. Soc. C. E. (by letter).—Mr. A. H. Sabin has called attention to the fact that one of the great advantages of the use of the sand-blast is the dry condition of the metal after being cleaned by it. This is certainly a great advantage and essential to the best efficiency of the preservative paint. It is also true that, unless the paint is applied soon after the cleaning is done, moisture is likely to accumulate on the steel, especially if the atmosphere is nearly or quite saturated with moisture. It has been urged, therefore, that the paint should be spread within the shortest possible time after the cleaning is done, and in no case should any cleaned surface be permitted to remain over night without a coat ot paint upon it. Some delay, say two or three hours, may be permitted when the atmosphere has only slight humidity. When the atmosphere is surcharged with humidity the moisture may gather on the steel immediately after it is cleaned. At such times no cleaning or painting should be done.

While, as Mr. Snow says, it may be considered no disadvantage to have some sand get into the raw paint, if it is to be subjected to the blast action of locomotives, yet screens are sometimes of advantage to prevent too large a quantity of sand getting into the paint in the buckets before it is applied to the steel. At times the wind may send large quantities of sand back to the painters and the paint become so filled with sand that it rolls under the brush and cannot be spread properly. It is not often found necessary, however, to use the screens between the nozzle-men and the painters.

The writer admits freely that neither the pan nor the hopper form of sand-dryer is scientific or highly efficient. A rotary dryer is, no doubt, a good form, where power is available and the exhaust steam may be utilized; but at Columbus, Ohio, the power was from 1,200 to 2,100 feet from the places where the cleaning was done. No doubt a better sand-dryer can be devised than any of those which have been used in the work done heretofore.

Mr. Seaman urges caution against the danger of extending the use of the sand-blast too far and cleaning steel which is already in good condition to receive the paint. The same thought was suggested in the paper, and it is certainly true that good judgment should be exercised. The intelligent application of the process in the cases where it is required to prepare the surface of the metal so that the paint, when applied, will adhere properly and give good protection against further corrosion is all that is contended for. For the reason that some of the paint was still good, some parts of the viaducts named in the paper were not sand-blasted down to the metal surface, but rust spots only were cleaned away. The parts where rust and corrosion have destroyed the paint, and where the paint is dead and disintegrating, should be cleaned thoroughly; and the sand-blast seems to be the best process for such purpose.

The black or magnetic oxide spoken of by Mr. Seaman is nearly all destroyed by the rusting of the metal before the shop work is completed, save, perhaps, where the thicker scale has formed. That all the mill scale is removed by the processes through which the steel passes in the shop is, the writer believes, putting the case rather too strong.

Mr. Fowler suggests permitting the metal to rust somewhat, in order to remove scale as far as possible, and then cleaning it thoroughly before painting. It will be observed, if a careful examination of old structures be made, that in many cases the mill scale has been covered with paint, and corrosion has attacked the steel and loosened the scale, making centers from which rust will extend.

The composition of mill scale, or, at least, of its characteristic, porous inner layer, makes it reasonable to expect just such results. Mill scale forms in two layers, the inner one being represented approximately by the formula $6\ FeO + Fe_2O_3$, and, as stated, is very porous and brittle. The outer layer contains a larger but varying proportion of Fe_2O_3. The air and moisture contained in this porous scale tend to destroy the paint spread over it by starting corrosion. This scale is magnetic. A galvanic action is said to be set up around the edges, and corrosion commences there and afterward extends under the scale and outward under the paint. It is considered important, therefore, that the mill scale be removed by some efficient means before the first coat of paint is applied.

Pneumatic Tools and Appliances.*

Pneumatic tools, as generally understood, are essentially portable tools, and do not therefore directly enter into competition with fixed machines, excepting in this respect that it has now been found, in many instances, that it is far cheaper to do certain work in position rather than take it under a fixed machine, and to this extent competition exists, and even where the actual cost of the machining is greater with the penumatic tool, the ultimate saving is greater still on account of labor saved in handling the work, and in other ways.

Dealing with the various types of pneumatic tools under separate headings, hammers and rivetters will be considered first. The standard type of deck rivetter consists of a single-valve long-stroke hammer, attached by means of a simple clip to the end of a weighted rod, which is itself attached to a small two-wheeled truck.

The objects are:—(1) To bring into use for the purpose of deck-rivetting a hammer of standard type, which can be also used for other forms of rivetting when detached from the jig.

(2) To assist the operator, since the balance weights shown add to the pressure exerted by his own weight; and he can again increase this by placing his foot on the bar or weights.

(3) To obviate the necessity of his laying the hammer down on the deck and picking it up again for each operation after chipping off the rivet flush. This is provided for by suitable stops and lugs in the trolley, and also in the bar adjacent to the hammer.

One of the great desiderata in the use of pneumatic tools is to reduce multiplicity of types, and for this reason the above described arrangement helps to fulfill this object, since it converts an ordinary longstroke hammer into a deck-rivetter.

The valuable assistance obtained by the use of a pneumatic hammer for caulking and chipping are well-known, but it may be mentioned that in certain cases the cost of caulking has been reduced from 2½ d. to ½ d. per yard, and at the same time the operator has been able to earn 30 per cent. more wages on the modified piece-work rate.

*Abstract of a paper by Mr. Ewart C. Amos, M. I. Mech. E., London, for the Manchester Assn. of Engineers, March, 1908.

Amongst a great bulk of reliable data now obtainable in respect to the saving effected by the use of pneumatic hammers, the following may be noted:—

(1) By the use of a long-stroke hammer on combustion-chamber work for marine boilers, the price of driving ¾-in. rivets in the seams has been reduced from 35/- per 100 rivets to 24/- per 100 rivets.

(2) A well-known boilermaker states that a long-stroke hammer is used for closing ⅞-in. diameter rivets in the back ends of flues of Lancashire boilers, which are tested to 175 lbs. per square inch, and the work is done by one man and a holder-up in two-thirds the time it takes two men and a holder-up by hand.

(3) The following is somewhat interesting.

COMPARISON OF HAND AND PNEUMATIC RIVETTING

Being controlled by the time limit allowed by the Boilermakers' Union.

How done	No. of Rivets Driven	No. of Rivetters	Holders-up	Boys	Time In Hours
Hand Rivetting.....	300	2	1	2	6
Pneumatic Rivetting	400	1	1	2	6

But even with this labor difficulty the saving in labor is not inconsiderable.

(4) A chipping hammer, when used for dressing the hardest kind of burr stones, will reduce the cost of dressing from 7 d. per square foot to 3 d. per square foot.

(5) A chipping hammer has proved very satisfactory when used for cutting doorways in a solid brick wall 2 ft. thick. The method employed was to cut a border line, or in other words one layer of brick out of the wall on each side of the doorway, and then cut one layer about every ten rows, after which it was possible to pry down the large pieces, and by this means one man was able to cut out two of these doorways in a day.

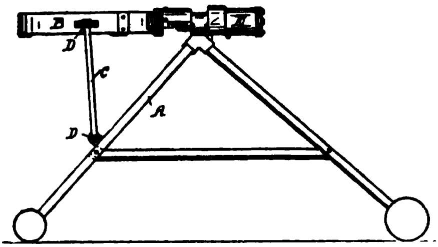
The advantages of compressed air as a motive force have, of course, been recognized for a long time, but the introduction of pneumatic tools has undoubtedly given its adoption a great impetus. In many shops it is frequently found that having installed an air-compressing plant other uses can be found for this form of energy beyond driving what are generally known as pneumatic tools.

A novel form of screen shaker has recently been placed on the market and is meeting with great success.

It is the common practice in most foundries in this country to screen moulding sand by hand labor, a somewhat costly process when compared with what can be done with the machine which is about to be described.

The object for which this machine has been designed is to provide a simple, economical and efficient machine for screening sand, and reference to the accompanying drawing will at once indicate its simplicity.

It may first be mentioned that the air pressure necessary to operate this machine most economically is about 80 lbs. per square inch, which is the usual pressure adopted for driving portable pneumatic tools, and the quantity required is 12 cubic feet of free air per minute.



ELEVATION OF "HANNA" SCREEN SHAKER—TRIPOD FORM.

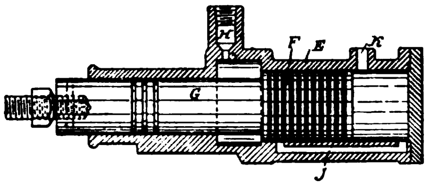
The machine is at present made in three designs. (1) As a tripod machine. (2) As a high frame machine for attachment to a wall, girder or similar support. (3) As a low frame machine for a similar method of attachment.

Referring to accompanying illustration, A is the tripod, B is the screen holder, into which an ordinary screen or riddle may be fixed.

The screen holder is supported directly upon two arms C-C, which are pivoted at the points D-D. In order to vibrate the screen holder, a cylinder, E, attached to the tripod, is provided with a reciprocating piston and piston rod, the latter being suitably connected to the screen holder so that the reciprocation of the said piston causes the screen holder to receive the necessary shaking motion.

In order to more fully understand the action of the compressed air upon the moving piston reference must be had to the other illustration, which shows the section of the cylinder and piston with the necessary parts. In this figure, E is the cylinder and F the piston, which is formed in one piece with the piston rod G. H is the inlet leading from the main air supply. J is a port leading to the back of the piston, and K the exhaust. The action of the compressed air in causing a reciprocation of the piston is as follows:—

In the drawing the piston is shown towards the front end of the cylinder, and on the admission of air at H, will force the piston and screener backwards. When the piston has travelled sufficiently back to uncover the port J, air will travel to the back of the piston and will counteract the backward motion of the piston and drive it with the screen holder forwards,



SECTION SHOWING PISTON AND CYLINDER WITH PORTS OF "HANNA" SCREEN SHAKER.

the exhaust taking place through the port K. By this arrangement it will be seen that the compressed air is caused to act constantly against the front end of the piston and intermittently on a superior area against the rear end of the piston, and in that way an automatic and constant reciprocation of the piston is obtained without the use of any valve.

Amongst the advantages offered by such a device are the simplicity and portability of the arrangement. The holder carries an 18-inch diameter screen, and screens can be changed in the fraction of a minute. When using a ½-inch-mesh riddle, the machine will shake all the sand that two men will care to shovel; and in actual practice in every day work in a foundry it has been shown that a laborer is able to riddle as much sand in 2½ minutes as a moulder and a laborer can do in half an hour. It is essentially portable, the tripod machine weighing only 100 lbs., whilst the post machine weighs only 50 lbs.

CHICAGO PORTABLE ROCK DRILL.

As already stated, the machine requires 12 cubic feet of free air per minute, or say 720 feet per hour, which will cost 2½ d. per hour, and add to this 1¼ d. per hour for depreciation and repairs, plus 7½ d. per hour for labor, we have as a total 2¼ d. + 1¼ d. + 7½ d. = 11 d. per hour, and the machine will have riddled as much sand in one hour as a man would do in five hours. The cost of his wages alone during this time would be 3/-, so that the saving effected shows at least 2/1.

The post machine can of course be used equally well as a fixed machine, and in this case steam instead of compressed air may be used to drive it when compressed air is not available.

Another development in the use of compressed air, is a portable rock drill, as shown on pages 2428 and 2430.

It has been designed to take the place of the ordinary rock drill for certain classes of work, and owing to its lightness and extreme portability (since it requires no mounting whatever) it has proved itself to be highly efficient and to have achieved this object.

Referring to the sectional views, it may be stated that compressed air causes the moving piston to reciprocate at a high speed, as in an ordinary pneumatic chipping hammer, and this in turn strikes the end of the bit, giving the desired percussive action to it. The drill bit is enveloped in a tube, and by means of a blast of air running through it, clears the hole of all obstruction. This arrangement is extremely valuable in cases where the class of rock being bored does not require the use of water.

For drilling "block-holes" in quarry work for "plug and feather" work, as carried out in cutting stone to desired dimensions (by drilling a number of small holes in line previous to splitting) and in many other classes of work, the saving effected in both time and labor over the old method of feeding the drill by means of a screw and adjusting the tripod in position is shown to be very considerable.

The mechanism is so simple and free from complication, and the machine is so easy to handle, that unskilled labor can be employed to use it. The machine complete, weighs only 50 lbs., requires 42 cubic feet of free air per minute, and will do the same work in 1-20th the time taken by hand. As an example of actual work done, a lad of 18 years has drilled 120 holes ½ in. diameter × 9 in. deep in granite in 6 hours.

In certain cases it is desirable that not only shall the tools be portable in the ordinary sense, *i. e.*, within the limit of the flexible air mains, but also that the whole plant, including the air compressor receivers, etc., shall be capable of being easily moved about. This is particularly the case in railway bridge repairs and similar classes of work.

Many such plants are now in use and are doing splendid work. It will be noted that the whole of the machinery is contained in the permanent way covered wagon, and this can be put in immediate operation wherever it may be placed, as it is entirely self-contained and portable. The plant consists of (1) 12 H. P. horizontal type boiler with necessary fittings, injector, etc. (2) a steam-driven air compressor, having a capacity of 134 cubic feet of free air per minute. (3) a water tank and pipes for supply of water used for cooling the air cylinder, the tank also serving as a feed-water tank to boiler. (4) air receiver. (5) flexible hose and connections. (6) small bench and vice. (7) eight pneumatic tools.

Such a plant costs approximately £670 exclusive of the truck, and is capable of operating six to eight pneumatic tools simultaneously.

Wherever greater portability is required, *i. e.*, independence of the railway track, and when it is desired to take it along the roadway, the same arrangement is used, but the truck is made lighter and ordinary road wheels provided. Semi-portability may be obtained by simply bolting the compressor down to timber or girder foundations, as is frequently done by gas-holder manufacturers and other contractors who may require the plant at work in one particular place for a few weeks, more or less.

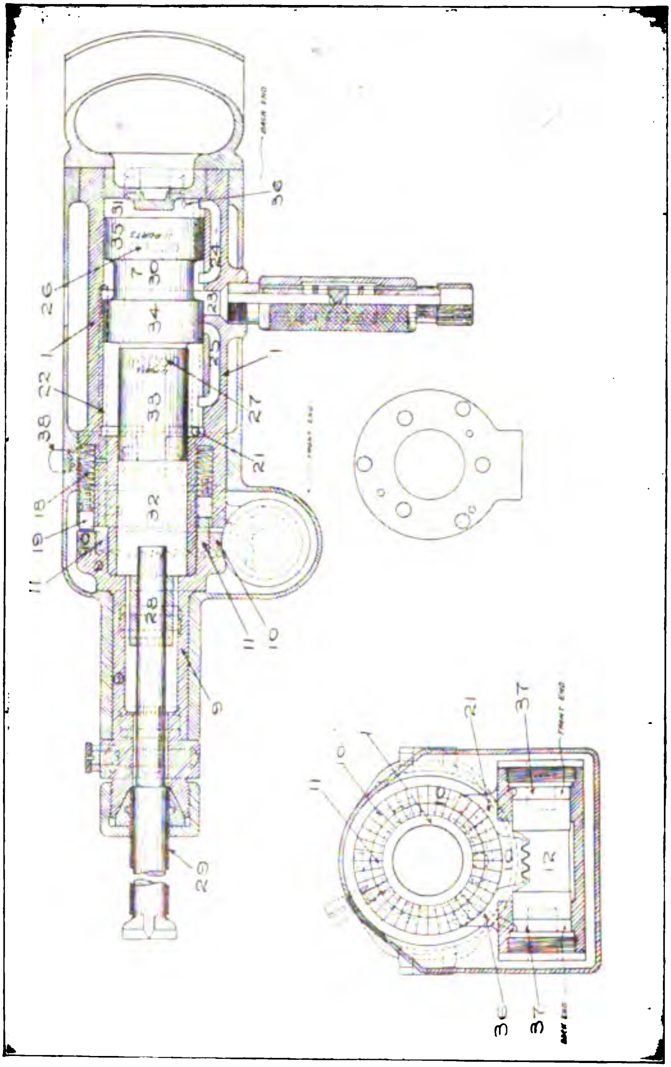
Again, where neither steam-power or electric-current are available, the compressor may be conveniently driven by an oil engine. In this case it is good practice to place the oil and air cylinder together on the same crank-shaft, the whole being mounted together with the air receiver on a road truck.

Last year Mr. E. C. Amos visited the United States, and a day was spent at the shipbuilding yards of Messrs. William Cramp & Sons, on the Delaware river, Philadelphia, with the object of investigating the progress made in the use of pneumatic tools on this class of work.

There are in use in this yard some 700 to 800 pneumatic tools of various description, a large number of which are devoted to rivetting of all kinds, including flush rivetting.

Messrs. Cramps' experience in the use of pneumatic tools is entirely favorable to their universal adoption for flush rivetting of all kinds, both on the ground of economy and also because the holes are better filled than with hand-driven rivets. In addition to this it is far less laborious for the operator.

If anyone doubts the statement about the rivet filling the hole, let him compare the difference between breaking up a pneumatic-rivetted boiler or ship and a hand-rivetted one; in the former case drilling out the rivets is generally the quicker way. Some actual figures given to the author at Messrs. Cramps' may be interesting to the members of this Association. These were obtained from actual every-day work, and were based on the driving of several thousand rivets. For instance, 1-in. diameter steel countersunk rivets,



SECTIONAL VIEWS OF CHICAGO PORTABLE MULE DRILL.

costing 4 dollars per hundred by hand rivetting, cost 3½ dollars when driven by pneumatic rivetter. Perhaps 2/- per 100 may not appear a great saving, but it must be borne in mind that there are a good many hundred rivets in a ship, and what is more important, the work done was far superior, in addition to which the operators earn more and are better satisfied and less fatigued. Another figure may be given, ¾-in. rivets in water-tight work, costing 2·75 dollars per hundred by hand rivetting, were done by the machine for 1·25 dollars, which must be admitted is a very great saving.

It may be interesting to state that in a large installation such as that in Messrs. Cramps' yard, the cost of air supply may be taken at about 8 to 10 cents per day per tool.

As to the time taken, a gang will close about 250 1-in. dia. flush rivets in the hull of a ship per day.

In respect to economy, which Messrs. Cramps have secured, it must be noted that it is the extensive application of jigs and appliances in connection with pneumatic tools that has made pneumatic rivetting so popular, and these appliances can now be readily obtained in this country when desired.

In addition to the rivetter and drill, the pneumatic chipping hammer finds much work in Messrs. Cramps' yard for cutting out manholes, etc., in addition to ordinary chipping, and generally the pneumatic tool is brought into action wherever possible.

Pneumatic tools have now passed the stage of experiment and, moreover, the standard machines are more or less familiar to those in the engineering profession, so that specialization becomes the order in this as in most branches of machinery.

Regarding the various data given in respect of the work done by pneumatic tools it might appear at first sight that the various results enumerated, somewhat conflict with one another, but it must be remembered (1) That they are the result of actual practice, and to that extent are interesting. (2) That outside conditions, not perhaps notified when giving the results referred to, have produced a variation in time and cost on what would appear to be quite similar jobs. (3) That ¾-in. rivets or any other size that may be named, take a longer or shorter time to close, according to their position and shape or head, and the same remark applies also to every class of work whether drilling, rivetting, or chipping, etc. In other words, that local conditions have to be taken into account when making a comparison, and finally it is especially necessary to take into account the human factor, which plays a very considerable part even when handling pneumatic tools.

The American Pneumatic Carpet Cleaning Company.

In light, clean, airy rooms, necessarily large, belonging to The American Pneumatic Carpet Cleaning Company, 536 West Twenty-third street, New York City, carpets and rugs are run through 40 foot machines, without a single fold, thereby preventing any possible chance of damage by creasing, and, as the goods are passed through by an automatic chain-carrier arrangement, every inch thereof is brushed from above and beneath by rapidly revolving brushes, releasing every particle of dust or dirt, and then, by the application of large volumes of compressed air, forced through the crevices of the goods from above and beneath, every vestige of dust, moth eggs, etc., are blown out and instantly taken away by a powerful suction device, which carries the objectionable matter into the furnace, under the boilers.

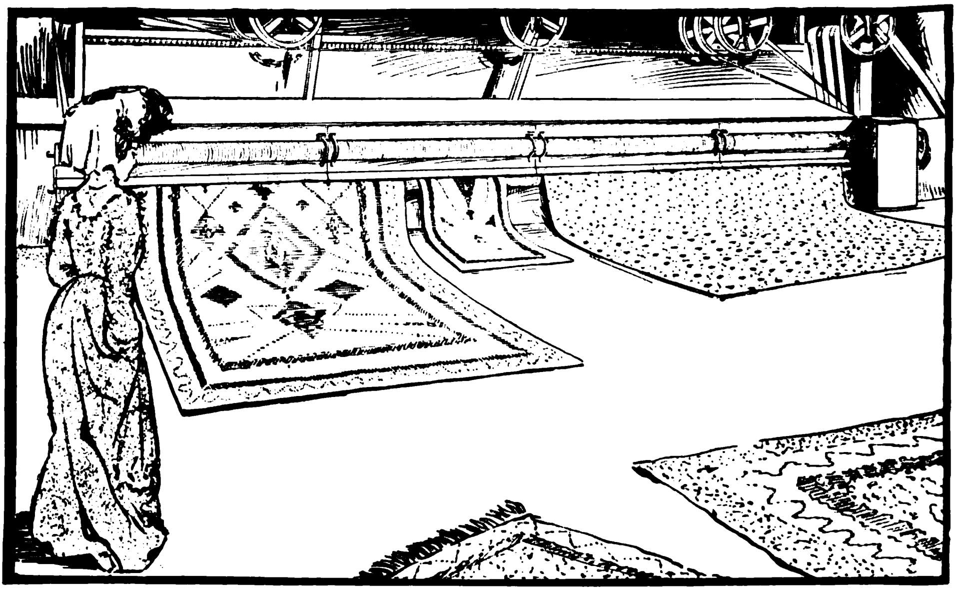
These machines are so arranged that both the air pressure and the revolving brushes can be adjusted, as the case may require, for heavy Axminster and Wilton carpets or fine, delicate fabrics.

Any size of carpet or rug can be handled on these 40-foot machines. Then, if soot and smoke are found to still adhere to the surface, the carpet is tacked to the floor in the airy shampooing-room and quickly, lightly "shampooed" without wetting a particle of the warp, just cleansing the smoky surface.

A glimpse into this company's plants reveals an equipment thoroughly modern, from basement to roof. In the former are located two immense 150 horse-power boilers, which supply power for operating the machine and supply steam to the air compressor. The latter, also in the basement, consists of two powerful cylinders and pistons capable of compressing air into a large tank or reservoir at a pressure of

CARPETS PASSING INTO MACHINE.

As carpets pass through the machine, they are brushed by a series of revolving brushes, and then great volumes of compressed air are blown directly through every fibre, removing all foreign matter.



CARPETS COMING OUT OF MACHINE AS CLEAN AS WHEN NEW.

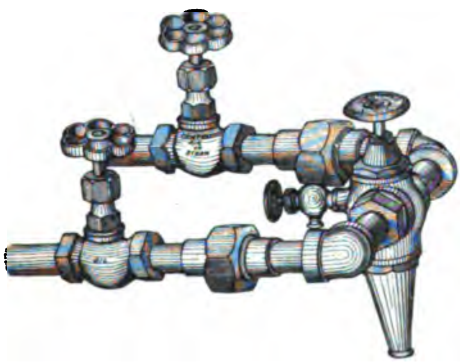
one hundred pounds to the square inch. One of these compressors alone was installed at a total cost of $8,000. Compressors of large capacity are required to maintain a lesser, but even, working pressure of air from the hundreds of jets which are in operation during the cleaning process.

Owing to the space required for inspecting and folding large carpets, one entire floor is devoted to the cleansing process and inspection, the two rooms being separate. Both are high, light, clean and airy.

Upon still another floor is the Oriental room, where Oriental rugs and all kinds of fine, delicate or rare rugs, tapestries and draperies are carefully repaired by experts. Often entire collections are carefully renovated, all breaks or tears repaired and returned fresh, clean and strong.

Moran Liquid Fuel Burner.

The oil burner herewith illustrated will heat from 22 to 25 square feet of grate



MORAN LIQUID FUEL BURNER.

surface and will equal a ton of good coal with 100 gallons of oil. There are no coal or ashes to handle, and the use of this device saves labor and gives dry steam. This appliance can be attached to all kinds of furnaces for melting steel, nickel, iron, copper, brass, babbit, lead or any other material requiring furnace heat. It can also be used with good results for annealing furnaces, muffles or any furnace designed for annealing process, and can be attached to angle or plate furnaces used in boiler or marine construction. The oil burners are also affixed to rivet forges, portable or stationary, while their usefulness for working on a ship's side or hole, for heating bent or fractured plates, is apparent.

This patent oil burner is placed on the market by James Moran, 47 Horatio street, New York, N. Y.

Various Uses of the Atmosphere.

Railways would find it difficult to get on without the use of compressed air. Boring plates of steel in the locomotive works is almost everywhere accomplished by the use of compressed air machines. The Great Eastern works at Stratford, England, have a complete outfit of pneumatic borers. Up-to-date signaling entirely depends on the use of air. The London and Southwestern has partially adopted the pneumatic signaling system. The points and signals are moved by compressed air, conveyed underground in pipes, and soon wires will be no more seen. The saving of time, labor, space and capital is enormous. The Southwestern is beginning to install the system at Basingstoke, and will gradually extend it over the rest of its line.

For cleaning, dusting and sweeping purposes compressed air far excels any broom or duster ever made. For carpets and cushions it is particularly useful. A pipe flattened at the end to the shape of a spade is used, and air, rushing with great force through the narrow slit, carries off every particle of dust. One man can do the work of three armed with brooms, while there is an equally immense saving in wear and tear, for air, of course, does not destroy a fabric as bristles do. Clothes and uniforms are also brushed in the same fashion.

Another industry in which air is ousting bristles is that of painting. Very soon the paint brush will disappear before the paint spraying machine. For covering large surfaces the economy effected by the paint spray is almost miraculous. By way of a test of what was possible, a man using a compressed air painter recently covered 46,000 square feet of surface with an even coat of paint in six and a half hours. A smaller air-brush has been made for the use of artists. The patent for this latter machine brought over $15,000.

At the Agricultural Hall, Islington, there was recently shown a pneumatic milking machine. The apparatus works by means of pulsators, and effects a saving of more than 50 per cent. of the time and labor, beside insuring that the milk shall be fresh and uncontaminated. The cows soon get used to it, and prefer the machine to the hand method.

For the ringing of heavy bells and of chimes, no power has been found to surpass compressed air. At the Church of Saint Germain l'Auxerrios, in Paris, which was finished in the year 1878, is an orchestral chime, said to be the largest in the world. There are forty-four bells in the set, and until a compressed air plant was installed it was found impossible successfully to ring them. One man plays them now as easily as if they were an organ. A keyboard is beneath his hand, and when he presses a key, an electric trigger opens a valve in the steeple, which admits compressed air to a piston connected with a clapper which strikes the bell.—From *London Answers*.

Rix Small Compressed Air Locomotives.

This small compressed air locomotive (Fig. 1) has been designed for running on a 16 per cent. grade, using a cog-geared track. Owing to the fact that it was necessary to keep the diameter of the wheels the same diameter as the cog gear, the wheels were made quite small, so that it does not make as handsome a looking arrangement as it might otherwise have done. The whole machine was designed for an inexpensive proposition.

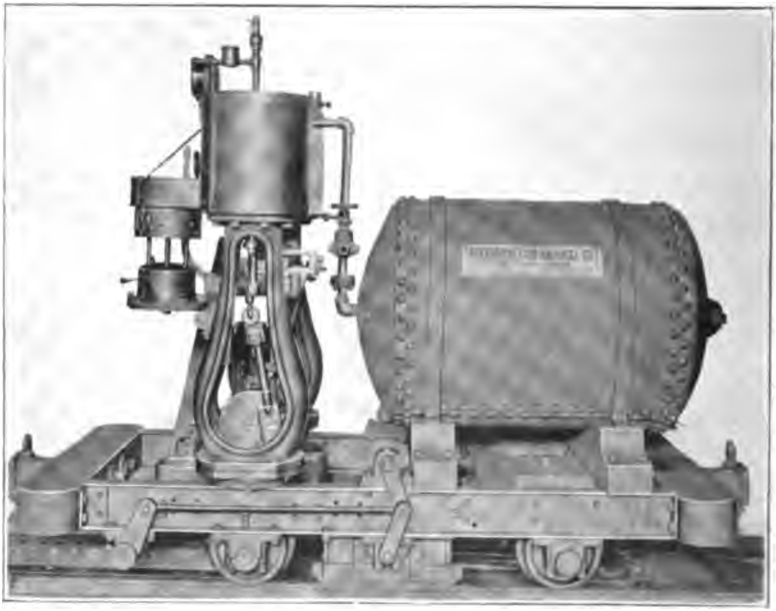


FIG. 1—RIX SMALL COMPRESSED AIR LOCOMOTIVE.

The engines are compound, the high pressure cylinder being 4 in. in diameter, and the low pressure cylinder 8 in. in diameter; both of these 6 in. stroke, calculated to run 300 R. P. M. and the engines are geared four to one to the main driving cog gear. The initial pressure is 120 lbs., the receiver being charged at 600 lbs. to the square inch. You will note that the cylinders are enclosed in a casing. This casing is made of double thickness of sheet iron with asbestos packing between them. By referring to Fig. 2, you will note that each cylinder in the casing is surrounded by copper coils marked E for the high pressure cylinder and K for the low pressure cylinder. Between the cylinders is a receiver. There is also a throttle valve, C, and the bi-pass valve, G, also arranged in the heated chamber. In front of one of the frames of the engine is located a primus coal-oil burner having four burners attached. This supplies heat to the casing. There is a hole for the heated air to escape at the bottom of the low pressure cylinder so that there is a continual circulation of heated air passing through the casing and out, and the chamber as near as can be estimated is at about four to five hundred degrees Fah. The cylinders and valve

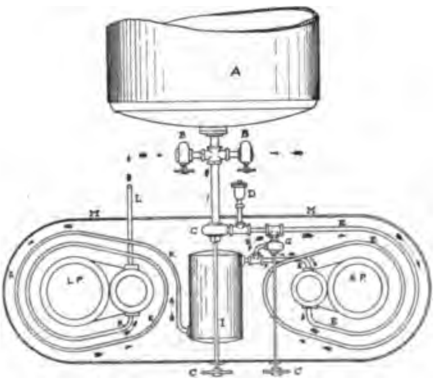


FIG. 2—PART PLAN VIEW RIX COMPRESSED AIR LOCOMOTIVE.

chests of both engines, being enclosed in the casing, are kept at that temperature continually, which is the particular and desirable feature about this motor. The air admitted through the main throttle passes around the copper coil valves and into the high pressure cylinder and is exhausted from there through the pipe F into the receiver I and passes through the copper coil K into the valve which is in the low pressure cylinder. After being used in the cylinder it is exhausted into the atmosphere.

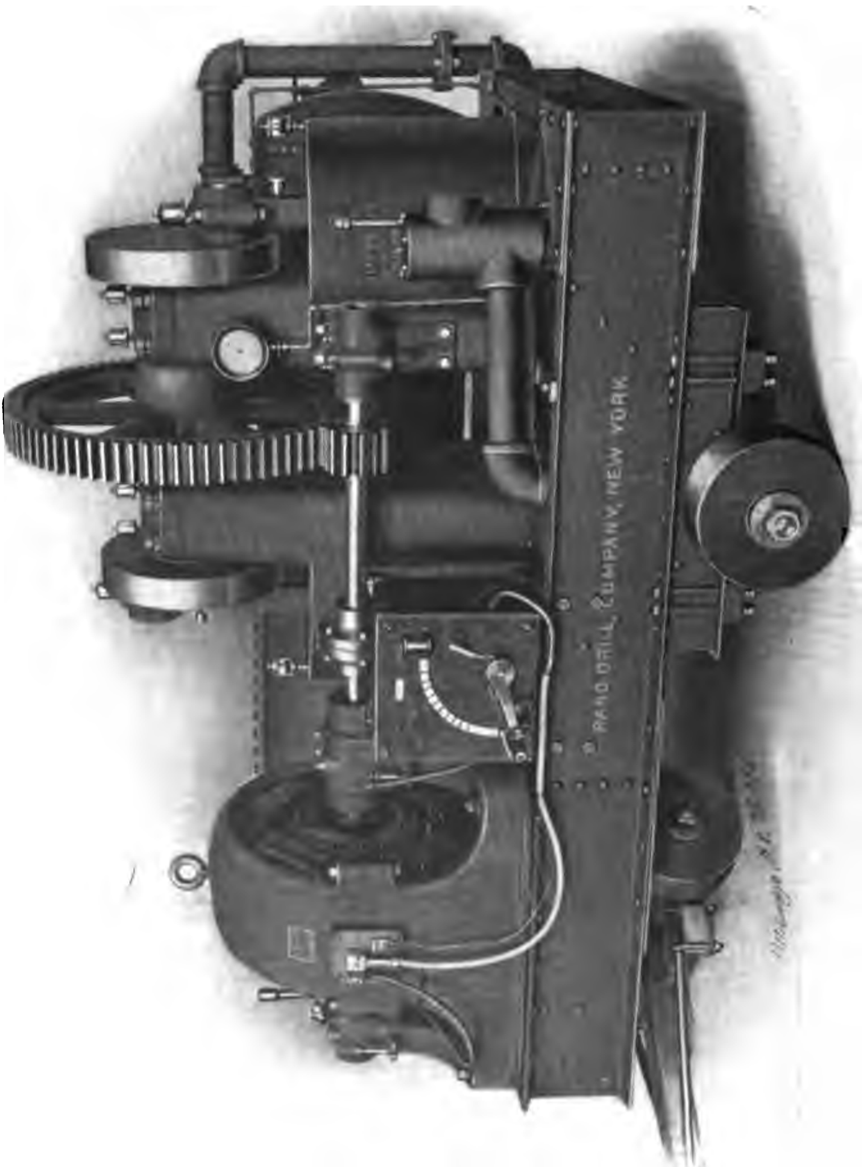
There is no reducing valve at all between the air in the high pressure receiver and the main throttle valve. There is no difficulty about freezing, because the throttle valve, being placed in the heated chamber, does not permit it. There is a bi-pass, G, which admits high pressure air into the receiver, I, if it would be required to develope at any particular time more than normal power and also to start the engines if the crank on the high pressure cylinder were not in a favorable position for starting.

It is claimed that this system of reheating is a thorough one, as well as being extremely simple and taking very little oil to do it. It is estimated that a H. P. will be generated by this process not to exceed seven cubic feet of free air per minute, compressed to 100 lbs. The great difficulty heretofore has been (in engines which require reheating and which were intermittent in their service) that the cylinders and valve chests become cool before the engine is put in service again and much power is lost thereby. In fact in hoisting engines before the compressed air can heat up the cylinder and valve chest, the hoisting is finished, and this action is repeated over and over again, and amounts to using air at a very slightly increased temperature above that of the atmosphere.

This device is the invention of Mr. E. A. Rix, president of the Rix Compressed Air and Drill Co., San Francisco, Cal., to whom we are indebted for the description.

Rand Portable Air Compressor.

The Rand Drill Company have recently built for the Jones & Laughlin Company, of Pittsburg, Pa., a new design of portable air compressor. This machine has two 12 x 12 vertical single acting plunger cylinders water jacketed and has a capacity of 275 cubic feet of free air per minute, the air pressure being 100 to 110 pounds. It is driven by a 50 h. p. Westinghouse motor, direct current, 220 volts, with starting rheostat, a raw-hide pinion on the motor shaft meshing with the cut gear of the compressor. The air receiver is 28 inches diameter by 8 feet in length. The outfit is mounted compactly on a wrought iron frame with heavy axles, wheels and shaft for moving it with horses from place to place. The Rand Drill Co., 128 Broadway, makes this design in sizes from 16 cubic feet to 320 cubic feet free air per minute.—*Iron Trade Review.*



RAND PORTABLE AIR COMPRESSOR.

Tullahoma, Tennessee, Water and Light Plant.*

The Tullahoma installation is located between Nashville and Chattanooga, Tenn., perhaps the first case on record in the South of a small municipality's supplying its citizens with water and light, with the source of power at such distance from the town as to require what is ordinarily termed a "high-voltage transmission line."

In designing the plant, it was decided to secure the water supply from deep wells, if possible to do so. A large spring, within about one-half mile of the station, might have been used, but was rejected in favor of wells, mainly because of its proximity to the cemetery, besides being subject to overflows at times. An 8-in. well was drilled within 100 feet of the station, and, after passing through the upper, or surface water, which has heretofore supplied the town the drill struck rock at a depth of about 100 feet. Into this the wrought-iron casing was tightly driven, in order to cut off all the surface supply. At 120 feet a strong stream was struck, which rose immediately to within 45 feet of the surface; and when tested with a 4-in. cylinder pump, it yielded the capacity of the pump —viz., 100 gallons per minute, with a reduction in head of only 6 feet. It was then decided that two such wells, chambered out to a total depth of 200 feet to allow proper submergence for the air-lift pipes, would yield a sufficient quantity of water to supply the town. The second well was placed about 80 feet from the first well, and struck the same vein at practically the same depth; and it proved to be even a better well than the first one. It was noticed, however, that the two wells were not far enough apart to prevent one being slightly affected while the other was being pumped.

For pumping the wells into a surface reservoir, the air-lift system was adopted as being best suited to the existing conditions; and a 12 in. x 12 in. duplex, single-stage compressor, arranged for belting to one of the 50-horse-power motors, was installed in the station. The suction pipe from this machine was taken outside the building, and the 4½ in. discharge was carried to a 36 in. x 10 ft. receiver, which was also located within the building. The air was then led to the two wells through proper-sized pipes, and the discharge from the wells was conducted to the reservoir through separate 5 in. galvanized-iron, screw-joint pipes. In piping the wells, 190 feet of 5-in. galvanized pipe was placed in each well, the same being suspended from a 5-in. long-sweep tee, to which the discharge to the reservoir was connected. Within the 5-in. pipe in each well a 2-in. galvanized iron pipe extended to within 5 feet of the bottom of the 5-in. pipe, and was fitted at the end with a perforated brass nozzle, which discharged the air spirally upward through 30¼-in. holes, or jets. After the installation was completed the wells were tested, and yielded continuously at the rate of 25,000 gallons per hour, the water being of excellent quality. Continued use of the wells since completion has increased the yield to a perceptible extent.

The wells discharge into a covered circular brick reservoir, or basin, of 80,000 gallons capacity—the diameter being 30 feet; the depth, 15 feet. From this the water is delivered to the elevated tank and distribution system by means of a vertical triplex pump of 750,000 gallons capacity per 24 hours, directly connected by double-reduction gears, to a 50-horse power induction motor.

* Abstract from a paper by Mr. Granbery Jackson for the Proceedings of the Engineering Assn. of the South, Feb. 12, 1903.

British House-Cleaning Device.

Frank W. Mahin, Consul at Nottingham, England, under date of April 25, 1903, writes in the "Advance Sheets of Consular Reports" as follows:

"The sidewalk in front of a large furnishing house in this city is daily blocked by crowds of people watching through the windows the working of a new cleaning device. The first inquiry of the surprised and admiring spectator usually is, 'Is that an American idea?'

"So far as is known here, there is nothing like this cleaner outside of England—not even in America—for the firm (Smart & Brown) exhibiting it informs me that it recently received from a Chicago dry-goods house an inquiry for a cleaning device on this same general principle.

"The system was invented by Mr. H. C. Booth, of London, and last year was taken over by a company which experimented with it in various metropolitan hotels, theatres, and other public places. Lately it has been tested in railway carriages, and now, its practicability being assured, agencies are being established throughout the British provinces.

"The apparatus consists, in the first place, of a machine composed of a 2 to 4 horse power motor—oil or electric—and an air pump, serving to maintain an 'exhaust' of several pounds to the square inch. The machine may be portable, on wheels, or stationary. To it is attached a filter—the dust receptacle—a tightly closed metallic vessel, with capacity of a peck or more. From the filter extends a 1½-inch rubber hose, which may be of any desired length up to about 700 feet. The hose terminates in a 'cleaner' or 'renovator,' which is a tube flattened out at the end into a kind of long slit. This is rubbed over the carpet or up and down the cloth covering of settees or chairs, from which it quickly sucks all the dust, extracting it not only from the surface, but also from the body of the substance and from underneath it—the underfelt being thus cleaned. Not a particle of dust can be detected if the carpet is then beaten. Indeed, in an experiment made in this city with a carpet returned as clean from a power beater, a considerable amount of dust was extracted by the vacuum process. The severe test of sprinkling a carpet with flour and thoroughly rubbing it in has been made, the vacuum cleaner removing every particle of the flour.

"No dust is raised in a room. All is sucked through the hose into the filter, whence it is removed and hygienically disposed of—analysis showing that it is composed of many deleterious substances. The pile and color of a carpet are restored by this process, and it is claimed that there is no injurious effect whatever.

"In a similar way, walls may be cleaned of dust, the cleaner being a brush of horseshoe shape, with an exhaust tube in the center.

"In hotels, theatres, large business houses, and the like, it is proposed to install permanent stationary plants, so that cleaning can take place daily, thus practically abolishing sweeping. Such a plant would be in the basement, with an iron pipe of small diameter leading to fixed points on each floor. At these points flexible hose would be attached, and the plant would be operated, collecting the dust in the basement. No skilled operators are required. Railroad and street cars, vehicles, and ships' cabins and saloons could all be cleaned daily by stationary plants.

"To clean residences, the portable machine can be placed in the yard or street and the hose extended into the different rooms. It is stated that the carpets, tapestry, upholstered furniture, mattresses, and bed clothing can all be cleansed of dust in a day, one man cleaning six or eight rooms. There are half a dozen different renovators attachable to the hose, adapted for carpets, chairs, walls, or bedding, as the case may be.

"Nothing is said about cleaning clothing, but there is no perceptible reason why the process would not serve that purpose.

"The sanitary feature of this mode of cleaning, in that it removes dust from the house and destroys it, is dwelt upon. The *London Lancet* considers the system of sufficient importance to particularly describe and approve it.

"The machines and apparatus are at present only leased and in no case sold by the cleaner company."

NEW YORK, May 28, 1903.

Editor of COMPRESSED AIR:

Dear Sir:—You probably have received copies of the "Advanced Sheets of Consular Reports," such as we enclose herewith, but we cannot restrain the desire to send you these for fear you might not have seen them. It certainly seems remarkable that our consul at Nottingham should know nothing about a device that has been repeatedly illustrated in your pages.

M. T. RICHARDSON CO.

Compressed Air Motors for Gathering Cars in Coal Mines.*

While the coal-mining practice, in regard to hauling on main roads, has advanced very rapidly in recent years by means of compressed air, electricity and ropes, that of gathering from rooms or working-places has remained almost stationary. Few large mines are without some method of mechanical haulage on

*By Mr. Beverley S. Randolph, Frostburg, Md., at the Albany meeting for the Transactions of the American Institute of Mining Engineers, February, 1903.

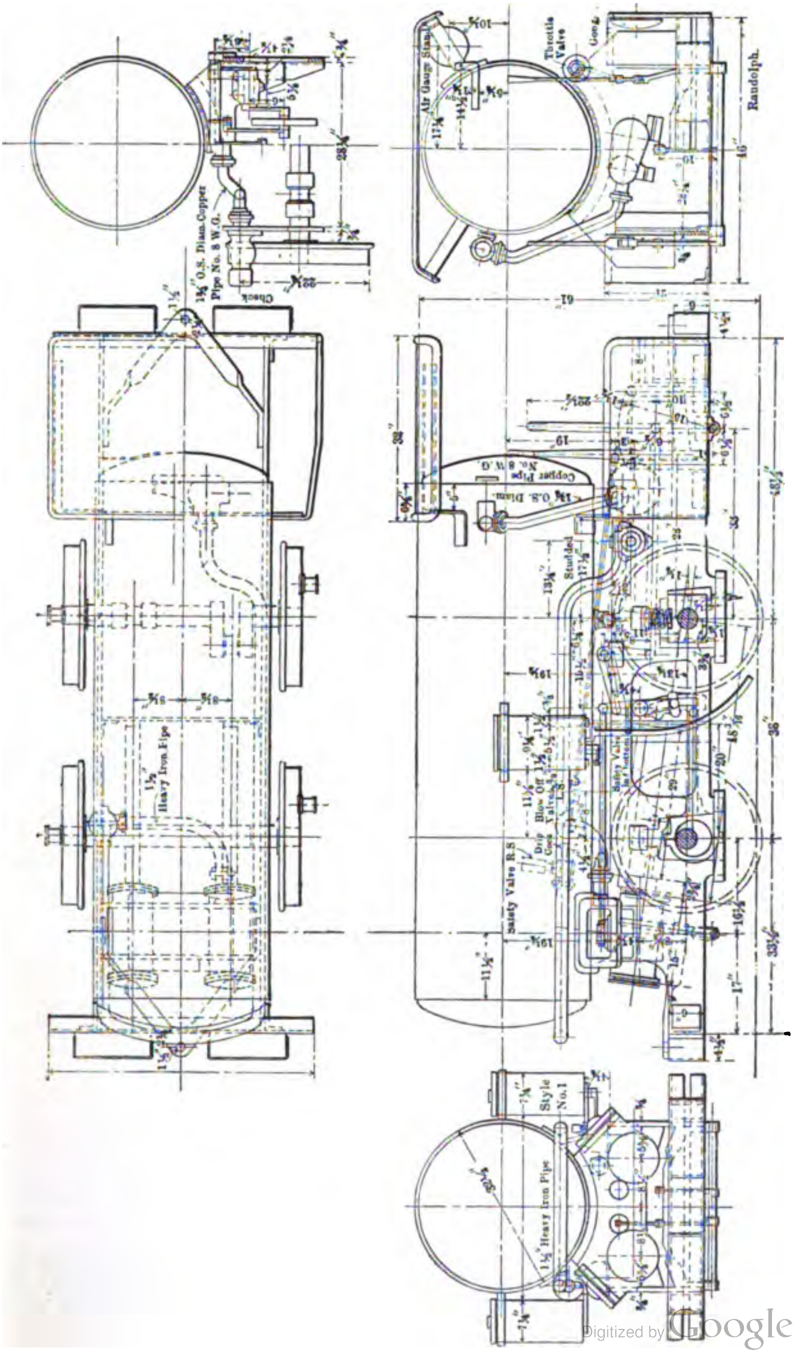


FIG. 1.—MOTOR USED BY THE CONSOLIDATION COAL COMPANY.

main roads, but the gathering from working-places is still done almost entirely by means of animals or men.

An effort to improve this have been made recently by the Consolidation Coal Company, under the direction of the writer, at its mines in the Georges Creek Region. The seam worked is the Pittsburg Bed, known locally as the "Big Vein." It is from 8 to 12 feet thick. Immediately overlying the coal there is from 5 to 6 feet of "rashings," consisting of thin alternating beds of shale and coal, which disintegrate rapidly on exposure to the air, and makes a very treacherous roof.

Rooms are driven 12 to 15 feet wide, with a single track close to one side. A line of posts is placed just far enough from this side to leave a clear space for the mine-car with a driver at the brake. This brings the post not far from the middle of the cross-bar, and provides more effectual support than if placed at the end. The tracks in these rooms are usually of 4 in. x 4 in. oak scantling, though of late years, owing to the advance in the price of lumber and the reduction in steel rails, more of the latter are being used. This track is laid by the miner. His pay for the work is included in the price per ton for mining. It is, therefore, as a rule, unskillfully and often carelessly laid, and cannot be relied upon to carry safely any weight materially greater than the loaded mine-car.

Compressed air was already in use on the main roads, driving motors weighing 30,000 pounds each, and which are used to haul mine-cars that have been assembled from the rooms, bringing them to the foot of a slope, from where they are hauled to daylight by means of a rope.

At the suggestion of the writer, the Baldwin Locomotive Works designed a motor, having the dimensions and general character shown in accompanying drawing (Fig. 1), and guaranteed not to weigh more than 8,000 pounds when charged. Loaded mine-cars frequently weigh 7,000 pounds gross, and their outside dimensions are then practically the same as the motor just mentioned.

Five of these machines were placed in the Company's Ocean No. 3 mine (Hoffman), displacing a number of mules, but leaving 19 still working. This opportunity was embraced to make a close comparison between the two methods of gathering.

The mules working in the North Heading and the South Heading deliver their cars directly to the rope on the slope. The other mule-routes deliver to the heavy motors mentioned above, as do all the motor-routes. The mules used weigh from 1,200 to 1,400 pounds, and are the best obtainable. Mine-cars weigh 1,600 pounds, and carry an average of 2.4 long tons.

The following table shows the work performed by the mules during a period of 18¾ working days in the month of December, 1902:

Route	Cars Moved	Average Haul	Constant	Tons Moved 1000 ft.
South heading.....	1119	2900 ft	$\frac{2.4}{1000}$	7788.24
North "	268	1300 "	"	836.16
1st Cross..........	1629	2100 "	"	8210.16
2d Cross..........	3042	1100 "	"	8030.88
3d Cross..........	747	400 "	"	717.12
Total.......				25582.56

This represents a total of 339 days' work for one mule.

The company's accounts show a cost of $1.15 per day for each day worked by a mule, including expense of replacing worn-out animals. Drivers are paid $1.98, and there is one with each mule. This makes a cost of $3.13 per day for each day worked by a mule. The cost per ton hauled 1,000 feet would therefore be

$$\frac{339 \times \$3.13}{25{,}582.56} = 4.15 \text{ cents.}$$

For the work of the motors during the same time we have:

Route	Cars Moved	Average Haul	Constant	Tons Moved 1000 ft.
Tippens...........	1122	2300 ft.	$\frac{2.4}{1000}$	6193.44
Scobies...........	1073	2050 "	"	5279.16
1st Klondyke......	1147	1835 "	"	5046.80
2d "	1032	1800 "	"	4458.24
3d "	1147	1865 "	"	5188.56
4th "	114	1992 "	"	544.92
Total..................				26661.12

This work was done by the five small motors operated by compressed air, working a total of 94 days.

This plant is supplied with steam by a battery of boilers, which also supplies steam to the large pumps. The plant consists of the following items, with their approximate first cost:

One straight-line Norwalk air-compressor, 18 and 28 compound steam, 18½, 13½ and 6½ three-stage air, 30-in. stroke	$ 5,300
5,600 feet of 5-inch pipe	5,600
3,100 feet of 2½-inch pipe	1,700
1,000 feet of 1½-inch pipe	300
2 motors, 30,000 lbs. each	6,000
5 motors, 8,000 lbs. each	10,000
Estimated proportion of boilers	1,000
Installation	4,000
	$33,900

Allowing $3,000 per year for interest and depreciation, to be earned in three hundred working days, would justify a charge of $10 per day from this source against the entire plant.

This same compressor also drives the large motors mentioned above, which weigh 30,000 lbs. each (60,000 lbs. for the two); the five small machines weigh 8,000 lbs. each (40,000 lbs. for the five). Dividing the general expenses according to the weight would result in four-tenths being charged against the small motors.

These general expenses may be summed up as follows per day:

Coal, 4 tons @ $1	$ 4.00
Fireman	2.00
Mechanic in charge of compressor	2.50
Interest and depreciation	10.00
	$18.50

The daily cost of operation of the five small motors would then be

5 Motormen at $2.67	$13.35
5 Brakemen at $2.03	10.15
General expenses, $18.50 x .4	7.40
Repairs and oil	3.00
	$33.78

Dividing this among the five machines would give $6.78 per day for each machine, and the cost per ton moved 1,000 feet would be

$$\frac{6.78 \times 94}{26{,}661.12} = 2.44 \text{ cents.}$$

In the matter of continuity of service, the motors show a great advantage. A broken-down motor can usually be repaired over night, while an injured mule can only be replaced by a new one that must usually be broken and inured to the work before he is thoroughly efficient, entailing loss of time and output in each case.

In the actual placing of cars in the workings, the motor has little or no advantage over the mule. After the train is made up, its higher speed and larger load place the mule at a great disadvantage.

The showing of the motors may, therefore, be expected to be better with long hauls than with short.

Owing to the fact that it is the practice in this mine to send the same motor or mule on different routes, depending on where miners may be loading coal, it is impracticable to present any discussion of this feature from the data at hand.

Ajax Drill Steel Sharpener.

While rock drills have been formerly sharpened by hand, the Ajax Drill Steel Sharpener, recently placed on the market, opens a new field which will be of decided interest to mine operators, contractors and others engaged in work where a number of rock drills are used. The Ajax Sharpener is an apparatus for sharpening drill steels by power instead of by hand. Its operation is such that the bits are formed in the same manner as when hand forged at a materially reduced cost and a greatly increased speed. This machine includes a vertical hammer, consisting of a modified air drill with anvil, dies and suitable support and guides which side set and forge the wings, and a similar hammer set horizontally and provided with a second set of guides, dies and a clamp which does the dolly work and forges up the face of the bit. The parts and general arrangement of the apparatus are shown in the accompanying illustration.

While strong claims are made for this machine they seem to be substantiated by the practical trials given; its capacity is about 1,200 steels in twenty-four hours, the time for each steel ranging from 30 seconds to one mintue. Bits sharpened in this way, it is claimed, are more regular and better than those sharpened by hand, and it is even said by those using the Ajax Sharpener that the machine-forged bits will put down from 100 to 300 per cent. more holes than those sharpened by hand.

At the United Verde and Homestake mines one machine in each case now does the work formerly required by twelve men. The air required to sharpen 600 drills in ten hours is about one-fifth as much as required to run one 3-inch drill underground. As an illustration of the saving which is claimed for this machine, it is pointed out that the United Verde Mines sharpened 500 steels in seven hours and 140 in seventy-five minutes. At the Homestake Mines 300 steels were sharpened in five hours. In both instances the machines were operated by green hands with only two weeks' experience.

AJAX DRILL STEEL SHARPENER.

A Pneumatic Revolving Crane.

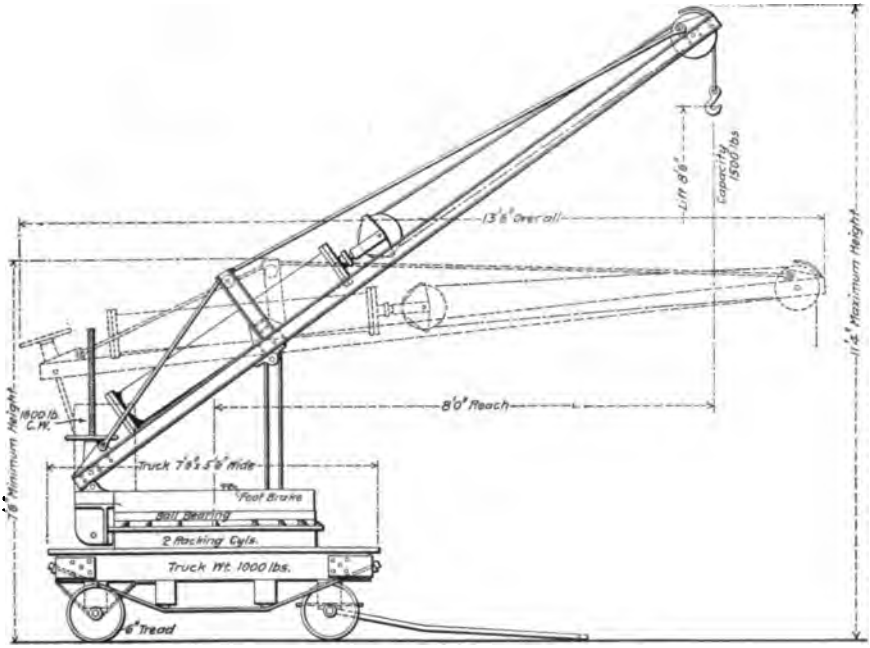
The accompanying drawing shows a special type of pneumatic revolving crane made by the Garry Iron & Steel Co., Cleveland, O., which differs somewhat from the standard types made by this company in having an adjustable boom and counterweight. These standard cranes are divided into two classes, B and C, similar in design, but of different capacities. Form B has a capacity of 1,000 lbs., 7 ft. reach, 12 ft. 6 in. hook lift and height from rail to top of boom of 9 ft. 2 in. Form C cranes are of larger capacity, 2,000 lbs. to 10,000 lbs., with a standard reach of 12 ft., standard hook lift 12 ft. 6 in., and height from rail to top of boom of 15 ft. 6 in. Both sizes are mounted on a heavy car and arranged for standard track gage. The gage may be altered to suit requirements or the cranes may be mounted on a special hand truck, as shown in the drawing, for convenience in moving about in storerooms, warehouses or platforms.

Unless specially ordered the crane cars are equipped with a set of rail clamps to prevent tipping when lifting the load. On special orders cranes are built with a counter balance on the turn-table as in the crane illustrated. This obviates the use of rail clamps. The cars are of extra heavy design and when built as a hand truck are fitted with four wide tread wheels. The crane base is bolted directly to the car and has a machined ball race on its upper face which contains 193 ground steel balls.

In the standard types, the bottom of the base is machined to receive the cylinder rack, guides, pivot and stop. The projecting ring on the under side of the base is machined for rollers and brake. The brake bracket is attached to the turn-table and hoisting cylinder and has secured to it an air cylinder and rollers actuated by a foot valve convenient to the operator. The hoisting cylinder is securely fastened to the turn-table and brake bracket and is additionally supported on the top of the turn-table by the vertical struts. The air is applied in such a way as to permit matic crane with a trolley which racks in

and out on the boom, giving four applications of power.

These cranes are particularly adapted to loading canal boats, freight cars, for coaling locomotives and all purposes requiring heavy lifting. In and about railroad shops and yards and on freight platforms they have found a large field. Each crane is tested to its full capacity before leaving the works, and the workmanship and material is the best possible.—*Railroad Gazette.*



PNEUMATIC REVOLVING CRANE.

the operator to handle the crane for all movements without changing his position. Heavy channels stiffened by top truss rods are used for the boom. Ordinarily the hoisting cable has one turn about the main sheave for hook lifts of 12 ft. or more, but this may be modified to suit requirements.

The standard type of crane can be furnished with traversing motor on the car or with hand traversing arrangement if desired. This company also makes a pneu-

Pneumatic Forging Machine.

We show herewith a half-tone of the Pneumatic Forging Machine, or "*mechanical blacksmith,*" manufactured by the Featherstone Foundry and Machine Co., Chicago, Ill. These machines have met with extraordinary success wherever installed; their range of usefulness is practically unlimited, and to a modern, well-equipped blacksmith shop they are indispensible.

The Pneumatic Forging Machine has a T-shaped frame, or bed-plate, and is operated by two cylinders, one forming and one adjustable die. On the longer arm of the bed-plate is mounted the upper cylinder, the piston of which transmits the power to the forming die. At either side of the shorter arms are the die-holding forms, which can be set to open and close at any desired distance between them, and one of which is operated by a lever connecting with the piston rod of the lower cylinder. The speed with which the blows can be struck is limited only by the rapidity with which a man can operate an angle-cock, as the return of the pistons is effected by means of compressed air; while the capacity of the machine for turning out work is restricted only by the amount of material that can be heated and handled.

bulldozer on account of the length of time required to change the dies.

The die-blocks are of a rectangular form and are provided with interchangeable rollers of the two inner corners, which come in contact with the metal as it is forced into the dies. One of these die-blocks is connected to the lower cylinder, and is capable of being used as pneumatic hammer, which greatly increases the range of usefulness of the machine, and the amount of work performed, at the same time permitting work of a superior quality to be produced. The construction of the dies is made very simple by this arrangement, the dies for nearly all of the difficult operations being simply lifted in and out of the forms.

The hammer piston and die-holding piston can be operated either separately or in

PNEUMATIC FORGING MACHINE.

By reference to the half-tone it will be seen that the piston rods pass through both ends of the cylinders, and on the driving end of the upper piston rod is a socket for receiving the stems of the male dies.

The great advantage possessed by the Pneumatic Forging Machine over all other forging machines, or bulldozers, lies in the fact that from one to three minutes only is required to change the dies necessary in the most complicated work, and in every case this can be effected before the metal in the furnace can be brought to the proper heat for working. This feature permits of the manufacture of a great many different shapes a day. It would be impossible to do this with the ordinary

conjunction with each other, while the force of the blow or static pressure in either case can be controlled at will. These adjustments are accomplished by the opening or closing of the cut-out cocks in the line of piping in front of which the operator stands. To strike a blow with the hammer the lever-valve just over the back of the cylinder is opened. This admits air to the back side of the cylinder. The cut-out cocks in the smaller lines of piping having been set properly, the air in the cylinder now passes around behind the opposite side of the piston, and it is forced back to the beginning of the stroke. When the piston arrives at the end of its return stroke the extension of the piston rod on the back end strikes the trip lever, which in its turn opens the exhaust. The operation of the piston actuating the movable die-holding jaw is made independent or contingent upon this procedure by turning the angle-cocks in the large and small lines of piping which run to this cylinder.

Eighty-five per cent. of the forgings for locomotives, and probably ninety-five per cent. of those for cars, can be turned out on this machine without the aid of a blacksmith's hammer. The terrific blow, in combination with the squeeze which follows, is one of the special features possessed by this machine not found in any other of like character. Rod straps, draw-bar yokes, frame buckles, pipe clamps, valve yokes, truck spring hangers, passenger car equalizers, and the like, of any dimensions may be made from the same dies by merely applying plates to the faces of the dies of such thickness as will furnish the desired sizes. By placing liners over the face of the die, in forming pipe clamps, it is possible to forge from twenty to twenty-five different sizes of clamps in one minute, while a locomotive main rod strap weighing 236 pounds has been forged in forty-seven seconds, and a valve yoke forged complete in five minutes. Turnbuckles are forged and welded in two operations, smoke arch braces with one blow, and the thimble for rope hoists or switch ropes is bent and grooved in a single operation.

In forming needle beam washers and safety straps for body truss rods, the die-blocks are screwed toward the center of the machine and form the sides of the female die. the proper shaped male die attached to the piston rod bending the heated bar around the loosely journaled rollers placed in the front corners of the form, and forcing it between the dies. In work with four bends the method of procedure is the same, except that the rollers are replaced by filling blocks which give square shoulders to the die forms. In forming draw-bar yokes a two-part die is inserted between the faces of the die-holders, which is firmly held by the vice-like action, and the bar operated on in three different positions. Riveting and welding operations can be simply performed on the machine by the use of either hammer.

The saving effected by the use of the Pneumatic Forging Machine is made obvious by the two following illustrations: A blacksmith and two helpers will average two valve yokes per day; using the Pneumatic Forging Machine the same three men can turn out from ten to fifteen valve yokes daily. A blacksmith and two helpers require about two hours to forge a 250-pound locomotive rod strap; using the Pneumatic Forging Machine the same gang can bend and shape eight to ten straps in two hours. The same saving can be effected in the manufacture of an unlimited number of forgings.

These machines are designed for a working pressure of 125 pounds, and are built in three sizes.

Pumping Water by Compressed Air.

Pumping water by compressed air has many advantages over the old methods, inasmuch as the natural sources of water supply are not conveniently located with respect to the desired point of delivery or to the motive power.

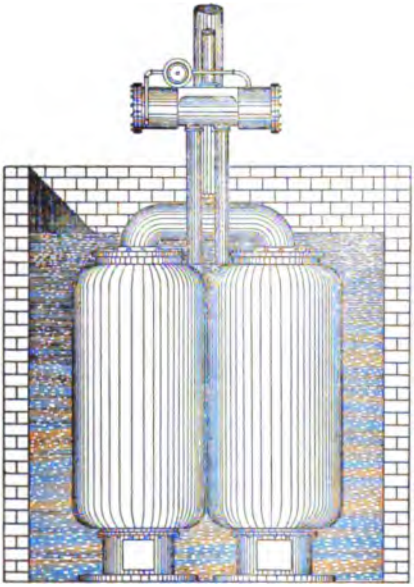
There has recently been placed on the market a pump which utilizes compressed air from any convenient source of generation for elevating modern and large quantities of air. This pump has been used by manufacturers, for draining mines and for domestic water supplies in which water is forced from wells, springs or cisterns to any height or distance required. In this last method, the water is aerated and purified and in no way contaminated or injured.

It consists of one or two water chambers, adapted to be submerged at the source of water supply, and an automatic air-valve located above the water and connected with the chambers by air pipes as shown. The automatic air-valve directs compressed air to and from the water chambers, from which the water is alternately discharged by the direct action or displacement of compressed air, without the intervention of pistons or other complicated mechanism. By the use of two cylinders a perfectly steady discharge of water is obtained. The automatic air-valve is by far the most important part of the apparatus.

It is actuated solely by compressed air applied on differential surfaces, and is entirely independent of the water chambers. in which there are no floats or other valve-actuating mechanism whatever. The automatic air-valve is constructed of cast iron with brass cylinder lining, containing differential piston-valves.

The piston-valves are kept pressure-tight by the use of pliable packings, which are held out by brass tension rings. These packings, being above the water, only come in contact with compressed air, which during compression, absorbs sufficient oil to thoroughly lubricate the packings.

It is claimed that these packings will remain perfectly tight for several years, under ordinary conditions. They are the



COMPRESSED AIR WATER PUMP.

only wearing parts of the valve and can be easily and cheaply renewed, if necessary. The water chambers are mounted upon a base casting, which contains screened annular water-inlet openings and foot-valves of large area.

A branch discharge pipe, having extensions, with discharge valves thereon, near the bottom of the chambers, forms a connection for the top of the chambers, as shown. The water chambers may be of any shape or size or of any material to conform to the requirements and conditions of the liquids pumped.

This pump is manufactured by H. L. Frost, Bristol, Tennessee, to whom we are indebted for the foregoing description and cut.

Book Review.

"Modern Machine Shop Tools." Their Construction, Operation and Manipulation, including both Hand and Machine Tools. By Mr. William H. Van Dervoort, M. E. 552 pages, size 6x9 in. Publishers, Norman W. Henley & Co., 132 Nassau street, New York City.

It is a complete, practical treatise of the most modern machine shop tools made to-day, showing their construction, operation and capacity, and giving speeds at which tools can be run. The chapters pertaining to the shape of tools, their proper cutting position and the steel they are made of, would be appreciated by mechanics. It is a complete course of instruction for students and apprentices, and a ready book of reference to a mechanic, foreman, superintendent or office. It shows at once the possibilities of a machine or tool or the proper method of doing work, and is a valuable book to have. The general arrangement and the index of the book are complete, so that any subject can be quickly found.

Notes.

In a plant recently installed in the South by the Pneumatic Engineering Company, 128 Broadway, New York, the air-lift system pumps nine million gallons of water per day from four 10-inch wells.

The Lunkenheimer Co., Cincinnati, has increased its foundry output 50 per cent. to meet the demand for its brass and iron steam specialties. A number of new machine tools are being installed as fast as they can be obtained.

The Sullivan Machinery Company will open a new branch office at the Missouri Trust Building, St. Louis, Mo. Mr. P. F. Jarvis, who has made St. Louis his headquarters for the past two years, will be the manager of the new office.

Where compressed air is available a badly pounding pump can be cushioned to any extent desired by connecting the air chamber of the pump with the compressed air line and regulating the amount of cushioning with a globe valve in the air line.

Bion J. Arnold is testing at Lansing, Mich., the electro-pneumatic system of air storage of electric power described by him in a paper read before the American Institute of Electrical Engineers last June, and reprinted in COMPRESSED AIR, August, 1902.

The Stilwell-Bierce & Smith-Vaile Co., of Dayton, Ohio, have issued catalogue No. 53, descriptive of their pumps, water heaters, compressed air machinery, etc. It contains over 100 handsomely printed pages, with many superb illustrations of their various types of machinery.

The air compressors in the railroad shops at Oakland Cal., compress air for all the yards and station signals besides providing the supply for pneumatic hammers and other shop tools. It takes 1,000 cubic feet of free air per minute to keep up the supply. Pneumatic tools are greatly in evidence in these shops.

A more elaborate use of compressed air was inaugurated in the West Eighth street freight yards of the Central Railroad of New Jersey Sunday, June 14, when all the switches in that yard, heretofore operated by hand, were controlled by a single operator in the tower with the aid of a pneumatic interlocking system.

The Norwich Compressed Air Company of Norwich, Conn., which has recently equipped a plant in that city, has filed with the secretary of state a certificate of organization. The company has elected these officers: President, John A. Inslee; vice-president, H. H. Gallup; secretary, J. T. Fanning, and treasurer, W. J. Hanford.

The Rand Drill Company, through their pneumatic tool department, report the recent sales of many large complete air plants, including their new "Imperial" Pneumatic Hammers and Piston Air Drills. Plans are now being drawn for an extensive enlargement of the Rand Drill Company works to meet these increased demands.

Chicago has been considering the pneumatic tube question. The council recently granted a franchise to the Chicago Postal Pneumatic Tube Co. for establishing a system in the city. The other bidders then appealed to Mayor Carter H. Harrison, who refused to affix his signature to it, until a fair test of the different systems can be made and passed upon by engineering experts.

Horace P. Marshall & Co., Leeds, England, have recently installed, as agents of the Consolidated Pneumatic Tool Company, Limited, a compound steam-driven air compressor of 1710 cubic feet capacity at the shipyard of Messrs. Vickers, Sons and Maxim, Limited, Barrow-in-Furness, this being the fourth and largest compressor put down by them in that department for pneumatic labor-saving tools.

Mr. A. M. Baird has been appointed to represent the Falls Hollow Staybolt Company, in Topeka, Kansas, and vicinity. Mr. Baird was formerly boiler maker at Santa Fe shops, Topeka, and has been in the employ of several of the leading western railroads in the capacity of foreman boiler maker. He is the inventor of several compressed air tools, among them the celebrated Baird staybolt nipper.

The Chicago Pneumatic Tool Company have just issued two special circulars illustrating various types of their pneumatic appliances, and containing several views showing the tools at work. Something new is shown in the special applications of the "Jam Riveters," their use in cleaning crown sheets on locomotives and expanding boiler tubes on locomotives with a sectional tube expander is pointed out. A novel yoke attachment for the Boyer Drill is also shown.

The value of an air receiver does not lie in the volume of air stored. It is in no sense a reservoir. The function of an air receiver is to convert the intermittent supply of air from the air compressor into a steady stream. A pulsating current of air through an air pipe would cause an enormous loss by friction besides racing the pipe and loosening the couplings. A parallel may be drawn between the fly wheel of an engine and an air receiver. Their functions are practically identical.

Rock drills are not efficient machines when operated under low pressures. This is true commercially or mechanically. Under such conditions a rock drill will work very slowly, but the labor required will be the same as if it were working at full pressure. The cost per foot of hole is therefore increased. Mechanically speaking the friction of the machine is practically a constant whatever the load. Hence with low pressures the ratio of friction to useful effective load is greater than with high air pressures.

The coal-mining industry of Westphalia, Germany, continues to be seriously hindered by the prevalence of sickness among the miners. The disease is caused by an internal parasite, and has spread so widely that it has become almost universal. It is estimated that 20,000 workers are suffering from it, some pits having as many as 90 per cent. of their staffs disabled. All attempted remedies have hitherto failed, and the disease for the present is baffling the local authorities.

In a recent discussion upon the use of pick coal-cutting machines objections were raised to this class of cutter because the vibration of the machine was said to have proved detrimental to the health of the miners. This statement was combatted and one of the debaters said: "We hear a good deal about machines shaking runners to pieces, but there is no foundation for such statements. When a man becomes proficient, a light, loose grip of the machine, and a small pressure on the foot block enables the runner to handle the machine at will, where the cutting is not exceedingly hard."

A company in England is introducing a vacuum process for cleaning railway coaches. In operation it is used with a wide nozzle in the same manner as pneumatic pressure is used in this country—the difference lying in that the dust is drawn into the nozzle and through piping to be deposited in a receptacle instead of being merely blown into the air whence it settles down again. The exhaust is derived from portable plants operated by electric motor or gas engines at small terminals and from larger, permanent plants at the larger terminals. The vacuum process is much more satisfactory in many respects than the pressure process and is well worth the investigation of officials concerned with coach cleaning.

In a recent paper by Mr. Henry S. Spackman, he says:

"I have had no personal experience with the pumping of marl from the dredge to the mill, but understand that the most successful device is a double cylinder with compressed air, the marl itself acting as a piston, the device consisting of two tanks which are alternately filled and emptied. After the tank is filled, the compressed air is turned on and the contents forced into the pipe line."

He also refers to compressed air as being substituted for the old mechanical agitators in a number of mills, and calls attention to the considerable advantage thus gained by its use.

The Annual Convention of the American Railway Master Mechanics' Association will be held at Saratoga, N. Y., on June 24th to 26th inclusive. Immediately following, on June 29th to July 1st, inclusive, the Master Car Builders' Association will hold their annual Convention at the same place. The place of meeting has been changed from Mackinaw Island to Saratoga.

While compressed air will incidentally be mentioned in the various discussions, the only subject which deals directly with it is that of "Steam and Air Line Connections," which is announced as one of the subjects for discussion at the Master Car Builders' meeting.

The Tabor Mfg. Co., of Philadelphia, have arranged with The Draper Co., of Hopedale, Mass., for the manufacture and sale of the Hand-Rammed Molding Machines, which the latter firm have been building for their own use.

The Draper Co. have had probably the longest experience in molding by machinery of any firm in this country, consequently their machines represent the result of years of experimenting, including the trying of many other makes now on the market. At present they have in operation in their Hopedale plant several hundred of these machines. They are light, cheap, on wheels and do not require power to operate them.

This arrangement represents a very important move in the molding machine business.

The Philadelphia Pneumatic Tool Co. have employed Mr. J. F. Ahearn, formerly with the Scully Steel & Iron Co., to assist Mr. A. G. Hollingshead, Western Sales Manager for the Philadelphia Company. This company have also appointed Mr. H. B. Griner, late Assistant Manager of the Chicago Pneumatic Tool Co., to a position in the main office of the Philadelphia Pneumatic Tool Co.

This company report orders for chipping hammers, riveters and drills from the Craig Shipbuilding Co., Toledo, Willamette Iron & Steel Co., Portland, Oregon, Kewanee Boiler Works, United Gas Improvement Co., J. D. Connell Iron Works, New Orleans, Chandler & Taylor Co., Allis-Chalmers Co., and others.

A new device has been patented in England, which is an improvement on the apparatus for forcing sewage by compressed air. This consists of a simple mechanical arrangement to reduce the friction upon the valve spindles employed in opening and closing the valves for the admission and exhaust of compressed air. The spindles are made independent and are coupled by a special coupling, which will allow for inaccurate fitting and also the wearing out of truth. Half coupling is secured to the end of each valve spindle of the plug valve, and a similar half coupling to the ends of the spindle moved by the float. The half couplings engage each other by means of studs made firm in one-half coupling but working loose in a slot on the other, therefore any slight difference in accuracy has clearance without affecting the movement required.

The Le Clear Mfg. Company, 107 Chambers street, New York, are putting on the market the pneumatic door check and spring. It is especially designed for use on screen doors or very light inside doors. It will go into a space of 3½ inches, and thus can easily be operated between the outer door and the screen door. It is held back in action, holding the door open when it has passed the center. The spring power is strongest when the door is in a closed position, holding the door tightly closed, and gradually decreasing in power as the door is opened. The air pressure is regulated by a thumb screw. The device can be used on either right or left hand doors by reversing it, without extra attachments. The manufacturers refer to the device as simple in construction and easily applied. It is furnished in regular bronze finish, bronze metal highly polished, and in bronze metal, antique finish. It is also made in special finishes to order.

The turntable of the Duluth & Iron Range Ry., at Two Harbors, Mich., has been equipped with a pneumatic operating motor. This application is very simple and yet the work of turning the heaviest engines is performed with the greatest ease. The arrangement consists of a double cylinder engine mounted between the wheels at one end of the table and operated by a single lever extending up through the table deck. The engine is connected by a universal joint on either side, to shafts which rotate the table wheels through appropriate mitre gears.

In view of the fact that a gasolene turntable equipment costs approximately somewhat in excess of $1,000, and an electric equipment costs in the neighborhood of $1,150, a disposition to obtain the advantage, without the usual cost, through the adoption of a plain arrangement of engines operated by air has been tried in several places. At least three different plans have been shown during the past year in the *Railway and Engineering Review*.

Mr. W. V. Turner, air-brake inspector, and Mr. Geo. R. Henderson, superintendent of motive power of the Santa Fe System, have patented an air-brake device, which makes it possible to recharge air brakes on a train while the brakes are set. The advantages claimed for it are stated as follows: "It will do away with the creeping due to the leakage of the train line. It maintains a uniform pressure on all of the reservoirs on the train, thus preventing the possibility of a train breaking in two. It allows the brakes to be recharged while set, thus making it utterly impossible for a train on a grade to start and run away while the brakes are being reset. The best brakes now in use have to be recharged every few minutes. The Henderson-Turner brake can be set on a train and the train will remain on the grade for a month if desired. In addition to the advantages of safety, the new brake is very economical, employing but two-thirds as much air as the best brakes now in use and allowing a great saving in pumps."

Some interesting and valuable particulars regarding turbine air compressors have been announced in a lecture by the Hon. C. L. Parsons, the inventor of the steam marine turbine. The Parsons Company is now making a specialty of this apparatus, and some very remarkable results in contrast with air compressing plants have been attained. In one case a compressor driven by an electric motor, supplying air at a pressure of 2 pounds per square inch, delivered 3,500 cubic feet per minute, and the efficiency of the plant as measured by the ratio of air horse power to electric horse power was 61 per cent. With the Roots blower, which was previously used, the efficiency measured was only 41 per cent. In another similar plant in work at a foundry near Leeds, England, 11,300 cubic feet of free air is supplied per minute at 3 pounds pressure. In this instance the air turbine is driven by a steam turbine running at 5,200 revolutions per minute, and the air horse power is 61 per cent. of that theoretically obtainable from the steam used

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The following extract is taken from a circular recently published by the Chicago Pneumatic Tool Co., of Chicago: "As the air taken into the compressor generally contains some particles of grit and dust it is almost impossible to prevent this foreign matter from entering into the working parts of the hammer, causing the ports to become clogged and rendering it inoperative. The use of a poor grade or heavy-bodied oil will also cause the same trouble. A good plan to follow in such cases is to clean by using benzine freely through the throttle handle. This dislodges all foreign matter and cuts the thick oil which can then be removed by blowing the air through the hammer. It is an excellent plan to submerge the hammer occasionally over night in a bath of kerosene and then blow out under pressure the following morning, and lubricate with a good quality of light machine oil. Where the air is unusually laden with foreign matter we would recommend the use of strainers or filters to be attached to the tool or placed in the supply pipe as the case may be."

The United States Consul at Genoa reports on a recent visit which he made to the Simplon in order to ascertain the character and progress of the vast work on the railway there, which means so much for the future of Genoa. He finds he was misinformed when writing an earlier report as to the nature of the obstacles encountered on the south side of the tunnel and as to the fears that it might prove necessary to change the course of the line. His examination on the spot removed all doubts on this head, for work is proceeding rapidly and uninterruptedly on both sides of the Alps; about 4,000 workmen are employed in the tunnel, and no fewer than 6,000 on the Italian section of the line between Isella, at the mouth of the tunnel, and Arona, the present terminus of the line running north from Milan. It is certain now that the work will be completed by the estimated date—July 1, 1905—for nearly two-thirds of the tunnel was finished by July last, and the worst obstacles have been met and overcome. The chief of these was the ever-increasing heat in the tunnel, caused by the growing volume of water, which, though it percolates through beds of limestone from nearly 6,000 ft. above the line, becomes very hot and flows into the tunnel at a temperature of from 112 deg. to 140 deg. F., rendering not only work, but life, impossible, without artificial refrigeration. By turning cold air on hot air, and cold water on hot water, the temperature inside has been reduced to 70 deg. The volume of water flowing from the south end of the tunnel is over 15,000 gallons a minute, and furnishes power sufficient to work the refrigerating apparatus and to compress the air by which the drills are worked. When completed the tunnel will be longest in the world—14 miles, against seven miles for the Mont Cenis and nine for the St. Gothard tunnels. The cost will be 70 million francs, or five million francs per mile.

A portable air-compressing plant has recently been constructed for the Bengal-Nagpur Railway, India. The plant which is an interesting one, consists of an air compressor, arranged to be driven by an electric motor by gearing direct, of an air receiver, water tank and all accessories, the whole being mounted upon a hand trolley suitable for a 4 ft. 8½-in. gauge.

The compressor, which is of the compound type, is capable of compressing 80 cub. ft. free air per minute to a pressure of 100 lbs. per sq. in. with the barometer at 29 inches.

The cylinders are fitted with cast-iron liners of special mixture and bored truly parallel, the space between the liner and the shell forming the water jacket.

The main bearings are formed in the compressor bed and are fitted with adjustable two-part gun-metal steps.

The driving gear consists of a cast-iron spur wheel fitted to the compressor shaft and a raw-hide pinion fitted on to the motor shaft.

The intercooler is of the pipe pattern, and provides a cooling surface of 16 sq. ft.

The air receiver, which is of steel. is 5 ft. 6 in. high by 2 ft. 6 in. diameter, of 25 cub. ft. capacity. The bottom end is dished inwards and is fitted with an angle-iron ring, for bolting to the truck.

The galvanized iron water tank is 10 ft. long by 3 ft. wide by 1 ft. 9 in. deep, and is provided with a loose lid 4 ft. long and fitted with rubber packing to prevent the water from splashing over when the trolley is moved.

The latter is built of mild steel of ample strength with forged eye-bolt at each end for coupling chain, and is also fitted with eye-bolts for lifting purposes. The axles are of mild steel 3½ inches diameter, and are fitted with four steel flanged wheels having suitable axle-boxes with oil wells.

The motor for this equipment has a speed of 700 revolutions per minute, and includes a suitable starting switch.

The compressor is fitted with a low-pressure cylinder 8 in. diameter, and a high-pressure cylinder 6 in. diameter, the stroke of both being 10 ins.

A patent automatic inlet valve is fixed on the inlet side of the cylinder, so that when the working pressure is exceeded the inlet is automatically closed, putting the piston into equilibrium by causing a partial vacuum on both sides of the piston. This allows the compressor to run free (or without resistance).

The cooling water is circulated, and at the same time cooled, by means of a small air-lifting jet fixed on the high-pressure cylinder.

INDEX.

U. S. PATENTS GRANTED APR. 1903.

Specially prepared for COMPRESSED AIR.

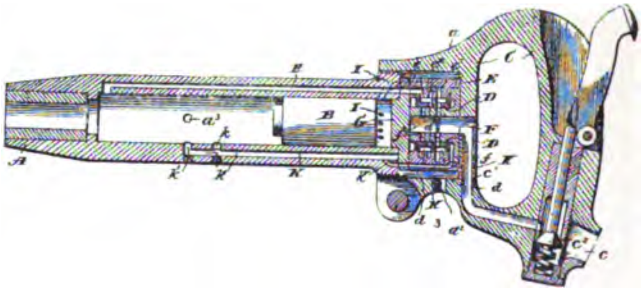
724,736. PNEUMATIC TOOL. Harold A. R. Prindle and John U. Adolph, Philadelphia, Pa. Filed June 19, 1902. Serial No. 112,-380.

The combination with a cylinder and a piston, of a valve having pressure-receiving surfaces to move it in opposite directions, means for intermittently applying pressure to one of such surfaces, and means for constantly applying a lower pressure to the other of such surfaces.

724,606. AIR AND GAS ENGINE. John B. O'Donnell, Kansas City, Mo.; Ella M. O'Donnell, administratrix of said John B. O'Donnell, deceased, assignor of one fourth to James R. Pollard, Kansas City, Mo. Filed July 24, 1902. Serial No. 116,825.

An air and gas engine comprising two cylinders disposed end to end, each containing a piston-chamber, with pistons therein mounted on a common piston-rod, center heads through which said rod passes, forming a partition between said chambers, compressed-air ports and gas-ports in the walls of said cylinders, upon each side, leading into said piston-chambers, valve-chambers interposed in the course of said air and gas ports having valves therein mounted on common, inwardly-projecting stems and controlling said ports, a longitudinal exhaust-passage in said partition, an exhaust-valve adapted to reciprocate therein, a governor located above the cylinders and having a depending stem, a cross-head on the lower end of said stem, a pendulum device suspended below said cross-head, having an adjusting-rod supported by said cross-head and mounted to rock thereon, an arbor forming the center of oscillation of said rod and pendulum, lateral arms pivoted at their lower ends to said adjusting-rod, and at their upper ends linked to said arbor, and lying between the projecting ends of said admission-valve stems, and means operated by the exhaust-valve for rocking said pendulum, so as to contact alternately with said stems and regulate the throw of said admission-valves.

724,688. PNEUMATIC-TUBE TERMINAL. Edmond A. Fordyce, Chicago, Ill., assignor, by mesne assignments, to Bostedo Pneumatic Tube Company, Chicago, Ill., a Corporation of Illinois. Filed June 16, 1900. Serial No. 20,542.



724,780. PNEUMATIC FEEDER. Edwin M. Bassler, Chicago, Ill., assignor of three-fourths to Eugene Worthing, Charles W. Rogers, and Julian W. Mathis. Filed July 5, 1902. Serial No. 114,416.

A pneumatic feeder, the combination of a hopper or receptacle for the material to be fed, a receiving-chamber communicating with the hopper, and an injector for an air-blast interposed between the hopper and the receiving chamber discharging into the latter and carrying the material thereinto.

724,830. PNEUMATIC TIRE. Wilbraham Edmunds, London, England. Filed Jan. 21, 1902. Serial No. 90,717.

725,127. MOTOR FOR PORTABLE TOOLS. Caid H. Peck, Elmira, N. Y., assignor to Imperial Pneumatic Tool Company, Athens, Pa. Filed June 9, 1902. Serial No. 110,-730.

A motor-driven tool, the combination of a casing, a head for the casing, admission and exhaust passages leading out from the center of said head, an eccentric shaft set between two disks secured to the head within the casing, a frame rotating upon said disks and a plurality of cylinders within the frame rotating upon the eccentric shaft, connections between the frame and cylinders whereby rotation is imparted from one to the other, ports and passages leading from the cylinders through the eccentric shaft to the admission and exhaust passages in the head, a spindle projecting from the casing in line with said rotating frame, and means for transmitting motion from said frame to the spindle.

725,128. MOTOR FOR HOISTS OR OTHER APPLIANCES. Cald H. Peck, Elmira, N. Y., assignor to Imperial Pneumatic Tool Co., Athens, Pa. Filed June 9, 1902. Serial No. 110,731.

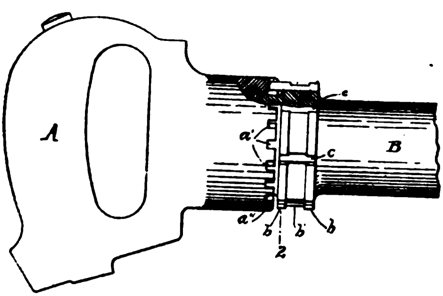
The combination with a tackle-hoist, of a casing, a motor within said casing coupled by a train of gears to a gear-head also contained within said casing, said gear-head and casing being adapted to be substituted for the hand-chain sprocket upon the hoist.

A complete article of manufacture, a casing, a motor to be driven by compressed air, or other fluid under pressure, and a reducing-gearing contained within said casing, the whole being adapted to be substituted for the hand-chain sprocket upon a hoist.

725,243. PNEUMATIC CLUTCH. Charles B. Goodspeed, Columbus, Ohio. Filed Oct. 3, 1902. Serial No. 125,806.

725,337. PNEUMATIC TOOL. Charles H. Haeseler, Easton, Pa., assignor to the Haeseler-Ingersoll Pneumatic Tool Company, New York, N. Y., a Corporation of West Virginia. Filed Sept. 18, 1902. Serial No. 123,833.

A pneumatic tool, the combination with the separable parts thereof, one part having a threaded end, the other part provided with

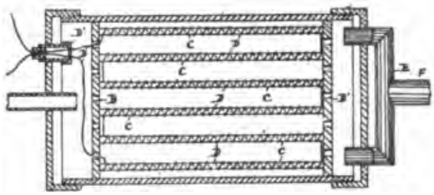


a threaded portion adapted to engage the thread upon the first-mentioned part, there being notches or grooves in the parts respectively adapted to register with each other, the number of notches or grooves in the respective parts differing one from the other and not being multiples of each other, of means through the medium of said notches and grooves to hold the parts together.

725,402. PNEUMATIC SIGNAL. Joseph H. Brady, Kansas City, Mo. Filed April 8, 1902. Serial No. 101,873.

725,450. AIR COMPRESSOR AND HEATER. Chas. R. Keller, Dayton, Ohio. Filed Feb. 9, 1901. Serial No. 46,602.

The combination in an electrical heating apparatus for heating air under compression, for motive power, a cylinder, two perforated disks arranged on the interior of said cylinder adjacent to the ends thereof, caps inclosing the ends of said cylinder and providing chambers between the perforated disks and said caps, a series of solid electrical



conductors arranged between said disks and serving to heat air introduced to the chamber between said disks, an air-inlet pipe through which air is inducted under compression at one end of the cylinder, and an air-outlet pipe at the opposite end of the cylinder through which heated air is discharged for the purposes specified, the inlet and outlet pipes communicating with the chambers in the ends of the cylinder.

725,588. APPARATUS FOR CONVEYING TOPS AND BOTTOMS OF CANS. John G. Rehfuss and Martin O. Rehfuss, Philadelphia, Pa., assignors to Bureau Can and Manufacturing Company, of Delaware. Filed May 6, 1902. Renewed Mar. 23, 1903. Serial No. 149,205.

A pneumatic conveyor for carrying tops and bottoms of cans to be applied to the body portions thereof, comprising a spring-actuated arm adapted to feed a top or bottom into said conveyor, and valves at the exit end of the conveyor normally held closed by the suction in the latter and designed to open under the impact of a top or bottom coming in contact therewith, as set forth.

725,624. PNEUMATIC STACKER. Chas. N. Leonard, Indianapolis, Ind., assignor by mesne assignments, to The Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Feb. 16, 1903. Serial No. 143,657.

725,801. TRACK-SANDING DEVICE. Thos. E. Townsend, Mahoningtown, Pa. Filed June 26, 1902. Serial No. 113,250.

A track-sanding device, in combination, a valve, means for delivering sand thereto, a gravity feed-pipe leading therefrom, and means for delivering an air current to said valve, the latter adapted to control the air-current-delivering means and the flow of sand through said gravity feed-pipe.

725,964. PNEUMATIC FIRE-ESCAPE. Israel Hogeland, Indianapolis, Ind., assignor by mesne assignments, of one-half to Adaline P. Campbell, Indianapolis, Ind. Filed Oct. 14, 1901. Serial No. 78,552.

A pneumatic fire-escape, the combination with a truck, of a tower arranged thereon and comprising a series of vertically-extending telescopic tubes, a crib or platform arranged at the upper ends of said tubes and adapted to be removed thereby, a source of compressed air carried by the truck, a distributing and controlling valve connected to said source, pipes connecting said valve with said tubes, whereby the latter are supplied with the compressed air for operating the crib or platform, and a telescopic shaft arranged at the side of said tower and having its upper end extending to the crib or platform and its lower end connected to said distributing and controlling valve, said shaft being provided with means to effect its operation from the crib or platform, whereby the distributing and controlling valve may be operated from the crib or platform when the latter is either in motion or at rest.

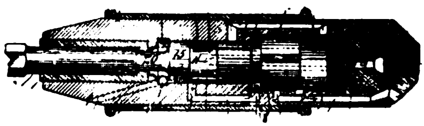
726,022. PNEUMATIC CARRIER. Charles H. Burton, Boston, Mass. Filed Dec. 3, 1902. Serial No. 133,663.

726,033. AUTOMATIC SWITCH FOR PNEUMATIC-DESPATCH APPARATUS. Frederick C. Cutting, Rochester, N. Y., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed May 15, 1902. Serial No. 107,456.

726,072. SAFETY-VALVE FOR PNEUMATIC TUBES. August Koenig, Lowell, Mass., assignor to Lamson Consolidated Store Service Company, Newark, N. J., a Corporation of New Jersey. Filed Jan. 16, 1902. Serial No. 89,940.

726,074. PNEUMATIC TOOL. Herman G. Kotten, New York, N. Y. Filed July 17, 1901. Serial No. 68,593.

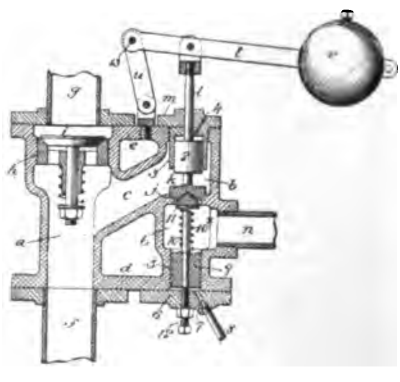
A pneumatic tool, a cylinder, a differential piston therein, a plurality of passages for admitting motive fluid to the exterior surfaces of the differential areas of said piston, and means for permitting the exhaust of the motive fluid from the small pressure area of said piston, when the latter has made its extreme backward stroke, without creating a cushion at the front of said piston when the latter delivers its forward blow to the chisel.



726,097. PNEUMATIC CARRIER. Otto S. Pike, Malden, Mass. Filed Jan. 28, 1902. Serial No. 91,597.

726,220. UNLOADING DEVICE FOR AIR OR GAS COMPRESSORS. William S. Fairhurst, Brooklyn, N. Y., assignor of one-half to John J. Riley, Brooklyn, N. Y. Filed July 8, 1902. Serial No. 114,750.

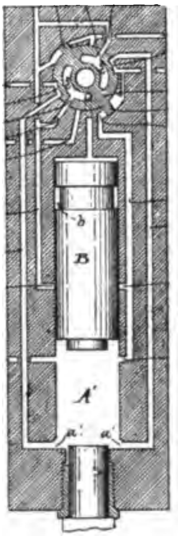
An unloading device for a compressor, a chamber in which is a valve-seat, an upwardly-opening relief-valve adapted to said



seat, a loading device applied to said valve for closing it, a cylinder in said chamber below the valve-seat having its lower part in communication with the receiver to which the compressor delivers, a piston in said chamber, a communication between said chamber and the outlet of the compressor above said valve, an outlet from said chamber to the atmosphere between said valve and piston, a spring interposed between said piston and valve for opening the latter and an adjusting-screw in the bottom of said cylinder for adjusting the piston therein to adjust the force exerted by said spring for opening the valve.

726,221. PNEUMATIC TOOL. Charles H. Haeseler, Easton, Pa., assignor to the Haeseler-Ingersoll Pneumatic Tool Company, New York, N. Y., a Corporation of West Virginia. Filed Oct. 11, 1902. Serial No. 126,904.

A pneumatic tool, the combination of a case provided with a piston chamber and piston therein, a valve-case, an axial valve



therein having chambers on opposite sides of its axis, openings extending from each of said chambers to the exterior of the valve and ports and passages leading from the pressure-supply and adapted in one position of the valve to register with said openings in the valve.

726,227. SUBMARINE BOAT. Simon Lake, Bridgeport, Conn. Original application filed May 28, 1901. Serial No. 62,207. Divided and this application filed Nov. 18, 1902. Serial No. 131,851.

The combination with the hull of a submarine boat, of a normally closed superstructure covering the upper portion of the same, means for admitting water to said superstructure, a discharge-pipe extending from the bottom of said superstructure to the top of the same, and provided with a normally open inwardly-closing check-valve, and means for admitting air under pressure to said superstructure to expel the water through said discharge-pipe.

726,459. AIR-BRAKE MECHANISM. Thos. J. Quirk, Buffalo, N. Y. Filed July 18, 1902. Serial No. 116,079.

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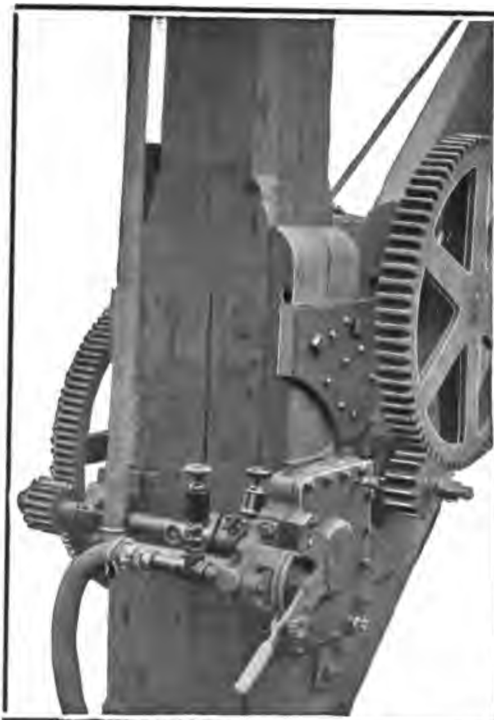

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Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, JULY, 1903. No. 5.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Compressed Air and Steam.

The superiority of compressed air over steam on contract work has already been successfully demonstrated, although all advocates of steam are not willing to admit it. It is pleasant, however, for those who know such to be the case to have their knowledge completely and unqualifiedly endorsed by such a conservative and reliable journal as the *Engineering News*. That publication takes a definite stand on the subject in a recent article which is re-published in another column of this number. While it is no great discovery on the part of the *Engineering News*, it serves to show that the whole engineering world will soon have to admit the advantages of compressed air in this direction at least.

Had it been deemed advisable it would have been easy to tell of a number of central power plants where compressed air has been used with great success in contract work. In the vicinity of New York no better illustration can be found than the plant erected by MacDonald & Onderdonk to assist in the construction of the Jerome Park reservoir.

The *Engineering News* might have added that compressed air was much superior to steam in many cases,where the work was not on contract but of a more permanent nature, as in quarries and mines. While its usefulness in quarries has long ago been conceded, many quarrymen have delayed the introduction of a central compressed air power plant on account of the initial cost and the necessity of abandoning their present machinery, which, while still serviceable, is, after all, of an antiquated type.

Most important and significant, therefore, is the recent decision of the Cleveland Stone Co. to establish a compressed air power plant at its North Amherst quarry, one of the largest in the world. This concern believes by the change that it will secure an increased output at a reduced cost. This action promises to be of special importance in quarrying circles all over the United States, and if it is a success, as we confidently predict, it will undoubtedly mean that owners of other quarries throughout the land will pursue a similar course and manufacturers of compressed air machinery will reap the harvest which will inevitably follow. While it will mean increased business for them, it will benefit the quarrymen, besides giving the public the stone more speedily and at a reduced cost.

Cleveland Stone Company's New Power Plant.

Mention has already been made of the order which the Cleveland Stone Company has given to The Ingersoll-Sergeant Drill Company for a complete compressed air power plant for its No. 6 quarry at North Amherst, O., one of the largest in the world.

The installation of this plant promises to be of special importance in quarrying circles, as it marks a distinct step in the history of compressed air for quarry work on a large scale. While the stone company supplies the foundations, building, and does the excavating, The Ingersoll-Sergeant Drill Company will furnish the complete plant in running order. As it was a very large venture and required a concern of high standing and much experience to successfully handle it, the fact that the order was given in the end practically without competition shows a pleasing recognition of that company's ability to cope with it.

The plant is to consist of two large Ingersoll-Sergeant Corliss condensing air compressors, 48 inch stroke, semi-tangye frames, having a combined capacity of 9,215 cubic feet free air per minute, steam and air ends compounded and of the highest refinement in economy throughout; also three Stirling water tube boilers, 258 rated horse power each, to carry 180 pounds working steam pressure; two independent jet condensers; two duplex boiler feed pumps; two duplex auxiliary low service pumps; three Roney mechanical stokers; one fan draft; water purifier system, etc., including some 10,000 feet of large air pipe and fittings as the main feeder around the quarry.

Among the machinery to be handled are nine very powerful hoisting stations, handling 22 derricks, some 15 channeling machines, 15 rock drills, pumps, blacksmith fires, steam hammers, grindstone and shop engine.

So many radical changes in the whole system of quarrying are in contemplation that it is claimed the output will be increased from 25 to 50 per cent. with the same labor force, while the coal consumption will be cut down two-thirds and the cost of production cheapened to a very material extent. It is said that this plant will give a cubic foot of air at less cost than any other plant in the world. It is expected that this new plant will be in operation by September next. Its completion will be awaited with more than the usual interest, as its success will undoubtedly lead other concerns to follow the example.

While compressed air has been used to a greater or less degree in stone quarrying, there is no quarry the size of the one at North Amherst which posseses a complete compressed air power plant. It cannot be regarded in the light of an experiment, however, as the smaller plants have already successfully demonstrated the success of compressed air in work of that nature.

The Advantages of Compressed Air over Steam on Contract Work.

We are accustomed to seeing a multitude of small steam boilers and engines on large contract jobs where derricks, concrete mixers, and drills are used. The saving in dollars and cents to be derived by the substitution of compressed air for steam on such works will be outlined in this article. To begin with there is always a large saving of coal where one large power generating plant is used in place of many smaller ones. Even well-informed contractors are not always aware of the extreme wastefulness of the small engine. Thus an 8-H. P. engine and boiler on a derrick may readily consume 800 lbs. of coal per 10-hour day, or 10 lbs. of coal per H. P. per hour; whereas an 80-H. P. engine will require only 4 or 5 lbs. to coal per H. P. per hour. Great as is the possible saving in the fuel item it by no means equals the saving in fireman's wages. One fireman can readily stoke a 100-H. P. boiler, yet where the engineman is kept at all busy on derrick work, there must be a fireman for every small boiler no matter how small it is. It is not uncommon, therefore, to see half a dozen firemen on a job where one would serve were he employed at a central plant.

Steam can, of course, be generated at a central plant and piped considerable distances, with increasing loss in steam pressure as the distance increases, even in summer months. In cold weather, long exposed steam pipes are entirely out of the question, hence we seldom see a central steam plant on contract work. But with compressed air there is no loss of pressure in the pipes, except the slight loss due to friction. In very cold weather there is no freezing up of the air pipes, provided the air is cooled before it begins its journey, thus removing the excess of moisture at the compressor.

The compressed air tank or receiver is not a reservoir of power as is commonly supposed. If it were it would have to be an enormous affair, whereas a small boiler-like reservoir is all that is needed. The functions of this receiver are to collect the water and grease that the air carries, and to equalize the pulsations in the air coming intermittently from the compressor. On bridge work a portable air-compressor plant mounted upon a flat car is often used to compress air for the pneumatic riveters. A gasolene engine operates the compressor, so that no fireman at all is required, and no boiler water is needed. Very often this item of water is a very expensive one to the contractor, and here again is where the air compressor driven by a gasolene engine is decidedly economical.

Coming now to the engines and drills themselves, of course, it is apparent that any engine ordinarily run by steam can be run by compressed air. The most familiar type of engine used by many contractors either with air or with steam is the power drill, and there is probably no class of engine where it pays better to use air than the power drill. The flexible marlin or wire-wound rubber hose leading from the pipe line to the drill is "rotted out" by steam in an exceedingly short time, as contractors having to make frequent renewals of this expensive hose are well aware. Compressed air, however, has no such deleterious effect. There is a further gain in the cylinder oil account, since more oil is consumed where steam is used. The fact, that with air the cylinder of a power drill is always cool, is of advantage also in that the drill can be more readily handled and shifted about.

We have drawn no fanciful picture of what may be done with compressed air from a central plant. One contractor, we know, has a 125-H. P. boiler furnishing steam to an engine driving an air compressor which furnishes air to operate six power drills, three cableway engines, one concrete mixer engine and one derrick engine. The first cost of such a plant is actually less than the first cost of separate boilers for each of the engines enumerated, while the cost of repairs and maintenance is far less. But what is of even greater moment is the fact that the fuel item is cut in two, and the wages item of firing is one-fourth what it is when using separate steam boilers.

Compressed air lends itself also to a variety of uses not possible with steam. Thus where there is iron work going on near masonry or excavation, air may be used to run pneumatic riveters, and these same riveters provided with a cutting tool may be used to dress stone. Concrete might thus be cheaply dressed on the face, and so effect a roughened surface that would not show every slight stain or variation in color. Small pneumatic hoists, blowers on forges and many other machines about the work lend themselves to operation by compressed air more readily than by any other form of power.—*Engineering News.*

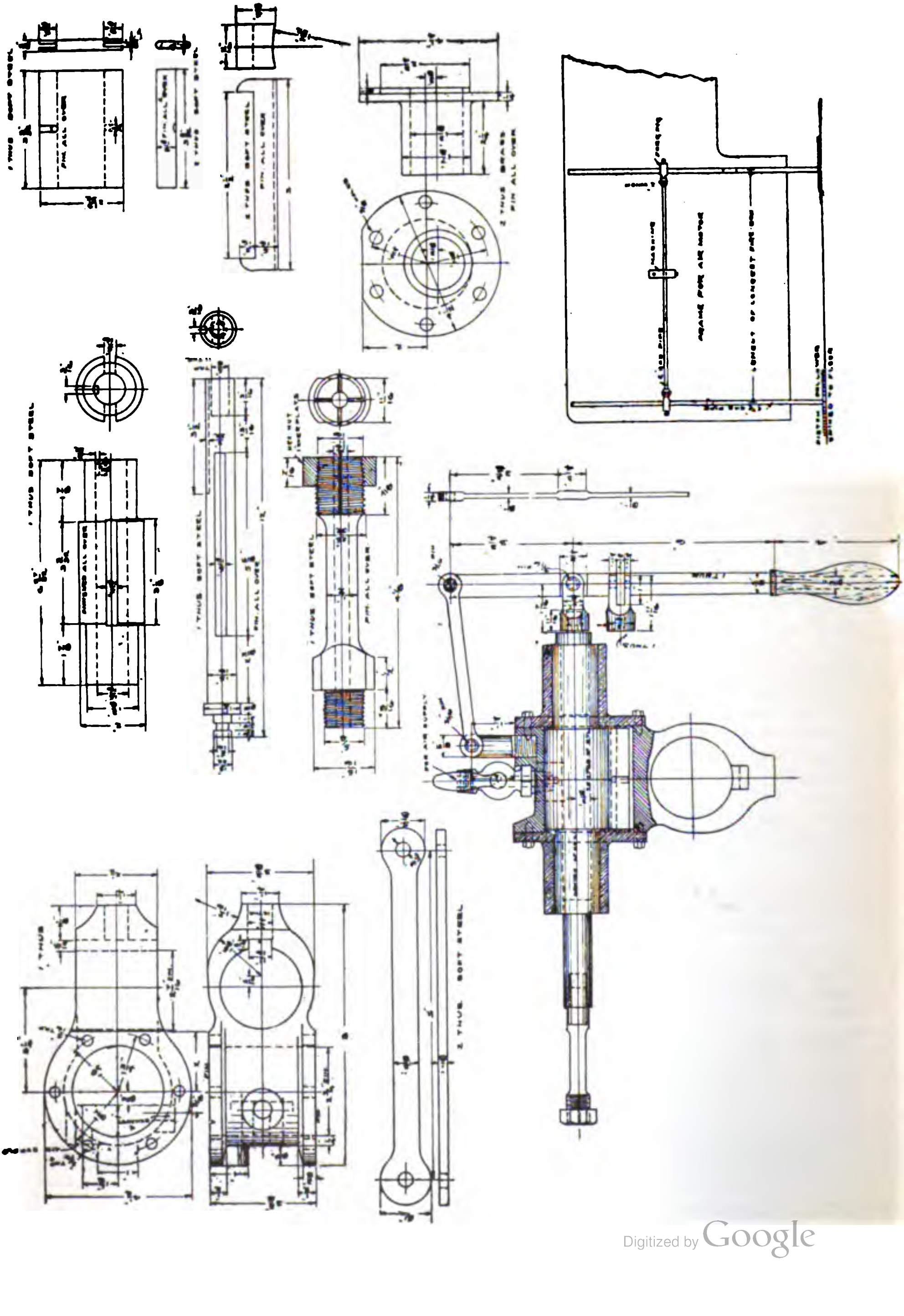
Air Motor for Drilling Staybolts.

The cut on page 2459 illustrates an interesting device for drilling telltale holes in staybolts. The apparatus is designed for use after the staybolts are in place. The machine is operated by air and is capable of drilling 36 staybolts per hour.

When in operation the machine is rigidly attached to a horizontal bar, which in turn is supported by two vertical members. The vertical supports are of 2½-inch gas pipe and the horizontal piece is of 2-inch pipe. In order that the horizontal bar may be raised and lowered to conform to the height of the rows of staybolts in the boiler, each end is attached by a 2-inch union to a forged lug which may be made to slip along the vertical piece and which is supplied with a set screw to hold it in any desired position when the proper adjustment has been made. The unions facilitate the dismembering of the parts of the supporting frame when not in use. In order that the frame may maintain a rigid, upright position, the vertical pieces terminate in wide bases, which may be spiked to the floor.

A lug is cast beneath the machine, which encircles the horizontal, or guide rod. A set screw maintains the position of the machine when adjusted.

The several parts of the machine are shown in detail and assembled. The center line of the drill is offset ⅛-inch from the



AIR MOTOR FOR DRILLING STAYBOLTS.

center line of the cylinder. The drill socket is applied to an arbor which extends throughout the length of the machine, terminating at the opposite end in a lug to which the feeding handle is attached. Revolving with, and about this arbor is a spindle, the diameter of the arbor being such as to allow it to slide longitudinally, without restraint, within given limits. This movement is given by the feeding handle, which is operated by hand.

Through the spindle is a 5-16-inch keyway 3 3-32 inches long, and through the arbor is a 5-16-inch keyway 5⅝ inches long. The keyways of the two are made to conform by a dowel pin. A steel feather 5-16 inch thick is inserted within the keyway thus made. In such a position with relation to the spindle and arbor the feather offers a surface to receive the force of air supplied through an airport passing through the walls of the cylinder. The force of the air against this feather rotates the spindle and arbor, thus giving impetus to the drill. In order that air may not leak past the edges of the feather, packing strips ⅛ inch thick are inserted.

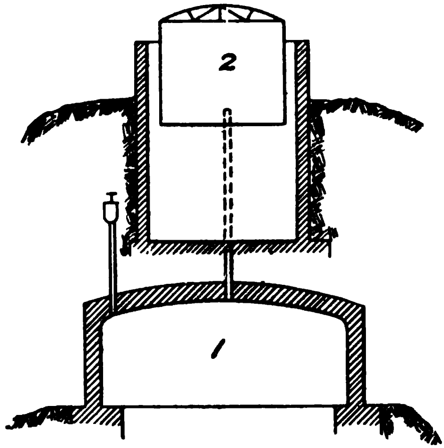
The offset of ⅜ inch between the center lines of the cylinder and the spindle exposes the surface of the feather, which extends beyond the diameter of the spindle, to the force of the air supplied. At the same time this offset is such as to cause the spindle to bear continually, though lightly, against the wall of the cylinder. This arrangement prevents the passage of air directly from the supply port to the exhaust port. Being thus obstructed across the shortest distance between the two ports, the air must pass around the spindle, and in so doing forces the feather around before it.

As explained above, the keyway through the arbor is longer than the keyway through the spindle and the arbor is of such diameter as to slide within the spindle. It is, therefore, evident that by operating the handle attached to the end of the arbor, the drill may be fed to or drawn away from the staybolt.

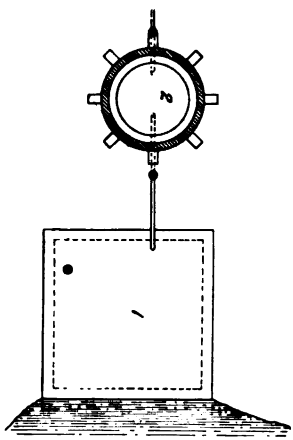
For the illustration presented herewith we acknowledge the courtesy of Mr. T. A. Lawes, superintendent of motive power and machinery of the Chicago & Eastern Illinois Railroad.—*Railway Master Mechanic.*

Utilizing Tidal Action.

Entirely new is the plan of Mr. Chas. Eugene Ongley, of Mons, Belgium, by which he proposes to utilize the rise of the tides for obtaining compressed air, which was noted editorially in the June



number of Compressed Air. While the inventor only claims to secure a comparatively slight pressure by his proposed method, he believes this pressure can be used to obtain higher pressures with the

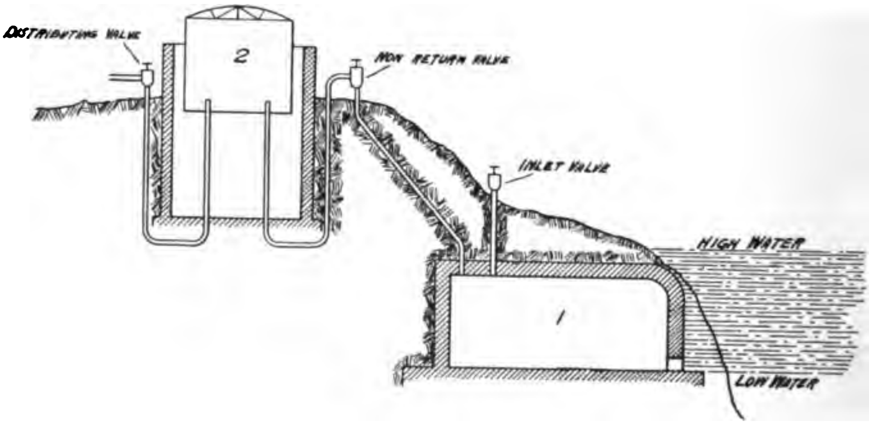


aid of accumulators or air engines worked by the compressed air secured in this manner.

The important feature of this invention consists of compressing air with the aid of the rising tide and includes a tunnel and conduit conveniently arranged in relation to the shore and adapted to admit and to confine the air as the level of the water rises with the incoming tide. The inner end of the conduit is to be in connection with a reservoir in which the air may be collected.

As first planned the tunnel will be constructed as a subterranean passage, made of brick, at right angles to the shore line, opened at the shore end and practically closed at the other. The roof will increase in pitch from the shore end and inward, so as to confine the air at the opposite end as the water level rises. At the inner end of the tunnel is to be placed a non-return valve, the pipe from which will connect to a receiver. The diameter of the outer end of the tunnel is to be small compared with that of the inner end, and the air contained in the tunnel will be imprisoned by the closing of the other end of the rising tide, and the air contained in it will be compressed. Instead of increasing the pitch of the roof as described the inventor also suggests having a tower or shaft at the inner extremity of the tunnel. Means may also be provided for trapping the air contained within the tunnel and preventing its partial escape while the water is entering.

While the force of the tide is not sufficient to obtain any heavy pressures, it is the belief of the inventor that large amounts of air can be compressed to be used to secure higher compression of a less volume or for forge and cold storage purposes. It can also be transported.



The Pneumatic Tube System of a Modern Department Store.*

The use of pneumatic tubes in transmitting money, papers and parcels of various kinds has become so extensive that the service is considered a necessity in the equipment of the modern mercantile establishment. The plan is not a new one. Improvements, however, which have been made in the system in the last two or three years have greatly increased its practical value. In the dry goods or department store, for example, it is valuable as a labor saver, dispensing, as it does, with the many cash boys, in some instances cash girls, that have been employed, and performing their work much more quickly, besides avoiding many mistakes which formerly occurred. There is no delay in "making change," as the amount due the customer is usually handed him by the salesman within a minute, sometimes less than a minute, after his money has been taken over the counter. The system also assists in checking or auditing the sales, for the charge or cash slip which represents the amount of the transaction is sent to the cashier or book-

* By Day Allen Willey for *Scientific American*.

keeper, where it is examined and verified before being returned.

In the ordinary store the pneumatic tubes extend from the cashier's and bookkeeper's departments to the principal sales departments, varying, of course, in number according to the extent of the establishment. Each tube is termed a "line" and is usually 2¼ inches in diameter. The tubes are generally extended along the ceiling or under the floors for the purpose of economizing space, and the terminals where the carriers are received and sent are of various shapes adjusted to suit the conditions. The system is so laid out that when a sale is made the clerk prepares his purchase check, gets the money from the purchaser, and places it in a small brass cylinder which can be unscrewed at the end merely by a twist of the fingers. To start the carrier, it is necessary only to insert it in the receiving end. The air forces it through the line to what is called the main station. This is usually in the cashier's office, for so many articles in the retail store are sold for cash that no entry is required. The carrier drops into the open receiver at the end of the tube, from which it is taken by the "change maker," who, as already stated, glances over the figures on the slip and verifies the total. If an error has been made, the slip and money are returned to the department from which they were sent. If correct, the slip is returned with the amount due the customer. If the sale is to be charged, the slip of course contains the name of the customer in addition to a description of the article and the amount due. As soon as it has been examined, the clerk in the cashier's office again places it in the carrier and inserts it in the tube or line connected with the bookkeeper's department. Here the memorandum is taken out, entered on the books and either the original slip or a duplicate is returned to the salesman.

These operations are usually performed in less time than it takes to read the description; for the carrier travels at a rate varying from 1,000 to 2,500 feet per minute, according to the air current. The length of a line is seldom over 600 feet. The current is produced by the blower system, and the mechanical plant installed provides for a force representing from one-fourth to one-half horse power to each line, depending upon the number of bends or curves and the amount of service. A store having a "50-line" service therefore requires an engine of about twenty-five horse power. In some systems the blowers are operated by steam power direct, but electric motors, either direct connected or bolted to the blowers, are preferred.

The air current is maintained in the tube system in the following manner: The various lines are connected with what may be called a main conduit, which leads to the engine room and to the blowers. These blowers draw the air from the various sending terminals of the line, expelling it through a conduit of suitable size, which may open in the engine room or be connected with the street. While the velocity of the current varies according to the speed of the blower fans, the minimum is rarely less than 2,500 feet per minute, the pressure in the tubes ranging from 6 to 12 ounces per square inch, the latter pressure being secured with a service of one-half horse power. The principle is simply the exhaustion of the air in the tubes to produce a partial vacuum. The effect is so powerful that, although the carriers and their contents weigh a half pound, they are transported without difficulty. The suction is not apparent twelve inches from the end of the receiver. Consequently, the end of the receiver can be placed over a desk or table on which light material, such as paper or currency, is spread. Incidentally the system is of considerable value from a hygienic standpoint, as it assists in the ventilation by continually changing the air in the apartment where the terminals are installed.

The carriers are merely cylinders of sheet brass covered at each end with felt to protect the metal from abrasion in passing around the elbows of the tube. They range from four to six inches in length for the ordinary store service, but do not fit closely against the side of the tube. Enough space is provided to allow the carrier to be borne along by the air current with little or no friction except at the turns, thereby permitting of a much greater speed than if the carrier acted as a piston and was continually in contact with the tubing. The receiving terminals are of two kinds, although both work automatically. The ones used in the cashier's and bookkeeper's department are merely open tubes, which are usually suspended over a receiving table or desk. An air valve is placed in the receiver at a point three or four feet from its end. This is so adjusted that merely the pressure of the carrier against it opens the valve. The carrier then drops by gravity to the end of the receiver, and is taken out by the cashier's clerk or bookkeeper. As soon as the carrier passes, the valve is shut by a spring, and thus the current is confined. The air is then diverted into a parallel tube connected with the sending terminal, the operation of which has already been described. The return tube to the sales department also terminates in the valve, which is located directly at its mouth. When the carrier is sent back, its impact is sufficient to open this valve, and it drops upon the salesman's table, the valve closing automatically and confining the air current as in the other instances. The system in the cashier's and bookkeeper's department requires some one to take the carriers out, in order that they may be examined as they are received, thus preventing unnecessary delay in making change. As the extent of the service is limited only by the power of the blower plant, some of the pneumatic systems which have been installed in department stores recently constructed are very extensive. Perhaps the largest in the United States is located in Philadelphia. It consists of over 250 stations, each connected with a line varying from 400 to 500 feet in length. A plant of 150 horse power is utilized, and in all nearly 20 miles of tubes are used. The power is sufficient to force the carriers through every line as rapidly as they can be inserted in the tubes.

Carriers of three and four inches in diameter are employed for transmitting papers and small packages in factories and warehouses, where bulkier material is required to be transferred from one portion to the other. The arrangement of the tubes is the same, and the carriers are received and dispatched according to the same plan, the power plant being, of course, correspondingly larger to meet the requirements.

Not only the blower, but the compressed air system is utilized in the long-distance tube service which is employed by the Government in New York and other large cities in connection with the Post Office Department. Thus far, the plants for transmitting mail have been principally used in conveying it between New York and Brooklyn by way of the present Brooklyn Bridge and between the main post office in New York and the Grand Central Station. Here carriers which are 10 inches in diameter and about 3 feet in length are employed. The most extensive installation of this kind, however, is in operation in Boston, extending from the retail shopping district on Harrison Avenue to Back Bay, South End, Roxbury, Dorchester, and other sub-stations. This system conveys carriers which are 10 inches in diameter. The tube is laid underground, and consists of ordinary cast-iron water pipe finished at the joints in order to make a close fit. It is laid like a water conduit, with lead and iron joints, the curves being of 12 feet radius to the center line. The bends were cast in sections, the standard of 90 degrees comprising three 30-degree sections bolted together. The carriers which, as might be imagined, were manufactured especially for the purpose, consist of sheet metal riveted together, but move through the tube on wheels, five of which are placed at each head. The carrier is opened at the side by a hinged door. On account of size and weight, the terminals are of special design. The receiving terminal consists of an air cushion closed at one end by a revolving valve, opened and closed by a cylinder and piston operated by the air from the tube. Ordinarily this valve is closed, but when a carrier enters the receiver, it compresses the air in front of it. This pressure affects a small auxiliary valve. When the carrier is brought nearly to rest, the auxiliary overbalances and moves the controlling valve of the main cylinder. This opens the revolving valve, and allows the carrier to roll out. Just at the end of the receiver two vanes are mounted, so that the pressure of the air behind the carrier tends to move them. This motion is made use of to restore the auxiliary valve to normal position and close the receiver. The carrier is placed in the tube by moving valves connected with an air lock.

The power for this system, which is over ten miles in length, is compressed air, the service requiring about 1,400 cubic feet per minute, the pressure varying from 1¾ pounds to 2 pounds. Before entering the compressors the air passes through a tank filled with calcium chloride, which effectually removes all moisture.

This tank is open to the atmosphere, and the pipe connections are so arranged that the air of the incoming line passes through the tank and returns to the compressor. Only such air has to be dried as is lost through leakage or used for operating the machines. The compressors are duplex belt-driven with 21-inch x 12-inch cylinders. There are two each at the main, South End, and Roxbury stations, and one each at Dorchester and Back Bay. The compressors are driven by 50 horse power, three-phase induction motors of the internal resistance type.

The system has been found to be an excellent substitute for wagons and other methods of delivery, and is largely used by merchants for sending parcels to the residence districts where sub-stations are located. At these they are sorted and distributed to the houses of the customers by teams and messengers. It is found that the average time required to deliver packages from the main station to any portion reached by the service in ten minutes, where from forty-five minutes to an hour would be required by the usual method of delivery.

Train Pipe Leakage.

The increasing use of air brakes in freight service is developing certain difficulties of operation and maintenance that are greatly reducing the efficiency of the brake service possible if certain conditions can be controlled. The principal manifestation of an unsatisfactory state is the large number of instances in which but few of the whole number of brakes in a train are connected. This is a most objectionable practice and just contrary to the ideas that led to the application of brakes to freight trains. The chief causes are few in number and at the head of the list is train pipe leakage.

If this leakage is of any considerable degree the pump is overtaxed, with abnormal wear and tear, and brakes are cut out of service until the pump capacity is sufficient to keep a working pressure. It also interferes with graduated brake applications on level track and is almost fatal to safe working on down grades, for when communication with the main reservoir is cut off, leakage acts in one respect as an engineer's valve in that train pipe pressure is reduced and the brakes are applied, but without manipulation on the part of the engineer. As the leak is out of his control, the application continues until the brakes are fully set, even though only a moderate force is needed or desired. It is therefore evident that train pipe leakage not only limits the number of brakes that can be used but also seriously interferes with the proper and normal actuation of those that are in service, and is one of the principal causes for excessive air pump repairs.

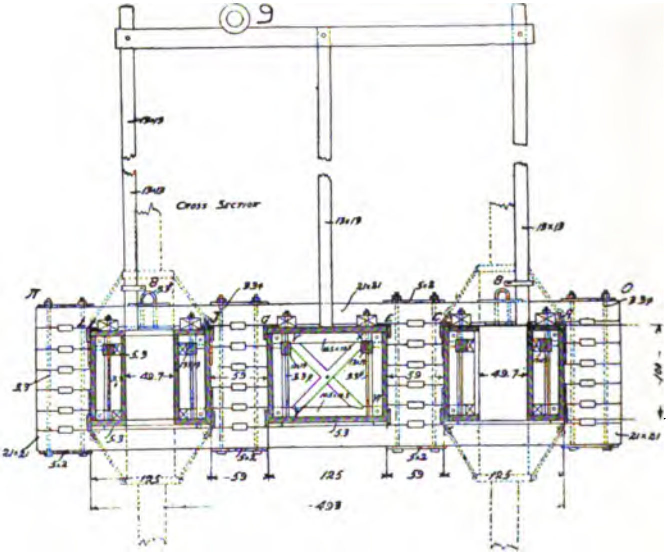
The principal source of leakage is from defective hose-coupling gaskets that have been injured by the practice of pulling the couplings apart when cars are separated, instead of uncoupling them by hand. While the construction of the coupling is such that this can be done without injuring the hose, yet a continuance of the practice destroys the gasket. It appears to be conceded that it is practically impossible to get trainmen to disconnect couplings by hand, and the remedy seems to be the substitution of a coupling that can be pulled apart when cars are uncoupled without in any way affecting its capability for making an air-tight joint.

It was to accomplish this object that the Westinghouse automatic coupler was brought out. For this coupler it is also claimed that it facilitates the making up of trains and insures the use of brakes in many cases where now there is a disposition to couple up just enough to meet the requirements of the situation as measured by the ideas of the trainmen. A train partially fitted with air brakes has elements of danger that are to be avoided as far as possible, and it would seem that anything that will automatically tend to assure the operation of all the brakes on the train is in the right direction.

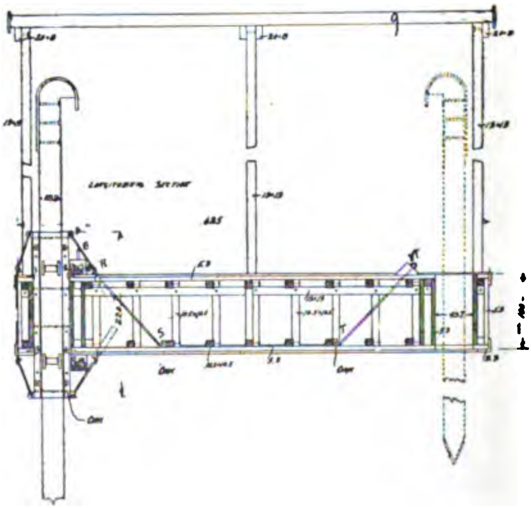
Submarine Drilling.

An example of the platform method for submarine drilling is afforded by the accompanying illustrations, which represent an outfit constructed by Mr. Leegaard, Government Harbor Inspector, Christiania, Norway.

The platform consists of three pontoons connected together by beams, braces and bolts; the pontoons themselves being built on frames, plated up with timber and well caulked and trussed inside to make them rigid to withstand the shaking produced by the working of the drill. At the ends of the pontoons are enough smaller than the guides to prevent sticking, should swelling occur. The spud guides are of oak, heavily bolted and

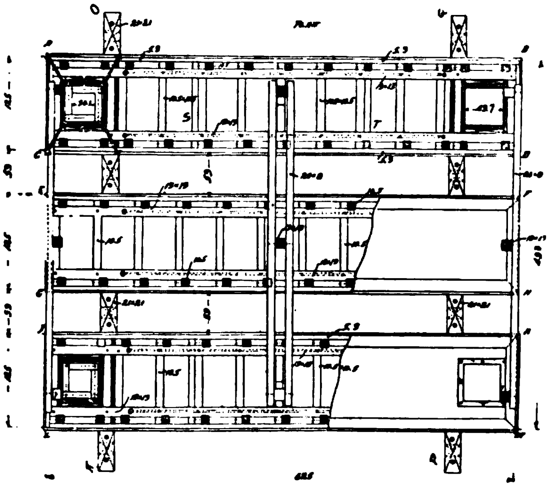


SECTIONAL VIEW, SHOWING COMPOUND BEAMS CONNECTING PONTOONS.

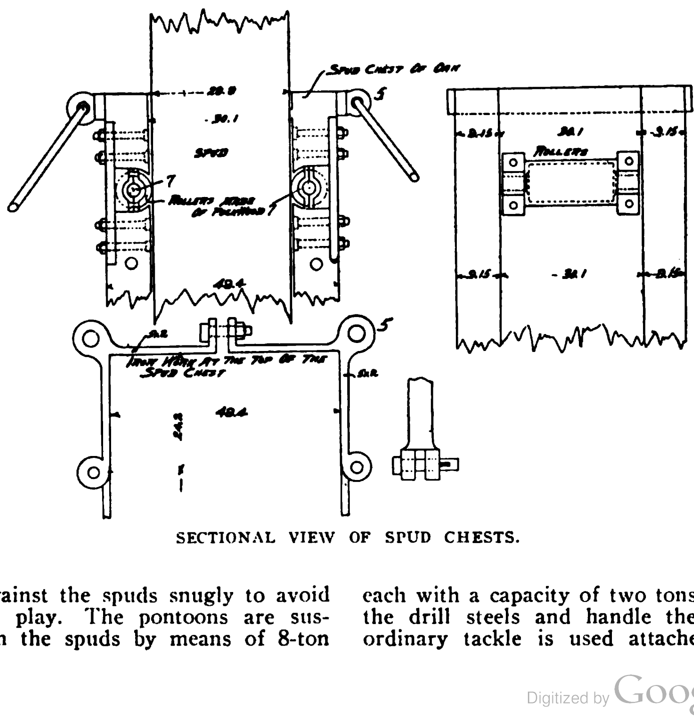


SECTIONAL VIEW OF PONTOONS.

suitable slides or guides for the spuds and water-tight bracing bulkheads. Heavy oak spuds are used and these are made held together with hoops running entirely around. These hoops are arranged for removing, so that the spuds can be taken out, which is necessary in case where the pontoons are to be transported. The rollers in the guides are placed in the ends differential blocks. In order to lift the spuds, four other differential blocks are used, attached to the framing overhead,

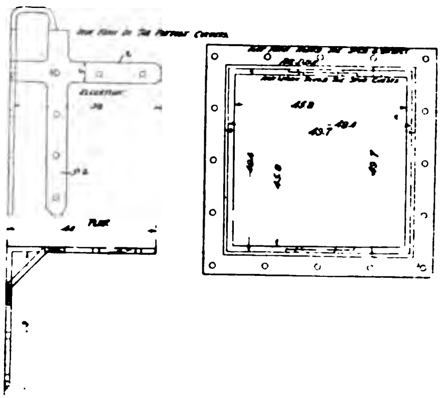


PLAN OF DRILLING PLATFORM.



SECTIONAL VIEW OF SPUD CHESTS.

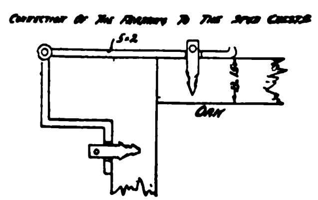
and fit against the spuds snugly to avoid too much play. The pontoons are suspended on the spuds by means of 8-ton each with a capacity of two tons. To lift the drill steels and handle the drill an ordinary tackle is used attached to the superstructure. The spuds are fitted with shackles, whereby the pontoons are suspended at the right height. This relieves the differential blocks of the load and throws the full weight on the spuds. The submarine tube and the drill steels are easily lowered through the opening between the pontoon, or the drills may be mounted on beams projecting over the side of the partition so that the equipment can cover quite an area at one setting. The entire weight of pontoon with drill, drill steels and crew is 22 tons.



IRON WORK ON THE PONTOON CORNERS.
IRON WORK AROUND THE SPUD OPENINGS.

The consort scow contains a boiler and a good steam winch, which is used to lift the broken rock and to handle the platform when it is floating. These platforms have proved very strong, and one of them has been working for two years without alteration.

By means of the Ingersoll-Sergeant drills and the arrangement just described, Mr. Leegaard has made excavations in very hard granite rock at the rate of 11 meters per day. In rotton rock and clay



the drill has been found to work very satisfactorily.

For blasting in clay and rotten rock the cartridges are enclosed in tin, with a wooden point, and a wooden rod is used to shove them down into the holes.

In speaking of this plant, Mr. Leegaard says: "Submarine rock drilling by steam is decidedly cheaper than by hand, not only as regards the running depth of a hole, but drills more deeply by cubic meter."

Michigan Mine Adopts New Plan for Air Compressor.*

The system of air compression to be installed at the Victoria mine in Ontonagon county, Mich., almost passes belief in its economy and simplicity. The water power of the canal is to be converted directly into compressed air power without the agency of machinery, and practically without expense for maintenance or labor after the plant is installed.

The system is not an experimental one, but has been adopted by the management of the Victoria after a careful and exhaustive inspection of several plants of the kind now in commission. There are five such plants operating in America and several in Germany. One is at Magog, Que., which has been in successful operation for six years, without expenditure for repairs or maintenance and without variation in the pressure of the air. This has a capacity of 150 horse-power. A second is in Ainesworth, B. C., which has been in operation three years and generates 500 horse-power.

In Norwich, Conn., is a plant of this kind generating 1,500 horse-power. All the industries of the place receive their power from the plant, including the street car lines. In some instances at Norwich the compressed air power is converted into electricity, while in others it is used direct. Another plant at Peterborough, Ont., is to be used in connection with one of the locks on the Trent Valley canal, under the immediate supervision of the provincial government. Another hydraulic air compressor is located in the Cascade range in the State of Washington. A similar plant in Germany has demonstrated a constant efficiency of 90 per cent. of the theoretical horse-power of the

* By Arthur L. Carnahan for *The Mining World.*

falling water. The largest one ever constructed is now planned for Montreal, where it is expected to generate 50,000 horse-power. The average efficiency of the hydraulic air compressor plants now in commission ranges from 75 to 90 per cent. of the water power expended in compressing the air.

The principle upon which the system is to be installed at the Victoria mine operates is that falling water entrains a large amount of air in bubbles, making the water foam. This water and air is then confined by falling through a pipe for a considerable distance, and the air in the foamy bubbles will separate itself from the water, being lighter. This separation cannot take place, however, while the water is confined in the pipe and under velocity. It is not until the water empties from the lower end of the pipe into a larger chamber that the air ceases to be retained in bubbles. But by that time it is trapped under a head of water represented by the height of the pipe, which in the case of the Victoria will be 370 feet. It is also at the bottom of a shaft 300 feet deep, which is filled with water. It will be seen, therefore, that the air is under a heavy pressure. It is calculated that the Victoria plant will maintain a pressure of 140 pounds of air to the square inch.

The installation of the system at the Victoria will necessitate the sinking of a 300-foot shaft into which the pipe for the falling water will extend and in the bottom of which the compressed air will be trapped. The trap will be a large chamber, into the top of which the pipe will discharge and from another point in the top of which a pipe will extend upward as an outlet for the compressed air. This outlet pipe will lead to a receiver on surface and the air will be piped thence to the different points of utilization.

The chamber at the bottom of the shaft will have an open space between its lower rim and the floor of the shaft, and the water, after having settled and given up its atmospheric contents, will flow out around the bottom of the chamber and thence to the top of the shaft, surrounding the pipe in which the descending water and air is contained, discharging finally into a spillway which will conduct it back to the river. Thus the air will be under a double head of water, one in the pipe leading downward for 370 feet and the other in the shaft leading upward for 300 feet.

The water will flow from the west branch of the Ontonagon river at the recently constructed dam and thence through the canal now being built for a distance of about 4,000 feet. Such portion of it as is to be used will pass, at the end of the canal, into a hopper with a hood covering. Down through this hood will pass 500 small tubes. The falling water will create a partial vacuum in the hopper and the air will be drawn down through the tubes of the hood and entrained in the water, filling it with bubbles.

It will flow immediately into the vertical pipe, which will be built in three increasing stages. The top portion of the pipe will be four feet in diameter, the middle portion six feet in diameter, and the bottom portion eight in diameter. The air is thus trapped and cannot escape, but must be carried to the bottom of the pipe.

From the top end of the pipe, it is a descent of 75 feet before the collar of the shaft is reached. Then it is 300 feet to the bottom of the shaft. It is estimated that between 25,000 and 29,000 cubic feet of water will be utilized per minute.

The principle of utilizing falling water for the compression of air was first applied in ancient times. It has been modernized by a number of inventors, each making improvements on his predecessors or branching out into new lines. One of the most successful of these is C. H. Taylor, of Montreal, who is the inventor of the method to be used at the Victoria. Mr. Taylor is expected to visit the Victoria shortly to look over the conditions there. The sinking of the shaft for the plant has already been commenced and it is expected to have the equipment installed by next spring.

Probably one of the oldest applications of the use of water power to the wants of man was a form of hydaulic air compressor which entrained air on the same principle that is now being applied. This was the well-known water bellows or trompe of the Catalan forges. The water was led to a hollow bamboo pole, set almost vertical, and entrained air with it in its downward passage. The lower end of the bamboo pole was introduced into a bag made of the skin of some animal, the air being allowed to escape from the water into the upper part of the bag, whence it was led by pipes to the forges. The water then passed from the lower edge of the bag.

An Englishman named Siemens invented an apparatus for the non-mechanical compression and exhaustion of air, somewhat on the principle of a steam injector. But it was confined principally to the production of a vacuum. It was used to operate the pneumatic dispatch tubes in London and for blast purposes in Siemens' furnaces and sugar works. Among other inventors who have worked on the direct compression of air by flowing water, through the medium of both vacuum and entrainment, were W. L. Horne, M. Romilly, J. P. Frizell, A. Baloche, A. Frahnass, Thomas Arthur and C. H. Taylor, the latter being engaged as consulting engineer for the Victoria plant.

Mr. Taylor was the first to introduce the plan of dividing the air inlets into a multiplicity of smaller apertures evenly distributed over the area of the water inlet. As stated before, the Victoria will have 500 of these air inlets. This insures the largest possible proportion of air being taken down with the water. He also introduced the idea of enlarging the bottom of the inflow pipe, which serves to diminish the velocity of the water and facilitate the separation of the air. A deflector plate set just below the water level in the compression chamber breaks the fall of the water from the down-flow pipe.

In the Magog plant, which is the oldest in America, the head of water before entering the down-flow pipe is 22 feet; the pipe is 44 inches in diameter and extends down through a ten-foot shaft which is 128 feet deep. At the bottom of the shaft is the compression chamber, 17 feet in diameter and ten feet high, the shaft being enlarged at the bottom to accommodate it.

A series of very careful experiments was conducted at the Magog plant a few years ago. It was then demonstrated that with a head of 19½ feet of water, using 4,292 cubic feet of water per minute, the equivalent of 1,148 cubic feet of free air per minute was recovered, which would represent 248 cubic feet of air per minute compressed to 53.3 pounds' pressure. This shows that out of one gross water horse-power of 158.1, 111.7 horse-power of effective work in compressing air was accomplished, which is an efficiency of 71 per cent.

This compressed air was then used in an old Corliss engine, without changing the valve gear in any way from what it was adjusted for steam, and 81 horse-power was recovered, showing a total efficiency of work, recovered from the falling water, of 51.2 per cent. When the compressed air was pre-heated to 276 degrees before being used in the engine, 111 horse-power was recovered. The heating required 115 pounds of coke per hour, equal to about 23 horse-power. The efficiency, therefore, recovered from the falling water and the fuel consumed was about 61½ per cent. It is calculated from other experiments, that had the compressed air been heated to 300 degrees the total efficiency secured would have been about 87½ per cent.

The plant in the Cascade range of mountains in Washington is unique in that it did not require the sinking of a shaft. The apparatus is constructed against the vertical wall of the canyon in the rugged mountain district in which it is built. The diameter of the down-flow or compressor pipe is three feet. The diameter of the up-flow or water discharge pipe is 4 feet 9½ inches. The total height of the apparatus is 260 feet. The capacity of the plant is based on the utilization of 2,000 miners' inches, equal to a flow of 53.2 cubic feet per second. It gives 200 horse-power of air at a pressure of 85 pounds to the square inch. The head of water is 45 feet.

In the application of the compressed air at the Victoria mine, it is planned to actuate all machinery at the mine and mill through this medium. This will include the hoisting engines and stamp head, and it is calculated that there will be scarcely any changes necessary in the valve gears or other mechanism.

Pneumatic Haulage Plants for Mines.

With the introduction of machine methods of mining in the collieries of this country the little mule, who has for so many years done his work so faithfully, is gradually being supplanted by locomotives operated generally by either compressed air or electricity. While there has been more or less contention regarding the relative advantages of the two kinds of power for haulage, electricity and compressed air, the compressed air motors are steadily gaining ground owing to their freedom from danger, their economy and simplicity. Of the compressed air motors which are in practical use, none have proved more successful than those manufactured by the H. K. Porter Co. These are being used regularly in a number of mines to-day and, where properly equipped with a suitable plant, are very successful.

The essential features of a compressed air haulage plant include a locomotive of suitable weight and power and constructed to carry sufficient compressed air to meet all of the requirements; a charging station or stationary reservoir which may be a pipe-line where long or diverging runs exist, or one or more storage tanks when the runs are short; an air compressor of suitable design; and power for operating the compressor.

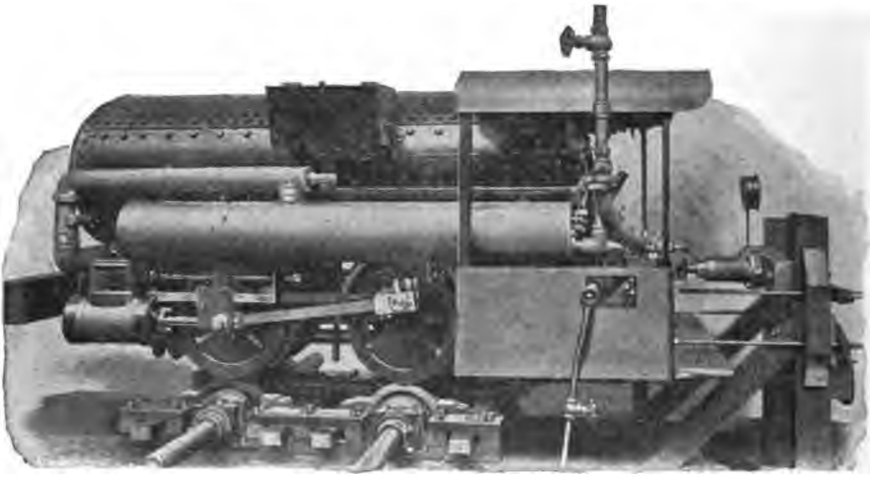
The general machinery of the air locomotive is quite similar to that of the steam locomotive, save that the weight is usually greater, the bearings larger and other details of construction stronger. The main differences are that instead of the boiler with its accessories for developing power the air locomotive is equipped with one or more main storage tanks which are charged with compressed air at high pressure, a regulator or automatic stop valve and an auxiliary low pressure reservoir in which the air is carried at a uniform working pressure for distribution to the cylinders. The cubic capacity and the pressure of air of the main storage tanks are determined by the amount of stored energy which the length of run, grades, weight of train and estimated resistances demand, the limitations as to height and width admissible also being taken into consideration.

The tanks, for all pressures up to 800 and 1,000 lbs., are made of flanged steel plates of high tensile strength. The thickness of the plates is proportioned to the pressure to be carried and to the diameter of the tanks in such ratio as to allow a large margin on the side of safety. Relief valves are adjusted to make it impossible to carry a higher pressure than is required. Of course, all dangers incident to the operations of the steam locomotive boiler, such as excess pressure, burnt crown sheets, or collapse of fire boxes or flues from low water, are entirely eliminated in the operation of the air locomotive, as the boiler and its accessories, which are the chief items of repair on a steam engine, are replaced by air tanks which are practically indestructible. The number of wearing parts being reduced to a minimum, the cost of repairs and maintenance is much less with air than with a steam locomotive. For easy grades, short hauls and light loads the single storage air tank of moderate dimensions and designed for a pressure as low as from 400 to 500 lbs., may be sufficient. In some cases even lower pressures may be used, but there is more economy in the use of a reasonably high pressure. For more severe requirements a larger cubic capacity usually in the shape of two or more storage tanks designed for a working pressure of from 800 to 900 pounds per sq. in. may be required. In rare instances it has been deemed advisable to use seamless steel tubes from 8" to 10" in diameter and carrying a pressure as high as 1,500 to 2,500 lbs. In cases of extremely long haul with heavy tonnage, where the limitations as to width and height are very severe, it has been found desirable to equip the motor with a separate air tender which can be uncoupled when so desired. This arrangement has been introduced with much success in a number of instances and with considerable economy in the installation of pipe line or receivers for storing up air between trips.

In operation the air locomotive is comparatively simple. The high pressure air in the main storage tank passes through the regulator and automatic stop valve to the low pressure or auxiliary reservoir. The regulating valve is intended to maintain whatever pressure may be found most economical for operating the motor. 140 lbs. per sq. in. is usually found generally satisfactory, although this pressure can be increased by adjustment of the stop valve to 150 to 160 lbs., when the work is particularly heavy, or when, in case of emergency such as getting derailed cars on the track, some excess of power is required. This regulation of air between the high pressure and low pressure reservoirs is designed to be at all times uniform, the air being admitted as fast as it is needed and at the required pressure. When the throttle is closed and no air is being used, the stop valve is arranged to close automatically preventing any leakage from the high pressure tank to the low pressure reservoir. It is also possible to operate the stop valve by hand as a positive stop valve should the motor be standing still for a considerable length of time, as over night or during days that the plant was not in operation. The duties of the operator are reduced to a minimum, as the pressure of the pipe line or receiver system is already established when the plant is designed or installed, thus insuring the motor its full complement of air in the storage tanks, and as the air is distributed to the auxiliary reservoir without any manipulation necessary by the operator. It is only essential that the low pressure air be used with the greatest economy, and to this end it is merely required that the air be used as expansively in the motor cylinders as is consistent with the amount of work to be done, the reverse lever being always operated as near the center, securing early cut-off, as practicable with the throttle wide open.

Ordinarily pneumatic locomotives are operated by using the air cold as drawn from storage tanks, but there are cases where it is deemed wise and economical to reheat the air before it enters the auxiliary reservoir on its way to the cylinders. The additional efficiency gained by this reheating varies from 35 to 50 per cent., depending, of course, on the efficiency of the reheating appliance used. For operating in gold or silver mines or for any conditions of service where the haul may be very long or where extremely narrow tunnels necessarily cut down a locomotive tank capacity and further where the cost of fuel is very high, it may seem desirable to use some system of reheating, of which there are several now being used with success.

One of the accompanying illustrations shows a shop test of a Porter air locomotive having 5" x 10" cylinders, designed for 18" gauge of track and equipped with a hot water reheater. All the reheating attachments and auxiliary reservoir are carefully covered with insulating materials, so that the air when once heated reaches the cylinders without any loss in temperature. The H. K. Porter Co. claims that its reheater can be used with safety in gaseous mines wherever the latest improved types of safety-lamps can be utilized. The main storage tank is constructed of one cylindrical sheet which shows the method of riveting. Arrangements for sanding the rails, etc., are shown in the picture. The locomotive rests on friction rollers, which are provided with a pony brake and the tractive force developed is measured by a dynamometer.



SHOP TEST OF PNEUMATIC LOCOMOTIVE.

There are two methods of charging locomotives, direct and by reservoir. Charging direct is generally considered wasteful because it involves a locomotive and compressor of practically double capacity. For very light work, however, where the trips are made only at considerable intervals, direct charging may be at least doubled by the addition of a stationary charging reservoir. The stationary reservoir is the most satisfactory and economical method in the majority of cases. Such a reservoir may consist of a pipe line or one or more storage tanks similar in construction to the locomotive storage tank except they are usually constructed with somewhat higher pressure.

By the receiver system the compressor is kept in nearly continuous operation at very nearly uniform speed, and with the proper system of governing requires little or no attention on the part of the engineer or operator. In early installations, even when the runs were long, the practice was to use large air receivers with very little pipe, the motor generally taking its charge direct from the receivers at the end of its round trip, but in a number of plants recently installed there has been a change in favor of a pipe line of a certain cubic capacity, the size and length of pipe depending largely on what point in the mine it was necessary to reach in order to arrange charging stations so that the motor could always receive conveniently the amount of air required for doing its work. After a pipe line is once installed it ordinarily requires no extensions. If additional locomotives are purchased the only essential feature is to have compressor capacity sufficient to charge the original pipe line to its full complement of air a greater number of times during the day in order that the additional motors when taking air should always have sufficient air to charge the tanks to the usual pressure. The general character of the service required and the local conditions determine the choice between the pipe line and a tank system of reservoir storage. In industrial establishments where no lines of pipes are desirable, one or two charging stations located near the storage tanks and connected thereto with pipe of small diameter have been used with success. Then there are certain conditions in mine services where the installation of the reservoir storage would be of temporary character on account of the likelihood of the plant only being operated for a few years, it then being necessary to take it up and reinstall it at some other point. In such a case it is believed that the most satisfactory course would be the introduction of the storage tanks and the location of one or two charging stations connected to the tank by 2 or 3 inch pipes. In cases where the pipe line extends the entire distance of the main haul, it has often been found advisable to locate a charging station at each end of the line. By charging at each end instead of once for the entire round trip, tanks of less cubic capacity and carrying lower pressures would be required on the motor and a corresponding reduction can be made in pressures and pipe line capacities. Air leakage is less dangerous than electric leakage, but with the marked advancement that has been made in the laying of pipe lines for high pressure work the element of leakage has been virtually eliminated.

In pipe installation it has hardly ever

REAR VIEW OF SINGLE-TANK AIR LOCOMOTIVE.

FRONT VIEW OF SINGLE-TANK AIR LOCOMOTIVE.

been found necessary to use any pipe above 6 inches in diameter; 5 inches has been the size very generally utilized and cases have frequently occurred where pipe as small as 2 or 3 inches has been found available. In pipe lines a mile or more in length the differences in pressure at the two ends has been hardly appreciable. The fact that while the motor is doing its work the pipe line is receiving a full complement of air from the compressor insures that any loss from friction does not work against the motor in any way inasmuch as the capacity of the pipe is such as to give the motor its full pressure of air when necessary, the cubic capacity of the pipe line and the pressure of the air in the same being such as to equalize almost instantly at the required pressure in the motor tanks.

For high duty work with pressures ranging from 500 to 1,000 lbs., three or four stage compressors are being generally used in recently installed plants. They take the air from the atmosphere and compress to the required storage pressure in the main pipe line of receivers. In some classes of service, especially mines where locomotives are not used continuously and where more air at the mine pressure could be utilized if it were available, the compressor may be so arranged as to furnish at a moment's notice a large quantity of air at a less pressure and with little or no loss of efficiency at a very slight increase at cost. The manufacturers, however, are advising against the use of a high duty compressor for operating a locomotive and then reducing this air compressor to the pressure required in the general mine system for running coal machines and other work. This, of course, would save the installment of a second pipe line for the low pressure system, but the loss of power would be enormous, as more cubic feet of free air would be required for the mining machines than for the locomotives, and the cost of compressing large amounts of air to high pressures, say from 700 to 900 lbs., and then reducing it again to 80 lbs. would be wasteful and uneconomical in the extreme.

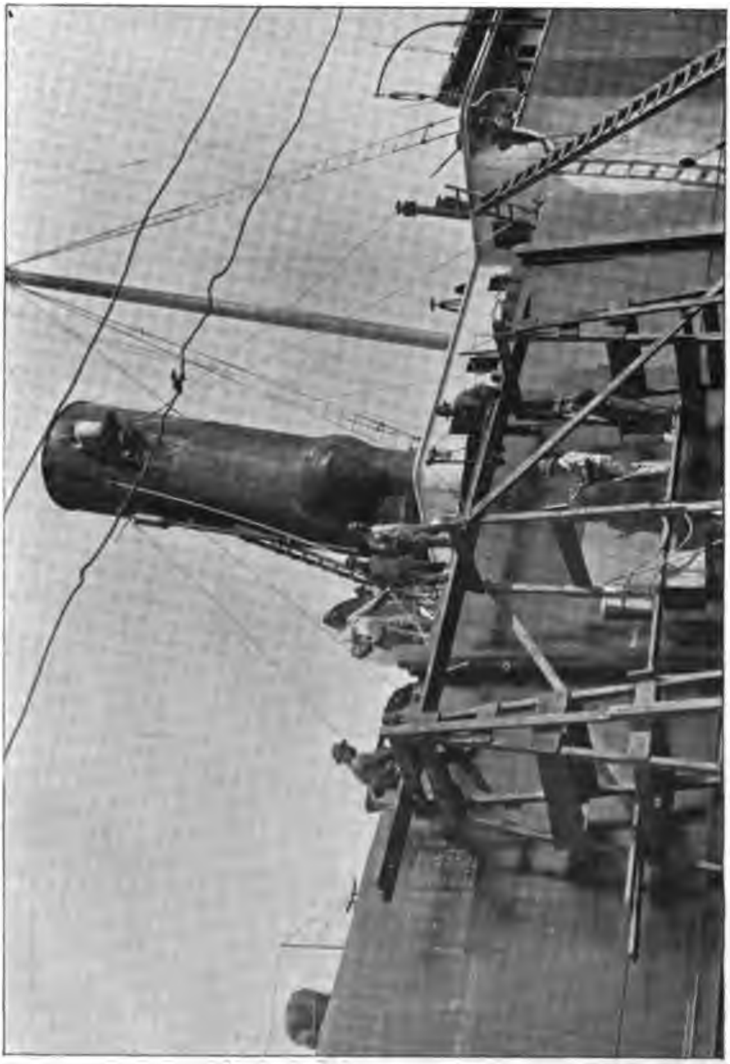
In some mines that have already installed low pressure compressor systems for running coal cutters, etc., and in cases where this compressor system represents a surplus of power, there has been installed a small two-stage compressor as a locomotive charger, taking the air from the mine system instead of from the atmosphere. This, of course, materially reduces the cost of the locomotive charging compressor, but it has its dangers, except in very large mines where the supply of air to the mine is greatly in excess to actual needs. The trouble will come about in this way. Assuming that a small two-stage compressor is designed to take air at 80 lbs. from the mine system and compresses it to 800 lbs., as long as the locomotive charger is getting its air at 80 lbs. there will be no difficulty, but if in the mine system the pressure is allowed to decline, as sometimes happens, the locomotive compressor will not get air at more than 35 or 40 lbs. pressure and in this event overheating appears inevitable.

To sum it all up, it might be said that the advantages of compressed air haulage are its simplicity, safety, handiness, economy and reliability, a combination of attributes which no other system of mine haulage possesses.

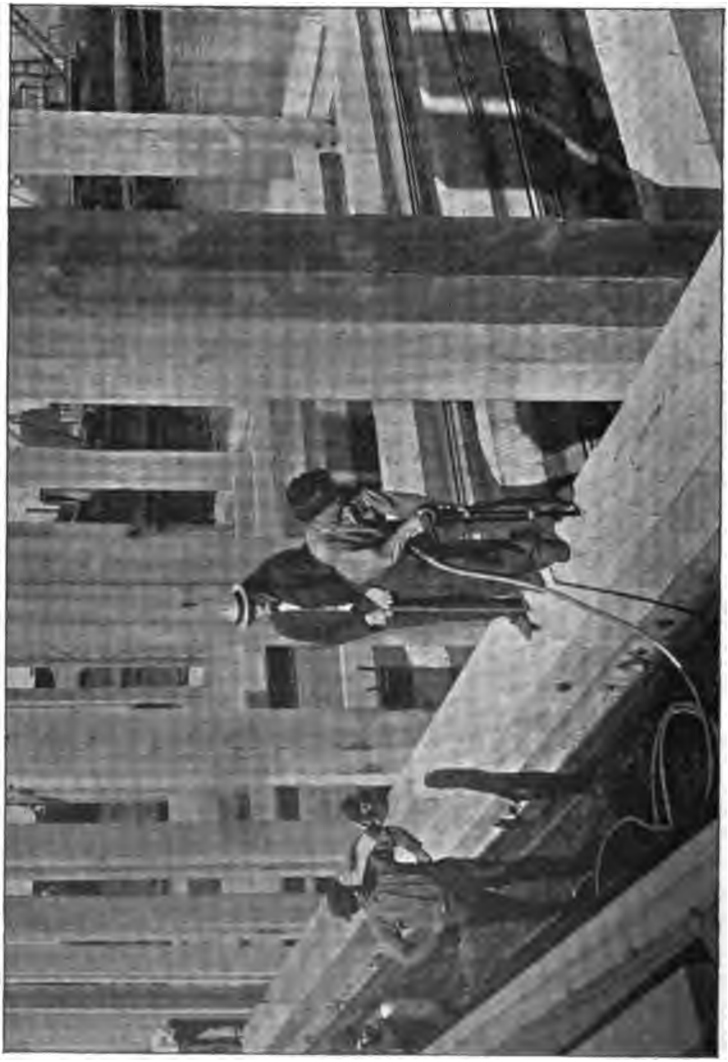
Compressed Air for Marine Work.

Among the various uses of compressed air which have been prominently brought forward within the last few years, is that of painting, the air being used to spray the paint wherever desired. Such a pneumatic appliance has been used with much success on the interior and exterior of large buildings. Along the same lines these pneumatic painting machines have been utilized in ship work. Now that the large steamers demand such frequent coats of paint, a rapid and effectual way of painting is of great advantage. The illustration on the opposite page, which was secured through the courtesy of The Cleveland Pneumatic Tool Co., shows one of its pneumatic painting machines at work on the side of a large steamer.

Another use of compressed air has been featured by the same company. The illustration on page 2475 shows a special riveting hammer used for driving drift bolts in crib work. The same pneumatic hammer can be used in the construction of docks and other marine work, and has, it is claimed, met with great success in that field.



PAINTING A SHIP WITH PNEUMATIC SPRAY.



PNEUMATIC RIVETING HAMMER FOR CRIB-WORK.

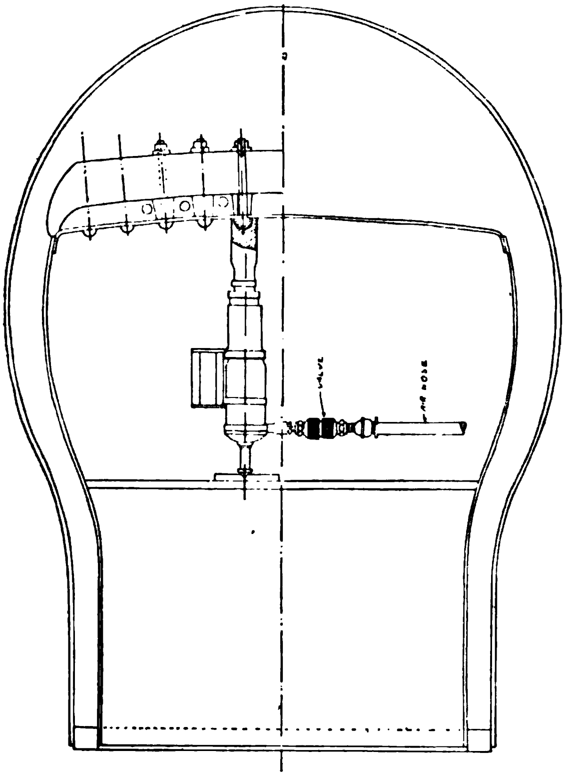
New Applications for Pneumatic Tools.

Among the new applications for pneumatic tools are two for the Jam Riveter, made by the Chicago Pneumatic Tool Co. It is now being used with success in cleaning crown sheets and expanding boiler tubes on locomotives. The accompanying illustrations show the method of doing this work.

In cleaning the crown sheets, a 2-inch plank is placed across the fire-box to support the riveter. It is arranged with cupped dies to fit over the rivet head or head of the stay bolt, the dies striking the sheet around the rivet head. When air is admitted to the machine the pressure holds the dies against the sheet while the riveter strikes a succession of heavy, rapid blows. The work is done without removing the crown bars or radial stays, and the results obtained, it is claimed, have been highly satisfactory not only in expediting the work, but also from the fact that the work is well done. This cleaning is usually done when the engine is in the shop for general repairs and when the tubes are removed.

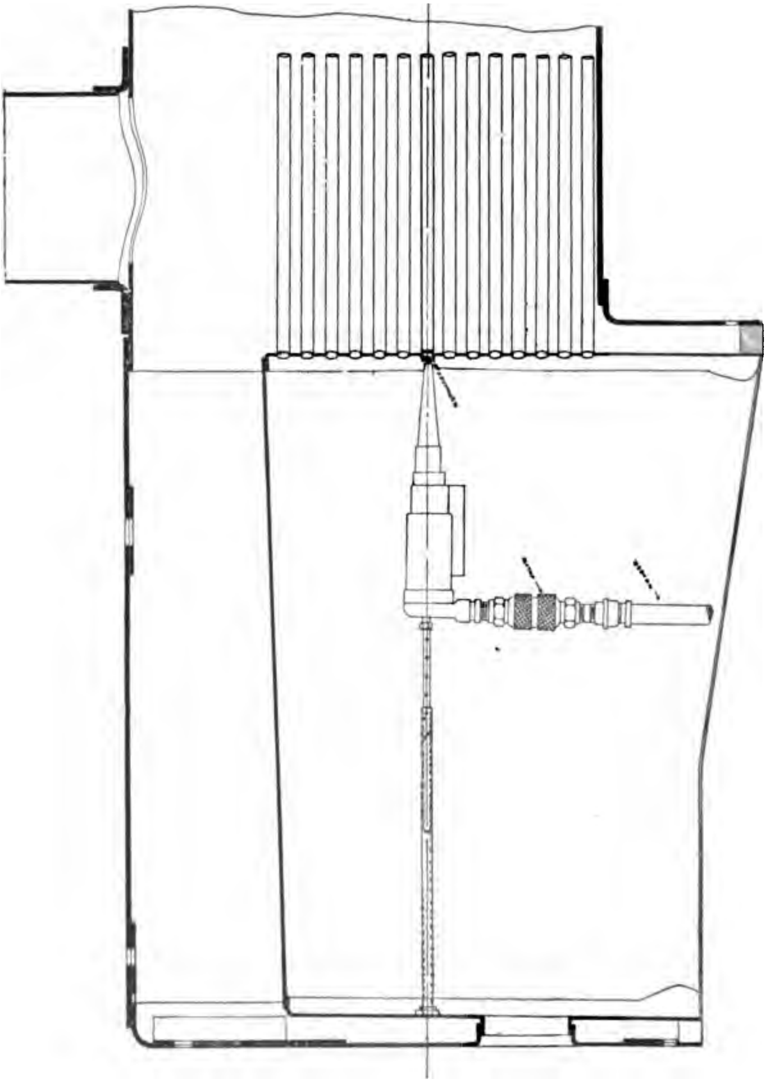
This method has been in use by the New York Central and Hudson River R. R. for about 18 months. At two of that company's shops in 1900, they were removing by the old method an average of 15 sets of crown bars per month. During 1901, they began using this method and showed a considerable decrease in the number of locomotives from which the crown bars were removed. In 1902, it was found necessary to remove the crown bars from only four locomotives.

The Jam Riveter has also been utilized with success in expanding tubes with a



CLEANING CROWN SHEETS WITH JAM RIVETER.

sectional tube expander. Tube expanding has been done to some extent with long-stroke riveting hammers, but the Jam Riveter is said to be more successful on account of its greater power. In performing this work the Jam Riveter is suspended by a counter balance leaving practically no weight for the workmen to hold up.



EXPANDING BOILER TUBES WITH JAM RIVETER.

The Ruth Flue Machine.

Inventors of labor-saving devices have found exceptional opportunities in the manufacture and repair of locomotives. One of the latest machines designed to assist in this work is the Ruth Flue Machine. It is driven by an engine using air or steam and is especially designed for cutting out and replacing boiler tubes. It can be used on any style of boiler, but is particularly adapted for locomotive use. It can also be utilized for drilling, capping and cylinder boring.

The machine is portable and, it is claimed, can be used for all purposes where practical portable power is necessary. By placing a pulley on the horizontal shaft of the machine, with the aid of the belt it can be used to drive any shop tool.

The accompanying cut of the machine shows a conical cylinder into which works a piston, upon the head of which piston is a swiveling platform upon which is mounted a modern engine. Upon the crank-shaft of the engine will be found a pinion which works with a gear on the horizontal spindle by means of which the shaft is rotated, the lateral movement of the shaft being accomplished by a hand-wheel and screw. The entire machine is mounted on an iron truck.

It is claimed that a flue expanded by this machine will give more mileage than a flue expanded by hand for the reason it is expanded gradually, the expander rotating continually from start to finish. The old hand method, it is said, is more apt to distort the holes in the flue sheets into all kinds of shapes. This flue machine has been placed on the market by Robert J. Emory & Co., 4652 Lawrence St., Newark, N. J., whose New York sales agent is W. W. Worthington & Co., of 114-118 Liberty St.

RUTH FLUE MACHINE.

Air Compression by Water Power: The Installation at the Belmont Gold Mine.*

This water power is situated in the township of Belmont, county of Peterborough, Ontario, about three miles in a north-west direction from the Belmont Gold Mine.

On the outlet of Deer Lake there are falls and rapids which give a head of 75 feet in a distance of 1,600 feet. Still further down the river there is another drop of 25 feet, all being on the property of The Belmont Gold Mine, Limited, Cordova, Ontario.

Deer Lake is about four miles long by a mile wide and holds a splendid reserve of water for the dry season. The lake is fed by a chain of smaller ones which extend north about 100 miles. This makes an ideal situation for a power plant.

After the power was acquired the question was electricity or compressed air. The generation and transmission of electricity would have cost less at the power house and to the mine, but it would have been necessary to have put up a motor driven air compressor at the mine to supply drills with air, and motors at hoists and engines. This would have brought the first cost of the electric installation to a higher figure than one large air compressor plant, besides the attendance, etc., at the motor driven compressor at the mine would swell the working costs. By installing one large air compressor at water-power and carrying the compressed air in pipes to the mine, branching it off in all directions to the shafts and mill, it would not be necessary to make any alterations on any of the engines or hoists. All that was then required to be done was to shut off steam and turn on air to the engines, hoists and pumps without any loss of time when air was turned on at power plant. This left the steam plant, boilers, etc., with all their connections as a good reserve power in the event of anything going wrong with the air power. In this arrangement, it permitted the using of machinery which was comparatively new, being only two or three years old.

One important point was the getting in of an air compressor plant large enough to do the mine work for a long time to come. As the underground requirements for air increased there could be more power developed at the falls by electricity to work the surface machinery. Then would be the time for considering the motor driven machinery, as by that time the proper size of machinery for handling the quantity of ore would be better understood.

The outlet of Deer Lake was formerly by two channels, 300 feet apart, through a fine grained diorite rock. The south channel was closed with a concrete and cement masonry dam, 85 feet long, 9 feet wide at top and 16 feet at base and 15 deep at the greatest part. On top of the dam are small piers 18 feet apart for bridging with timbers for a passage across. Underneath this and over the top of the dam the surplus water goes when stop logs are in at the slide way on the north dam. The north dam is 75 feet long with a 25 foot slide for the passage of logs. In front of the north side is a forebay with a 30 foot rack. This is where the water is taken out of the lake for the power, through a 7 foot square opening in the dam with a gate on the side next to the lake. The gate is worked by means of a rack and pinion wheels wrought by worm shaft and wheel. The water intake to the flume is reduced from 7 feet square to cylindrical by means of steel work with flanges and fasteners for the wooden staves of flume pipe. On top of the dam, behind the gate and going down into the water entrance of the flume pipe is a man or air hole. Without such the shutting down of gate at the dam, allowing the water to pass through the wheel, would create a vacuum in the flume, causing a tendency to collapse or disturbance to staves, resulting in much trouble and annoyance through leaks when water was turned on again.

The flume pipe is 1,550 feet long, 6 feet internal diameter and made of 2½ inch pine staves, 6¼ inches wide, radial edges, butt joints with saw drafts cut 2 inches into both ends into which was placed a steel plate ¼ of an inch wider than the stave to embed into the staves on both sides. No two joints come together, but at irregular intervals, the staves being cut in 12, 14, 16 and 18 foot lengths and clamped with 2000 3-16 x 2 inch steel bands and fastened with grip fasteners. The pipe is carried on 12 inch square timbers circled out to take the outside circle of the flume, and these bearer timbers are placed 8 feet apart, centre to centre. The

*By D. G. Kerr, C. and M. E., Deloro, Ont., for *The Canadian Mining Review*.

steel bands are spaced 3 inches apart at the lower end and 24 inches at the top. There are two curves in the flume of 20° each. The 6¼ inch staves were too wide and rigid to be sprung into place on the top of the flume, so 1-3 of the top staves going around the curves were made 3⅛ inches wide.

The bed of the flume was cut through ridges of rock for the first 900 feet from the dam, 3,960 cubic yards of rock excavation being done by steam drill in the winter season. At the lower end there is 217 cubic yards of stone piers to carry the flume over a low piece of ground before arriving at the power-house, and inside of the power-house a steel tube takes the place of wooden staves.

The cost of the wooden flume, made of pine, came out at $3.00 per foot, while the estimated price for this length of steel (flume only) was $15.00 per foot. The power-house building lies north and south and the part which contains the compressor is 40 x 50 feet. South of this is a cooler room 43 x 16 feet, and north of the main part is the water wheel part, 64 x 35 feet. The water-wheel is a double 50 inch bronze Leffel wheel with double discharge and running at 210 revolutions has a capacity of 800 horse-power, taking 7.500 cubic feet of water per minute. The water gates of the wheel are made of cast steel, and the casing of ½ inch steel plates with cast-iron heads. The water-wheel is carried on a steel shaft which extends at one end for the transmission of the power by means of a rope pulley, 5 inches in diameter and 6 feet 4 inches wide across the face, with 30 grooves for 30 1¾ inch cotton ropes. On the top of the wheel casing is a dome 2 feet in diameter by 10 feet high with valve, and just above this valve are two pipes, 12 inches in diameter, having spring valves and leading into draught tubes. This is an arrangement for the relief of undue pressures from water ram, such as might be caused by the water-wheel gates on a long flume through which water is traveling at a certain rate, being shut down quickly. This arrangement takes the place of a stand pipe; costs less and there is no danger of its freezing, as it is all under cover. On wheel case is a gauge showing water pressure and head in feet, and on draught tube is a vacuum gauge giving the vacuum in inches. The water-wheel, wheel casing, etc., were furnished by The Wm. Hamilton Mfg. Co., Peterboro.

Underneath the wheel is the tail sump, and from that the tail race going into the river. This was excavated out of solid rock to a depth of 20 feet and has cement masonry walls with steel beams and bolts with which the wheel casing is held in place. This tail sump is carried west underneath wheel to take the water from another wheel of 350 horse-power, for which there is provision for water made on the steel part of flume by means of a tee piece. When this other wheel is at work the water velocity through the six-foot flume will be brought up to about 10 feet per second. The intention is to develop this 350 horse-power with a direct driven dynamo, alternating current.

The air compressor which is driven by these 30 1¾ inch cotton ropes from pulley on water-wheel shaft is built on the compound horizontal principle; high pressure cylinder, 30 inches diameter; low pressure cylinders, 48 inches diameter and with a 4 foot stroke. The cylinders are water jacketed, provided with improved accessible inlet valves and fitted with metallic packing on the piston rods. It is rope driven by means of a 20 foot pulley, 6 feet 4 inches across face, weighing 60,500 lbs. and built in sections on massive concrete and cement foundations, 14 inches high. Running at 65 revolutions, or a piston speed of 520 feet per minute, it will have a capacity of 6,500 cubic feet of free air per minute.

The low pressure air cylinder intake is connected together by branch pipe from the 3 foot pipe to the atmosphere outside. This 3 foot pipe lies horizontal on the top of the low pressure air cylinder, one end going to the south and the other to the west end of the building. The air is compressed in the low pressure cylinder to 30 lbs. pressure and is then discharged through a 14 inch pipe to the intercooler, and from there, after being cooled, to the high pressure cylinder, from which after being compressed to a pressure of 100 lbs. per square inch, it passes into the after-cooler. The inter-cooler and after-cooler are filled with brass tubes through which flows cold water and the compressed air passes and repasses over the outside of the tubes and is cooled down to within 10 degrees of the temperature of the water used. In this cooling process there is considerable moisture deposited, as it is only by cooling the air to the lowest temperature that a high extraction of the moisture can be had.

The air leaves the after-cooler through a 12 inch pipe or ordinary oil well casing, having fine screwed couplings and tested to 600 lbs. pressure. Half a mile out from the compressor is an air receiver to collect any moisture which may have passed the after-cooler. This moisture is drawn off every day.

The 12 inch pipe line from the compressor to the mine is 15,000 feet long. At the end of this pipe line at the mine is another air receiver to collect any moisture which may have been carried into the pipe line. The only time of the year that any moisture is expected to be carried this length, is when spring sets in and the heat of the sun frees any moisture from the inside of the pipe. This will be very little, as the air receiver near the compressor is in a low swamp, and the air line leaving it for the mine has a gradual raise of 50 feet into the 2,000 feet, thus draining moisture back into the receiver. The pipe line has 18 expansion joints and is mostly all buried in sand to prevent expansion and contraction.

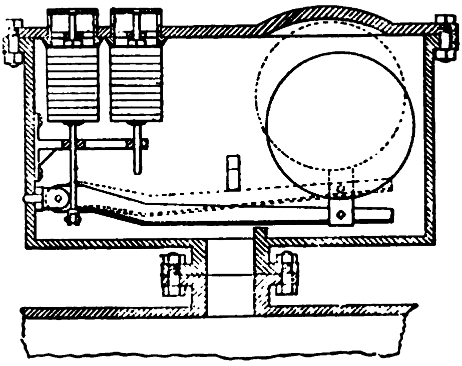
The foregoing is only a slight description of the plant. As it was only started running in August, 1902, and has not been run up to its full capacity yet, the loss in pressure due to friction in transmission cannot very well be arrived at. The loss at present is less than 1 lb., but using the full quantity of air the loss is expected to be 3½ lbs. What I would like to have completed, but found impossible in the short time that the plant has been running, is a complete comparison between summer and winter of the temperature at which the air is taken into the compressor, the amount of moisture extracted and the temperature of water used in coolers.

During the past winter there was only one shut down owing to freezing. This was caused by the moisture in the receiver half a mile out from the compressor being allowed to freeze through not being drained off every day. The ice formed in a honeycomb form until it interfered with the air pressure at the mine, reducing same to 65 lbs., while there was 105 lbs. at the compressor. Shut down and found the receiver full of this honeycomb ice. After taking out same, started up again and covered up the receiver with a shed, banked so as to keep off the intense frosts and permitting the moisture to be drained off.

At the mine I have had no trouble with freezing up except with a Corliss engine and a 14 inch duplex pump. I find that engines with slide valves give no trouble, due to non-expansion of air inside of cylinder.

A New Air Valve.

A few years ago a 72-inch steel pipe storm water sewer was laid in Jersey City, discharging under pressure. This pipe was practically level for 2,100 feet, with its invert about 5 feet below mean low water; it received the drainage from the "Heights" partly through a 40-inch cast-iron pipe 1,500 feet long and partly through a 48-inch cast-iron pipe 1,600 feet long. The speedy and certain removal of air from these mains during storms occurring when the mouth of the sewer would be sealed by the tide was absolutely essential.



TUTTLE'S AIR VALVE

For this purpose Mr. Arthur S. Tuttle, M. Am. Soc. C. E., in 1900, designed an air valve which has given such good satisfaction that he decided to place it upon the market. It is automatic in action both for discharging air or other gases collecting at the high points of pipes carrying water or other liquids and for admitting air to the pipe in the event of the rapid removal of the liquid tending to form a partial vacuum.

The apparatus consists essentially of a closed chamber to be connected to the pipe by a flanged nozzle, containing one or more buoyant poppet valves on vertical spindles and a float attached to a lever. Over each poppet valve is a small turret with openings to the atmosphere. The cover is flange-bolted to the chamber so as to be readily removable for inspection, cleaning or repairs. The action of the valve is very simple. Assuming first the case of a pipe being filled, the chamber contains only air and the poppet valves rest upon the bracket seats shown so as to leave the air passages to the atmosphere open. When the water nearly fills the chamber, the buoyancy of each valve causes it to close promptly. The chamber will remain sealed so long as there is liquid enough to keep the valves seated. If, however, air or gas accumulates in the chamber, the water will gradually be forced from it, and the buoyant weight at the end of the lever will finally drop, under the action of gravity, and cause the lever to bear upon a pin extending from the side of the valve spindle, thus opening the valve and permitting the escape of the air. If the relative proportions of the valve have been properly made to suit the pressure in the pipe, equilibrium can only be restored by carrying the poppet valve down and holding it open until disengaged by the rising of the float arm, as the water rises in the chamber. The travel of the arm and float are limited by a stop, as indicated. The spindle of the valve is held in a vertical position by guides so that it will always come to an even seating. The float being wholly contained within the air-chamber is caused to rise and fall solely by reason of its buoyancy and weight without regard to the pressure within the chamber. The several parts are so constructed and arranged that the buoyant weight has a very limited movement and only operates to open the buoyant valve after the air-chamber has become approximately full of air. As the air escapes from the chamber and the water rises in the same, the buoyant weight will be given its maximum elevation by flotation long before the water rises sufficiently in the air-chamber to close the buoyant valves by flotation. A considerable period is thus permitted to elapse between successive operations of the apparatus, as the valve is not opened until the chamber is approximately full of air and is not closed until the chamber is approximately full of water.

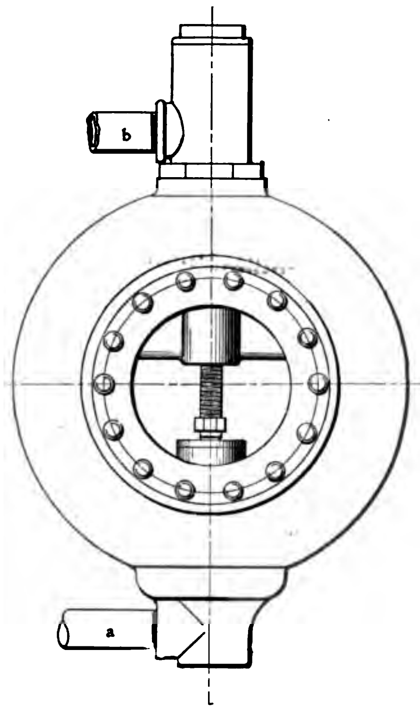
It is claimed that this new air valve is very positive and reliable in action and does not permit the escape of water, although promptly discharging any accumulated air or admitting air so promptly as to prevent collapse in the event of a sudden emptying of the pipe caused by breakage or otherwise. The importance of these properties and the convenience of the wholly automatic action of this valve will be recognized by those who have had experience with air valves. This valve is being placed upon the market by the Eddy Valve Company, of Waterford, N. Y.—*Engineering Record.*

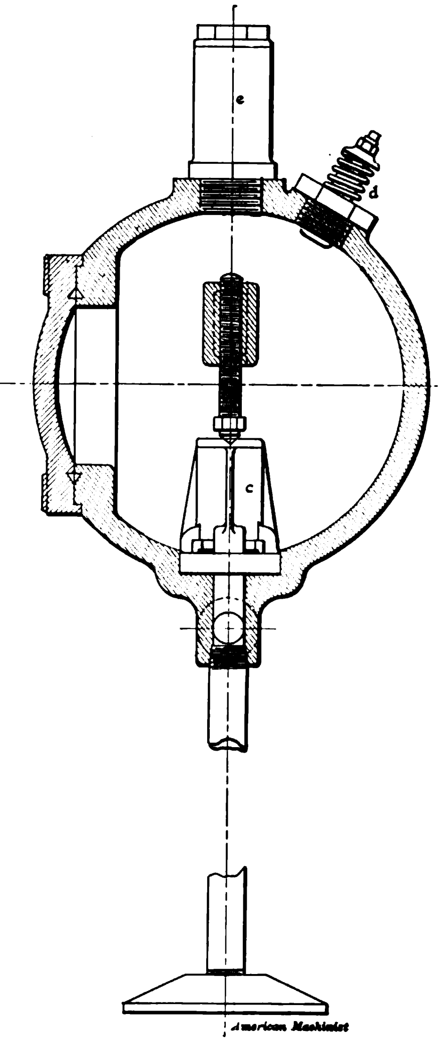
An Automatic Air Chamber Charging Device.

A year or more ago there was quite a discussion in the *American Machinist* on the subject of automatic air chamber charging devices, and several such, made up from pipe fittings, were shown by correspondents.

The illustration on the next page is a more matured design for this purpose which has been applied to several large pumping engines and with very satisfactory results by the Nordberg Manufacturing Company, of Milwaukee.

The main globe casting, which is of 13 inches interior diameter, is located near the water end of the engine and is connected at *a* with one end of one of the pump cylinders and at *b* with the air space in the air chamber. The connection at *a* being with a pump cylinder, the interior of the globe is subject to alternate pressure and suction. During the suction stroke the globe is filled with air by the valve *d*, and during the pressure stroke this air is expelled through the valve *e* and the pipe *b* to the air chamber. The valve *c* is introduced to control the ingress and egress of the water. On the one hand air must not enter so freely as to more than fill the globe and then escape to the pump cylinder, and on the other the globe must be so nearly full of water that the rise during the pressure stroke will expel the air. With free egress of the water it might easily escape in such volume that, opposed by the compressed air above it, it should not rise to a point where the air would be expelled. On the contrary, there is no danger of having too much water in the globe, as the return of the water from pipe *b* is prevented by the valve *e*, any drop of the water level insuring the entering of a fresh supply of air. To insure working conditions it is essential then that the water shall enter the globe more freely than it escapes from it. Valve *c* is therefore an obstruction valve only—that is, it has a hole through it for the water to escape. During the





AUTOMATIC AIR CHAMBER CHARGING DEVICE.*

pressure stroke this valve opens freely and the water enters and expels the air, but during the suction stroke the water can only escape through the hole and the flow outward being more restricted than that inward, it is made certain that the volume of water escaping from the globe will not be in excess of that which will again completely fill it and expel the air on the succeeding pressure stroke.—*American Machinist.*

* We are indebted to the Nordberg Mfg. Co. for the use of this cut.

The Use of the Sand Blast.

At the time the One Hundred and Fifty-fifth street viaduct was cleaned in the year 1897, the consulting engineer, Mr. Edw. P. North, wrote a number of prominent engineers for their advice and suggestion, as to the best method to be employed, and we have taken the liberty of re-copying a few of the replies received, which we are enabled to do through the courtesy of Edgar T. Ward & Sons, Boston, who have published a small pamphlet comprising these letters.

" Relative to painting of iron-work, I would say that I examined the sand blast cleaning at One Hundred and Fifty-fifth street with great interest. Twenty years ago I went to Philadelphia and had some zinc sheets cleaned by the sand blast at the works of General Tilghman, and also inspected the steam blast then in use for cutting stone; I was therefore sure that the action of the blast would be very effective for cleaning the scale from iron-work, and I found the improved appliances at One Hundred and Fifty-fifth street were acting with a degree of success that even exceeded my anticipations. From my experience with painting iron-work in this city I have become convinced that it is nearly impossible to have structural iron-work properly cleaned and painted on the clean iron surface before erecting. This should not be so. But at present the shops do not seem to be properly equipped for cleaning iron-work and removing scale and for painting before the rusting has commenced. In the case of a viaduct recently erected in this city all possible care was taken to have the clean metal well painted before it left the shop. A reasonable degree of success was obtained with the main structure, but the railing from the Belmont Iron Works was sent here with a coat of paint applied to a rusted surface, and this railing is now, after little over a year's exposure, a mass of rust, while the rest of the structure is in very good condition. I am convinced that money spent in painting a surface not previously cleaned from rust in a thorough manner is wasted, and I regard your experiments as being valuable in the highest degree. I considered expenditure made for the purpose of getting a perfectly clean surface on which to paint to be eminently wise, and if success is not found to follow your painting on this clean surface it would be a reasonable deduction that iron-work is unsuitable for use in structural work exposed to the action of the elements.

I anticipate that the result of your experiments will be highly successful; if these experiments prove costly, it is not more than would be expected from pioneer attempts. I hope that before many years constructors of iron-work will awake to the importance of proper cleaning and painting in the shops, and for the cleaning before painting I cannot think of any process that will equal the sand blast in efficiency." Horace Andrews, M. Am. Soc. C. E., City Engineer, Albany, N. Y.

"As to the judiciousness of the method pursued cleaning the viaduct at One Hundred and Fifty-fifth street by means of sand blast received, I crave your permission to reply at some length.

The appropriations for the maintenance of bridges in Baltimore for some years past having been very small, no painting has been done, consequently quite a number of the bridges are sadly in need of paint, one particularly, Argyle Avenue Bridge, over the Pennsylvania Railroad, concerning which we spoke to you when we visited the One Hundred and Ffty-fifth street viaduct. This bridge is situated between the portals of two tunnels, and so close to one portal that the smoke coming from the tunnel frequently envelopes the bridge; also, all locomotives of trains going west which stop at Pennsylvania Avenue Station, stand immediately under this bridge, and since the engine-men fire up, preparatory to the trip through the next tunnel, the escaping gases and steam have played havoc with all members of the structure, which has not been painted since erection, twenty years ago. The wooden floor being in very bad condition and having to be renewed, we removed it entirely before the cleaning of the trusses began, so that access could be obtained to all members of the structure. The scale on this bridge was over ¼ inch thick, and the iron and steel were pitted to a depth of 1-32 inch to 1-16 inch; the cross-section of web of floor-beams was reduced fully 1-16 inch, and the other members to as great an extent. One thing which was especially noted was the fact that the erection numbers painted on the floor-beams were distinct, and when the paint was scraped away the iron was perfectly clean. Unfortunately, it was impossible to discover the kind of paint used, but it was presumably white lead. Chipping hammers, steel scrapers and brushes were used to clean this bridge, the labor for which cost about 5 cents per square foot, but I do not consider the result satisfactory. We had much difficulty to have the laborers clean the iron thoroughly, for they were too prone to slight the work so as to seem to accomplish much rather than to obtain the best results, which fact militates greatly against cleaning by scraping, etc.

Whilst this work was in progress, I visited the One Hundred and Fifty-fifth street viaduct, where the sand blast was in operation, and returned feeling thoroughly dissatisfied with our efforts, and convinced that the sand blast should be used for cleaning structures, so favored the purchase of a plant.

So little care is really taken to properly clean iron in the shops before the first coat of paint is applied, that frequently corrosion begins before the paint is applied, producing the results with which bridge engineers are so familiar; and since there are so many inferior paints used, it is not strange that they peel off and crack, and allow corrosion rathen than prevent it.

To preserve a structure and obtain the full amount of use from it, it is necessary that it be kept free from rust by some method, and too much care cannot be taken for its preservation; it is not sufficient, as the layman ordinarily considers, to erect a structure and then leave it alone; but frequent painting is absolutely necessary, how frequent depends upon the conditions to which the structure is subjected and the preservative used. In the past, hammers, scrapers, brushes, etc., have been used for cleaning structures, but results have proved unsatisfactory; and I cannot too heartily recommend the use of sand blast on structural iron before the first coat of paint is applied in the shops, and upon structures which are to be cleaned preparatory to painting." Layton F. Smith, Assistant Engineer in Charge of Bridges, Baltimore, Md.

"With reference to the use of the sand blast in cleaning the metal-work under your charge, I would state that my experience and observation in the line of paint on metal structures have led me to the following conclusions: Where a structure has become corroded it is essential that all rust be thoroughly removed before the application of new paint. Scrapers and steel brushes do this but imperfectly, and the irregularities, and frequent inaccessible surfaces caused by structural connections, render it practically impossible by such methods, without an expenditure of time and labor which would ordinarily be considered prohibitory. There is no question but that the portion of the One Hundred and Fifty-fifth street viaduct over the Manhattan Elevated Railroad tracks had reached a condition requiring prompt and thorough treatment. Cleaning by the usual methods would have been very costly, and at the best unsatisfactory. The cleaning done by the sand blast as far as the work had progressed at the date of my inspection, was admirable and complete, leaving the naked metal surface entirely clear, as could not be done by the processes usually applied.

There can be no question as to the comparative results of the sand blast and the usual appliances. It is to be expected that experience in the appliance of the sand blast will result in lessening the cost of application. Doubtless the cost of the usual hand manipulation of scraper, brush and chisel to produce any approach to the thoroughness of the sand blast would now cost far more.

In conclusion I would state that for the foregoing reasons I believe the use of the sand blast was judicious, and in accordance with an appreciation of the importance of dealing thoroughly with the question of metal coatings, which has only, within a recent period, begun to receive the attention its importance demands." Charles M. Mills, Assistant Engineer in Charge of Gray's Ferry Bridge, Philadelphia, Pa.

Receiver Pressure in Air Compressors.

A correspondent writes *Power* as follows:

The question frequently comes up as to why an air compressor will pump up a receiver pressure greater than the boiler pressure. This, of course, refers to the steam-driven machine with the usual balance wheel or wheels. I have known this to happen on locomotives, under certain conditions, and in this case it is the well-known direct-acting Westinghouse air pump.

It does look curious to some of us, but it really is in accordance with natural laws. Take, for example, the ordinary machine driven by a slide-valve engine with a throttling governor. Its valve may cut off somewhere between one-half and three-quarter stroke, or a little later. The balance wheels are rather substantial and their momentum comes in good play. Keeping in mind the law of compressible gases and the general appearance of a compressor indicator card (air end), I think it can be easily demonstrated. Suppose 105 pounds gage to be the receiver pressure and the boiler pressure to be 100 pounds. For simplicity's sake, I am using round numbers and ignoring the effects of the heat resultant from the compression of the air; but possible leaks at inlet valves, piston and piston rod may in a measure offset this. Now, beginning at one dead center, follow the action of both ends through a revolution. The air cylinder is filled with air at atmospheric pressure and the inlet valves are closed. The steam cylinder is taking steam at a sufficient pressure to maintain the necessary speed, depending on the position of governor valve of course. Supposing the valve to cut off at three-quarters stroke and expansion to begin before the air discharge valves open, it can be plainly seen that the engine easily overcomes internal friction of the entire machine, together with the resistance of the air to be compressed with an admission pressure considerably below boiler pressure.

The pressure on engine piston is continually decreasing as expansion goes on; at the same time air pressure is continually increasing until after discharge valves open. But remember the stored-up energy in our balance wheels; and right now (when the engine is lacking power and most needs it) is when it gets in its work. Let us also remember that our crank-pin is traveling continually faster in relation to the piston and its load, so that as it nears the dead center the flywheel energy has greater advantage, or, we might say, greater leverage on the piston and load, and passes over. On the return stroke the operation is simply reversed in the steam and air cylinders, respectively.

Of course there is a limit to all things, and how much the receiver pressure can be made to exceed the boiler pressure will depend on the speed, the size of the machine compared with the demand for air, and especially on the relative diameters of the steam and air cylinders. It is plain that the larger the air piston (after it exceeds the diameter of steam piston, which it sometimes does) the less is the possibility of this action.

Other things being equal, it appears to me that the later in the stroke the discharge valves open, the higher can the receiver pressure be pumped with a given steam pressure. Now, the higher the receiver pressure is carried the later the valves open. Any leaking of inlet valves, piston or piston rod has the same effect. So will a restricted inlet pipe, as we have really a less volume to start with.

I have in mind an article by Mr. F. Riddell, some issues back, in which he mentions the experiences of a Western visitor who made a wooden cover for the 6-inch inlet pipe, with a 1½-inch hole in center, fitted with a shutter for regulating according to conditions.

Wouldn't heavier balance wheels help out sometimes, provided of course that the compressor is not too large and can be kept at a reasonable speed?

In regard to the Westinghouse air-brake pump, it doesn't often cut this caper, and I will not take time to explain how it can come about; but when it does happen, it has the advantage of taking steam practically full stroke and has the momentum (and weight on down stroke) of pistons, etc., to assist, as would also leaky inlet valves or clogged air strainer.

The above is my theory on the question, which I have seen brought up several times in different papers. I have not gone into deep mathematics in regard to compression and effects of heat on pressure, etc., nor have I attempted to show the exact point of discharge valve opening, but used the plain example to illustrate my ideas. W. A. G.

Hanna Portable Pneumatic Screen Shaker.

The Hanna pneumatic screen shaker is the simplest possible arrangement of a valveless piston working in a cylinder, the piston directly attached to a holder arranged to hold the ordinary 18-inch, outside diameter, circular *foundry riddle*. The whole mounted either on a tripod (Fig. 1) or on a frame (Fig. 2), to be held by sockets fastened to posts or building walls. There is practically only one moving part, and no joints working under reversing strains.

Through a one-half inch mesh riddle the machine will shake all the sand that two men will care to shovel. Through one-fourth mesh all that one man should shovel; other sizes in proportion.

The machine will use about 12 cubic feet of free air per minute, and is designed to work at 80 pounds gauge pressure. The cost of compressing 1,000 cubic feet of free air to 80 pounds gauge pressure depends upon the compressor used, and upon the arrangements for handling and cooling the air before, during and after compression. The minimum may be stated at about 1½ cents, and the maximum may run up without any extraordinary circumstances to 6 cents, or 4 3-10 cents for 720 feet, the amount that the screen shaker might use in one hour. There is no reason for expecting such an expense, but it might be estimated that there would be a cost of 2 7-10 cents per hour for repairs on machine, compressor, hose, couplings, pipe line, riddles, etc., and the total operating expense for one hour would amount to 15 cents for one man and 7 cents for air and repairs; total, 22 cents. Should the question arise as to what there is to show

FIG. 1.

FIG. 2.

for this expenditure, the answer would be: "As much sand as this one man would have riddled by hand, or have wheeled to stationary machine in five hours." Cost of wages alone, 75 cents; saving, 53 cents.

It is emphatically a portable machine (see Fig. 3), and was designed with this as the guiding idea. The machine being easily moved, you can screen your sand right where you want to use it.

FIG. 3.

The tripod machine weighs 100 pounds; one man handles it. The Post machine weighs 50 pounds; a boy can handle this. There are other so-called portable machines on the market, weighing from 500 pounds to a half ton, mounted on four-wheel trucks, or to be placed by crane.

Miners' Phthisis.

It was a cause of satisfaction when it was publicly announced that the Transvaal authorities had appointed a commission to inquire into and report upon the health of miners and the conditions of labor in the mines; also that the Chamber of Mines had offered prizes for practical suggestions as to the best means of obviating the dangers to miners caused by the inhalation of the fine dust produced by rock drills.

The Chemical, Metallurgical & Mining Society of South Africa very properly set aside a few of its meetings to discuss miners' phthisis. A series of interesting talks was the result.

Reviewing the various opinions given, the *Mining Journal,* of London, England, says: "It must be admitted that it is difficult in discussing a malady induced under circumstances where there is probably more than one cause in operation to assign to each its proper share. All impure atmospheres reduce the vital resistance of the individual who is obliged to breathe them for a lengthened period. Even small quantities of CO and CO_2 are harmful, but as a rule the effects of these gases are transitory. They do not leave any structural changes behind in the respiratory organs. There is nothing in the lung upon which they exercise an injurious influence. The gases enter into physico-chemical relations with the constituents of the blood, and in acute poisoning they induce death by asphyxia. Oxygen, in a word, is not conveyed to the tissues. It is difficult, therefore, to understand how a transitory condition with no associated circulatory or structural alteration of the pulmonary tissues can give rise to miners' phthisis. The only gas that is apparently capable of causing changes in the lungs is nitric peroxide, but it is so virulent in its action that it induces acute pulmonary inflammation, which is apt to cause death in two or three days. The fact that Rand miners' phthisis is more rapidly fatal than that of the coal miner—a circumstance explained by the particles of grit in silicosis being harder and more angular than those of coal in anthracosis—and that a rapidly developing form of phthisis occurs similarly in men who follow dusty occupations above ground are facts that point to dust and not gas being the principal agent in causing the disease. How far in addition miners' phthisis on the Rand may not be tubercular is a point upon which the discussion has thrown little or no light. This part of the inquiry is still under consideration. Before any united action can be taken there must be a closer agreement of opinion as to the causation of the malady."

Notes.

Among the latest catalogs and price lists is a substantial little volume issued by the Lunkenheimer Co. of Cincinnati, O., manufacturers of valves, injectors, oil cups and steam specialties.

A new publication just issued by the W. J. Clark Co. of Salem, O., is pamphlet No. 24, which illustrates and describes some of the important products of these manufacturers of metal specialties.

Galland & Henning Co., of Milwaukee, has just contracted for the installation of 20 pneumatic drums at a cost of $1,900 each. They are to be supplied by The Conrad Schreier Co., Sheboygan, Wis.

The Empire State-Idaho Mining and Developing Co. has purchased motors for driving concentrating mill machinery and the compressed air plant in the mines at Wardner, Idaho. The electric transmission line is 90 miles long.

One of the largest turntables on the Pennsylvania Railroad System has been put in operation at Bradford, Pa. It is eighty feet long, is operated by compressed air and the largest engines can be easily turned on it. For months the company had to turn their large engines on the "Y."

A company has been organized at Delphi, Ind., to manufacture the Harris compressed air pump, which is being successfully operated in the oil field near here. It is claimed that a well producing ten barrels per day by usual methods, can be made to run in excess of 100 barrels by means of this pump.

In the *Iron and Coal Trade Review*, Mr. E. Kilburn Scott, M. I. E. E., A. M. I. C. E., writes on electric winding engines and describes in the course of his paper a compressed air apparatus for controlling a very large winding engine when the effort required to work the main levers becomes too great.

Mr. Ben Johnson, superintendent of machinery of the Mexican Central Railroad, recently presented a paper before the Railroad Club of Mexico in which he described his attempts to utilize the exhaust from air pumps on locomotives in raising the temperature of the feed water. He claimed that a slight economy resulted.

The Long Arm System Company of Cleveland, manufacturer of the Long Arm electrically operated hatchway for war vessels, has received orders from the Government for hatchways for the battleship "Louisiana" and for the cruisers "Maryland" and "West Virginia," now building by the Newport News Shipbuilding & Dry Dock Company.

Pneumatic cushions and mattresses are not new, but the chief trouble with them has been that they bulge into hillocks and hollows. A. A. Young claims to have hit upon a stay that will hold the air mattress in place and mattresses made with them are now being boomed by the Pneumatic Mattress and Cushion Company, 35 Broadway, New York City.

In view of the increased number of explosions of late on the Baku fields, Russia, the Russian Imperial Technical Society has decided on the recommendation of Mr. A. I. Mancho, a member of that society, to make a number of tests of the gas in various wells by means of the Shaw Gas Tester, which has already been described in COMPRESSED AIR.

The Eastern Vacuum Cleaning Co., Ltd., was registered in England, June 8th, with a capital of £40,000, its object being to acquire interests in patents, licenses, concessions and the like relative to the production, treatment, storage, application, distribution and use of air either rarified or compressed and to carry on a business as carpet and general cleaners.

Ten months ago Gillott coal-cutting machines of the disc type were introduced into the Mynheer splint seam, 2¾ in. thick, at the Dundonald Colliery, Fifeshire—compressed air being used as motive power. In the interim the output has risen from 50 to 300 tons a day. It is stated that a face of 160 yards is holed comfortably in six hours.

A competition was held at the Deutsche Seewarte, Hamburg, on April 1, 1903, for the best contrivance for measuring wind pressure. The competition was open to foreigners, and prizes of $1,250, $750 and $500 were awarded. An additional prize of $750 was offered to the contrivance which would be judged the best after a certain time for trial.

One of the latest of auxiliary appliances for automobiles is an air brake. A small air pump worked by a cam on one of the axles forces the air into a steel compression tank. The pump is arranged to work automatically, ceasing action when the pressure rises above eighty pounds, and beginning when it falls below forty. The compressed air is also used for blowing a whistle and for inflating the tires.

The offer by the empire of Austria-Hungary of a prize of $45,000 for a canal lift works to be built on the Danube and Oder River Canal, furnishes an excellent opportunity for American mechanical engineers familiar with the latest advances in structural steel and machinery work. American mechanical engineers are rated at their full value in that country, where already a number have received consideration for professional services.

Another saving in time is being made possible by the Schenectady (N. Y.) Railway Co., which has placed an air compressor in the basement of the building where the waiting-room of the company is located. Heretofore it has been necessary to send many of the cars equipped with air brakes to the car barns after each trip to have the supply of compressed air replenished. This afforded occasion for considerable delay which is now eliminated.

Berlin, for instance, has a pneumatic tube system superior to any quick delivery system of New York. By it telegrams, letters and postal cards can be sent from one part of the city to another more quickly than by telegraph, at a cost of 6 cents a card, or 7½ cents per letter. If you pay 12 cents, you can have a prepaid answer. This post is called the rohr, or tube, post. Its offices are distiguished by a red lamp, and are to be found in all parts of Berlin.

Inventors of compressed air appliances and other machinery will be more or less interested in a new organization which was formed November of last year, called the Inventors' and Designors' International Protective Association. Its object is to protect the inventors who may join it from any infringement of their patents and to eventually secure more stringent patent laws. The home office of the association is located in the *Times* Building, St. Louis, Mo.

In a circular recently issued by the Russian Customs Department, it was announced that appliances for the use of firemen, consisting of specially made masks with apparatus for the storage of compressed air, or for the purpose of pumping air under the masks while the firemen are at work, are to be dutiable on importation into Russia hereafter. India rubber or other hose through which the air may be conducted under the masks is to pay duty according to the material from which it is made.

The Compressed Air Company, of New York, which has met with many reverses since its organization, is to be merged with a prominent railway equipment company. The capital stock of the consolidated concern will be $6,800,000. Compressed Air stockholders are to get one share of the stock of the consolidated company for two shares of Compressed Air. They are also assessed $3 a share. Alexander C. Soper and Newell C. Knight, of Chicago, are on the directorate of the Compressed Air Company.

The practice of placing a shut-off valve on the main line leading from an air compressor to the receiver, usually situated outside the building, is one which should be discontinued, though fortunately, not in general use. A valve so located may have its sphere of usefulness, but it is difficult to discover just what it is. It is doubtful if a valve placed in the position indicated would pay for its cost and installation. A valve beyond the receiver is recommended, and it can often be employed to advantage.

A new water supply system for the Wisconsin University buildings and the Capitol at Madison, Wis., will be installed this summer. The appropriation of the

Legislature for this purpose four years ago, amounting to $16,000, was found insufficient to build a suitable water tower, and since the Legislature just adjourned refused to increase the appropriation, Acting Dean Turneaure, of the College of Engineering, who has the matter in charge, has decided to install the compressed air system. The present system is totally inadequate.

In the new Schenectady shops of the American Locomotive Co., compressed air is to be utilized to operate small pneumatic riveting and caulking hammers in the boiler shop and the chipping hammers and moulding hammers in the foundry. There are two air compressors, an Ingersoll-Sergeant with a 12½ x 14 inch cylinder, which is belted to the jack shaft, and a Corliss cross compound two-stage compressor built by the Laidlaw-Dun-Gordon Co. with 30 and 18 inch air cylinder and 18 and 30 inch steam cylinders and a 36 inch stroke. The air is to be used at 90 lbs. pressure.

In all the Baldwin-Westinghouse electric locomotives built for heavy haulage work the manufacturers are now recommending a complete air brake equipment. If the service is high speed the air compressor employed may be either motor or axle driven. If slow speed, only the motor driven type is declared serviceable. The Westinghouse Air Brake Company is manufacturing three standard sizes of these motor driven air compressors, which is said to be self-operating, noiseless, dust and water proof. Their capacities run from 11.8 to 29 cu. ft. of free air per minute.

The action of an air compressor is such that the resistance offered by the air that is being compressed is increased from the commencement of the stroke to the point at which the required pressure is reached, and the object and advantage of the fly-wheel is to equalize what would otherwise be an irregular working of the engine. The delivery of compressed air is intermittent, whilst the demand for compressed air is continuous. The receiver enables the maintenance of a uniform pressure notwithstanding the short operation of each stroke occupied in the delivery of compressed air at the required pressure.

The mechanical department of the Pennsylvania Railroad is in the "market" for better and quicker methods for cleaning steel cars with compressed air. It is an unusual thing for the Pennsylvania to go outside and especially to competing lines for information of any kind. The Pittsburg & Lake Erie, however, some time ago installed what is considered one of the best devices for cleaning steel cars. Compressed air is used. The Pennsylvania railroad heard of this, and recently sent Messrs. Gray and Nicoll, of Altoona, to investigate the machines. They were taken in hand by L. H. Turner, superintendent of motive power of the Lake Erie.

In the manufacture of soda and mineral waters, it is important that the water to be charged should come in contact with carbonic acid in the form of a fine spray or a thin film in order that it may be thoroughly saturated. A German inventor, Mr. Jan Frederick Beins, aims to accomplish the desired result with the aid of a small air pump operated by a water motor. The water is spread out into a thin film by being forced through the unglaced porcelain walls of the chamber, and there it comes in contact with carbonic acid, which is held under small pressures. To obtain sufficient pressure to force the air through the pores of the porcelain, a simple form of compressor is used.

By increasing the air pressure from the usual standard of 70 lbs. to about 110 lbs., and introducing a pressure regulator attachment, the Westinghouse quick action brake has been converted into what is known as the Westinghouse high-speed brake. This provides for the automatic regulation of the shoe-brake pressure, beginning with comparatively heavy pressure at high speeds and reducing the same relatively as the speed slackens, with the idea that this is the most scientific and efficient way of stopping trains. The extended use of this device has shown results very gratifying to the manufacturers. They claim that its absolute reliability, a quality above all others requisite in brake apparatus, has been fully proven. A claim is also made that a train equipped with such brakes will stop in about 30 per cent. less distance than that required for stopping a similar train under the old conditions.

The Science and Art of Mining, London, Eng., writes as follows:

"In all coal mines which are not free from possible mixtures which go to form an explosion, electric transmission in its present imperfect condition is hardly reliable; therefore, steam in the mine being out of the question, wherever hauling ropes are not applicable to advantage compressed air is an excellent servant, such as for coal cutting machines, pumps away in the workings, hauling beyond the effective limit of ropes. And to do the work to advantage, we should see to it that our air compressing appliances are right. The air compressors themselves should be equal to the highest possible call upon them, and the pipes for transmitting the compressed air should be large enough to do so at a linear velocity not exceeding 100 feet a second. By such means we avoid the terribly low efficiency that is too often obtained."

In a paper on the technical application of liquid air, read by Dr. Carl von Linden before the Cold Storage and Ice Association of London, Dr. von Linden expressed the opinion that liquid air cannot be spoken of to-day as a promising technical application of great importance, if there were no other property to consider beyond its low temperature.

In concluding his remarks he declared that the mistake had been recognized in regarding liquid air generally as "The Cold Storage Agent of the Future," "The Explosive of the Future" and "The Motor of the Future," but with due limitations he perceived in all these directions problems of greater and lesser importance, the solution of which, by liquid air, offers good prospects and appears worthy of the strenuous efforts of the engineer.

"Compressed air on tap" is not a novelty, but the idea of utilizing an ornamental railing as an air receiver is something which is decidedly new. Many of the employes of a factory at Dayton, O., use wheels in going to and from their work. Frequently the tires have to be "pumped up" and the management hit upon a plan which would save both time and labor.

Near the entrance to the factory several iron railings have been erected to protect ornamental grass plots which have been laid between the sidewalk and the street. A section of one of these railings has been connected with an air pump at the factory and a supply continually forced through the tubing. Three or four valves, attached to lengths of rubber hose, have been inserted in the railing, and when the cyclist wishes to harden his tire it is only necessary to attach the air hose and turn on the cog as he would the gas-jet in his room.

In the building of the new dam and power plant at Spier Falls on the Hudson River, by the Hudson River Water Power Company, an air compressor plant has been used with much success. This dam, which is built from Mt. McGregor to the Luzerne Mountains, is for the purpose of supplying electric power. It is expected that the generating plant will be ready for operation this summer and that the huge masonry dam will be completed within a year. With the increase in the price of coal last fall it was found that steam which had been used for power up to that time was very expensive, and a compressed air plant was established. The compressors are electrically driven with power from the Mechanicsville plant of the Hudson River Power Transmission Co. The plant consists of two 27 and 17 x 30" and one 14 and 22 x 16" duplex compound compressors driven by a General Electric synchronous motor when furnishing air at 80 lbs. pressure. The compressors are all rope driven. Eight inch main air lines lead to the various parts of the work from which the smaller lines are tapped and carried to the various pumps, hoisting engines, etc., which small line is provided with a reheating apparatus.

If an ordinary stud be screwed into a "blind" hole, there will be a certain amount of air trapped and compressed in the hole by the studs as it is forced in. Now, the pressure of this compressed air acting on the stud is liable to loosen it, and cases constantly occur of loose studs from this cause; to avoid this it has been suggested that a groove be cut along the threads so as to leave a small air passage just below the threads; up this the air, or oil used for lubricating the tap, can pass. A similar thing takes place in case of covered nuts, so that it is possible to take similar steps to stop the action. In the case of small ones a groove up the screw as described would do, but in the case of large nuts, such, for instance, as are used for securing the propeller on the shaft of a screw steamer, a hole is usually drilled in the top of the nut, and a screw fitted to the hole to maintain the water-tightness of the cap. Where the bolt or shaft is horizontal it is better to have the hole near the edge, and, after tightening the nut up, to fill the hole with soapy water and replace the small screw. By having the hole at the edge it is evident that it can be turned up so as to be at the highest point for all the air to be driven out.

A blow-out of compressed air in the south heading, section B, of the Boston Subway Extension tunnel under Boston Harbor, on June 19, resulted in a cave-in that buried one or more men and injured several others. The tunnel passes under the harbor from Atlantic Street Station to East Boston. A shield was being used with an air pressure of 12 lbs. per sq. in., and, according to local newspaper reports, one of the workmen struck his pick into a seam of quicksand, whereupon the compressed air began to escape with a loud noise that was called an "explosion of compressed air." One of the inspectors who was in the shield at the time of the accident reported that during the first outburst the air escaped for about 10 seconds, then stopped for a second, then escaped for a minute, stopped again and finally escaped steadily for 15 minutes. Another inspector estimates the time of air outrush at about 5 minutes. The velocity of outgoing air was so great as to draw one workman into the earth where he was buried. The "explosion" has caused a depression in State street 10 ft. deep and 50 ft. square, and several buildings are leaning badly. Thirty men were in the drift at the time of the accident, and it is remarkable that more were not killed. The tunnel itself was not seriously injured.

Mr. Joseph Price, an English engineer, has recently devised and patented in England several changes in appliances for raising deep-seated waters by compressed air, particularly from deep-bored or artesian wells. The principal features of his invention are the substitution of a rising main, the area of which increases as the point of delivery is approached; the provision of an adjustable annular air ejector at the point where the compressed air is released; and the introduction of subsidiary or starting ejector at a high level when desirable.

The first of these, it is claimed by Mr. Price, permits the compressed air to expand freely in rising without increasing the velocity and consequently the application of the rising column of water. The ejector discharges the air at a high velocity which, it is said, induces an initial flow of the water overcoming its inertia and leaving thus less work for the power to do otherwise. The supplementary ejector, applied only when the lowering of the water level to obtain the supply has to be considerable, is used to effect a preliminary partial lowering, when it may be closed and the air allowed to issue from the lower ejector, thus avoiding the excessive pressure when the whole head has to be overcome at once.

Typewriter operators will be interested in learning of a new device that has recently been invented and patented by Jas. S. Parmenter, of Woodstock, Ont. The device consists of a pneumatic means of returning the carriage to the starting point after a line has been written.

By the use of this apparatus the work of shifting the sheet is transferred from the hands to the feet. The device consists essentially of a pneumatic cylinder supported on and secured to the carriage frame and having an arm extending against the end of the spacing lever or crank, a piston and hollow rod extending into the cylinder, an air pump suitably supported, preferably near the floor, underneath the typewriter desk, a tubular connection between such pump and the hollow rod extending into the cylinder and a sliding pedal having an operative connection to the piston of the pump.

At the end of each line it is necessary for the operator merely to push the sliding footrest away from him and the carriage at once passes across its bed and at the same time the spacer is acted upon to push the copy further along and the work is then in position to commence a new line. With such a device as this it would not be necessary to remove the hands from the keyboard for any purpose and the speed of a writer would be considerably increased thereby.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Editor of COMPRESSED AIR:

In your May issue of COMPRESSED AIR I was pleased to see the prominence you have given our plant, with illustrations. I want to correct, however, your illustration No. 2, which you say is when the carpet is nearly cleaned. We do not handle carpets that way at all; in fact, the whole carpet is cleaned on the screen at the foot of the operator. On the table, where you see employed the man without the head, is wearing apparel being dusted by compressed air. We clean lots of women's skirts especially and do wonderful work.

The latest effort and success in the use of compressed air with us is the cleaning of horses. In this case we use air from 30 to 50 pounds pressure. The air is run through a brass coil of a National water tube heater, which is put into an old oil barrel. This pipe with the air in it is surrounded by water, which we heat with steam to boiling point, so in this way the air feels soothing instead of chilly to the horses. In applying it to the horse we have about a four-inch nozzle (a little pipe with a slit in it). We hold this in one hand and a common horse brush in the other, loosening the dirt with the brush and blowing it out with the air. We have eight horses with various dispositions, and while at first the noise and the hose, etc., makes them feel a little bit nervous, I think they are getting used to it and rather like it. It makes them slick and clean as can be; in fact, it gives them a silky appearance.

In addition to that we use the compressed air on all our machinery and in cleaning all our goods, bedding, etc., that we make before packing same for shipment. GEO. J. KINDEL, Proprietor,
Denver Compressed Air
Cleaning Works.

[Mr. Kindel has since written us to say that the cleaning of horses with compressed air has proven a complete success.—Ed.]

Editor of COMPRESSED AIR:

Mr. Kent in his "Mechanical Engineers' Pocket Book" quotes Mr. Kimball as saying: "When air is compressed, all the work which is done in the compression is converted into heat and shows itself in the rise in temperature of the compressed gas." Mr. Kimball then admits that the energy of cooled compressed air comes from the heat it had before compression.

Now if the heat of compression can be turned into power, then this power, plus the power that can be obtained from the cool compressed air, may more than equal the power required to compress the air: but if the losses have been so great as to leave no considerable surplus, then the exhaust air can be used to condense a liquid which the free air will evaporate and from the vapor more power can be obtained.

Carbon dioxide becomes a liquid at 890 lbs. pressure, 70 deg. F. The heat of compressed air can be used to evaporate this liquid and from the vapor power can be obtained. The carbon dioxide will have to be kept confined and used continuously.

Carbon dioxide can also be used in the other apparatus in which it is condensed by the exhaust air and vaporized by free air. From this vapor the third installment of power can be obtained. The free air used to evaporate this carbon dioxide becomes cold in passing through the vaporizer, and can be used to condense the carbon dioxide vaporized by compressed air. Trouble from the low temperature of the air exhaust can be avoided by using a compound engine.

Why cannot this whole apparatus be made so efficient that the surplus power will equal the power required to compress the air? Theoretically, nearly twice as much can be obtained.

JOHN M. WOODS.

INDEX.

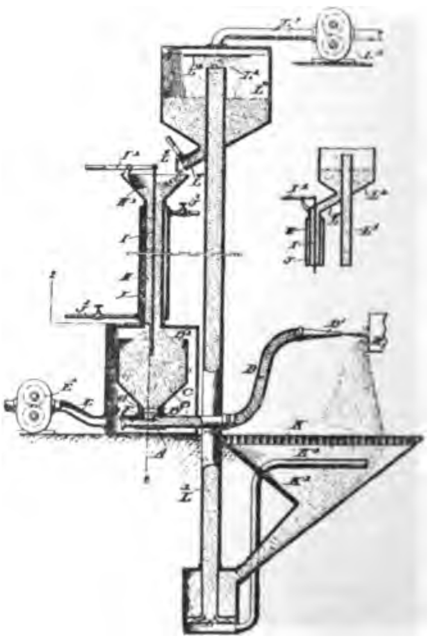
U. S. PATENTS GRANTED MAY, 1903.

Specially prepared for COMPRESSED AIR.

726,913. PNEUMATIC-ACTION FOR MUSICAL INSTRUMENTS. Frederick W. Hedgeland, Chicago, Ill., assignor to W. W. Kimball Company, Chicago, Ill., a Corporation of Illinois. Filed Sept. 3, 1901. Serial No. 74,066.

727,030. SAND-BLAST MACHINERY. Benjamin C. Tilghman, Jr., Philadelphia, Pa. Filed July 8, 1902. Serial No. 114,765.

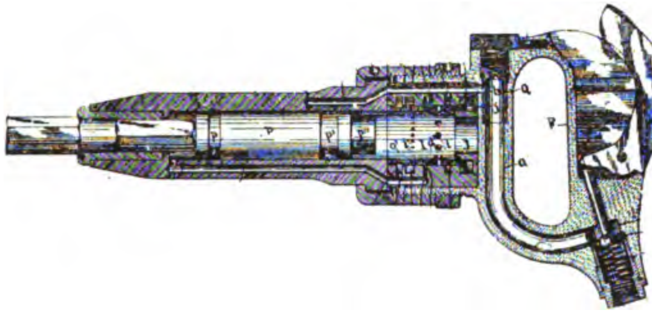
A sand-blast machine having a combining-chamber into which the sand and pressure fluid flow and mix and from which the mixed fluid and sand are led for use, said chamber having a passage for the entrance of sand, the combination therewith of a sand-feed conduit arranged to deliver sand to the said passage and in free communication with said chamber at is base, said feed-conduit being at the top free from the pressure in the combining-chamber and extending above its base connection with said chamber to a height which will give a sand-pressure at the chamber connection in excess of the fluid-pressure at the same point, and a restricted sand-blast nozzle through which the mixed sand and fluid issues from the chamber and by means of which the pressure in the chamber is maintained at a considerable degree above atmospheric pressure.



727,394. AIR-BRAKE. Joseph Lipkowski, Paris, France, assignor to Societe Generale des Freins Lipkowski, Paris, France. Filed Jan. 31, 1903. Serial No. 141,316.

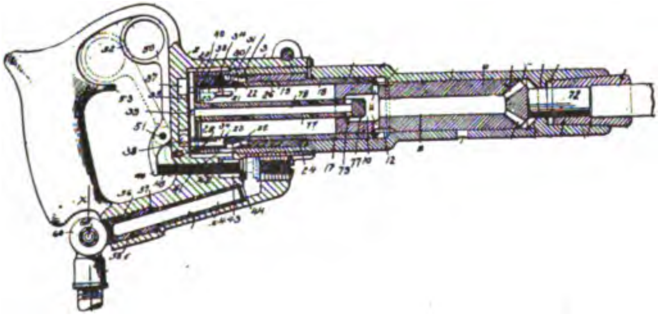
727,431. PNEUMATIC TOOL. Clarence W. Peck, Athens, Pa., assignor, by direct and mesne assignments, to Imperial Pneumatic Tool Company, Athens, Pa. Filed July 17, 1902. Serial No. 115,958.

An impact tool, the combination of a cylinder, a reciprocating piston therein, a cylindrical ported valve movable in line with the piston in a chamber at one end of the cylinder, and an enlargement on the valve travel-



ing in a separate chamber, to and from each side of which motive fluid is admitted and exhausted at each stroke of the piston to shift the valve.

727,954. PNEUMATIC HAMMER. Franklin M. Iler, Marion, Ohio. Filed June 17, 1901. Serial No. 64,794.



A fluid-pressure hammer comprising a cylinder or casing, a piston reciprocating therein, a sleeve-valve also reciprocating between the piston and the cylinder or casing and provided with a port, the cylinder or casing being provided with inlet and outlet ports with either of which said valve-ports may register, the sleeve valve closing one of said ports when the valve-port is in register with the other, the piston fitting within said sleeve-valve and being adapted to close its port and by compression ahead of it to exert a pressure on the valve tending to move it in one direction.

727,696. PNEUMATIC SPRING. Burrus L. Sanders, Dalton, Ga., assignor of five-eighths to A. B. Mason, Florence, Ala., and W. S. Sanders, Dalton, Ga. Filed Apr. 23, 1902. Serial No. 104,348.

728,068. PNEUMATIC PRUNING-SHEARS. Wesley Young, San Francisco, Cal. Filed Feb. 16, 1903. Serial No. 143,578.

728,084. ACID OR OTHER LIQUID DISTRIBUTING SYSTEM. William L. Colson, Savannah, Ga., assignor to Frank M. Wever, Savannah, Ga. Filed May 19, 1902. Serial No. 108,015.

An acid or other liquid distributing system, the combination with a compressed-air-supply pipe, an acid or other liquid transfer tank into which the compressed air is admitted through said pipe to force the liquid therefrom, of an air-vent communicating with the compressed-air-supply pipe, a valve automatically operated by the pressure of air to close the vent in said air-supply pipe when compressed air is admitted through said supply-pipe to the tank and to open said vent when the said air-pressure is cut off, and an acid or liquid supply tank or reservoir communicating with said tank.

728,069. PNEUMATIC PRUNING-SAW. Wesley Young, San Francisco, Cal. Filed Feb. 16, 1903. Serial No. 143,579.

728,413. MECHANISM FOR COMPRESSING AIR OR OTHER GASES. Willie H. Reynolds, Chicago, Ill., assignor to the M. and P. Co. of Chicago, Chicago, Ill., a Corporation of Illinois. Filed Dec. 2, 1901. Serial No. 84,314.

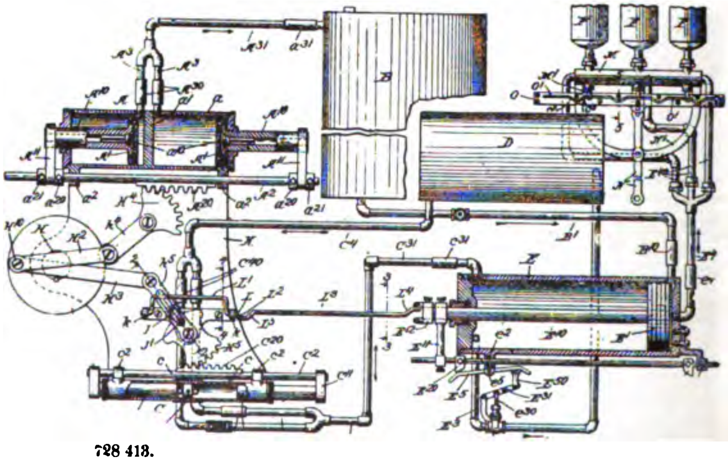
A gas-compressing mechanism comprising a gas-compressing pump, a liquid force-pump, a high-pressure storage-chamber for compressed gas, a piston-chamber and a piston therein, said piston-chamber having at one side of the piston an inlet from the gas-compressor and an outlet to the high-pressure chamber and valves controlling the same, and having at the other side of the piston an inlet from the liquid force-pump, and an outlet both provided with check-valves, and means for operating the compressor and the force-pump.

728,511. PNEUMATIC STACKER. Francis L. Stallard, Macy, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Feb. 6, 1903. Serial No. 142,160.

728,917. PNEUMATIC ELEVATOR FOR COTTON. John W. Hicks, Shreveport, La. Filed Mar. 3, 1902. Serial No. 96,527.

A pneumatic elevator for cotton comprising a separating-flue, a dust-box below it, a partition between the dust-box and the separating-flue, having a smooth surface over which the cotton passes, and a series of wire-cloth deflectors arranged in the flue, alternately, on opposite sides thereof, and having chambers behind them, communicating with the dust-box through openings in the partition, each of said deflectors being arranged to slant toward the central portion of the next succeeding deflector, whereby the cotton is caused to strike or abut against the deflectors successively, and the dust is thereby shaken out of the cotton, and caused to pass into the dust-trough through the communications between the dust-box and the chambers behind the deflectors.

729,014. PNEUMATIC APPARATUS FOR CONTROLLING DURATION OF EXPOSURE IN PHOTOGRAPHIC SHUTTERS. John E. Thornton, Manchester, England. Filed Oct. 16, 1899. Serial No. 733,789.

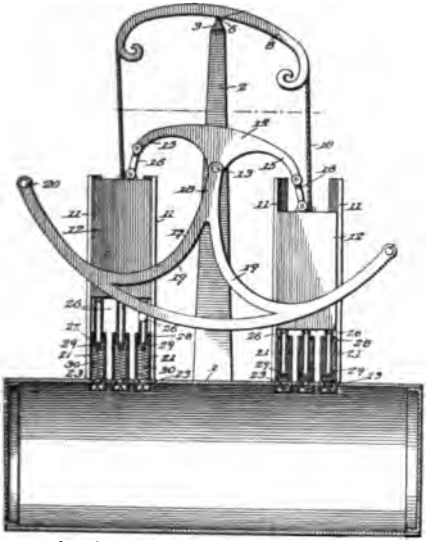


728 413.

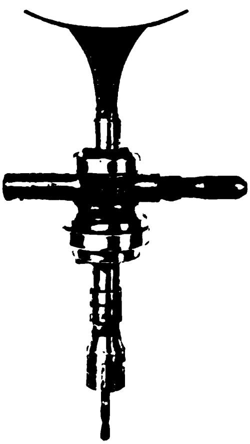
728,966. PRIMARY PNEUMATIC-VALVE IN MECHANISM FOR PLAYING MUSICAL INSTRUMENTS. Robert W. Pain, New York, N. Y., assignor to the Aeolian Company, New York, N. Y., a Corporation of Connecticut. Filed Apr. 21, 1902. Serial No. 103,880.

728,149. AIR-COMPRESSOR. John C. Williams, Kansas City, Mo. Filed Mar. 12, 1902. Serial No. 97,929.

An air-compressor comprising a storage-cylinder, a plurality of air-compressing tubes connected to the cylinder, plungers co-operating with and movable through the upper ends of said compressing-tubes, said plungers having upper open ends, counterbalancing-weights



operating in connection with the plungers and contacting with the upper open ends of the latter, and operating mechanism attached to the said weights.



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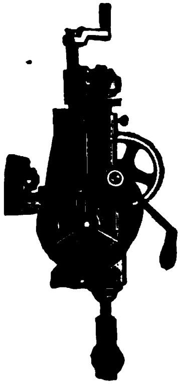

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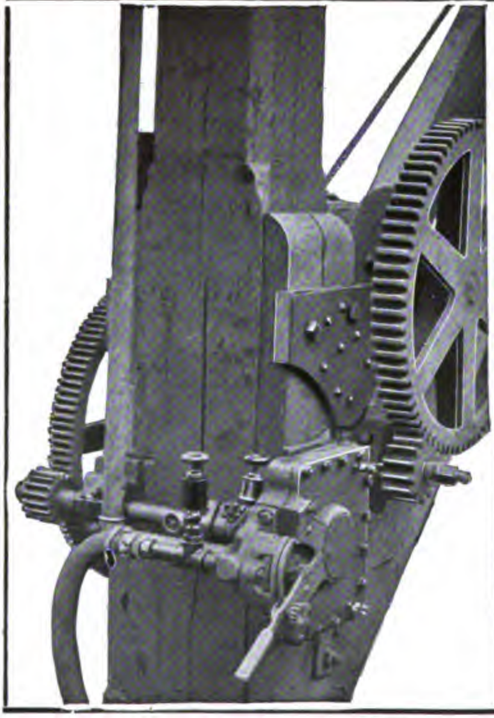


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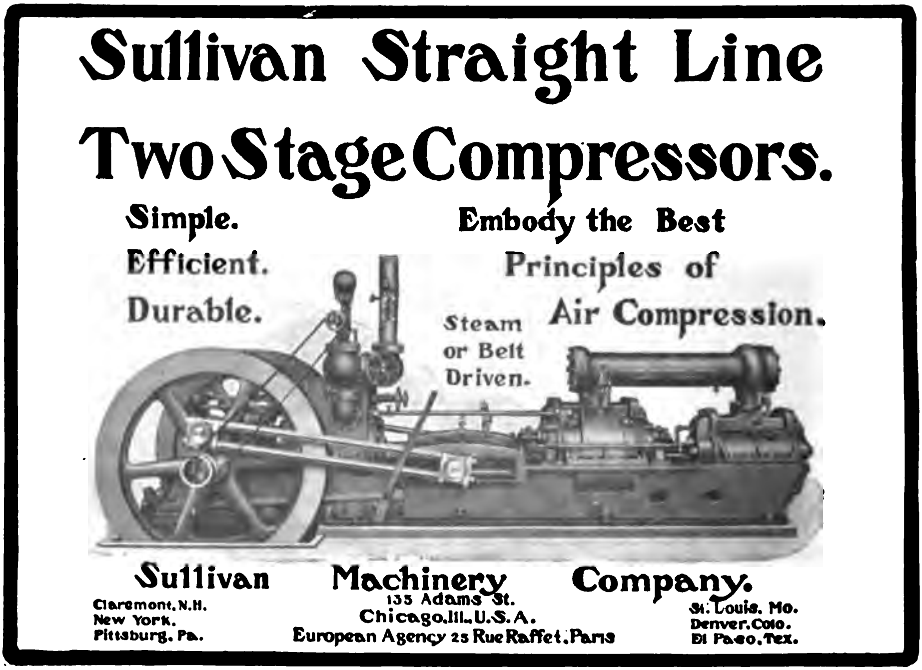
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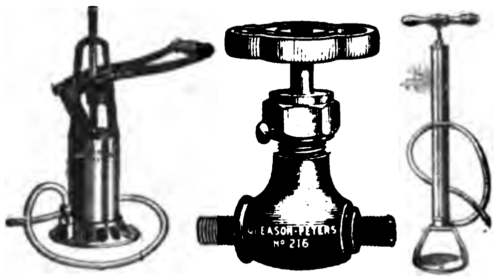
A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, AUGUST, 1903. No. 6.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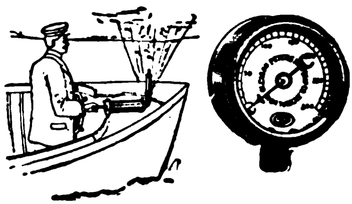

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"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Publicity for Compressed Air.

It is probable that the people of New York have had the practical value of compressed air from a mechanical point of view brought home to them with more force than ever before since the work on the Subway has been in progress. Hardly a contractor employed on this great underground railway has not utilized this form of power transmission to a considerable extent. Rock drills have been a common sight, while pumps, hoists, tools and a host of other practical applications of air under compression were commonly noted.

In two ways has this been of great value to the manufacturers of compressed air machinery. There is probably no other engineering work of the present decade which has been so eagerly watched by the engineer, who has sought to learn how the many problems inevitable in such an undertaking have been solved. Compressed air has figured prominently, and its varied and successful uses are going to result in its extensive adoption on other public works, where it has heretofore figured but little. Then, too, the public at large has unknowingly been coming to a realization of the importance of compressed air in undertakings of that nature. While it is undoubtedly true that the public will have little to say as to the methods employed, depending on the expert engineers for such details, yet the more the people know of the importance of compressed air in industrial work the greater will its sphere extend.

Because air is such a commonplace thing, always with us, unseen and yet powerful, the unthinking man forgets what an important factor it is. Electricity, on the contrary, is frequently displayed in almost overwhelming fashion. What is more impressive than a severe summer shower with its accompanying electrical display? It is to be expected that the more demonstrative force should acquire a greater place in the public eye. One imagines all sorts of wonderful things of it, while the latent power of the air around us is forgotten. Even when the air itself, rushing along at great speed, carries danger and destruction in its path, many are accustomed to think of what they call wind rather than the air as the all powerful factor. It requires, therefore, some vast undertaking like the New York Subway to bring home to the people the mechanical value and practical application of the air we breathe.

Compressed air machinery has been steadily gaining ground, as has been shown in the issues of this publication, and the future will see it used even more generally than now. Nevertheless, such publicity is going to materially assist in hastening that progress.

Accidents to Air Compressors.

It sometimes happens that one of our good friends points out to us an account of an accident at a compressor plant in which the compressor itself is, according to published prints, responsible. Without in any way throwing discredit on the daily newspapers of the country, we must contend that almost without exception these accounts are woefully inaccurate and place the blame on the compressor, where it does not belong. The reason for these errors is generally lack of information or knowledge of the true cause.

There are cases where false ideas of economy have led to the use of cheap lubricating oils, the deposit from which is inevitably injurious and may be the cause of an explosion. Much more often, however, some gross carelessness is responsible for the accident. Like every other machine, the compressor must be cared for and well treated and will prove harmless as long as it receives proper attention. It will, as well as any other mechanism, attain dangerous possibilities if neglected. The compressor is a valuable machine and needs even more careful attention than a steam engine. Air discharge valves should be looked into regularly once a week. Because with proper care a compressor will behave so well, there are some who have acquired the mistaken idea that it can be left to itself. It is true there are few machines that cause as little trouble as an air compressor if given proper and regular care, so it is particularly important that the attention be given at the right time and in the right way and the efficiency of the machine kept unimpaired. If this course was more generally followed, accidents with compressors would be a rare occurrence.

Air vs. Electric Hoists.

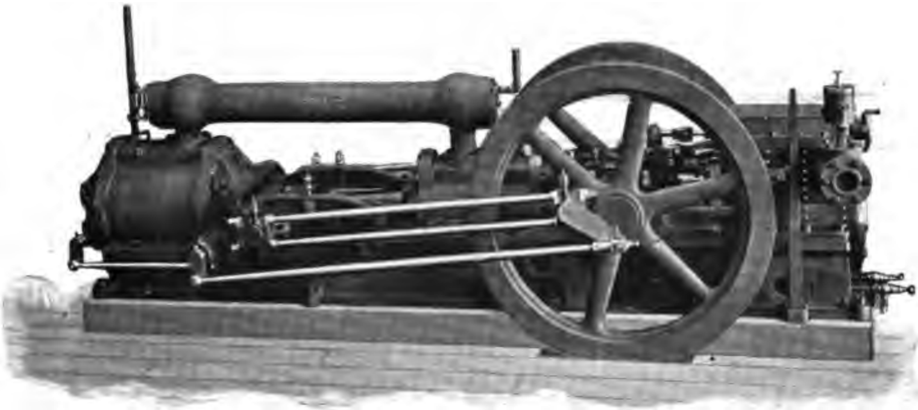
An inquiry has come to us from one of our friends for some accurate data showing the comparative merits of compressed air and electric hoists. As far as we know, nothing on the subject of an exhaustive nature has ever been published. Compressed air and electricity have figured in many a controversy, but these really allied powers have hitherto confined their comparisons to other fields. While the circumstances under which they are called upon to operate may make a vast difference in the relative merits, we are confident that in the long run the advantage lies with the compressed air hoists; provided, of course, that a good reheater is used. The air hoist has always the benefit of simplicity in construction, identical with the best steam practice, for an air hoist is little more than a steam hoist with air as the motive power.

For the benefit of our correspondent and for our readers as well, we shall be glad to publish any letters on the subject which may tend to throw some light on the question of the relative merits of the two classes of hoists.

Electro-Pneumatic Switches.

While the electro-pneumatic block system has been in operation on the Central Railroad of New Jersey for over thirteen years, the first power operated plant of interlocking switches has just been installed at the West Eighth street yard, Bayonne, of that railroad. The system in question governs the main line switches and those connecting with the freight yard and freight lines to Port Johnston, the yard at this point being one for receiving coal trains for Port Johnston.

The plant, which has been installed by the Union Switch and Signal Company, of Pittsburg, Pa., is one of that company's latest improved type. The construction throughout is of the most stable kind, with iron signal poles having internal connections for operating the semaphor arm poles, mounted on concrete foundations, galvanized piping and other details of the modern interlocking system. While the interlocking switches are not new on the Jersey Central, they have been heretofore operated by hand from the signal tower. This new plant substitutes compressed air controlled by electricity for hand power. Both switches and the accompanying signals are operated by air at 65 pounds pressure per square inch, taken from the two-inch main air line which runs from Jersey City to Bound Brook to operate the automatic block signal already mentioned. This line is supplied from three compressing plants, which are located at Jersey City, Roselle and Greenbrook.



NORWALK COMPRESSOR USED BY CENTRAL RAILROAD OF NEW JERSEY.

This interlocking system in the West Eighth street yard includes one tower where the switches are manipulated. The machine in the tower contains eight levers for the operation of 20 switches and three sets of movable joint frogs. Then there are five levers for the operation of 15 signals, making a total of 13 operating levers. In addition, there are ten spare levers, so that considerable additions to the plant may be made at any time without having to enlarge the machine.

The air cylinders for operating the movable joint frogs are 8 x 7½ inches stroke; those for single switches, 8 x 6½ inches, and those for the signals, 3 x 3½ inches stroke. The operation of the cylinders is, of course, controlled in the usual way in plants of this kind through the medium of electromagnet valves, operated from the machine. The supply of electric current for operating all the circuits through the interlocking machine, necessary for this control, is secured from a gravity battery in the tower, consisting of four series of 16 cells each, arranged in series. All main line signals at this point assume a danger position when trains pass through on the track which they govern, signals being made semi-automatic in their control through the medium of track circuits, so that there is no interruption at this plant of the electro-pneumatic automatic block signal system. These signals differ from the purely automatic, inasmuch as they are interlocked with the switches and are controlled in the interlocking tower. Upon their assuming the danger position on the passage of a train, they will remain so until the train passes out of the block section controlling it, thus preventing the display of a clear signal by the operator. One train following another waits until the first train has cleared the block beyond the interlocking point. This plant, in the design of apparatus, is similar to that installed at the Boston Southern Station some few years ago. It also corresponds to the three large plants recently installed at the new Albany station on the N. Y. C. and H. R. R. R., the Auburn branch of the West Shore and the connection with the main line at Syracuse Junction.

Mention has already been made of the electro-pneumatic block signal system. It was put into operation over a part of the road in 1890, and was extended January, 1893, to Bound Brook, where the four tracks of the Central end. This system is a very simple one, and is operated with much success. In the few wrecks that have occurred on that line, it has been subsequently proven that the signal system was not at fault, and that the blame for the accident rested elsewhere. The signal towers are at varying distances apart, usually not more than half a mile, and sometimes much less. There are two semaphores for each track, one showing the danger signal when the block in front is occupied, and the other serving as a cautionary signal to show that the second block in advance has not been vacated. They receive air pressure for operating from the main pipe line already referred to, the cylinders being controlled through the medium of electro-magnet valves, which in turn are controlled in the usual way from track circuits.

Three compressing plants, located respectively at Jersey City, Roselle and Greenbrook, keep the pipe line fully supplied with air. At the Jersey City station are two compressors, which not only are utilized for furnishing air for the block signals, but supply a certain amount of compressed air for shop use. One of the machines is an Ingersoll-Sergeant straight line Class "A" compressor, with air cylinder 16¼ x 18 inches and steam cylinder 16 x 18 inches, which supplies 518 cubic feet free air per minute, and requires a boiler of 70 horse-power. The exhaust steam is also used to operate one of the boiler injectors in connection with a quarter-inch pipe from the boiler. The compressor discharges through a 4-inch pipe into six reservoirs, 30 x 36 inches inside measurement, the six being connected in series with 3-inch pipe. There is also one Norwalk straight line air compressor which is used for block signals and shop use. It has air cylinders 10 and 6¾ x 12 inches, and a steam cylinder 10 x 12 inches. Its capacity is 207 cubic feet of free air per minute, requiring 28 boiler horse-power. It discharges through a 2-inch pipe into the reservoirs.

INGERSOLL-SERGEANT COMPRESSOR USED BY CENTRAL RAILROAD OF NEW JERSEY.

At the Roselle power plant there is another Norwalk straight line compressor, with air cylinders 14 and 9½ x 16 inches, and steam cylinder 14 x 16 inches. Its capacity is 427 cubic feet of free air per minute, and it uses a boiler horse-power of 28. The pipe from the compressor is four inches, which is reduced to three, leading to the reservoirs. There are six of these similar to the ones at Jersey City. Of that number three are connected in series next to the power house, which are in turn connected with the other three on the other side of the railroad tracks.

The equipment on the Greenbrook power house consists of an Ingersoll-Sergeant straight line Class A compressor with air cylinder 14¼ x 18 inches, and steam cylinder 14 x 18 inches. This supplies 398 cubic feet of free air per minute and requires 55 horse-power of boiler. A 3-inch pipe leads to the six reservoirs similar to those at the other stations which are connected in series with 3-inch pipe.

We are indebted to Chief Engineer J. O. Osgood and Superintendent of Motive Power W. McIntosh, of the Jersey Central, and to General Manager J. G. Prout, of the Union Switch and Signal Company, for material in preparing the article.

The Air Turbine.

While the steam turbine has already demonstrated its usefulness and economy, the application of the same principle for compressing air is new. In *Cassier's Magazine* for May, 1903, there is a brief mention made of the subject. It is said that an important discovery has lately been made in the form of the blades, which enables this principle to be used with success for the air compressor, the original steam turbine or other high speed machine being coupled direct to the air turbine. The air turbine is very similar to the steam turbine, which usually consists of alternate rows of moving blades and guide blades and is driven at a high speed. Each row of blades increases the pressure and gives a perfectly steady blast. In the article mentioned it relates that such a plant, installed for a lead works on the Tyne, supplied 3,500 cubic feet of air per minute, at 4 inches mercury pressure. It is said when this plant is set to work an increase of 30 per cent. was noticed to the output of the furnace, due, apparently, to the steadiness of the blast.

Cassier's Magazine further tells of the furnace engine now running at the Barnley Iron Works, New Leeds, London, which consists of a steam turbine running at 5,200 revolutions per minute driving the air turbine. The output is rated at 11,300 cubic feet of free air per minute, at three pounds pressure. The power in the useful output of air was found to be 61 per cent. of that theoretically obtainable from the same amount of steam used in the theoretically perfect engine, between the same limits of temperature.

It is explained that in all these plants no air valves are required as the moving vanes maintain the pressure of the blast so that, as in the case of the original steam turbine, the repairs are practically nil and the efficiency of the plant will be maintained indefinitely. When an increased pressure is required to clear the furnace, it is possible to increase the speed of the steam turbine by opening a bye-pass admitting high pressure steam to the low pressure part of the cylinder, and the pressure given by the air turbine is thus increased in proportion.

A high pressure two-stage air compressor on the turbine principle is reported as now being constructed for the George Goch mine, at Johannesburg, South Africa. It is fitted with condenser, pumps and intermediate cooler, and is designed for an output of 4,000 cubic feet of free air per minute, at 80 pounds pressure.

Air Lift Plant at the San Antonio Abad Cotton Mills in the City of Mexico.

A mistaken idea prevails among many that the people of Mexico are not taking advantage of the latest mechanical contrivances. An excellent illustration of an up-to-date plant recently installed is that of the air lift plant which has just been started for the San Antonio Abad Cotton Mills, an entirely Mexican concern, located in the City of Mexico.

There are two artesian wells supplying water for the boilers and for the various processes of manufacture. Well No. 1 is 590 feet deep and cased to the bottom with 5-inch pipe. Well No. 2 is 459 feet deep and cased to the bottom with 4-inch pipe. The water is raised to two iron tanks on the roof of the building, the combined capacity of which is 50,000 litres or about 13,200 gallons. The discharge into these tanks is 28 feet above the ground. The water level in the wells when not pumping stands at from 2 feet to 8 feet below the surface, varying at different seasons.

Heretofore the pumping has been done by means of two Pulsometer pumps, Well No. 1 being connected to a No. 3 Nye Pulsometer having a 3-inch discharge to the tanks; Well No. 2 with a Korting Patent Pulsometer No. 0.45. At a test made by the superintendent prior to installing the air lift, the two Pulsometers raised in two hours 44,507 litres, equal to 5,887 gallons in one hour, or 98 gallons per minute. This test was made when all the machinery was shut down, hence the supply of steam to the Pulsometers was larger and more regular than when the machinery is going. The superintendent estimates that if the test had been made when all the machinery was running, the quantity of water raised would have been one-fourth less. He calculates the amount of steam used by both Pulsometers at about 15 horse-power, and the supply of water was always more or less irregular owing to excessive condensation in the steam pipes, the Pulsometer at Well No. 1 being about 200 feet away from boiler room.

The air lift plant was a complete success from the moment air was turned on. So far only Well No. 1 has been connected, the central air pipe system being used. Photograph No. 1 shows the method of connecting; the smaller pipe (painted white) is the 2-inch air supply, the large vertical pipe is the 5-inch discharge pipe which is carried directly up to the roof and then along the floor of the roof, a distance of about 165 feet, to the tanks, where it again assumes a vertical direction to the top of the tank, where both water and air are discharged, making a lift of 28 feet from the mouth of the well, besides the horizontal "push" of 165 feet. It is intended later on to discharge the water into a small tank

FIG. I—SHOWING PIPING AT WELL NO. I, THE MACHINE TO THE RIGHT BEING THE DISCARDED PULSOMETER.

placed nearly over the well and high enough to let the water flow by gravity and syphon into the large tanks 150 feet away. This will obviate the friction and back pressure of the long horizontal pipe and of so many elbows. To the right of the well in illustration No. 1 may be seen the now discarded Pulsometer pump. The first test with the air lift in this well was made in June. Following is an abstract of the result as taken down by the superintendent of the mill:

Total length of 5-inch discharge pipe from well to tank, 192 feet, with 5 elbows.

Central air pipe in well, 1½ inches diameter, lowered to 30 meters = 98 feet below the surface.

Length of 2-inch air pipe from receiver to well, about 200 feet.

Speed of compressor, 142 revolutions = 98 cubic feet free air per minute, developing 10 H. P.

Starting pressure at receiver, 47½ lbs.

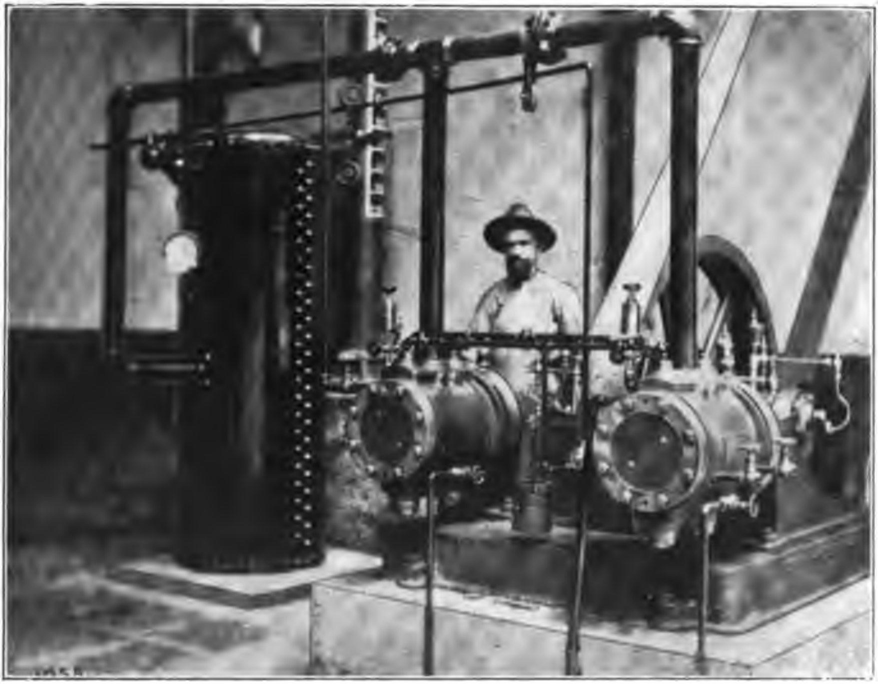


FIG. 2—COMPRESSOR PLANT AND FLOATING INDICATOR AND REGULATOR.

Total depth of Well No. 1, 180 meters = 590 feet.

Cased to the bottom with 5-inch inside diameter pipe.

Depth of water level from surface, when not pumping, 2 meters = 6 feet 6 inches.

Vertical height of discharge pipe above well, 8.5 meters = 28 feet.

Horizontal distance from well to tank, 50 meters = 164 feet.

Working pressure at receiver, 43 lbs.

Quantity of water raised per minute, 725 litres = 192 gallons.

Cubic feet free air per gallon, 0.51.

Horse-power per gallon, 0.0521.

The air compressor used (Fig. 2) is an Ingersoll-Sergeant duplex belt driven class "J," the two cylinders being 8-inch diameter by 6-inch stroke. The free air capacity of the compressor at its present working speed of 142 revolutions is 98 cubic feet per minute. Making due allowance for the lower density of the atmosphere at this altitude (7,350 feet), this is equal to 78 cubic feet at sea level. The compressor, which is located in the main engine-room, delivers its air to a vertical steel air receiver 24 inches diameter by 6 feet high, set close by it (photo. No. 2), from whence it is conducted through 2-inch pipe a distance of about 200 feet to Well No. 1. This air pipe enters the 5-inch discharge pipe through one of the horizontal openings of a 5-inch cross, placed just above the mouth of the well, where the air pipe, being reduced to 1½ inches, descends for 30 meters inside of the 5-inch pipe. On the opposite opening of the 5-inch cross is inserted a short length of 2-inch pipe with a globe valve, elbow and nipple, so that water may be drawn from this point whenever desired by means of rubber hose or for filling buckets, etc.

One of the interesting features of this plant is the novel method adopted by Mr. Goyarzù, the superintendent, for keeping the depth of water in the tanks on the roof under perfect control automatically (see Fig. 3). A heavy wooden float is suspended on the water by means of a light wire, which passes over small pulleys along the roof and then down into the engine-room alongside of one of the iron columns that support the roof; this end of the wire carries a pointer attached to a counter weight. As the float moves up or down the pointer is carried with it and indicates the depth of water in the tanks on a scale prominently painted around the column so that the engineer can see at a glance from any part of the room just how much water there is in the tanks. The same wire is extended and passing over another pulley which is suspended above the air cylinders; it is then attached to the weighted lever of the un-

FIG. 3—SHOWING 5-INCH DISCHARGE OF WATER INTO THE TANKS ON THE ROOF.

loading device. When the float in the tanks has reached the desired height, say 80 centimeters, the wire pulls up the regulator lever and the compressor is unloaded, *i. e.*, continues running, but ceases to compress air until the lowering of the float in the tank releases the regulator lever and the machine starts compressing air again. By means of this "floating regulator" the wasting of water, which would otherwise go through the overflow pipe, is avoided and only the necessary amount of work is done by the compressor to keep the water tanks filled to the required level. This arrangement can be readily seen in the photo. No. 2. JUAN CUYAS.

The Use of Pneumatic Tools in the Preparation of Fossils.*

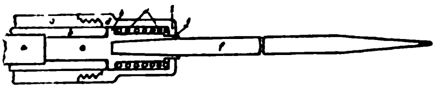
The tedious work of removing fossils from their matrix by means of the hammer, chisel and awl has led to various experimentation with machine tools in the hope of devising some more rapid method. The dental engine and the electric mallet have been in use in some laboratories for a number of years, and have proved very efficient in such work as the removal of hard matrix from small skulls. However, their efficiency has so far been limited to light work. This is probably due in a large part to the fact that the tools used are those constructed for the lighter work of dentistry. It is also generally conceded that electric appliances have not proved a success in percussion tools.

Pneumatic tools were introduced into the paleontological laboratory at the Field Columbian Museum by the writer some four months ago, and may now be said to have passed through the experimental stage. The application of these tools to fossil-cleaning has proved so successful that it has seemed worth while to call attention to their use in this work.

The pneumatic hammer as used in chipping and riveting metals and in stone-cutting is too well known to require description here. However, only the lightest hammers used in stone-cutting come within range of our present consideration. These are manufactured by a number of firms in the United States and are of two types, the pistol-grip and the straight cylinder. The latter type has been adopted by the writer on account of greater convenience in bringing the tool into use in work in all positions. Experimentation has shown that the smallest hammers on the market as stone-working tools are heavy enough for any work on fossils. A still smaller size would often be convenient.

The hammer in use consists of a cylindrical chamber in which a five-eighth-inch steel plunger having a five-eighth-inch stroke is caused to play upon the head of the chisel at the rate of 3,000 to 3,500 strokes per minute. This rapid succession of light blows sets up a vibration in the chisel which, with even a slight pressure against the work, gives it a remarkable cutting capacity. In fact a chisel so driven will cut an indurated clay as rapidly as an ordinary hand tool will cut chalk.

The chisels commonly used in stone-cutting are made uniformly of one-half-inch square or octagon steel about nine inches in length. Of these one and one-half inches of the head end is turned down to three-eighth-inch diameter, so as to fit into the chamber of the tool and provide the shoulder necessary to hold the chisel at the precise point which will render the stroke of the hammer most effectual. These chisels are used indiscriminately in all sizes of stone hammers and are ill adapted for the preparation of fossils. The requisite for such delicate work is a keen stroke under complete control. This has been in a measure attained by fitting an attachment to the stone-cutting hammer.



CROSS-SECTION OF PNEUMATIC HAMMER, WITH TOOL-HOLDING ATTACHMENT.

In the accompanying figure *a* represents the plunger, *b* the hard steel barrel and *c* the softer outer jacket of the hammer. A tempered steel cylinder *d* is attached to *c* by a heavy thread; this holds in position a separate tool head *e*, which receives the blow of the hammer and bears the chisel *f* in a taper socket. A coil spring *g* acting against the shoulders *h* and *i* in turn receives the blow of the hammer or any part of it not utilized in work at the point of the chisel. The tool head *e* is fitted to a square opening in *d* at *j* which pre-

* By E. S. Riggs, of Field Columbian Museum, for "Science."

vents rotation. The taper-socket holds the chisel in place so that it may be guided by the hammer; when desired the chisel may be readily released by placing in a vise and tapping the tool head lightly. One escape-vent is directed forward so as to blow away dust and small chips from the work. For chisels, one-fourth-inch round steel cut in six-inch lengths and drawn to a point of one-eighth or three-sixteenth inch in breadth is most efficient. For finishing a broader bladed chisel may be used to advantage.

This appliance makes it possible to dispense with the unnecessary weight of metal in the chisel so that a keener stroke and a greater cutting capacity result. At the same time the manipulator is relieved of the necessity of holding the chisel in place with the left hand and so avoids the benumbing jar caused by the vibration.

The advantages of this hammer over the old-fashioned hammer and chisel are its much greater cutting capacity and its freedom from the jar which causes so much breakage in specimens encased in hard matrix. The relative cutting capacity depends upon the nature of the material to be removed. If it be sandstone, by which tools are rapidly dulled, blocking off in large pieces by means of hammer and chisel will be found more expedient. Or if it be a very hard substance, such as quartz or chalcedony infiltrations, a method of spalling by means of a square-poled hammer may prove more efficient than either. But in limestone or any of the indurated clays the superiority of the pneumatic hammer is at once evident. This is especially true in the case of complicated specimens where there are deep cavities or foramina to be developed. In such work the pneumatic chisel can be used wherever its point can be introduced, while with the old-fashioned hammer and chisel one is often at a loss for room to hold and strike. The cutting capacity of a chisel is much greater also when used with the pneumatic hammer, as the point can be made much harder without danger of breaking. Chisels made from a high-grade English steel of 1.4 per cent. carbon chilled to a file-like hardness may be used four or five hours in concretionary clays without need of grinding.

The advantage of relieving the specimen from the jar of the hand-hammer can scarcely be overestimated. In working out dinosaur vertebræ from a concretionary matrix by means of hand tools we have often found it necessary to break the specimen to pieces with a hammer in order to remove the chalcedony-filled masses of concretion from the cavities. The use of the pneumatic chisel has made it possible to remove the matrix from such cavities, with but little injury to the specimen. The tendency to chip off thin edges with flakes of the matrix is also avoided.

Skill in the use of these tools is readily acquired. By adapting the size of the chisel to the work in hand and gauging the amount of air admitted to the tool by means of a push-button throttle valve, the stroke can be reduced so that a scale may be removed from the most delicate surface.

Efficiency Test of the Air Lift.

Notice has already been given in COMPRESSED AIR of the new form of air lift, designed and patented by Mr. Jos. Price, an English engineer. This possesses a new rising main which, unlike the old ones, increases in diameter as it nears the top. It is claimed by the inventor that if permitted to do so the compressed air will slowly expand while rising, as the pressure of the water above is lightened. To admit of this expansion the water above the air must of necessity be moved at an increased speed. The claim is that a large portion of the energy stored in compressed air has heretofore been uselessly consumed in imparting this additional rapidity of motion to the water.

The *Refrigerating Engineer*, an English publication, tells of an efficiency test recently made of an air lift of this type at the electric supply station of the Central London Railway at Leeds Road, Ilford, London. The report of the test is as follows:

"The well is bored 10-inch diameter to 400 feet deep, the rest of the water level being at 44 feet before pumping. The plant was arranged as for raising a supply of 10,000 gallons from 130 feet below to 20 feet above surface, and (excepting as regards the tubes) on lines dictated by the best American and German practice for parallel rising mains, which require 144 cubic feet of air to be compressed for the above duty, equalling a ratio of at least 5½ vols. of air to 1 of water, and a ratio of submergence to lift of 3 to 2.

"The rising main is of tubes increasing in area as the air expands in rising, thus maintaining a minimum of friction throughout, and has an internal air tube with adjustable annular ejector for economizing the air used and utilizing its velocity of discharge, which is at 336 feet below the surface, the water being delivered for testing purposes at 5 feet above surface over a weir fitted with a gauge for measuring the depth of flow.

"The air compressor, some 50 feet from the well, is of the two-stage type, with intercooler, proved to compress 144·2 feet of free air to 100 lbs. pressure of 115 strokes a minute, indicating 22 horse-power in the compressor, and is driven directly, through gearing, by an electric motor combined on the same bed plate and arranged to run the compressor at the above speed, viz., 115 strokes a minute.

"The plant was run continuously for 14 days and nights, lowering the water to an average level of 127·0 feet from the surface, or a total lift of 132 feet, the average flow over the weir, gauged every hour, being 3·31 inches, or 11,660 gallons per hour, say 195 per minute.

"During this run it was found that the air compressed (144 cubic feet) was much in excess of that required, and that a quantity could be leaked away without affecting the flow. This quantity was gauged by a hole through a thin plate as about 44 feet, thus reducing the volume actually used to 100 feet per minute, or a ratio of 3·2 volumes of air per volume of water, with lift 132 feet.

"On the completion of the above test, arrangements were made for slowing the motor, ultimately to 83 revolutions of the compressor, or as 115, 83, 144, 104 cubic feet, at which speed the flow was 3·80 inches, or 200 gallons per minute, the total lift being $119 \times 5 = 124$ feet, the water having risen in the well during the stoppage. This works out as 3·25 volumes of air per volume of water, thus verifying the estimate made previously by leakage measurement.

"Lifting 200 gallons per minute through 124 feet equals 248,000 foot pounds, and the power is as 144·2, 104, 22, 15·88 horse-power or 524,000 feet pounds, so, dividing the former by the latter gives about 47·3 per cent. efficiency.

"For fair comparison with precedent practice it is necessary to correct:—1st, for excess of the submergence over the standard 3 to 2, in this case, 31 feet; 2d, for the temperature which at time of observation was about 80 degs., or 25 degs. above the normal temperature. With these corrections the volume ratio of air to water becomes 2·7 to 1, and the efficiency 5·55 per cent."

Pneumatic Tube Service.*

The mythology of the ancient Greeks and Romans represents the messenger of the gods as a young fellow whose heels are shod with wings through which the air became the medium of his flight in conveying the messages and commands of his imperial masters. In the sacred poetry of the ancient Hebrews the "wings of the wind" constituted the chariot of omnipotence in the swift execution of sovereign purpose and command. The ancient literature of numerous other early civilizations is replete with the same figure.

In our day the "wings of the wind" as messengers have passed from symbol to fact—from mythology and poetic fancy to practical reality. The lithe, athletic Mercury, winging his swift course on the breast of a favoring wind with messages from imperial Jove to the lesser deities has become a little cylindrical "carrier," darting away with the rapidity of a bird on the wing under the impulse of a confined and directed air current, carrying its message safely locked within against harm or loss, and, after a brief period of swift flight, delivering its charge at its appointed destination.

The art of pneumatic dispatch tubes for the conveyance of messages, parcels, freight matter and even passengers in its theoretical aspect is over two centuries old. It is not the purpose here to treat of its early history and experimental development. It may, however, be noted that the art had its earliest development in Great Britain in the first half of the last century, and the records of the British Patent Office for the twenty years between 1835 and 1855 show astonishing activity and interest among

* By Edmond A. Fordyce, for *Cassier's Magazine.*

inventors in the art of pneumatic transmission of express and mail matter through closed conduits and tubes. The streets of London, Paris and other cities of Continental Europe were the scenes of numerous early experimental pneumatic tube plants, most of which, though successful mechanically, failed because of financial difficulties.

One of the oldest of the United States patents relating to the art was granted more than thirty years ago to Mr. Alfred Beach, of New York. It provided for a tube system which contemplated the carrying of passengers in cylindrical carriages traveling in a 10-foot tube or conduit and designed to be driven by an air current at a speed largely in excess of modern express railway speed. The drawing of this old patent shows the car at a station, with doors in the walls of the tube and car thrown back and passengers leaving and entering the car. But the scheme did not go beyond the experimental stage, though it is but fair to say that the causes that proved fatal to its practical development did not so much reside in mechanical impossibilities as in the enormous expense and outlay of capital which the construction, operation and maintenance of such a plant would have involved. But in our day of gigantic engineering and financial operations initial expense constitutes no serious obstacle to an enterprise which can be subsequently made to pay fair profits on the capital invested; and if on its mechanical side the fuel energy required for the transmission of a given weight of matter a given distance by pneumatic tubes can be reduced below the amount used to accomplish the same by the steam locomotive or electric motor, we may yet see pneumatic transmission applied to the direct propulsion of vehicles for passenger service, as well as for mail and express service.

Undoubtedly the most extensive, and thus far the principal, service which the pneumatic tube art has rendered has been in transmitting money and memoranda of sales between the sales counters and the cashier's office in dry goods and other shops—a mechanical convenience with which the public has grown so familiar that it is now regarded as an indispensable part of the equipment of every first-class retail establishment. And along with the development of the pneumatic store-service system has come the more tardy application of the same principle to the distribution of mail and express matter in large cities. Several of these have for a number of years enjoyed the benefits of rapid collection and distribution of mail matter through underground pneumatic tubes.

The earliest practical application of pneumatic transmission outside of shop and mail service was in the distribution of telegrams and telegraphic news matter. Prior to 1887 the Western Union Telegraph Company, in the United States, had established in New York a pneumatic service of its own for sending messages singly or in bundles between the branch stations and the main office, and for supplying the daily newspapers of the city with their associated press telegrams and special dispatches, these being sent in carriers through 1½-inch individual pipes leading to each point of collection and delivery.

In 1893 the City Press Association, of Chicago, out of patience with the slow and unsatisfactory delivery of telegraphic news dispatches by messenger boys, contracted for and installed beneath the streets of Chicago fifteen miles of the most costly and elaborately constructed pneumatic tubes ever put into service. These tubes connected the main office of the Western Union Telegraph Company with the offices of the association, the various newspaper offices, the City Hall, the Central Police Station and several other points, and since that time messages that, in the hands of some dilatory messenger boy, used to keep the newspaper presses waiting for half an hour, are now shot to their destination in but a fraction of a minute. This system, which was designed only after a thorough inspection of all the leading systems of Europe, is perhaps the most satisfactory of its kind ever installed, no expense having been spared to make it perfect in every detail.

Pneumatic tubes are coming to be regarded as an indispensable part of the mechanical equipment of large public libraries. In one of the earliest pneumatic transmissions of this kind the slips calling for the book, or books, desired were shot from the central distributing desk through pneumatic tubes to attendants at the stacks, the books themselves being sent to and from the delivery room by basket conveyors. Similar systems have since been installed in a number of large libraries, and constitute probably the most important and effective part of the time and labor saving equipment of such institutions. As messengers, they do their work with all the celerity of the telephone—and do it withal in perfect harmony with the spirit of silence that pervades the atmosphere of a library, which the telephone could not do.

The success of large-tube systems for the transmission of mail matter has led to an extension of such systems in express service for the delivery of parcels and packages from the retail shopping districts of large cities to the outlying residence districts. Through such large tubes merchandise and express matter may be sent, with but a few seconds or minutes at the most consumed in the actual transit between the distributing and receiving stations. The immense convenience of such a speedy system of parcel delivery may be appreciated from the fact that purchasers in shops frequently find that their purchases have been delivered and are awaiting them long before their return home.

Of late years pneumatic tubes have come to be extensively adopted also in warehouses, packing-houses, railway freight depots and other similar places. In the case of warehouses and supply houses of all sorts, the tubes are laid between the various buildings, and serve to connect the main office with the different shipping and receiving points of the establishment. Orders, requisitions, receipts and all kinds of mail matter are sent through these tubes, dispensing with the services of messenger boys heretofore employed; and, what is more important, eliminating almost entirely the time element—almost to the same extent, in fact, as the telephone and telegraph have eliminated it.

Three of the largest American railway systems recently installed in connection with their freight depots systems of pneumatic tubes by which all freight receipts, way bills, checks, etc., received at the different doors are dispatched to a central office, signed and returned to the door of the warehouse from which they were received, thus permitting the teamster to get the goods without the necessity of going to the main office, waiting in line and then returning to his wagon. It is, perhaps, impossible to estimate the time that is thus saved; but it would be no exaggeration to say that where business is heavy this pneumatic system saves from a quarter to a half hour of an employe's time in connection with each delivery.

One large manufacturing company uses the system for connecting different buildings of its plant, and sends blue prints, small tools, samples of material, etc., through the tubes from different departments, all connecting with a central office, something like a telephone exchange, where the goods are re-sent, if necessary, to other buildings or departments.

One large electric supply company recently installed a pneumatic tube line over half a mile in length, through which orders received at the main office are sent to the railway warehouse and are filled and shipped from there. Previous to the adoption of the pneumatic tubes these orders were sent by messenger boys, a method which involved a considerable loss of time, and frequently a mistake or loss in the delivery of the order itself. In another large pneumatic messenger installation the system has dispensed with the services of fifteen messenger boys; and in filling orders for railway delivery from twenty to thirty minutes are saved on each order, which means that an order received twenty or thirty minutes later than formerly is now filled and gotten off on the same day the order is received, while before the adoption of the tube system these orders would frequently have to go over until the next day. Many large factories have put in pneumatic tubes between their main offices and their various departments for the quick transmission of orders, blue prints and paper memoranda, which have hitherto required the services of one or more messenger boys. In still other departments of the business and manufacturing world too numerous for specific mention air currents as messengers to replace the tardy, tired and sometimes lazy feet of messenger boys and men are gradually coming into use. The old adage that "Time is money" was never truer than in the present day; and a system of messenger and express service that practically converts time into money, besides contributing an increased element of safety, is bound to meet with public favor and acceptance to an ever-increasing extent.

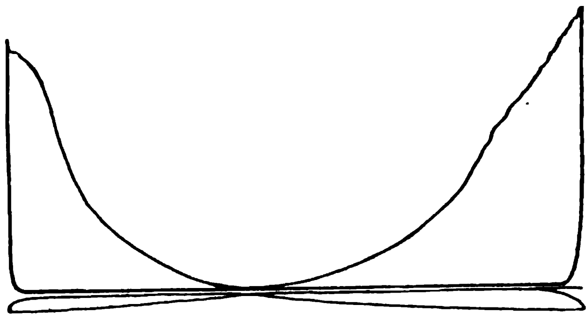
Compressed Air Running Steam Engines.

Some 50 engines are running in Norwich, Conn., by compressed air generated at the power station of the Continental Compressed Air Company at Taftville, on the Quinebaug river, and results so far show that the power is entirely satisfactory if the cost does not prove to be too great. These engines vary from 2 to 250 horse-power. The plant is located three miles from the furthest point of distribution, and compressed air is carried in pipes this distance with immaterial loss of pressure. The 90 pounds pressure at the compressor is reduced to 88 pounds at the furthest point of consumption, and the average loss of pressure in transmission is only about one pound. Fifteen hundred horse-power is thus distributed in the city of Norwich.

The Taylor system of hydraulic compression is used, the plan being similar to those at Magog, in Quebec, and at Ainsworth, in British Columbia. A dam gives a fall of 18 feet and at the foot of the fall is the compressor. The shaft is 208 feet deep and 24 feet in diameter, opening toward the bottom into a bell-shaped chamber with a maximum diameter of 52 feet. The downflow pipe in the centre is 14 feet in diameter. Generally speaking, the downflowing water receives large quantities of air in the form of bubbles, a tendency to a vacuum caused by the rapid flow compelling this influx of air. The bubbles are compressed in the long fall, and the air is separated from the water by means of a separator at the base of the shaft. The air is dry, no trouble resulting from the presence of moisture not even so much as in air compressed in the ordinary mechanical compressor.

The Continental Company is not yet ready to announce the price of its power. The initial price, to prevail until arrangements are made for metering, is $50 a year per horse-power. Some anxiety is expressed as to what the future price will be. The customers realize that the plant cost a good deal of money because of accidents during freshets, several times the machinery being washed away by the Quinebaug, which, though like a mild trout stream at ordinary seasons, in time of freshet is a roaring torrent. It is said that it cost nearly $750,000 to build the plant complete.

But while the cost of the power may be more than is required to run a steam engine by steam generated on the premises, yet the compressed air is cheaper than electricity distributed from stations in the vicinity of Norwich, it is claimed, and the advantages over steam are material, especially in the ability of an engine to stand up to its work when a great additional load is suddenly put upon it, as in such a plant as that of the Rogers branch of the American Wood Working Machinery Company, at Norwich, where heavy wood working machines are tested. A test of the engine under compressed air was made, every machine in the shops being started up, throwing three times the average load upon the engine. The only change noted was that the revolutions went down from 124 to 118, where under steam the fall would be from 124 to 90 revolutions with only twice the average load.



CARD FROM AIR OPERATING ENGINE.

Compressed air is admitted to the cylinder of an engine just as steam had been admitted. No change was made in the engine. The compressed air is passed through a heater before going to the cylinders, the heating process adding greatly to the efficiency, so that heating the air to 324 degrees F. gives an additional horse-power at the rate of about $8 a year. The advantage over steam is that no matter what load is put on the engine the gauge pressure remains unchanged, instead of having the steam pulled down, as must happen with the ordinary engine and boiler if heavy machinery, such as wood planers and molding machines, are set going on top of the usual shop load.

Some idea of the workings of compressed air as a substitute for steam in a steam engine may be obtained from the accompanying card reading of a Corliss engine: Boiler pressure, 88 pounds; revolutions per minute, 55.5; scale, 40; piston diameter, 26 inches; stroke, 48 inches; piston rod, 3 13-16 inches; exhaust pressure, 3 pounds; developing 80 horse-power.—*Iron Age.*

Lifting Water by Compressed Air.*

At the last meeting of the society, held in Warren, I had the pleasure of listening to a paper entitled, Air-Lift Versus Deepwell Pump, by Brother McConnoughy. The interest taken in that paper, together with numerous requests, including one from our president, for a paper on this subject, has led me to present some of my observations on the operation of the air-lift pump. I will confine the first paper to the air-lift itself and the well, and will give the principal proportions of the apparatus as it is generally used, viz., in what appears to be the more practical and economical form. I shall mention very briefly the apparatus for producing the compressed air required, because information of that kind can be obtained of almost any manufacturer of air compressors, as well as from works on compressed air. The history of the air-lift pump I shall omit altogether, as it would add but little information of a practical nature. I might state at the outstart that I have failed to find in printed form information on this subject which would seem to be of any practical use to engineers who may be called upon to construct or to superintend the sinking and fitting up of a well for an air-lift. The information at hand at the present time seems to be very scarce, indeed, and this is especially true in view of the large numbers of air-lifts in successful operation and the high economy obtainable in this type of pumping apparatus.

The complete apparatus necessary for the successful raising of water by the air-lift system consists of an air compressor and the necessary air regulators; an air-tank or receiver large enough to furnish a steady flow of air to the well, and to break up the pulsations of the compressor; a pressure gauge and valves suitable for regulating the pressure and flow of air, and the necessary length of pipe of the proper sizes. In order to enable the well to work successfully and economically the pipe should be properly proportioned. When the pipe is too large the water is apt to blow out in a spray and with great force, which is obviously very wasteful both of air and water. When the pipe is too small the air is apt to rise to the surface of the water in small bubbles, and without producing the desired results. When the air-pipe is outside of the water-pipe, I have found the proper relation between the diameters of the air and water-pipes to be as 1½ to 4, which gives a ratio of actual cross-sectional area of 6.24. When the air-pipe is situated inside the water-pipe the same ratio of actual cross-sectional areas should obtain, and in this case the diameter of the water-pipe is

$$D = \sqrt{\frac{a \times 6.24 + A}{.7854}},$$ in which a and A represent the actual internal and external areas of the air-pipe. The proper areas of the air and water-pipes, together with the required depth of submersion and the introduction of the air into the water-pipe at the proper point, are the principal factors which determine the success of the air-lift.

The water-pipe should be submerged to a depth of 18 inches for each foot lift above the lowest water level in the well; in other words, the best results are obtained when submersion = .5, the lift being measured from the lowest or the working water level, as it is called. It will be seen that the depth of submersion for the best results should not be less

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* A paper read by Gustav C. H. Freidrich before the Ohio Society of Mechanical, Electrical and Steam Engineers.

than $1\frac{1}{2}$ times the total lift measured from the working water level.

When the well is being worked, the water level falls below the level reached before water is pumped out. To illustrate the foregoing rule, suppose we wish to elevate water 25 feet above the surface of the ground, and that when drilling the well, water is obtained at a depth of 40 feet below the surface. The lift is now $40 + 25 = 65$ feet. Applying the foregoing rule for depth of submersion we have $65 \times 1.5 = 97.5$ feet, or practically 100 feet, thus giving a total height of 165 feet from the point where the air enters the water-pipe to the point of discharge. After drilling to a depth of $165 - 25 = 140$ feet, we are ready to find the working water level in the well. First put the water and air-pipes into the well; then drop a float attached to a string into the well. Pass the string over a pulley and attach a weight to the free end. The weight should be just heavy enough to take up the slack in the string and at the same time allow the float to descend with the water level as the latter is lowered by pumping. The distance the weight rises will indicate the depth of the working level below the level first obtained in the well, and the latter level should be employed when making calculations involving lift and depth of submersion.

A very simple as well as convenient arrangement for measuring the fall of the water level in the well can be made as follows: Take a pulley whose circumference is 12 times the circumference of the shaft upon which the pulley is mounted; then wind the float string around the pulley and fasten another string to the shaft, so that it will be wound on the shaft as the float string unwinds from the pulley It will be seen that this arrangement reduces the travel of the string on the shaft to a convenient distance and one that can easily be measured. Suppose the water level in the well falls 10 feet. The corresponding additional depth of submersion will be $10 \times 1.5 = 15$ feet, and if the well is not deep enough it should be drilled to a sufficient depth to permit the increased depth of submersion to be obtained, and this is done in order to make the total depth of submersion equal to $1\frac{1}{2}$ times the lift, which proportion, as has been pointed out, is necessary for the best results. If it is not practicable to increase the depth of submersion after finding the working level, the height of the lift may be decreased a corresponding amount; otherwise the efficiency of the lift will be to some extent affected. If the well had been drilled deeper than necessary at the outstart, the increased depth of submersion could readily be obtained by simply lowering the pipes to the required depth. It will be seen that the lower water level in the well also determines the necessary change in the point at which the air should enter the water-pipe. With a fall of 10 feet when pumping, the air should enter the water-pipe at from 38 to 40 inches from the lower end of the pipe; with a fall of 5 feet the air should enter at from 24 to 26 inches from the lower end of the water-pipe, and with a fall of from 1 to 3 feet it should enter at a point 18 to 20 inches from the lower end of the pipe. For other distances the same ratio may be used. A well put down to the depth previously determined and fitted with pipes of the sizes indicated by the rule can be cemented over and buildings erected over it without fear of trouble, because the well will need no further attention, and all that is required is simply to supply it with air as long as the pipes last. A number of wells can, of course, be operated from the same compressor. The necessary machinery can be located in the engine-room or in any convenient place, and the air-pipes run to the different points of distribution.

Coming now to the question of air required for raising water, it is estimated that 1 cubic foot of air will raise 1 gallon of water, but in wells that are properly proportioned there will be a saving over the amount of from 40 to 47 per cent.; that is to say, the air used will be 60 per cent. of the above estimate as the maximum and 52 per cent. as the minimum. This serves to illustrate the fact that wells vary, as, for instance, along rivers, where the water rises and falls, causing the water level in the well to fluctuate. To illustrate the application of the rule for volume of air required, if we wish to raise 100 gallons of water we shall need 60 cubic feet of air as the maximum and 52 cubic feet of air as the minimum, the required volume carrying from the maximum to the minimum according to the conditions in each individual case. The average air pressure is 60 pounds per square inch. When starting to raise water it requires a somewhat higher pressure because there is a solid body of water from the surface in the well to the point at which the air enters the water-pipe, and this column of water has to be moved by the first discharge of air. When the well has reached its normal working condition the water-pipe will contain a number of short columns of air and short columns of water. These short columns of air and water are discharged alternately, and in the pipe they form a continuous chain, the intermittent discharge continuing as long as the proper amount of air is supplied and as long as there remains water to be pumped.

The principle upon which the operation of the air-lift depends may be explained as follows: The pressure of the atmosphere being 14 7-10 pounds, in a perfect vacuum water can be lifted to a height of 34 feet. We know that as the water piston is drawn forward in the cylinder a partial vacuum is created behind it and the pressure of the atmosphere on the outside of the suction pipe causes the water to rush into the latter. The suction valve then closes and on the return stroke the discharge valve opens the piston, forcing the water to a higher level.

In the air-lift pump the pressure of the atmosphere is not removed from the surface of the water in the pipe, as it is in the suction pipe of an ordinary pump. We have the atmospheric pressure on the surface of the water outside of the well and also in the pipe. The short columns of air previously mentioned act as pistons in the air-lift pump, the propelling force being that due to the difference in specific gravity between air and water. The specific gravity of a solid is the difference between its weight and the weight of a like volume of distilled water at 39.2 degrees F., the weight of the water generally being represented by unity, or 1. Taking the weight of water as 1, the specific gravity of air is .0012. Air being elastic and compressed to 3, 4, or 5 atmospheres, as the case may be, when liberated under the water is found to be very buoyant, and, as expansion is confined to the limits of the pipe, it forms a large bubble and carries the water above it to the surface, the air column becoming longer as it ascends on account of the removal of the weight of water above it, thus allowing the air to continue to expand, until finally it flows from the pipe a little above atmospheric pressure. It will be seen that the water which is removed by the air lessens the weight of water in the pipe, or, in other words, the weight of the column in the pipe is less than that of a similar column outside of it. This in turn causes the water to rush in at the bottom, because of the greater weight of the column on the outside. Other bubbles are formed, thus causing a continuous chain of short columns of air and water as long as air is supplied. One important advantage to be derived from the use of the air-lift pump where water is to be used for condensing purposes or domestic use is that the air during expansion absorbs heat, and this tends to lower the temperature from 2 to 4 degrees F.; that is, water having a normal temperature of 50 degrees in the well will have a temperature of from 48 to 46 degrees when discharged.

There is no particular advantage to be gained by employing special arrangements for introducing the air into the water-pipe. The air may enter from the side or at the centre with equally good results. The economy of this system can be figured out by any engineer without much trouble, because about all that is necessary is to find out how much steam will be required to compress 1 cubic foot of air to the required pressure, which may be taken at 60 pounds when making calculations.

The cost of compressing air offers good material for a subsequent paper on the air-lift pump.

The "Liernur" Pneumatic Sewerage System at Stansted.

Considerable interest has been taken by municipal engineers in the first British installation of Liernur's pneumatic sewerage system at Stansted, in Essex, which has now been in operation for about a year. Stansted is a large village with a population of about 2,000; its higher portion already possessed a system of sewerage by water carriage, but for some years past the lower portion had given the district and parish councils much anxiety as to its efficient drainage, owing to the physical difficulties presented. The basin-like formation of the country rendered the adoption of a system of sewerage by gravitation almost impossible, owing to the large expenditure of water which would have been necessary for adequate flushing.

The engineers of the "Liernur" system availed themselves of every possible fall for the conveyance of the sewage, a great part of the liquids reaching the storage tank by gravitation. For the carriage of the sewage remaining in the syphon boxes and sewers the vacuum suction is utilized, as frequently as experience dictates. Consequently, by this system of conveyance it is possible to guarantee that the whole network of sewers is thoroughly cleansed and filled with pure air every day, or as often as desirable. From the starting of the gas engine, the complete service of the "Liernur" system over the whole network of street sewers and house connections, in all about two miles, takes only fifteen minutes.

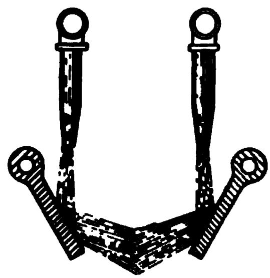
The area served by the "Liernur" system is of a varied description so far as levels are concerned; with one exception the branch sewers are laid at an average depth of 2 to 3 feet. The one exception is the extremity of the pipe line crossing the railway, and this has been laid at a lower depth (9 feet), in order to allow of the connection of the sewers of a large building estate now being developed. No provision was necessary for storm water drainage, the village possessing a system of surface water sewers. A 4-inch rising main is carried from the pumping station to the high level existing sewer, from whence the sewage is conveyed by gravitation to the irrigation farm. The complete system is of cast-iron pipes, fittings, etc., throughout, and as each pipe was laid, the joints were tested by water pressure.

The pumping station is small. The machinery consists of the following: A boiler plate vacuum reservoir (with a capacity of about 2,800 gallons), provided with gauge glass and safety valve; a gas engine, 8 h.-p.; a vacuum pump of ¾ h.-p.; a lifting pump, for pumping the sewage to the high level sewer; and pulleys, cocks and other small fittings. Adjoining the pumping station is the storage tank, with a capacity of 30,000 gallons, which represents the quantity of sewage estimated to be delivered in three days. The lifting pumps and storage tank could be dispensed with and a lower power gas engine used in most cases and where the pumping station is situated immediately at the outfall works.

We understand that the capital cost at Stansted was under £2 per head; the working expenses come to 10d. per head per annum (including lifting the whole sewage 40 feet). The system has now been working at Stansted satisfactorily for the last ten months, during which period the population now connected has increased from 800 to 1,000, comprising all the lower district of Stansted.—*Engineering Times* (London).

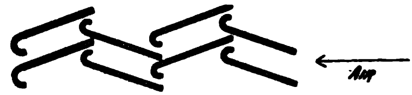
Washing the Air.

In order to meet unusual conditions at its Pittsburg station, the Pittsburg and Lake Erie R. R. has adopted a system of washing air used for heating and ventilating the building, which is now being operated with success under the direction of J. N. Campbell, electrical engineer of that company. Owing to its original features it has excited considerable interest and comment.



SPRAYS AND BAFFLE PLATES IN AIR WASHER.

Leading down from the roof there are two large air ducts about 8 feet by 20 feet each, which extend to the basement directly to the washers. These air washers are rectangular iron boxes



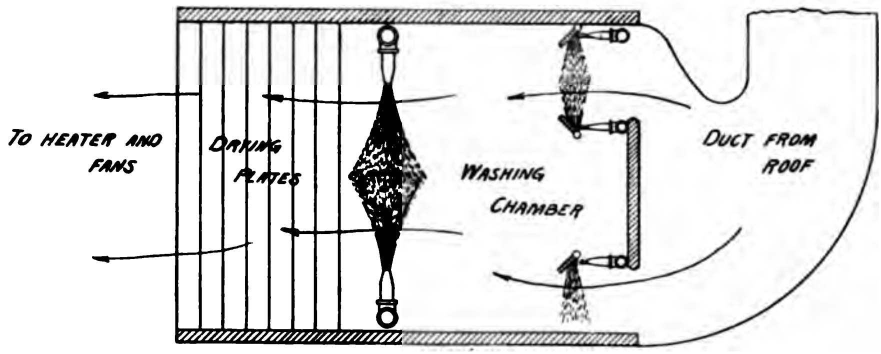
PLAN OF DRYING PLATES

about 12 feet by 5 feet wide and 8 feet high, the air entering along the top and bottom of one of the sides. This air on entering passes three sets of water jets, the two top ones having 12 sprays each and the bottom one 14 sprays. The air leaves this washer through the opposite side of the chamber, which is open, but in doing so passes through two more sets of the water jets, one of which sprays vertically downward from the top and the other one vertically from the bottom. Each of these sets also has 12 sprays. These sprays are about 11 inches apart on each pipe and are simply open nozzles about one-eighth of an inch in diameter, and the water is directed with a pressure of 15 to 20 pounds per square inch against a baffle plate which is adjustable, allowing the spray to be turned in any desired direction, as shown in the sketch.

The air from the washing chamber passes by a series of seven rows of plates against which it impinges and drops the water which is held in suspension. These plates are formed as is shown in the sketch on the opposite page.

From these drying plates the air passes through a heater having grates through which water is circulated at any temperature to give the air the desired temperature, and from this heater the air is drawn by a fan and discharged into the building. There are three of these fans and four suction fans drawing off the impure air and discharging it through ducts to the roof.

This system, it is said, cleans the air very thoroughly and provides the entire ventilation for the building, there being no windows in the building that can be opened, and a constant temperature of from 68 to 72 degrees is maintained during the entire year. The air seems to have very little moisture retained in it, and the pressure that is maintained through the building is about one-half an inch of water. The entire system was manufactured and installed by the Thomas & Smith Co., of Chicago.



PLAN OF AIR WASHERS.

Pneumatic Hammer for Railway Shops.

Finding the demand imperative for pneumatic tools in a railroad shop, R. M. Cole, foreman of the Union Pacific's shops, at Ellis, Kansas, designed one himself which has since been used there with considerable success. He has constructed a 58-pound pneumatic hammer which is used for breaking out staybolts and shearing crownbar bolts. It will shear, he reports, a 1-inch bolt at one or two blows, and can work at the rate of 50 or 60 blows per minute. He has also made a small one of 22 pounds for driving out flues. This one, it is said, will knock out a set of 200 flues in an hour and a half. Two men are required to operate either hammer.

Mr. Cole himself has described the operation of the pneumatic hammer as follows:

"The valve for the large hammer is of the piston variety; it has two rings on each head. The heads are 1⅜ inches diameter, ¾ inch thick and coupled on a ⅜-inch rod 4⅛ inches apart, back end of the stem being coupled to a lever. The bushing is 1⅜ inches on inside, 1⅝ inches on outside, and is 10½ inches long.

"The casing for the bushing is made

of three 1¼-inch gas-pipe Ts, with the thread drilled out to 1⅜ inches in diameter, and the centre bored out ⅛ inch large to allow the air to pass entirely around the bushing. They are held together with a collar on one end and a nut on the other end of the bushing. The bushing has twenty-six ¼-inch holes for each port; the holes are arranged in two rows running entirely around it, thirteen in each row. The ends of the T are faced off to insure an air-tight joint. The barrel of the hammer is common 5-inch pipe, with heads grooved for pipe to fit in, and held together with four ⅞-inch bolts. The barrel is 24 inches long, with ports so drilled as to allow pressure to escape and prevent a rebound. The hammer is made from an old crankpin turned to fit the pipe loosely, the pipe not being bored. The smaller hammer has only one row of holes at the end. It is about 7 inches long. Each hammer has a steel pin in the end to strike the bar, which is held by the gas-pipe. The small hammer uses 1-inch Ts bored in the same manner as the large one. Both hammers use the same bar, which must be a fair fit in the 1¼-inch pipe. The small hammer is very convenient where a heavy blow is wanted on a bar, and can be operated easily and quickly."

Pneumatic Tube Franchises.

Mayor Harrison's action in sending back to the Chicago City Council the pneumatic tube ordinance attracted considerable attention to the terms which the Chicago Postal Pneumatic Tube Company, the Chicago branch of the Pneumatic Service Company, made with that city. The ordinance has since been revised, passed by the Council in its new form and returned to Mayor Harrison for his approval. The revised ordinance now provides for 3 per cent. of the gross receipts to be paid to the city as compensation. In addition, a forfeit of $50,000 is required as a guarantee that eight miles of tube will be completed in one year. The city also gets from the company without charge a double line of conduits to carry fire-alarm and police telegraph wires from the downtown district to the stock yards. The company is also to dig the trenches, supply the conduits and turn them over to the city without cost. By the provisions of the ordinance the company is absolutely limited to the transmission of mail.

It is interesting to note that in Boston the parent company has a 99-year franchise with the privilege of carrying parcels as well as mail, and gives only 2½ per cent. compensation.

In St. Louis the only compensation is 5 per cent. after the first four years. In Philadelphia the company has a perpetual franchise for both mail and packages. There is no compensation at all on the mail contract, and 3 per cent. annually on the gross receipts of the package delivery.

The Shepard Pneumatic Motor Hoist.

Compressed air as a motive power for hoisting is now so widely used, and may so admirably fulfill the requirements, particularly for handling light and medium loads, that a review of some of the conditions of use which seem to contribute to its satisfactory and economical application, should be of interest.

The pneumatic motor hoist is of comparatively recent development, and is still in its formative state. It has reached no general form common to all makers, but is found in nearly as many separate and distinct designs as there are individual builders. Consideration of the subject will, therefore, be limited to the application of compressed air for hoisting, only in this type of hoist.

The small pneumatic motor is not of itself very efficient; the success which it will meet, therefore, in competition with other forms of motive power for hoisting, will depend largely upon its excellence in other respects, and also upon the efficiency of the hoisting gear to which it is attached. It was early recognized that the compactness, simplicity, lightness, and ease with which it could be installed, would give the pneumatic motor hoist a decided advantage over any other hoisting apparatus of its class, provided in other vital characteristics it could be made satisfactory. It is practically the only form of power hoist which can be suspended by a single hook and occupy a sufficiently small head room to permit its use in all places where the hand chain hoist was formerly employed.

One of the first problems met in designing the hoist was the selection of a suitable type of gearing, to reduce the speed of the motor and to intensify its power sufficiently to enable it to handle the maximum load. The choice of a type of gearing like the worm or differential

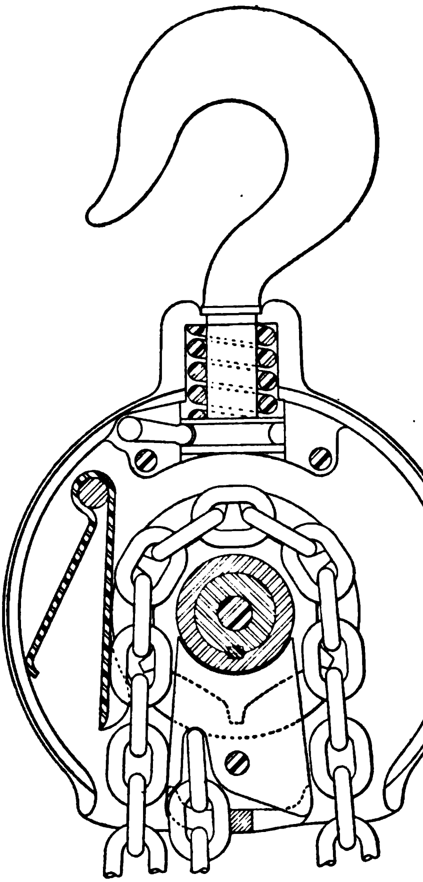


FIG. I.

would have eliminated all problems, such as sustaining the load and its smooth and safe descent. Unfortunately, however, any type of gearing which will retain the load without a brake, will be inefficient. Lowering a given load liberates exactly the same amount of power as was absorbed by it while being hoisted. The hoisting mechanism would reverse and permit the load to run down, unless the measure of its friction is equal to or in excess of the power stored in the object lifted. If the measure of its frictional loss equals or exceeds that of the useful work done, its efficiency will not exceed 50 per cent., and will probably be much less. The convertion of the motive power of the steam plant to actual hoisting, by whatever means, is accomplished only by several transformations. The careful engineer will, at least, look with regret upon a loss of so much as 50 or 60 per cent. in a single one of the transformations necessary. As a matter of fact an efficiency of 40 per cent. is all that may be reasonably looked for in the best worm or differential types of hoisting apparatus, and in any but the very best of its class it will be even less. If the hoisting mechanism is, however, made up of a train of spur gearing of efficient design, an entirely new set of conditions are introduced. When power is shut off from the motor, an instant application of a brake is necessary to retain the load, and this must be partially continued while the load is being lowered, or else the motor must be capable of absorbing nearly as much power when it is running backward as it gave out in the act of hoisting. In the latter case, complete release of the brake is practicable and preferable. The substitution of spur gearing offers a perfect solution of the problem so far as securing high efficiency is concerned. The loss of power with spur gearing need never exceed 25 per cent., and may be reduced to 20 per cent. or less; combined with a high speed pneumatic motor, it corrects the only remaining difficulty, that of sustaining the load safely, and controlling it during descent. Unlike the electric motor, the pneumatic motor is capable, not only of developing power, but in equal measure of absorbing power, it may, therefore, propel the gearing while hoisting the load, or restrain the gearing while lowering the load. Its ability to fulfill the latter function, and thus avoid the complicated apparatus which would otherwise become necessary, gives to it an advantage which far outweighs its small lack of efficiency. A high speed pneumatic motor was, therefore, chosen because of the ease and certainty with which the load could be sustained by a brake applied directly to the motor shaft; the high speed of the motor insures a high ratio of gearing between the lifting sprocket or drum, and the motor; and insures the load being sustained even with a very light application of the brake, hence with a brake of moderate power, a large margin of safety is obtained. High speed in the motor, and consequently a high ratio between the motor and load hook for hoisting apparatus, affords relatively the same advantage as the high ratio between the dial and measuring points of the micrometer; in either case an easily-controlled movement of the one part effects the greatest nicety needed for the other part. With a pneumatic motor, during the process of lowering the load, even with the supply hose disconnected and the brake entirely inoperative, if the throttle is released, both the supply and exhaust parts will be closed and a vacuum will be created during one stroke of the piston and compression during the other stroke; the intensity of both the vacuum and compression will increase until the load is arrested. In practice, two or three turns of the motor only will be necessary to bring the load to rest. Absolute safety is, therefore, offered against accident, even with the most careless operative. The throttle and brake operate in conjunction; the brake automatically grips the motor, when pressure is cut off, and at the same time the exhaust and inlet ports are closed. Either of these conditions would hold the load suspended.

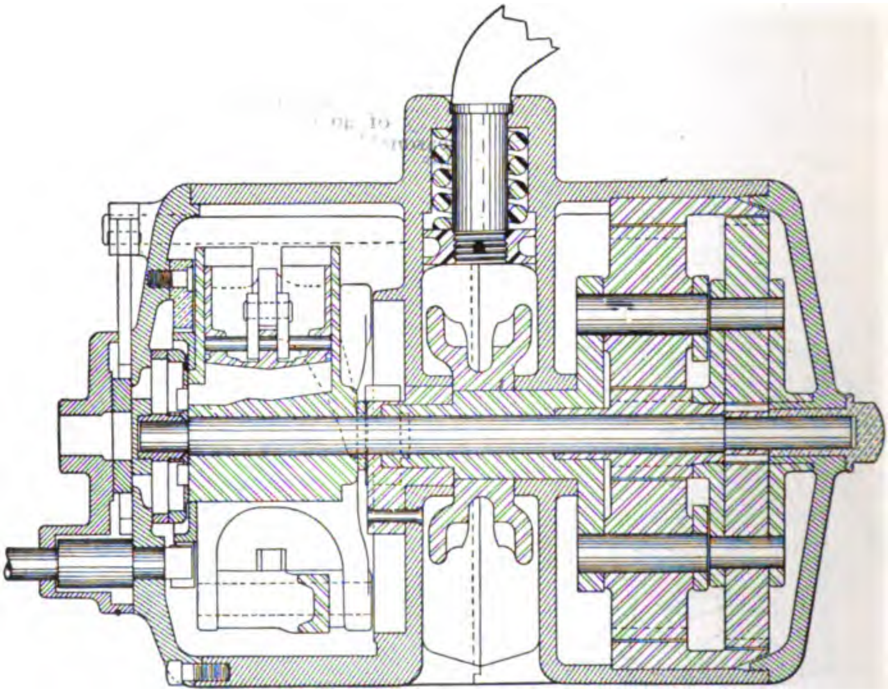


FIG. 2.

The motor used is of the piston type of simple design, consisting of three single acting cylinders radially mounted upon a hub on the driving shaft. Each cylinder carries a bell crank, to one end of which is attached the piston, to the other end a roller, suited to revolve about a stationary eccentric. Air pressure acting upon the pistons successively pushes them outward, causing the rollers to bear forcibly upon the eccentric, just at the time they pass its highest point. As the rollers under load roll down the incline formed by the eccentric, they propel the cylinders forward in their circular path. Air pressure is led to and exhausted from the cylinders as the ports in the hub rotate alternately past the supply and exhaust openings in the cover plate of the hoist shell. Self-adjusting metallic packings are used in the pistons and on the face of the hub which therefore, practically without load other than that due to the air pressure. Inertia and momentum strains are nearly eliminated, since every moving part of the motor traverses a truly circular path; it, therefore, runs without the least vibration, and adapts the hoist for the most exacting service. In foundry practice, for instance, the entire absence of vibration, either in the motor or gearing is found to

FIG. 3.

will keep the parts perfectly air-tight. The bearings are not subject to reversal of stress, hence they do not need adjustment, and are durable and quiet running. Centrifugal stresses, which have been an objectionable feature of motors of this type, are nearly balanced between the piston at one extremity of the bell crank and its heavy arm and roller at the other extremity. The fast running bearings are be of great advantage. When desired, the hoist is provided with a governor valve which is controlled by the load hook, and which will supply at all times exactly the amount of air required to handle the load, resulting in a decided economy in air consumption. The spur gearing used between the motor and lifting sprocket or cable drum, is compactly arranged in two separate trains; it is enclosed within the conditions the most favorable for efficiency and durability. The motor is also fully enclosed, and runs in a bath of oil; copious lubrication of every running part is, therefore, assured and attendance is reduced to an occasional replenishing of the supply of oil. No oil is ever fed to the motor with the air supply, hence none is ejected from the exhaust opening, and the supply in the motor case is only very gradually consumed. Nearly all the troubles attending the use of the air motor, have

FIG. 4.

securing proper lubrication. It will suffer injury very quickly from want of oil for either its internal or external wearing surfaces. A method by which all wearing surfaces are constantly bathed with oil, without giving the lubricant direct access to the interior of the motor, where it may be carried to the exhaust opening and thus wasted, should effectually prevent injury to the wearing surfaces, and promote as long a life as in any other form of motor. This in connection with the effective methods used for packing every part subject to pressure, enables it to retain its efficiency indefinitely.

The Shepard hoists are made in two types; those using a chain running in a sprocket wheel, and those using a wire cable winding upon a drum. The distinct advantage of the chain type is the ease with which an auxiliary high-speed hoist may be provided by attaching a hook to the free end of the chain; the main load hook is then attached to a lower block carried by two strands of the lifting chain, and is used for loads approaching the maximum which the hoist will handle, while the hook attached directly to the free end of the chain and running at double the speed of the block, is used for light loads up to half the capacity of the hoist. In all cases where the sprocket and chain are used, a spring chain guard is provided which effectually prevents the chain from climbing the sprockets, or any jar to the load from movement of the chain in the sprocket; because each link of the chain is firmly seated by the spring guard before it is subjected to any load.

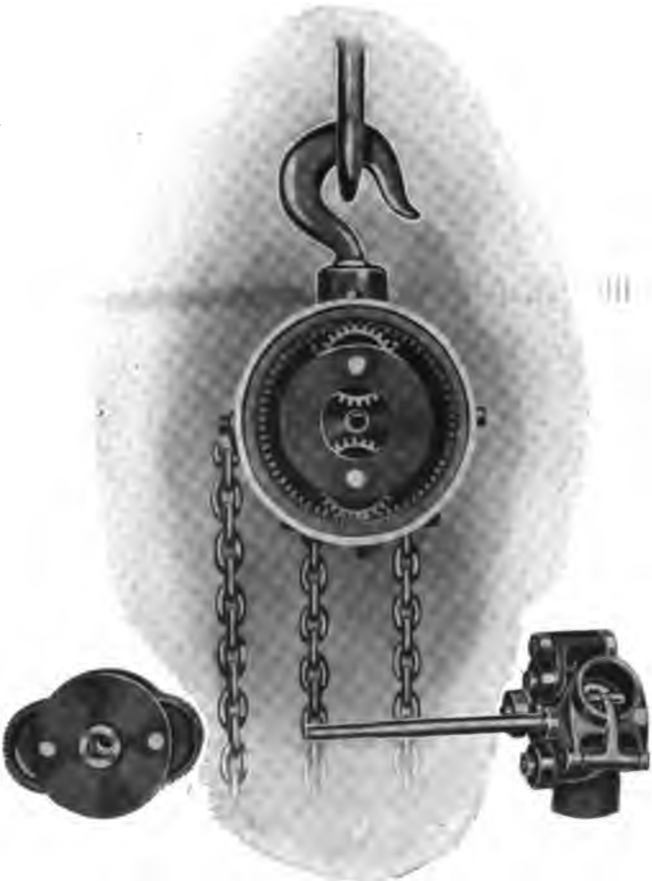


FIG. 5.

Referring to the illustrations: Figure 1 shows a transverse section elevation, through the lifting sprocket, and hook by which the hoist is suspended, showing the spring chain guard and governor spring upon the stem of the hook. Figure 2 is a sectional elevation longitudinally through the entire hoist, showing the motor and its controlling and reversing valve at the left, the lifting sprocket at the center and the hoisting gearing at the right. Figure 3 is from a photograph of the motor in position in the hoist shell, and Figure 4 of the gearing in position in another compartment of the hoist shell. In Figure 5, the component parts are seen removed from the shell. Attention is called to the fact that removal and replacement of all the working parts in either the motor or gearing compartments is practicable without in the least disturbing the adjustment, hence inspection, repair, or renewal of any worn member is possible with the least trouble or delay. Figure 6 illustrates the hoist as seen under working conditions, and shows to advantage its compactness and symmetry of form. It is farther interesting as illustrating one of those few cases in which compactness and symmetry are not obtained at the expense of efficiency and perfect accessibility.

FIG. 6.

Where conclusions have been drawn in the foregoing, which are not based upon accompanying proofs, they are only such as appear to be thoroughly established after a careful observation of the hoist under actual and trying conditions.

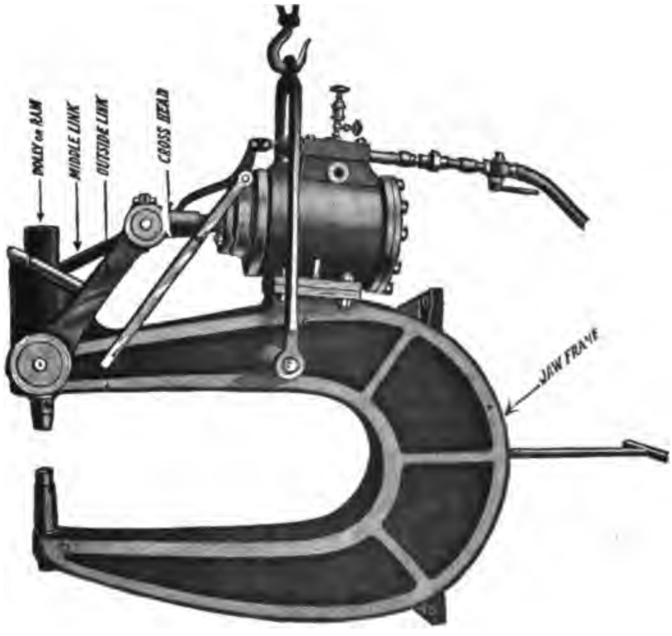
FRANK A. HATCH.

The Allen Pneumatic Riveters.

John F. Allen, 370-372 Gerard avenue, New York City, was the pioneer in the manufacture of portable pneumatic riveting machines and one is sure to find "Allen" riveters included in the equipment of the leading railroad and other machine shops of the country. The simplicity in construction of these machines, combined with ease of operation, together with the very satisfactory results obtained in their use, has lead to them being widely imitated.

A good idea of the standard type of Allen Riveter will be obtained from a study of the engraving presented herewith, which shows a machine with 10-inch cylinder and capacity up to 1-inch rivets. In its construction the piston rod connects levers of different lengths, forming a toggle joint. The lower ends of the larger levers are attached to fixed centers on the frame and the end of the central short lever is attached to the dolly-bar, into the lower end of which the head-tie is screwed. By this latter arrangement any change that is desired in the distance between the dies can be easily effected.

A different leverage is obtained which affords a pressure not found, it is claimed, in any other riveter, patent rights on which were granted Mr. Allen. There is also a patented cut-off contrivance which prevents any possible leakage of air. The dolly-bar acts in a direct line with the axis of the rivet. The capacity of the Allen riveters is guaranteed and riveters with 8-inch cylinder will handle rivets up to 5/8 inch; 10-inch cylinder, 1-inch rivets and 12-inch cylinder, 1¼-inch rivets. The machines are balanced and when hung up may be operated in either a vertical or horizontal position. Lugs are furnished with all sizes above 25-inch reach, by means of which



ALLEN PORTABLE PNEUMATIC RIVETER.

they may be fixed in position as stationary machines. All Allen riveters may be operated by steam or compressed air, and it is stated are much lighter in weight than any other machines that are built for the same work.—*Railway Master Mechanic.*

Compressed Air for Pumps.*

The following inquiry has come to me: Will you please give us the best and shortest rule you know for determining suitable sizes for air compressors for operating pumps? We often have to figure on the sizes of air compressors for pumps at various distances from the compressor and from the tank, at different elevations and also at different pressures. Take, for example, the following: What size air compressor will be required to deliver 60 gallons of water per minute against a head of 150 feet? The pump is 1,000 feet from the compressor and 3,000 feet from the tank or reservoir; air pressure 80 pounds, gage. We would like to get the shortest rule that would fit a case of this kind. We have a rule to compute the size of the compressor, but are asking for one that will answer our purpose better.

If anyone has a "rule" for a case of this kind he is to be congratulated; I don't know any, and I don't know how one could be made. The mode of computation in the case should not be any finer than the data, so it would be quite rough. Two very essential particulars would be the size of pipe permissible and the style of pump employed, neither of which is given. I assume the pipe to be of adequate size and that an ordinary steam pump is used, such being the common practice, and no other being suggested. Now a gallon of water = 231 cubic inches, or .1337 cubic foot, and .1337 × 60 = 8.002 cubic feet of water delivered per minute. The head equals 150 × .434 = 65.1 pounds. As the air pressure maintained is 80 pounds, we may assume that if the air and the water cylinders of the steam pump are of equal diameter the excess of air pressure over the water head may be sufficient to keep the column in motion, and that a volume of air equal to the volume of water, or 8.022 cubic feet of air at 80 pounds, will be required. There are leakages and usually unaccounted-for losses to be made up and the clearances, which in a steam pump are enormous, to be filled, so that 50 per cent. at least should be added to the above, making, say, 12 cubic feet of free air per minute at 80 pounds pressure required. 80 pounds gage, or 94.7 absolute, = 6.45, say 6.5, atmospheres, so that 12x6.5 = 78 cubic feet of free air per minute required. The air volume is taken at normal temperature, as that of course is the temperature of the air as it enters the compressor, and the compressed air also will have cooled to near the same temperature by transmission through the 1,000 feet of pipe. No account is taken of the air pipe friction in this transmission, as it would not be appreciable if the pipe was of suitable size.

It may be worth while to note the power at each end of the operation here considered: 60 gallons × 8 1-3 pounds per gallon × 150 feet = 75,000 foot pounds, and 75,000 ÷ 33,000 = 2.27 horse-power. We found that 78 cubic feet of free air per minute would be required at the compressor. To compress, without cooling, 1 cubic foot of free air per minute to, say here, 85 pounds pressure requires .1655 horse-power (Richards' "Compressed Air" Table V), then 78 × .1655 = 12.9 horse-power. This represents an efficiency of 2.27 ÷ 12.9 = .176. If they will use steam pumps and uneconomical air compressors this is the result to be expected and which is quite commonly attained. When I first began to know something of the practical use of compressed air I encountered such results as this and was naturally disgusted, but I was compelled to accept them, and no satisfactory progress seems to be making toward better general economy with compressed air for pumping.

*By Frank Richards in the *American Machinist.*

This article, in the *American Machinist*, evoked a communication on the subject from E. A. Rix, of San Francisco, in which he said:

"Replying to the article on 'Compressed Air for Pumps,' by Frank Richards, we have to suggest that a rule which might suit your correspondent would be as follows: The mean of a great many experiments with direct-acting pumps using compressed air at 90 pounds pressure in the main, shows that a cubic foot of free air compressed to 90 pounds will yield 135 foot-gallons of work, and that inasmuch as the air in direct-acting pumps is used practically at full pressure, the relative work which may be done by air at 80 pounds would be in the proportion of 80 to 90. This being the case, the problem which you present, viz., 60 gallons per minute, 150 feet high, would represent 9,000 foot-gallons. Dividing by 135, it would require 66 6-10 cubic feet of free air compressed to 90 pounds, and at 80 pounds would require 66 6-10 times 90 divided by 80, or 75 cubic feet."

In the following issue, another communication regarding the same article appeared from F. M. Leland, of the Risdon Iron and Locomotive Works. He referred to the original article and submits a catalogue giving tables for pumping plants. He said:

" Mr. Richards figures that to pump 60 gallons of water per minute, 150 feet high, would require 78 cubic feet of free air per minute. His figuring is all right, with the exception that we think that 50 per cent. is a little too much to add. For instance, take our table and take the ratio of diameters as he gives them, viz., air and water cylinders the same size, run this line out until you come to 150 feet head, and you will note that it requires 1.04 cubic feet of free air per gallon of water pumped. Multiply this by 60 and the result is 62.4 cubic feet.

"The actual amount of free air required, according to Mr. Richards' article, would be, say, two-thirds of 78, or 52 cubic feet. If he would add about 20 per cent. to this instead of 50 per cent., this would give him what our table says is the correct amount. We have used these tables quite frequently and found that they are fairly correct.

" We note the concluding paragraph in Mr. Richards' article, in which he comments on the uneconomical conditions of pumping water with compressed air. In this connection we would say that there are many conditions in the mining countries where economy cuts but very little figure. For instance, it often happens that a mine is located 200 or 300 feet up the hill from a large stream. These large mountain streams have a very rapid fall, often 300 or 400 feet in a mile; it is a very simple matter to go back half a mile or so and catch up 400 or 500 inches of water, run it along the hillside in a flume or ditch to a head box and run it down the hill in a pipe to get 200 or 300 feet head. You use this on a tangential water wheel and operate a belt-driven or direct-driven compressor. In most cases the water is free of cost and the compressor is geared to run a certain number of revolutions, and when the pressure gets up to a certain point it blows off and goes to waste.

" Mr. Richards also speaks of the wastefulness of the ordinary steam pump. This is a recognized fact in the mining world, but if ever Mr. Richards worked at the bottom of a 200 or 300 foot shaft with a steam pump for a companion he would be apt to bless the man who invented compressed air. Not only does a steam pump heat up the atmosphere and spoil the air, but when you are lowering it and setting it in a new position the handling of the hot pump breeds profanity. There are many things to be said in favor of the much abused steam pump, although economy is not one of them."

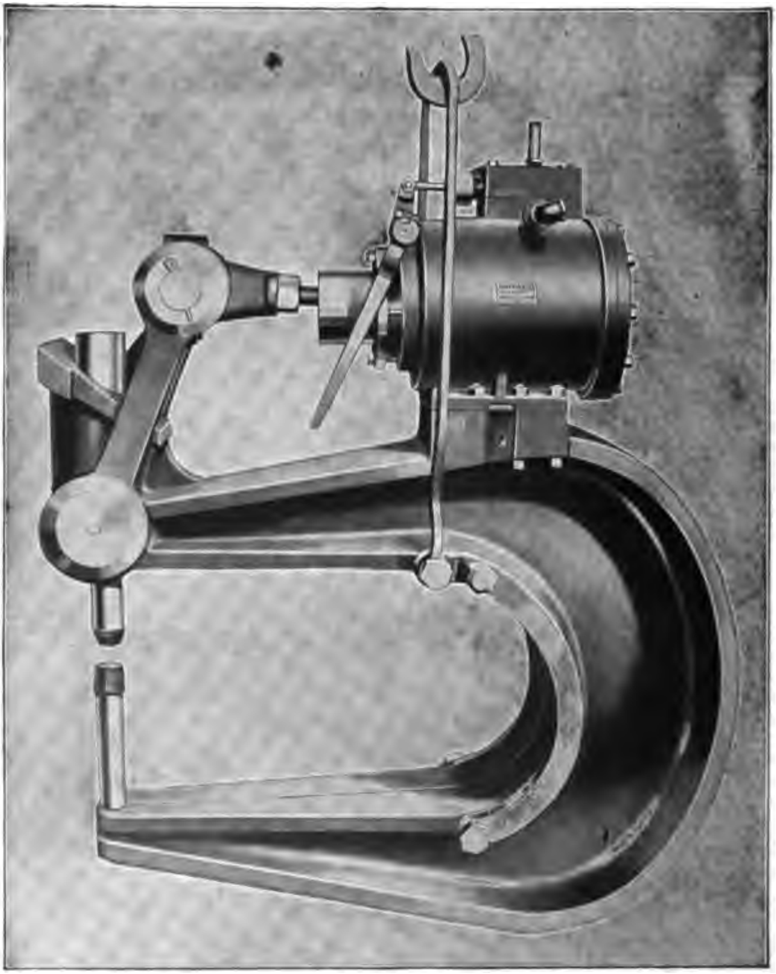
At the close of this communication the following comment was editorially made:

" [There is an interesting discrepancy here between the figures of Mr. Rix and those of Mr. Leland. Those of Mr. Rix come so near to my result as to be a practical confirmation of it. My way of computing and my allowance for the uncertainties which are certain to exist come from actual experience, when for a few years I was in a position where it was quite desirable for me to make out as good a case as possible for compressed air. I never in practice saw such high economy as Mr. Leland figures out, and if he has reliable practical evidence to back him he has good stuff to advertise.

" In speaking of the waste in the use of compressed air in pumping, I distinctly do not therefore in any case advocate the use of steam instead for pumping mines or shafts or tunnels. Of course, the air is generally incomparably preferable. What I do object to is *the use of the air in the ordinary steam pump*, with its enormous clearances to be filled and its lack of all means of using the air expansively, when it would be such a simple matter to produce a pump with a crank movement which would give a small and constant clearance, and with some cut-off or other expansion gear. When such a pump is used for the pumping I will cut a big chunk off the 50 per cent. allowance, which otherwise I still think necessary.—FRANK RICHARDS.]"

The Chicago Pneumatic Tool Company's compression riveter (see illustration) is made in two sizes, Nos. 1 and 2. The No. 1 weighs 1,900 pounds, has 30-inch reach, 16-inch gap and capacity up to ¾-inch

results. The principal parts comprised in its construction are a cylinder, toggle joint, plunger and frame. The piston rod connects two levers of different length, forming the toggle joint; the lower ends of the larger levers are fitted to trunnion bear-



COMPRESSION RIVETER.

rivets, inclusive. The No. 2 weighs 2,275 pounds, has 36-inch reach, 20-inch gap and capacity up to 1-inch rivets, inclusive.

These machines are designed principally for structural work and are in general use

ings on the frame, and the end of the short lever is fitted to a bearing block in plunger. The die holder is screwed into lower end of plunger, by which arrangement any desired change in the distance between the dies is easily effected. The plunger has 3½-inch stroke and acts in a direct line with the axis of the rivet. The machine is balanced in any position and hung by a bail, enabling the operator to turn it in any direction with slight effort.

Compressed Air Pump for Painting.

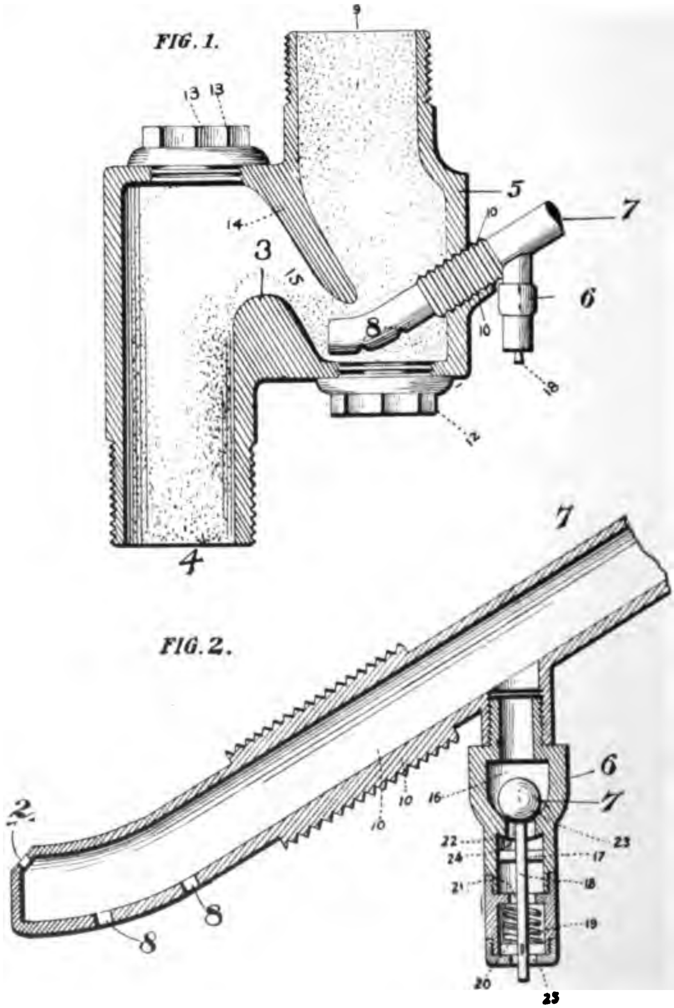
A portable compressed air pump for painting, whitewashing and spraying has been placed on the market by the Humphryes Mfg. Co., Mansfield, O. The ac-accompanying illustration shows the machine equipped with a 3 in. hand air pump, a galvanized iron tank, 8 x 30 in., for storing air, and another tank of the same material, 12 x 30 in., for the liquid, whatever it is. The smaller tank is filled with air from the pump. After the large tank is filled with liquid and the valve closed between the funnel and the tank, the valve between the two tanks is opened, allowing the air to pass into the larger one through a pipe extending to the bottom. When the gauge of the air tank registers 40 lbs. pressure all liquids, it is claimed, can be exhausted from the tank without further use of the pump. The machine is easy to transport, can be operated by one man, and the chief claim for it is that it is economical and very simple to operate.

COMPRESSED AIR PAINTING MACHINE.

The Edwards Simplex Air Sander.

FOR USE ON EITHER LOCOMOTIVE OR STREET CARS.

The accompanying line drawing shows an upright sectional view of the trap. These sanders have been in use for some time on the P. and L. E. R. R., and it is claimed by the motive power officials that they have many points of advantage over other styles of sanders now on the market, viz.: The nozzle is always buried in the sand and pointing toward the opening it readily discharges the sand over the bridge where gravitation along with the blast carries it to the rail. It can be readily seen that it does not require but a small amount of air to operate this device as the sand cannot cake



EDWARDS SIMPLEX AIR SANDER.

or pack in the trap, it is guaranteed by the inventor and manufacturer to put sand on the rail as long as there is sand in the box and trap. The inventor and patentee of this device is F. H. Edwards, proprietor of the American Metallic Packing and Supply Co., of Cleveland, O., who are placing it upon the market. —*Railway Master Mechanic.*

Allier's Air Painting Machine.

The Allier painting machine, an illustration of which is shown herewith, is designed to meet the requirements of railways for rapid, economical and efficient painting of stations, woodwork in general and repainting of cars. The machine is a recent invention and is manufactured by the C. L. Bastion Mfg. Co., 76-82 Illinois street, Chicago. The manufacturers claim it has given most excellent results, the same having been evidenced by the demand for the machine. Among the points in which it excels, it is claimed that it uses only one-third of the amount of paint used by other white-washing machines. It gives a satin finish with no streaking, and one machine will do the work of ten men with brushes. It is so constructed that the paint and air meet at the outlet, forming a fine spray. The trouble with white-washing machines has been that they squirt the paint instead of spraying it. This deficiency has been met by the Allier machine, which is found to spray the liquid effectively. The Allier machine is operated at 90 pounds pressure for thin mixtures on rough surfaces, and for thick mixtures on smooth surfaces the pressure required is 100 to 110 pounds. The nozzle of the machine is held from 12 to 15 inches from the work, and so held as to strike the surface squarely. It is claimed that this is the only machine that successfully handles cold water, oil, mineral or graphite paint. The tests made show that the cost of two coats of paint by means of this machine is one-third the cost of two coats by hand.—*Railway Master Mechanic.*

ALLIER'S AIR PAINTING MACHINE.

The Diamond Sand Blast.

After careful experimenting, note of which has been made from time to time in COMPRESSED AIR, the Shaver Sand Blast Machine, known as the "Diamond Blast," has been perfected and is now on the market. It is controlled by the American Diamond Blast Co., with New York offices in the *Times* Building, 41 Park Row.

The original idea of the sand blast was suggested by nature, the wind picking up little grains of sand and grinding away the rocks against which they were hurled. The first machine was a hand-throwing machine. This was followed by the air blower, which was really the first practical machine. While large volumes of air and sand were required, only comparatively low pressures could be produced even with the use of great power.

The next step was the introduction of compressed air, which revolutionized the sand blast, for while increasing the pressure it reduced the horse power and sand required. The early machines, however, were large, cumbersome and complicated and even those working with compressed air were only able to operate at from 10 to 30 pounds with a maximum possibly of 40 pounds to the square inch.

The "Diamond Blast" is the result of some of the latest improvements in this class of machinery and will work anywhere from 10 to 250 pounds pressure to the square inch. It is generally considered, however, that the most desirable pressure is from 50 to 80 pounds. The "Diamond Blast" uses a hose and nozzle of smaller diameter than has heretofore been the custom. The advantage claimed for this change is the use for a greater pressure with a less expenditure of power and a smaller amount of free air. The machine is so arranged so that the operator can control both the volume of air and the amount of sand or other abrasive material he desires to use. This permits the use of different quantities of sand according to the requirements of the work. The operation is very simple. There is a valve which controls the air and a lever which regulates the flow of sand. To discontinue the operation it is merely necessary to lower the lever and turn the valve.

Being of simple design the machine can be taken apart and put together again in a short time with, it is said, but little trouble.

THE DIAMOND SAND BLAST.

In construction, the tanks are made of steels and of first class material, galvanized inside and outside. Other parts are made of brass, thereby preventing oxidation should any moisture reach them.

It is claimed that the action of the "Diamond Blast" is not abrasive, cutting or grinding in the usual meaning of these terms. It is true pulverization by the successive impact of the grains of flying sand. The operation consists of throwing a stream of rapidly moving sand against the object to be operated upon. As each grain acts alike the abrasion resulting from the hole is uniform in depth and texture of roughness.

The action is extremely rapid; momentarily depolishing glass; instantly changing the previously bright surface to obscure or ground glass, a little longer cuts deeper and in a very short time apertures are readily pierced through sheet and plate glass. Granite, stone, marble and slate are just as amenable to its action.

Iron, steel and other metals have their surfaces easily smoothed, reduced or coarsely granulated, according to force and abrasive power used.

The abrasive need not be harder than the material to which it is applied, as the hardest steel, corundum or carborundum are readily pierced with sand.

The energy contained in a single flying grain of sand is small, even while traveling at a great velocity, but it is the very small area upon which this is expended that makes cutting by it possible.

Sand averaging 1-50 inch in diameter and propelled by a pressure of 40 pounds to the square inch, will cut granite most rapidly. Such sand grains will weigh .005 grain and will be moving 500 feet per second, and will contain about .00176 foot pound energy. This energy, distributed over the area of impact which is .00000004 square inch, is at the rate of 440,000 foot pounds per square inch. (Hiscox.) The action of the blast is different in granite, iron and glass, though the effect produced is not only the desired one, but without parallel.

Steam and Air Hose Couplings.

While a small detail, perhaps, the importance of successful steam and air hose couplings cannot be overestimated. They play a very important part in the successful installation of mining machinery and now that some of the larger questions have been solved, inventors are turning their attention to these details and are simplifying these and other appliances

GIBBONS HOSE COUPLING.

which are used in the operation of the mine.

One of the newest is the Star steam and air hose coupling, the invention of W. A. Gibbons. The principal features claimed for it are easily determined, a saving of repair bills, and strength and saving in first cost. Many couplings used have had clamps that were hard to place on the hose, requiring the use of a vise to adjust them. No vise is necessary for this kind. With the Star coupling a common union is all that is necessary, where in other cases a special one belonging to the coupling itself must be replaced by one of the same kind.

It is further claimed that this new coupling can be attached in 80 per cent. less time than any other one now in use. McNeil & Co., of Joplin, Mo., are the owners of the patents.

Notes.

The Compressed Air House Cleaning Company of Southern California has been incorporated in that State, with a capital stock of $75,000. The directors of the concern are Wm. M. Garland, Harry Gray, Clarence A. Miller, W. C. Norman, Hulett C. Merritt.

The Wisconsin University, located at Madison, that State, is soon to have a compressed air storage water supply system which will not only supply the university, but the State capitol building as well. Note has already been made that such installation was intended. It is now said the work will be started this summer and hurried to an early completion.

The advantages of a steady blast, easily controlled, have finally induced several manufacturers of window glass to try machines for blowing glass by compressed air. The experiments now under way have been quite generally satisfactory. If the new method does all that is promised it will soon displace the present process of glass blowing, which is slow, costly and very wearing on the health of the men.

The amount of air required by a rock drill depends much on the make or design. It is commonly estimated that a 3-inch drill will consume about 15 cubic feet of air per minute, compressed to a pressure of 60 pounds. A 3½-inch drill will use about 20 cubic feet per minute. These figures, which are about a general average, may be used for choosing a compressor which is to operate drills at sea level.

Among the deaths recorded during the last month was that of Mr. E. G. Patterson, a well-known engineer and railroad man of Titusville, Pa. Mr. Patterson invented a method of track ballasting by compressed air, which was illustrated and described in a previous number of Compressed Air. He was an old subscriber to Compressed Air, and contributed several interesting articles to this publication.

A newcomer in the field of compressed air machinery is the Pilling-Kruse Air Engine Works, Bucyrus, O., which concern has gone into the manufacture of compressed air hoisting engines for all purposes, both stationary and portable, and for any height of lift. The claim is made that it can be so constructed that the hoisting rope will not ride and that the requirements of speed will be met with. The new factory of the concern, a two-story structure, has just been completed.

Thomas Chalmers, one of the founders of the firm of Fraser & Chalmers, constituent part of the Allis-Chalmers Company, died at Chicago July 13. Mr. Chalmers came to America from Scotland in 1843. He had a part in building Chicago's first water works, a single pump at the foot of the river; installed the first steam heating apparatus in the city, that in the old Dearborn school, and was one of the engineers of the old Illinois and Michigan Canal.

There are few readers of Compressed Air who have not heard of the International Correspondence Schools of Scranton, Pa., whose courses by mail have proved so uniformly successful. An addition has been made to the already extensive curriculum, which consists of a course in advertising. The International Schools have long been famous for their up-to-date advertising methods, and they now propose to teach other people how to be equally successful. While the advertising course is principally adapted for retail advertising, it will undoubtedly be of considerable value to those connected with large manufacturing concerns.

It is reported that liquid air is finding some commercial use in Berlin, and can be secured two litres (0.528 gallons) at a time for about 30 cents American money. It is said that the receptacles for delivering it are made of glass with double walls, the space between the walls being filled with an insulating material, the walls being silvered to prevent radiation of heat, and the whole enveloped with an insulating material. They retain their temperature for 14 days. Remembering that a drop in a glass of water will produce freezing, it is reported that it will be utilized for refreshing drinks and improving the condition of the air in the sick room.

Some interest has been aroused by the statement made in the daily papers telling of the incorporation of the New York-Buffalo Air Car Railway at Newark, New Jersey, with a capital stock of $125,000, of which $1,000 is paid up. The incorporation papers were drawn by James B. Dill, a New York corporation lawyer, and were filed at the office of the County Clerk of Essex County by the New Jersey Registration and Trust Company of East Orange. Neither Mr. Dill nor the East Orange Company will have anything to say about the plans. It is generally reported that the company will operate an air line railway between New York and Buffalo under patents taken out by Dr. Adolph Brodbeck, of Salt Lake City. According to the daily papers, the motor power will be compressed air, and the cars will be run on a steel rail at a speed of 95 to 100 miles an hour.

Among recent sales of street railway apparatus, the Westinghouse Traction Brake Company reports an order from the Los Angeles Railway Co., Los Angeles, Cal., for 80 street car air brake equipments with motor driven compressors. These equipments are to be fitted to new high speed cars which are being built by the St. Louis Car Company.

The Westinghouse Traction Brake Company has also lately closed contracts for the following motor driven compressor air brake outfits:

Sixteen to Oakland Transit Company, Cal.

Seventeen to North Shore Railroad Company, San Francisco, Cal.

Twelve to Indianapolis and Northwestern Traction Company.

Sixteen to Indiana Railway Company, South Bend, Ind.

With compressed air taking such a prominent part in the construction of the Rapid Transit tunnel in New York, all sorts of methods have been tried with more or less success to increase the efficacy of the compressed air machinery required. A portable air compressing machine plant was built at the De La Vergne Refrigerating Machine Co., and used continually in one section of the tunnel. It proved quite satisfactory in various instances, especially for compressing air for pneumatic tools. The outfit consisted of a Hornsby-Akroyd oil engine geared to a slow speed air compressor and placed on a strong steel frame with four substantial road wheels. Attached to it was a patented cooling water apparatus by the use of which only 30 to 40 coolers of water were required to operate the engine for the whole day, and practically no water was consumed. The air receiver was placed in the bed of the truck while the oil tank was fitted inside the frame.

In shaft sinking or small tunnels, columns with an adjusting screw at one end only are generally used. One drill is mounted on each by means of a special clamp that permits the drill to be adjusted so as to put in a hole at any height or angle. In larger tunnels a column with an adjusting screw at each end is employed, with one or two swinging arms, on which the drills are mounted. Just below the arm it is customary to place a safety clamp, which enables the arm to be loosened and swung to one side to change the bits and then swung back without losing the alignment. An arm cannot be used with the single-screw column, because its leverage will turn the columns and work the drill out of line. Allowance must be made in setting up the columns for 8 to 12 inches of blocking under the screws, as they will not work without it. The screws should be worked short, using blocking so far as possible, as this gives greater stiffness without liability to work out of alignment. Shafts up to 8 feet in depth, unless in very hard rock, should not use more than one drill on a single-screw column.

Two new circulars have been received from the Chicago Pneumatic Tool Company. These are advance sheets of a new catalogue. One is devoted to pneumatic drills. It illustrates Little Giant drills, flue-rolling, reaming, tapping, wood-boring machines and the Boyer piston air drill. A number of attachments for the drills are also shown, such as angle gears, flue cutters and flue expanders. The pamphlet closes with a statement of results of tests made with these machines, which illustrate their advantages over hand work. The other circular illustrates and describes pneumatic hammers and riveters. It includes valuable tables illustrating the possibilities of reducing the cost of work by their use. Such records are very seldom seen in catalogues. We have also just received special circulars Nos. 38 and 39, illustrating various types of pneumatic tools, with views of the tools at work. Special attention is directed to applications of the Boyer drill and "jam riveter," a new method for cleaning locomotive crown sheets with the riveter and of applying the Boyer drill to a yoke similar to those used in riveting. These are important functions of air tools believed to be entirely new, and are sure to find a good reception in locomotive shops.

The new electric motor cars of the Central London Railway (underground), which take the place of the separate electric locomotives formerly used in the operation of the line, have a motor truck at one end only. The cab covers the entire length over this truck, behind which the steel underframe is dropped low to receive the body of the car. The cab is 9½ feet long and 6½ feet wide over the frames, while the width over axle boxes is 7 feet 2½ inches. The wheels are 34 inches diameter, with a wheel base of 6 feet. With a current of 200 amperes at 500 volts, each motor is designed to give a tractive effort of 2,500 lbs. at the rail, and a speed of not less than 18 miles an hour. At 80 amperes and 500 volts the tractive effort is 650 pounds and the speed 27 miles an hour. The gear ratio is 1 to 4, with cut steel gears. There is a motor-driven air compressor, with a capacity of 35 cubic feet of free air per minute compressed to 90 pounds pressure in a main reservoir of 8 cubic feet capacity. When the pressure reaches 90 lbs. the motor is automatically cut out, but the circuit is closed again when the pressure has fallen to 80 pounds. The Westinghouse quick-acting brake is used, and a hand brake is also fitted. There are 22 lamps on the car: 14 in the passenger compartment, 1 over the rear platform, 3 for the instruments in the cab, 1 in the switch compartment and 2 in the headlight. The two latter of 32 c. p. and the others are of 16 c. p.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of Compressed Air. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

Editor COMPRESSED AIR:

We have no objection to giving you the facts regarding the explosion which wrecked the discharge chamber of one cylinder of our 20¼-inch by 24-inch duplex air compressor.

The accident occurred through error in judgment on the part of one of our employes in endeavoring to cut off one cylinder and use only the other as a single compressor.

In his endeavor to accomplish this he closed the discharge or outlet valve while the machine was running.

We roughly estimate that the pressure reached 800 pounds at the time the casting gave way.

The iron appeared at the fractures to be of good grade and flawless.

Yours very truly,

FREMONT CONSOLIDATED MINING CO.

(Signed) ARTHUR GOODALL,

Manager.

[We presume that when Mr. Goodall states that his employe closed a discharge or outlet valve he means that he closed a throttle in the discharge pipe which leads from the discharge valve to the air receiver. It is impossible to close the discharge or outlet valves on a compressor, as they open and close automatically. This explosion resulted in the death of Mr. Paddington, the superintendent.—ED.]

Death of Mr. James Cooper.

With the death of Mr. James Cooper at Montreal, on Saturday, July 11, a prominent figure in the manufacturing circle of Canada passed away. As president of the James Cooper Manufacturing Company, which concern represents the Ingersoll-Sergeant Drill Company in Canada, Mr. Cooper was prominently identified with the air compressor and mining machinery interests of the Dominion. His death came after a three weeks' illness and just before the arrival of his wife, who had been hurriedly summoned from a trip through Europe. Mr. Cooper was 68 years of age.

He began his business career with the firm of Rice, Lewis & Co., of Toronto, and later went with Frothingham & Workman, in both instances traveling for them. He associated himself in 1872 with Mr. Fred Fairman, under the firm name of Cooper, Fairman & Co. While they dealt chiefly with heavy hardware at the start, they gradually became interested in manufactures and were pioneers in the manufacture of barb wire. This was gradually developed, until a distinct corporation, under the name of the Dominion Ware Manufacturing Company, with Mr. Cooper as president, was organized. On the same line was the Dominion Wire Rope Company, of which Mr. Cooper was also the president. Another branch company, for the manufacture of patent pipes and elbows, was headed by Mr. Cooper. An extensive business in compressors and mining machinery was gradually built up, and the James Cooper Manufacturing Company organized to control it. The firm of Cooper, Fairman & Co. was dissolved in 1889, but Mr. Cooper retained his interest in the various manufacturing firms, besides doing a very large general railway supply business, representing a number of prominent American and British manufacturing concerns.

He was a man of noble character,

MR. JAMES COOPER.

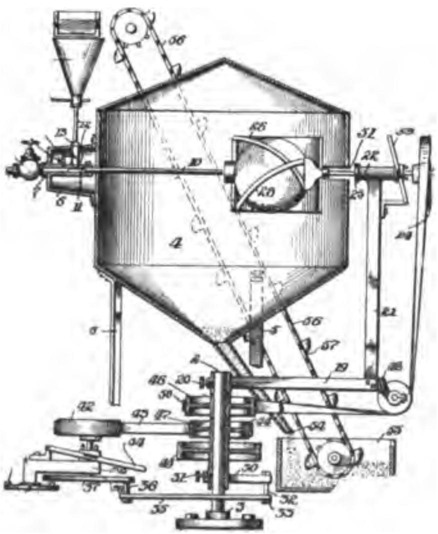
beloved by his associates and held in high esteem as one of Montreal's highest citizens. His manner to everybody was uniformly courteous and considerate. Being a man of means, he was liberal in his distribution of charities, giving freely, but in so quiet and unostentatious a manner that his name seldom appeared. We understand that after providing liberally for his widow Mr. Cooper has left his entire fortune to charity.

INDEX.

U.S. PATENTS GRANTED JUNE, 1903.

Specially prepared for COMPRESSED AIR.

731,812. SAND-BLAST. John Perdew, Monaca, Pa., assignor of one-half to Harvey Strong, Coraopolis, Pa. Filed June 4, 1902. Serial No. 110,223.

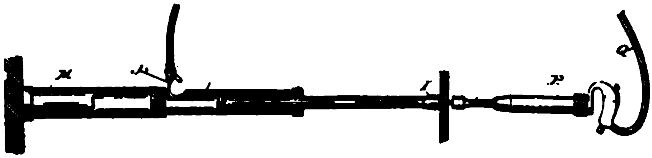


A device of the character described, the combination of a body portion having sand-blast pipe arranged on the interior thereof with a suitable source of sand connected to said pipe, a means for actuating the sand, a work-holder within said body supporting means for the same, means carried thereby for rotating the work-holder, means for oscillating the work-holder, and means for operating simultaneously said oscillating and rotating means.

732,375. FLUID-PRESSURE BRAKE APPARATUS. Joseph Reichmann, River Forest, Ill. Filed Aug. 18, 1902. Serial No. 120,025.

A fluid-pressure brake apparatus, the combination with appliances adapted to charge the brake-cylinder with air pressure from the auxiliary reservoir and to charge the brake-cylinder with air pressure from the main reservoir independently of the auxiliary reservoir, and to exhaust the air from the brake-cylinder through an independent passage leading directly to the atmosphere, and a single line of pipe connection, of a main reservoir, a train-pipe and a valve device interposed between the main reservoir and train-pipe and adapted to govern the supply of air pressure from the main reservoir to the train-pipe.

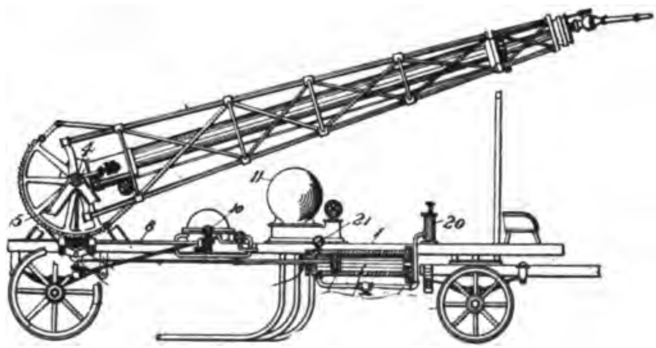
731,772. PNEUMATIC RIVET-HOLDER. Elias Gunnell, Chicago, Ill., assignor of one-half to W. Irving Babcock, Chicago, Ill. Filed June 20, 1896. Serial No. 596,293.



731,772.

A portable pneumatic holder-on for riveting, adapted to be interposed between the work and a support or abutment, and consisting of a pneumatic cylinder, a piston in the form of a rod projecting from the cylinder, and provided with a rivet-holding head at its extended outer end, means for admitting and releasing air near the rear end of the cylinder, and a detachable section on the rear end of the cylinder, the construction and arrangement being such that the tool is adapted to be held in position alone by the pressure of air in the cylinder.

731,889. AUTOMATIC PNEUMATIC BALANCE FOR WATER-TOWERS OR THE LIKE. Henry H. Gorter, San Francisco, Cal., Filed Sept. 11, 1902. Serial No. 122,910.



731,889.

An automatic pneumatic balance for water-towers and the like, the combination of a compressed-air cylinder, a piston operated thereby, a piston-rod therefor, a swinging tower operatively connected with said piston to move the same to compress the air in said cylinder by the descent of the tower, and means, independent of the compressed-air cylinder, for elevating said tower.

730,121. UNLOADING MEANS FOR AIR-COMPRESSORS. Ebenezer Hill, Norwalk, Conn. Filed Nov. 12, 1902. Serial No. 130,956.

A multiple-stage compressor, the combination with cylinders operating at different pressures, of an escape-valve controlling an outlet from the duct between the cylinders, a communication between the system beyond the high-pressure cylinder and said escape-valve, whereby the escape-valve is moved to open the outlet from the interduct when the pressure in the system beyond the high-pressure cylinder exceeds the predetermined maximum, and a valve controlling an opening into the high-pressure cylinder and adapted to be rendered inoperative by the drop of pressure resulting from the opening of the escape-valve.

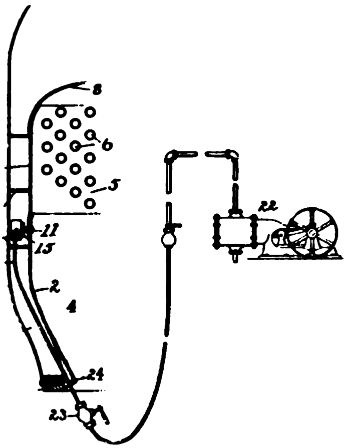
730,474. PNEUMATIC TIRE. Edwin B. Rayner, Piqua, Ohio. Filed Oct. 30, 1902. Serial No. 129,456.

730,315. TRIPLE VALVE. Paul Synnestvedt, Pittsburg, Pa., assignor to the Westinghouse Air Brake Company, Pittsburg, Pa., a Corporation of Pennsylvania. Filed Oct. 17, 1902. Serial No. 127,724.

731,314. PNEUMATIC LIFE-BELT. Johan A. Malmqvist, Campello, Mass. Filed Aug. 20, 1902. Serial No. 120,373.

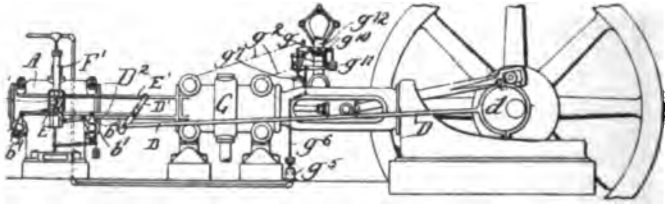
729,947. PNEUMATIC STACKER. Charles N. Leonard, Indianapolis, Ind., assignor, by mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Feb. 16, 1903. Serial No. 143,658.

730,207. PNEUMATIC TOOL. Dennis G. Foley, Hartford, Conn. Filed Aug. 29, 1902. Serial No. 121,489.



A combination, a comparatively short base or support having the greater part of its interior surface threaded, a comparatively short casing having the greater portion of its outer surface threaded to fit the thread in the base, and having a pressure-chamber, an anvil projecting within the pressure-chamber and a fluid connection for admitting a pressure medium within said chamber.

731,692. AIR-COMPRESSOR. George de Laval, Cambridge, and George P. Aborn, Boston, Mass., assignors to The Geo. F. Blake Mfg. Co., New York, N. Y., a Corporation of New Jersey. Filed July 25,1901. Serial No. 69,638.



731,692.

An air-compressor, the combination of inlet-valves each having a stem, a disk fixed on each stem, and having a plurality of notches or projections, levers upon said stems provided with means for temporarily engaging the notches or projections and operated from the eccentric of the engine to move each disk in one direction, and a device operated from said eccentric and controlled by the varying pressure of the air compressed, and connected for positively and variably moving the disks in an opposite direction, in accordance with the variations of air pressure, to close said valves.

731,234. AIR-BRAKE VALVE MECHANISM. Edward G. Shortt, Carthage, N. Y., assignor to the International Air Brake Company, Jersey City, N. J., a Corporation of New Jersey. Filed Apr. 16, 1900. Renewed Mar. 14, 1903. Serial No. 147,865.

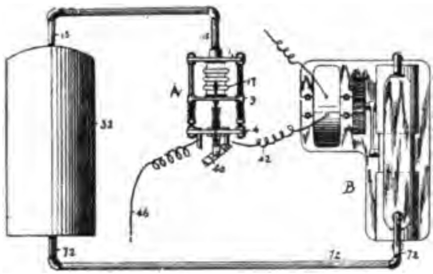
730,565. PNEUMATIC-ACTION FOR MUSICAL INSTRUMENTS. Johann D. Philipps, Frankfort-on-the-Main, Germany. Filed Nov. 28, 1902. Serial No. 133,128.

730,714. PNEUMATIC APPARATUS FOR DENTISTS OR PHYSICIANS. Paul H. Stehley and James H. Hulings, Parsons, W. Va., assignors of one-third to Frazer P. Stehley, Keyser, W. Va. Filed Oct. 2, 1902. Serial No. 125,652.

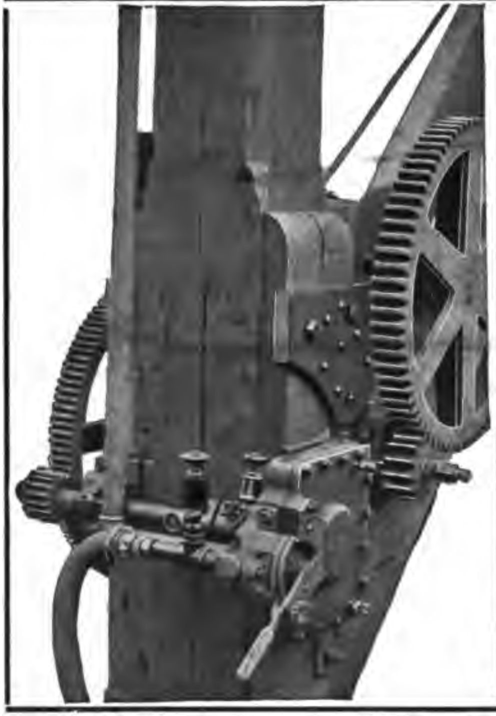
A pneumatic dental apparatus for supplying either a liquid or a gas under pressure, consisting of a reservoir-kettle having a pendent depression extending from the top to near the bottom and open at the upper end, a detachable receptacle seated in said depression and having a stopper provided with a pendent tube extending to near the bottom, and an external stop-cock, pipe and nozzle communicating with said pendent tube, a second pipe connecting said detachable receptacle with the top of the kettle, an air-compressing device fixed to the kettle and discharging into the same, and two separate pipes, connecting with the kettle, one entering the top of the kettle to carry off air or gas and the other extending to near the bottom of the kettle to carry off water under the pressure of the supernatant air or gas.

730,715. TERMINAL FOR PNEUMATIC-DESPATCH TUBES. Ernest Steinbock, Chicago, Ill., assignor to National Pneumatic Service Company, Chicago, Ill., a Corporation of Illinois. Filed July 3, 1902. Serial No. 114,194.

730,791. GOVERNOR FOR PNEUMATIC PRESSURE. William H. Nightingale, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Mar. 17, 1902. Serial No. 98,633.



In a pressure-governor, supports therefor, rods connecting the supports, a cross-head adapted to move on the rods, and an air-tight flexible cylinder secured at one end to one of the supports and its opposite end secured to and moved by the cross-head and a compressor, and a switch for the governor, controlling the compressor.



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VOL. VIII. NEW YORK, SEPTEMBER, 1903. No. 7.

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Those who fail to receive papers promptly will please notify us at once.

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VOL. VIII. SEPTEMBER, 1903. NO. 7

Compressor Explosions.

Like all good friends, the air compressor has to be properly treated or there is likely to be trouble. In the published reports of accidents of compressor plants it is usually the habit to throw the entire blame on the compressor, when, as a matter of fact, the responsibility for the accident lies with some outside agency.

A similar case is to be found in the reports of the accident which occurred at the compressor plant of the Fremont Consolidated Mining Company, Amador City, Cal., early in June, which resulted in the death of Mr. Purrington, the superintendent of the mine. According to the statement made by the management of that company, as given in the August issue of COMPRESSED AIR, the compressor was blameless. The accident, according to this statement, occurred through an error in judgment on the part of one of the employes, who attempted to cut off one cylinder of a 20¼-inch by 24-inch duplex air compressor and use the remaining cylinder as a single compressor. In his endeavor to accomplish this he closed the throttle in the discharge pipe, between the compressor and the receiver, while the machine was running. The result can be easily understood.

It is roughly estimated that the pressure reached 800 pounds to the square inch before the casting gave away. After the accident the wrecked cylinder was examined and the iron at the fracture appeared to be of good grade and flawless.

The Steam Engineer's Knowledge of Compressed Air.

The steam engineers of to-day are finding that a better knowledge of compressed air and compressed air machinery is a very important requirement for the man who is to take charge of the modern power-house and engine-room. Compressed air has come forward with surprising rapidity during the last few years, and the many practical uses to which it is now applied makes it a necessity in shops and factories where, until a short time ago, it was utterly unknown.

Compressed air power plants of considerable magnitude have been installed at mines and various mechanical establishments, and require the services of engineers with a thorough acquaintance with compressed air, as well as a knowledge of steam and other branches of engineering. In addition to these plants of major importance, there is hardly a factory or manufacturing establishment of importance that does not use compressed air in one way or another.

In places of this class where the compressed air is of secondary importance the compressor is generally placed in the engine-room, to be cared for by the engineer in charge. It may be operated by steam cylinders of its own, deriving its steam supply from the same boilers as the steam engine, or it may be power driven by belt or chain. In an electric power plant electricity should undoubtedly be used to run the compressor. Where water-power is available a water wheel or turbine will easily operate it. In any of these cases, however, the air cylinders themselves require care and it behooves the steam engineer, or whoever may be in charge of the plant, to understand the construction and operation of this machinery so that he may fulfill his duties in caring for the entire plant.

The general introduction of pneumatic tools has done much to include air compressors as part of the equipment of every up-to-date machinery establishment. The wonderful saving of labor secured by their use in so many lines makes compressed air in many cases an absolute necessity if the plant is to keep abreast of the times both in capacity and cost of construction. The compressor is installed as a result. In many such cases it is not large enough to require the constant attention of one man, so it falls to the engineer to see that it is kept running.

An air compressor is a well-behaved machine when given proper attention. A machine of standard make will run with little or no trouble, provided it is given proper care. As this is as essential to the successful operation of any compressor as of any steam engine, it becomes very important these days for the steam engineer, if he desires to be successful in his line, to acquire some practical knowledge of compressed air and compressed air machinery.

The Homestake Mammoth Air Compressor.

The Homestake Mining Co., of Lead, South Dakota, has just completed the installation of its new air compressor at the Ellison Shaft and now has it in service supplying air for drilling operations underground. The compressor is one of the largest ever built, having a rated capacity, at its maximum speed, of 9,000 cubic feet of free air per minute, this amount being sufficient, under mine conditions of operation, to run fully 125 power drills.

In order to secure the necessary floor space for this monster compressor it was necessary to blast out the side of the mountain back of the Ellison Hoist, and here is located the engine-room, 37 feet by 105 feet, where the machine is in operation.

The compressor was built by the Ingersoll-Sergeant Drill Co., and is of the duplex Corliss pattern with air end of that company's well-known "piston inlet" type. The steam end is cross-compound condensing Corliss with Wheeler surface condenser and cooling tower and designed to operate under the highest economy. The air end is of the two-stage type with intercooler of large capacity for cooling the air between compressions. The dimensions of the compressor are as follows:

Steam end:

Low pressure steam cylinder, 60-inch diameter by 72-inch stroke.

High pressure steam cylinder, 32-inch diameter by 72-inch stroke.

Air end:

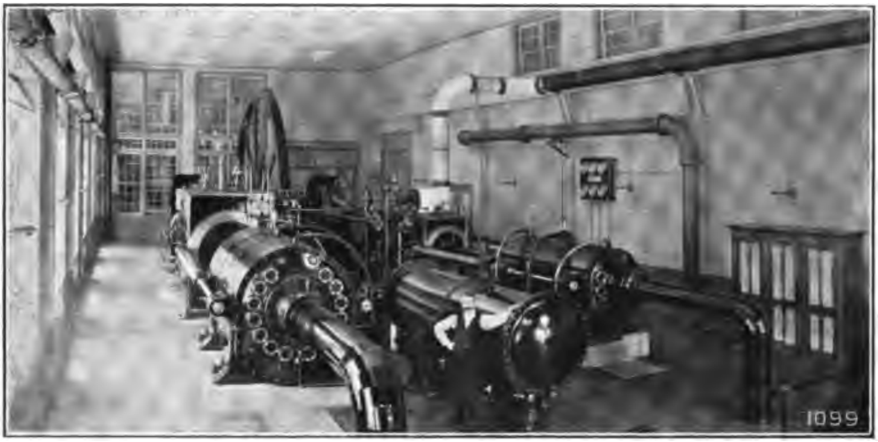
Low pressure "piston inlet" air cylinder, 52¼-inch diameter by 72-inch stroke.

High pressure "piston inlet" air cylinder, 32¼-inch diameter by 72-inch stroke.

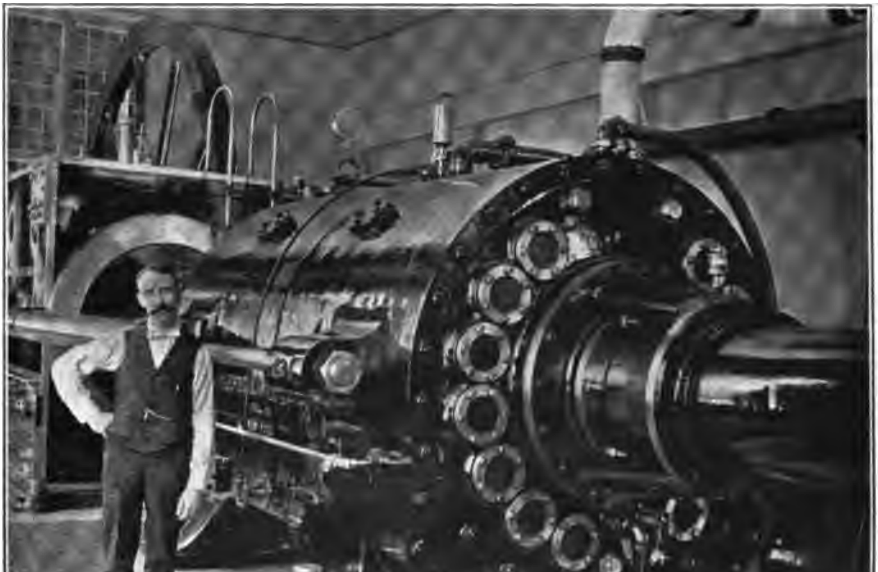
The total weight of this machinery is nearly 600,000 lbs., the flywheel alone weighing 50 tons.

On entering the engine-room one is greatly impressed with this grand piece of machinery at work and also with the superior manner in which it is installed, indicating the highest order of mechanical ability in the engineering department of the Homestake Co.

There are two other air compressors furnishing air underground at this mine. Both of these machines are of the duplex Corliss pattern with "piston inlet" air cylinders. One is located at the Old Abe Shaft and has steam cylinders 24-inch diameter by 60-inch stroke and air cylinders 26¼-inch diameter by 60-inch stroke. The



INGERSOLL-SERGEANT AIR COMPRESSOR JUST INSTALLED BY THE HOMESTAKE MINING CO.



LOW PRESSURE AIR CYLINDER ON THE NEW COMPRESSOR JUST INSTALLED BY THE HOME-STAKE MINING CO.

other is at the Highland Shaft and has steam cylinders 20-inch diameter by 42-inch stroke and air cylinders 22¼-inch diameter by 42-inch stroke. These two compressors, together with the new machine at the Ellison Shaft, furnish air for the operation of about two hundred Ingersoll-Sergeant rock drills in the mining operations underground.

Adjoining the engine-room of the large compressor is that of the Ellison Hoist, and here is installed, in marked contrast with the large machine, one of the smallest "piston inlet" compressors built. This little machine is of the following dimensions:

Two simple steam cylinders, each 10-inch diameter by 12-inch stroke.

Low pressure air cylinder, 16¼-inch diameter by 12-inch stroke.

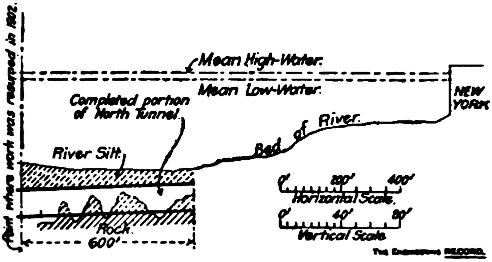
High pressure air cylinder, 10¼-inch diameter by 12-inch stroke.

The air from the above compressor is used to operate the air cylinders, furnishing the power to start, stop, reverse and apply the brakes to the Ellison Hoist.

Under the same roof is a third air compressor, of the three-stage type, also built by the Ingersoll-Sergeant Drill Co. This furnishes air at 900 lbs. pressure for the air haulage locomotive distributing ore from the shafts to the various mills.

The Hudson River Tunnel.

The Hudson river electric railway tunnel from the foot of Fifteenth street, Jersey City, to the foot of Morton street, New York, will have two parallel tubes about 15 and 18 feet in diameter. At the New Jersey end there will be two approaches, one from the Pavonia Ferry and the other from a point near the ferry of the Central Railroad of New Jersey. With these facilities and connections with the lines of the North Jersey Sreet Railway Company, which serve the Jersey City railroad terminals, the Metropolitan Street Railway and the Jersey City, Hoboken and Paterson Street Railway, the tunnel will be able to afford rapid and direct transportation for a large number of passengers between New York and New Jersey and will avoid the delays to which the ferryboats are subjected by fogs and congested traffic. The tunnel was first promoted by the late Col. De Witt C. Haskins, who started work in 1874. Work was continued intermittently until 1882, when, after constructing about 2,000 feet of the north tube of the tunnel,



PROFILE OF FINISHED CONSTRUCTION.

the original company suspended operations. An English company was organized to carry on the work and abandoned it after 600 feet of the south tube had been completed. Finally the New York and New Jersey Railroad Company was incorporated with a capital stock of $8,500,000, and has resumed work on both tubes of the tunnel, which it is hoped will be completed without further interruption.

The tunnel will have a maximum depth of 102 feet below water level. The distance from the tunnel to river bottom varies from 5 to 65 feet, and the tunnel is driven at a grade of about 2 per cent. When work was commenced there were few precedents of such construction on a large scale under similar conditions; and as the conditions were very difficult, the work was costly and dangerous, and it has been reported that over $4,000,000 were expended upon it. It was originally known as the North River tunnel, and the work was in charge of some of the first men in this country to use the pneumatic process. A shield was not at first employed and the attempt to excavate the very fine soft silt in a large heading eventually caused a disaster which cost many lives. The excavation was made under pneumatic pressure and the cast-iron lining segments were fitted into position as rapidly as possible, so as to leave the least possible amount of unsupported earth and silt. Great difficulty was found in keeping up the pressure, as the earth was not dense enough to retain the air thoroughly, and its escape was immediately followed by an inflow of water. This was always preceded by a hissing sound which gave warning so that the men could usually stop the hole with clay before the water commenced to enter. On one occasion a leak suddenly developed which was so large that it was impossible to stop it with the clay and straw at hand, because they were immediately forced through the opening by the air pressure. In this emergency Capt. John Anderson, the superintendent, with great heroism, placed his body in the opening and remained there until his assistants could insert clay between him and the earth and gradually close the dangerous leak. Later on a large leak occurred and before all the men could escape, the door of the air-lock became jammed so that it could not be operated and the remainder of the men working there were drowned. These events happened many years ago under the earlier administration, but they are of interest as showing the perils which were met, and the great advance in methods and appliances which have since been made and prevent the danger of future accidents of a similar nature.

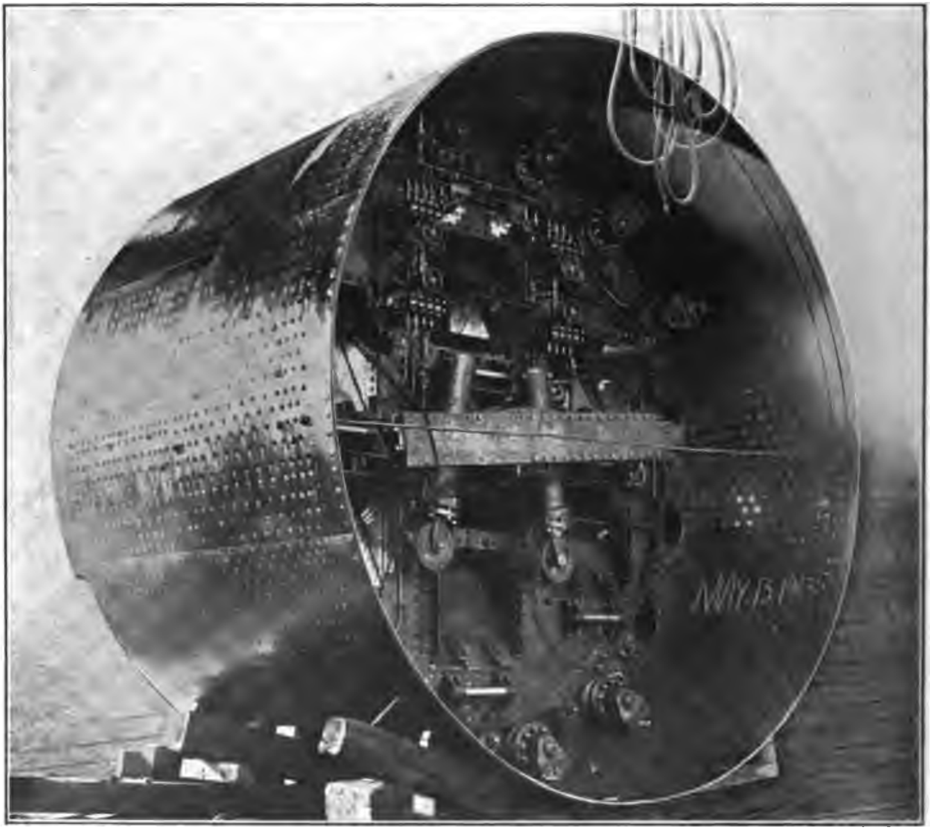
The principal difficulty in the construction lies in the very soft silt which has to be penetrated, the very thin roof which is left over the tunnel, and in the fact that the surface of the bed rock is so irregular that in some cases the tunnel is partly in rock and partly in silt. No large tunnel has previously been built with a shield working partly in silt and partly in rock, and the work which is now in progress by this method is consequently of special interest.

The shaft at the west end of the north tunnel is 30 feet in diameter and 65 feet deep. It is lined with brick and is enclosed in the power house where the operating plant is installed. The north tunnel has a clear internal diameter of 18 feet 1¼ inches and an external diameter of 19 feet 5¼ inches. The south tunnel has corresponding diameters of 15 feet 3 inches and 16 feet 7 inches, and both are built with cast-iron linings or shells, made with segmental plates flange-bolted together. The north tunnel shell is composed of rings 20¼ inches long, each of them having eleven segments and a key 11 inches long at the crown. The segments have a web 1½ inches thick and flanges on all sides 8 inches deep over all and about 2¼ inches thick at the base. They are slightly tapered and have parallel bearings for steel bolts 1¼ inches in diameter. The inner edges of the flanges have wedge-shaped clearances for packing and the flanges are stiffened by transverse ribs or webs about 10 inches apart and 1 inch thick. Through the centre of each segment there is a grout hole 1¼ inches in diameter which is closed with a screwed plug. The weight of one ring, 20¼ inches long, is about 12,765 pounds, which is equivalent to 7,565 pounds per linear foot, the segments thus weighing a little more than 1,100 pounds each. The lining for the south tunnel is composed of similar rings 24 inches long, each made with nine segments and a key and weighing 11,340 pounds, equivalent to 5,670 pounds per linear foot. Each circular joint in the south tunnel lining has 67 bolts and each longitudinal joint between segments has four bolts.

Work was abandoned on the construction of the north heading of this tunnel by Messrs. S. Pearson & Sons, contractors, in 1891, and the tunnel was made secure and allowed to gradually fill with water. The work on the south tunnel, after having been driven for some 550 feet of the New Jersey shaft, was abandoned, bulkheaded and closed up in 1882.

At the time of the abandonment by Messrs. Pearson & Sons, the north tunnel had been driven 3,895 feet in the direction of New York. In the latter part of 1896 and the early part of 1897 the bondholders took possession and gave instructions to have the tunnel freed of water, for the purpose of examining its condition. On completion of this work, it was found that the work previously done, with the exception of some 470 feet, was in a satisfactory condition and reorganization then proceeded, during which time the tunnel was maintained, regularly pumped and kept in good condition until in April, 1902, orders were given to prepare to proceed with the construction work. The plant which had been installed on the New York side of the river had been entirely removed, the shaft allowed to fill up, the top was covered and it was completely abandoned. At the New Jersey shaft the existing buildings were of light wooden construction, and the machinery installed therein was for the most part out of date and in very bad condition. It was decided to make a complete sweep of all the existing plant and to remodel the whole installation with an entirely new and modern equipment for safe and rapid construction, and at the same time to build the plant work itself under its own chief engineer.

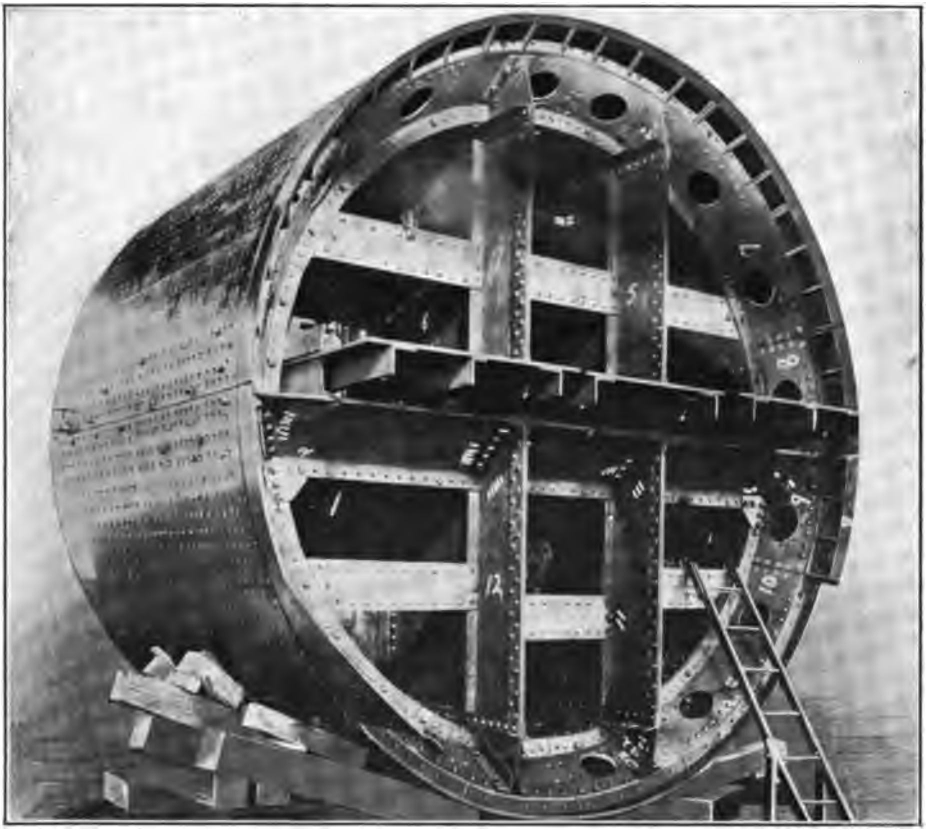
A steel frame building, constructed by the American Bridge Company, was covered with corrugated iron and divided internally for the various offices and dressing rooms necessary for carrying on the work and to accommodate the machinery installed on the surface.



REAR OF SHIELD, SHOWING JACKS, VALVES AND SEGMENT ERECTOR.

fireproof, so that there might be no danger to the works from fire at the surface buildings. Plans and specifications were drawn for the completion of the works, and although eleven bids for the new construction were invited, only one was received. This tender was not considered satisfactory, and the company then decided to carry out the construction This included four 150-horse-power locomotive type boilers, working at a pressure of 100 pounds per square inch; two 400-horse-power Berryman feedwater heaters; two Ingersoll-Sergeant straight line piston inlet air compressors, having a 22 by 24-inch steam cylinder and a 26¼ by 24 inch air cylinder to supply air inside the locks; and a

22 by 26¼ by 24 inch reserve Ingersoll-Sergeant duplex compressor for alternate duty with those above; one 20¼ by 30 inch Ingersoll-Sergeant straight line piston inlet compressor, installed for operating compressed air at high pressure, for use in running rock drills and the haulage engines installed in the tunnel. Each compressor has a 48-inch air receiver 15 feet long. The General Electric Company installed an entirely new electric lighting plant, with four 25-kilowatt marine type direct-driven generators, each wound for 125 volts pressure and operated on the three-wire system, and having a capacity sufficient for carrying on work in both the north and south tunnels. A 10 by 20 inch double-cylinder Lidgerwood hoisting engine with reversing gear and double drums was installed to operate the balanced cages in the shaft. For the operation of the shield in the tunnel duplicate 16 by 2 by 12 inch hydraulic pumps were installed and connected to an accumulator carrying a constant pressure of 1,750 pounds per square inch. The pumps and the pipe lines in the tunnel are efficient for a pressure of 5,000 pounds per square inch, and the valve arrangements permit of cutting out the accumulator pressure and pumping directly on the tunnel pressure line, to attain any pressure between 1,750 and



FRONT OF NEW SHIELD, SHOWING MOVABLE CANTILEVER PLATFORM.

5,000 pounds. The hydraulic pipe line in the tunnel is 2 inches in diameter at the pumps and is reduced in two stages to 1½ and 1¼ inches at the face. There is a 5-inch pipe line and a 4-inch air pipe line in the tunnel for pneumatic pressure for the locks, and a 3-inch pipe for the high pressure for the drills. Two of the old air-locks in the tunnel were removed and two are retained for the two-stage system. They maintain a constant pressure of 15 pounds inside the first lock and the varying additional working pressure beyond the second lock.

The shield built and installed by Messrs. Pearson & Sons has been overhauled and altered in many respects, and in its present condition is being used for the north tunnel with entire satisfaction. This shield, however, was designed for use only in the Hudson river silt and was not originally adapted for use when rock occurred at the invert and silt over the arch. Construction was therefore suspended after it had been advanced a short distance, and an excavation was made in the front of the shield, in which an apron was built. This extended 6 feet in advance of the face of the cutting edge and reached from side to side of the shield itself. It was built of 12-inch I-beams and ¾-inch steel plates, riveted solid with the shield itself and heavily stayed. Under it the sides and face of the excavation were heavily timbered and closely poled. The apron permits the advance of the shield in all cases where the rock does not extend 6 feet above the lower part of the cutting edge. The apron thus affords a 6-foot shelter for the men drilling and excavating the rock below it, and, in the chief engineer's opinion, has given absolute satisfaction in its operation.

The shield measures 19½ feet inside of the tail piece and is advanced with sixteen 8-inch hydraulic jacks. The pressure developed in the jacks corresponds with the amount necessary to push the shield forward, and varies day by day, according to the character of the soil. The cast-iron lining plates are assembled in the rear of the shield by a double-acting radial hydraulic erector, with hydraulic swivelling gear. The erector is independent of the shield and is moved forward as needed.

The north tunnel is equipped with a cable hauling system installed by the John A. Roebling's Sons Company, Mr. S. A. Cooney engineer. This is built in three independent sections, which are separated by the air-locks. The first section, 1,575 feet long, reaches from the foot of the shaft to the first air-lock; the second section, 1,660 feet long, reaches from the first to the second air-lock; and the third section extends, with a variable length, from the second air-lock to the working face. Each section is operated by an 8¼ by 10 inch special hoisting engine, built by the Lidgewood Manufacturing Company for this service, according to the requirements of the Roebling Company. The engines are designed for continuous winding and built with double-grooved drums and operated by air at 70 pounds pressure, except for the first section, which is operated with steam direct from the boilers. The first two engines exhaust to the open air, the third one, beyond the second lock, exhausts under the intermediate tunnel pressure.

A temporary wooden floor is built through the tunnel on its horizontal diameter, and on it are laid two 21-inch tracks, about 5 feet apart on centres, which reach from the shaft to the working face. In the bottom of the shaft the engine for the first division of the cable system is set on the working platform, with its axis at right angles to the tracks. The hauling cable for the first section is carried on friction sheaves from the engine to the air-lock, where it engages a horizontal sheave and returns to the hoisting engine, both parts lying on the centre lines of the tracks. At the engine the cable is adjusted by a gravity tension carriage, which allows 5 feet take-up. Both tracks converge to the doors at both ends of the single lock. There is a permanent track carried through the lock and it connects with the tunnel tracks by short sections, which are removed by hand when the lock doors are closed. The cars are pushed into and out of the lock by hand to engage the cable traction just outside the lock. The second lock is a double one, with the 3½ by 4½ foot doors in line with the centres of the tunnel tracks. The second cable section is similar to the first, except that its engine has the axis parallel to the tracks and is seated alongside on the platform close to the pressure end of the first lock. The third section is operated by an engine located just beyond the second lock, under the track platform. The axis of this engine is at right angles to the tracks, and the rope leaving the drums is deflected over a vertical longitudinal sheave and passes down the centre horizontal deflecting sheaves, and the bight is brought back parallel with and underneath the tracks to a point at first located near the heading 700 feet away from the engine. Here it engages a

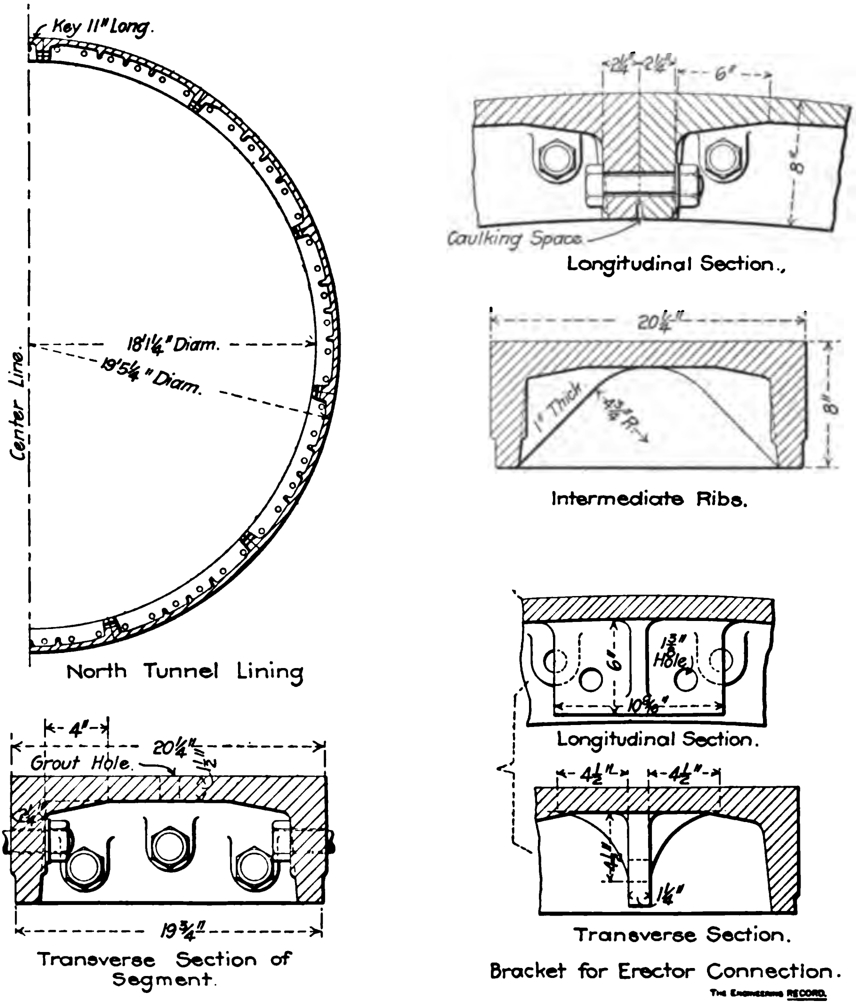
EXCAVATING UNDER TEMPORARY COVER IN FRONT OF SHIELD, HUDSON RIVER TUNNEL, NEW YORK.

of one track to the heading, where it engages two horizontal sheaves and returns to the air-lock in the centre of the other track. Here, instead of going directly to the drum, it is led around vertical sheave in the gravity tension carriage, and returns from it to a horizontal sheave near the air-lock, around which it passes to the drum, thus completing the circuit and providing between the tracks two hauling parts, which may, without moving the engine, be lengthened or shortened by making a corresponding displacement of the tension carriage, thus enabling the haulage system to be extended 700 feet as the heading advances. All of the machinery and all the cable, except what lies between the tracks to receive the car grips, is underneath the temporary platform. The deflecting sheaves at the heading are rigidly attached to a 10-foot section of the tracks, which also carries at the front end a solid platform plate, with guides converging to the ends of the track rails, so that when a car is pushed beyond the end of the track to receive its load the guides centre it on the track without trouble. The platform plate is horizontal, but the 10-foot rails connecting it with the main track are inclined upwards at a grade of 5 per cent., to allow room below for the deflecting sheaves and also to serve as a check and absorb the velocity of the empty cars released from the cable. When the heading has advanced from 10 to 20 feet beyond the end of the cable system, the tension carriage below is moved back a corresponding distance and the movable section of the track and front platform are moved forward on the working platform and secured there ready for continued service, the whole operation being easily and quickly made, and not requiring special adjustment. After the heading has advanced 700 feet beyond the point where the cable system was installed, another length of rope can be spliced to the 3,000 feet at first used, and the system continued indefinitely.

At each end of each division of the rope system, the returning rope is provided with a stop which engages a lever in the car grip and releases it so that the car is automatically stopped on its arrival. The departing rope is carried on two guide rollers 20 feet apart, which can be raised by a lever so as to throw the rope against the open grip on the car. Two men are required at each end of each division, one of them to raise the cable and the other to operate the grip on the car. No hand work is required to release the car from the cable. There are about 40 steel cars, each weighing 1,400 pounds and having a capacity of 2,600 pounds. They are fitted with toggle grips adapted from those used by the Roebling system of aerial tramways. The grips have adjustable jaws, made to take up the wear, and are operated by two levers, a long one, set by hand, to engage the cable, and a short one, moved by an automatic stop, to release it. Both of them are set against adjusting screws, which hold them at a point just past the centre of the toggle, so that when set they remain in equilibrium. The ropes are driven at a speed of 300 feet a minute, and the system has a calculated capacity of 300 tons in ten hours. At the west end of the tunnel the track has a grade downward away from the shaft, but at the east end the cables have to pull the cars up an incline of about 2 per cent.

The new air-locks have been installed in the south tunnel, the required machinery is under contract, and it is expected that the construction of the tunnel will be resumed in September. The shield was designed by Messrs. Jacob & Davies, and is being built by the Watson-Stillman Company. It is of special construction, as shown by the accompanying illustrations, made from photographs taken in the shop. It is stiffened by vertical and horizontal frames and by transverse diaphragms, and is provided in front with a movable cantilever working platform, which may be protruded beyond the cutting edge if necessary. In the rear are arranged the hydraulic jacks, valves and other mechanism necessary for moving the shields and for operating the erector, which is a diametrical arm concentric with the shield and commanded by hydraulic apparatus. It receives the segments, which have special brackets for connection with it, and sets them in place inside the tail of the shield. Special tools and apparatus have been furnished by the Watson-Stillman Company and by the Cockburn Barrow and Machine Company. The construction work has been somewhat irregular, on account of the great difficulties and the obstacles encountered. Some of the rock has given considerable trouble. The conditions have been severe for the workmen, and the lengths of the shifts have been reduced from four to three hours as the maximum pressure increased to 48 pounds. A medical expert is in attendance, and the men conform to careful regulations concerning work and diet. A hospital has been provided and prompt attention is given to any case of the bends. Since the installation of the cable service the men are taken to the heading in the cars, and thus save 20 minutes of the time formerly required to make each trip.

recently executed has been between 4 and 5 feet per day of finished tunnel, built under exceptionally difficult and hazardous conditions, with 65 feet of water and only 10 feet of soft silt over the crown of the tunnel.



DETAILS OF CAST-IRON LINING.

Since the operations have been resumed, work has progressed actively, with the one exception of delay caused in changing and altering the shield. Progress in rock and silt on the work

The authority of the New York Department of Docks has been given to occupy surface over the old shaft, for construction purposes. A fireproof steel building, 80 feet square, will be erected for the accommodation of workmen and for the installation of the machinery, similar to that on the New Jersey side. The shafts, however, are different, as the one on the New Jersey side is an open one and the headings are reached through horizontal air-locks in the tunnel, while on the New York side, instead of sinking an open shaft, a closed caisson was sunk and access was had to it through a small steel shaft, terminating in a T-shaped air-lock at the bottom. This shaft is too small for the new workings, and will be torn out and replaced by a larger one, with a T-shaped air-lock above the surface. A hoisting cage will be operated inside this shaft for the removal of the excavated material in cars and for taking supplies into the tunnel. This plant will be used for the construction of that portion of the approaches which is to be lined with cast-iron plates, and from it will be driven the river portions of the tunnel to meet the headings from the New Jeresy shaft. A second shield, similar to the one described, is now under construction, and will be operated from this plant.

The entire work of construction is under the direction of Mr. Charles M. Jacobs, M. Inst. C. E., who is chief engineer for the New York and Jersey Railroad Company, and also for the contractor, the Hudson River Improvement Company.—*Engineering Record.*

The Diamond Coal Cutter.

Reference has been made in COMPRESSED AIR to the Diamond Coal Cutter, better known perhaps as the "Garforth," out of respect for its inventor, and to its use in the coal mines of England, but no description of the machine itself has yet been given in this publication, nor has any attempt been made to tell of the circumstances that led up to its introduction.

Mr. W. E. Garforth, M. I. C. E., F. G. S., was managing director of Pope & Pearsons' West Riding Colliery, when he was confronted in the working of his collieries by two problems. There was the ever present question of the workman, and he wished to get his coal without the use of explosives. Coal cutting by machinery was not entirely new in England, any more than it was in the United States, and he determined to attempt to solve his problems by utilizing machinery in the mines. He obtained samples of every coal-cutting machine that was then on the market, and gave them all a trial. Not finding that any of them answered exactly his requirements, he set about constructing one with the aid of the experience he had so gained, and thus evolved the Diamond machine. In this he had the assistance of several practical mining engineers, who were working with him at the time.

The Diamond machine has the usual rectangular framework common to nearly all coal-cutting machines of the long wall type. The cutting is done with the assistance of a disc, which is supported by a strong bracket standing out in the middle of the length of the machine, the bracket being securely bolted to the middle of the inner side of the frame, and the disc being supported at its centre and over a portion of its inner periphery,

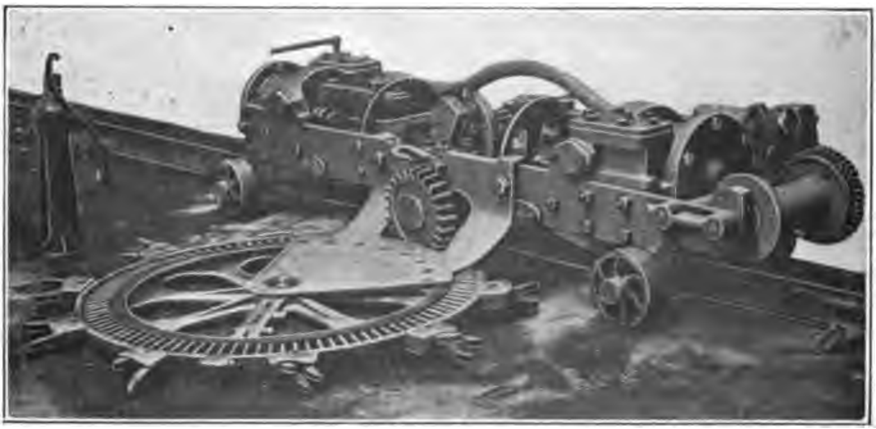
DIAMOND COAL CUTTER FOR MAKING CUT ABOVE THE FLOOR.

the latter by a brass arc which is bolted to the bracket and which runs within a groove in the periphery of the disc. It is in the driving arrangement that this machine differs particularly from others of the disc type. In place of a single air cylinder at one end of the frame, there are two fixed, one at each end, using air at 40 to 50 pounds pressure per square inch. Where the machine is electrically driven the motor is divided into two of smaller size, one located at either end. The machine is made to cut at floor level, the frame running directly on the floor of the mine for that purpose, but it can also be adjusted, by shifting the bracket supporting the disc, so that the undercutting may be done at any height desired.

The coal-cutting machine is set on two rails along the coal seam which is to be undercut. There are three sets of rails and, as the machine passes from one pair to the next, the first pair is removed and placed in front. In addition to the wheels which rest on the rails a portion of the machine near the coal face is supported by two flat-faced wheels, which run on the ground, giving the machine three sets of supports instead of two, as is customary. In case of any cutting down, should the machine be lifted off the rail farthest from the coal face, it is still supported by the flat-faced wheels and those on the rail nearest the coal face.

The large wheel or disc cuts horizontally in any part of the vein most desirable or in the fire clay underneath the solid coal, and as the earth beneath the seam is cut out to uniform depth of a few feet, the machine draws itself along the rails and sprags are introduced behind the wheel to support the coal. The coal in most of the deep mines in England is induced to fall by its own weight, as soon as the sprags are withdrawn, and the falls, it is said, invariably have a larger percentage of large coal and less of crushed or small coal than under the old-fashioned pick cutting system, while the necessity of the blast, with its accompanying dangers, is almost eliminated.

In thick seams the machine is usually run in one direction only, although it is fitted with reversible gear, which is often found useful to enable it to be withdrawn should a fall occur, preventing its forward movement. After it has completed a cut (which may be of any length, from 500 to 1,500 feet long) it is brought down to the gateway and back around to the same starting point. It is mounted on a specially designed fitting arrangement, with the wheels placed within a short distance of each other, which is to overcome any difficulty with respect to the removal of the machine. In thin seams the machine cuts backward and forward, thus saving the extra cost of making head room to flit the machine. In this way the whole district is worked out before the machine is removed. In one instance the machinery had been regularly at work, going backward and forward on a long wall face, and was not removed for a period of four years, or until all the coal in that district was worked out.



DIAMOND COAL CUTTER FOR UNDERCUTTING AT LEVEL OF FLOOR.

The machine has been in use in a number of colleries and has, like other coal-cutting machines, demonstrated its ability to increase the output and at the same time reduce the cost. Mr. Garforth's trouble with his workmen was thus successfully overcome in that, with the aid of the machine, he was able to pay better wages and increase his output materially.

While making an investigation of the conditions in the English coal mines, Mr. L. J. Daft, of New York, who has as extensive an acquaintance with the American mining methods as any man in this country, said, concerning the Diamond or "Garforth" machine:

"I found the Garforth built almost exactly the same as the old well-known Gillet & Copley machine, which has been built at Barnsley, England, for many years, except that it has more powerful cylinders, and the disc on which the cutting bits are inserted is made sufficiently large in diameter to undercut 5 feet deep. I also noticed that it makes a higher curve or undercut, and hence, if cutting in coal makes more slack, at the same time making more room for the coal to roll out in good shape. In this instance the machine was doing the undercutting in a strata of bastard coal and slate, some 6 or 7 inches thick, which lies immediately beneath the coal seam. It was taking out virtually the whole of this dirty band, which left ample height for the coal to fall, and which did fall, too, shortly after it had been undercut.

"It was doing its work rapidly, but I think I noticed that the strain on the machine, owing to the increased diameter of the cutting disc, was greater than on other machines having smaller discs, and, consequently, the repair bills on this machine will no doubt be greater. This, however, is an unimportant matter, when you take into consideration its marked increased capacity, which by far outweighs the question of repairs. I considered this the best long wall machine I have ever seen in operation.

"They have a number of these machines working in this particular seam, and in connection with which the Ingersoll machine is now being used for driving some of the headings, and preparing the territory for the operation of the Garforth machine."

Accompanying this sketch are two illustrations of this machine, one showing it prepared for undercutting at the level of the floor, and the other for undercutting in the centre or top part of the vein. In the first will be noticed that the machine stands very low, its height being less than 2 feet, which is of considerable advantage when working where there is little space. Besides being capable of working in thin veins, it requires but 2 feet 9 inches between the props or pack walls and the coal face.

Electro-Pneumatic Operation of Blast Furnace Bells.

One of the latest achievements in the operation of blast furnaces is the dispensing with workmen on the furnace top. There are more desirable places to work than on the top of a blast furnace, and a number of recent accidents have fully demonstrated that it is dangerous as well as undesirable. Modern furnaces are no longer charged by hand barrows hoisted to the top and then dumped into the hopper by a crew of men; they are charged by mechanical means, the machinery being operated at the bottom of the furnace.

To a great extent the single bell and hopper has been supplanted by the double bell and hopper, and where this has been done the efficiency of the furnace has been increased by the saving of the gas that formerly escaped from the top of the furnace every time the bell was lowered.

The use of two bells has led to a more perfect means of operating them.

When two bells are used it is always desirable that one should be closed before the other is opened, and this should be done without any liability of failure on the part of the apparatus, or any mistake made by the operator.

The Union Switch & Signal Company, of Swissvale, Pennsylvania, manufactures an electro-pneumatic apparatus that accomplishes this in a most satisfactory manner. It is strictly interlocking, and one bell cannot be lowered until the other is in place.

This company has just finished installing this apparatus on six furnaces for the Lackawanna Steel Company, of Buffalo, N. Y. These are the largest and most modern furnaces in the country, and are the first to be equipped with apparatus of this kind.

The equipment in general is shown by cuts 6 and 7, taken from the top of the furnace, and at the skip hoisting-house at the bottom; it is shown in detail by Figures 1, 2, 3, 4 and 5.

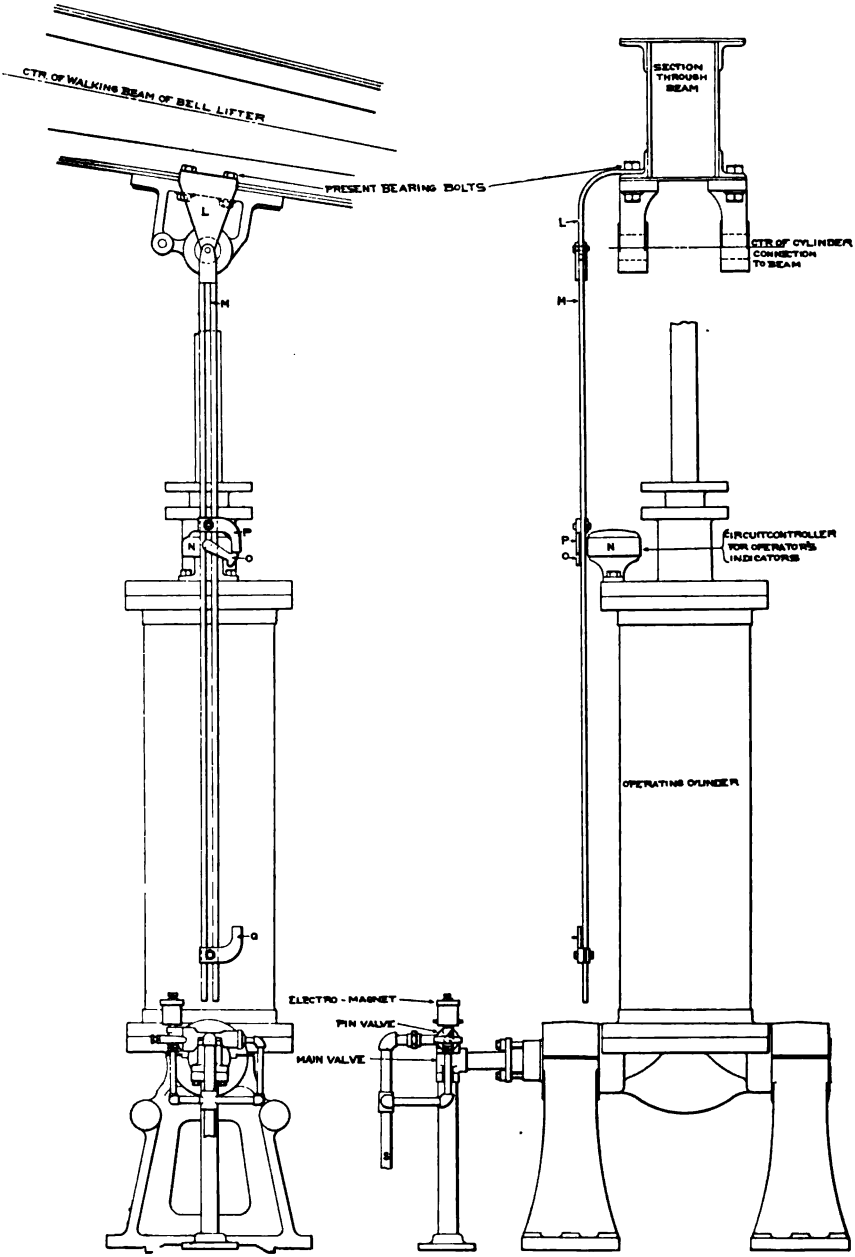

CTR. OF WALKING BEAM OF BELL LIFTER
PRESENT BEARING BOLTS
SECTION THROUGH BEAM
CTR OF CYLINDER CONNECTION TO BEAM
L
M
N
P
O
Q
CIRCUIT CONTROLLER FOR OPERATOR'S INDICATORS
OPERATING CYLINDER
ELECTRO-MAGNET
PIN VALVE
MAIN VALVE
S

FIG.I.

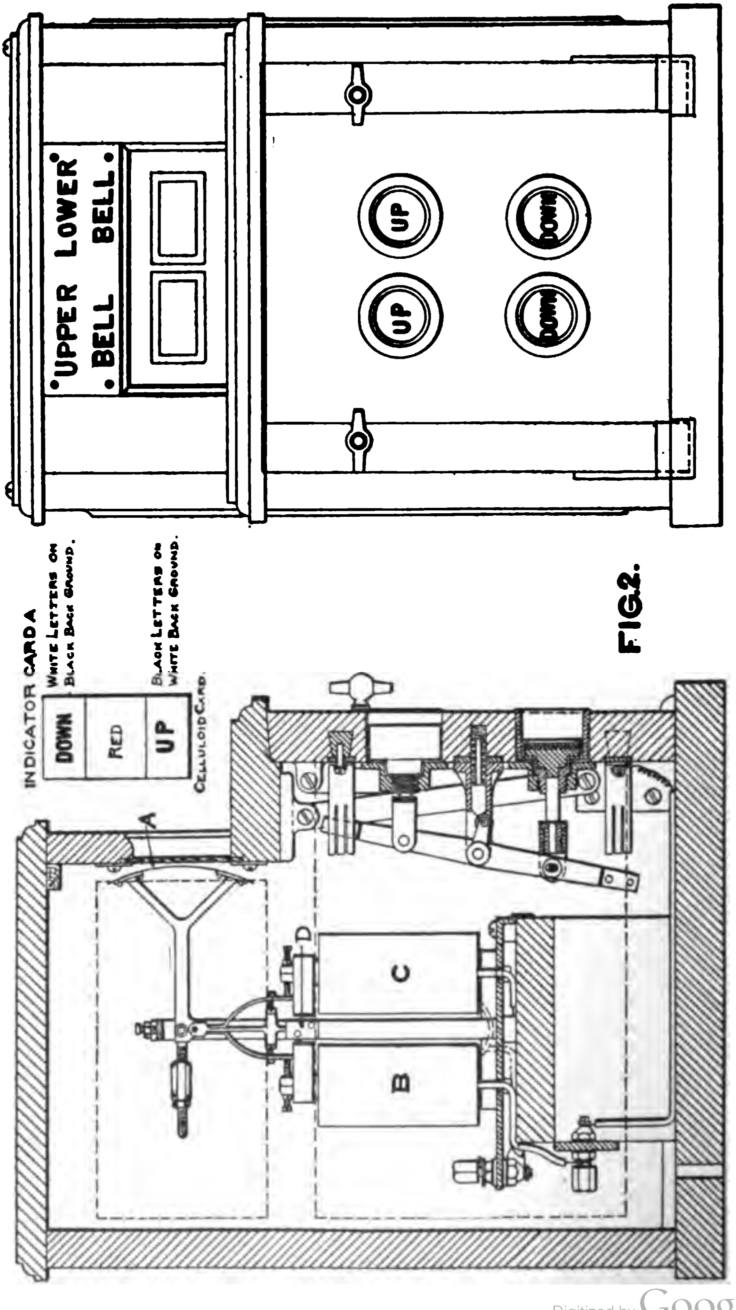

"UPPER BELL"
"LOWER BELL"
UP
UP
DOWN
DOWN
INDICATOR CARD A
WHITE LETTERS ON BLACK BACK GROUND.
DOWN
RED
UP
BLACK LETTERS ON WHITE BACK GROUND.
CELLULOID CARD.
A
D
C
B

FIG. 2.

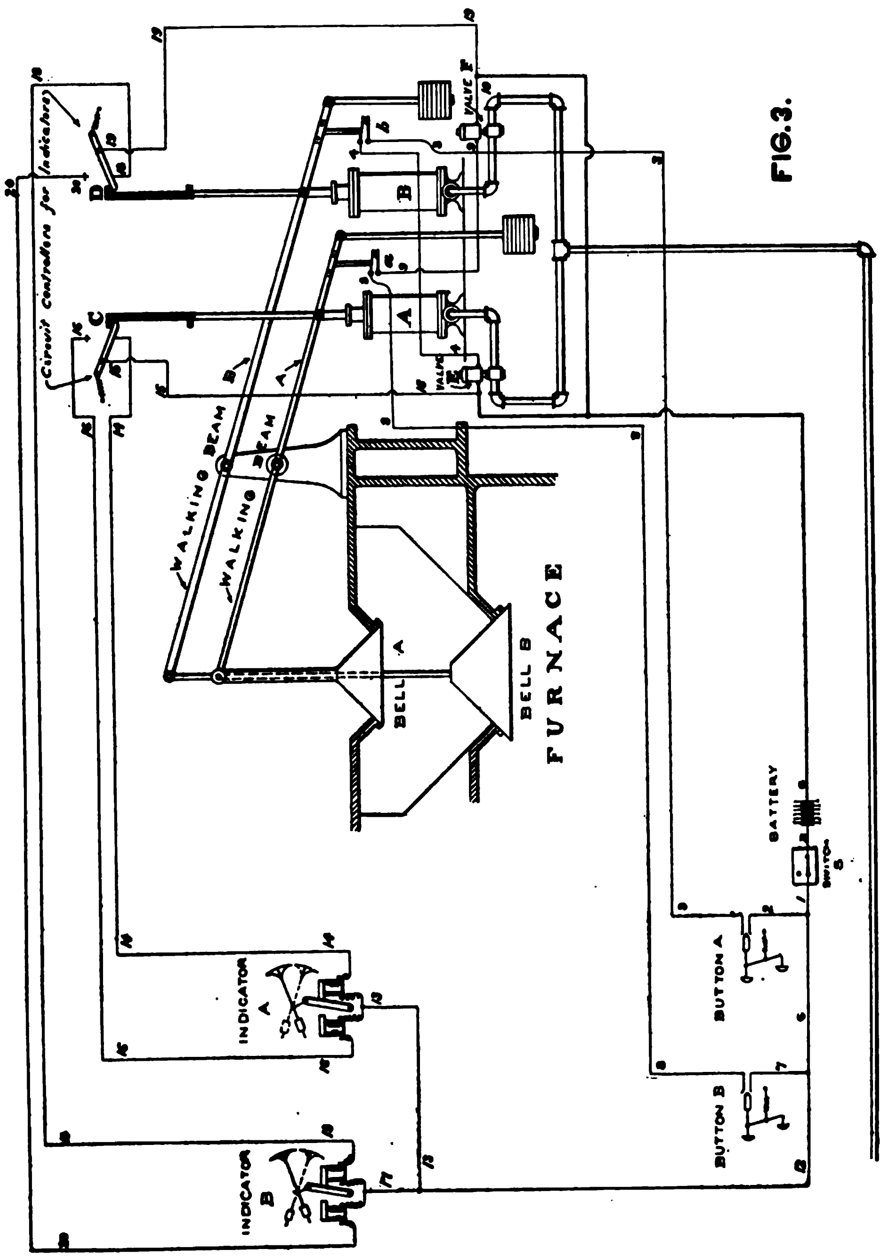

Circuit Controllers for Indicators
WALKING BEAM
WALKING BEAM
BELL A
BELL B
FURNACE
VALVE E
VALVE F
INDICATOR A
INDICATOR B
BUTTON A
BUTTON B
BATTERY
SWITCH S

FIG. 3.

Figure 1 shows the device as it is connected to the operating air cylinders used to lower the bell at the top of the furnace.

Figure 2 shows the push button apparatus used to operate the valve mechanism. This is placed, together with a storage battery, switches, etc., in the skip hoisting-house at the bottom of the furnace.

As shown in Figure 1, the valve operating device is located at the bottom of the operating cylinders. The duty of this valve mechanism is to open and close the air valve leading to the operating cylinders. The operating cylinders are single acting, taking air at the bottom of the piston only; this raises one end of a

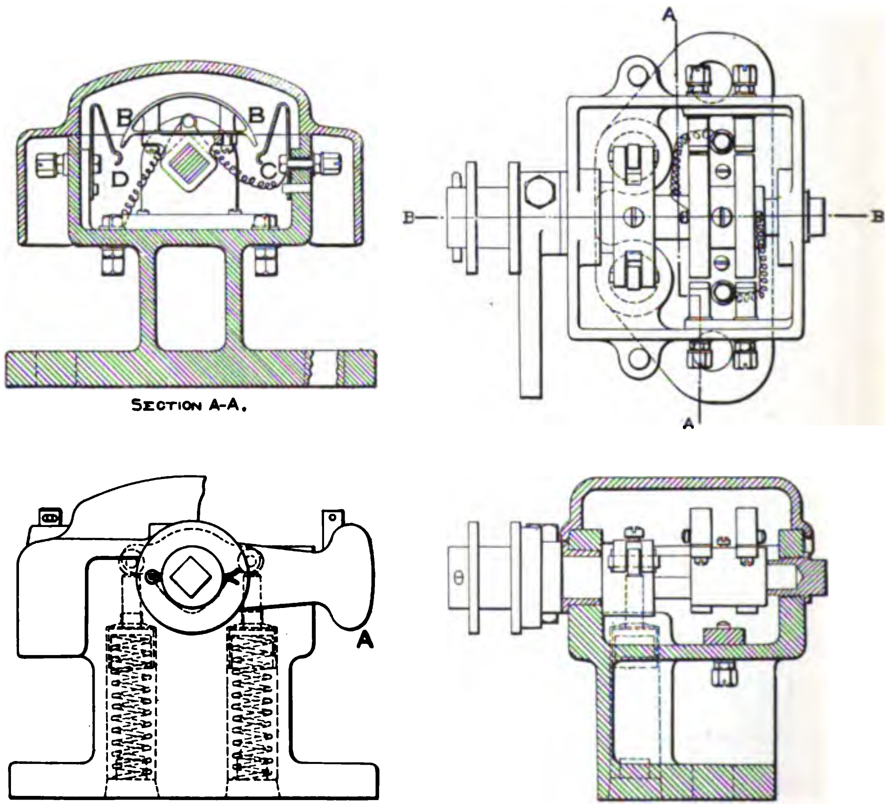


FIG. 4.

SECTION B-B.

Figure 3 shows the arrangement of wiring, contacts, valve operating mechanism, indicating device, batteries, etc.

Figure 4 shows the circuit controller in detail.

Figure 5 shows the detail of electromagnets, pin valve, piston and slide valves.

walking beam, thereby causing the lowering of the bell attached to the other end of the beam. The bell is raised to the closed position after the air is exhausted from the cylinder by the force of gravity acting on the counter-weights attached to the beam on the same end as the piston.

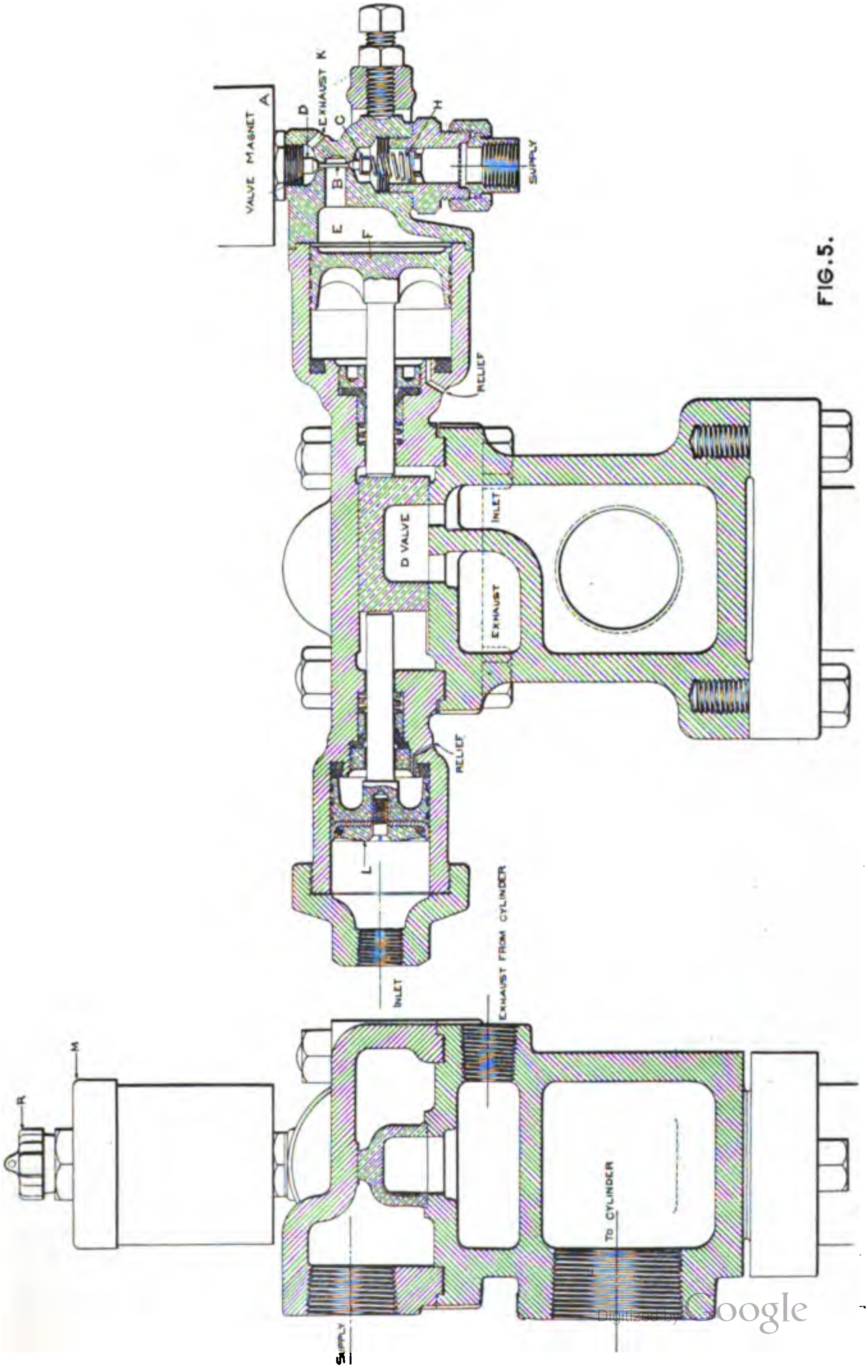

VALVE MAGNET
A
D
EXHAUST K
C
B
E
F
H
SUPPLY
RELIEF
INLET
D VALVE
EXHAUST
RELIEF
L
INLET
EXHAUST FROM CYLINDER
TO CYLINDER
SUPPLY
M
R

FIG. 5.

N is the circuit controller; it is entirely protected from the weather; it is shown in detail in Figure 4.

When the bell is down the circuit controller opens the circuit as shown at *a* and *b*, Figure 3, and also opens or closes indicating circuit as shown at *C* and *D*.

P are two arms attached to guide *M* that operate the shaft of circuit controller by making contact with arm *O* when the bell is lowered or raised.

Guide *M* is attached to the same beam as the piston of operating cylinder, and in line with the piston.

Figure 2 shows the push button and indicating apparatus. This can be placed at any distance from the top of the furnace, as the only connection is electrical, and that by means of a seven-wire cable placed in iron conduit. The bells are lowered or raised by pressing the desired button shown at the lower part of the instrument.

At the upper part of the indicating device are two glass windows, through which may be seen the indicating card *A*, Figure 2. The central part of this indicating card is red, and shows red when the bell is traversing from one extreme to the other. The upper part of the card is marked "down" and the lower part "up," thus showing through the small windows when the bell is in either of these positions.

The electro-magnets *B* and *C* control the movements of indicator card *A* through the medium of armature *D*, which is attracted toward *B* or *C*, as the case may be, when the circuit is closed or opened through circuit controller *N* as shown in Figure 1.

The electrical connections are shown at Figure 3.

As seen in Figure 3 the bell *A* cannot be lowered unless bell *B* is up in place, contact at *b* made, and a complete circuit established through electro-magnet *E*. The same is true of bell *B*; it cannot be lowered unless bell *A* is up in place, and the circuit completed through contact *a* and operating electro-magnet *F*.

Figure 4 is self-explanatory, the circuit being open when arm *A* is horizontal, and closed when arm has partly revolved above or below the horizontal position, thereby making contact at points *B* and *C* or *B* and *D*, whichever is desired.

Figure 5 shows the electro-magnet operating valve. The closing of the circuit through electro-magnet *A* lowers the pin valve *B*, opens the valve at *C*, and closes the valve *D*, thereby allowing air to fill the space *E* and move piston *F* to the left, causing the movement of the *D* valve to the left, and opening inlet port, allowing air to enter the operating cylinder that hoists the bell.

The breaking of the circuit demagnetizes electro-magnet *A*, and allows the pin valve *B* to rise, due to the pressure of the spring *H* at the bottom; this closes valve *C* and opens valve *D*, allowing the air to escape from space *E* through valve *D* and exhaust opening *K*. The pressure being removed from piston *F*, the *D* valve is at once moved to the right by means of piston *L*, which is at all times connected with the air supply; this allows the air to exhaust from the operating cylinders through the *D* valve and exhaust port, thereby hoisting the bell. If at any time the bell should not be completely hoisted, owing to the hopper not being entirely empty, the indicating device will show red, and the other bell cannot be lowered until the hopper is empty or the obstruction removed.

Should necessity demand it, a mechanical device operated from the top of the furnace is provided for hoisting or lowering either bell singly or together. This is done by removing cover *M* or plug *R*, Figure 5, from the electro-magnet and pressing down on pin valve *D*, Figure 5.

There is a great saving of air in this device over the old way of having an air valve at the bottom of the furnace at the end of a long air-pipe, for the pipe and the cylinder had to be filled with air at each operation. The apparatus here described moves the bell very quickly and with little jar.

The time required to lower or raise the bell of a large furnace is about ten or twelve seconds. The power required is insignificant, being but nine watts, or about .00121 H. P.

Current is furnished by four small storage cells, two being used while two are being charged or held in reserve. One set of two cells will operate the apparatus for forty-eight hours.

The battery is charged from any source of direct current; in this instance it is supplied from 220 volt direct current mains through three two ampere resistance lamps in series.

Owing to the small current consumed, a gravity or other form of primary battery can be used.

L. H. Thullen.

The Hydraulic Installation at the Panuco Mines in Mexico.*

The gold and silver mining properties of the Compania Minera de Panuco are situated on the western slope of the Sierra-Madre Mountains, about 70 miles inland from the port of Mazatlan. Their mill is almost centrally situated amongst the various mines, several of the winding shafts being close to the mill, probably within 400 meters.

In exceptionally dry seasons the whole of the milling and mining machinery is run by water power, assisted at times by steam power; in average seasons, however, the whole plant is run by water power alone.

The water-power system comprises two reservoirs of different altitudes above the power station, which are respectively termed the high level and the low level dams or reservoirs.

The high-level reservoir comprises a dam of about 9,500 cubic meters of masonry, with a mean height of about 12 meters and a maximum height of 20 meters above the bed of the reservoir, which forms a natural watershed of about 800,000 cubic meter capacity, with an approximate maximum vertical height of 2,250 feet above the turbine nozzles. The reservoir is tapped a little distance from the masonry dam by a steel pipe line of varying diameter, from 16 inches downwards. This pipe line, which is about 8 kilometers in length, is laid above ground, the underside of the pipe being about 12 inches above the ground. It is supported by the flanges resting loosely on cast-iron plates, which in turn rest on a block of stone sunk not more than 6 inches into the ground. This tube line conveys the vertical head of water of 2,250 feet direct to the high-level turbines.

The low-level reservoir consists of a masonry dam of about 2,200 cubic meters of masonry work between two cliffs, that form the sides of a small mountain creek, by which means a reservoir is formed of about 200,000 cubic meters capacity. From one side of the dam the water is tapped by an 18-inch steel pipe line, which conveys a vertical head of water of 240 feet for a distance of about 3 kilometers, to the power station.

The water-power plant above ground comprises six Pelton wheels, so arranged as to drive the entire milling plant and machinery, either by the high-level supply alone or the low-level supply alone, or the two running together. All the turbines are belted direct, where possible, on to the main countershafts of the various departments of the mill and engineering shops, and to air-compressors, for the distribution of energy to the distant parts of the premises, not exceeding 2 kilometers. Electrical energy is only being used for lighting purposes.

In unusually dry seasons the turbine nozzles are changed to a smaller size, sufficient to run about 75 per cent. of the whole machinery, while the remaining 25 per cent. is run by steam power.

The spent water from all turbines is collected in a small reservoir, and is conducted by means of a steel pipe line, 18 inches diameter, down the shaft of one of the mines near the power house, on to a Pelton wheel driving a pair of horizontal air compressors, situated at a depth of about 130 meters below the water level in the above-ground power house reservoir; these compressors, 24 by 24 inches, being belted from the turbine to run at 120 revolutions per minute.

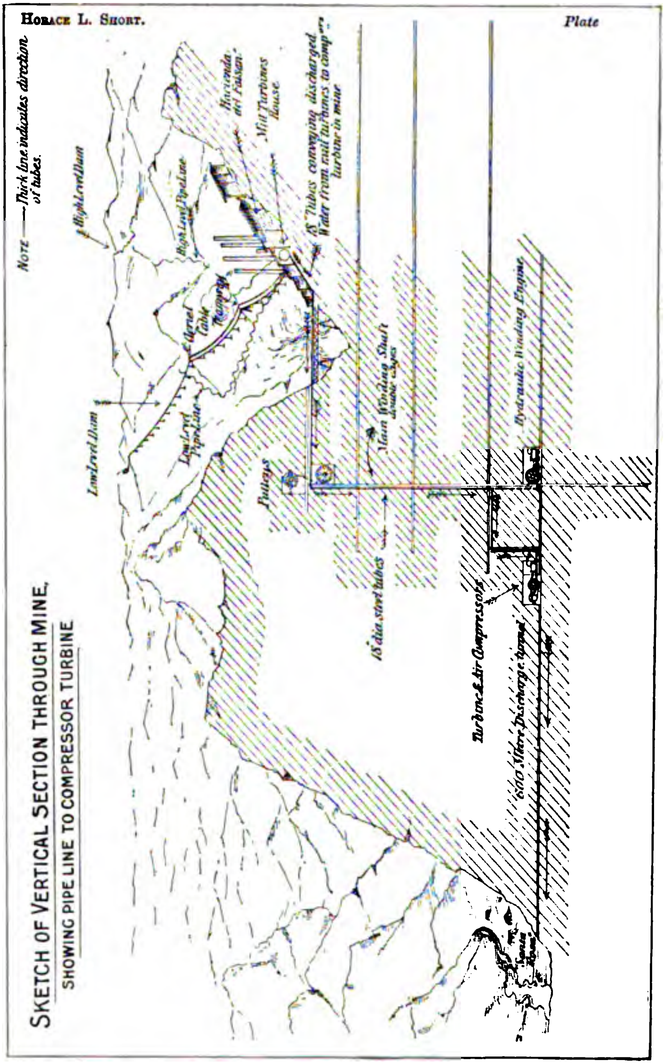
A tunnel about 600 meters in length, with a slight fall from the turbine well, carries off the spent waters from the turbine to the outside of the mine (see illustration). This tunnel is driven mainly for this purpose, but at the same time it drains the upper workings, and also cuts off 130 meters head of water, pumped from the lower workings; it also aids in the ventilation of the mines, and serves as a prospect drive, several payable veins being encountered. In this position the compressors are centrally situated for the distribution of compressed air to the various winding and hauling engines, pump and rock drills in the mine.

It may be of interest to mention a few small details which materially add to the successful running of the installations.

By using buckets with the dividing edge and lower lip filed to a knife edge, and the water surface of the bucket truly filed and polished, the brake horse power is increased fully 10 per cent. over that

*Abstract of a paper by Horace L. Short, read before Institution of Mining and Metallurgy, London, as published in the *Engineering and Mining Journal*.

obtained with buckets not filed and polished; this refers to the high-level turbines, where the greatest diameter of nozzle used does not exceed ⅞ inch diameter. In the low-level Pelton wheels, however, where nozzles from 2½ to 3½ inches diameter are used, the effect is not so great, not being more than 1 to 2 per cent. according to size of nozzle used.



HYDRAULIC INSTALLATION AT PANUCO, MEXICO.

The starting and stopping valves, which were close to the turbines, consist of one massive 6-inch gate valve, together with a small by-pass gate valve to each turbine, whose area was about double that of the average nozzle used with the turbines. This by-pass is, of course, to relieve the main valve from the excessive one-sided pressure, so that it may be opened without undue exertion, and without running the risk of scor ng or damaging the valve face.

The pipe line is fitted with several specially constructed spring relief valves; these are mainly for the purpose of relieving the almost instantaneous rise of the pressure, and consequent shock that arises, owing to the ram action that takes place when the water issuing from the nozzles is suddenly arrested either entirely or partly. On several occasions accidents of this class have happened, but they were chiefly caused by unlooked-for intruders; on one occasion the nozzle was found blocked by a small fresh-water fish; on another occasion by a fresh-water lobster, and a large eel, although every precaution was taken to guard against such intruders.

Refuse oil and "swarf" from the milling and mining machinery is found to form a very good protective surface against oxidization, when smeared over the exterior surfaces of the air and water pipes inside the mine; this treatment gives much better results than either tar or paint.

All belt pulleys in connection with both the milling and mining machinery throughout are of unusually large diameter, and all belts are run at an unusually high speed. The following is an instance in point: A 12-inch wide six-ply canvas-rubber belt running at the unusual speed of 7,500 feet per minute, over pulleys 36 inches and 120 inches diameter, respectively. This was examined after running continuously at this speed night and day for two years, and was found to be practically in as good condition as when first put on; and an 18-inch wide six-ply belt running at 5,000 feet per minute, under similar conditions to the above, gave equally satisfactory results. In all cases diagonally riveted joints in the belts were found to be preferable and more reliable than laced joints.

All pulleys from 36 inches diameter upwards are built with hardwood belt faces, wrought-iron spokes (disks in the smaller sizes), and cast-iron bosses. The chief advantages of these pulleys are that they can be quickly and cheaply built; are very light and strong; and that a carpenter can turn the belt face of a 10-foot diameter by 24-inch face belt pulley in its working position, in two hours. If the shaft runs a little eccentrically, the belt face runs perfectly truly, which would not be the case if the pulley had been turned up in the table. Again it is often found that large, broad belts stretch more on one side than the other, with the result that the belt tends to run off the pulley; the remedy for this is to turn the crown a little nearer to one side of the pulley than the other. With a wood rim pulley this can be done while the belt is running, no stoppage being necessary; in fact, the operation can be performed in a few minutes, whilst with the iron pulley it is sometimes a very serious and difficult matter. If the belt face of the pulley is made properly, and of hard and well-seasoned wood, the face will last for six or eight years, and it is only a question of an hour, perhaps, to skim up the face again, and the pulley will be as new.

In the belt-driven air compressors (24 by 24 inches), which are of American manufacture, great trouble was at first experienced with the flywheel driving belts, and it was impossible to run the compressors up to more than 40 pounds to the square inch air pressure, owing to the excessive vertical flapping of the belts, which were very soon destroyed. This, of course, was due to insufficient mass in the flywheel rim, which was increased 50 per cent. by the addition of cast-iron segments, bolted on to the underside of the rim; this addition enabled a pressure of 75 to 80 pounds per square inch to be attained, without undue injury to the belts, and no trouble was afterwards experienced from this cause. These air compressors have a water cooling jacket round the cylinder and cylinder covers, and indicator diagrams were frequently taken to ascertain the efficiency of the water cooling system. From the diagrams taken with and without the cooling water in operation, a difference of from 5 to 7 per cent. was shown in favor of the cooling system, the air pressures being 45 and 75 pounds per square inch receiver pressure.

All air and water pipe flanges are made extra heavy and of special form, to employ the least possible number of bolts. Generally two bolts are used in pipes up to 4 inches diameter, and three in the larger sizes.

All air mains are of light steel tube from 10 inches diameter downwards. The oil that escapes by the oil collectors near the air cylinders is carried, by the compressed air, along the air pipes and the greater part is deposited on the inner surface of the pipe line; therefore, although this oil is lost at the collectors, it serves to prevent oxidization of the inner surface of the pipes, and serves the two-fold purpose of enabling a thin tube line to be used, and of preventing rust from being carried along by the air in the pipes to the various engine cylinders, which, of course, would be highly detrimental to the inner surface of the cylinders, valves, etc. It was found that the oil collected from the compressor cylinders (heavy cylinder oil) could be advantageously used over again three times, each time being thoroughly strained before using. It should not be mixed with new oil, but used by itself, and fed into the cylinder with a sight feed lubricator.

Thin sheet asbestos near, and brown paper at a distance from, the compressor cylinders, was used for making all air pipe flange joints, the ordinary rubber packing, besides being more expensive than the above, being entirely unsuited for the purpose, as the oil, carried along the pipes by the air, rapidly decomposes the rubber; innumerable and constant leakages result, and frequent stoppages are necessary in order to replace the packing.

The following system was adopted in a flywheel pumping engine, running on compressed air, used expansively in a 10 by 20-inch cylinder, with expansion valve. A super-heated jet of steam is admitted at either end of the cylinder during the admission of air, through fine perforations directly opposite to the air admission ports; the steam is generated in a small vertical boiler close to the engine, the steam pressure being a little above the air pressure, and both air and steam can be cut off independently of each other at any part of the stroke. Many tests went to show that the system was very economical and well worth adopting. To use air expansively, it is absolutely necessary either to heat the air sufficiently to prevent freezing up the exhaust port, or some means must be adopted to prevent the exhaust port being stopped up with ice; otherwise excessive back pressure has to be overcome by the piston. Heating the air is the simplest and best method of overcoming this difficulty, as it not only clears away the ice, but it also conduces to economy. The above system can easily be applied to existing engines at small cost, and will soon pay for itself several times over. The reason that the electrical transmission system was not adopted in any of the above installations, was chiefly due to the fact that in the milling and engineering department the conditions were such as to allow the turbines to be belted directly to all the main countershafts; secondly, as a large number of rock drills are used in the mines, and as, up to the time of the commencement of the installations, no satisfactory electric rock-drilling system was upon the market, it was deemed advisable to use compressed air for this purpose, as its use also enables the rock drill to be used in headings where there is poor ventilation and oppressive temperature. The exhaust air from the drills not only materially aids in the ventilation, but also considerably lowers the temperature of the surrounding air in the immediate vicinity, thereby enabling the operators to perform their work under better conditions than would be the case if an electric rock drill were used.

In the machine shops many pneumatic tools are in use; the steam hammers in the smiths' shops are run by compressed air in place of steam; the largest hoisting plant is run direct by a water-power motor, and the general existing circumstances seem to point in favor of compressed air being used for general underground purposes; and this, after the fullest consideration, has been finally adopted, and the general results obtained after its installation fully justify its adoption.

The total available power of the above-ground turbines together, is between 750 and 800 horse-power for three months in the year, while an average output of about 400 horse-power can be obtained by judiciously manipulating the high and low level water supplies throughout the year, the requirements of the mill and engineers' shops being about 450 horse-power.

The underground power capacity is

about 250 horse-power, which, in the wet season, can be raised to 350 horse-power, if desired.

The whole plant has given entire satisfaction, and has enabled the company to open up additional low-grade veins, which they can now work at a profit.

In case the metal in the mines should give out, the plant can be very cheaply turned into an electrical power station, for the transmission of energy to the various other mining properties which surround the mines of this company.

Compressed Air in the Elevation of Tailings.*

A good deal of experimental work has been done from time to time on the application of compressed air to the elevation of wet pulp. On account of the flat nature of most of our mill sites, elevation of the pulp has to be provided for, and the various methods in vogue show considerable loss of time in the replacing of wearing parts. During the last two years the writer has carried out a great many experiments with a view of devising an elevator that will give continuous work with a minimum of wear.

The results do not show a high efficiency for the power employed, but the lift is continuous in operation, very cheaply installed, and possesses no wearing parts. The lift was tried working in a bore hole of 8 inches diameter, but in many cases it is more convenient to sink a small well for the purpose. The result to date showed that the most efficiency was obtained when the depth of the well was not less than the height of the lift required. The pressure of air required in pounds per square inch was (approximately) half the number of feet to be lifted. In the majority of cases the lift required varied between 20 feet and 50 feet, and the air pressure required between 10 pounds and 25 pounds per square inch.

In most existing installations the air compressors in use were delivering air to the receivers at about four times that pressure, and when air so compressed was expanded to perform its work at a reduced pressure, it was apparent that the power exerted in originally compressing the air above the working pressure required at the lift was absolutely lost.

Thus, at the Mount Malcolm mines it was found that the lift only gave an efficiency of 35 per cent. of the compressor, under the following conditions:

Height of lift above surface of well	52 ft.
Depth of well	54 ft.
Air pressure at receiver per square inch	58 lb.
Reduced air pressure at lift	27 lb.

The air was conducted from the receiver through a reducing valve to the lift. The rising main was a 4-inch black pipe, and the air inlet through 1-inch pipe. This elevator was capable of lifting 100 tons tailings in 24 hours. The most wear was shown on the top bend, which had a life of about six months; in the rest of the pipe the wear was normal.

In this instance, had the air been taken direct from the compressor at the working pressure of 27 pounds, the lift would have shown a much higher efficiency.

It became apparent that to work this system with economy, an independent compressor, designed expressly for giving large quantities of air at low pressure, must be employed. The writer subsequently installed two such—one at the Guests Gold Mine, Mount Morgan, and a similar one at the Lancefield Gold Mine, Laverton. In both cases small compressors were geared on to the line shaft, and they delivered their air, without any receiver, direct to the foot of the lift. Under such conditions the only back pressure on the compressor was the weight of a column of water equal to the submerged part of the lift and the rising or falling of the level of the surface of the well was a perfect governor to the compressor. Unfortunately, it has been found impracticable up to the present to calculate the efficiency returned by the lift under these conditions, on account of the difficulty in arriving at the actual horse power used by the compressor; but in both cases these lifts are regarded as eminently satisfactory by the managers.

It appeared to the writer that under the last-named conditions the efficiency of this lift was much greater than had hitherto been estimated. The following data, however, taken from observations at the Guests Gold Mine, do not show a high efficiency. This was probably due

*Paper by J. W. Archibald, in Transactions of Australasian Institute, M. E.

to the fact that the compressor was a very crude one, and that being above the capacity required, the back pressure of air may have averaged less than the figures taken. At this mill, of 20 stamps, there is 11.25 cubic feet of pulp, containing 93 pounds sand, delivered per minute. This was elevated 28 feet, equal to a lift of 21,000 pounds 1 foot per minute. Theoretically this would require 11.25 cubic feet of air, at a pressure of one atmosphere (or 22.5 cubic feet atmosphere) delivered to the lift per minute, and this would work out at the equivalent of one horse power. But as the capacity of the lift was considerably greater than was required, the suface of the pulp was generally about 4 feet below the top of the well, and the lift air gauge showed a pressure of from 9 pounds to 11 pounds. This lift has a 4-inch column air inlet through 1-inch pipe; depth of well, 28 feet; height of lift, 27 feet. The compressor took 50 cubic feet of atmosphere per minute, which, at 11 pounds pressure per square inch, was (approximately) 32 cubic feet, and as that was brought from the air compressor cylinder directly into contact with the cold pulp, there would be a considerable loss due to the lower temperature. This had not been accurately determined, but he estimated it at about 14 per cent. (on the basis of 18 per cent. of one atmosphere), and, making allowance for that, they would have 29.7 cubic feet of air at the temperature of the pulp. Therefore, the volume of compressed air in the rising main would be at 2.64 to 1 of pulp—an average compression of 6 pounds of air. At 11 pounds pressure the average load against the compressor piston was 8.914 pounds per square inch, which would work out in the compressor employed at 2.165 horse-power. This was employed to lift (approximately) 21,000 pounds 1 foot per minute, showing an efficiency of only 32 per cent. of the power required for the compressor.

The principal points in favor of this system are:

1. Cheapness of installation.
2. Absence of wearing parts.
3. Uniform continuity of operation.

The cost of installation involves the sinking of a well or bore hole to the depth required to be lifted, and an ordinary pipe of the size required from the bottom of the well to the delivery point, and an air pipe from the compressor to the bottom of the delivery pipe. When the rising column was of a size proportionate to the volume required to be lifted, there was very little sign of wear on the pipes, except on the top bend, which wore out on top in about six months.

Regarding uniformity of operation, when the installation was once made, there was no chance for anything to go wrong. Pieces of stone, which might be washed into the well through the breaking of screens, were carried up through the pipe without difficulty.

At both the mines mentioned there had been no stoppage during the last nine months from any cause due to the faulty working of the elevator. At the Guests mine the pipe was vertical to the required height, and thence horizontal over a series of vats; but the rising column may also be taken in a sloping direction.

As the efficiency of all compressors decreases in proportion to the pressure required, it is evident that the pneumatic elevators will give greatest efficiency where the lift required is not very high. In cases where the lift required is not excessive, the cheapness of installation, coupled with the unfailing continuity of operation, may be found to be strong recommendations for employing this form of elevator.

German Tests of Coal Machines.

While the European mining engineers have not been so quick to take advantage of the recent inventions in coal-cutting machinery, yet they are deeply interested in the subject, and the most enterprising of them have been using various types of coal-cutting machines for some time.

As in America, there are tests which invariably result in proving the advantage of machine methods in coal mining. Such a test is described in a recent issue of *Glückauf*, a German mining journal, which account was translated and appeared in the *Colliery Guardian*, published in London, and is given in substance in this article.

A previous experience with coal-cutting machines, according to this German authority, has demonstrated their advantages and the special utility of the percussion machines for working under difficult conditions of bedding. It is a well established fact that the use of these machines results, as a rule, in a considerable diminution of the cost of labor per ton of coal, and an increase in the percentage of large coal and therefore an improved selling value, to which must be added the possibility of taking out seams that were hitherto classed as unworkable. If, notwithstanding these advantages, the employment of machines on a large scale is still confined to relatively few mines, the reason for this is mainly to be sought in the poor results that have been obtained in certain pits in consequence of the defective training of the men, ignorance in connection with the installation and working of the machines, and the selection of unsuitable forms of cutting bits.

The chief object of the experiments was to ascertain the air consumption and amount of time required by the different machines (new and old) under conditions as near the normal as possible, a secondary object being to compare the efficiency of various cutting bits, and to deduce from the results conclusions as to the laws underlying the use of coal-cutting machines in general.

The experiments themselves were performed in the four bottom roads of two seams of bituminous coal, 22 inches and 36 inches thick respectively, of normal solidity, the upper seam containing a 2 inch parting of shale. The machines were under the charge of a skilled operator and two helpers. The necessary compressed air was drawn from an ingot-iron boiler, with a capacity of 307 cubic feet, set up close to the working place, and connected with the compressed air main. This boiler was also fitted with a spring pressure gauge, and work was continued until the pressure had fallen from 4-4½ atmospheres to 2·8-3 atmospheres. The volume of air consumed was determined according to the following formula: With a given initial pressure, a, the volume of air in the boiler is $(a+l)$ times the cubical capacity of that vessel; and when the pressure has finally receded to b atmospheres the volume is $(b+l)$ times the capacity of the boiler. Hence the volume of expanded air consumed is $(a+l)\ J-(b+l)\ J=(a+b)\ J$. All that was necessary, therefore, was to determine the difference of pressure at the commencement and end of the test, and multiply this difference by the capacity of the boiler.

The results showed a comparatively low consumption of air in all the machines. Even the apparently considerable differences consequent on the varying dimensions, age of machine and kind of cutter, are almost destitute of importance when referred to the pecuniary outlay involved. With a good compressing plant, 1 cubic meter of compressed air at 4 atmospheres pressure cost ⅛d. to ¼d., or 3-16d. on the average, and the consumption of air in undercutting 1 square meter of coal to the average depth of 68 inches ranges between 25 and 43 meters. Since these figures correspond with 5 and 8·6 cubic meters of air under 4 atmospheres pressure, the cost of the air varies between 1d. and 1½d. per square meter, a practically immaterial difference. Greater importance attaches to the difference in time consumed, the quickest, for a depth of 68 inches being twenty-one minutes, and the slowest thirty-four minutes, which, at the rate of 1·6 shillings per shift for the two men, makes a difference of 4d. in the cost, or six times the difference due to the varying consumption of air.

Following the English text the conclusion to be drawn from this is that the volume of air consumed may generally be disregarded, attention being concentrated on the rapidity of working, and a sufficiently strong construction of the machine to minimize the risk of loss of time through breakdowns. These conclusions were also confirmed by numerous experiments, wherein the stoppages caused by defective construction or other sources of hindrance led to loss of time and money, and which, on account of their imperfect results, are not recorded in the table. In any case it cannot be ignored that small and light machines that can be worked by one man are advantageous, although the advantage is confined to the saving of time effected in setting the machine up and dismounting, and would disappear in working places when more than one man is employed at a time. Light weight is also of some importance in the case of steep seams. The average time consumed in making the various cuts was as follows: 20 inches, 19·7 minutes; 40 inches, 22·2 minutes; 60 inches, 25 minutes; 68 inches, 27 minutes; and 80 inches, 30 minutes per square meter undercut, and indicates the advisability of making broad cuts of segmental shape.

Machinery in New Mexico Silver Mines.

Introduction of modern methods in mining machinery is bringing a number of silver mines in New Mexico into a highly profitable state. Where extreme difficulties were met with in making these mines pay under the old method, the present few years have seen some important changes. Among the most noteworthy are at Modoc Mine, in the County of Donanna, New Mexico.

This mine has been equipped with air drilling and hoisting machinery and a new working shaft sunk which greatly facilitates the removal of the ore. The power plant of the mines and the concentration mill contains two 60 H. P. tubular boilers, one 50 H. P. slide valve steam engine, which supplies the power to the mill; a 10 H. P. slide valve steam engine operating a dynamo for electric lights, and a 16 x 18 inch Leyner steam actuated straight line air compressor. The air compressor furnishes air for eight New Water-Leyner drills and two hoists in the mine, and also, when required, furnishes air for cleaning screens, etc., in the mill. The air is transmitted to the mine by a 4-inch pipe at very little loss. In the concentration mill pneumatic concentrators are used.

MODOC MINE, SHOWING UPPER TERMINAL OF TRAMWAY.

The results of the use of dry concentrators are being awaited with much interest by the mining men of that section, as many valuable properties have remained idle for years simply for lack of water or other means for cencentration purposes.

The illustrations used for this article were obtained through the courtesy of *Mines and Minerals*, which recently published an exhaustive description of the mines in the Organ mining district.

WATER-LEYNER AIR DRILLS MOUNTED ON COLUMN WORKING IN STOPE, AT MODOC MINE.

CONCENTRATION FLOOR, MODOC MILL, SHOWING BATTERY OF HOOPER PNEUMATIC CONCENTRATORS.

Economical Repairs to Air Pumps.*

In order to give what we considered the best practice for repairs to the 9½-inch air pump an accurate account of both labor and material was kept to ascertain definitely the most economical way of doing the work creditably, and we have found that the following is the best.

The practice of partially overhauling pumps on engines should only be indulged in to a very limited and unavoidable extent. It has been found a much more economical and reliable practice to remove the pump from the engine and give it a thorough overhauling in the air-brake repair room, than to attempt to repair it on the engine in the round house

We have adopted the plan of overhauling air pumps at our general shop. This eliminates improper repairs being made at the smaller, outlying places, and the carrying of extra stock at those points for making repairs, which is one of the greatest expenses attached to a railroad company. It can be readily seen that the repairs to air pumps will be much more satisfactory and economical when done at a general, centralized point, and under the direct supervision of a competent and thorough air-brake man. There are two very important factors we must bear in mind; first, "Workmanship"; second, "Standards." Only such men who have proved themselves competent and who have been thoroughly instructed by the general air-brake inspector, should be employed on repairs to air pumps. Standard sizes and parts should be adhered to as much as possible.

Air pumps should first be put into a vat or tank containing a strong solution of lye, and allowed to soak until all grease and dirt have been removed. Steam should not be admitted direct into the vat, as with this method the solution is rapidly diluted. A coil with a drain should be used. The pump should be removed from the vat and thoroughly blown out with steam until all ports and passages are perfectly clear. This work should be done by a helper. The pump should then be turned over to the air-pump repair man, and should be thoroughly dismantled.

The practice of scraping main valve bush No. 75, and applying a new one instead, is an extravagance, to say the least. The main valve bush should be pressed out of the head, put in a lathe, and bored to 3 5-16 of an inch, after which a bushing should be turned to fit the main valve bush that has been bored, and should be forced in, bored to standard size and properly faced, ports to be drilled through the new bushing. The bush is now ready to be pressed back into the head. This work can be done for 85 cents, and against $4.75 for a new bush is a saving of $3.90.

The left main valve cylinder head should be placed in a lathe and bored to 2 3-8 of an inch, after which a bushing should be turned and pressed into the head, bored and faced to standard size, and ports properly drilled. This work can be done for 40 cents, and against 75 cents for a new head, is a saving of 35 cents.

The large and small main valve piston packing rings Nos. 78 and 80, should be removed and new ones applied and properly fitted. Our experience has been that home-made rings do not give the proper wear and life that rings furnished by the Westinghouse Air-Brake Company do. The main slide valve and its seat should be properly faced. When the main slide valve has 3-64 of an inch play between shoulders of the main valve stem, it should be scraped and a new valve applied.

Next remove the reversing valve chamber bush No. 73, and apply a new one. Also apply a new reversing valve No. 72. We have found that when bush is renewed an old reversing valve should never be applied.

Three-sixty-fourths of an inch play between valve No. 72 and reversing valve rod, when valve is new, calls for a new rod; however, templets should be used to ascertain which part is worn and needs renewing.

It should also be noted that the reversing valve chamber cap is properly fitted on bush No. 73 and on the head proper.

Care should be taken that the distance between the knob on the end of the reversing valve rod and shoulder is of the

*Correspondence by Mr. Otto Best, Air Brake Inspector of the N. C. & St. L. Railroad, at Nashville, Tenn., as published in *Railway and Locomotive Engineering*.

proper length, the reversing valve plate should be removed to ascertain the exact condition of the under side. If worn on either side, apply a new plate.

Steam piston and rod No. 65 should be examined, and it is quite essential that the rod be perfectly true. New piston packing rings should be applied. Great care should be taken in the workmanship in applying rings, otherwise the pump will blow, and back pressure will be materially increased.

When a packing ring is cut, that portion of it nearest the ends has a tendency to remain straight. When the ring is reduced to the size of the cylinder, the result is a poor fit for almost one-third of the circumference. To obviate this trouble, and thereby secure better fitting rings, it is necessary to either file off the outside of the rings nearest the ends, or turn them up in lathe after the rings have been cut. Either plan will do, just so the rings are made to fit the cylinder properly. The same is applicable to the air cylinder piston packing rings.

In applying piston No. 66 it is desirable that lock nuts should be used on the end of the piston rod, as furnished by the Coffin-Megeath Supply Company, Franklin, Pa.

It is the most advisable and most economical way, when necessary to bore steam and air cylinders, to bore them to a standard of 9⅝ of an inch and apply new pistons and rods.

The centerpiece needs more than passing notice. If the piston rod has been turned down in order to true it up, new glands should be applied, and as close a fit on piston rod without binding.

Stuffing box nuts should fit nearly, and the box itself should be carefully examined to see that it is properly secured and tightened in the centerpiece. Air valve seat No. 87 and valve cage No. 88, when worn, should be removed and new ones applied; also new air valve No. 86. Care should be taken that the lift of air valves does not exceed 3-32 of an inch.

It is not advisable nor practicable to use new air valves with old valve cages or valve seats unless seats are properly trued. All copper joints should be annealed.

All repaired pumps should be put on a test rack and run a sufficient length of time to assure their efficiency before being placed in active service.

By following the above recommended practice of repairs, the failure of air pumps on our line of road has been reduced to a minimum. For the year ending June 1, 1903, there were but three air pump failures, which were reported as follows: "Reversing rod broke." "Main piston rod broke," "Reversing plate bolt worked out."

Track Tamping with Air Blast.

When steel ties were laid on a section of track on the Bessemer and Lake Erie Railroad, through Greenville, Pa., two years ago, it was found that tamping with bars or tamping picks could not be effectively performed. To meet the emergency an air block tamping apparatus was arranged, which, it is said, did the work very satisfactorily.

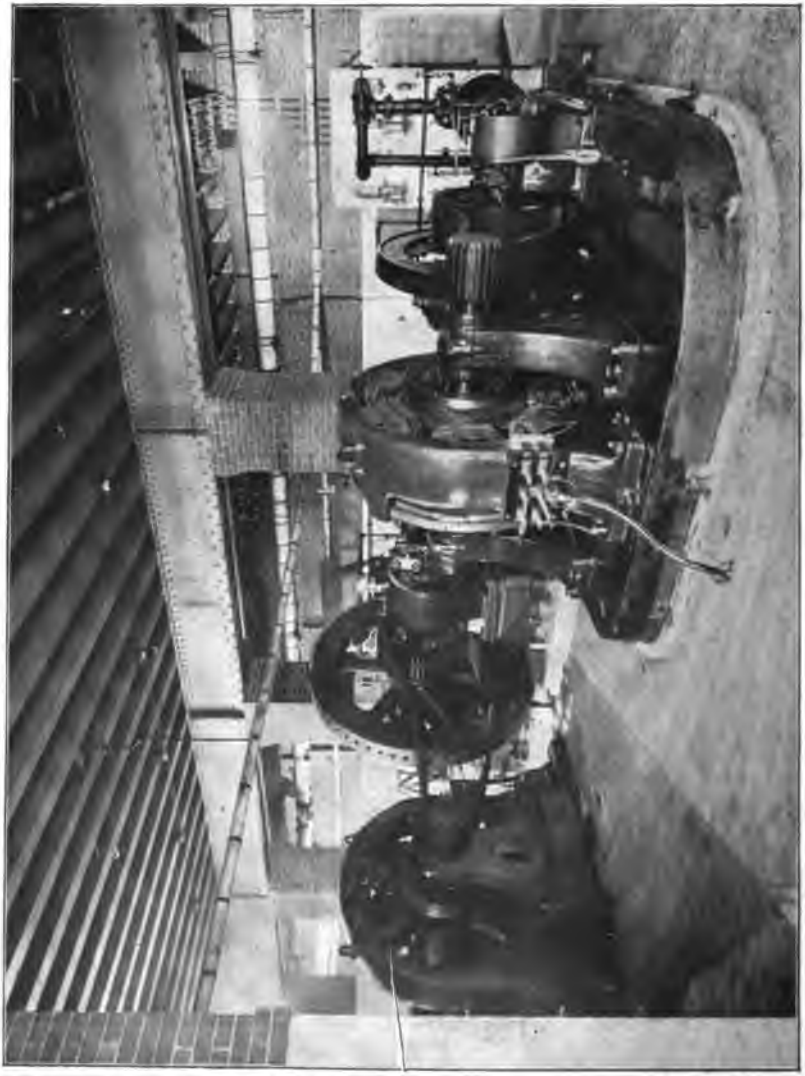
The steel ties used were of the inverted trough section, with flaring sides, about 3½ inches deep. The rail was fastened to the tie by means of bolts and clips, the former being passed through the top table of the tie. The ballast used was broken slag. In surfacing the track the desired end was secured by blowing pulverized slag in the ends of the ties to fill the space caused by lifting the rail to grade.

This track tramping apparatus consisted of a blower clamped to rails, turned by two cranks. The blast thus secured passed through a hose connected with a piece of pipe crooked at the bottom to insert under the ties. The material for ballasting was heaped into a funnel or hopper at the top of this piece of pipe.

The idea of tamping tracks by blowing fine gravel or other material under ties with an air blast is by no means new. Mr. F. R. Coates, now chief engineer of the Chicago Great Western Railway and then road master of the New York division of the New York, New Haven and Hartford Railroad, made some experiments in this direction six years ago. He investigated this idea and was quite encouraged with the results. Subsequently, however, this subject seems to have dropped out of sight until utilized by the Bessemer and Lake Erie Railroad.

Compressor Plant at Terminal Station.

An interesting description of the new passenger terminal station of the Chicago, Rock Island & Pacific, and Lake Shore & Michigan Southern Railroads, on Van Buren and La Salle streets, Chicago, was given in a recent number of the *Western Electrician*, a Chicago publication. Under the title, "Electricity in the New Rock Island–Lake Shore Terminal Station in Chicago," some interesting details concerning the electrical equipment of the



ELECTRICALLY DRIVEN COMPRESSORS AT CHICAGO TERMINAL STATION.

station were described. In the course of the article the following reference was made to the compressor plant:

"Of considerable interest are the electrically-driven air compressors. They were furnished by the Ingersoll-Sergeant Drill Company, and are both of the cross-compound type, one having a capacity of 500 cubic feet per minute and the other 1,000 cubic feet. The air is used for testing air brakes in the yards, pumping water from the deep well into a large tank, from which the other pumps draw their supply, for cleaning cars and also for various purposes around the plant. The compressors are driven, as shown, by two large motors—one of 150 horse-power and the other of 75 horse-power—to which they are connected by the Renold silent-chain drive. It is said that the larger compressor is one of the heaviest applications of this driving system yet made."

There were several illustrations for this article, one of which was a picture of the electrically-driven compressors, which is reproduced through the courtesy of the *Western Electrician*, on the opposite page.

Smallest Air Engine Ever Built.

To compressed air has come the distinction of operating the smallest engine in the world. This remarkable piece of mechanism was built by Mr. A. G. Root, of Danbury, Conn. It rests on a ten-cent piece, and stands no higher than the same coin on its edge, and yet is so perfect in its construction that a slight air pressure operates it with all the precision of a huge Corliss.

This tiny engine, which will probably be seen at the St. Louis Exposition next summer, was built by Mr. Root without drawings or model, simply making one part and fitting the next one to it. It was all done by hand and occupied his spare time for nearly a year.

To give some idea of the size of this miniature air engine the measurements of the various parts will be of interest. They are given in 64ths, 32ds and 16ths of an inch. No part is ½ inch in any direction. The steam chest is 6-32 by 9-32 of an inch, and the cylinder is 8-32 by 9-32 of an inch, with a stroke of 3-32 of an inch. The main shaft has an extreme length of 5-16 of an inch, and has attached a flywheel 7-16 of an inch in diameter; the largest diameter of the shaft is recorded as 3-64 of an inch. There is a band of gold 7-64 of an inch wide; the crank has a length of 4-16 of an inch; the crank wheel is 6-32 of an inch in diameter. The cylinder, which is sheathed with ebony, has an extreme diameter of 3-16 of an inch and a bore of 5-64 of an inch. A silver feed pipe is 2-32 of an inch in diameter; the valve rod has a diameter of 1-64 of an inch, and that of the piston rod is less than 2-64 of an inch. This tiny mechanism is built of steel, brass, silver and gold, and weighs complete 3 pennyweights.

SMALLEST ENGINE EVER BUILT.

The accompanying illustration shows the exact size of the engine. The engine is horizontal, but if it had been constructed as a vertical one it would have occupied a floor space of 7-16 of an inch. Despite its very small size this air engine operates just as regularly and successfully as the large machines, and has attracted much attention wherever it has been shown.

An Old Type of Compressor.

A type of compressor not often found these days has been in use for some time at the power house of the Albemarle Zinc and Lead Co., Fabers, Nelson county, Va. The only means for cooling the cylinder is a ⅜-inch pipe attached to a ¼-inch opening and injecting directly into the cylinder. This pipe has to be left wide open or the cylinder becomes very hard. The water injected, of course, goes into the air receiver and every half hour or so has to be blown out. To prevent this water going into the air receiver it was suggested that where two lines connected through a ⅜-inch pipe in place of the pet cocks that are on the end of it in the air cylinder, and were they to be joined to a Mason steam trap, the surplus water would be drawn therein and thus keep the water from the air receiver.

This type of compressor appears to be an application of the old water displacement system. This principle was used quite successfully in the early days and even now finds a place on the continent. It is a reasonably efficient method so far as the action of the compressor is concerned, but it is very defective owing to the limited speed at which the compressor must run. It does not seem likely that a trap connected with the cylinder drips as proposed will give satisfaction. In this place it might be possible to build a marble or wooden tank about the air cylinders and keep it filled with running water, thus doing away with the injection water.

Rock Island Air Brake Instruction Car.

The accompanying engraving was made from a photograph of the Rock Island air brake instruction car No. 2,500. In the lecture and demonstrating room are the air appliances of two locomotives, 13 freight car brakes and one passenger car brake, as well as sectional instruments worked in tandem. The locomotive equipments can be coupled so as to represent a "double-header" freight with coach in rear, "single-header" freight or "one-car" passenger trains. One of the locomotives and coach is for demonstrating the high-speed brake, pressures and reducing valves on brake cylinders. The necessary pressure gauge, tell-tales, slack adjusters, etc., are in proper connection. In addition to these appliances, there are steam and hot water heating systems, electric headlight—engine and dynamo complete—in working order, pneumatic track sanders, vacuum driver brake instruments, injectors, lubricators, pop safety valves cut in section; also colored charts, blackboards, literature, rules, etc., governing their operation and maintenance.

ROCK ISLAND AIR BRAKE INSTRUCTION CAR.

The adjoining room is equipped with boiler, air pump, water pump, tank, injector and coal bunker for supplying steam and air for demonstrating and heating the car, which are connected up in such a manner as to be able to supply "air" and "steam heat" to a full train should the engine fail in these respects with this car en route. The opposite end is the office, library and living room, with usual commodities for the instructor. All is lighted with electric (incandescent and arc), gas and oil lamps. All persons whose duties in any manner bring them in contact with train air appliances are required to attend the lectures and pass a satisfactory examination, when certificates are issued indicating their proficiency. The car is in charge of Mr. W. J. Hartman, air brake expert, who at present is touring the line.—*Railway Age.*

An Air Compressor in the Wilderness.

While the idea of a sectionized air compressor for transportation across lands where railroads are practically unknown is by no means new, there is always more or less interest taken in any of the achievements of progressive manufacturers of compressed air machinery in which many and difficult obstacles are overcome.

It was not long ago Messrs. A. & Z. Daw, of London, Eng., received word of the complete success of such an enterprise in which they were primarily interested. One of their air compressors, which was manufactured by Mr. Robey & Co., Ltd., of Lincoln, Eng., was carried through 110 miles of bush into the wilds of Africa, and after a trip of two months the whole machine was safely delivered at its destination, with no part damaged or missing.

Readers of COMPRESSED AIR will find an account of Messrs. Daw's enterprise in *Engineering*, an English publication. Concerning the air compressor and its unusual trip, *Engineering* says:

"The Ashanti Goldfields Corporation, in order to expedite some very important development work at their mines in Ashanti, decided to lay down an air-compressing and rock-drill plant, and applied to Messrs. A. & Z. Daw to meet their requirements. The difficulties of transport in this recent addition to the British Empire—the great natural wealth of which is now being made manifest by British enterprise—are of such a nature, pending the completion of the railway, as at the time to cause great misgivings as to the feasibility of building a machine (subject to such heavy work and strains as an air compressor) in such small sections as to admit of its being taken up country by native carriers. The distance from Cape Coast Castle to the Ashanti Goldfields mines is 110 miles, the pathway to the mine being for the greater distance through a primeval forest. Full particulars of the difficulties of transport were given by the consulting engineer to the Ashanti Goldfields Corporation, who fixed the limits of weights of each section at 80 pounds to 90 pounds, except for the cylinders, crankshaft, and rims of the flywheels, which parts were limited in number, and were not to exceed 250 pounds each in weight. To these limits of weights Messrs. A. & Z. Daw, in conjunction with Messrs. Robey & Co., Ltd., designed and built a compressor.

"The compressor is of direct-acting duplex type, consisting of two 13-inch diameter steam cylinders, and two 12-inch diameter air cylinders, all with 18-inch stroke, carried on a massive wrought-steel foundation plate built up in sections of 90 pounds. The steam and air cylinders were constructed in sections of 250 pounds, the liners being whole; all joints are metallic, and to keep within the limits of weight the steam cylinders have loose steam chests. The 5½-inch diameter crankshaft required special care, and was built up in five sections, varying in weight from 200 pounds to 226 pounds each section, and was so dowelled together as to prevent the possibility of error on its re-erection. The two flywheels are each 7 feet in diameter, and built up in 36 sections. The air cylinders are fitted with Daw patent balanced inlet and delivery valves.

"On completion of this unique air compressor it was exhaustively tested by the consulting engineer of the Ashanti Goldfields Corporation, and although weighing 15½ tons, built up in the remarkably small sections above described, it worked with the greatest smoothness and steadiness. The compressor was designed to run at 133 revolutions, or 400 feet piston speed per minute, and was run for several weeks in the shops at its maximum speed with very satisfactory results.

"The compressor was then dismantled and packed, special care having to be taken in the packing to meet the great difficulties to be contended with in landing goods at Cape Coast Castle and the absence of all roads through the country; and the following particulars of how the landing and transport were effected in getting this first compressor into Ashanti will be of interest.

"Owing to the known difficulties, a special transport officer was sent out from England by the Ashanti Goldfields Corporation in charge of the compressor. The landing was effected by means of surf-boats, which, on grounding on the sand, were turned over on their sides, and the heavy packages rolled up beyond the reach of the seas, the cases, in most instances, being covered by sea water. Previous to the arrival of the vessel, it had been arranged that about 600 carriers should be present to take all the parts of the machine inland, over rivers and through swamps, many of which were dangerous to human life. The corporation also ran the risk of losing important sections (especially when the loads are not cut down to a weight which could be conveniently handled), thereby rendering the machine useless until a renewal could be dispatched from England."

Notes.

Compressed air has already proved dangerous in the hands of practical jokers. The last victim is K. Reaski, a lad employed at the Schenectady works of the American Locomotive Company. It is claimed that his injuries were of a very serious character.

The Mining Reporter declares that the automatic drill sharpener run by steam or compressed air is a machine that marks an advance in that kind of work. Its advantages are in economy and rapidity. COMPRESSED AIR has already noted one type of these machines which is now on the market.

Compressed air is now being used by the C. & M. B. Railroad to clean the passenger coaches at its Lancaster, Ohio, shops. An air compressor has been installed there which compresses the air to about 80 pounds. A steady stream of air is used to clean the cushions in the cars, while a sweeping machine is being introduced to take the place of a broom.

The Los Angeles Railway Company is having 80 new cars built to be used in the streets of Los Angeles, Cal. They are operated by electricity and are equipped with Westinghouse air brakes with motor-driven compressors. Among the other cities which have recently ordered similar equipments are Oakland, Cal.; San Francisco, Cal., and South Bend, Ind.

The H. K. Porter Co. has just issued a revised edition of its catalog of "Light Locomotives." It conforms with the usual style of the catalogs of that company, but contains some material which has not been printed heretofore. Considerable space is devoted to pneumatic locomotives and the necessary equipment for operating them in mines and other industrial establishments.

The Colliery Guardian, an English publication, reports that coal-cutting machines are being introduced into the northern fields of New South Wales, compressed air being used in one colliery and electricity in another. The innovation has not been resisted by the miners, although they are reported to be unsettled respecting the altered conditions of labor and the rates of pay.

The patent rights for a hoist operated by compressed air, the invention of Mr. C. H. Peck, of Elmira, N. Y., have been purchased by the Imperial Pneumatic Tool Company, of Athens, Pa. The principal feature of the hoist is a construction which permits it to be used in that class commonly known as tackle or chain hoists, which are used in machinery shops and other structural works.

In an exhaustive description of the boiler shops of the Babcock & Wilcox Company, given recently in the *Engineering Record*, note was made of the general use of pneumatic tools throughout the shop. The compressed air for these tools is supplied by two Ingersoll-Sergeant Class JC belt-driven air compressors. One of these has air cylinders 14 and 7¼ by 17 inches, and the other 24¼ and 16¼ by 16 inches.

Compressed air and electricity are to be combined to operate a mammoth clock, which, it is reported, will be one of the features of the St. Louis Exposition. The two powers will operate the hands, which are to sweep over the face of a dial 125 feet in diameter, composed of a flower garden with appropriate blooming plants aranged in groups to represent the hours. The Johnson Service Company, of Milwaukee, is supplying the electric and pneumatic apparatus.

Pneumatic tools and other modern appliances for working stone have come to stay, declares *Rock Products*. In this case a number of them will keep coming right along, for these not only lighten and improve the work, but help make it possible to push stone in the places where it would otherwise be barred by the excessive cost. In another note this same paper adds: "This is the time of the year when operators in the quarries look with favor on pneumatic appliances as compared to steam, for it is hot enough without the steam at work."

Among the new catalogs that have made their appearance during the month of July is one issued by the Ingersoll-Sergeant Drill Co., illustrating and describing its rock drills, mining and quarrying machinery. It is known as No. 43. The catalog is handsomely printed and bound and contains much new material as well as a great many new cuts, which not only illustrate the various products, but show the machinery in actual operation. There is some valuable information regarding the construction and use of the drills and other machinery, in addition to a very full description of the different types. Some of the illustrations show important engineering undertakings now in progress in which Ingersoll-Sergeant machinery is figuring.

The efficiency of compressed air in operating pumps under ground in mines is greatly increased by reheating the air at a point near the pumps. When the ventilation is good this is generally easy to do. A compound direct-acting pump, heated sufficiently to prevent freezing will pump double the amount of water with the use of a given amount of air that a single pump will. One suggestion to prevent the freezing of a mine pump is by aranging the drip from a pipe so that a small stream of mine water will flow upon the exhaust opening. This usually keeps the temperature at a point somewhat above freezing. A large exhaust opening is much easier to keep from clogging with ice than is a small one.

The annual meeting of the American Mining Congress will be held at Deadwood and Lead, South Dakota, September 7 to 12. This gathering promises to be one of unusual interest, as it will be held in one of the most famous mining sections of the country. In the last quarter of a century the famous Black Hills of South Dakota are reported to have produced in gold alone $121,000,000. Several excursions have been arranged, one of the most instructive of which will be to the Homestake Company's properties. This company has one of the largest and most complete compressor plants to be found in any of the mines of that district. This plant will undoubtedly be of great interest to the visitors. A description of a compressor recently added to its equipment is given in this issue.

Among the quarries that have recently been equipped with more extensive compressed air power plants are those of the Granite Railway Company, located near West Quincy, Mass. Important improvements to both quarries and cutting yard have only recently been brought to completion. Adjoining the new building in the cutting yard is a brick power house containing boilers, a 150-horse-power engine and a 115-horse-power Ingersoll-Sergeant air compressor which has a capacity of 638 cubic feet of free air per minute. This supplies compressed air for surfacing machines and pneumatic tools, as well as for operating three powerful hoisting engines. Heat will be supplied to the new building in winter by means of a blower operated by an independent engine.

The Ingersoll-Sergeant Drill Company, which has placed a line of pneumatic tools on the market, reports immediate recognition of the superiority of the Haeseler "Axial Valve" hammers. Among the latest purchasers of these tools are: Niles-Bement-Pond Company, Ramapo Iron Works; MacPherson Switch & Frog Company, Creswell & Waters Company, Waren Foundry & Machine Works, Chicago, Rock Island & Pacific R. R., Brown Hoisting & Conveying Machine Company, Howard Iron Works, International Boiler Works Company. The "Axial Valve" mechanism used in the construction of the Haeseler hammers has produced a steady working and unbreakable valve.

Another experiment with the Westinghouse air brake has been made in England, for the purpose of solving the problem of controlling freight trains traveling at high speeds on steep descending grades. The Northeastern Railway Company recently conducted a series of important trials on its lines, which at one point attain an elevation of 1,800 feet above sea level, and is one of the steepest sections of railway in the United Kingdom.

Forty heavy coal cars comprised the train, each car being equipped with Westinghouse rapid-acting brake apparatus, the air pressure being operated from the engine. Despite high speed, unfavorable climatic conditions and traveling on the down grade, the train was brought to a stand in a very short distance, the application of power on both front and rear wheels of the train being practically simultaneous.

The trials were conducted under the supervision of the leading officers of the Northeastern Railway and representatives of the Westinghouse Brake Company, and are said to have been highly satisfactory.

INDEX.

U.S. PATENTS GRANTED JULY, 1903.

Specially prepared for COMPRESSED AIR.

732,696. PORTABLE PNEUMATIC RAM. Joshua B. Barnes, Springfield, Ill., assignor of one-half to C. A. Thompson, St. Louis, Mo. Filed Jan. 21, 1903. Serial No. 140,019.

A compressed-fluid ram, comprising a cylinder, a tool-holder movably carried at one end thereof, a piston reciprocating within the cylinder, a valve-chamber having inlet and exhaust ports for the motive fluid and having passages leading to opposite ends of the cylinder, a valve controlling said passages, manually-operated means for throwing said valve in one direction to admit the motive fluid in rear of the piston to propel it forward and fluid-pressure-operated means for returning the valve to initial position.

732,789. AIR-BRAKE FOR VEHICLES. Joseph S. Smart, Wait, Mich., assignor of one-half to James Perkins, Wait, Mich. Filed Mar. 14, 1903. Serial No. 147,822.

732,856. DIRECT-ACTING COMPRESSED-AIR BRAKE. Wilhelm K. M. Hildebrand, Gross-Lichterfelde, near Berlin, Germany. Filed June 16, 1902. Serial No. 111,893.

A valve mechanism for direct-acting compressed-air brakes, comprising a valve in the direct passage from brake-pipe to brake-cylinder, only closing at high pressure in the brake-pipe, and a distributing valve connecting the auxiliary air-reservoir with the brake-pipe and with the brake-cylinder, and only opening when said valve closes, all substantially as and for the purposes described.

732,892. COMPRESSED-AIR LOCOMOTIVE HEATER. Wilson R. Pratt, Topeka, Kans. Filed Oct. 15, 1901. Serial No. 78,743.

A compressed-air heater, the combination with a casing of inlet and outlet means for conducting air into and out of said casing, burners mounted in the casing, flues in said casing, hollow protecting-shields mounted in said flues; to receive the flame from the burners of the heater, and apertured supporting means for the shield for holding the same above the burners, said means engaging the flues.

733,223. AIR-FORCING DEVICE FOR VENTILATION OR SIMILAR USES. Jean B. Le Reau, dit L'Heureux, Detroit, Mich., and Joseph Le Reau, dit L'Heureux, Windsor, Canada. Filed July 18, 1902. Serial No. 116,038.

733,315. ELECTROPNEUMATIC VALVE. Frank L. Dodgson, Rochester, N. Y., assignor, by mesne assignments, to Pneumatic Signal Company, Rochester, N. Y., a Corporation of New York. Filed Oct. 25, 1901. Serial No. 79,942.

An electropneumatic valve, an electromagnet having an armature, a double-seated valve, a valve-casing having ports connecting a supply with an outlet through one valve-seat, and closing the exhaust when the armature is in one position, and a port connecting the outlet with the exhaust through the second valve-seat and closing the supply when the armature is in the other position, means for operating said valve by movement of said armature, and means for independently adjusting the distance between the armature and the valve and the distance between the armature and its magnet without disconnecting any parts of the mechanism or disturbing any other adjustments.

733,429. BRAKE-VALVE. Frederick E. Schmitt, New York, N. Y., and Lewis E. Moore, Phœnixville, Pa. Filed Jan. 22, 1903. Serial No. 140,086.

A valve for operating an air-brake system, consisting of a valve-chamber connecting respectively with an air-reservoir and an air-brake cylinder, a valve-plug movable in said chamber, means by which the operator may move said plug so as to open communication through the valve between the air-reservoir and the air-brake cylinder, and means actuated by the pressure in the air-brake cylinder for moving said plug in the reverse direction, in combination substantially as described.

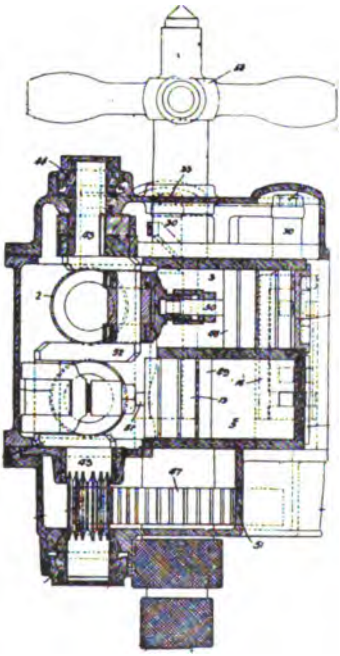
733,497. RIVETING-MACHINE. George E. Martin, Philadelphia, Pa., assignor to the Pedrick and Ayer Company, Plainfield, N. J. Filed Aug. 14, 1902. Serial No. 119,610.

733,917. SELF-PLAYING ORGAN AND PNEUMATIC ACTION THEREFOR. Joseph E. Prante, Chillicothe, Ohio, assignor of two-thirds to John M. Patridge and Henry Holberg, Wellston, Ohio. Filed July 7, 1902. Serial No. 114,557.

The combination, with a pneumatic for organs having a casing, of a block secured in the casing in communication with the pneumatic and having a dust-chamber, an air-channel extending from the chamber through the block, and a dust-discharge opening from the bottom of the chamber.

733,960. PNEUMATIC DRILL OR LIKE MACHINE. George H. Hayes, London, England, assignor to Chicago Pneumatic Tool Company, a Corporation of New Jersey. Filed Dec. 4, 1902. Serial No. 133,906.

A hand portable pneumatic tool of the type set forth, a fluid-pressure cylinder, a piston working therein, a crank-shaft connected to said piston, an oscillating controlling and reversing valve consisting of a single part ar-



ranged across or at right angles to said cylinder, a sleeve on the machine-handle, and means operatively connecting said valve and the sleeve whereby the valve may be moved longitudinally for the purpose of reversing the revolution of the crank-shaft and tool.

733,971. LIQUID RHEOSTAT OPERATED BY COMPRESSED AIR. Koloman de Kando, Budapest, Austria-Hungary. Filed May 25, 1901. Serial No. 61,916.

A liquid rheostat and a compressed-air conduit therefor, a throttle-valve in the conduit adapted to more or less cut off the air-supply from the rheostat and means in the electric circuit to control the movement of the valve.

733,986. ATTACHMENT FOR PNEUMATIC FEEDING-TRUNKS. Thomas R. Marsden, Oldham, England. Filed Mar. 7, 1903. Serial No. 146,700.

734,023. HEATING APPARATUS FOR CLOSED RECEPTACLES. John A. Waters, Stamford, Conn. Filed Aug. 4, 1902. Serial No. 118,313.

The combination with a heat-generator, of a plurality of ovens each having a vent, means for supplying air under pressure to the heat-generator, a pipe leading from the heat-generator and having branches to the individual ovens, a plurality of separate pipes for distributing the heated air to different locations within the ovens to enable articles therein to be uniformly heated, means for controlling the heated air admitted to each oven, and means for independently controlling the outlets from the different pipes in each oven.

734,028. AIR-PUMP MECHANISM FOR MOTOR-VEHICLES. Rollin H. White, Cleveland, Ohio, assignor to the White Sewing Machine Company, Cleveland, Ohio, a Corporation of Ohio. Filed Apr. 21, 1902. Serial No. 103,854.

An automobile, the combination of a fuel-tank, an air-pump, an engine, and means for connecting and disconnecting the engine and pump, with a pipe connecting said pump and tank and having a relief-opening, and valve-mechanism adapted to simultaneously establish communication through said pipe between the pump and tank and to close said relief-opening, and *vice versa*.

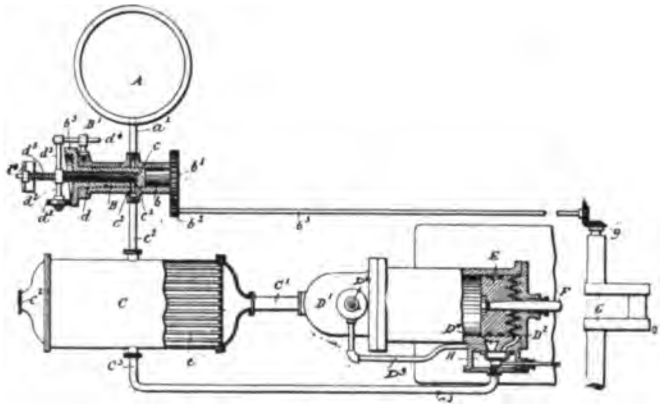
734,067. PNEUMATIC STACKER. Louis Holland-Letz, Chicago, Ill., assignor to the Plano Manufacturing Company, Chicago, Ill., a Corporation of Illinois. Filed Feb. 3, 1902. Serial No. 92,326.

734,262. MUSICAL INSTRUMENT. William E. Haskell, Philadelphia, Pa. Filed Mar. 28, 1901. Serial No. 53,194.

A musical instrument, the combination with a pneumatic tracker-bar comprising the metal plate; of means to progress a perforated web with respect to said metal plate; a series of orifices in the front of said metal plate; a series of metal conduits; a series of metal nozzles, whose rear ends are respectively connected to the metal conduits and form continuations thereof, and whose front ends are seated in the metal plate, in respective communication with said orifices; each of said metal nozzles being of greater area at its rear extremity than at its junction with said metal plate and the rear extremities of said metal nozzles, being alternately divergent in staggered relation with the axis of the series; and a casing member comprising upper and lower boards secured at their front edges to said tracker-bar and forming a chamber coextensive with and inclosing said series of nozzles.

734,220. COMBINATION INTERNAL-COMBUSTION AND COMPRESSED OR LIQUID GAS OR COMPRESSED OR LIQUID AIR ENGINE. Frank Bryan, London, and Abel H. Bayley, Niton, Isle of Wight, England. Filed Feb. 26, 1901. Serial No. 48,973.

A liquid air or gas engine, the combination with the supply-reservoir and converter, of a movable measuring-chamber having ports adapted to alternately communicate with said reservoir and converter and automatically deliver the measured charge to the converter in direct opposition to the pressure in the converter when the pressure in the same is below the required working pressure.



734,265. TUNNEL CONSTRUCTION. David L. Hough, New York, N. Y., assignor to the United Engineering & Contracting Company, New York, N. Y., a Corporation of New York. Filed Feb. 7, 1903. Serial No. 142,287.

The combination with a tunnel-shield and a tunnel-lining, of a pneumatic bag packing interposed between the shield and the lining, and a stiffening-plate within the bag to hold it in shape when inflated.

734,319. PAINTING-MACHINE. John Grahn, Madison, Wis. Filed July 15, 1902. Serial No. 115,615.

A painting-machine, the combination of a brush provided with bristles and a pair of webs of flexible material disposed amid said bristles for discharging a painting fluid thereto, and means for connecting said flexible web with a source for supplying paint.

734,356. COOLING DEVICE FOR EXPLOSIVE ENGINES. Martin Offenbacher, Furth, Germany, assignor to The Firm of Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nurnberg A. G., Nuremberg, Germany. Filed Dec. 30, 1902. Serial No. 137,197.

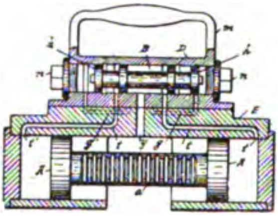
A combination with an engine having a water-jacket, water-circulating pipes therefor, a compressed-air pipe connected with the circulating-pipes and valves in said circulating-pipes whereby water may flow into the packet or be forced therefrom.

734,466. PNEUMATIC SHEET-FEEDING MACHINE. George F. Leiger, Chicago, Ill., assignor to himself and Lewis Benedict, Chicago, Ill. Filed June 3, 1901. Serial No. 62,959.

The combination with pneumatic sheet engaging and forwarding mechanism, a vacuum-chamber, a valve-box connected with said vacuum-chamber, and pipes connecting said pneumatic sheet engaging and forwarding mechanism with said valve-box and opening into the same, of a rotary valve seated in said valve-box and adapted by its rotation to open and close the openings of said pipes into said valve-box at suitable intervals as said valve rotates, and mechanism for rotating said rotary valve.

734,276. PNEUMATIC TOOL. Foster M. Metcalf and Martin C. Abbey, Battlecreek, Mich. Filed Feb. 10, 1903. Serial No. 142,808.

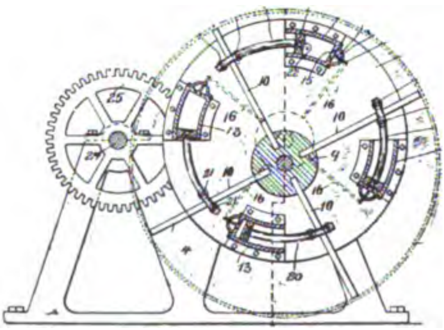
A pneumatic tool, the combination of two oppositely-arranged pressure-chambers, a double-headed piston having one of its heads oscillatingly mounted in each pressure-chamber, supply-chamber in communication with



each end of said pressure-chambers, an oscillating controlling-valve mounted in said supply-chamber adapted to control the admission of pressure to the ends of the pressure-chambers, a disk valve rotatably mounted to control the admission of pressure to the supply-chamber, a chuck-spindle rotatably mounted and connected with the disk valve and means carried by the main piston for operating the chuck and simultaneously the disk valve.

734,303. AIR-COMPRESSOR. George Code, Melrose, Mass., assignor, by direct and mesne assignments, to United States Atmospheric Oxygen Company, Boston, Mass., a Corporation of Maine. Filed Sept. 15, 1902. Serial No. 123,396.

A pumping apparatus comprising a rotatively-mounted cylinder and piston, and a rotatively-mounted actuator for said piston, one



axis of rotation being eccentric to the other, the cylinder being mounted with its bore in the direction of its path of travel.

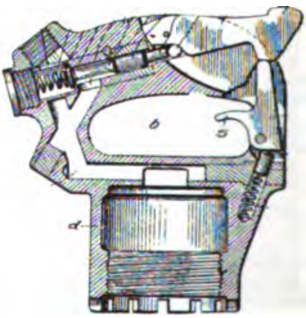
734,473. AIR-BRUSH. William H. Shepler, Chicago, Ill., assignor of five-eighths to Albert Ahrens and Charles Orchardson, Chicago, Ill. Filed July 28, 1902. Serial No. 117,278.

A device of the class described, the combination with a pigment-valve, and receptacle for a supply of pigment, means of connection between said receptacle and said valve, means for opening said valve, a nozzle for compressed air contiguous to said pigment-valve and means for opening and closing said nozzle, of a hollow chamber connected to said nozzle and having a fixed relation thereto and adapted to hold a supply of compressed air.

734,540. PNEUMATIC-DESPATCH-TUBE SYSTEM. Charles A. Gray, Kansas City, Kans., assignor to Gray Pneumatic Carrier Co., Kansas City, Mo., a Corporation of Missouri. Filed Feb. 13, 1903. Serial No. 143,271.

734,700. THROTTLE-VALVE LOCK FOR PNEUMATIC HAMMERS. Charles H. Haeseler, Easton, Pa., assignor to the Haeseler-Ingersoll Pneumatic Tool Company, New York, N. Y., a Corporation of West Virginia. Filed May 26, 1903. Serial No. 158,777.

A pneumatic hammer, the combination with the handle, of an air-passage in said handle, a valve controlling the pressure of air through

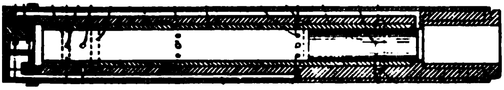


said air-passage, a lever adapted to control the operation of said valve, and means adapted to directly engage and lock said lever.

734,765. PNEUMATIC TOOL. William H. Soley, Philadelphia, Pa., assignor of one-half to Thomas H. Dallett, Cheyney, and

George A. Dallett, Philadelphia, Pa., trading as Thomas H. Dallett and Company, a Firm. Filed June 3, 1902. Serial No. 110,033.

A pneumatic tool, in combination a piston-chamber and piston therein, a valve-chamber and a main valve therein, a pilot, or supple-



mental valve in the piston chamber adapted to act in advance of the piston and connect one main-valve-operating passage with the piston-chamber.

734,773. MECHANICAL DEVICE FOR RECEIVING SAND AND DISCHARGING IT THEREFROM UNDER PRESSURE. William H. Stuart, Baltimore, Md., assignor to Economy Locomotive Sander Company, Baltimore, Md., a Corporation of Delaware. Filed July 26, 1902. Serial No. 117,213.

A sand-delivery device containing sand receiving and discharging passages in and through which a body of sand or other finely-comminuted mineral substance is introduced under atmospheric or higher pressure and discharged therefrom by fluid-pressure, said passages having their inner walls provided with a substantially smooth and non-oxidizable surface.

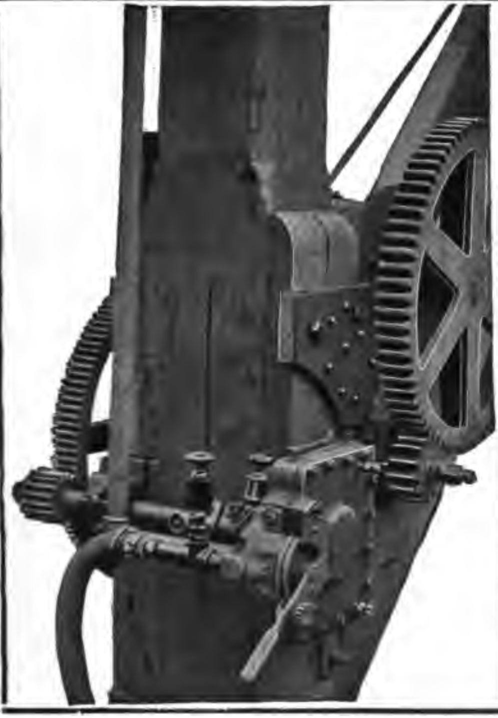
734,904. CONTROLLER FOR HYDRAULIC AIR-COMPRESSORS. William J. Linton, Woodstock, Canada, assignor to the Taylor Hydraulic Air Compressing Company, Limited, Montreal, Canada, a Corporation of Canada. Original application filed Feb. 21, 1900, Serial No. 6,044. Divided and this application filed Dec. 5, 1900. Serial No. 38,849.

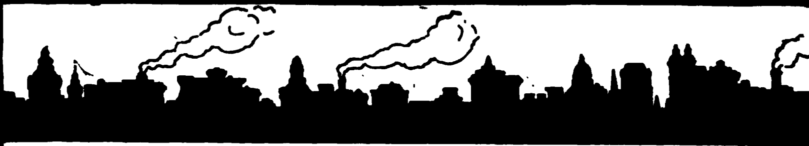
An air-compressor of the class described means for automatically controlling the air-supply to said compressor. The combination with the air-supply pipes of a hydraulic air-compressor of the class described, of means for automatically controlling the passage of air through said air-supply pipes.

734,979. PNEUMATIC-ACTION FOR MUSICAL INSTRUMENTS. Horace T. Skelton, Cambridge, Mass. Filed Oct. 30, 1902. Serial No. 129,475.

735,005. APPARATUS FOR UNLOADING AND DISTRIBUTING STEEL RAILS. Henry Ware, Springville, N. Y. Filed Mar. 25, 1903. Serial No. 149,543.

The combination of a car, a pneumatic hoist suspended therefrom, means for operating said hoist from the air-brake system of the train, and a skid attached to one end of said car.





An invitation is extended by "Compressed Air" to all delegates attending the American Mining Congress to communicate items of interest especially in connection with their experiences in the Black Hills.

Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, OCTOBER, 1903. No. 8.

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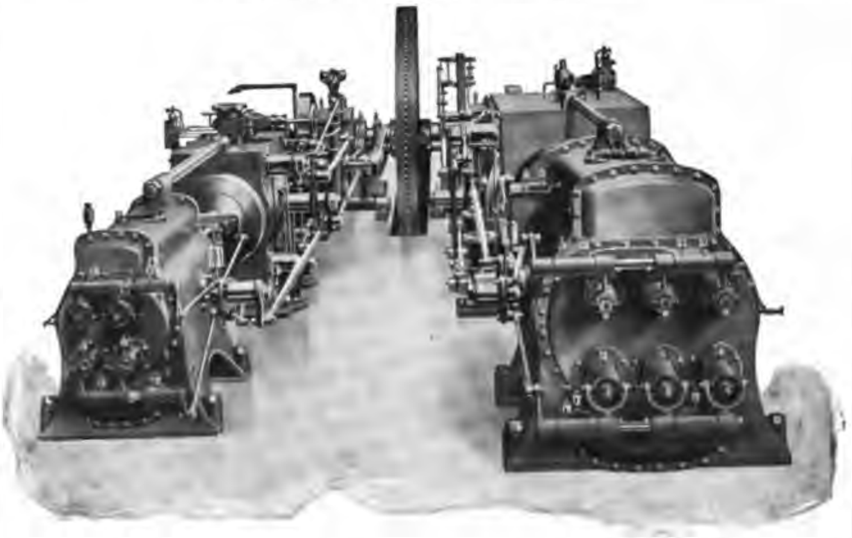

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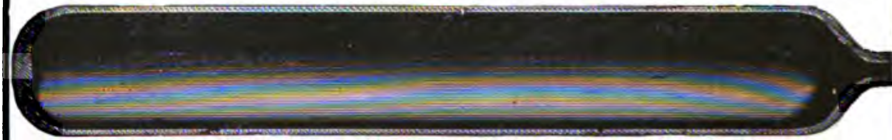

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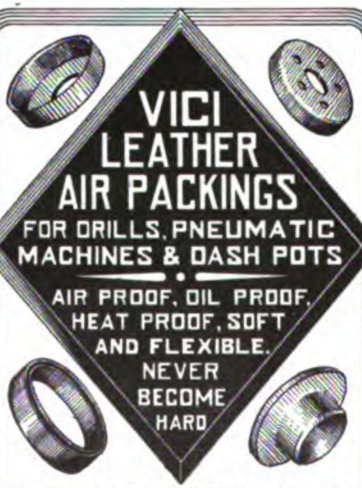

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A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Improvements in Methods of Tunneling.

While the uncertainties of a ferry service to transfer passengers and freight across the Hudson river to New York still remain to vex and trouble, the importance of securing some other method than by boat has long been realized, and schemes to either bridge over or tunnel under the broad river were devised several decades ago. The first actual steps toward the practical solution of the problem were made in 1879, when a tunnel to connect Jersey City and New York was begun. The enterprise began auspiciously but, on account of financial trouble, which ultimately resulted in checking its progress, was many years delayed. Public attention is now once more directed to it, and there is every reason to believe that this tunneling enterprise, with several other similar projects, will soon be brought to a successful culmination.

The comparison of the methods used when the Hudson river tunnel was started in 1879 with those which have followed in the present operations serve to show very clearly the progress that has been made in tunneling methods. In no way is this progress more evident than in the changes that have come in the air compression machinery, which plays such an important part in this subaqueous tunneling enterprise. To assist in illustrating this point is the article which appears in this issue of COMPRESSED AIR telling, among others, of an old type of air compressor which was used in the construction of the Hudson river tunnel from the start of that enterprise in 1879 till the work was temporarily abandoned in 1891. It presents a striking contrast to the compressors now used for the tunnel work as described in an article in the September issue of COMPRESSED AIR, reprinted from the *Engineering Record,* which gave a detailed description of the present operations under the charge of Chief Engineer Jacobs.

Most important among the improvements to the compressor, which particularly apply to the construction of a subaqueous tunnel, is the compounding of the air cylinders. By this method the air is not burned, and the odor of burned oil once complained about disappears entirely. The compounding of the air cylinders with an inter-cooler between them permits a high compression without great heat, which invariably accompanied the old method.

Of considerable importance is the change in the manner of cooling the compressed air. The old plan of injecting water directly into the cylinder has been almost entirely replaced by water-jacketed cylinders and heads, which serve to cool the air almost as effectively and greatly diminish the wear on the cylinder itself, as well as simplifying the compressor and the draining of the air receiver and pipes. In the air valves as well the progress of the last score years is very noticeable. For inlet valves, those of the piston type have demonstrated their value in a great majority of cases. Improvements in the poppet type of valves have also come with time. Then there are a host of minor changes, which, valuable in themselves, are but working for a common end, with the result that the air compressor of to-day is a far more efficient and yet much simpler machine than ever before.

The Development of the Straight Line Air Compressor.

In New England, noted for the longevity of its citizens, one sees very frequently the parents, children and grandchildren living together under the same roof, but the only time the writer ever had the pleasure of meeting this condition in an air compressor plant was at one installed by Mr. Chas. Haskin, contractor, to conduct operations in the pneumatic tunnel at Jamaica Plain, one of the suburbs of Boston. If it were not for the fact that these machines had done good service in many of the Eastern States, one might be inclined to think that the bracing climate, and good habits of the New Englanders had challenged these venerable compressors to uphold the reputation of the manufacturer by establishing for themselves a record-breaking career. Besides one's interest in everything which has done good service, this plant would attract attention from the fact that these compressors, the product of the same manufacturer, are all of the straight line, self-contained type—each representing in itself a distinct period in the development of this class of machine.

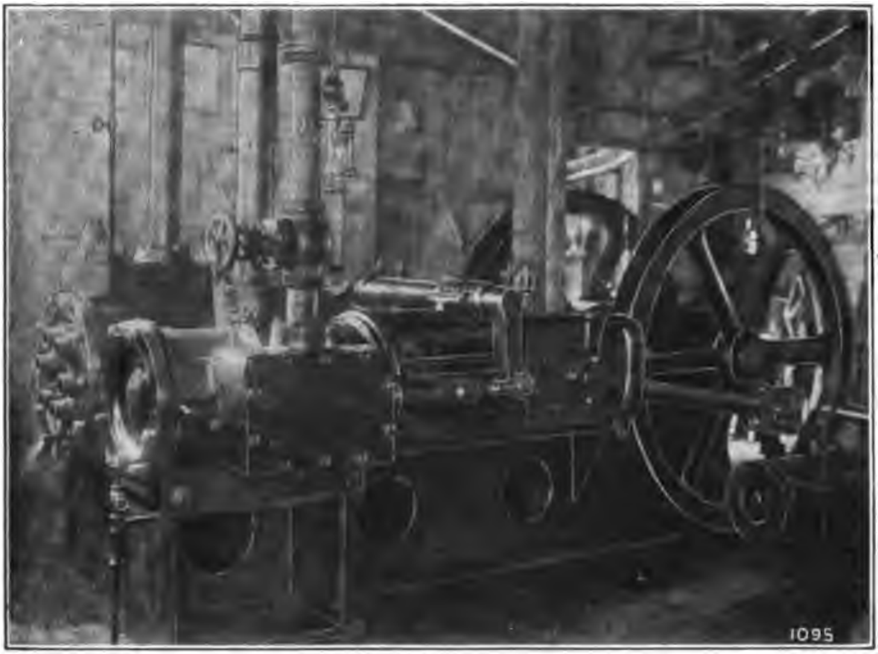
In Figure 1 is illustrated the earliest type: here you will notice that the position of the air cylinder is quite different from that of the modern machine, being placed close to the steam cylinder. Between it and the steam cylinder is passed the main shaft upon which is mounted the necessary eccentrics to drive the steam valves and so forth. The crosshead, as you will see, is carried out

NO. 1—EARLIEST TYPE OF STRAIGHT LINE COMPRESSOR.

to the opposite end of the machine from the steam cylinder. You will also note the water injection pump placed on the side of the air cylinder which is operated from an eccentric on the main shaft. By means of this injected water the necessary cooling is produced, the cylinder not being water jacketed. The air cylinder is fitted with poppet inlet and discharge valves of quite a different construction from those in modern machines. The steam valves are of the regular Meyer cut-off type.

from the crosshead. The valves are poppet inlet and discharge. A tail rod is carried through the back-head of the air cylinder. The entire machine when compared with its predecessor is much simpler in construction and more accessible for repairs and oiling.

Figure 3 is a cut of the present type of straight line machine. The construction, on the whole, is very similar to illustration No. 2, the greatest difference being in the air cylinder. In this machine



NO. 2—SIDE VIEW OF SOMEWHAT IMPROVED TYPE OF STRAIGHT LINE COMPRESSOR.

Figure 2 shows the next period of development. Here you will note the relative position of the steam and air cylinders, the crosshead and guides being placed between them, and the main shaft being placed back of the steam cylinder. Besides the very different arrangement of details in this machine from that of the former type, there is also a marked improvement in the type of air valves. The air cylinder, as formerly, is of the water injection type, the pump being operated

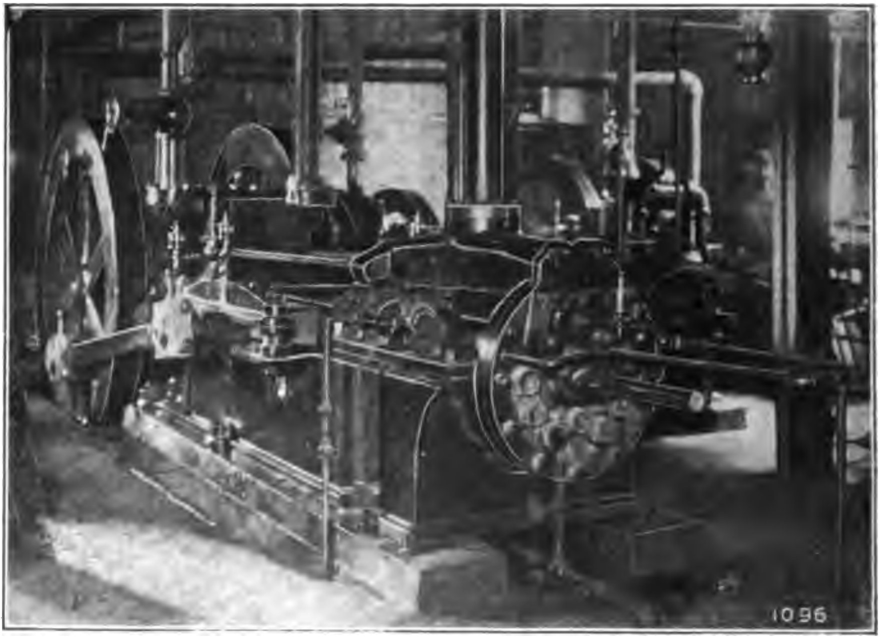
the water injection pump is dispensed with, the air cylinder and heads being jacketed, and in place of the poppet inlet valves, a piston inlet type has been adopted. The discharge valves of the poppet type are placed in individual sockets, which facilitates any necessary inspection and increases the safety of operation. Again the crosshead is built on the swivel block principle, the rods being screwed into a coupling block placed in the centre of the crosshead, which is a hollow steel casting. Through the centre of the crosshead and through the coupling block is passed a vertical pin. This construction adjusts itself to all uneven wear in the connecting-rod brasses, thus equally dividing the load on the pins, preventing any lateral strain on the connecting and piston rods. Where possible, many of the working parts have again been made more accessible and simplified in their construction, while the adoption of the latest processes of manufacture and the wide experience gained as to the proper materials to use in construction should make this type a worthy descendant of its venerable predecessors.

Mr. Haskin very kindly supplied the writer with a history of these compressors, extracts of which may be of interest.

"No. 1 was bought by D. C. Haskin and used at the Hudson River tunnel from 1879 to 1891. During that time it was in use night and day for about three years. I bought it in January, 1893, and used it on pneumatic work continuously for the Commonwealth of Massachusetts until March, 1895; from March 10, 1895, on the pneumatic tunnel under the Providence River until October 15th of that year.

"No. 2 was purchased in 1881, and used in conjunction with No. 1. From June, 1896 to July, 1897, rock drills on the Neponset Valley sewer were run by it night and day. No. 1 was employed on the pneumatic work of completing the Buffalo intake tunnel from June to October, 1897, inclusive; No. 2 being on the same work from August to October.

"Both machines were used in building three pneumatic tunnels for the Massachusetts Pipe Line Gas Company from March, 1898, to June 1899, inclusive. They were again on pneumatic tunnel for the Metropolitan Water Board from Chelsea to Charlestown from October, 1899, to March, 1901. No. 2 was used in doing a small tunnel at Rockland, Maine, for two months during 1901. Both machines were started on pneumatic work for the Metropolitan Water and Sewerage Board, April 1, 1902, and have been running constantly to date, April 23, 1903.



NO. 3—MODERN TYPE OF STRAIGHT LINE COMPRESSOR.

"In all places where they have been running the work has been unremitting and on the present work they have not been shut down more than five hours each, in all. They have the original brasses, and some of the valves are those which came with them when bought. They have never been in a shop for repairs; the cylinders are in good condition. The piston rings in air cylinder have been renewed twice."

This certainly shows a very remarkable record of endurance and brings before us the fact that with proper attention the life of a well-constructed air compressor should be almost indefinite.

R. S. Carter.

Transmission of Power by Compressed Air.*

Although used in isolated cases for a much longer period, the general employment of compressed air as a means for transmitting power or converting it into more manageable forms may only be said to extend back some fifteen years. Primarily confined to a very limited scope, the area of usefulness served by compressed air has yearly widened, and it is still continuing to make very rapid strides.

It is an undoubted fact that we are indebted to American engineers for the present improved condition of compressed air engineering, although many of the most important solid improvements—at any rate, in compressors—have been evolved in this country, the adoption of reciprocating rock drills, and the further spread of the use of these to so many shop tools owes most to the United States.

At the same time it is satisfactory to note that within the last few years a distinct change has been noticeable in the attitude of English engineers toward compressed air. Formerly it was regarded as quite an outside line of manufacture, confined to a few firms which could be counted on the fingers of one hand. But things have changed to such an extent that there are now quite a large number of firms making a specialty of both compressors, motors, and special tools.

The more compressed air is used the more rapidly will its use spread, because when an installation is once put into a workshop and the compressed air is there—as it were "on tap"—new uses will be continually presenting themselves, and the owner of the factory will soon find out new uses to which he can put this useful medium.

The position of compressed air is a peculiar one among other methods of transmitting power, inasmuch as it possesses advantages which render its use almost imperative for many kinds of work.

In the first place, the material or medium of transmission is the atmospheric air, of which there is everywhere an inexhaustible supply, which does not suffer any deteriorating effects in its use, and is therefore available for ventilating the space around the motor when it has done its work and been discharged. It is this quality which makes compressed air so especially suitable for transmissing power to the working faces of mines and tunnels.

The medium of transmission in this case, then, costs nothing to the user, but it requires pipes to retain and convey it.

In speaking about compressed air machinery it is usual to speak of "free air" as opposed to compressed air. By free air is meant the air at the pressure of the atmosphere in which the air compressor is working. This, at the standard barometric pressure of 29·98 inches of mercury, has a pressure of 14·7 pounds on each square inch exposed to it, and this pressure may vary with the variations of barometric pressure at the one place, and it gets smaller the further the compressor is raised above sea level. For instance, while the pressure is somewhere about 15 pounds per square inch at sea level, it falls to about 10 pounds at an altitude of 1,000 feet above the sea. So that "free air" does not mean necessarily air at any definite pressure, but simply air at the pressure to which compressed air will fall when released from pressure and allowed to go free at the point in question.

If this is free air, then it may be said that any of this free air which is forciby diminished in bulk, and consequently raised above this pressure of the free air, is "compressed air."

Another great advantage which com-

*Paper by W. C. Popplewell, M. SC., A. M. Inst. C. E., in *The Mechanical Engineer* (Eng.).

pressed air possesses is that its density is comparatively low, and this enables it to be sent along the pipes from point to point without any ill effects being felt from the inertia of the moving column of air. In this it is far superior to water. Besides the first cost of the water itself, it must only be allowed to flow along its pipes at a very slow speed, for if the speed were to be great any sudden stoppage of the column of water would lead to a great increase of pressure, with possible danger to the pipes; also, the friction of the water in the pipes is so very much greater than in the case of air for the same speeds. This advantage of air as compared with water is of still greater importance in the working of high-speed reciprocating motors. At the present time a very large proportion of the compressed air used in engineering work is employed for working high-speed reciprocating tools making many strokes a second, and it is obvious that a practically inelastic, heavy fluid like water could not possibly be used in these, and it is only with air that it is possible to obtain the rapid succession of admissions, expansions, and exhausts which are needed in machinery of this class.

The Uses to which Compressed Air Can be Put.—It is almost impossible to give anything like a complete list of the uses to which compressed air is put, but the following notes will help to convey some idea of the immense width of its application:

Power Transmission Proper.—In this is included all cases where the power is developed in one place, and is transmitted to a more or less distant point to be made use of in a motor for driving machinery. Among these may be mentioned motors for driving the machines used for charging gas retorts and for discharging coke ovens. In engineering shops many tools and appliances are used in this way, such as hoists, cranes, portable tools for riveting, both direct-pressure and impact tools, drilling, chipping, reaming, caulking, pneumatic hammers, portable jacks, and many other lesser uses.

Under this head also comes the establishment of general power transmission installations like those in Paris and Birmingham, where the power is sent from a central station to all parts of a district, to be used for any purpose for which compressed air may be suitable.

Power transmission in coal and metalliferous mines is one of the most important fields of usefulness for compressed air, and it is not too much to say that it is its use in this direction that has done as much as anything else to bring compressed air into its present general use. In mines compressed air is used for drilling, channeling, and rock and coal cutting generally, as well as for hauling and pumping.

Pumping.—Without being transmitted to a great distance, compressed air may and frequently is used for pumping, either by driving direct-acting pumps in the same way as steam, by the direct action obtained in the air-lift system of pumping, or by the use of air-displacement pumps. Very often the pump is placed immediately at the top of the shaft from which the water is to be pumped.

Railway Brakes.—Many thousands of brakes are now worked either by air compressed to a pressure above the atmosphere, or by air at atmospheric pressure working on pistons which have been relieved from the atmospheric pressure on the opposite sides or vacuum brakes.

Supplying Pressure to Workings.—In some engineering works at the present day it is found advisable, and indeed necessary, to have the work carried on in an atmosphere of compressed air, either to prevent the inrush of water or a fall of the material which is being worked. Examples of these uses are to be found in such cases as the Blackwall Tunnel, where the work was carried on through soft earth under the bed of the Thames, and the work was carried on between an air-tight shield and the face of the tunnel. It is also used in submarine works, in diving-bells, and for sinking foundations in caissons.

Other Uses of Compressed Air.—A few of the principal further uses to which compressed air is put are accumulators, the Bessemer process of steel production, diving dresses, chemical processes, bell ringing and organ blowing, sandblast apparatus, street railway cars, cleaning carpets, sheep shearing, operating clocks, blast for furnaces, refrigerating machines, Shone sewage ejector, dynamite guns, filtering water and displacing oil, steering gear on ships, moulding machines in foundries, painting and whitewashing, and many other minor uses.

It will be seen that compressed air is of almost universal application.

Besides possessing the advantages which have been mentioned, compressed air is clean, easy to manipulate, and fairly economical for transmission purposes.

The Question of Economy.—Regarding the question of economy very much has been said and written, but apparently many of the writers on the subject have devoted most of their energies to discussing in all its minute details the question of the economical *compression* of air, and have left efficiency of the mains and motors to take care of themselves.

Compressed air carries along with it, in addition to its possibilities of economical working, several collateral advantages which cannot be taken into account and represented by numerical results, but which none the less represent definite gains in economy. Some of these have already been mentioned.

In the first place, it may safely be said that all parts of a power transmission installation should be made as efficient as possible, taking into consideration both the percentage of the power yielded for the power expended at the compressor, and at the same time taking into account not only this power efficiency, but also the cost at which it is arrived at and the cost at which the plant is maintained.

When a power transmission installation is put down a prime mover of some kind drives the compressor at one end at a certain cost, initial and for maintenance; and the air motor yields a certain percentage of the power put into the compressor at the far end of the line of mains. Although each part of the system should be as efficient as it is possible to make it, the fact must not be lost sight of that it is useless to strive after extraordinary degrees of efficiency when this is attained by an exorbitant expenditure in first cost or in maintenance. Where power is cheap and plentiful, as where there is an abundance of water-power available, there is no need to make use of the most expensive types of compressors in order to effect a comparatively small saving in the power transmitted. Any gain in economy, which is probably not desired by the owner of the works, will be swallowed up in interest on the greater first cost. On the other hand, where there is no natural supply of water, and transport renders fuel rare and costly, it will probably pay to put down a compressor of the very best kind, and the reduced fuel consumption may be expected to pay for the initial first cost. Also where the total power dealt with is large, it will pay better to use a high-class compressor than in small installations, where any gain in economy would only be represented by a very small sum of money. There are many cases where the cost of the compressed air installation is of small importance as compared with the gain in other directions. For instance, where a tunnel is being driven through a soft river bed, as was the case with the Vyrnwy water pipe for the Liverpool water supply, the cost of supplying the compressed air was of little importance as compared with the immunity from danger to the lives of the men employed on the work and the safety of the works themselves. If there had been a failure in the maintenance of the air supply at the working face, especially at high tide, when the pressure of the top of the tunnel was greatest, it is very likely that the face of the tunnel where the men were working would have fallen in, with a result which would have cost thousands of pounds to repair and some lives would undoubtedly have been lost. So that in this case it was of the utmost importance to maintain the air pressure at any cost, and for the purpose strength, durability, and good workmanship count for more than clearance and valve refinements, though there is no reason why these two should not go hand in hand.

On the other hand, there are many instances where the improvements in the economical working of compressors, and still more of the motors used, have made it possible to use compressed air, when, a few years ago, it was found to pay better to use hand labor. In one instance of this kind, where air motors were used for actuating a certain class of machinery for a time, it was found that the use of compressed air was more costly than doing the work in the ordinary way by hand labor, so that it was considered wise to discontinue the use of air for a time; but more recent improvements and developments in the economical working of the compressors and motors have made it possible to return to the use of compressed air with a very clear gain in economy.

It may be said without the fear of contradiction that in the majority of cases, when a man thinks of spending money on a compressed air installation he is induced to do so not only because he thinks he can save so many pounds a year by so doing, but because he will be able to carry out some process more quickly and more perfectly than by the older methods. We are told that there are some 30,000 Westinghouse brakes at work on the railways of this country and in America. The Westinghouse air pump or compressor is one of the most wasteful which can be conceived as compared with the larger compressors, but there is no question about the desirability of its use in this direction. The advantages possessed by the Westinghouse air brake for convenience and certainty of action far outweigh any disadvantages which may be possessed by the compressors when regarded from a strictly economical point of view.

At the same time any waste of power means waste of money, and unless there are very valid reasons for this waste it should be avoided as far as possible. Every part of a compressed air system must be as economical in its working as it can be conveniently made without sacrificing other and more important advantages, and generally speaking the larger the installation the more important it is to have economical machinery.

The first part of an air installation is the prime mover which drives the compressor. Of recent years great improvements have been made in these. The most usual form of motor is a steam engine, and this should be of the most economical type that can be obtained at a reasonable price. Most of the larger sizes of compressors are now provided with Corliss valves and gear on their steam cylinders, and it must not be forgotten than a gain of 5 per cent. in economy in the steam engine is also a gain of 5 per cent. all through the system.

A great deal of attention has been and is now being paid to the question of economical compression. Better valves, less clearance, quicker speeds, and the introduction of stage compression have all done much to improve the general efficiency of air compressors. Every attention ought to be paid to the details of design so as to reduce the friction of the mechanism as far as possible and give a high mechanical efficiency. Piston-rod packings and piston rings are often causes of losses which, unfortunately, are not easily appreciated and located. The piston of an air compressor has not the same advantages as the piston of a steam engine, there being no condensed steam to act as a lubricant, and there is often a considerable amount of air leaking past the piston, and this leakage is difficult to detect.

The compressors of the present day, as made by the best firms, are fairly economical in their working, and there is not too much room for further improvement in this direction. But very much more attention has been given to improving compressors than to other parts of compressed air systems—if the details of many types of pneumatic machinery are excepted. Where motors are used for driving machinery by compressed air there is room for improvement in the greater use of expansive working, in the improvement in mechanical efficiency, and in the more general adoption of reheating the air before it is allowed to enter the motor.

While much attention has been paid to improvements in the design of compressors, not only have motors had to take a second place to compressors, but the mains also have not received the attention they deserve. It is no use to strive after a 5 per cent. gain in efficiency of compression at the cost of £50 and then to allow a 10 per cent. leakage of the air after it has left the compressor, especially when a little care in putting the joints together and a little more care in selecting the most suitable kind of packing would have saved the loss, at little or no cost. Too small a diameter for the air which has to be transmitted, too sharp bends, too many corners, all these interfere with the efficient working of the pipes. People who use compressed air are too apt to think that if they have a good compressor at one end and a good motor at the other any kind of a pipe will do so long as it serves to carry the air from the compressor to the motor. There is room for new designs of air pipe joints, which shall be air-tight, cheap, easy to make, and at the same time offer little resistance to the passage of the air.

Objections to the Use of Compressed Air.—One very potent cause which has interfered with the adoption of compressed air in many cases has been the extraordinary prejudice against its use on the ground that the accumulation of ice in the mains and in the passages of the motors prevents the proper working of these parts. It cannot be denied that ice does very often collect in the pipes and ports, but one has only to look at the hundreds of successful installations of compressed air to be assured that the ice bogey is one that can easily be laid. Air always contains some percentage of water either in the form of visible moisture or invisible aqueous vapor, and the lowering of the temperature consequent on the adiabatic expansion of the air in the motors to a point below the freezing point of water, often causes the freezing of the moisture in the air, and this frozen moisture soon finds a resting place in the air passages. It accumulates against any projections or sharp bends in the pipe, and may in time cause the complete stoppage of the pipe. But by reheating the air before expansion, by making the inside surfaces of the pipes and passages smooth, and by avoiding sharp corners, it is perfectly possible and not difficult to prevent the closing up of the passages. These are important points to be attended to in the design of air motors and in the arrangement of piping, and the omission to attend to a single point may render impossible the working of an air motor. By proper attention to details of construction and design there is no fear of any trouble arising from an accumulation of ice in the pipes. It is a pity, however, that this question of ice has taken such a hold on some sections of the engineering public, who fail to see that compressed air could not have reached its present position among the means for transmitting power if this trouble had always been present.

Necessary Precautions.—The air which is taken into the air cylinder during the suction stroke should be drawn from a point outside the engine-house and where the air is cool and clean. Air drawn from the inside of the house is generally warm, and this makes the cooling arrangements less efficient, and moreover there is generally some dust in the air which tends to accumulate and clog the valves and passages.

When a complete compressed air installation has been put in, and the pipe connections made, it is well to close all the outlets from the pipes, work the compressor until the full pressure is reached at all points in the system, and then to allow the whole plant to stand, and meanwhile watch the pressure gauges. If there are any leakages in the pipes or connections they will very soon be shown by the falling of the pressure gauges. Besides a test of this kind on the first installation of the plant, it should be repeated at intervals to make sure that the compressor and pipes have retained their efficiency so far as air-tightness is concerned.

Compressed Air vs. Electricity.—Much has been said of late years as to the comparative suitability of compressed air and electricity as means for transmitting power, and much controversy has in consequence arisen. This controversy has generally been applied to the case of the transmission of power in mines. A thorough investigation of this point involves the consideration of a great many different points in relation to both compressed air and electricity. The advocates of each system can produce figures to show that the particular system advocated by them is the better. It is impossible to give all the arguments here, but it may be interesting to look at some of the chief considerations which may be expected to weigh for and against the use of compressed air.

In the first place, there are a number of qualities possessed by the one and not by the other. Compressed air has these advantages which electricity has not: The air sent out at the exhaust of the motors does not require to be got rid of as in the case of steam and water; but, on the other hand, when the motors are used in a mine or confined working of any kind, the exhaust air is a distinct gain, as it very largely helps in the ventilation of the space in which the work is being done. This is not a point which can be given a money value, but, all the same, it is a most important one, and is especially useful when air motors are used in the confined and often gassy workings of collieries. Another advantage contained in this exhaust air is to be found that the exhaust air cools as well as ventilates. Owing to the nature of a compressed fluid, when the pipes are full of compressed air, there is always a small reserve of power which can be made use of at once without working the compressor, and this reserve of power is only a question of receiver capacity. Moreover, a compressor can be automatically controlled, so that its running is made to accommodate itself to the demand for air, and as soon as a sudden demand for a large supply of power is come upon the compressor it responds at once, and supplies the power as wanted. A third advantage inherent to compressed air is to be found in its elastic nature when used in quickly moving motors. Nothing but an elastic fluid could be made to work rock drills and pneumatic tools in the same satisfactory way, and it is equally applicable for use in lifts and riveting machines, although in some few cases it is advisable to interpose an incompressible fluid like water or glycerine between the air and the piston which is being actuated, so as to obtain a steady, even motion.

None of these qualities are possessed by electricity, but it has its own, which give it an advantage for some purposes. It has no exhaust, and no possible freezing up of passages. It is especially applicable when any rotating machinery has to be driven. One of the greatest advantages which electricity possesses is that its leads and conductors are extremely flexible, and can be turned in any direction without the trouble of making fresh joints.

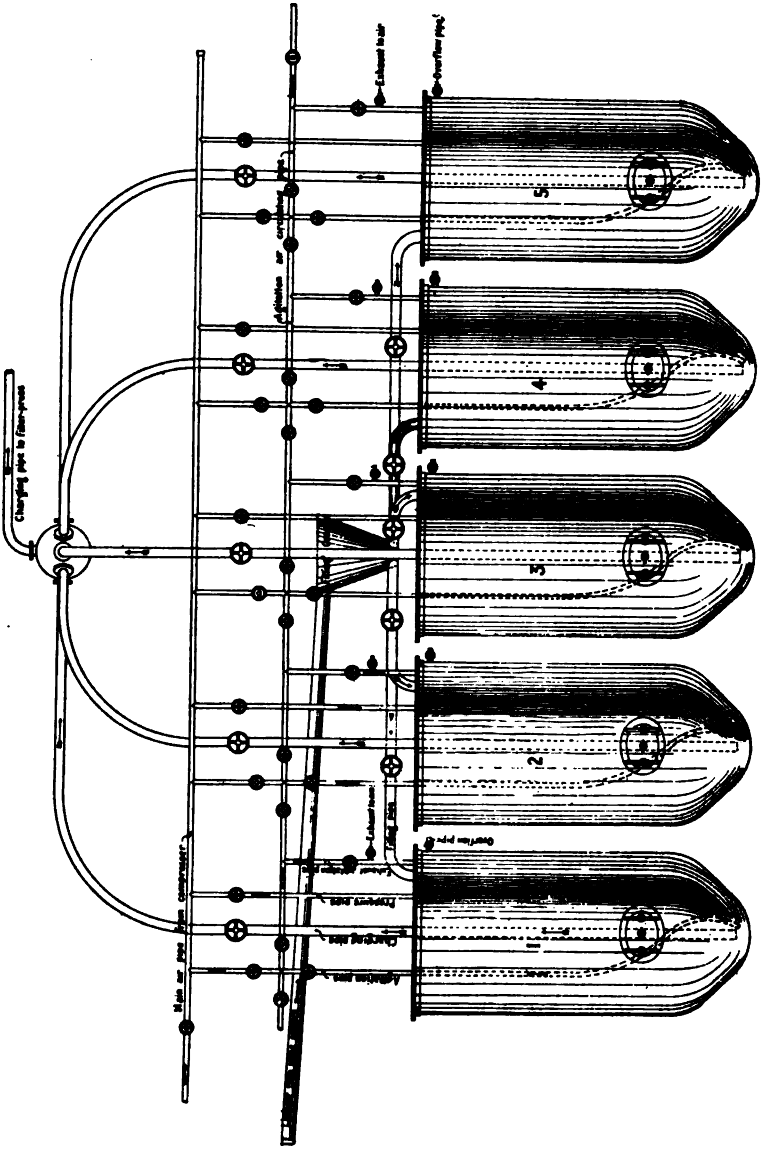
The disadvantages often urged against the use of compressed air for transmission purposes are its rather lower total efficiency as compared with electricity, the smaller flexibility of its pipes when compared with the electrical conductors, and the greater cost of these. On the other hand, besides the special advantages which have been mentioned in using compressed air there is no fear of a combustible and explosive atmosphere being ignited by sparking, as is the case where electric motors are used. This remark applies more especially to the cases where electricity is used for transmitting power to the workings of coal mines and where the air may be heavily charged with the inflammable fire damp. Various devices are employed to render the danger of such ignitions and explosions as remote as possible by inclosing the motors in air-tight casings or allowing them to work in an immediate atmosphere of carbon dioxide, and the increasing use of alternate current motors will largely conduce to the required end. But at the same time it must not be forgotten that where there is an electric current there must always be danger, because whenever the circuit is broken there is a spark of some kind produced, and where conductors are exposed to the rough conditions which are to be found in a coal mine there must always be a possibility of sparking, if not so much from the motors, but from accidental injuries happening to the conductors themselves.

It seems not altogether fair to compare compressed air and electricity as means for transmitting power on general lines, because the conditions which suit one will probably not be those which are most suitable for the other. There are some classes of machinery which are far better driven by compressed air than by electric motors, and there are cases where it is undoubtedly better to employ electricity. The mere fact that the use of electricity for power transmission is making such large strides and at the same time the use of compressed air has not received a check, but is rapidly widening year by year, only goes to show that there is plenty of room for both, each in its own particular sphere. The only thing about which there is any difficulty is in deciding which is the more suitable in a particular instance which admits of the employment of either one or the other.

Cyanidation at the Kalgurli Mine, Kalgoorlie.*

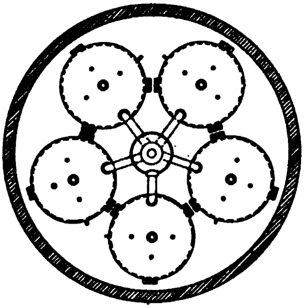
Air-lifts.—Air-lifts are sometimes alluded to in technical works as air-lift pumps, but while they do the work of pumps, they are not pumps, because they have no working parts, and for all practical purposes no wearing parts either.

* Abstract of paper by Mr. Edwin O. Watt in the Transactions of the Australasian Institute of Mining Engineers, as published by the *Engineering and Mining Journal.*

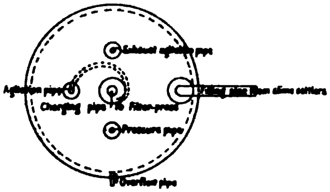


PNEUMATIC AGITATION AND FILTER-PRESS PRESSURE TANKS.

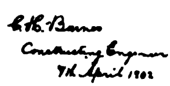
Air-lifts have been working under various conditions on the Kalgurli and Hainault mines, Kalgoorlie, W. Australia, for about twelve months. At present there are on the Kalgurli mine, in addition to the miniature lifts attached to the sand-vats, which are very small and inexpensive to work, two 8-inch and one 6-inch lifts in constant work, and on the Hainault mine one 6-inch lift taking away the products



Suggested Arrangement of Five Tanks.



— Plan of Top of Tank. —



from a 10-stamp battery, but now being used only when the sand-pump is under repair. Nearly all the ore reduction works on the field are using one or more of them.

Amongst metallurgists and authorities on the field it is pretty unanimously acknowledged that, although they possess many advantages over a pump, they have proved rather expensive to work. Their efficiency on the actual steam power generated at the boilers is small; certainly not greater than has been estimated by Mr. Archibald, who introduced them into the district.

Pneumatic Agitators.—On the Kalgoorlie field the usual practice for the treatment of auriferous slime is to stir it with cyanide or bromo-cyanide solutions in steel vats with mechanical agitators for a period of from sixteen to twenty-four hours, afterwards charging it into pressure-tanks and thence to filter-presses. On the larger mines there are two exceptions to this rule, viz., on the Golden Horseshoe mine, where the slime is pumped direct into filter-presses, and cyanide solutions are afterwards pumped through at high pressure, and on the Kalgurli mine, where the slime is agitated by compressed air for three hours. It is with the latter process I wish to deal. The advisability of introducing oxygen in some form to the solutions during cyanidation is generally recognized by all metallurgists and cyaniders. and many experiments have been made of late years with the object of obtaining a cheap and reliable method of accomplishing this end. About twelve months ago experiments were started on the Kalgurli mine with the object of determining whether or not the pressure-tanks for the charging of the filter-presses could not also be utilized with advantage as pneumatic agitators. It had been previously noted that when slime was allowed to stand in the pressure-tank and compressed air was allowed to flow through the pulp to prevent its settling, a higher percentage of gold was extracted from the slime thus treated than if it were allowed to pass directly through from the mechanical agitators to the filter-presses. Slime pulp, previously untreated by cyanide, was then allowed to run into the pressure-tanks, where cyanide solution was added, and the whole pulp gently agitated by a stream of air for five hours. Some idea of the amount of air being used for this purpose may be formed when I say that it was about as much as would be blown from a good blacksmith's bellows. It was found that after five hours' treatment in this way the extraction of the gold contents was about 5 per cent. higher than when the slime was agitated by mechanical stirring for twenty-four hours, and that the cyanide solution came away 35 per cent.

richer in available cyanide than was the case after stirring. The time of agitation was then reduced to three hours, and an equally good gold extraction was obtained with a somewhat smaller consumption of cyanide. After two hours' agitation the gold extraction was not so good, but further experiments showed that an equally good result could be obtained in two hours when a larger volume of air was allowed to pass through the slime. A sample of concentrated sand was then treated in the same way. Before treatment 87 per cent. of this sample remained on a screen of 110 holes to the linear inch, and the gold contents were equal to 4 oz. 17 dwt. per ton. After three hours' treatment only 34.7 per cent. of the sample remained on the same screen, and the residues assayed under 3 dwt. per ton, thus showing that in three hours 32.3 per cent. of the sand had been reduced to slime, and a gold extraction equal to nearly 97 per cent. had been obtained. The exhaust air from the treatment of this sample came away warm in consequence of the friction generated by the sand particles grinding against each other. Subsequent grading analysis showed that this grinding action was always very marked when the pulp contained a large proportion of sand, but that, when fine separated slime was under treatment, there was only a slight diminution in the size of the particles, and under these circumstances the air came away cool. All these experiments were made on roasted sulpho-telluride ore. Experiments made with unroasted sulpho-telluride ore and potassium cyanide solutions did not give an extraction equal in any case to 60 per cent. of the gold contents. The results, however, proved so satisfactory that it was decided to continue to work the process. The exhausting air smelt so strongly of cyanogen that it was realized that a still greater saving of cyanide might be effected by passing the air through a series of pressure-tanks, instead of allowing it to exhaust direct through the atmosphere. On the treatment works there were only two pressure-tanks, and it was decided to install a set of five, using the same stream of air for the series. Some alterations were made in the design of the pressure-tanks, and the necessary pipes were attached to convey the air in a continuous stream through the pulp in each tank. The diagram on page 2595 shows the arrangement by which the combined pneumatic agitators and filter-press pressure-tanks are being worked at present on the Kalgurli mine. For the sake of clearness of illustration the set is shown in a straight line, but they are really being worked in a circular pit. Each agitator is 6 feet 6 inches in diameter and 13 feet 6 inches deep, and is usually charged with about 6 tons of slime in a cyanide solution of 0.10 per cent. of available potassium cyanide. After agitating for three hours the circulating air is shut off and the high pressure air is turned on to the top of the pulp. This drives the slime up the filter-press charging pipe into filter-presses, where, as previously explained, the auriferous cyanide solutions are recovered from the pulp. After discharging the slime from the agitators the tank remains full of compressed air at a pressure of about 30 lbs. per square inch. Instead of being allowed to blow into the atmosphere, as is usual under these circumstances, the air is used for discharging another agitator, or is allowed to circulate for agitation until it falls below the pressure required for that purpose. The air pressure required to agitate one agitator is about 3¼ lbs. per square inch, and for five agitators about 22 lbs., but this pressure varies slightly, according to the consistency of the pulp.

For charging filter-presses it is not convenient to work with an air pressure much under 30 lbs. per square inch, for, although it was found that a pressure of 10 lbs. would charge a 5-ton filter-press full, it took nearly an hour to do it, whereas a pressure of 30 lbs. per square inch will charge a 5-ton press in ten minutes. An experiment made with the present set of five pneumatic agitators may prove of interest to metallurgists. The agitators were charged with approximately 6 tons of ordinary slime in a solution of 0.10 per cent. of available potassium cyanide, and the usual stream of air was passed through for three hours. A sample of the solution was then taken from each agitator. No. 1 agitator, which first received the air, indicated .060 per cent.; No. 2, .100 per cent.; No. 3, .115 per cent.; No. 4, .115 per cent., and No. 5, from which the air exhausted into the atmosphere, .060 per cent. of available potassium cyanide.

This experiment showed that in two of the series there was an actual increase in the amount of cyanogen in the solution, due to the volatile cyanogen passing over from the preceding agitators. The results of this experiment have been confirmed by other tests made on the Kalgurli mine and by laboratory tests made on other mines on the fields. When the Kalgurli mine agitated the slimes by mechanical stirrers for twenty-four hours it cost about 2¼ lbs. of potassium cyanide per ton to obtain a good extraction. With the present pneumatic agitators the consumption of potassium cyanide has fallen to about 1 lb. per ton, and the extractions are better.

The composition of the ore is practically the same, and the consumption of potassium cyanide on the separated sands has not varied. While I am of the opinion that the introduction of compressed air to the pulp in this way is beneficial in consequence of the fact that it oxidizes the cyanide solutions, I think that the beneficial action is more largely due to mechanical than to chemical causes, as instanced by the great attrition that takes place by the ore particles rubbing against each other, especially when these particles are not already in a very fine state of division. By reference to the diagram it will be seen that the agitation pipe is peculiarly bent, so as to give a violent rotary movement to the pulp. This, combined with the action caused by the surging of the air through the material, causes the particles to rub heavily against each other; the larger particles are thus worn away and the gold is cleaned and burnished, and thus rendered readily amenable to dissolution in cyanide solutions. This process of agitation has now been at work in the Kalgurli mine for ten months, and has been subjected to severe tests and has not failed. Its originality consists only in the method by which the air is admitted and used. The number of pipes and valves over the agitators appears at first glance somewhat complicated, but in actual practice it has not been found to be so, and the management have not experienced any difficulty in getting the attendants to understand the arrangements after a few minutes' explanation. No time has been lost by any fault of the arrangement, and no part of the plant has shown any perceptible wear.

New Pneumatic Devices.

With the rapid growth of the compressed air appliances, commonly known as pneumatic tools, the various manufacturers of these tools are constantly

CHICAGO PLUG DRILL.

developing new or improved types and enlarging the general scope of the old ones. The Chicago Pneumatic Tool Company, of Chicago, has recently placed three devices on the market, a description of each of which may be interesting to those who are keeping in touch with the development of this branch of compressed air machinery. The Chicago plug drill, as shown in the accompanying illustration, consists of an arrangement whereby a regular Boyer hammer is equipped with a drill and a rotating device. In construction it is simple. It consumes 20 cubic feet of free air per minute at 80 pounds pressure and, it is claimed, will drill a hole ⅝ of an inch in diameter by 3 inches deep in any kind of stone. It is used in all classes of plug and feather work and is said to be a practical machine for either top or side

CHICAGO AIR FORGE.

line work. Its weight, 18 pounds complete, makes it necessary for the operator to use only one hand.

Another new comer is the Chicago air forge, which differs from others manufactured by that company in that it is an air blast-forge for coal or coke, instead of using oil as fuel. The hose connection through which the air enters the forge is a ¼-inch standard pipe connection. The air, passing through a 1-16-inch needle valve jet, forces the fan to revolve rapidly and as the fan is open to the outer air, the blast of free air is continually blown upon the fire. It operates with an air pressure of from 60 to 100 pounds, and consumes approximately from 5 to 7 cubic feet of free air per minute. It is 3 feet high over all, and

CHICAGO SAND RAMMER.

the pan or fire box is 20 inches in diameter by 10 inches deep. The forge weighs 114 pounds complete.

Another new device is the Chicago sand rammer, which is shown in one of the accompanying illustrations. The chief advantages claimed for it are its light weight, 17 pounds, and the fact that this machine can be operated by a man standing up, thereby eliminating the necessity of continually bending over. It has a piston 1 1-16 inches in diameter and 7-inch stroke. It uses 30 cubic feet of free air per minute, and is claimed to give 500 blows in that space of time.

Portable Pneumatic Cranes.

No modern railway shop or terminal station is complete these days without a compressor plant. The great increase in the number of labor saving devices operated by compressed air has made this form of power transmission one of considerable importance to establishments of this nature. Particularly is it valuable where there is much loading and unloading to be done, and where considerable material of weight must be handled from any point within a considerable radius. The pneumatic cranes, particularly the portable ones, figure prominently under such conditions. Through the courtesy of the Garry Iron and Steel Company, of Cleveland, Ohio, we are enabled to publish illustrations of several of this company's pneumatic cranes which are now in active use. A description of a revolving crane manufactured by this company was published in the June issue of COMPRESSED AIR.

The smaller crane, shown in Figure 1, can be operated by either air or steam, and is mounted on a flat car, has a capacity of 1,000 lbs., a reach of 7 feet, and a lift of 12 feet 6 inches. This crane can also be mounted on a hand truck for convenience in moving it about in the storeroom or warehouse. On a separate platform, Figure 2 shows a crane of larger capacity, 4,000 pounds, used at the Collinwood shops of the Lake Shore & Michigan Southern Railway. This particular one is mounted on a hand truck, but, like the other, it can be placed on a standard car. This form of crane is mounted on a turn table.

FIGURE 1.

The air cylinder which operates the hoist sets on an incline and is securely fastened to the turn table as well as to the boom. The operating valve for this cylinder is of special design. It is so arranged that the volume of air is exhausted from one end of the cylinder to the other, or, in other words, when lifting the load the air, being at the front side of the piston, is exhausted through the valve to the other side of the piston, and the same volume of air is used for pressure behind the piston to lower the hook. The body of the valve is heavy cast iron, while the valve proper is of brass, tapered and ground to fit, and held in position by a Helican spring.

The boom is composed of heavy channels stiffened by top truss rods. The hoisting cable is usually made for a 12 feet 6 inches lift. The top of the turn table is one casting, to which is attached the operating valve, and also has a lug projecting downward, which engages with the buffer stop on the turn table base. The turn table carries the buffer stop, which consists of special castings, rigidly connected with the base, arranged with a buffer compression spring to lessen the work due to the inertia of the crane and load when completing its revolutions. To the top of the turn table is attached a pinion, securely bolted to it and passing over the pivot, which is secured to the turn table base. The air applied passes through pipes in this pivot, the connections from the pivot pipes being of hose in connection with a Moran flexible joint, thus permitting the operator to stand on the top of the turn table and govern all movements of the crane without changing his position.

FIGURE 2.

The cylinders for revolving the crane are attached to the turn table base back of the cylinder head, and held to the cylinder by guys is the moving rack attached to the piston rod, the top of the rack being additionally separated by a rack guide, which in turn is bolted to the crane base. This rack engages with the pinion which is bolted to the top turn table, and, by admitting air to the rack cylinders, the turn table top is revolved in one direction. Naturally the stop comes in contact with the buffer on the turn table base, which occurs just before the piston has reached the end of its stroke. By admitting air to the opposite end of the cylinder the movement of the crane is reversed. In the crane already described, the hoisting cylinder is 21 inches in diameter and the racking cylinders 10 inches in diameter.

Either air or steam can be used for hoisting the load, revolving the crane and working the brake, and in special cases can be used for driving the crane and car along the track. The crane does not carry a storage reservoir, but can be connected either with an air line in the yard, or with a crane pipe line on the locomotive tender. These cranes are designed for an air pressure of 80 pounds per square inch.

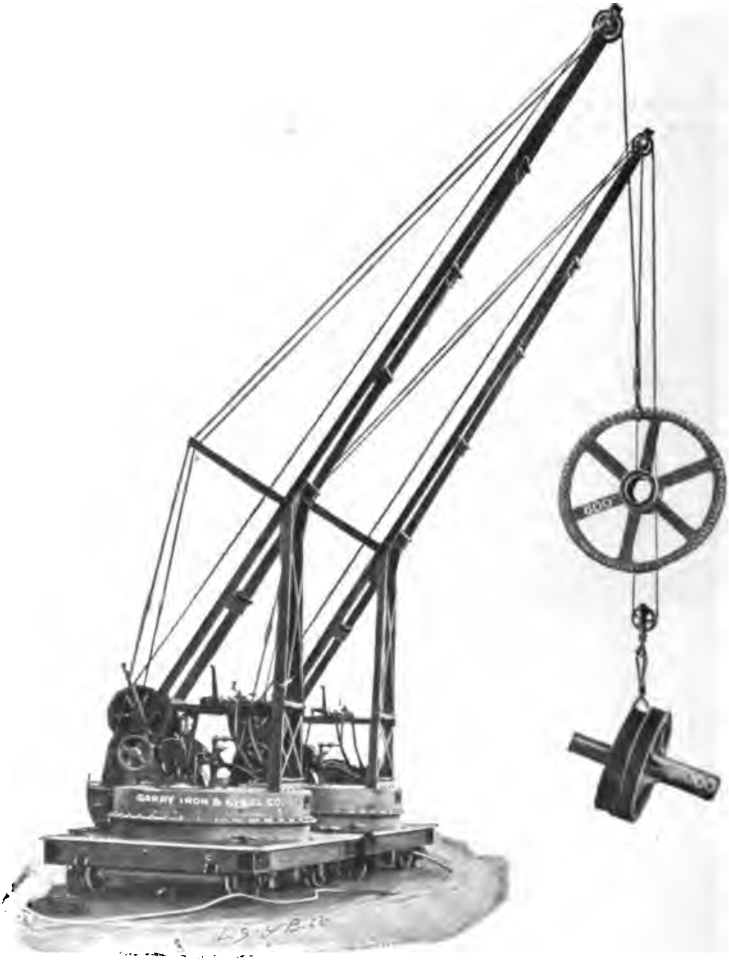


FIGURE 3.

More elaborate still is the pneumatic

crane shown in Figure 3, which has a reach of 12 feet with a height of boom suitable for a hook lift of 25 feet above the top of the rail or with sufficient cable to give a hook lift of 100 feet for use in building and excavating. The load is hoisted by a pneumatic motor, geared to a drill, thus maintaining the hook lift by the length of a cable. This crane is also revolved by pneumatic power.

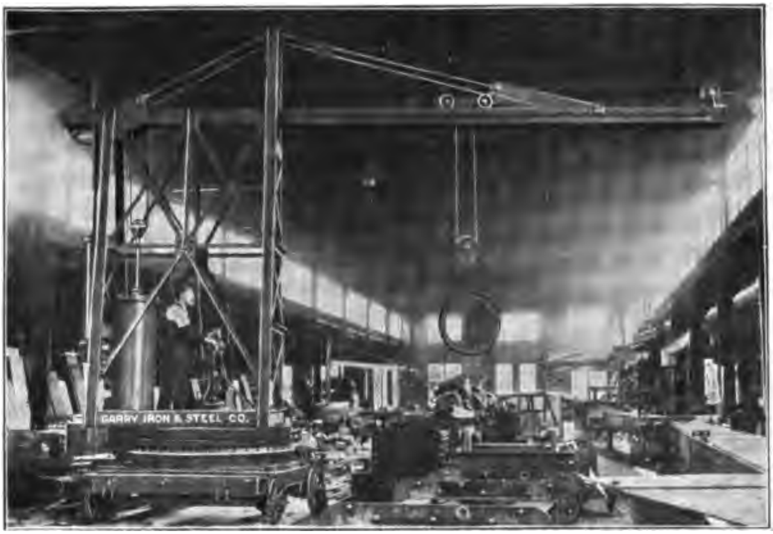


FIGURE 4.

Of a different type is the crane shown in Figure 4, which is mounted on turn table and car, and is for use in shops loading and unloading material where a variable reach is necessary. The crane is revolved, the load hoisted, and the trolley run in and out by air pressure.

Electrically Driven Compressors.

While compressed air and electricity are frequently considered as rival forces, yet, as a matter of fact, they are found more and more frequently together as allies rather than as rivals. The electrical driven compressor is by no means new and the field for this form of compressor seems to be constantly growing. The Christensen Engineering Company is now manufacturing a line of these motor driven compressors, ranging in capacity from 4 to 1,000 cubic feet of free air per minute. The smaller sizes are made for portable as well as stationary service.

In the Christensen machines the electric motor and the compressors have been designed to form a compact self contained unit. The air is compressed in the cylinder by a double acting piston, which is operated by means of a connecting rod and steel crank shaft. The latter is mounted in bearings located within the frame of the machine. This shaft carries on the motor end a helican gear, which is driven by a pinion on the armature shaft of the motor. The gear and pinion are of the helican herring bone type with teeth cut by special machinery. It is claimed for them that they are almost noiseless.

The gear and the crank chamber are connected to form an enclosure, which is partly filled with oil, with which all the working parts, including the air cylinder, are automatically lubricated. The gear and the pinion operate continuously in the oil bath. The machine, it is said, will remain lubricated as long as the oil is kept up to the level determined by the filling block on the side of the crank chamber. Either an alternating or continuous current may be used in the electric motor. The lower frame of the motor is of cast iron and the entire machine is mounted on a cast iron base. The design of the motor in the compressor is such that, it is claimed, every part can be easily and quickly reached.

An automatic governor is designed to start and stop the motor compressor at the desired minimum and maximum pressure. This governor consists of an ordinary pressure gauge mechanism, with a special hand, which, upon coming in contact with the conducting stud at the position of minimum pressure, allows the current to flow through a magnet coil. This coil operates a plunger to which the contact pieces for the motor circuit are attached, thereby closing the circuit and starting the motor. As soon as the pressure reaches the desired maximum, the end strikes another stud and the current passes through a second solenoid magnet, thereby pulling the plunger in another direction and opening the motor circuit.

For portable service the Christensen Company mounts one of its electric driven compressors with automatic governor and an air receiver on a suitable hand truck, which can be moved wherever necessary. This portable outfit is useful wherever pneumatic tools or other compressed air appliances are used and an expensive system of piping is not desirable. In these cases the compressor is taken to the work instead of transmitting the compressed air from a stationary compressor at a distance. These compressors were sometimes mounted on a wagon and transported by horse for use in drilling and bonding rails in electric railway or other work where electric power can be obtained. It is only necessary to make a connection to a trolley wire by means of a hook or pole for the purpose of obtaining power for the motor. For similar kinds of work the compressor is sometimes mounted on a car which runs on rails.

Electro-Pneumatic Inter-Locking at Solvay, N. Y.

The New York Central & Hudson River Railroad has recently installed and put in service an electro-pneumatic interlocking to protect the junction of the Auburn Branch and the West Shore connection with the main line at Solvay, N. Y. The connecting track between the West Shore and the New York Central being 2,200 feet long two towers have been put in and one power-house is used to furnish compressed air for both interlocking plants. The interlocking machine in tower No. 2 controls the switches and signals of the New York Central plant and is provided with 30 working levers and five spare spaces. Fourteen levers are used to control 29 switches and four pairs of movable point frogs and 16 levers to work 37 signals. Tower No. 1 at the junction of the connecting track with the West Shore main line has an 11-lever machine with six working levers and five spare spaces. The small number of levers required for the functions controlled is one of the chief advantages of the electro-pneumatic machine. With a mechanical machine a lever is usually required for each switch or signal operated in order not to put too great a load on the connections, but with the electro-pneumatic as many switches can be worked by a lever as will permit of the proper routes being set and the signal levers, in addition to selecting between the arms of a route signal, can be used to control the arms of a signal reading in the opposite direction. When turned to the right a lever may be made to work one signal and another when turned to the left.

There is no direct interlocking between the machines in the two towers, but protection for traffic over the single-track connection from the New York Central main line track No. 4 to the West Shore road is secured by means of the Union lock and block system, which is interworked with the electro-pneumatic machines and effectively prevents the display of a clear signal from one tower over this route should permission have been granted from this tower for the clearing of signals at the other for this movement. The Union lock and block system also applies on the main line tracks 1, 2, 3 and 4 of the New York Central for the control of trains entering the block on either side of the towers. Track circuits are used to control all main line signals. The signals governing these protected tracks are semi-automatic and remain in the stop position whenever the track is occupied.

The apparatus used is the electro-pneumatic manufactured and installed by the Union Switch & Signal Company under the supervision of Mr. P. G. Ten Eyck, signal engineer of the railroad company. The power-house, which was furnished complete by the railroad, is located just east of tower No. 2 and contains a repair room in addition to the air compressing plant. Two sets of equipment are provided, so that if one should fail the other may be used to furnish the necessary power to run the plants. One set is operated by means of an electric current from the lighting plant of the city of Syracuse, and consists of a Western Electric 15-horse-power, 220-volt, 40-ampere, 60-cycle motor directly geared to an air compressor. To charge the storage batteries furnishing current for the electro-pneumatic machines, a Holtz-Cabot 1-horse-power motor dynamo is used which transforms the city voltage of 220 to 20 volts. Two sets of storage batteries with seven cells of 120 A. H. chloride accumulator type in each set are used, one set being charged while the other is discharging.

The equipment intended for use in case the city supply should fail consists of a Fairbanks-Morse 20-horse-power gas engine, which is belted to an air compressor made by the Rand Drill Company. Connected to the gas engine is a 110-volt dynamo, which, in case of emergency, is used to generate electricity for lighting the signals in addition to charging the storage batteries.

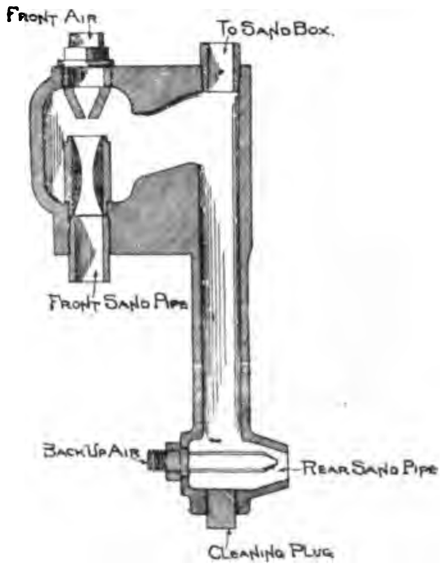
For cooling the compressed air a manifold condenser having 58 square feet and an intercooler with 200 square feet of surface have been provided. The running water used to cool the cylinder and air passing through the intercooler is stored in a 6 by 12 feet cooling tank and used over and over again. The air storage tank measures 5 by 10 feet.

The signal lamps are lighted by two 4-candle-power lamps, connected in parallel on a 110-volt circuit and placed in tandem in the center of the lens so that if one lamp goes out the other will furnish light. The main feed wires to the signals are run on poles and have waterproof insulation. The connection between the mains and the signal lamps is made by twin lead-covered wires run in an iron conduit.

The wires carrying the current to operate the switches and signals of the plant are in cables and as far as possible are run in trunking and buried in the ground. The electro-pneumatic magnets controlling switches have a resistance of 130 ohms and for signals 420 ohms. The relays for track circuits are the Union Company's universal type, with 5 ohms resistance. The signal poles are of iron, with the connections inside of the mast. The main posts of the bracket poles are of channel iron and lattice construction. Galvanized pipe has been used for all air supply, the mains being 2 inches and the branches ¾ inch and covered with wooden conduit.—*Railway Age.*

Pneumatic Track Sander.

J. H. Waters, assistant master mechanic of the Georgia Railroad, has invented a pneumatic track sander, which has been



PNEUMATIC TRACK SANDER.

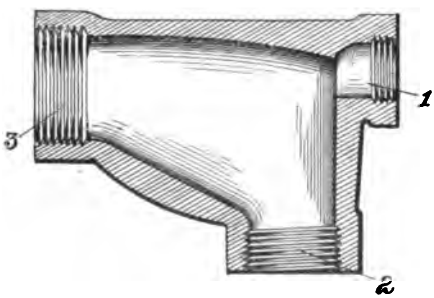
since placed on the market, and is used, it is said, with considerable success by a number of railroads in the South.

The accompanying illustration shows this double convertible sander, which is so arranged that a gravity feed may be used in case of failure of the air system. There is a combination of two ejectors, one vertical, for forward sanding, the other horizontal, for backward sanding, both being fed from a single pipe to the sand box. The back-up ejector is separated from the other and dropped below the running board so that the air jet can be removed when necessary to clean it out without disconnecting the pipe.

The upper or forward ejector can be located at any point above the running board, preferably close to the sand box. The air jet to the latter is contained in the cleaning plug, and, it is claimed, is easily removed to clear any obstruction. The sand blast for forward sanding is all on a loose tube, which can be renewed at a small cost. It is claimed for this arrangement that it takes care of the ejector case entirely, so there is no wear on it. An ordinary wrench is all that is necessary to take care of the sander. It can be emptied through the forward pipe without allowing any of the refuse to get on the engine machinery.

A Pneumatic Siphon.

Among the recent inventions which have served to bring out the further use for compressed air in the foundry is that



PNEUMATIC SIPHON.

of Andrew J. Weekley, of East Pittsburg, Pa. He has patented a pneumatic siphon to remove the sand, filings and scales from difficult recesses and spaces within iron molds and the like. He claims to have perfected a siphon that will rapidly remove the refuse without clogging or otherwise obstructing the passage, and that while extremely simple, strong, durable and comparatively inexpensive to manufacture, it is highly efficient in its use.

Molders have experienced considerable trouble in removing the refuse matter from small recesses in the castings. The undesirable material is generally loosened by means of a rod and is then ready to be drawn through the suction pipe. Mr. Weekley's invention regulates the passage of the compressed air which causes the suction. The accompanying cut, which shows a sectional view of the body of the siphon, illustrates the peculiar arrangement whereby Mr. Weekley claims to overcome any clogging or obstruction. He says that any lumps or other bodies of solid material will pass readily through it, since they are not required to make a turn in the chamber at direct right angles to the air inlet pipe.

In this illustration, 1 is the inlet or suction pipe which has its inner board downwardly deflected; 2 is the air inlet pipe, and 3 the discharge pipe.

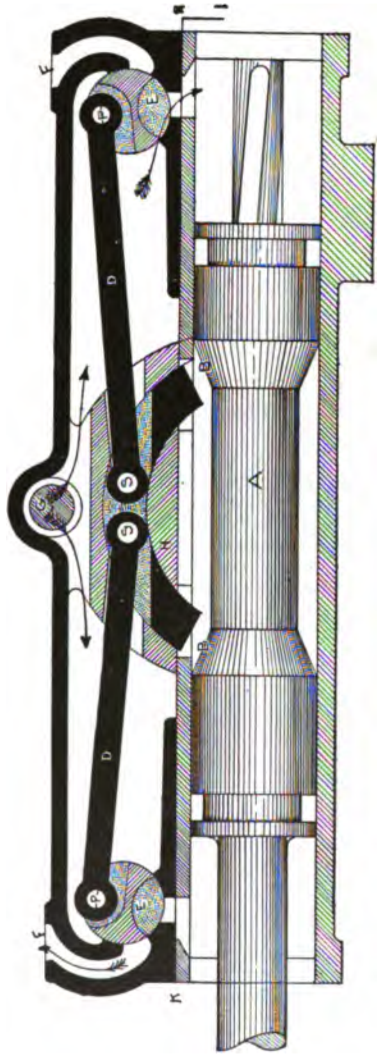
Cleaning Air by Washing Instead of Filtering.

It has been demonstrated that much the larger share of trouble caused by imperfect contacts in switchboard connections in telephone exchanges can be prevented by proper ventilation of the operating rooms, and that implies thorough cleansing of the air entering them. Many experiments have been tried in the way of dry-cleaning by filtering through screens of wire and cheese-cloth or cotton-batting, but all such devices require frequent renewal. sometimes at considerable trouble and expense. By continued use any filter of this character must deteriorate and eventually become clogged, and in order to avoid the results of neglect it ought to be practically automatic. This point is essential in an air-cleaning system. In the case of one large telephone company very satisfactory results have been obtained by passing the air supply through a fine spray of water and afterward precipitating the moisture with the collected impurities and discharging it into the sewer. The water, which is taken up at high velocity and held in mechanical suspension, is extracted by centrifugal force by passing it through a series of tubes in which spirals are so placed as to give the air a whirling motion, causing the suspended particles, which are heavier than the air, to be thrown outward and brought in contact with the tubes, from which they flow through perforations to a drip-pan below. The washing process imparts about 70 per cent. humidity at a temperature of 70 degrees Fahr. in the operating room. This is considered the most desirable for health and comfort and avoids the excessive dryness sometimes resulting from other systems of heating and ventilating. Moreover, in summer time, with the temperature outside at 80 degrees Fahr. and with the normal temperature of the city water, the air delivered to the rooms can be readily reduced to 70 degrees. This is a supplementary advantage which must appeal at once to sufferers from extreme summer temperatures everywhere, and with the growing knowledge that such an advantage is available will undoubtedly come the insistence that buildings should be kept cool in one season as well as warm in another.—*Cassier's Magazine* for September.

The Torpedo Baby Drill.

The Torpedo baby drill is the latest of that type of rock drill to make its appearance on the market. It is controlled by the Rix Compressed Air Drill Co., of San Francisco. It is similar to the North Star baby drill with the exception of the piston valve chest and cylinder, which are designed with the idea of accomplishing more work. By its construction it is claimed that this drill will give more than 100 blows per minute in excess of any other drill of that type. With its increased speed it is claimed that it will strike harder and that the repairs will be less. The new valve motion will run at full speed, it is said, on any stroke from 2 inches to the full stroke of 5 inches. Reference to the accompanying cut will make the construction and operation of this drill easily understood.

A is the piston which impinges on a circular rocker operating within the Torpedo valve chest which is bolted to the cylinder on the line *KK*. The circular rocker is held in position by the



THE TORPEDO BABY DRILL.

bronze guide *H*, which is removable. Attached to the rocker by the pins *SS* are two valve rods *DD* which are attached to the circular valves *EE* by the pins *PP*. These circular valves *EE* are Corliss valves which fit within steel bushings. The inclined surfaces *BB* on the piston, coming in contact with the ends of the rocker, slide the rocker in its seat, and cause the valve to open and close. In this drill the ports are 7-16 of an inch wide by 1⅛ inches long, just about twice the opening used in the ordinary baby drill. The movement of the rocker is simple and always in the direction of the motion of the piston. The air is admitted into the valve chest at the opening *G*, and when the valve is open it passes through the ports, which are about half an inch deep, into the drill at either end. The exhaust is at the ports *F* and *F* on each end of the drill. The valve rods *D* are made of tool steel.

This valve system is the invention of Mr. A. D. Foote, superintendent of the North Star Mines, Grass Valley, Cal.

Miners' Phthisis.*

Applying the term miners' phthisis to the deeply pigmented and somewhat solid state of lung found in miners who during life have exhibited signs and symptoms of pulmonary disease of a more or less chronic character, Dr. Oliver said that, while the malady had generally been regarded as the result of breathing a dust-laden atmosphere, it was much less common now than fifty or sixty years ago. This circumstance he attributed to the improved system of ventilation of our coal-pits. Miners' phthisis as a morbid entity has been known since 1703, when Ramazzini drew attention to it. In 1860 Peacock proved microscopically and chemically the identity of the particles of dust found in the lungs with the dust of the atmosphere in which the patient had worked during life. There was sufficient evidence to show that pneumokoniosis was a dust disease and due to occupation, also that the phthisis bore a distinct relation to the form and character of the dust inhaled, for, as Hirt had shown, in each hundred workmen suffering from pulmonary consumption caused by dust, metallic dust was responsible for 28 per cent. of the cases, mineral dust for 25·2 per cent., animal dust for 20·8, and vegetable dust for 13·3 per cent.

There are two ways by which the pathology of miners' phthisis could be studied. (1) Pathological inquiry in man, and (2) physiological experimentation in animals. The dust that is inhaled under ordinary circumstances gets caught on the nasal, pharyngeal and laryngeal mucous membranes. Should particles of dust reach the trachea and bronchi, they become entangled in the mucus secreted by the tubes, and are either wafted outwards by ciliary motion, or are coughed up. This barrier apparently becomes broken, for as life proceeds the lungs of all persons, of town dwellers especially, become more or less pigmented. Discoloration of the lung is quite consistent with health. There must be, therefore, something superadded to the pigmentation to cause the lungs to become pathological. When particles of dust reach the pulmonary alveoli Dr. Oliver showed that while the amount of local reaction was determined by the form and character of the dust particles, there were present in the alveoli large wandering cells which were distinctly phagocytic in their nature. By these cells particles of coal dust were swallowed and transported into the plasma spaces of the alveolar wall and into the lymphatics, by means of which they were carried to the bronchial glands. The pulmonary lymphatics run under the pleura, in the interlobular septa and on the walls of the blood-vessels and small bronchi.

Dr. Oliver exhibited drawings of microscopical sections of lung taken from a Transvaal gold miner, whom he had seen in consultation with Dr. Dodds, of Cramlington. In the lung, in addition to marked fibrosis, there can be seen large cells filled with black granules, some of which have wandered outside the alveoli. These cells disintegrate and liberate the black particles. Newly-formed fibrous tissue can be seen interpenetrating itself between these large cells. To Dr. Oliver pneumokoniosis is not a tuberculous disease. Tubercle is often met with in miners' phthisis, but when present it is an accidental and, therefore, a secondary infection.

Speaking of the causation and experimental production of anthracosis, Dr. Oliver eliminated the gases liberated by the coal, and those formed as a result of the explosives used in the mine, as playing any part in pneumokoniosis. Claisse and Joués' experiments upon animals that

*Synopsis of an address by Thomas Oliver, M. D., F. R. C. P., physician to the Royal Infirmary, Newcastle upon Tyne; introductory to a discussion at the Swansea meeting of the British Medical Association, July, 1908.

had inhaled the smoke from burning lamps were alluded to, in so far as confirming the previous statement, viz., that the lungs could become deeply pigmented and yet health be maintained and no pathological alteration occur in the lung tissue. Trotter, of Bedlington, looks upon anthracosis as an epiphenomenon in pulmonary disease, and attributes the fibrosis not so much to the coal itself as to the accompanying particles of stone from the sandstone strata and seggar clay, etc.

The most important point is how far miners' phthisis is or is not a tuberculous lesion. One of the strongest advocates of the tuberculosis theory of anthracosis is Dr. Tripier, of Lyons—to him tubercle is not a coincidence nor a secondary infection, but the principal cause of pneumokoniosis. Since Koch discovered the tubercle bacillus there has been little written upon the subject of miners' phthisis. One of Tripier's patients was a miner who had worked for fifteen years in the Mont Cenis and St. Gothard tunnels. The construction of both these tunnels was attended by a great loss of human and equine life. Many of the miners died from pulmonary disease and from anæmia due to ankylostomiasis. The tunnelling of the Simplon, which is going on at present, has been conducted with a remarkable freedom from tuberculous lung disease—a circumstance which is attributed by Dr. Volante, of Iselle, to the excellent system of ventilation that prevails. There is plenty of smoke in the tunnel and the air is fouled by the respiration from the men and horses, but as the perforation of the rock is accomplished by machine drills under hydraulic pressure, and water is automatically sprinkled on the debris at the time of the drilling, there is no dust, and to this circumstance is largely due the remarkable absence of lung disease among the miners.

After renewed allusion to the part played by phagocytes in conjunction with dust in causing pneumokoniosis, Dr. Oliver summarized his conclusions thus:

1. Miners' phthisis is not caused by the inhalation of any of the gases present in the mine.

2. In pneumokoniosis there may be not only excess of fibrous tissue, but even cavities and tubercle.

3. The disease is, however, non-tuberculous.

4. Accepting this view of the pathology of the disease, there is hope that by improved ventilation and by allaying the dust with water, miners' phthisis may still further be diminished.

Rock Drills.

It has been stated that the correct principle of successful rock drilling is to get a hole into the rock, of the right size, as rapidly as possible with the least hand labor, the amount of mechanical energy taking a secondary place.

There are two ways of drilling; one, the auger drill, which bores the rock; the other, the percussive drill, working by direct impact, that is, by striking repeatedly in the same spot, and by simply bruising or chipping away the rock. The Ingersoll-Sergeant people say that long and expensive experience has shown finally that a reciprocating, punching, or percussive drill is the best suited for drilling rock. The advantages of a power machine over hand labor in percussive drilling under most circumstances are obvious, and the essential features of a good rock drill are as follows:

First and foremost, the mechanical principle and construction must be perfect; there must be no hitches about it; it must always be ready to operate and be under the absolute control of the operator, so that a hard or light blow, either long or short, can be struck at his will.

It must be light, so as to be portable, easily erected and dismantled; compact, so that it can be used in restricted and out-of-the-way places; it must be made of exceptionally good materials, to insure durability of all its parts; it must not be complicated, and it must be made up of pieces so formed that they can be quickly removed, all being interchangeable; it must be so simple that its successful operation is readily mastered by the men at hand, and it must not have any parts which grit, exposure, or rough usage can seriously damage.—*Mines and Minerals.*

Pneumatic Ash-Handling Plant for the Chicago & Alton Ry.

At its yards in McKinley Park (formerly Brighton Park), Chicago, the Chicago & Alton Ry. has recently installed a plant for handling ashes dumped from locomotives which use the roundhouses at this point. The plant consists of pits in two tracks, with a loading track between; buckets running upon trucks in these pits, and a pneumatic crane spanning all three tracks. The arrangement is not entirely new, having been in use for some time by the Pennsylvania R. R.

Figure 1 is a view of one of the pits of the plant, with the buckets therein. Each bucket is carried upon a 4-wheel truck and sets in a rack attached to the truck. The trucks are run to position under the ash pans of the locomotives, and at convenient times are lifted by the pneumatic hoist and dumped into cars on the centre loading track. As the bucket is hoisted it is lifted off the truck, and when high enough to clear it is moved laterally to position over the cinder car, as shown in Figure 2. The bucket is dumped by hoisting it still further until arms attached to the interior of the two halves of the shells meet with a ring attached to the hoisting cylinder, which serves as a stop to trip the shells of the bucket. Figure 3 shows the bucket in the tripped position.

FIG. 1—PNEUMATIC ASH-HANDLING PLANT, CHICAGO & ALTON RY.

All of the movements necessary to the operation of the hoisting of the buckets and the lateral travel of the same are accomplished by means of compressed air apparatus. The main hoist is a simple cylinder with a piston lifting direct. The lateral travel of this hoist, to move the bucket to position over the cinder car, is accomplished by means of an air cylinder,

FIG. 2—PNEUMATIC ASH-HANDLING PLANT, CHICAGO & ALTON RY.

FIG. 3—DUMPING THE BUCKET.

wire rope and pulleys, the arrangement of which is quite clearly shown in the illustrations. At the left of the picture in Figures 1 and 2 may be seen the platform for the operator, who controls the movements of the plant by means of ordinary air cocks.—*Railway and Engineering Review.*

Cleaning by Compressed Air.

House cleaning by compressed air has proved as successful in England as in the United States. The patents for the methods of vacuum cleaning controlled in America by the General Compressed Air House Cleaning Company, of St. Louis, Mo., are used in England by the British Compressed Air Cleaning Company. This concern is reported to be operating with great success in England and in South Wales, and is said to be rapidly forming subsidiary patents through the Provinces. All the usual branches of house cleaning are cared for, and occasionally the English company departs from the beaten path and experiments in other lines. A description of such an experiment is reprinted from the Burton (England) *Mail* of August 6, 1893, as follows:

"An experiment is being tried at the extensive maltings of Messrs. L. and G. Meakin, Burton, which cannot fail to be watched with great interest by the brewers of Burton and the industries allied with the staple trade of the town. We refer to a system of 'kiln-pricking' by means of compressed air. To those whose business is connected with kilns and malting there is no need to relate the tedious way in which the kilns are pricked, but to the uninitiated it will be interesting to know a few details.

"Without use of any technicalities, we may say that a kiln is a large room, whose floor is composed of tiles, each a foot square, and each containing 720 small holes. On this floor is spread the malt. Fires are made in a room underneath, and the heat, rising up through these holes, accomplishes the kilning of the malt. In the course of the year these holes are bound to become clogged up by the minute particles of dust, inseparable from barley, as from everything else. So it becomes necessary for them to be cleaned out. In order to do this, perhaps 20 boys are turned into the kiln with prickers, which resemble nothing so much as a short stout needle fixed in a gimlet handle.

"The kiln we have in mind is one of 150 quarters capacity, and by extreme diligence the 20 lads might accomplish the "pricking" in a little under three weeks. Each hole has to be pricked separately, and it is quite likely that when the lads are working the pricker and about to clear the hole they will chip a portion of the tile, and if there are several bad chips in a tile a new one, costing about tenpence, is necessary. Such a system as this, at the best, is crude, but as it is the only system, maltsters have to do as well as they can and foot the bill.

"A short time ago Mr. Lewis Meakin was in London, and saw at work one of the British Compressed Air Cleaning Company's machines cleaning a club. Being struck with its simplicity and efficacy, and also the probability of superseding the present tiresome method of "kiln pricking" with advantage to all concerned, he arranged with Mr. F. L. Bronaugh, the managing director of the company, to bring the machine and other apparatus to Burton, to see if it would answer the purpose.

"It has proved of some use; indeed, the effect has been startling. There is really little to describe in the process, it is so remarkably simple. You observe in the yard of the malting a miniature furniture van, which is an engine. You hear the throb, throb, throb of the petrol-actuated machinery, and notice small hose-pipes going aloft to an upper story window. You trace these pipes to their end and see a huge cannister. From this emanate other diminutive hose-pipes; the ends of each are held by boys.

"You hear a tremendous hissing, as of escaping steam, but you see nothing, absolutely nothing, beyond the mere fact that these boys are moving the nozzles of the pipes backwards and forwards over each of the foot square tiles, across which a damp mop has previously been run to soften the dirt in the holes. "Where's the dirt?" you ask. That is blown clean through into the fire room below; anyway, it does not trouble the kiln any more.

"Now for a few comparative statements. Under the style which has obtained up to the present, a boy was 12 minutes, working hard, in cleaning one tile, with its 720 holes; with the compressed air he can do it in half a minute, with much less trouble to himself, and with much more cleanly effect.

"Under the old style the holes could not be thoroughly cleared, for there was bound to be some dust or dirt left clinging to the bottom edge of the holes. But with the force behind it of 140 lbs. pressure to the square inch, the accumulations of dirt are removed with a rapidity which is startling, and an effectiveness which is gratifying.

"It is computed that by this means a huge kiln, which it formerly took 20 boys three weeks to clean, can be cleansed by four or five boys in—at the most—a day and a half. Next, as to the cost! As this has only been tried as an experiment, Mr. Bronaugh cannot yet promise that it will be any less than under the other method. Certainly, he says, it will not be more, and very soon, when he has been able to make his calculations, he hopes to do the work at a cost which will be 25 per cent. less than the old style.

"This should insure the new method an appreciative reception in Burton, where there is considerable scope for the work of such a machine. Already, the engineers of many of the big breweries have seen the apparatus at work at Messrs. Meakin's maltings, and have expressed themselves as highly satisfied with it.

"We have said sufficient to show that the method under notice is immeasurably superior to the method which has been in vogue hitherto. The increased efficiency, a vast saving in time and substantial reduction in cost, is sure to bring the method into favor in Burton. Thanks must be accorded Mr. Meakin, who was so soon to recognize the possibility of its adaption to the purpose mentioned.

"The compressed air system was brought before the public for the purpose of cleaning carpets, draperies, chairs, walls, from dust without any of the usual tiresome preparation for 'spring cleaning' being made. The machine will gather up the dust from any material, and is in use at the Royal palaces. Mr. Bronaugh has received instructions to clean the large carpets at the offices of Bass, Ratcliff and Gretton, Ltd."

The Gas Turbine.

In connection with a discussion on the steam turbine at the Master Mechanics' Convention, at Saratoga, Prof. Hibbard, of Cornell University, announced that there were prospects of developments in the field of the gas turbine at the General Electric Company's works, Schenectady. A gentleman, who recently received an advanced degree at a Western university in virtue of a very thorough investigation on the subject of the gas turbine, is now in the employ of the General Electric Company, and the inference is that he will have at his disposal the extensive facilities of this company for conducting experiments that may eventually lead to a successful gas turbine. This gentleman is Mr. Sanford A. Moss, who has made a special study of the subject of gas turbines since 1898. He received the degree of Master of Science at the University of California, and has also studied at Cornell University, specializing upon the same subject —that of the gas turbine.

The great thermodynamic advantage of the steam turbine over the steam reciprocating engine is that there is no condensation and re-evaporation through contact with metal surfaces which are alternately heated and cooled. The only condensation in a steam turbine to amount to anything comes from the conversion of the energy of the steam into work. In the gas turbine there is, of course, no condensation to enter into the question, but there is an opportunity for another and more important gain through the abolition of the water jacket. It is a singular fact that the turbine is theoretically and probably practically capable of effecting a saving over the reciprocating engine, whether used with steam or with heated air, but because of entirely different reasons in each case.

It is well known that the efficiency of the gas engine depends mainly upon the degree of compression pressure attained in the working fluid. When operating upon the Otto cycle the gas and air are compressed to as great a pressure as practicable and then are exploded, giving a still higher pressure. This same process can be employed in connection with a gas turbine and has been advocated for that purpose. Under this plan the air and gas would be compressed and exploded in a chamber lined with refractory material, and would then discharge through a diverting nozzle and impinge against the blades of a turbine wheel, as in the case of the De Laval steam turbine. The diverging nozzle would act as an expansion nozzle, to reduce the pressure of the gases to atmospheric pressure and convert their potential energy into kinetic energy before doing work upon the wheel. The discharge would occur in puffs, an impulse being given as often as an explosion occurred.

Another method of accomplishing the result would be to have the combustion element burn continuously in contact with compressed air in a refractory chamber from which the heated air would discharge continuously through the expansion nozzle. The pressure in the chamber would remain constant under such conditions and the question of efficiency of the apparatus would depend solely upon the pressure that was attained through compression, as the relative amount of work done in an engine working upon this cycle does not depend upon the temperature of combustion. The efficiency of this cycle is not as high as that of the Otto cycle, but for turbine purposes would have the merit of giving continuous discharge through the nozzle instead of intermittent discharge. This plan of compression and then heating under constant pressure was employed in the well-known Brayton petroleum engine, one of the pioneers in the gas engine field.

The perfection of the gas turbine will not be an easy proposition. It will either have to be accomplished by individuals, working in a haphazard way through a long period of years, or by the concentrated efforts of some large firm like the General Electric Company. The latter plan will undoubtedly result in the quicker solution of the problem. One of the problems will be that of the temperature of the gas and its effect upon the metal of the turbine wheel. While the hot air will not come in contact with any of the bearings of the wheel, it is evident that the blades might not stand up to their work if subjected to a very high temperature. The fact that all bearings and wearing surfaces, however, would be removed from contact with the hot gases would undoubtedly make the water jacket unnecessary. —*Machinery.*

The Raising of Water from Deep Wells and Borings by Compressed Air.*

The use of compressed air for power transmission has been a matter of careful study and experiment on the part of engineers for some considerable time past, but it is only during more recent years that the "air-lift" system has been applied to any practical extent in this country.

The successful adoption of the system of raising water by the use of compressed air is dependent upon the conditions peculiar to the case under treatment, and it is therefore essential that the waterworks engineer, before resorting thereto, should carefully cônsider whether the special circumstances of the case are such as to fully warrant its adoption, and the author hopes in the course of the present paper to point out from his own experience what he believes to be the special circumstances to which the system is particularly applicable.

Before referring to the details of the plant—Corporation Waterworks, Tunbridge Wells—under the author's charge, it will be convenient briefly to review some of the general principles governing the operation of compressed air in raising water.

The experiments carried out in the United States by Dr. Pohlé, of Arizona, who for some years past has been engaged in the application and development of this system for raising water, oil and other liquids from underground sources, have proved that the main principle upon which the system operates is the following: Air under the necessary pressure, and of suitable volume, is admitted to the bottom of a pipe immersed in the water to be lifted in the manner shown on the accompanying sketch—Figure 1. By this means alternate bands or columns of air and water are formed in the water-pipe or "rising main," and the air does not, as might perhaps have been anticipated, pass through the mass of water. The result of this is that the aggregate weight of the water in the rising main is insufficient to balance the column of water in the boring, and the pressure of the latter therefore produces

* Paper by William H. Maxwell, Assoc. M. Inst. C. E., Borough and Waterworks Engineer, Tunbridge Wells, read at the Bolton meeting of the British Association of Waterworks Engineers.

an upward movement of the air and water column in the rising main. As the force lifting this column is the head of water at A—Figure 1—it follows that the height to which the water can be lifted depends upon the depth to which the pipe is immersed below the pumping level of the water in the boring, thus the higher the

COMPRESSED AIR MACHINERY FOR RAISING WATER FROM DEEP BORE WELLS AT TUNBRIDGE WELLS CORPORATION WATERWORKS.

"lift" required the deeper must be the point at which the air is injected relatively to the normal water level therein, and so the height to which the water has to be raised determines the minimum depth to which the boring must be driven.

With regard to the best proportion between the immersion of the air nozzle and the "lift" of the water opinions vary, but the author found that in his case the most economical result was obtained when the ratio was 3 (of immersion) to 1 (of lift) at the start, and 2·2 to one at the finish of the test—see Table I. Under these conditions the efficiency worked out at 36·8 per cent. calculated from the steam diagram, and at 46 per cent. calculated from the compressor diagram, the volumes of air used and water lifted being in the proportion of 2·69 of the former to 1 of the latter.

From the results of his own tests and those of others, the author has prepared the following table showing the approximate horse-power required to compress one cubic foot of free air to different pressures per square inch:

	Pressure in lbs. per sq. in.	H. P. required to compress 1 cu. ft. of air.
1. Solvay Works, Saaralben.........	176	0.434
2. Brostowe Estate, near Friedheim.	140	0.376
3. Tunbridge Wells Waterworks....	100	0.201
4. Ditto	80	0.189
5. Ditto	60	0.159
6. Sugar Factory, Glogau	45	0.145
7. Yard Works, Zwickau............	30	0.121
8. Rossland Mines, B. C.............	95	0.134†

† This excellent result was probably due to the use of intercoolers.

With regard to the quantity of air required to lift a given volume of water to any specified height, the author has found the following formula to give results in accordance with his own experience:

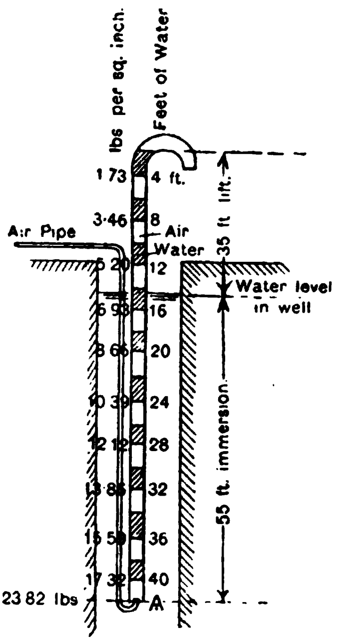
X = cubic feet of free air per minute;

A = gallons of water required per minute;

B = " lift " of water in feet;

$$X = \frac{A \times B}{125}$$

From this formula it is, of course, a simple matter to ascertain the quantity of



Aggregate head of water in rising main = 40 ft. = 17·32 lbs. per sq. inch

Aggregate head in well = 55 ft. = 23 82 lbs per sq inch

FIGURE I.

water that can be lifted to any given height by a given quantity of air.

With regard to the proportions between the areas of the air-pipe and the rising main, the author considers that further experiments are required before it can be decided what proportions will secure the most economical results in practice; it is evident that the velocity of the water in the rising main is an important factor in this case, but as regards the air-pipe the author considers that the velocity of the air should not exceed about 20 ft. per second.

It has occurred to the author, as it has no doubt to others who have watched an air-lift plant in operation, that the excessive velocity and force of the discharge must involve a considerable waste of energy, and that some appreciable economy would be effected were it possible to utilize this force in any practical way.

In considering the design of the compressor, it is obviously important in the interests of economy to provide either " two-stage " or " three-stage " machines, with inter-coolers, according to the amount of compression required. Thus for pressures above 60 lb. per square inch and up to 300 lb. per square inch " two-stage " machines are most suitable, and from this to 1,000 lb. per square inch " three-stage " machines are desirable. The cooling of the air is also of great importance in this respect, and care should be taken to start with an air supply at the lowest temperature obtainable.

Description of Tunbridge Wells plant.—The main factor which influenced the decision to apply the "air-lift" system at Tunbridge Wells—which decision was arrived at prior to the author's appointment as waterworks engineer—was the possibility of operating the boring from the existing pumping station and avoiding the erection of any buildings, foundations or machinery requiring personal supervision at the site of the boring, which is situated some 530 yards away from the pumping station. The boiler power was also sufficient to supply the steam required for the compressors without any additional boilers, settings or buildings for same, and the air-compressing plant involved no extra attendance, as a new steam pumping plant was then being installed, and one extra mechanic was able to attend to both sets of plant.

The compression is carried out in two stages, the first to a pressure of 25 lb. per square inch, and the second, after inter-cooling, to the pressure required, which varies from 90 lb. to 100 lb. per square inch, according to the depth of the water in the boring. The air is delivered into a large steel receiver situated in the engine-house, whence it is conveyed to the wells by means of a 4-in. cast-iron pipe. This main is formed of ordinary spigot and socket pipes with lead joints, which, however, shortly after starting the plant, showed signs of leakage adjacent to the receiver. This was traced to the expansion and contraction of the pipes due to the high temperature of the air, and was effectually prevented by fixing a cooler on the air-pipe between the second-stage compressor and the receiver.

There are two sets of engines and compressors designed to deliver a sufficient volume of air to lift the desired quantity of water, if needs be, over a standpipe 20 ft. high above ground level. The engines are compound, with cylinders 8 in. and 12 in. diameter, respectively, the air-compressing cylinders being 10 in., first stage, and 6 in. second stage, diameter, respectively. The stroke in each case is 14 in. The air cylinders are water-jacketed at sides and covers. The clearance in the air cylinders does not exceed 1 per cent. of the capacity. The air is drawn from outside the building and is carried in an earthenware pipe under the floor to the inlet valves, so that it enters the compressors at the lowest possible temperature.

The inter-cooler—between the first and second stages of compressors—is formed of a series of "Rows" tubes cooled by circulating water. This is also fixed outside the engine-house.

Provision is made for draining off the water which is precipitated in the receiver owing to the compression of the air, and, similarly, any oil carried forward by the air from the cylinders is also precipitated here, and drained away from time to time. As a further safeguard, another trap is provided near the boring for the same purpose. In some cases, however, the receiver is filled with coke in order to arrest any oil carried forward with the air.

The boring is 350 ft. deep, penetrating the Wadhurst Clay to a depth of 204 ft. 6 in., and the Ashdown sands to a further depth of 145 ft. 6 in. The upper portion is lined with 15-in. steel tubes, and the lower portion, 150 ft., with steel perforated tubes, 13½ in. diameter. The rest level of the water is about 96 ft. from the surface, and the pumping level, when drawing at the rate of 32,000 gallons per hour, is about 120 ft. from the surface, but on the cessation of pumping the water resumes its rest level very rapidly.

The water pipe or rising main is 7 in. diameter, and is carried to within a few feet of the bottom of the boring. The air pipe was originally 1½ in. diameter, but was subsequently increased to 2½ in. diameter, an alteration which reduced the air pressure required from 105 lbs. to 91 lbs. per square inch, the latter figure corresponding very closely to the head of water above the bottom of the air pipe, and thus proving the loss by friction to be reduced to a minimum. In a trial run for 10¼ hours made soon after the plant was installed, an average of 31,402 gallons per hour was raised from this boring under a head of 133 ft., whereas an ordinary single-acting pump, such as could be fixed in a boring of this small diameter, would not give more than about 18,300 gallons per hour. The plant was made and erected by Messrs. Hughes and Lancaster, of London and Ruabon, and the cost, including two compressors with compound engines, air main, air and water pipes in borings, condenser feed and air pumps, was £3374 17s. 6d.

Cost and efficiency of working.—In Table I. the author has given a summary of the results obtained by tests at various times and under different conditions of water level, which he believes will prove interesting. Here it will be seen that the most favorable result was obtained in trial I, when the proportion of immersion of air pipe to lift of water was 3 to 1 at the start, and 2·2 to 1 at the finish, the volume of air used per volume of water lifted being in the proportion of 2·69 to 1. The efficiency in this case was 36·8 per cent. calculated on the water raised proportionate to the indicated horse-power developed in steam cylinders and 46 per cent. calculated from the indicated horse-power shown by air cylinder diagrams. Unfortunately, on this occasion the fuel consumption was not recorded, so that the cost per 1,000 gallons of water raised could not be obtained.

From trial No. 5, however, with a much less immersion of air pipe, and when the proportion of air used to water lifted was more than double that in the former case, the cost of fuel worked out at 1·073d. per 1,000 gallons for a maximum lift of 125 ft. 9 in., the price of coal being 25s. 5d. per ton.

During the earlier months of the present year, with water levels varying between the depths of 98 ft. and 118 ft. below surface, under regular working conditions, the

TABLE I.—*Tests of Air Lifts—Tunbridge Wells Waterworks.*

1	2	3	4	5	6	7	8	9	10
Date of test.	No. of test.	Water levels below ground surface.		Average rate of delivery per hour in gallons.	Cubic feet of water delivered per minute.	Cubic feet of air per minute (atmospheric pressure.)	Volumes of free air to 1 of water.	Ratio of immersion of air pipe to lift.	
		Start.	Finish.					At start.	At finish.
		ft. in.	ft. in.						
June 3d, 1901	1	84 0	106 0	24,100	64·8	178·6	2·69	3·01 to 1	2·2 to 1
April 11th-17th, 1901	2	89 0	130 9	29,055	77·5	377	4·8	2·8 to 1	1·6 to 1
July (latter part), 1901	3	94 0	124 0	30,446	81·2	285·3	3·5	2·6 to 1	1·72 to 1
July 14th-20th, 1902	4	120 0	158 6	19,785	52·8	447	8·4	1·8 to 1	1·13 to 1
October 7th, 1902	5	103 9	125 9	27,636	73·7	421·8	5·7	2·27 to 1	1·69 to 1
October 21st, 1902	6	109 7	124 6	27,187	72·7	394	5·4	2·1 to 1	1·71 to 1
February 12th, 1903	7	98 6	112 8	26,289	70·1	260·5	3·7	2·46 to 1	1·96 to 1

NOTE.—The fuel cost per 1,000 gallons raised, test No. 5, with water levels varying between 108ft. 9in. and 125ft. 9in., was 1·078d., with coal at 25s. 5d. per ton. During the early months of the present year (1903), with water levels between 98ft. and 118ft. below surface, the fuel cost was ·97d per 1,000 gallons.

fuel cost came out at a fraction under 1d. per 1,000 gallons raised.

The comparatively unfavorable results shown in trial 4 were accounted for by the fact that at this time the water level was at an unusual depth, and the ratio of immersion to lift was consequently reduced to 1·13 to 1—end of trial. On this occasion a test was being made of the maximum yield of the strata, and all the wells and borings were being drawn upon to the utmost possible extent. In this case the quantity of air required per unit of water lifted rose to a proportion of 8·4 to 1, and the "efficiency" fell to 17·7 per cent. on the indicated horse-power in steam cylinders, and 22 per cent. on indicated horse-power in air cylinders. The cost of fuel—at 25s. 5d. per ton, as before—worked out at 1·53d. per 1,000 gallons raised. The author has given this result for the purpose of showing the effect of reducing the proportion of immersion to lift, but, of course, these figures must not be taken as representing the working of the plant under ordinary and fair conditions.

In trial No. 7 the efficiency worked out at 26·1 per cent. on steam cylinder diagram, and 32·5 per cent. on air cylinder diagram.

Table II. gives the working results obtained with four examples of air-lift plant on the Continent.

Table III. gives hourly records of a six-hour test carried out with an air-lift plant at Grinnel, Iowa, on August 16th, 1902. In this case the lift was exceptionally great, being 258 ft. The water main was 3½ in. diameter, and the air pipe fixed outside the water main was 2 in. diameter. The boring was 2,000 ft. deep, and the air pipe extended to a depth of 557 ft., thus giving an immersion of 299 ft., or a proportion of 1·16 to 1 of "lift." The water was delivered 3 ft. above surface level. The boring was lined with 10 in. diameter tubes into the rock, and was continued unlined of a diameter of 6⅝ in. The compressing plant was second-hand, and all pistons and valves were leaky, so that the air actually delivered was less than the piston displacement. The average efficiency worked out at 29·6 per cent.

At this boring a test was made with an ordinary pump, when the average rate of delivery was only 4,500 gallons per hour, compared to an average of 7,394 gallons per hour obtained by the air lift plant.

Comparison between different systems

TABLE II.—*Tests of Continental Air Lifts.**

Place.	—	Depth of immersion of air pipe in feet.	Height of delivery in feet.	Ratio of immersion to lift.	Diameter of rising main (inches).	Diameter of air pipe (inches).	Quantity of water raised in gallons per hour.	Water raised in gallons per minute.	Water raised in cubic feet per minute.	Quantity of air at atmospheric pressure, cubic feet per minute.	Volumes of air to 1 of water.	Mean pressure in air chamber, pounds per sq. inch.	I. H. P. of steam cylinder.	I. H. P. of air cylinder.	Ratio of work in air cylinder to work in steam cylinder (per cent.).	Cubic feet of air required at atmospheric pressure per gallon of water.	Ratio of H. P. in raising water to H. P. of air cylinder (per cent.).	Ratio of H.P. in water raised to I. H. P. (steam).	Velocity of water entering rising main, feet per second.	I. H. P. per cubic foot of air at pressure stated in Column No. 11.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Sugar Factory at Glogau	1	95	42·75	2·22	6¼	3	27,700	461·7	78·87	215	2·91	45¼	30·96	27·47	88·8	·465	22·3	19·3	5¾	·144
	2	93	45	2·07	6¼	3	37,000	616·7	98·7	280	2·84	44¾	40·43	35·12	86·9	·454	24·3	20·8	7¼	·144
	3	95	42·75	2·22	6¼	3	39,600	660·0	105·6	328	3·1	45⅛	50·15	42·54	84·6	·51	20·1	17·05	8	·153
	4	95	42·75	2·22	6¼	3	40,000	666·7	106·67	425	3·98	48⅜	70·64	59·16	83·6	·654	14·8	12·2	8¼	·166
Yard Works, Zwickau.........	5	63·25	45	1·4	7$\frac{9}{16}$	4$\frac{15}{16}$	53,700	895·0	143·2	348	2·43	30½	...	43	...	·389	29·5	...	7¾	...
Brostowe Estate, near Friedheim	6	301	203	1·48	2	1	2,190	36·5	5·84	28	4·8	139¼	...	10·52	...	·766	21·6	...	4⅜	...
Solvay Works, Saaralben......	7	403	229	1·76	2$\frac{7}{16}$	1⅜	2,870	47·83	7·65	44·7	5·84	176	...	19·4	...	·938	20	...	4¼	...

* *Zeitschrift des Vereines Deutscher Ingenieure*, 3d September, 1898. Columns 3, 7, 8, 10, 17 and 19 have been added by the author.

TABLE III.—*Official Six-Hour Test of Air Lift made at the Waterworks of Grinnell, Iowa, August 16th*, 1902.

The well has the Pohlé system of piping, with a 3½ in. water pipe and a 2 in. air pipe placed outside the water pipe. The depth of the well is 2,000 ft., and the length of air pipe 557 ft. The lift is 258 ft.

Percentage of submergence	= 53·6 per cent.
Gallons per minute (average)	= 128
Cubic feet piston displacement	= 135
Cubic feet air per gallon (average)	= 1·09 (6·8 volumes air to 1 of water)
Percentage of efficiency	= 29·6 per cent.

Time.	Gallons of water pumped.	Cubic feet of air per gallon.	Coal consumed.	Gallons of feed water.	Boiler pressure.	Air pressure.		Water level below surface.	
						Starting.	Working.	Normal.	Pumping.
			Pounds.		Pounds.	Pounds.	Pounds.		
One hour.	7,833	1·06	500	187	80	188	181	240	256
"	7,626	1·06	250	180	"	"	181	"	256
"	7,187	1·08	250	165	"	"	182	"	253·8
"	7,500	1·08	250	157	"	"	181	"	256
"	7,344	1·1	250	157	"	"	181	"	253
"	6,875	1·17	500	150	"	"	182	"	253·8

of pumping.—Having to provide a pumping plant for a boring of 15½ in. diameter and 400 ft. deep, situated in an isolated and somewhat inacessible position, the author has made a careful estimate of the comparative cost of pumping and maintenance with the three alternatives of (1) air lift; (2) steam engine; and (3) oil engine; both the latter operating ordinary borehole pumps, and in each case taking into account the capital charges involved. The results are shown in the following statement, the lift being assumed as 100 ft., and the working hours 3,000 per annum:

(1) *Compressed Air Plant.*

	Per 1,000 gallons.
Capital charges, labor and repairs..	1·16d.
Fuel as per test October 7th, 1902..	1·073d.
Total	2·233d.

(2) *Steam Engine and Borehole Pump.*

	Per 1,000 gallons.
Capital charges, labor and repairs..	2·4d.
Fuel—average of tests by the author.	0·5d.
Total	2·9d.

(3) *Cheap Fuel Oil Engine Plant and Borehole Pump.*

	Per 1,000 gallons.
Capital charges, labor and repairs.	1·53d.
*Crude oil fuel..................	0·25d.
Total	1·78d.

Advantages and disadvantages of air-lift system.—In conclusion, the author will summarize some of the most important general features of the air-lift system as ascertained from his own experience. The most suitable conditons under which the system may be applied appear to be those which exist at Tunbridge Wells, viz., where a boring is situated in an isolated and somewhat inaccessible position and the air-compressing plant can be placed on an existing pumping station, involving but little outlay in the erection of new foundations or buildings, or the purchase of additional land, and without incurring the provision of additional labor at the site of the boring. To secure satisfactory results, however, it is important that the difference between the rest level and the pumping level of the water should not be excessive; that the fluctuations of the same should be ascertained beforehand, and that the ratio between the immersion of the air pipe and the total lift of the water should be adjusted to the most suitable proportions, and not greatly varied in ordinary working.

Although it cannot be denied that the cost of fuel involved by the air lift exceeds that required with a steam or oil-driven pump of the ordinary form, yet the author believes that, under suitable conditions, the former will prove to be preferable, taking all charges into account in each case. The absence of any moving parts in the boring

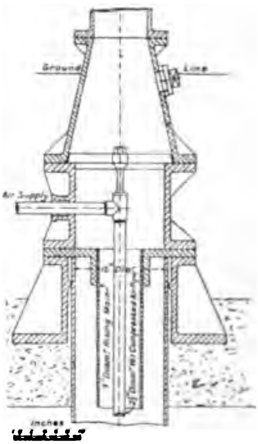


FIGURE 2.

secures a great reduction in the cost of repairs and maintenance, as well as in supervision and all other charges incidental to an additional pumping station. There is also a great advantage in the use of the air lift in cases where the water contains iron, as the aëration is carried out very thoroughly in the boring, and after the water has reached the surface the precipitation of the iron takes place more speedily. On the other hand, the system is by no means suitable to all circumstances, and should not be resorted to unless the conditions of working are specially favorable to its use.

*At a trial of a crude oil engine plant, working at Grantham, the cost of fuel averaged only 0·188d. per 1,000 gallons raised 100ft., the price of crude oil being 2¼d. per gallon.

Compressed Air Locomotive Haulage Plant.

In installing the compressed air haulage plant for the Homestake Mining Company at Lead, S. D., the primary object was to eliminate the fire risk incident to the use of steam locomotives, which had been used for this service for a number of years previous to the introduction of the present compressed air locomotive. The service for which this locomotive is used is to haul 2,000 tons of ore daily an average distance of from 1,200 to 2,000 feet, from the crushers at the hoists to the various stamp mills. This quantity of material is handled daily in from eight to nine hours. As previously stated, the primary object in using compressed air was the elimination of fire risk; but on account of the greater weight and power of the compressed air locomotive, a substantial reduction in the cost of operation has been effected, by accomplishing the required amount of work in one shift of eight or nine hours, in place of three shifts of eight hours previously required, when the work was performed by steam locomotives of less capacity, thus effecting a saving in wages of about $20 per day; and as the cost of fuel for operating the compressor is no greater than that required to operate the steam locomotives, this saving in wages is a clear gain. The plant has, it is said, exceeded the guarantees made for it by the contractors, the H. K. Porter Company, of Pittsburg.

The plant consists of:

One H. K. Porter Company compressed air locomotive; weight in working order, 27,600 pounds; cylinders, 9 inches in diameter by 14-inch stroke; driving wheels, four in number, 26 inches in diameter; rigid wheel base, 5 feet 3 inches; length over all, 18 feet; height, 7 feet; width, 5 feet 2 inches; gauge of track, 22 inches.

One three-stage, straight-line, Ingersoll-Sergeant steam-actuated air compressor; steam cylinder, 16 inches in diameter by 18-inch stroke; with double-acting intake air cylinder 12 inches in diameter by 18-inch stroke, compounded with two smaller single-acting air cylinders properly proportioned for a final pressure of 950 pounds to the square inch. The steam cylinder is equipped with Meyers adjustable valve gear, and the air cylinders with Ingersoll-Sergeant standard type of poppet inlet and discharge valves. All the compressing cylinders are water jacketed, and intercoolers of ample capacity are provided for cooling the air between the first and second and second and third stages of compression.

Two thousand feet of six-inch special pipe is used for the double purpose of conveying the air from the compressor to convenient charging station locations, and also to serve as a sufficient stationary storage to provide for the practically instantaneous charging of the locomotive. Except for the storage requirements, a much smaller size of pipe could have been used.

Air Cushion Resistance.

We have received the following question: "What would be the resistance to a piston entering a cylinder containing 5.95 cubic inches of air? The air would act as a cushion. The piston is 1.55 inches in diameter and enters the cylinder 3 inches. The total depth of the cylinder is 3.15 inches, so that there is .15 inch of clearance or of compression space at the end of the stroke. The piston, which is a good fit in the cylinder, travels a foot or more and makes 60 strokes a minute."

The resistance at the end of the stroke in this case would be so great as to be probably quite impracticable. The ratio of the initial and final volumes would be $.15 \div 3.15 = .0475$, and for this ratio of volumes the ratio of absolute pressures for adiabatic compression would be .0138. The absolute pressure when the piston entered the cylinder being 14.7 per square inch, the final absolute pressure would be $14.7 \div .0138 = 1065.21$, or the gauge pressure $1065.21 - 14.7 = 1050.5$. The area of the piston being $1.55^2 \times .7854 = 1.88$, the resistance at the end of the stroke would be $1050 \times 1.88 = 1,974$ pounds. This would be the theoretical resistance; the actual resistance, which it is impossible to determine in advance, would be considerably less than this, caused by the inevitable leakage of the piston. The mean resistance for the entire travel of the piston in the cylinder would be: $14.7 \div .0867 = 169.55$ pounds per square inch $\times 1.88 = 318.75$ pounds mean pressure on the piston. This also would be reduced by piston leakage. The unexplained factors used in this case are taken from an elaborate table on The Expansion of Steam and Gases in "Appleton's Cyclopedia of Applied Mechanics." This table was compiled by the late Richard H. Buel, C. E., and is invaluable for a wide range of computations relating to expansion and compression. It deserves to be better known and more generally employed.—*Am. Machinist.*

Notes.

The Engineer Publishing Company, Cleveland, Ohio, has purchased the publication *Steam Engineering* and consolidated that paper with the *Engineer*, beginning with the September issue.

A distinctive feature of the Midland Hotel, which has recently been opened at Birmingham, Eng., is the water supply, which is secured from a well sunk to a depth of 600 feet. The water is driven by compressed air in the storage tanks. Throughout the hotel the water is utilized for both sanitary and fire uses.

The second annual convention of the Master Steam Boilermakers' Association will be held in the Farmer's House, Chicago, October 7 to 10. Now that pneumatic tools have proved themselves so effective for riveting, compressed air has proved an important feature in the work of the boilermakers. As such it will undoubtedly figure more or less in the discussions at the convention.

The Cleveland Pneumatic Tool Company is now well established in its new plant at Cleveland, Ohio. The shop is located at Second and Hawthorne avenues, and is much better located and equipped than the old factory. The product of this company is not confined to pneumatic hammers alone, but drills, valve cranks, etc., are also made. The September 3d issue of the *Iron Trade Review* has an illustrated description of this plant.

The *Engineering Record* for September 5th contained a description of the new power plant of the Pittsburg-McKeesport and Connellsville Railroad, located near Connellsville, Pa. At this plant compressed air for the oil system is furnished by a Westinghouse steam compressor mounted on the engine-room wall and pumping into a storage tank in the basement. The oil return and drip pipes are fitted with connections at various points, and regularly blown out by the air blast. The compressed air is also employed for cleaning electric machinery and the switchboards. The pipe system extends to all parts of the power-house. The air is supplied to 100 pounds pressure.

A demonstration was recently made at Dolcoath, Cornwall, Eng., with water jet appliances for rock drilling. There were present at the time representatives and managers of a number of Cornish mines. The device revived, in what was claimed a more handy and practical manner, the principle of forcing water into the holes which was tried in Cornwall at the inception of rock drilling operations. This was subsequently allowed to lapse. It was claimed by some of the friends of Mr. Geo. J. Tyacke, of Camborne, Eng., that this appliance was his patent. This assertion is now contradicted by the Cornish *Telegram*, which states that Mr. Tyacke was under the mistaken impression that he could obtain a patent for the well-known principle of forcing water by means of compressed air, which was the substance of the device worked at Dolcoath.

In the construction of the subway under the Harlem river compressed air was used to assist in the construction of the tunnel. Owing to the treacherous nature of the soft material under the clay which would have to be penetrated for the working chamber, provision was made for using it. A two-stage compressor made by the Norwalk Iron Works Company was installed and so modified that it could be used as two separate low-pressure compressors ordinarily, but could be quickly changed to operate as a two-stage machine for high pressure if the need should arrive. The air was used at pressures only sufficient to correspond with the amount of water above the roof of the coffer dam or working chamber, which varied, of course, with the tides. This coffer dam or working chamber, which was built under water in a trench, proved successful and there was little trouble in the erection of the tubes and concrete walls.

An interesting application of compressed air was recently shown on board the submarine boat "Protector." With the aid of pneumatic pressure a diver recently dropped from this boat without admitting a drop of water into the interior of the vessel. The diving apartment, which is 8 feet in length, is at the bow of the submarine boat. The diver and his assistant went into it, and after the door in the bulkhead was hermetically sealed, compressed air was forced into the chamber until a pressure of 18 pounds to the square inch was obtained. This was sufficient, when the trap in the bottom, 12 feet below the surface, was open, to keep the water out. This arrangement serves two purposes. In case the "Protector" becomes so disabled that it can not rise, the crew can escape through the trap door and ascend to the surface of the water. Through the diver's chamber, also, men can be sent to the bottom of harbors to cut wires connected with submarine mines or telegraph cables.

Two recent contracts by the Union Switch & Signal Company are those for the Interborough Rapid Transit Company (Subway), of New York, and the North Shore Railway, of California. The Westinghouse electro-pneumatic system is to be installed on the first named, but a new feature is to be introduced, that of using alternating current. It is obvious that the use of track circuits on third-rail roads, where the rails are used for the return circuit, and at the same time for the signalling circuit, introduces what may be serious complications. In order to avoid these difficulties, the signals will be controlled by alternating current, through relays that are sensitive to alternating current only, and which will not be affected by the direct current used for train service in the subway. On the North Shore Railway, which runs about thirty miles north from Sausalito, California, across the bay from San Francisco, the electric semaphore system of automatic block signals is to be used with a track circuit. This being a high tension third-rail electric road, alternating current will be used for the signal system.

An important project is that now in progress by the Vancouver Power Company. That company is building an electric plant for the purpose of supplying the city of Vancouver with power. The electricity is generated by water-power which comes from two deep lakes. They are to be connected by a tunnel which is now being constructed. The tunnel is 9 feet wide by 9 feet in height, with round corners, and is being driven from both ends by compressed air drills. Before the machine drills and air compressors arrived, hand drills were used and the forward progress was 2 feet per day at each end, but since the installation of these machines this has been increased to 10 feet per day. The plant at each end includes a 100 horse-power boiler, a 60 kilowatt 500 volt generator and a 4 drill two-stage Leyner air compressor. Rand drills are used in the headings. The ventilation is provided for by a 12-inch galvanized iron pipe through which the air is exhausted by means of an air-jet under 100 pounds pressure, acting as an injector. This is only put in operation for a few minutes after each blast to remove the smoke, the exhaust from the air drills furnishing all the fresh air necessary at other times.

That portion of the South African gold fields known as the Rand is now recovering from the effects of the Boer war, during which many of the mining plants were partially if not totally destroyed. The Kleinfontein Mine, which suffered severely, has been consolidated with the Kleinfontein Central Mine, the new undertaking being called the New Kleinfontein Mine, and a complete new plant erected. The air compressing plant suffered as well as the rest, and is now being rebuilt by the firm of Walker Bros., of Wigan. It consists of a two-stage compressor arranged to compress the air up to 80 pounds per square inch, and to furnish sufficient air at that pressure to drive fifty rock drills 3¼ inches in diameter. The air compressors are directly connected to the steam engine which drives them. The steam engine is also compound, and works with steam superheated from 500 to 550 degrees F. The steam cylinders are 55 and 28 inches in diameter and the air cylinders 48 and 30 inches in diameter, with a 60-inch stroke. The valve gear of the steam engine is of the Corliss type, controlled by a governor.

Another compressor was partially wrecked. The same firm is now installing the new low-pressure side for this compressor. When the work of reconstruction is completed this will be one of the best-equipped mines in South Africa.

In the erection of the Atlantic avenue viaduct, which is designed to carry the Long Island Railroad over and under street grades from the old Brooklyn city limits to the Flatbush avenue station, Brooklyn, practically all of the riveting was done by compressed air. As soon as the girders were set in position the erectors are followed by six gangs of four men each operating Chicago pneumatic riveters. There were 650 ⅞-inch field rivets in each panel, and each gang drove about 200 rivets in eight hours, these together finishing about two panels a day.

The pneumatic hammers were operated by air at a pressure of 120 pounds supplied by a portable compressor plant set up on the ground under the completed structure and occasionally moved forward as the erection progressed. This plant was of special design and exceedingly compact and simple in construction, being calculated for service under any ordinary circumstances and to be transported and operated with the greatest possible ease. The 8¼-inch by 12-inch Ingersoll-Sergeant compressor had a capacity of 650 cubic feet of free air per minute, sufficient to operate seven pneumatic hammers, and was seated on a 4-foot by 10-foot steel platform, which also supported the 13 horsepower Dale engine. At one end there are three transverse horizontal 18-inch air receiver tanks, each 4 feet long, which were connected together and set behind the flywheel.

The Chicago Pneumatic Tool Company has issued the following official statement regarding certain stories about that concern which have been repeated and published of late:

"In the first place, President Duntley is not going to resign. It is due to his knowledge, energy and ability that the pneumatic tool business has grown to its present vast proportions. This is fully recognized by the directors, and none of them desire his resignation. The report that he does not have the confidence of Mr. Schwab or Mr. Matthiessen is entirely without foundation, and there is no justification in the report that he anticipates retiring or that any stockholders desire him to do so.

"The fact that Mr. Schwab has purchased from Mr. Pam the stock owned by the latter is true, and this transaction was a private one between them. It originated with them, and none of the other officers or stockholders had anything to do with it. Therefore, Mr. Pam, having sold all of his stock, it naturally followed that he should resign from the directors, which he has done entirely of his own accord. The above transaction is but one of the many which are continually passing between Mr. Schwab and Mr. Pam, and has no significance whatever. The fact that Mr. Matthiessen is at present in Chicago is true, but he is not examining the accounts of the affairs of the company; simply attending to other affairs in which he is interested. The executive offices of the company are to be moved to New York, and it is due to this fact that some of the directors have tendered their resignations. Mr. Schwab is the largest stockholder in the company, and has expressed a desire to take an active part in the direction of the company's business, as has also Mr. Matthiessen. Their action is entirely justified by their present holdings in the company, and as they both live in New York, it is necessary that the executive offices be located in that city.

"As regards Messrs. Wacker, Chalmers and Lynch, these gentlemen agreed when they accepted places on the board that they would do so only if the executive offices were located in Chicago, as it would be impossible for them to attend meetings in New York City, as they could not take the time from their other affairs. Naturally, therefore, when they learned of the proposed change in location they were opposed to it, as they felt it impracticable for them to continue on the board and executive committee, and they accordingly tendered their resignations. There is no other significance whatever attached to their resignations. In all probability the number of directors will be reduced from fifteen to nine, as the members are widely separated and it is difficult to obtain a quorum with the present number. The affairs of the company are in a most flourishing condition and the prospects are exceedingly bright for them to continue so in the future. The various plants are working increased forces in order to adequately fulfill the requirements. Their foreign offices report a correspondingly cheerful outlook. The business for the month of August just past exceeded that transacted in August, 1902, and there is every indication that the present month of September will be very satisfactory as regards sales of pneumatic appliances."

INDEX.

U.S. PATENTS GRANTED AUG., 1903.

Specially prepared for COMPRESSED AIR.

735,217. PNEUMATIC APPARATUS FOR PRODUCING MATS OR BATS OF FIBROUS MATERIAL. Julius De Long, Brooklyn, N. Y. Filed Dec. 6, 1902. Serial No. 38,876.

An apparatus for producing mats or bats of fibrous material, the combination with a molding-chamber the walls of which are constructed to impart any desired shape, size or contour to the mat or bat in transverse cross-section, of means for producing a current of air for conveying fiber into said molding-chamber and packing and molding it therein.

735,544. AIR-BRAKE SYSTEM. William B. Mann, Baltimore, Md. Filed June 8, 1903. Serial No. 159,920.

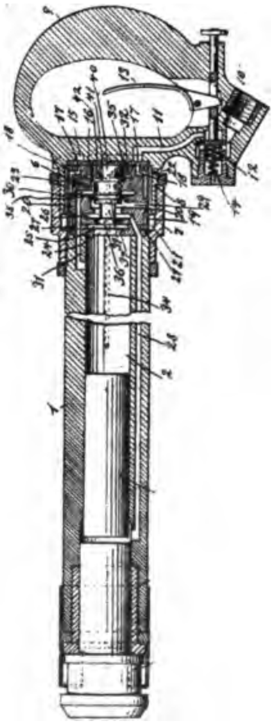
An air-brake system, the combination of a plurality of connected storage-tanks containing compressed air, and automatically-operating means preventing the escape of air therefrom when said tanks are disconnected.

735,909. PNEUMATIC PASSAGE-WAY. John G. Rehfuss and Martin O. Rehfuss, Philadelphia, Pa., assignors to the Bureau Can and Manufacturing Company, of Delaware. Filed Dec. 27, 1902. Serial No. 136,852.

A pneumatic passage-way, rectangular in cross-section, and provided with inwardly-bent guide members projecting from its opposite parallel walls forming contracted passage-ways for the travel of articles between the free ends of said guide members, as set forth.

735,861. PNEUMATIC-TUBE SYSTEM. Wilbur G. Davis, Newton, Mass., assignor to the Single Tube Transmission Company, Boston, Mass., a Corporation of Maine. Filed Dec. 1, 1902. Serial No. 133,351.

735,589. IMPACT-TOOL. Charles B. Richards, Cleveland, Ohio, assignor to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Original application filed Dec. 24, 1900, Serial No. 41,005. Divided and this application filed Feb. 20, 1902. Serial No. 94,923.



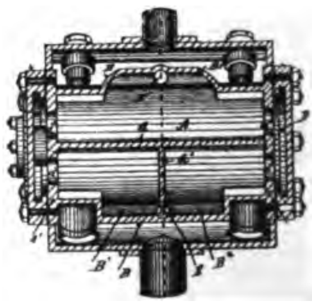
An impact-tool, the combination with a plunger-cylinder having air-distributing ports and channels at both ends and having the inner end exhaust a distance from the inner end, and a plunger reciprocating in said cylinder, of a valve-chamber having one end open to the inner end of said cylinder, a valve in said chamber and having one end exposed to the pressure at said cylinder end, and a leak-passage from the live-air inlet to such exposed end of the valve.

735,981. RAILWAY AIR-BRAKE. Peter Jacobson, Milwaukee, Wis. Filed May 18, 1903. Serial No. 157,514.

736,253. AIR - COMPRESSOR GOVERNOR. James H. Herron, Erie, Pa., assignor to Herron & Bury Manufacturing Company, Erie, Pa., a Corporation of Pennsylvania. Filed Oct. 6, 1902. Serial No. 126,220.

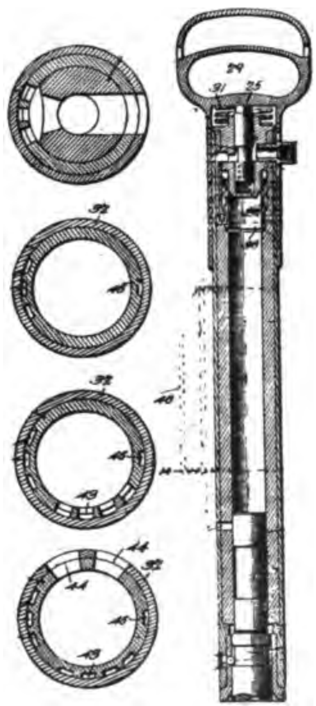
The combination, with a compressed-air receiver, and plunger-cylinders provided with plungers for raising the valves of an air-compressor; of a governor-valve case, a pipe between the said valve-case and receiver, pipes between the said valve-case and cylinders, a valve-shell secured in the said case and provided with holes arranged in pairs and a loaded governor-valve slidable inside the said valve-shell and normally connecting the said cylinders with the atmosphere, said valve and its case being provided with suitable air-passages substantially as set forth which operate normally to connect the said cylinders with the atmosphere through one pair of holes in the said valve-shell and to connect the said cylinders with the said receiver when the said valve is slid from its normal position by the pressure of the air in the said receiver through the other pair of holes in the said valve-shell.

736,254. AIR - COMPRESSOR - CYLINDER WATER-JACKET. James H. Herron, Erie, Pa., assignor to Herron & Bury Manufacturing Company, Erie, Pa., a Corporation of Pennsylvania. Filed Nov. 4, 1902. Serial No. 130,049.



The combination of an air-compressor cylinder, radially-projecting flanges on the ends thereof having openings therein, chambered cylinder-heads secured to said flanges and communicating with the openings therein, a water-jacket having water-inlet and water-outlet openings therein surrounding said cylinder and secured to the peripheries of the flanges thereon, longitudinal and annular ribs between the cylinder and water-jacket whereby the water entering the inlet-opening of the water-jacket is compelled to travel predetermined paths along the cylinder and through the cylinder-heads before passing out of the outlet-opening in the water-jacket.

736,555. PNEUMATIC TOOL. Charles H. Shaw, Denver, Colo. Filed Nov. 11, 1901. Serial No. 81,937.



A pneumatic tool, the combination of the cylinder having at one end an annular valve-chamber of a diameter greater than the bore of the cylinder, said chamber having two concentrically-disposed shoulders arranged in different planes, a peripherally-ported annular valve guided within the chamber and adapted to fit against said shoulders, said valve having a central bore of a diameter equal to the bore of the cylinder and the area of the lower face of said valve being less than the area of the upper face thereof, means for closing the upper portion of the valve-bore to form a dead-cushion space within the valve, a piston adapted to enter the bore of the valve after leaving the cylinder and to effect an opening movement of said valve by the compression of air during the latter portion of the piston stroke, the valve-opening movement being in the same direction as that in which the piston is traveling, a piston-controlled port leading to the valve-chamber, longitudinal ports or passages formed in the valve between one of the peripheral ports and the upper end of said valve to permit the entrance of air under working pressure to said valve-chamber, and ports or passages leading through the walls of the cylinder and controlled by said valve.

736,398. AIR-PUMP. Louis E. Hoffman, Cleveland, Ohio. Filed Nov. 20, 1902. Serial No. 132,087.

An engine, the combination with the air-pump having a notched oscillatory pump-rod, and a lever actuated by a reciprocatory part of the engine, having a projection adapted to engage the notch of an engaging gear, including a lever under control of the operator, and a connecting-rod between the lever and the pump-rod extensible to accommodate variation in distance due to the reciprocation of the pump-rod.

736,680. PNEUMATIC TUBE. Louis G. Bostedo, Chicago, Ill., assignor to Bostedo Pneumatic Tube Company, Chicago, Ill., a Corporation of Illinois. Filed May 17, 1897. Serial No. 636,974.

A pneumatic-tube system, the combination, with a main tube and its branch, of carriers, a pivoted switch for diverting the carriers from the main tube into the branch, a cylinder closed at both ends and having a piston operatively connected with the switch, a motor-fluid-supply pipe connected with the main tube and having branch pipes connected with the opposite ends of the cylinder, a valve controlling the supply of motor fluid to said branch pipes, whereby either end of said cylinder may be placed in communication with the main tube, a selective device, separated devices on the respective carriers for operating the selective device, and mechanism intermediate the selective device and the valve for shifting the valve and switch, substantially as described.

735,549. SUCTION-VALVE FOR COMPRESSORS. Ernest A. Menking, Pittsburg, Pa. Filed Mar. 6, 1903. Serial No. 146,500.

A valve structure for compressors and the like, comprising an internally-threaded ring having a valve-seat, a valve having a stem provided with a head, an inclosing cage constructed of substantially semi-cylindrical sections, each formed externally with semi-cylindrical projections, which are flush with said ring, and each also having a semi-cylindrical internal extension, the two latter uniting to form a guide for the stem, a spring surrounding the guide, said guide having recessed portions constituting a bearing for one end of the spring, and a bearing for the other end of said spring, adapted to be applied over said head, said cage-sections having another internally-threaded ring surrounding the same adjacent the head, and each section having a semi-cylindrical threaded extension at each end to receive said first-named ring and the ring last named.

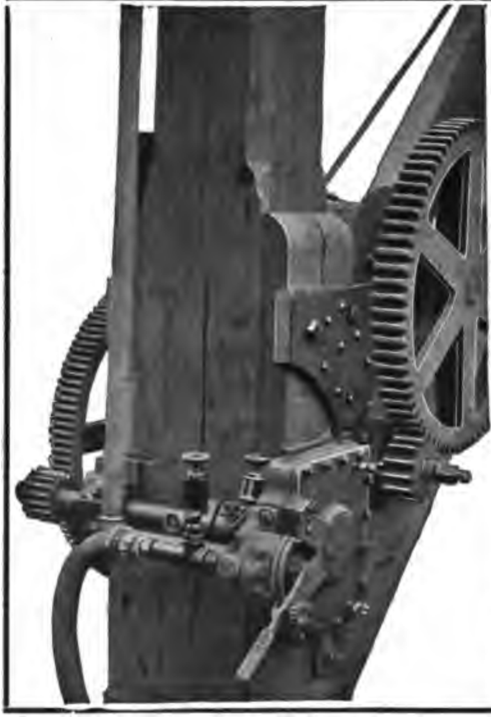
736,778. AIR-PUMP. Walter M. Reason, Pontiac, Mich. Filed Dec. 14, 1901. Serial No. 85,926.

736,958. PNEUMATIC CLOCK. Ernest Girod, Hounslow, England. Filed Sept. 12, 1902. Serial No. 123,156.

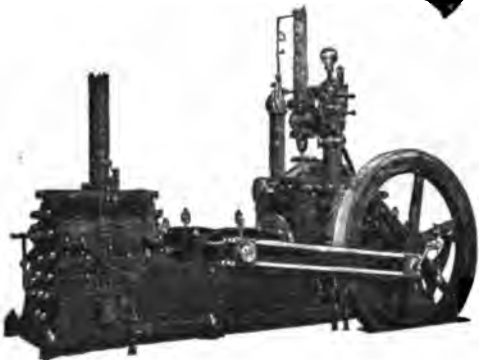
An apparatus of the class described consisting of the combination of an air-compressor operated by water-pressure, an air-motor, a pair of guided weights, a pivoted cross-head on the air-motor adapted to life each of the two weights alternately, a clock, a pipe leading to time-indicating dials, valves for distributing air to the air-motor and said pipe, a weighted lever adapted to urge the clock, a rotating shaft, cams thereon adapted to open and close the said valves, and a mechanism adapted to permit the weights lifted by the air-motor to rise freely and in descending to drive the cam-shaft.

736,986. AIR-PUMP. Jay B. Lyford and Charles E. Hartman, Bridgeport, Conn. Filed Feb. 25, 1902. Serial No. 95,601.

737,363. PNEUMATIC MOTOR-VALVE MECHANISM FOR AUTOMATIC PIANO-PLAYERS. Thomas Danquard, New York, N. Y., assignor to Kohler & Campbell, New York, N. Y., a Firm. Filed Apr. 26, 1902. Serial No 104,739.



"BOYER" CHIPPING HAMMER



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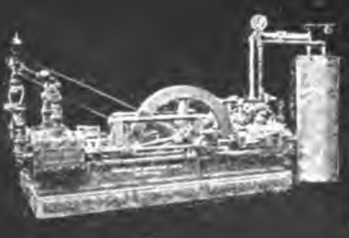

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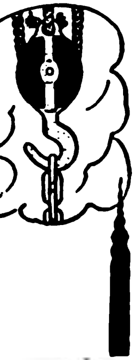

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VOL. VIII. NOVEMBER, 1903. NO. 9

Developing the Air Compressor.

The attention of makers of air compressors is being attracted more and more by the possibilities of the electrically driven compressor. Much has been said in COMPRESSED AIR about those apparently rival powers, compressed air and electricity, which are gradually coming to work in harmony with each other. That the coming years will see great developments along that line, any one who is acquainted with the progress of compressed air machinery cannot doubt.

The general movement among the manufacturers of the United States who use machinery of any size is to abolish the long lines of shafting, and to substitute the direct-connected or geared motors, supplied with current from one or more large generators in a central power station. Belt machines are still plentiful, but each new factory shows a tendency to eliminate much of the shafting and belts, taking advantage of the economies and greater safety which have been proven in almost every case to follow the introduction of individual electric motors for each machine. To meet these changed conditions, the designs of many machine tools and other labor-saving contrivances have been more or less altered. Air compressors will naturally be similarly affected. A wide variety of requirements for electrically driven compressors will preclude, for the present, at least, the adoption of any standard types, and such machines will in most cases continue to be designed to suit the demands of each individual case.

While the next few years promise a rapid development of these electric machines, it does not mean that the belt-driven compressor is to be superseded. It will tend rather to a further extension of the use of compressed air machinery. There was a time when the economical development of power in the air compressor was the least thought-of subject during its construction. Economy of floor space and small first cost were the principal considerations. The competition of electricity and the general progress of the age have combined to change this viewpoint. Now the compressor manufacturer is carefully considering the problem of securing the most economical results from the machine and is willing to sacrifice much toward accomplishing this end. The result is a wonderful improvement in the efficiency of compressed air machinery.

Among the recent improvements which have figured in this direction are the improvements in the efficiency and durability of the valves, the compounding of the cylinders with an intercooler between them, and the water-jacketed air cylinders. While the wisdom of cooling the air during the course of compression has been realized and this policy is being generally pursued, the advantages to be obtained by reheating the air just previous to its use do not seem to be so well appreciated. It is along these lines that some great economies can be and surely will be made in the near future.

Compressed Air for Railway Brakes.

There is no more important application of compressed air than as the power operating the brakes on the modern railway train. Since the advent of the railway air brake, wonderful improvements have been made possible in the running of trains, while the factor of safety has been greatly increased. While the locomotive brakes do not absolutely require air to operate them, no other arrangement has yet been found which will in any way fill its place in controlling the brakes of an entire train.

It is only of late years that the use of air on freight trains has been general. This has been brought about through legislation. There can be no doubt that these brakes greatly reduce the danger of operation in the freight service. Failure, however, to take advantage of these brakes or attempts to operate them improperly still result in occasional accidents. The friends and advocates of this system should do all in their power to extend an intelligent understanding of the brakes among the men who are called upon to operate them.

One interesting feature of the air brake question was discussed at length in a paper read before the Traveling Engineers' Association, bv Mr. Frank P. Rosch, of the Chicago & Alton Railroad, extracts from which are published in another part of this issue.

Pneumatic Tube System in the New York Stock Exchange.

There is probably no place in the world where such a volume of business is transacted within so few hours, where accuracy is so imperative, and speed such a factor as on the floor of the New York Stock Exchange.

In planning the erection of their new and palatial quarters in the building just completed, the Building Committee of the "Exchange," in addition to all the numerous details and modern improvements which go to make up the luxuries and comforts expected at the present day in a building of this nature, were confronted with a problem, which to the average layman and even the experienced member of the Exchange would seem to be beyond human power to satisfactorily solve.

Taking into account a few of the outside matters upon which to a large degree the business of the "Exchange" depends, notably the business with the several telegraph and cable companies,

THE ARBITRAGE DESK, WHERE MEMBERS WHO DO AN ARBITRAGE BUSINESS WITH LONDON OPERATE.

news bureau and messenger service, and the problem presented was, first, how to arrange a service so that two members of the Exchange sending telegrams or cablegrams at the same instant, by different companies, would be sure of their reaching the operators' hands simultaneously.

Second, how to arrange a service so that the several telegraph, cable and messenger companies would receive such messages without advantage to either, regardless of the distance of their offices from the floor of the Exchange. In addition to the above, it was also imperative that members should have the same service from all portions of the Exchange floor.

As the number of members of the old Exchange had increased, the space formerly occupied by telegraph and cable companies, as well as messenger offices,

THE MEMBERS' DESK, ONE OF FOUR ON THE BOARD ROOM FLOOR.

had to be given up to the Exchange proper, and these companies had to seek new quarters.

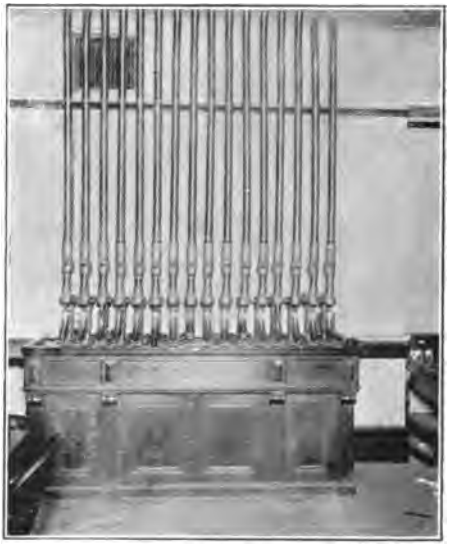
One of the telegraph companies had its office located immediately under the Stock Exchange Board and all the members had to do was to drop their messages, both telegraph and cable, through an opening in the floor to the room below, where they were picked up by messenger boys and turned over to the operators, whereas with other companies it was necessary for the members to go to the entrances of the Exchange and hand their messages to boys to take to companies in adjoining buildings.

It will be readily seen from the above how important a problem the Committee had before them, especially as the number of messages was generally from 10,000 to 15,000 during the five hours of each day's session of the Exchange, even without any unusual excitement in the market.

After a careful examination of all modern methods of transmission, the Building Committee finally decided on a system of pneumatic tubes as being the most satisfactory, because *sure*, *secret* and *safe*.

To ascertain the volume of business that would necessarily pass through the tubes an account was taken of all messages sent from the Exchange for several years previous, the daily average ascertained, and this amount *more than doubled* to allow for future growth. The future location of all the several outside companies was also ascertained and the length of pipe necessary to run from each to the floor of the Exchange. With this data the contractor proceeded to lay out, construct and install the plant.

There are 93 pneumatic tube terminal stations located on the Board Room floor; of these 70 stations connect with the various telegraph and cable offices; 10 stations connect with the Bond Department, one with the Secretary's offices, one with the Luncheon Club, one with the smoking-room, and the balance with the officers and other departments. Each station is designed to accommodate one carrier every five seconds, thus giving a capacity of twelve per minute. The time of transmission to any point is four seconds, irrespective of the length of the line, allowing one second for the



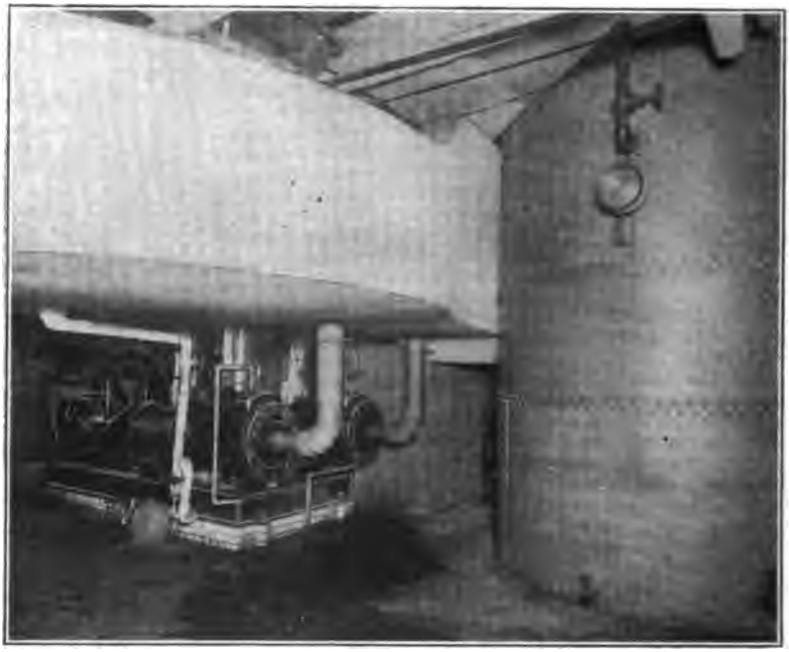
DESK OF THE WESTERN UNION TELEGRAPH COMPANY.

terminals to readjust themselves, giving a total capacity of 300,000 in a day of five hours.

The method of operating is as follows: After receiving a message intended for delivery, the carrier containing the message is placed in the tube and the terminal door closed. This operation automatically turns on the air behind the carrier, and forces it to the extreme end of the tube, or its destination; the air is then automatically shut off, the door opens at point of dispatch, and the tube is in condition to receive another carrier.

There are four central stations on the Board Room floor in addition to a separate station for members doing arbitrage business with Europe, all of which correspond with and carry out the elaborate scheme of decoration found throughout the entire building. The desks are of oak with marble back, corresponding with the wainscoting and pillars, and the terminals, themselves of rather ornate design, are finished in antique copper.

While a technical description of the method of operation of this plant would not be pertinent in this article, a rough outline may be of interest to the general reader. The system is known as a Pressure System, wherein air is compressed into tanks or reservoirs, and there held until required for the despatching of carriers. The compressors used in compressing air are of the duplex type, automatically controlled, such control being regulated by the air pressure in the reservoirs, thus giving an absolute equality of pressure at all times, under all conditions. This air is conveyed to the various stations by means of iron pipes, and at the different terminals is connected with the tube system.



AIR COMPRESSORS AND AIR RESERVOIR.

The tube system itself is of brass, with a diameter of 2¼ inches, all exposed portions being finished in antique copper.

The system is so designed throughout that power is only used as required, or in proportion to the work done, thus assuring the greatest economy, while its capacity is more than ample to meet any extraordinary conditions, or panic. should one arise.

A few of the many advantages gained over old methods in the transaction of business on the floor of the Exchange are the following. First, it does away entirely with messengers on the Board Room floor and eliminates the confusion that formerly existed in the old Exchange.

Second, it gives to each member the same service.

Third, each and every telegraph and cable company and outside messenger departments can receive their messages in the same period of time that their competitor does, regardless of their distance from the Exchange floor.

Fourth, the service is instantaneous.

Fifth, it gives increased space on the Board Room floor for members.

Sixth, there is no possible chance of delay through tardiness or dilatoriness of messenger boys.

EDMUND A. FORDYCE.

The American Mining Congress.

The American Mining Congress held its sixth annual meeting at Deadwood and Lead, South Dakota, September 7–12, many representative mining men from every part of the United States being present. The meetings of the Congress were divided about equally between Deadwood and Lead, each city vying with the other in the entertainment of its guests.

The Honorable Leslie M. Shaw, Secretary of the Treasury, addressed the Congress at its opening meeting on "The Mining Industry and its Relation to American Finances." We quote the following from this address:

"It is an error to rate the importance of our many industries according to their relative productiveness. Our factories and workshops produced $13,000,000,000 gross in 1900; agriculture, $4,000,000,000; forestry, $2,000,000,000, and mines, $1,000,000,000, about equally divided between metallic and nonmetallic products. Yet it must occur to all that manufacture—apparently our greatest wealth producing industry—is dependent upon iron, copper, lead, zinc and other metals, and equally upon coal and other nonmetallic minerals. Our manufacturing interests would dwindle into significance but for our mines.

"A people's prosperity is not measured by its capacity to produce more than by its capacity to consume, and this capacity to consume is in turn dependent upon the earning capacity of the individual, and the earning capacity of the individual is again dependent upon native and acquired ability. So, if America be great, it is because God in His wisdom stored the mountains with the richest minerals, overlaid the valleys with a most fertile soil, and then gave it to people competent, in some slight degree at least, to improve their opportunities."

Interesting and instructive addresses on Black Hills geological formations were presented by Dr. J. E. Todd, State geologist of South Dakota; Mr. Nelson H. Darton, of the Geological Survey; Dr. John D. Irving, of U. S. Geological Survey; Dr. C. C. O'Hara, of Rapid City, South Dakota; and Mr. John Blatchford, superintendent of Golden Reward Company, of Deadwood.

In the old Bullock Hotel building, at Deadwood, and in the Hearst Public Library building, at Lead, were shown very fine and instructive displays of Black Hills minerals. A number of the mining companies also sent in for display, for a few hours, gold bullion amounting to about $65,000.

Among prominent mining men from distant points the following were noted:

Mr. E. P. Low, of Honolulu, Hawaii, who spoke on "The Mining Resources of Hawaii."

Honorable E. W. Parker, of Washington, D. C., who addressed the Congress on the subject of "Coal."

Dr. J. A. Holmes, chief of the Department of Mines and Metallurgy of the St. Louis Louisiana Purchase Exposition, made an address on "Government Agencies for the Advancement of Mining" and "Mica Deposits of the Black Hills Region." Dr. Holmes also addressed the meeting on the subject of the "St. Louis Exposition."

An address on "The Supply of Gold" was made by the Honorable George E. Roberts, Director of the Mint.

Mr. C. W. Merrill, superintendent of the Homestake cyanide plants, read a very valuable paper on the subject of "Metallurgy of the Homestake Mine Ore."

Ample opportunity was afforded all visitors to the Congress to inspect the mammoth plant of the Homestake Mining Company, at Lead, and on Thursday afternoon, through the courtesy of Superintendent T. J. Grier, the unusual opportunity was offered to members and delegates and their friends of a visit to the underground workings of this great mine. The entire mine, with the exception of the 700-foot level, was shut down for the occasion, and the visitors, nearly 600 in number, were taken down the Star Shaft to the 700-foot level, where they had a chance to inspect some of the mammoth stopes which have been worked out and others in which work is now progressing; also the manner of stoping, back-filling and timbering, which was of great interest to the practical mining men, most of whom had never before visited the Homestake Mine. From the Star Hoist the visitors were taken underground to the Highland, about a half mile distant, where they came to the surface.

The Homestake Company hoists to the surface every twenty-four hours about 4,000 tons of ore, and compressed air plays a very important part in the work of excavation underground, where the drilling is done by 223 air drills, of the following patterns:

216 Ingersoll-Sergeant.
3 Leyner.
2 Rand.
1 Sullivan.
1 McKiernan.

The compressed air to operate these drills is supplied by three huge Corliss air compressors, manufactured by The Ingersoll-Sergeant Drill Company. After the ore is hoisted to the surface, an air haulage locomotive, with its load of 28 four-ton cars, now accomplishes in one eight-hour shift the work of three shifts of steam locomotives. At present air haulage is used only on the 100-foot level, but arrangements are being made for testing air haulage on all the underground levels of the Homestake Mine.

The final meeting was held September 12, and the Congress adjourned to meet at Portland, Oregon, next year.

Westinghouse Electro-Pneumatic Turret System of Control.

The announcement was made in the *Railroad Gazette*, on May 15 last, that the Westinghouse Air-Brake Company had equipped the experimental car of John B. McDonald, of the Interborough Railroad, New York City, with a new system of electro-pneumatic train control. At the Saratoga convention of the American Street Railway Association this month a complete apparatus for one car in working order was exhibited for the first time. Following this, the details of the system are now given. The principal parts of the apparatus and their location and connections are shown in the accompanying engravings.

The new system operates on the same principle of electro-pneumatic control as is used in the orignal Westinghouse system. The method of accomplishing the movements of the main controller under each car is, however, radically different. All of the safeguards of the old system have been embodied in the new and with some additional ones. Current is taken from the track circuit and after passing through a lamp resistance is used for charging storage batteries from which the power is taken for controlling the pneumatic switches in the main circuits. The control leads carry only 14 volts, which eliminates danger from short circuits and accidents in coupling the wires from car to car in the train. By using storage batteries the control circuits are independent of the track cir-

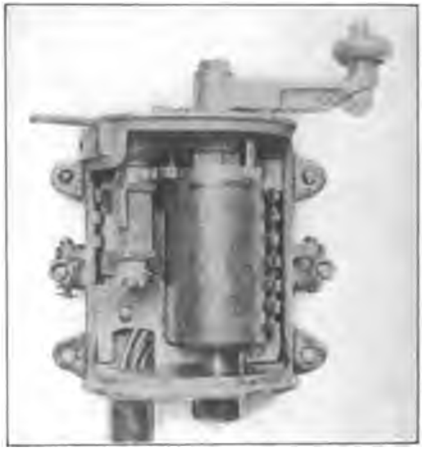


FIG. 1—MASTER CONTROLLER SWITCH, COVER REMOVED.

cuit and the motors can be manipulated even if a fuse is blown out or the third-rail de-energized. Compressed air for operating the pneumatic valves and switches is taken from an auxiliary reservoir connected through a feed valve to the air-brake train pipe. A check valve in the connecting pipe assures at all times a sufficient supply of air to provide applied when the power is on. This is accomplished by the introduction of a pneumatic cut-out switch in the battery circuit which is connected to the brake cylinder and which opens whenever there is air pressure in the cylinder. The apparatus hereafter described is for one car only, but of course the control of any number of cars in a train is possible

FIG. 2—TURRET CONTROLLER MOUNTED UNDER CAR.

against failure of the brake system so that both controlling current and operating power for the main switches are independent of any other apparatus under the car. The controller and reversing handles are interlocked and cannot be moved unless they are both in their proper positions of off or ahead or reversed. The controller handle has an by conducting the battery wires from any master controller to all the turret controllers under the cars through a train cable. This cable consists of only seven wires carrying 14 volts, so there is little complication and no danger from high tension currents.

The apparatus for one car consists of a main controller, reversing switch, limit

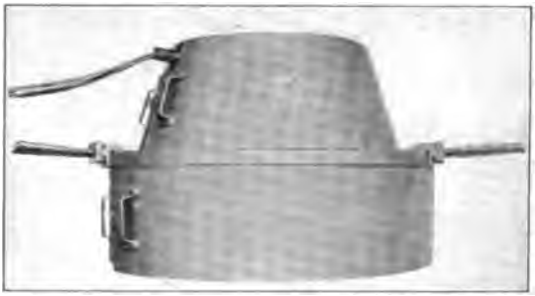


FIG. 3—TURRET CONTROLLER, COVER ON.

automatic spring return to shut off the current in case of accident to the motorman, and is also connected to the brake system to apply the brakes when such an automatic cut-out is made. Power cannot be applied to the motors when the brakes are on or the brakes switch, resistances, two master controlling switches, 14 cells of storage battery, reducing valve, circuit breaker relay, supplementary reservoir, four 7-point receptacles and three junction boxes. As applied to the cars of the Interborough, the total weight for each car is 1,711

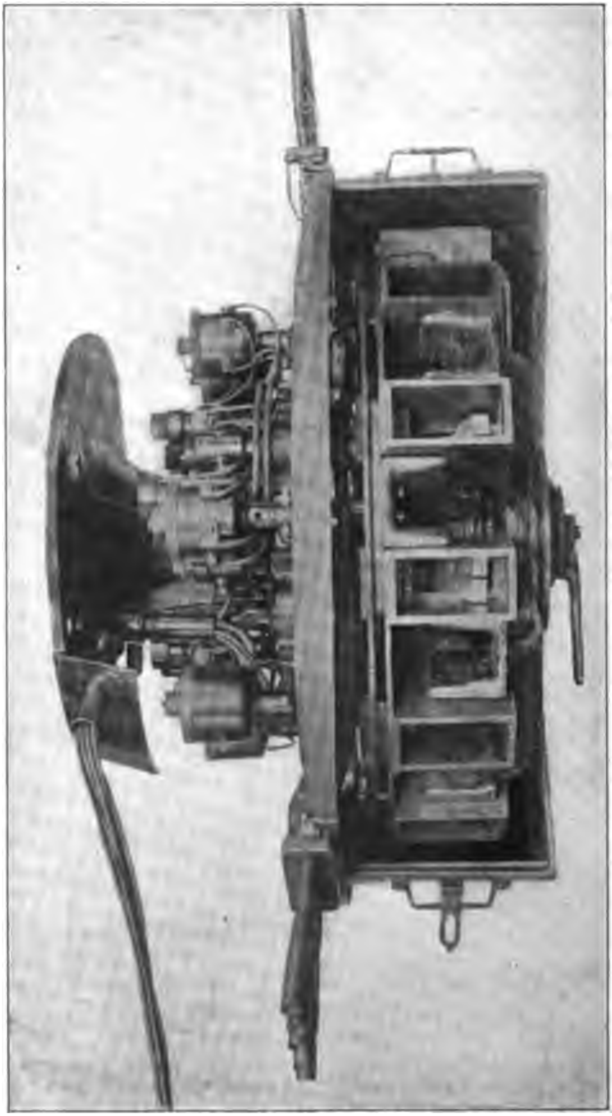


FIG. 4—TURRET CONTROLLER, COVER REMOVED.

pounds, exclusive of wiring and insulation. With the exception of the master switches, battery switches and junction boxes, all of the apparatus is supported from the floor under the car. The main circuit wires are carried up into the car at only one point, connecting to a main switch in one of the motorman's compartments.

In the motorman's cab at each end of the car the master control switch with the brake valve alongside are mounted on the end panel. The master switch shown with the cover removed in Fig. 1 is mounted with the handle 34 inches above the floor, or about level with the window sill. It is 7½ inches high, 6 inches wide and but 4½ inches deep, so that when not in use the door of the compartment may be swung back against the end panel and enclose the whole apparatus. The rotating cylinder is hard wood with copper plates and spring fingers. The battery circuit wires are brought out through the bottom of the switch box and down the panel to a junction box 13½ inches high, 5 inches wide and 3 inches deep, from which they pass through the floor to the pneumatic switches under the car and to the coupling plugs to the other cars in the train.

The main controller, Fig. 2, is hung from the floor of the car as near the track as possible to save wiring. The system takes its name of "turret" from the appearance of the cover as shown in Fig. 3.

Fig. 4 shows the controller with cover removed. Thirteen switches operated by air and controlled by magnetic valves, Fig. 5, are mounted around a central casting which serves as a reservoir to supply air to the pistons. These pistons operate against 70 pounds spring pressure, which insures a positive break to the switches and also allows any length of break necessary to prevent arcing. The 13 switches have one common blow-out coil located in the center of the turret. The arc is blown out radially since the magnetic field is horizontal due to the pole pieces for the blowout being formed by the arms of the spider supporting the switches. The contacts of the switches cannot weld or stick under the strong positive air pressure moving them, and by making the finger levers flexible there results a slight rubbing of one contact surface over the other which further prevents any welding or roughness. Several of the switches move together so that only eight pneumatic cylinders and valves are required for making all the necessary contacts. The section of the controller, Fig. 6, shows the arrangement and general dimensions of the valves and switches.

Figs. 7 and 8 show the reversing switch with cover on and removed. This is mounted under the car, near the truck, and is of the reciprocating type with copper contacts. It is operated by two pneumatic valves admitting air on opposite sides of a piston, and connected to

FIG. 5—ELECTRO-PNEUMATIC VALVE.

the reversing handle of the controller. A limit switch is placed in the battery circuit which prevents the controller valves from opening in too rapid succession and causing a rush of current to the motors. This valve is mounted near the reversing switch, both being on the opposite side of the car from the resistance.

The wiring diagram, Fig. 9, shows the connections for one car. The switches 1 to 13 are controlled by the solenoids shown above them. Nos. 1 and 2 work together and control the circuit breaker. Nos. 3 and 11 together make the series connections, and Nos. 5 to 10 act successively through the limit switch in cutting out the resistance on the third

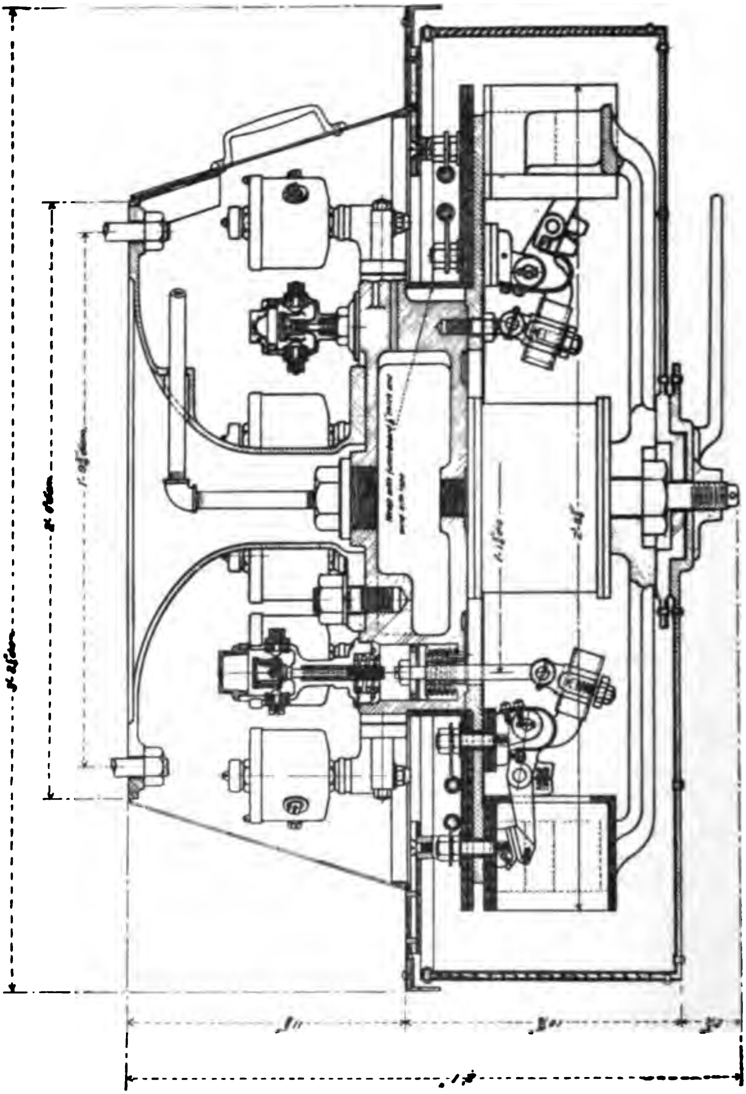


FIG. 6—SECTION THROUGH TURRET CONTROLLER.

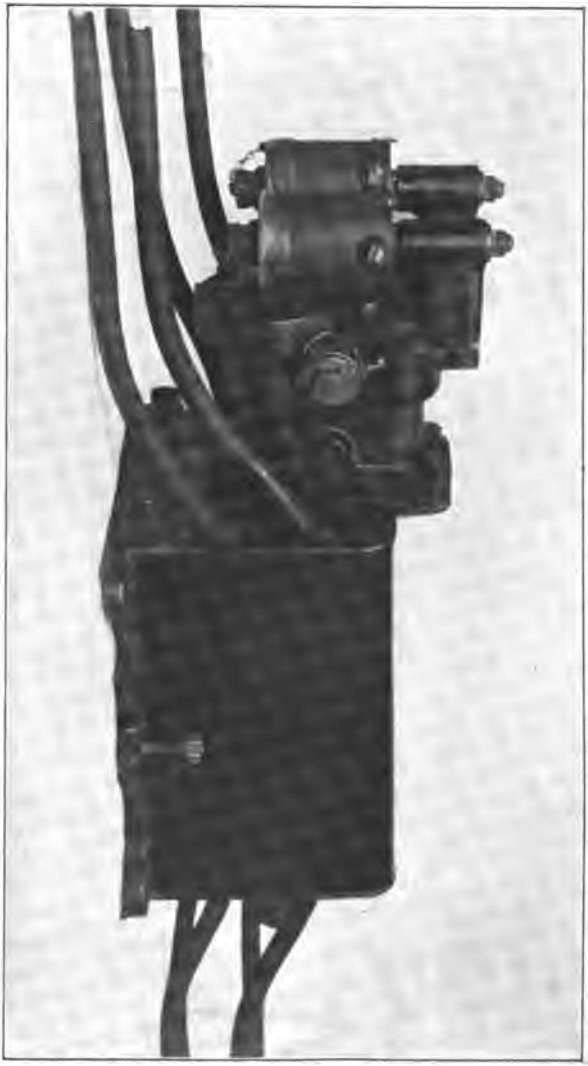


FIG. 7—REVERSING SWITCH, COVER ON.

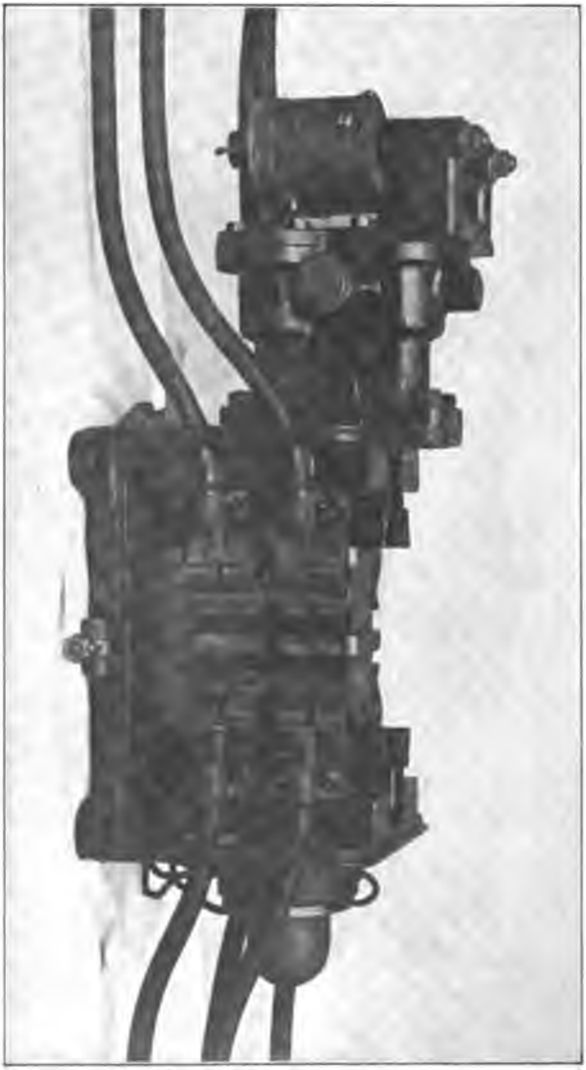


FIG. 8—REVERSING SWITCH, COVER REMOVED.

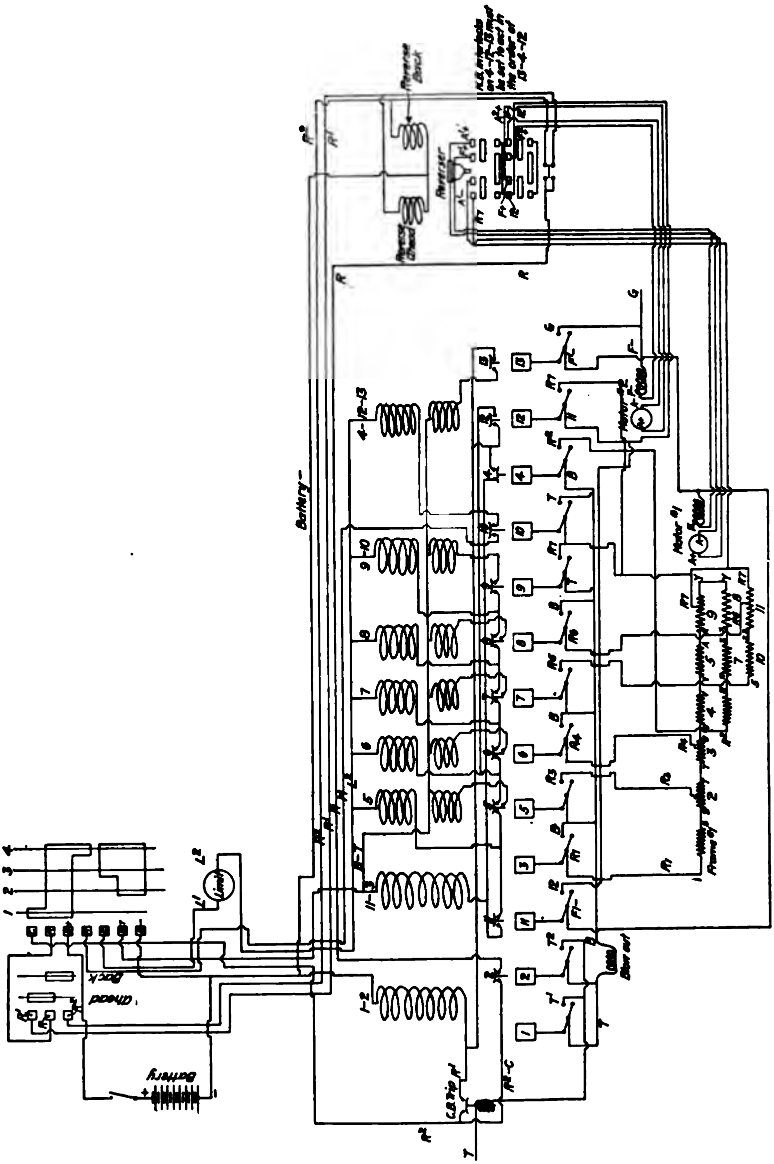


FIG. 9—WIRING DIAGRAM FOR ONE CAR.

notch of the master controller. Nos. 13-4-12 open switches 3 and 11, cutting out the series connections and throw the motors into multiple, then pick up the resistance controlled by 6, 7, 8 and 9, until the maximum speed is reached. The car being at rest, the movement of the master controller handle to the first notch from the "off" position closes the battery circuit through the reverser, moving that switch to the position controlled by the contacts made with reversing handle. This closes the circuit-breaker relay circuit and actuates the pistons 1 and 2 through to the coil shown above them, which movement closes the circuit-breaker. The next step closes the connection between rheostat R1, or maximum resistance and the motors, and at the same time makes the necessary series connections through 11 and 3. The third step cuts out the resistance by bringing switches 5 to 10 successively into play, each switch as it closes, closing the battery circuit for the next valve. Holding coils shown above each piston cut out the limit switch after each main switch has closed and prevent the limit switch releasing the contacts already made. The limit switch may be set to give any required acceleration and acts automatically in opening the battery circuit and preventing the pneumatic valves from opening too rapidly and burning out the motors with a sudden rush of current. The fourth step, or multiple position, closes switches 4, 12 and 13, and these in closing open 3 and 11 and establish a circuit through the holding coils of 6, 7, 8 and 9. The resistances controlled by these switches are then picked up in succession until maximum speed is reached.

The storage batteries used consist of two sets of seven cells each, type D-5 batteries of the Electric Storage Battery Company. They are enclosed in a box under the car and weigh, complete, 300 pounds. They are charged at night when the lamps are on, and either is sufficient to supply current for the day's run. All of the wiring in the car is enclosed in electro-asbestos conduits to guard against fire.—*The Railroad Gazette.*

Coal-Cutting by Machinery.*

In placing before the Manchester Geological and Mining Society the results of practical experience in the working of coal mines with mechanical coal-cutters, I cannot hope that this communication will rank in literary merit with the many excellent contributions of previous writers on the subject, addressed to this and kindred societies; but at least I feel that the information may be interesting and possibly useful, being the record of actual operations, under varying conditions, extending over a considerable period.

The subject is full of interest and of vital importance to the mining industry. It is likely to become more prominent in the immediate future, and as there are many difficulties and prejudices to be encountered and overcome, I believe it to be the duty of everyone, who can from experience add to the general knowledge thereof, to set forth to the best of his ability the information he has acquired.

THE ADOPTION OF THE MACHINE.

Some five years ago difficulties which had arisen in connection with the working of a seam at a colliery under my charge suggested the adoption of coal-cutting machines; with what amount of success the initial attempts were attended may be judged by the fact that we now have in regular operation 15 rotary machines and 14 percussive machines.

The application of the mechanical holing machines materially affects the working of coal seams, and the selection of a suitable machine for the purpose is of great importance. Such being the case, the machine must always be subject to the requirements and conditions of the mine, since the mine cannot always be modified or the conditions adjusted to suit the machine. At the same time the machine is only to be regarded as a substitute for the pick, and a more powerful and a more perfect implement, but like the pick in the sense that it requires skill and intelligence to use it, and in the fact that a good workman can obtain with it better results than a poor workman can be expected to show.

*** Paper by Mr. Owen Hughes, read before Manchester Geological and Mining Society, Manchester, England, April 21, 1908, with remarks on it made at this meeting.**

Perhaps many of the failures with coal-cutting machines are due to a want of recognition of these facts.

Difficulties are to be expected, and these we must overcome; and whilst the system of mechanical coal mining offers many advantages, it must be understood that it is not calculated to relieve the mining officials of any responsibility or make their lot more happy. It is not a case of mining made easy, nor will the introduction of the machine tend to lighten their duties. It rather tends to raise the standard and develop the intelligence of the colliery official. As to the machine operation, there can be but one result. Give a good workman a high-class tool and he himself becomes a better, a more skilful man, and in every sence a superior type of workman.

THE ADVANTAGES CLAIMED FOR MACHINE-CUTTING.

The advantages claimed for the systematic working of coal seams by mechanical coal-cutters are too well known to need mention here, but it may be said that experience teaches us that most, if not all, the claims have been fully realized, viz.:

1. An increase in the proportion of round coal.
2. Smaller loss in working (that is, a greater yield per acre).
3. In most mines a reduced working cost.
4. The necessity for explosives is reduced, in some mines amounting to entirely dispensing with shot firing, thus removing a great element of danger.
5. A larger output from a smaller area in a given time.
6. Reduced loss and cost of timber, together with fewer accidents from falls of roof.
7. A larger daily wage for the collier, whilst relieving him from the most dangerous and most laborious part of his work, viz., holing.

PREJUDICE OF THE MEN.

One of the first and often the most serious of the difficulties to be overcome in many cases is prejudice.

We have been singularly free from objection on the part of the men, and it may be interesting to explain how the first machine was introduced without arousing their opposition.

The first mine into which we introduced a machine was one of the following section:

Metal roof.

"Ley" 6 in. (which falls with the coal).

Coal, 2 ft. 9 in.

Fire clay, 1 ft. 2 in. (too hard for hand-holing).

Two mines below, in close proximity, had previously been worked leaving the upper seam hard, woody, and difficult to work by hand. The getting price paid to the collier was 3s. 6d. per ton, including allowances, but men could scarcely be induced to work in the seam even with the offer of increased allowance.

COMMENCING OPERATIONS ON A SMALL SCALE.

A machine of the Gillott's type was introduced. Operations were commenced on a limited scale. The "drawings" were reduced to the shortest possible distance, and the machine was commenced at the outset on a face only 25 yards in length. This necessitated a mere handful of men, one might say, to keep in good humor, and served as a training ground for the few employed.

At each succeeding cut the face extended and the number of men on the face was increased one or two at a time as required. In this way the operations developed gradually to the full extent, whereas had a start been made with a long face and with 80 or 100 men, it is more than probable some malcontent would have raised difficulties and unsettled the others, and to pacify the larger number would have proved a greater task than the education of a few men at a time.

Eventually the length of working face became 170 yards, across which the machine cut each night.

The coal holed by the machine at night time was dealt with by the colliers during the following day, and at the same time they prepared the face for the next cut.

During the second half-year after the commencement of this machine, it worked 145 days, or rather nights, and the amount of coal got by it was 14,278 tons, or an average of nearly 100 tons per day.

Encouraged by the success of the first attempt more machines were obtained and put to work in this and other mines until at the present time we have about 30 machines of one type or another regularly working in the various seams. Two or three machines are also kept ready for work in the event of those in service getting out of order.

COMMENCING A CUT.

At this point it may be well to describe, generally, the system adopted with the machines and the preparation of the coal face.

I will describe a face with only one machine working, and cutting across from end to end.

To commence the cut we form, say at the extreme left of the coal face, what we call a chamber or stable; this is an opening into the coal as wide as the machine, and as deep or deeper than the wheel or cutter; where this is not done you will generally find the middle portion of the coal face in advance of the cutting ends, and the face gradually being worked into a curved line which is not desirable.

We find this plan preferable to that of commencing the cut by starting the machine at an angle with the face and gradually working the wheel under the coal, as can be done with some machines, for by commencing at one of these properly made stables the machine at once attacks the coal with a cut of full depth and proceeds across the face. It is also important that the machine should cut out and finish in the open, otherwise the machine wheel would remain under the coal, which might break and fall upon it, and also make it more difficult for the collier to get the coal out. For this purpose a chamber like the one at the commencement of the cut is made either by hand holing or a heading machine, and the machine cuts right through into this chamber, where it remains in readiness to commence the next cut across the face in the reverse direction.

TIMBERING.

The roof in the case of most of the mines referred to may be described either as bad or very bad. Timbering is carefully and systematically carried out; indeed this is an essential feature of the system of working.

Before the machine commences to cross the face and hole the coal, the roof is supported by bars set at right angles with the line of face. At one end the bars are notched into the coal, and at the other end are supported by props. The nearest row of props is set about 4 feet 6 inches from the face for a Gillott's machine, but with the Diamond machine, which is narrower, the distance bars need not be so great.

The props and bars are set 4 feet apart.

To each machine there are three men who are classed as first, second and third man. The duty of the first man is to superintend the front of the machine and to see that the rails have been properly laid by the third man, whose work it is to lay the rails in advance. The second man stops and starts the machine, and is called the "driver."

Behind the machine, as it progresses, the "driver" sets a prop under each bar about a foot from the face, since the under-cutting of the coal has weakened the support of the bar at the face. Sprags in the ordinary sense of the word are not used with machine-cutting, but wedges of timber are inserted in the cut at frequent intervals. Let me here point out the necessity of having a plentiful supply of props and wedges in each place for the use of the machine men, otherwise they will have to go in search of some and thus stop the progress of the machine.

GETTING AND FILLING THE COAL.

As a rule the holed coal breaks down and away from the roof, with little necessity for blasting, in large blocks with a cubical fracture, yielding good-sized cubical lumps, which find much favor with the customers, and the round coal is sounder and larger than that got by hand-holing.

The collier gets and fills the coal at a price which includes drawing the tubs to a maximum distance of 200 yards. He also during the process of removing the coal sets the props and bars as previously described, and prepares the face for the next cut.

YIELD OF LARGE COAL.

In the case of one seam 4 feet 4 inches thick the cost of machine-cutting leaves little or no margin as compared with hand-holing. For the latter the collier is paid 2s. 8d. per ton. By machine the collier receives 1s. 11¼d. per ton, and it costs 4¼d. per ton for cutting and cleaning out the holing, which amounts to

2s. 3½d., leaving only 4½d. per ton for power, maintenance, etc.

Detailed particulars of these items, and other costs, are given later on.

In such a case one expects the question: Where lies the advantage of machine-cutting?

It has already been mentioned that a reduction in the getting cost is not the only advantage, indeed it is not always the most important point, and in the case of the mine to which I refer there is an increase of 18% in the proportion of round coal which is equal to 10d. per ton increase in the selling price; this will, I think, justify the adoption of machines, even in the absence of other advantages. By hand-holing this mine yields 52% of round coal, then the face has to be stepped, owing to the difficulty of keeping up the roof with a straight face. With machine-holing the mine yields 70% of round coal. The face line is, of course, straight, and moves more quickly than the handworked face, thus the difficulty with the roof is overcome.

The stated proportion of round coal is that which passes over a mesh 1¼ in. square.

AVERAGE RESULTS OF WORKING.

The average results of working are set forth in detail in the following particulars which relate to tests recently made (under ordinary conditions) to ascertain the fuel consumption for machine cutting.

All the figures giving the weight of fuel consumed, etc., were very carefully ascertained for the purpose of this paper. In each case all other operations were stopped during the test, no steam being used for winding, pumping or hauling, so that the steam was used for air-compressing only.

No. 1 Test, which lasted four hours.

Five Gillott's machines were working at this colliery; all were holing in the floor.

No. 1 machine worked three hours and cut 45 yards (the full extent of the face that happened to be ready). The depth of undercut was 2 feet 10 inches and the area of the cut, 42 square yards, yielding 38 tons; the mine being 2 feet 10 inches thick.

Nos. 2 and 3 machines were working in a newly opened mine in which the extent of face was limited for the reasons previously explained.

No. 2 worked two and a quarter hours and cut 42 yards.

No. 3 worked one and a quarter hours and cut 20 yards, or a total of 62 yards for both machines.

The coal is 2 feet 7 inches thick, the depth cut averaged 2 feet 11 inches and the area cut was 60 square yards, yielding 49 tons.

No. 4 machine worked four hours and cut 75 yards in length, and 3 feet under, or 75 square yards, yielding 102 tons; the mine being 4 feet 4 inches thick.

No. 5 machine cut 51 yards in four hours, 2 feet 11 inches deep in the same seam (4 feet 4 inches thick), and from a cut of 49 square yards produced 68 tons of coal.

The total yield of coal from the five machines was 257 tons.

The total area cut was 226 square yards.

	£	s.	d.
Weight of common slack consumed, 4 tons 3 cwts., at 4s. 6d. per ton................	0	18	8
Stoker and engineman's wages one-third of a shift........	0	2	8
	1	1	4

	d.
Cost per ton for fuel and wages to compress the air for the machines	0·99
Cost per superficial yard of holing for fuel and wages to compress the air required.................	1·13

To give the cost per ton only is not a satisfactory figure for comparison, as the tonnage result depends a great deal on the thickness of the seam, hence the reason for also giving the cost per square yard of undercut.

The compressed air was conveyed to a maximum distance of 750 yards, the nearest machine was 650 yards from the compressor.

No. 2 Test, which lasted six hours.

A similar test was conducted at another colliery where four machines were at work. The following particulars show the results:

No. 1 machine worked six hours and cut 61 yards by 2 feet 10 inches deep, or an area of 57 square yards; and produced 36 tons of coal from a mine 2 feet thick.

No. 2 machine worked six hours in the same seam and cut 66 yards by 2 feet 10 inches deep, producing 39 tons of coal from an area of 62 square yards.

Both these machines were cutting in *very hard dirt*.

No. 3 machine worked three and half hours in a mine 3 feet 7 inches thick, and cut 57 yards by 2 feet 10 inches deep, or 53 square yards; the yield of coal was 61 tons.

No. 4 machine worked in a seam 3 feet 7 inches thick and cut 53 yards in four and quarter hours, 2 feet 10 inches deep = an area of 50 square yards, and produced 56 tons.

Nos. 3 and 4 machines cut as far as the face was ready, coal being down in the way.

The total yield of coal from this test was 192 tons.

The total area cut was 222 square yards.

	£	s.	d.
Weight of slack, commonly known as "Dant" consumed at the boilers was six tons, at 3s. 6d. per ton.	1	1	0
Stoker and engineman's wages, half shift...........	0	4	0
	1	5	0

	d.
Cost per ton for fuel and air-compressing	1·56
Cost per supl. yard for fuel and air-compressing	1·36

The maximum and minimum distances from the compressor to the machines were 2,000 yards and 700 yards, respectively. In all these cases the machines were working practically on the "end" of the coal.

The inclination of the mines is about 1 in 7.

The following particulars of cost refer to the getting of coal at the colliery where No. 1 test of fuel consumption was made. The figures relate to six months working with machines, and are compared with the cost of hand-holing.

Three machines of the Gillott's type were employed, one working in a mine 2 feet 10 inches thick, and two in a mine 4 feet 4 inches thick. The extent of face in the 4 feet 4 inches seam was 230 yards, and the advance of the face in six months was 110 yards (*i. e.*, 25,300 square yards of cutting). With hand-holing the face cutting). With hand-holing the face would only have advanced 40 yards during the same period.

The yield of coal from the three machines was 38,090 tons.

The cost of datalling work required in the ordinary drawing roads of these mines when worked by hand-holing is very great.

DETAILS OF COST PER TON.

	s.	d.
Cost per ton for cutting and clearing dirt from under the coal		4·25
Paid to collier for filling, timbering, cutting out, and drawing the tubs to a maximum distance of 200 yards.	1	11·50
Repairs to machine, including hose pipes, sharpening cutters and laying air-pipes =		·42
Cost of compressed air power as shown in No. 1 Test =		·99
	2	5·16

For hand-holing the payment to the collier was 2s. 8d. per ton, thus showing a saving in favor of the machines of nearly 3d. per ton.

To this must be added a gain of 10d. per ton in the selling price due to an increase from 52% to 70% of large coal, making a total gain of 1s. 1d. per ton.

The following particulars show the result of six months working at the colliery where No. 2 test of fuel consumption was made.

The mine in this case is 2 feet thick. The machines hole in the dirt under the coal, which is of a very hard nature.

Two Gillott's machines were worked on a face 200 yards long and during the last six months the face has advanced 90 yards. With hand-holing the face in this mine has advanced only 38 yards in the same time.

The yield of coal from the 18,000 square yards of cutting was 10,060 tons.

DETAILS OF COST PER TON.

	s.	d.
Cost of cutting and cleaning dirt from under the coal....	0	6·25
Paid to colliers for filling, timbering, cutting out and drawing the tubs up to 200 yards.	2	1·25
Repairs to machines, including hose pipes, sharpening cutters and laying pipes........	0	1·47
Cost of power (compressed air) as per No. 2 Test......	0	1·56
	2	10·53

The price paid to the collier was 3s. 10d. per ton; thus showing a saving of 11½d. per ton in favor of the machine; there was also a further gain of 9½d. per ton in the selling price, due to an increase in the proportion of round coal from 43 per cent. to 58 per cent., or a total gain of 1s. 9d. per ton.

The higher cost per ton for repairs, etc., in this case is to be explained by the fact of the holing being very hard, and the mine thin, yielding a lower tonnage for each superficial yard of cut.

In neither of these cases have I taken into account the cost of plant or depreciation. The power plant is used for other purposes, and it is difficult to correctly apportion the share which should be borne by the coal-cutting operations.

THE IMPORTANCE OF ADAPTING THE MACHINE TO THE MINE.

Earlier in my remarks I ventured to point out that a machine which gave excellent results in one mine might prove a failure in another. In other words, each mine must be separately studied and a suitable type of machine introduced to meet the particular requirements.

As an instance I may quote the case of a mine of hard coal, 4 feet 6 inches thick, with 12 inches of "ley" which came down with the coal.

A Gillott's machine was first put to work on a face 90 yards long.

The price paid for hand-holing, including the removal of the ley, was 2s. 8d. per ton, the coal being worked on the face. The Gillott machine worked on the end and holed about 2 feet 10 inches under the coal. Shots of 3 oz. had to be put in every 2½ or 3 yards apart to break the coal down, and this, together with the large amount of pick work necessary, gave no advantage as regards the proportion of round and small which remained the same, viz.: 50 per cent. of each, and the cost was about the same as for hand-holing.

The Gillott machine was therefore deemed unsuitable for this mine, and a Diamond machine cutting 4 feet 6 inches under the coal was introduced. The results were remarkable, the proportion of round coal was increased by 22 per cent. Instead of shots being fired as stated, only one 3-oz. charge was required every 20 or 30 yards, and sometimes no blasting was necessary.

The saving in cost per ton was as follows:

	Hand worked.		Gillot's machine.		Diamond machine.	
	s.	d.	s.	d.	s.	d.
Cost for cutting and clearing the dirt from under the coal	......		0	4·25	0	4·0
Paid to collier for filling, timbering, cutting out and packing the "ley" and drawing the tubs up to 200 yards	2	8	2	3·50	1	8·0
Power, say	....	..	0	1·00	0	1·0
	2	8	2	8·75	2	1·0

The saving in favor of the Diamond machine was nearly 7¾d. per ton, to which must be added 1s. 0½d. per ton increased selling price, due to an increase from 50 to 72% of round coal, making a total gain of 1s. 8¼d. per ton.

It should be explained that in this particular case a block of coal was being worked out which had been left in the midst of old works and pillars for more than 20 years.

During the time occupied, rather under 12 months, no repairs were necessary to the machines. The sharpening was done by the smiths, together with the colliers' picks, and no separate record was kept. The pipe-laying was done by the machine men.

In another mine 3 feet 6 inches thick, two machines recently started are now working on the "end" of the coal. One machine is a Gillott, the other a Diamond. The underclay is too hard to hole in so that both machines hole in the coal, which sticks to the roof and the floor. The Gillott machine leaves three or four inches of bottom coal which has to be got up with the pick, and the cut is not deep enough to cause the coal to break away from the roof, consequently there is a lot of pick work, the proportion of small coal is high and the cost is nearly the same as for hand-holing.

The Diamond machine, on the other hand, cuts to the floor level, and leaves no "bottoms" on, whilst the deeper cut (4 feet 6 inches) causes the coal to break away naturally in large blocks. No explosives have been used in this mine for coal getting, and with the latter machine the necessity for blasting would almost appear to be removed.

The comparative costs per ton are as follows:

	Hand worked.	Gillott machine.	Diamond machine.
	s. d.	s. d.	s. d.
Cost of cutting	......	0 3·25	0 2·25
Paid to collier for filling, cutting out, timbering, and drawing the tubs up to 100 yards	2 4·5	1 11	1 3
Repairs to machines, sharpening, etc., not taken into account in either case	......	......	......
Fuel and wages for power, as per test No. 1	......	0 0·99	0 0·99
	2 4·5	2 3·24	1 6·24

The saving in favor of the Diamond machine is 9d. per ton. The increase of round coal from 50 to 74% is equal to 1s. per ton on the selling price; the total gain in favor of the Diamond machine is 1s. 9d. per ton.

PERCUSSIVE MACHINES.

Hitherto I have referred only to machines suitable for longwall faces; our application of mechanical coal-cutters, however, also includes machines of the percussive type, usually described as mechanical picks.

For certain purposes we have found these to be most useful appliances. Of course, they cannot compare with the disc machines in longwall working, nor are they intended for that purpose. We have employed the Ingersoll-Sergeant and the Champion machines for heading out purposes. Both are perhaps capable of further improvement, but they have good points, and the results with them are very encouraging.

The Ingersoll can be transported from place to place intact. It requires considerable skill to work it to the best advantage, but when the knack of working it properly is acquired a good man can undercut with one machine an average of four places, each 10 or 12 feet wide and 3½ feet deep, in a shift of nine hours (including meal times), and also flit the machine from place to place, provided the headings are not too far apart.

The Ingersoll makes a cut something like that made in hand holing, *i. e.*, high at the front and tapering out at the back of the cut, so that the proportion of small coal is not appreciably reduced when holing in the coal; but these machines will hole in the underclay, which would be too hard for hand-holing.

The Champion machine, on the other hand, is capable of doing an equal amount of work and of making a parallel cut of a uniform height of only about three inches in any desired position, and is equally applicable to flat or steep seams. We have found it a very handy and useful machine. It is not difficult to transport it, but if it could be designed for removal without the necessity of taking it to pieces it would be a great improvement.

A great advantage with this machine is the fact that it is easily learned, and manipulated at less cost than some other heading machines. With it a seam would yield a larger percentage of round coal, and when fixed a lad can work it.

There is a difficulty in working the Ingersoll in steep seams; but, on the other hand, it can be employed to advantage in thick seams where there *might* be a difficulty in applying the Champion machine owing to the extra length of standard required.

We have found both machines very useful in cutting the necessary strait work through the shaft pillar, and also in driving to the boundary in the case of a mine which is to be worked by means of disc machines on the system known as "longwall retreating."

We have a seam 2 feet 8 inches thick which is too costly to work on the pillar and stall method, the field rate for strait work being 6s. per ton. On the other hand a very bad roof makes longwall working very costly, on account of the expense of maintaining pack roads. In these circumstances four Ingersoll machines were introduced to cut out to the boundary. The levels through the solid coal are 35 yards apart, with cut-throughs only, as required for ventilation. These levels are to be carried out to the boundary, and the intention is, when the boundary is reached, to work the coal out by a retreating longwall face with disc machines.

The cost of driving the levels with the Ingersoll machine is:

	s.	d.	
Collier for getting the coal down, filling and drawing the tubs	2	3	per ton.
Cutting	1	0	"
	3	3	per ton.

as against 6s. per ton by hand.

The places are 12 feet wide and 9 inches of ley is got down by the collier, after which the roads stand without further expense.

We also have a seam of the following section, viz.:

	ft.	in.
Coal	1	8
Very hard dirt parting..	2	5
Coal	2	4

A down brow was being driven where water proved very troublesome. It was very costly working by hand, and not more than two yards per week was driven. An Ingersoll machine was put to work, which holed in the middle dirt on the top of the bottom coal; four yards of this coal was always left on to keep the water back. By this means the brow was driven 10 to 12 yards per week.

The places are, of course, driven in considerably less time than would be possible by hand-cutting.

These punching machines require an air pressure of from 50 to 70 pounds per square inch. The higher the pressure the better results will be obtained from the machines.

To facilitate the working of either of these punching machines it is important that the necessary platform for the Ingersoll, and the packing pieces for the Champion machine should be provided in each working place.

General Remarks.

POWER.

The working of coal-cutting machines is, of course, a case of power transmission. My own experience relates to compressed air power only. I have no personal experience of electricity for this particular purpose.

I am anxious that the fact of all the coal-cutting machines at the collieries referred to being operated by compressed air shall not be interpreted as an indication of any want of confidence on my part in electrical energy. I believe that good results are being obtained by electrically driven machines.

It is with regard to compressed air that I have to speak, and I would here call attention to several details which enabled certain difficulties to be overcome. It is remarkable how largely the operations are affected by what are apparently minor details. It is to be feared that in many cases where the operations have been unsuccessful, the real cause of failure has been some minor detail which has perhaps not had sufficient attention, or has probably escaped notice altogether.

In working a coal-cutting machine it is necessary to provide ample power. The load is most variable and difficult to estimate.

Pipes conveying the air are often too small, necessitating a high velocity of the air, which means great loss of power in frictional resistance, and a low pressure at the machines. Often the initial pressure of the air is too low; it should never be below 50 lbs., and 60 lbs. is better, although not by any means too high.

We usually put in pipes of the following dimensions, viz., pipes of 5 square inches area up the gateways for supplying one machine, but this size of pipe should not be longer than 150 yards. The pipes from the bottom of the gateways to the bottom of the pit shaft, if not too great a distance, should not be less than 7 square inches area, and pipes of a rather larger area from the compressor and down the shaft. The area of the pipes should be increased in proportion to the number of rotary machines intended to work off them.

Difficulties are sometimes experienced with ice forming in the exhaust ports of the machine. This is an inherent trouble with compressed air motors, but the trouble may be reduced to a minimum. We have succeeded in overcoming the difficulty in rather a simple way. As near to the machine as may be convenient we place a receiver—a cast-iron pipe of 18 inches to 2 feet diameter × feet long. The inlet air enters at one end of the receiver. The opposite end is closed. The outlet pipe leading to the machine is connected to the receiver *at the top near the other end.* This has the effect of deflecting the air and of separating from it a large portion of the moisture, which is thrown down and collects at the bottom of the receiver, from which it can be drained from time to time by means of a tap. Whether this is a true explanation or not, it is a fact that since the adoption of these receivers, with the outlet pipes at right angles with the inlet pipes, we have had no trouble with freezing either at the coal-cutting machines or hauling engines.

The flexible hose used for coupling up from the machines to the air pipes is rather expensive and should be taken great care of, and put out of the way when not actually in use. The iron or steel pipes should be extended from time to time, and so arranged as to enable the machine to be connected with not more than four 30 feet lengths of hose, service taps being provided on the pipe line every 40 or 50 yards for the purpose.

Pipes with screwed joints are not to be recommended, nor are spigot or faucet joints. Flanged pipes which can be coupled together at either end, with joints such as the Acme and the Eadie joints, are generally to be preferred as being more easily handled.

Pipes conveying compressed air should be so fixed that the joints are visible so as to detect any leakage; and out of the way so that the flanges cannot be damaged either by a fall of roof or a passing tub.

DUST AND NOISE.

A great objection to air-driven machines is the great noise of the exhaust and the clouds of choking dust in a dry mine. The exhaust in the Gillott and certain other machines blows directly on to the floor. The best remedy for this is a baffle plate of sheet-iron fixed under the exhaust which not only deadens the noise to some extent but overcomes the difficulty from dust almost entirely and keeps the bearings of the machine clean and cool.

TYPES OF DISC MACHINES USED.

The Gillott machine is the one we have used more extensively up to the present, but the Diamond machine possesses a number of important features which greatly enhance its value, and, as I have shown, it gives better results under certain conditions.

The Diamond machine does not take up so much space in width, but on the other hand it is somewhat longer than the Gillott, and whilst it permits the row of props being set nearer the face, it is not always so easy to handle, where its extra length might take up too much room. The Diamond can *also* be made to cut actually on the floor level. The several sizes of this machine cutting from 3 feet to 6 or 7 feet in depth renders it more adaptable to varying conditions. The simple mode of attaching the cutters is excellent.

I should also say, that, where a depth of undercut not exceeding 3 feet is sufficient, the Gillott is a very handy machine.

I should like to mention here that I do not believe all mines can be successfully and profitably worked by machines. We have more than one seam where I feel sure the introduction of machines would prove a failure.

SAVING OF TIMBER.

It has been mentioned that one of the advantages of machine cutting is the reduced cost of timber.

This is not because a smaller quantity of timber is actually in use, but rather because the amount of lost and broken timber is less.

With hand-holing and a slowly advancing face, the weight comes on and breaks the timber. With machine-mining the faces move so quickly that the timber can be withdrawn and reset before much of it is called upon to carry any great weight.

REPAIRS.

With regard to repairs, when a machine seriously breaks down, we find the best plan is to send it up the pit to be thoroughly overhauled and put in good working order before it is allowed to be put to work again. In the meantime, one of the reserve machines will have been brought into operation.

The plan of tinkering at a disabled machine in the mine is not to be recommended; no doubt a machine can be patched up to continue working for a short time, but sooner or later it will break down again and cause delay, and the last state of the machine will be worse than the first.

SPEED OF CUTTING.

By way of showing what is possible with coal-cutting machines, on one occasion we made preparations for a special test with a Gillott's machine.

To give a quicker rate of advance the usual propelling gear was modified. The hauling rope, instead of being passed round a pulley attached to a prop ahead of the machine and brought back to the drawbar of the machine, was paid out singly for a distance of nearly 70 yards and secured to a prop. This gave not only a greater length of travel without having to stop to readjust the hauling rope, but also doubled the usual speed of travel.

Every facility was given for straightforward cutting, and the rails were laid well in advance of the machine.

The distance cut along the face was 65 yards, the depth of cut 2 feet 10 inches, and the time occupied 67 minutes.

Of course, this was a special test, and does not represent the usual rate of cutting, but it shows what is possible for a short time under very favorable conditions.

THE MINE OFFICIALS AND THE MACHINES.

For the successful working of coal-cutting machines it is very desirable, indeed it is most essential, that the mine officials, although not themselves operating the machines, should be capable of doing so if occasion should arise. At least they should be quite familiar with the details of the machine and its operation, otherwise it is possible some machine men may be inclined to impose upon them and give all manner of excuses to account for slow progress or unsatisfactory work.

Some machine men will not hesitate to take advantage of the inexperience of the officials, as the following instance will show.

In one of our collieries a machine had already been introduced before my employers took it over. The machine had only worked intermittently and with indifferent results. The men alleged that the machine constantly broke down, and although the face was only 70 yards in length they only occasionally cut across it in 14 hours. We changed the officials; the new under-manager, a man who knew a coal-cutter when he saw one, personally superintended a cut. Operations were commenced at 5.30 P. M., and at 9.30, four hours later, completed the 70 yards. The men recognized the new intelligence, and afterward breakdowns and stoppages were few, whilst additional machines were introduced.

In conclusion, I will give another source of trouble at one of our collieries which was alleged to be a want of air pressure. The machines were not giving good results and were making slow progress. The engineman insisted that the pressure had been kept up all night. An automatic pressure recorder was fixed, to make a chart showing the exact pressure of the air at any moment during the 24 hours. In the face of the indisputable evidence of this instrument the men recognized the futility of their old excuse, and there were fewer complaints of want of air pressure.

The President said: "I feel sure the Society is to be congratulated on the fact of having had a paper on coal-cutting from Mr. Hughes. He has more coal-cutting machines at work than any one else in this part of the world, and he was really the right man to give us a paper on the subject. I am sure we shall all be agreed that the paper, if not the best written on the subject, comes very near being so. So far as I can judge it is full of practical information, and put in a way that mine managers can understand. He has not been shy in giving us the cost. In some quarters there is a shyness in regard to matters of cost of machines in comparison with the cost of labor."

Mr. Smethurst moved a vote of thanks to Mr. Hughes for his valuable communication.

Mr. R. Winstanley said he had pleasure in seconding the motion to Mr. Hughes, who had passed several years at collieries under his own supervision. He was consequently proud to know that Mr. Hughes had followed up his early training and paid such attention to the subject of machine coal-cutting, as was revealed by his paper.

The motion was cordially approved.

Mr. Garforth—I think the paper is one of the best I have ever listened to, and I endorse all that the President and others have said in its praise. I am rather surprised at some of the figures given by Mr. Hughes. They are better than I expected; but, as he says, every seam requires different treatment, so that a machine while suitable in one seam may be a failure in another. In one of the mines which I am associated with we have a large quantity of work done by machines. Out of a total output of 553.000 tons, 420,000 tons were cut by machinery, and I am glad to say we are raising over 1,000 tons a day as the product of machines in one seam of coal which has been at work for nearly four years without a single accident occurring at the coal-face. Immunity from accident is a matter which I should like to see referred to by Mr. Hughes. The advantages which we gain as regards safety and freedom from accident are, I think, the most pleasing features connected with coal-cutting. But there are many interesting points connected with the introduction of machinery which will lead to a more scientific system of mining. A straight line of cut produces a straight line of fracture, and that leads to a straight line of timbering, which I believe will overcome many of the difficulties now met with in attempting to introduce systematic timbering. That is a large question, but if at some future time you would like to see 50 or 60 photographs I have had taken in connection with this subject, and which may help in this discussion, I need not say with what pleasure I shall have them brought here. I have only to congratulate Mr. Hughes once more on his very good and practical paper.

Mr. Gerrard—May we take that as an offer?

Mr. Garforth—Yes; I may add that judging by the fact that the photographs have been exhibited on two different occasions by request, members will understand they may be of service to those who have not had much experience in coal-cutting.

Mr. Dury Mitton—I have listened with very great interest to Mr. Hughes's paper. I made a few notes of pertinent things to ask questions about, but Mr. Hughes has forestalled me by answering, in his paper, the points I thought of, which shows how fully he has covered the ground. I was rather surprised, as the last speaker said, at some of the figures. In regard to the increase in the yield of coal, I should like to know how Mr. Hughes arrives at his percentage—whether he took the whole of the coal coming out of the mine or not. His figure seems to me rather high. He does not mention anything about depreciation for coal-cutters in his comparison between the cost of hand labor and machine work. I think that should be taken into consideration for there is a large amount of wear and tear. He gives so much for repairs, but the amount he mentions is very low, when you come to think that they do wear out and have such a heavy strain to bear. A few weeks ago I was watching two coal-cutters at work in a 3-foot mine with very hard stone underneath, and it struck me that the Diamond machine was the most successful. It was undercutting between 60 and 70 lineal yards a shift, and there was no trouble with it; but the other was working very unsatisfactorily, namely, the Morgan-Gardner machine. It struck me that with a rotary machine we seem to get more power than with a chain machine. I was also impressed with the immense amount of sparking given out by the Morgan-Gardner machine, whether that was due to the fact that the power was not directly applied at the end of the holing or not I cannot say, but if the sparking resulted from that fact it certainly was unfavorable to that machine which was only cutting about 30 yards in one shift. That was the only experience I had had of the Morgan-Gardner. It would be interesting to hear further on this point as the sparking from the cutters is a danger. I should like to ask Mr. Hughes as to the pressure of air he has on his rotary machine.

Mr. Burrows said there was everything in favor if the deep cut if the coal could be filled out quickly. He wished to know if Mr. Hughes made a point of clearing the coal out each day.

Mr. Pilkington asked if Mr. Hughes could say which was the best machine to use when a steep mine had to be dealt with. The dip of his mine was 1 in 3½, and he had three kinds of machines at work. The machines had not been working long enough for him to be able to come to a definite conclusion.

Mr. Percy Wood said his experience had been that the Gillott machine holed too deep, and he was much surprised one night while watching it cutting, perhaps, four or five yards. As it cut along there was not a spade full of coal obtained from the machine. The coal dropped down, and practically every particle of it was removed by the machine, being ground up to dust and mixed with the dirt in which the machine was cutting. They had therefore to stop the machine because it was cutting too deep, and that was principally on account of the machine working along the line of the cleavage in the coal. Probably it would be better if it was worked across the line of "shut." As to the cost of repairs, his experience had been very different from that of Mr. Hughes. They had one machine, and after working two months it had to be brought out of the pit and, practically, they had to repair a good half of the machine.

If necessary repairs went on at that rate the machine would be worn out in twelve months.

Mr. Hughes, in replying, said the pressure of air was from 50 to 60 lbs. per square inch at the compressors. He knew of a Gillott machine which had been working for 12 years, and he was informed that it was in as good condition now as it was six or seven years ago. The stated percentages of slack made by the machines and by hand-holing, were the results of special tests which were made periodically. With regard to Mr. Burrows's question in the case of the mine, 4 feet 6 inches thick, he thought that for six months a day never passed without the loose coal being cleared from the face; the drawing roads were made 20 yards apart, with a temporary, or what was sometimes called a blind road, between these, but in another case where the coal face was 250 yards long and there was only one machine to do the work with which they had not been able to clear the coal out every shift. Of course, it was intended to put more machines in. If we had a machine making a cut, say 4 feet deep, and sufficient machines to cut across the face each day, it would help to get the coal out sooner if the drawing roads were arranged as already stated. It was also advisable to have the drawing roads near each end of the face closer together to enable the coal to be cleared out quickly so as to allow the machine to be put to work at the proper time. As to there being any difficulty in timbering in conjunction with the deeper cut, his experience showed that the roof could be controlled much easier. He had had no experience of machines working in steep mines, so could not say which form of machine was the best for working them. In reply to Mr. Wood, if the coal came over on the machine when working on the face of the coal, the difficulty might be remedied by putting the machine on "half end." If that would not answer he would put it to work on the "end" of the coal, and if not satisfactory then he would take the machine out of the mine. In regard to repairs it was expensive to send fitters down the pit to repair machinery. If the necessary repairs were so extensive that the man in charge of the machine could not put them right, he found it was much cheaper to take the machine out of the mine to the fitter. A great deal depended on the care taken of the machines by the machine men. On more than one occasion men had been discharged because of the frequent repairs that their machines required.

The President suggested that the meeting had perhaps lasted long enough, and that it would be well to defer further discussion until the paper had been printed and placed in the hands of members. With regard to the question of financial gain, he wondered how it was that coal-cutting machines were not used in every mine if the gain was, as Mr. Hughes said it was in his case, from 10d. to 1s. 9d. a ton. Tenpence would be a handsome profit, but 1s. 9d. was very great. He was not certain that in considering the machines they were quite fair. There was the point about the increased quantity of round coal. In a large number of cases the increased quantity of round came from the fact that the machine holed in dirt and the man in coal. He wanted to know whether the machine could hole in dirt that a man could not hole in. He knew it was usual for the collier to hole in coal, but it was a matter of custom, and he did not think it fair to give all the advantage to the machine cutter. There were many mines in which if the men were willing they could hole in the dirt, and if the masters were willing to give them threepence a ton more probably they would gain this additional advantage of round coal. Then they did not take into account the quality of the slack. That which the machine made was almost worthless, but the slack which the man made was not so. Two-thirds of it would make "nuts." Of course, machines made less of it. As to sparks, there seemed to be some doubt whether sparks would light gas or not. He had occasion to make a test the other day, in connection with an explosion which could not be accounted for. One person said it was caused by sparks. He took the man who held that view to a colliery where there was some gas coming up a pipe from the workings below. Bunches of sparks were produced by striking a steel pick against ironstone, but they did not succeed in lighting the gas. Afterward they lighted household gas quite readily by the same means. He had never been satisfied that sparks, ordinary sparks—

he was not speaking of electric sparks—would light gas in mines, and hence he did not think they had much to fear from coal-cutters striking sparks on pyrites or anything of that kind. One point which he thought was in favor of machines—was that by their means it seemed possible to do away with the blasting of the coal almost entirely. He understood that Tonge's Hydraulic Cartridge had been found to be quite capable of getting the coal after it had been well holed by a machine coal-cutter.

Mr. Garforth—As to sparks produced in the process of holing I do not remember a case during thirty years where they have caused an explosion. Gas lies near the roof, the cutting is generally done near the floor, producing a certain amount of dust, which smothers the sparks that are given off. As regards electric sparks produced at the brushes or commutator, I have made some experiments with enclosed electric motors in a highly explosive mixture in a specially constructed chamber on the surface. I used a mixture consisting of 10 per cent. of manufactured gas and 90 per cent. of air. In six recorded experiments we have not had a single mishap with the enclosed electric motors, while in every case with open type electric motors we have been able to ignite the gas surrounding the machine.

Mr. Dickinson—Now and then one sees a spark of greater intensity than ordinary sparks, and also there is the difficulty in the fire damp varying in proportion to the mixture of air, and also in the purity of the gas which sometimes makes it more highly explosive.

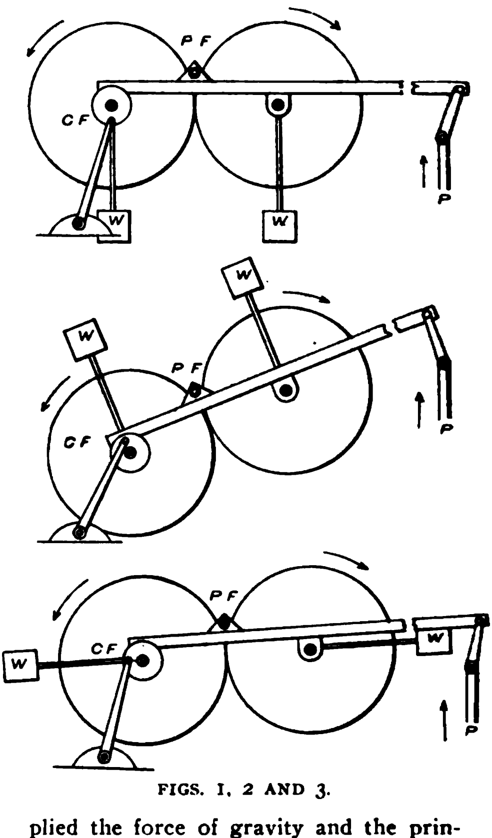
Mr. Tonge, referring to the President's remarks on the lighting of gas in mines by ordinary sparks, and also to Mr. Dickinson's saying there were varying proportions of air and firedamp, and also in the purity of the gas, "which sometimes makes it more highly explosive," said he would like also to point out the fact that there was occasionally a certain percentage of carbonic oxide (carbon monoxide) present with the carburetted hydrogen; and as this gas ignites at a temperature of 1184° F., which is more than 400 degrees Fahrenheit below the ignition point of firedamp, there can be little doubt but that this is sometimes the cause of gas being fired unexpectedly.

A New Air Compressor.

In a recent issue of the *Engineer*, W. E. Fish, of Kirksville, Mo., writes of a new air compressor which has recently been invented by a man in his town. Through the courtesy of the *Engineer* we are able to publish this article with the original illustrations.

Mr. Fish's contribution is as follows:

"In this machine, the inventor, Mr. C. J. Pollock, of Kirksville, Mo., has ap-



FIGS. 1, 2 AND 3.

plied the force of gravity and the principal of levers in a very ingenious way.

"The figures show the principles upon which the machine works. It is a series of compound levers. The crank is a revolving leverage with the crankpin as a shifting fulcrum. Fig. 1 is, as it stands, ready to start on the upward stroke; power is applied by a steam cylinder at *P*, the end of the oscillating frame. Fig. 2 is the position at the top of the stroke with weights, *W W*, ready to start downward by gravity.

"Fig. 3 is at one-half stroke downward: As the crank-fulcrum, *C F*, nears the bottom centre it acts as a toggle-joint, giving tremendous force at the end of the stroke, so that the energy stored in the radial weights, *W W*, is used when most needed.

"Being the first design, and built in a small shop without the aid of a draughtsman, the compressor is a very crude, awkward looking affair and not well proportioned, but it has given some interesting results. It is 80 feet from the boiler, which carries a steam pressure of

FIG. 4—THE AIR COMPRESSOR.

65 pounds, supplied through 50 feet of 1¼ inch bare pipe. The steam cylinder is 4⅞ by 28 inches, and steam is cut off at 16 inches, and exhausted at 24 inches; 4 inches not being used by reason of the angle of the oscillating frame. The weights having been raised, fall by gravity, compressing the air in a cylinder 5 9-16 by 24 inches (one-fourth larger in area than the steam cylinder) into a receiver at 140 pounds pressure. By reason of the fulcrum at the crank continuously growing shorter, the power increases as the piston descends, giving a maximum at the end of the stroke, just where it is needed. The air compressor runs with this load at 60 revolutions per minute. The design has been very much improved since the first machine was built, making it more compact."

Working Granite with Compressed Air Tools.

An industry in which pneumatic tools bid fair to effect a revolution is the working of granite. Up till a few years ago the granite tombstones which are to be seen in every cemetery, and the elaborately carved granite blocks which are now so popular for the fronts of banks and public houses, were dressed by hand with a hammer and chisel in much the same way as we may suppose the Egyptians carved the Sphinx. Now a jet of air is doing the mason's work, and instead of expending much time and muscle on his task the workman has simply to guide the pneumatic chisel over the surface of the stone. The saving in manual labor is very great. The work is done more rapidly and more cheaply by these tools than by hand, and it might also be said more efficiently, for a pneumatic chisel can be operated in recesses and out-of-the-way places in which there would not be room to strike a blow with an ordinary hammer.

Aberdeen is the centre of the granite industry in Great Britain, and there is no granite working establishment there of any consequence which has not an equipment of pneumatic tools. The heart of a pneumatic plant is the compressor, or pump, which forces the air into a large tank or reservoir. From this central point the air is conveyed in pipes to all parts of the works, and the connection with the actual tools is made with a length of india rubber hose so that the workman can move the apparatus from place to place.

Where a workman would have had a hammer and a chisel in his hands, now he has a pneumatic chisel, and he has simply to direct it in the required position. The number of blows that a tool like this strikes is marvelous. The jet of compressed air operates a piston, to which either a hammer or a chisel can be attached, and the admission of the air can be so regulated by valves as to give anything from 2,000 to 15,000 strokes a minute. As might be supposed, the vibration caused by such a rapid movement as this is very great. A visitor to a granite yard is generally given one of these pneumatic tools to hold, and unless he grips it tight it is apt to jump out of his hand. One could think that the constant use of such tools would injure the workman's arms and lead to cramp. So far, however, there have been no instances of this.—*London Sphere.*

Displacement Pump.

Simple in construction is the new displacement pump illustrated herewith which the Latta & Martin Pump Co. of Hickory, N. C., has placed on the market. A valve at the top of the pump is so constructed that compressed air can enter

DISPLACEMENT PUMP.

only one cylinder at a time and the air so entering forces the water from the cylinder by displacement. When all the water is expelled from that cylinder, the small copper bucket in the same, being unsupported by the expelled water, operates as a weight, and by pulling down the small lever in the valve, actuates a trip for releasing the exhausted air, and at the same time turning the compressed air into the other cylinder where the same operation is repeated. It is claimed that with this system water can be pumped from any distance against any elevation and in any quantity, the operation of the entire system being at the same time controlled at will by the engineer in the boiler, engine or power room, wherever located irrespective of the location of the water supply.

The Combined Straight-air and Automatic Engine and Tender Brake.*

With the advent of the modern powerful freight engine a new condition in train braking arises, a condition heretofore comparatively unknown, viz., stopping long trains without breaking in two. If the brake is held on until the train comes to a full stop, this danger is eliminated, but the trouble is in enforcing the rule governing this feature. A close personal check of the causes of break-in-twos where long trains are handled with heavy power showed that 78 per cent. were due to releasing at slow speeds.

On our division of less than 120 miles the usual number of break-in-twos monthly run from 40 to 48, or an average of 44 per month. Seventy-eight per cent. of this equals 34.32. Of these about 20 per cent. were broken couplers, requiring renewal. About 45 per cent. were broken knuckles, the remainder being due to other causes. The cost for renewal of these broken couplers and knuckles, less "credits," would equal $84.56 monthly, or $1,014.72 annually. But the cost of labor and material for break-in-twos is but a small proportion of the actual cost. When the cost of detentions and train delays and frequent damage either to equipment or to lading on account of trains parting and running together are considered we can readily see the necessity for some device that will aid in checking this evil. The last Car Foremen's Association report gives us a cause of trains parting: "Release of brakes at slow speed without proper resistance on the engine or head-end cars." Among the recommendations made to overcome this evil is the following:

"We would recommend that all engines in road service be equipped with straight-air; or if this does not meet with the approval of the officials, it would be necessary for the superintend-

* Extracts made by the *Railroad Gazette* of a paper read before the Traveling Engineers' Association by Frank P. Roesch, of the Chicago & Alton R. R.

ent to issue bulletins to trainmen requiring that where slow-downs are made, where the speed is not to exceed 8 m.p.h., that the train be brought to a full stop, or have the trainmen set up about six retainers on the head end of the train or set at least from four to six hand brakes. The application of straight-air on the locomotive, however, is the best method of overcoming break-in-twos from this cause."

With the increase in locomotive power, the train length has increased proportionately, and as the brakes release on the head end first, the increased train length allows the full release on the head end of the train while the rear brakes are still set. This causes the surge and damage when brakes are released at slow speeds.

Another new phase in railroading due entirely to increased power and the demand for quick movement is the increase in size and power of yard and switch engines. The larger types of freight engines hauling such immense trains into the yards required a proportionate increase in capacity of yard engines to handle these trains. This necessitated a more efficient brake to handle these trains expeditiously, as with the present or automatic brake it was soon noticed that the repeated heavy reductions required gave insufficient time for recharging, thus reducing the holding power of the brake and causing the engineer to put more dependence in his reverse lever than in his driver brake, naturally resulting in a slower movement and greater damage, not only to his engine, but to equipment and lading as well. It was in the train yard that the first demand was made for a more flexible brake and it was ably met in the new combined automatic and straight-air brake.

In order to ascertain the extent of its use at present and the success it has met with, a list of questions was sent to members. Twelve roads reported having the device in use.

In regard to the cost of maintenance over the plain automatic brake, the replies from members having used the device for periods of from six to eighteen months show that the cost for repairs as yet has been nil.

Other advantages not spoken of previously are as follows:

1. It quickens switching and reduces the incident damage to lading and equipment. It has been estimated that the time saved by a yard engine equipped with this device over one equipped with the ordinary automatic brake, if expressed in dollars and cents equivalent to wages of crew, is about $1.25 per day. At this figure it would pay for itself in one month.

2. If the brakes are released on long trains, it prevents the slack from running out and the train from separating, especially at low speeds.

3. It prevents the slack of long trains from running in or out so suddenly, by reason of change of grade (sags or humps) or curvature, as to cause serious shocks and breaking in two.

4. It can be used to slow down or stop trains where the brake work required is not heavy, thus reducing pump labor, stuck brakes, wheel sliding and the breaking in two, incident to starting long trains with the brake-shoes dragging, or sometimes brakes stuck on cars toward the rear of train—a not uncommon result with automatic held on until the stop is made.

5. It prevents the slack from running out and aids the car retainers in controlling speed while descending heavy grades.

6. It holds the train and engine and enables the automatic brakes to be recharged when standing on grades, thus having the train brakes ready for immediate use at the start. It increases the safety when work requires that someone go under the engine, rendering it impossible for the engine brake to leak off. The latter prevents the possibility of the engine getting away when no one is present, even though the throttle leaks.

7. It enables control of speed while weighing cars.

8. It increases the mileage between tire turning, where tire-dressing shoes are used.

9. It decreases repairs to the automatic brake valve and the foundation rigging by reducing the use of the brake valve in emergency applications, something practiced by hostlers and yard enginemen everywhere.

The only disadvantage, if it can reasonably be classed as such, is that it requires additional parts. But these reduce rather than increase the labor and expense of engine brake maintenance, with one exception, that it requires more frequent adjustment of driver and tenderbrake piston travel than with the automatic alone, due to the increased labor these brakes perform. To offset this, however, there is less reversing of the engine.

The double-check valve and straight-air valve are the only additions to standard brake parts. Several of these have been in use for nearly two years and many for shorter periods, yet no case has been reported where repairs have been required. The only parts liable to require renewal are the small leather seats.

Transmission of Compressed Air for Power.

In connection with the use of compressed air for power purposes many questions of a more or less technical nature have to be confronted, and the one "Which is the most economical size of pipe to use for the transmission of the compressed air from the place of compression to that of consumption?" is by no means the easiest to answer.

It is evident to every one that the larger the pipe the greater will be the economy of transmission. On the other hand, however, the price of pipe increases so rapidly for the larger sizes that the point is soon reached when the interest on the increased first cost exceeds the saving due to the reduction of friction produced by the passage of the air through the pipe.

Only the other day the writer was asked which was the cheapest size of pipe to use on a certain job, everything considered. The inquirer was surprised that he did not get an offhand answer to the question, and evidently got the impression that the writer was not as much of an engineer as he claims to be.

An account of what the correct determination of the answer would involve may prove instructive to those busy business men who, although claiming that time is money, are constantly expecting their engineering friends to answer their technical questions gratuitously.

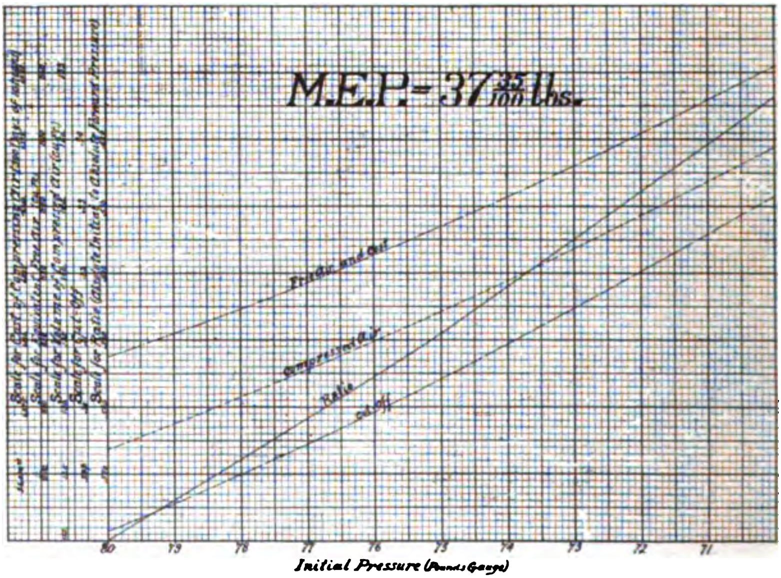


FIGURE I.

In the case under consideration a large compressor was furnishing air under 80 pounds gauge pressure for various purposes, and it was desired to also connect onto this compressor a pump situated in a mine 2,500 feet distant.

It was considered desirable to maintain

the present pressure at the compressor. The pump was of the fly-wheel type, having an air cylinder twice the diameter of the water cylinder. It was provided with a Meyer cut-off valve and was expected to raise 45,000 gallons per hour against a head of 300 feet.

The pressure on the water piston being gallons per minute, which equals 105.27 cubic feet. The air piston having four times the area, it must have a displacement of 421.08 cubic feet, which, when allowing 7 per cent. for clearance and ports, gives a cylinder capacity of about 451 cubic feet to be filled every minute.

The mean effective pressure equals 37.35

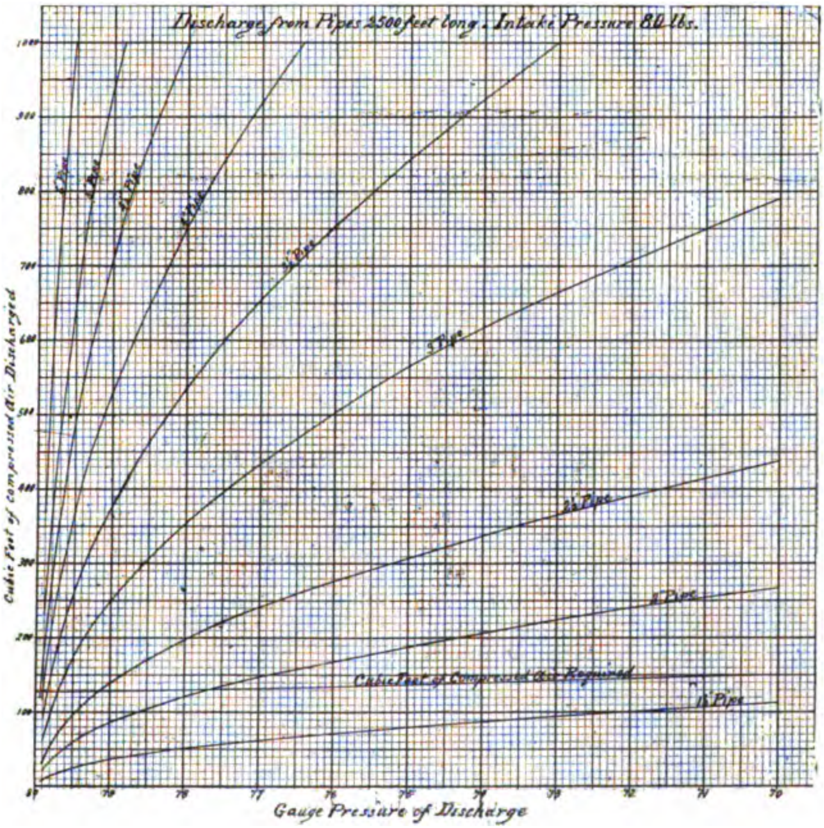


FIGURE 2.

300 feet head, or 129.9 pounds per square inch, and making an allowance of 15 per cent. for friction, we see that in an air cylinder of twice the diameter the mean effective pressure must be 37.35 pounds per square inch.

Again, the piston displacement in the water cylinder must be 750 gallons plus 5 per cent. (allowance for slippage), or 787½ pounds per square inch and is a constant. It must also equal the absolute initial pressure at the throttle valve times R and minus the absolute back pressure, in which R is the ratio of absolute initial to absolute mean pressure during the forward stroke.

In the case of a slow running pump exhausting direct into the atmosphere, we are safe in considering the absolute back pressure as equal to 14.7 + 1. = 15.7 pounds.

This gives, when P equals the throttle valve pressure, M. E. P. = 37.35 = P R − 15.7.

We know that for adiabatic expansion

$$R = \frac{2.451\left[1 - \left(\frac{1}{C}\right)^{.408}\right]}{C} + \frac{1}{C}$$

In which C equals $\frac{1}{\text{cut-off}}$.

We also know that P × volume is constant for a constant temperature.

Now, using this information and allowing ¼ of a cent as the cost of compressing 100 cubic feet of free air to 80 pounds gauge pressure, we are enabled to plot the following curves:

Having thus ascertained the number of cubic feet of air required, when compressed to different pressures, it remains to be determined what volume will be delivered by pipes of different sizes at various discharge pressures, but a constant intake pressure of 80 pounds.

The most generally accepted formula for the flow of compressed air in pipes is that of D'Arcy, which is

$$D = C\sqrt{\frac{d^5 (P_1 - P)}{w\, l}}$$

In which

- D = cubic feet discharged (measured at discharge pressure).
- P_1 = intake pressure (gauge).
- P = discharge pressure (gauge).
- l = length of pipe in feet.
- c = co-efficient or constant for given size of pipe.
- w = density or weight in pounds per cubic foot (measured at intake pressure).

By reference to tables for c and w this equation may be solved and plotted as shown below for various sizes of pipe, and if we again plot the curve for the required number of cubic feet of compressed air as found by chart No. 1, we can see at a glance the result of using any size of pipe.

We are now able, with the help of the above curves, to make up the following table, in which column four is figured for one year of 3,000 working hours:

Size of Pipe.	Cost of Pipe on the Ground.	10 per Cent of Difference	Cost of Compressing the Air if Said Size of Pipe is Used.	Difference.
2"	$281.25	......	$6195.00	......
2½"	449.25	$16.80	6157.50	$37.50
3"	589.85	14.06	6138.75	18.25
3½"	742.20	15.46	6135.00	3.75
4"	843.75	10.13	6133.50	1.50
4½"	1015.62	17.19	6132.50	1.00

It appears that, in the matter of first cost and running expenses, there is an advantage in favor of the 3-inch pipe. But this advantage is so slight that, when the probable temporary nature of such work is considered, we feel certain the 2½-inch pipe would be the best size to use on this job.

If the distance between the compressor and pump was less, the advantages of using a 3-inch pipe would be greater, while, on the other hand, if the distance was increased sufficiently, we should have to use a 3-inch pipe in order to get sufficient power at the terminus.

L. C. Bayles.

A Demonstration of Pneumatic Tools.

A demonstration of pneumatic tools was recently given at Westminster, London, England, at the works of the Consolidated Pneumatic Tool Company, which concern represents the Chicago Pneumatic Tool Company in England, and brought forth an emphatic endorsement from the usually conservative *Pall Mall Gazette*.

In describing the demonstration and commenting on the achievements of the pneumatic tools, the *Pall Mall Gazette* said in part:

"The underlying principle, as technicians are aware, is the application of air compressed in a high degree to tools of various construction, which automatically work a drill, or hammer, or what not, fixed at the end. The operator controls the instrument by a steel handle shaped to the hand like the haft of a saw, as well as by an arm formed by the joint of the air tube, and where he needs a hand to direct the tool more carefully, he can adjust the butt of the instrument to his breast or shoulder like an ordinary brace-and-bit. To see a fitter take up a breast drill and put holes through a ½-inch plate was an experience.

"A hand-sized rock drill was picked up from an unpicturesque heap, the air-tube was screwed up and the pressure shut on; in a few seconds the drill was nosing its way through a block of limestone. The only accompaniment to the grinding sound was a tiny fountain of white powder and dust coming away in a wisp of smoke. Mr. Diem added that lately an operator with this drill had bored three 5-foot holes while the older-fashioned tool alongside was being fixed upon its tripod. The entire weight of the drill was 40 pounds, it used only 42 cubic feet of air per minute, and a blast arrangement kept the hole clear of all obstructions, a point worth considering in boring without water. The tube was then switched onto a pneumatic chisel, and presently this was cutting pieces of the thickness of a Bock cigar from a steel plate set on end. It was equally effective in dressing stone. Another tool put a "tap" into holes already drilled, and another expanded and cut boiler-tubes away from the inside, so that they could be released from the end plate at a touch. The operator is relieved from the weight of the tool by a pulley arrangement and swung weights. Another tool, a hammer this time, put a head on copper stay-bolts with perfect roundness and finish, and this led up to the wonders of the tool as a riveter.

"The deck-riveter is, for the sake of easy transit, mounted on a sort of carriage, like an outrigger on wheels, and by its use a youngster of eighteen, it is claimed, rivets 2,000 rivets per day in one of the Birmingham shops. In the room, where three boiler-plates had been set up and bolted, rivets of an inch and a quarter thick were brought in from the forge and driven home in a fraction of the usual time; finished, moreover, with perfectly rounded heads with an excellent flush. The celerity attained with the ¾-inch rivet was amazing. One riveter keeps two forges going. Where a rivet is condemned, the head is chipped off, the drill is put through and the remainder is crumbled away, all by pneumatic process, and in a tithe of the time spent over a bad rivet in the ordinary way. In the open air we saw a Tynan heater belching air and oil-spray upon a ½-inch plate, and this burst of flame, when forced through a shaped fire-brick, narrowed the heated area down to the size of a shilling. A ½-inch plate, it is said, 3 feet across, has been rendered white hot inside of six minutes. Another development of the pneumatic idea was a giant nipper, which, at a touch of the hand, nipped a cold steel rod into pieces in a way to make a crustacean blush without boiling.

"Clearly, the possibilities of the pneumatic tool are enormous, and one fails to conceive, even by taking thought, all the uses to which it has already been put. An American workman has adapted it to the painting of tinware baths, and the paint is sprayed by a draft of air instead of being slopped about by hand, as it used to be. This means a surprising saving of time, not to mention the improvement in the evenness of surface. For similar work where enamel is used, the old process used to be to sprinkle it by hand or out of a pepper castor; the new process is to spread it on a disc or plate, and then tap the plate with a tiny air hammer going at 3,500 taps to the minute. But, after all, the chief conquests of the pneumatic idea have been in the dockyard and boiler-sheds, the machine shops and masons' yards of two continents. The invention is American, but that fact has in no way impaired its acceptance in Europe. The Flensburger Company, we learn, pays a bigger dividend, and possesses in its new yard more modern machinery than any other shipbuilders in Germany; it is a staunch user of pneumatic inventions."

The Report of the South African Miners' Phthisis Commission.

Publicity has been given to the report of the South African Miners' Phthisis Commission. This Commission was appointed by Lord Milner, December, 1902, to inquire into the extent phthisis prevails, to ascertain the cause of the disease, and to make recommendations as to preventative and curative measures, which should be adopted either by legislation or otherwise.

The Commission was composed of Mr. H. Weldon (Chairman), Dr. C. L. Sansom, Mr. R. M. Cutlin, Dr. W. T. F. Davies, Mr. Francis Drake, Dr. S. Hawarden, Mr. J. Harry Johns, Mr. E. Perrow, Mr. J. R. Williams, Dr. C. Porter, and Mr. J. Stratford (Secretary). The mine managers of the Witwatersrand were requested to allow the medical officers attached to the mines to supply information. In addition, upwards of 200 mines were circularized, but from these only forty-five replies were received.

The Commissioners state that miners' phthisis in the Transvaal is largely confined to miners who have worked for some time in metalliferous mines, and who have been engaged more particularly in rock drilling in the gold mines. Of the 4,403 miners officially declared to be working underground in the gold mines of the Witwatersrand, 1,210 were medically examined by the Commission. Of this number 187, or 15.4 per cent., were certified by the examining doctors to be affected by the disease, while a further 88 were suspected cases. These numbers quite confirm the impression as to the extent to which miners' phthisis prevails and the urgent need for preventative measures. Especially so is this the case when it is known that the malady cuts off men before their prime, for the average age at death is only 35.5 years. Of the 187 miners certified as suffering from phthisis, 20, or 10.7 per cent., gave a family history showing a tendency to pulmonary consumption. The malady seems to be especially prevalent among the rock-drill miners, for, of the 187 miners certified as suffering from the disease 172, or 91.98 per cent., had been employed on rock drills. The majority of these men had only worked 6.4 years on the machines. As some had worked in other countries than the Transvaal, they had therein, at any rate, incurred the risk of contracting silicosis. The detection of the disease in the early stage is not always easy. It is stated, and the announcement is very important, that there is no appreciable amount of tuberculosis among the miners.

The Commission specially investigated the following: (1) Character and harmful properties of the inorganic particles held in suspension in the mine atmosphere; (2) Mine ventilation, including the composition and quantity of the air circulating throughout the working places in the mine, also the composition of the gases given off during blasting operations; (3) Mine sanitation; (4) Living conditions of the miners.

During the operations of blasting, drilling, shoveling, etc., especially in the dry gold mines of the Witwatersrand, large quantities of dust are given off. It is a common opinion that the phthisis of gold miners, or silicosis, is a consequence of the inhalation of minute particles of inorganic material with which the mine is charged. In support of this belief there is the fact that while the disease is not entirely confined to rock drillers, yet it is more prevalent among them than in any other class of underground workers; also that of the different kinds of work undertaken by rock-drill miners, "raising" is the most dangerous, largely owing to the circumstance that in "raising" the holes which are bored by the rock-drill machines have an upward inclination, into which water is not usually injected, in contradistinction to boring "wet holes," which are either horizontal or have a downward inclination.

During the boring of a hole by rock-drill machinery there is sometimes as much as 0.185 grain of dust in a cubic foot of air. This dust on microscopical examination is found to be composed of exceedingly sharp-pointed siliceous particles. In order to combat the evil effects of dust, especially in mines where water is not available for laying it, the wearing of a respirator is recommended by the Commission. The Commission states that it is not in a position to recommend any special form of respirator.

As the Witwatersrand mines are ventilated mostly by natural means, the supply of fresh air in the mines varies with the atmospheric conditions on the surface. In the ends of drives, rises and winzes the atmosphere is harmful, since it is liable to be contaminated by noxious gases evolved during blasting or exhaled from the lungs and bodies of the miners. Systematic ventilation is therefore recommended, "so that fresh air may be caused to enter each mine in sufficient quantity to sweep through the drives (to within a reasonable distance from their ends), and thus dilute and carry away up to the surface the injurious gases and particles of organic and inorganic matter that may be held in suspension in the air." Attention is also directed to the composition of the air from the compressor and the danger that accompanies the use of inferior oils (or oils of low flash point) for lubricating the air cylinders of the compressor engine. Lubricants used for this purpose ought to be incapable of being decomposed into, or of giving off, injurious products under the conditions they are subjected to in the air cylinder of the compressor. A solution of soft soap can satisfactorily replace the oil.

While acknowledging that the bulk of the medical evidence points to miners' phthisis being the result of the action of dust upon the lungs, the Commissioners also discussed the point as to whether deleterious gases in the mines might not act as predisposing causes or tend to accelerate the disease. "Gassing" frequently occurs in the Witwatersrand mines. Before blasting, the air in the mines was found to contain: Oxygen, 20.38; carbon dioxide, 0.11; carbon monoxide, 0.13; nitric oxide, 0.0004; while after blasting the amounts respectively were 19.90, 1.59, 0.39 and 0.0078.

The Commissioners find fault with the general sanitary condition of the mines, the manner in which the disposal of human excreta is arranged for and the absence of provision of adequate facilities for washing, also for changing and drying the clothes of the miners.

Accidents Due to Combustion Within Air Compressors.*

The phenomenon described by Dr. Ledoux, involving an apparently abnormal high temperature in the air cylinders of compressors, has not been, so far as I know, discussed in technical literature. The common formula for the adiabatic compression of dry air does not account for heat sufficient to flash ordinarily decent cylinder oils, nor do the text-books include in their theoretical statements any quantitative consideration of the effect of leaks in the ideal machines which they contemplate.

At the beginning of the stroke the air in the cylinder has come from three sources, namely, that which was left in the cylinder clearance spaces on the previous stroke; that which has leaked in from the discharge valves and past the piston; and that which has been drawn in from the atmosphere.

The air which was left in the clearance had, when under compression, the temperature of the discharge; but on the retrograde movement of the piston it expands and performs work, falling in temperature to the temperature just previous to compression; therefore, the clearance air need not be considered in this investigation.

The air coming from the leaks expands from the high pressure of discharge to the low intake pressure of the cylinder, without performing work except in creating velocity in its own mass; but as it comes to rest in the cylinder, its temperature becomes that of the discharge.

The air is presumed to be dry and the compression adiabatic. I am well aware that compressors universally have water-jackets, but I credit these with no cooling effect on the air during compression. The lubricant on the cylinder walls and the thin film of air in actual contact with the jacketed surfaces may experience a slight cooling; but the mass of air is so remote from these influences as to be unaffected thereby. The presence of watery vapor in the air itself will sometimes keep down the temperature, and. more often, unskilful readings of a thermometer placed at a distance from the cylinder will give apparent results much lower than the temperatures actually existing directly at the discharge valves.

Applying the formula to a single-stage compressor, at sea level, compressing to 88 pounds or 7 atmospheres, the atmospheric air being at 62 degrees Fahr., we have the following temperatures of discharge, when the leaks of piston and discharge valves are as stated:

Leak.	Temperature.
0	459° Fahr.
0.01	466 "
0.02	475 "
0.04	489 "
0.06	506 "
0.08	524 "
0.10	544 "
0.12	566 "
0.14	589 "
0.16	615 "

EFFECT OF LEAKS ON TEMPERATURE OF COMPRESSED AIR AT SEA LEVEL.

This, however, is not a full presentation of the case of the single air cylinder compressor, for the reason that a very large proportion of compressors, in this country at least, are used at points high above the sea level—4,000 feet is a moderate assumption for an example.

* Abstract of remarks by Mr. E. Hill in a discussion of a paper by Dr. A. R. Ledoux before the American Institute of Mining Engineers, as published in COMPRESSED AIR for June, 1903.

The barometer would be at 25.7 inches, and to produce 88 pounds gage pressure of this thin air requires eight compressions. Therefore, at 4,000 feet the same heat is developed in producing 88 pounds as is developed in producing 8 atmospheres or 103 pounds gage at sea level. We have therefore:

Leak.	Temperature.
0	496° Fahr.
0.01	504 "
0.02	512 "
0.04	530 "
0.06	549 "
0.08	570 "
0.10	593 "
0.12	618 "
0.14	646 "
0.16	675 "

EFFECT OF LEAKS ON TEMPERATURE OF COMPRESSED AIR AT 4,000 FEET ALTITUDE.

Either of these cases—at sea level or at a higher altitude—shows the possibility of a temperature fully sufficient to produce gas from the oil lubricant and to cause it to burn, creating excessive heat and an increased development of gas, quickly followed by explosion.

It will be seen that there is a rapid increase in heat as the leak increases. The calculation is made on leaks which are percentages of the cylinder capacity. A leak is constant, whereas the intake of the compressor depends on the speed of the machine. It follows therefore that a leak of, say, 2 per cent. of the intake capacity of 125 revolutions becomes 10 per cent. when the compressor is slowed down to 25 revolutions per minute. This quite agrees with experience. In several cases of violent explosions brought to my notice the compressor was running slowly at the time. The oil feed was probably adjusted to the maximum speed of the machine, and thus was excessive for the slow speed. A larger proportional leak—a liberal quantity of oil—and the result is easily comprehended.

The remedy for these dangerous conditions is to have the compressor made with compound air cylinders. Such compressors, properly proportioned, when compressing to 8 atmospheres or 103 pounds gauge, would develop under normal conditions 245 degrees in each cylinder.

Compound compressors are less liable to have leaks than are single cylinder machines, because there is less difference in pressure between the discharge and the intake side of the pistons.

But in the best modern designs of compressors, the harmful effects of leaks are entirely overcome by causing the air which leaks past the pistons to go through an intercooler and to be thoroughly cooled before it again enters the cylinders for compression. This keeps the temperature down, and pressures of from 3,000 to 5,000 pounds are obtained without inconvenience or anxiety.

It should be remembered that combustion is more vigorous under higher pressure than in the open atmosphere. No doubt there is likewise an easier oxidation and a lower flash point for oil under pressure in the cylinder than under ordinary conditions outside. In many cases a noisome gas is generated and distributed in the mine long before the final explosion. Workmen at the front, instead of receiving pure, cool air from the exhaust of the drills or other machines, breathe a foul, stupefying and sometimes fatal mixture.

[This appeared in a recent issue of the *American Machinist* with the following comment: "We publish this more because it is an explanation of a serious matter offered by one whose opinion commands respect than because we agree that the effect of leakage is apt to be serious."—ED.]

Building the Cleveland Stone Company's Power Plant.

Readers of COMPRESSED AIR will remember the large compressed air power plant for the North Amherst, Ohio, quarry of the Cleveland Stone Company, mention of which has been made several times in these columns. Through the courtesy of the Ingersoll-Sergeant Drill Company, which concern has the contract for furnishing the complete plant, we are enabled to show the progress being made in its construction.

The accompanying illustration shows the two huge Corliss compressors being erected. The steam cylinders are in position, and the air cylinders are being connected. They are both of the Ingersoll-Sergeant Corliss condensing type with 48-inch stroke and have a combined capacity of 9,215 cubic feet of free air per minute.

What makes the plant of special importance in quarrying circles is not so much the size, which is nevertheless unusually large, but the fact that the entire power for the quarry is to be supplied by this plant which is installed by one company alone, and that certain radical changes in the whole system are planned, which, it is claimed, will greatly increase the output and reduce cost.

Naturally the quarrymen all over the country are looking at this plant with all interest, and on its success or failure will depend the course of many others. There seems no reason to believe that two such experienced concerns as the Cleveland Stone Company and the Ingersoll-Sergeant Drill Company, would enter into such an undertaking unless they were assured of its success, so this plant has the promise of being one of much importance to the compressed air trade.

PARTIALLY COMPLETED POWER PLANT OF THE CLEVELAND STONE COMPANY.

Notes.

The British Compressed Air Cleaning Company, Ltd., the progress of which was noted in last month's COMPRESSED AIR, has just established a separate company in Wales under the title of the South Wales Compressed Air Cleaning Company, Ltd. The offices of this concern are at Cardiff.

COMPRESSED AIR has received a copy of the thirty-seventh edition of Gurley's Manual of American engineers' and surveyors' instruments through the courtesy of Messrs. W. & L. E. Gurley. It contains much valuable information which will be of use to those planning and building compressor plants or for quarrying and tunneling operations.

A new appliance has recently been added to the fire brigade of London, England. It is known as a first-aid machine, and is always in readiness to answer the first call. It consists of two cylinders, the large one containing air and water, and the small one containing compressed air to a pressure of 1,000 pounds to a square inch. The compressed air is used to work a small but powerful stream at the fire, pending the arrival of the steamers.

While molding machines are no longer a novelty, the Tabor Manufacturing Company, of Philadelphia, has recently placed on the market several types of pneumatic molding machines which will interest all who keep in touch with the work of the foundry. In a catalog just issued these machines are described at length, and a number of illustrations shown. There are also pictures of the interior of the Tabor Company's shop. This same company will shortly issue another catalog covering hand-ramming molding machines.

The use of compressed air for the operation of pneumatic tools has become a prominent feature in the economics of large manufacturing establishments. Especially is this true of the shipbuilding industry. In each of the larger shipyards several hundred pneumatic tools are now in use. At the plant of the New York Shipbuilding Company, in Camden, N. J., there are now in use about 400 portable riveters, calkers, drills, etc. Air pressure of 110 pounds per square inch is supplied by an air compressor capable of 5,000 cubic feet of air per minute.—*The Iron Age.*

The Colne *Times*, of England, reports a remarkable invention. After about 22 years' labor, Mr. Joseph Hoskin, of 39 Alexandra road, Morecambe, formerly of Colne, has patented an injector apparatus for the purpose of driving engines with compressed air instead of with steam. It is claimed, at least, that the invention will save 65 per cent. in coal used for a boiler, and it will work, if desired, with compressed air only in the present state of boilers, without removing same. Further, Mr. Hoskin claims that in connection with motor cars his discovery should displace petrol as a motive power.

Liquid hydrogen is by far the coldest liquid known at the present time. At ordinary atmospheric pressure it boils at —422 degrees F., and reduction of the pressure by an air pump brings the temperature to —432 degrees, at which the liquid becomes a solid, resembling frozen foam. According to Professor Dewar, to whom the credit is due of having liquefied hydrogen in 1898, the liquid is a colorless, transparent body, and is the lightest liquid known to exist, its density being only one-fourteenth that of water; the lightest liquid previously known was liquid marsh gas, which is six times heavier. The only solid which has so small density as to float upon its surface is a piece of pith wood.—*Cassier's Magazine.*

Whenever an operation or a trade or an industry tends to extend, or when it is desirable or necessary that it should extend, mechanics and machinery must come into action. Manual or animal effort soon reach the limit of their power and efficiency; and whatever machinery is capable of doing it performs with incomparable patience and accuracy. The increased mining depth and the increased demand for coal have forced machinery on by leaps and bounds. To wind the coal in the United Kingdom alone represents approximately a million of horsepower, and the hauling and pumping and ventilating will represent probably an equal amount of power. This could not be provided either by human beings or animals, and if provided would be impracticably expensive.—*Science and Art of Mining* (Eng.).

Pneumatic drills are highly praised in a paper recently read before the Institution of Civil Engineers by Mr. A. F. Yarrow. In his ship yard it is now the practice to drill the rivet holes in the inside strakes of plating with electric drills. The plates are then sheared and put in position. The outer strakes of plates are next put in place and drilled by the pneumatic tools, the inner plates acting as jigs. Mr. Yarrow considers it impossible to have more accurate workmanship, for the system places it beyond the power of the men to do bad work. This method of drilling does not affect adversely the cost or speed of construction. In punching a plate, a gang of men punching it is much more rapid than drilling, there are many more men employed. Moreover, punching must be done on one plate at a time, while several plates can be drilled simultaneously. —*The Engineering Record.*

An interesting description of the improvements being made on the Pennsylvania Railroad, between Pittsburg and Philadelphia, is to be found in the issue of the *Engineering News* for September 24. It includes an account of the construction of the Gallitzen tunnel, which parallels the old Allegheny tunnel. As usual, compressed air figures very prominently in its construction. A single heading is driven from each end of the tunnel and in each there are in operation four drills operated by compressed air. Two of the drills are mounted on columns. Two other drills, mounted on tripods, widen out the heading made by the others. A steam shovel operated by compressed air is being used to load the cars at the end of the heading. Despite the fact that there is only a single track in the tunnel, thereby limiting the use possible under such conditions, this compressed air shovel is regarded by the contractor as a decided success in its tunnel work.

Referring to the extended use of pneumatic tools, Mr. Robinson, of Glasgow, one of H. M. Inspectors of Factories, gives some interesting facts relating to the development of mechanical devices. Among them he cites jobs formerly done by journeymen which can now, with these pneumatic tools, be undertaken by apprentices. In one case he heard of a job which was finished by an apprentice in three or four hours. Under former conditions that same work would have occupied an average journeyman more than a day. On the other side of the question, which, of course, must be regarded, Mr. Sedgwick, of Leicester, comments upon the effect of mechanical development upon the smaller trades, which gives support to the impression that the days of the "Little Mester" are numbered. This gentleman states that the continued introduction of labor-saving machinery, and the consequent subdivision of labor, is slowly, but surely, directing the trade into the hands of large employers and limited companies, and with these the little man has but very

either the home or foreign markets.—*Hardware Trade Journal* (England).

At the Air Brake Convention, held in Colorado Springs, last April, there was a series of four tests of air pumps. These tests were briefly and substantially as follows:

The first test consisted of a drilled diaphragm placed either in some convenient point near the brake valve or at the rear of the tender, and the pump run at about 100 or 140 strokes per minute, being required to keep up a pressure against a 3-16 inch opening in the diaphragm.

Test No. 2 consisted of a similar arrangement described in No. 1, except that the speed of the pump was about 60 or 70 strokes per minute, and was required to keep up a pressure against an escape port 3-32 inches in diameter.

Test No. 3 consisted of a gauge screw into the bottom head of the air cylinder of the pump, and at a slow speed, pressure passing by the packing rings would pile up in pounds in the suction end of the cylinder and show on the gauge.

Test No. 4 was called the "oil cup test" and was made by opening the oil cup on the top end of the air cylinder, and running the pump at a slow speed. If air blew out of the oil cup on the down stroke, it meant a leakage of pressure past the packing rings. This degree of leakage either passed or condemned the pump.

Under the title "A Notable Example of Central Station Supply of Electric Power and Light," the *Engineering Record* published in its issue of September 26 a description of the new building of Marshall Field & Co., of Chicago. As usual, compressed air is called upon to play no unimportant part. There are two 11½-inch by 12-inch by 5½-inch by 21-inch Ingersoll-Sergeant air compressors which supply air at 40 and 20 pounds gauge pressure for operating elevator doors and sewerage ejectors, respectively.

One 8-inch by 8-inch vertical air compressor of the same make furnishes compressed air at 60 pounds pressure for physicians and dentists occupying the upper floors of the building. This air is first washed by being passed through a water bath and then forced through a special filter containing sterilized cotton gauze. One 8-inch by 8-inch Christensen compressor supplies air at 80 pounds pressure for carpet renovators. The air compressors are all chain-driven from variable speed motors. The pneumatic cash carrier system consists of two No. 9 Root blowers, which are driven by 75 horse-power motors and two No. 7 Connersville blowers which operate by a 40 horse-power motor. The blowers are of the piston type and are operated on approximately 2 inches of vacuum supplied for the 200 cashier stations.

The eighty-third meeting of the American Institute of Mining Engineers was held in New York, October 13th to 17th. The session was in all respects a very successful one and was largely attended by engineers prominent in the mining industry of the country. The headquarters of the Institute were made at the Murray Hill Hotel, but the sessions were held in various halls of kindred organizations, and educational institutions. A series of very interesting papers were presented, giving some important information as to the mines and mining methods in various portions of the country. Then there were trips to several metallurgical plants in the vicinity of New York, an inspection of the Rapid Transit Subway and a visit to the United States Military Academy at West Point. The members also saw something of Columbia and New York Universities. A reception and dance at Sherry's and an informal reception at the American Museum of Natural History were pleasant interruptions in the routine of the session.

The only paper in which compressed air primarily figured was a discussion of Mr. Clarke's paper "Electrical Apparatus for Coal Mining" by Mr. W. L. Saunders. This discussion has already appeared in the columns of COMPRESSED AIR. Incidently, compressed air was mentioned frequently and its prominence in the mining industry of the country was frequently demonstrated.

Many different designs of steam-driven pumping plant have been used for this purpose from time to time, but, given suitable conditions, nothing has proved so simple and effective as the method of raising deep well water by compressed air introduced by Mr. William H. Maxwell, A. M. I. C. E., at the Tunbridge Wells Waterworks in the year 1900. This is apparent from a study of the data arrived at by a series of careful tests with the plant in question, and the experience of its several years' satisfactory working, as recently described in an interesting paper read by Mr. Maxwell on the subject before the British Association of Waterworks Engineers at Bolton, an abstract of which we hope to give in our next issue. The paper is of greater interest from the fact that the plant in question is one of the first permanently installed in this country on a fairly large scale for the purposes of public water supply. Engineers as a rule have hitherto looked somewhat suspiciously upon the use of compressed air for such a purpose, owing to their doubts as to the economy of this system and the want of actual experience upon which to base their designs for such a plant. They will be greatly assisted in this direction by the results of experience supplied by Mr. Maxwell in his paper, who has now demonstrated by a series of independent and accurate trials that this method of raising water, where proper conditions favorable to its adoption obtain, may be employed with perfect success and economy of working. Even with coal costing the high figure of 25s. 5d. per ton, the fuel cost of raising the water through a 100-foot lift is a fraction under a penny per 1,000 gallons; and when the smaller capital charges are also taken into account, the system has very decided advantages where the proper proportions of "immersion" of the air-pipe to the "lift" of the water can be secured. Considerable saving in labor is also effected from the fact that the well may be several miles distant from the main pumping station, where any additional machinery may come under the supervision of the existing staff, and the air be conveyed in pipes to the wells, where no attendance or buildings are required. The air is discharged at a suitable pressure at the bottom of the well, which, in the present case is 350 feet deep, and the water is thus made to flow at the surface at the rate of over 30,000 gallons per hour. —*Sanitary Record* (Eng.).

Since F. F. Proctor went into the amusement business, New York theatregoers have discovered that high-class performances at reasonable prices are a decided success. With his four charming playhouses in New York, Mr. Proctor is offering a variety of amusement that wins for him universal praise. The Twenty-third Street Theatre is an excellent place in which to pass a few hours at any time. A continuous performance by high-class vaudeville artists is changed each week. Stock companies are presenting some of the best plays at the Fifth Avenue and One Hundred and Twenty-fifth Street Theatres, while the Fifty-eighth Street Theatre is devoted to visiting companies of good reputation. It was an experiment on Mr. Proctor's part, but the cordial support which has been given him by the people of New York and vicinity has fully demonstrated the success of his undertaking.

INDEX.

U.S. PATENTS GRANTED SEPT., 1903.

Specially prepared for COMPRESSED AIR.

737,681. VALVE. John B. Waring, East Orange, N. J., assignor, by mesne assignments, to Waring Patents Company, New York, N. Y., a Corporation of New York. Filed July 1, 1901. Renewed Feb. 4, 1903. Serial No. 141,931.

737,682. REDUCING-VALVE. John B. Waring, East Orange, N. J., assignor, by mesne assignments, to Waring Patents Company, New York, N. Y., a Corporation of New York. Filed Nov. 17, 1902. Serial No. 131,601.

737,709. BUMPER FOR RAILWAY-CARS. Thomas Collins, San Jose, Cal. Filed Apr. 18, 1902. Serial No. 103,488.

A device consisting of a suitable body secured to the car, a secondary member pivoted to said body and formed with a plurality of chambers, reciprocating plungers in said chambers, and a cross-head pivoted to the coupling of the car and connected to said plungers, said plungers being formed with a small perforation and a check-valve leading to said chambers substantially as and for the purpose set forth.

737,906. COMPRESSED-AIR OR OTHER SIMILAR BRAKE. Adolphe Chaumont, Brussels, Belgium. Filed July 23, 1901. Serial No. 69,352.

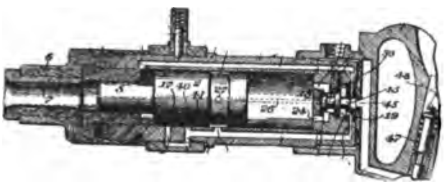
For the purpose of effecting the adjustment of the brakes for a certain stroke of piston, a device utilizing the screw-brake and consisting in providing parallel with the rod of the screw-brake a graduated rod provided with an index in front of which is displaced the nut or its continuation which attains respectively the positions of the rod when the brake-gear reaches the minumum and maximum positions of piston stroke respectively, this latter remaining motionless owing to the provision of an aperture in the rod.

737,941. VALVE OR CUT-OFF FOR TANKS. Peter J. Leithauser, Clarendon, Tex. Filed July 2, 1903. Serial No. 164,050.

738,102. PNEUMATIC-CARRIER SYSTEM. Wilbur G. Davis, Newton, Mass., assignor to the Single Tube Transmission Company, Boston, Mass., a Corporation of Maine. Filed Jan. 2, 1903. Serial No. 137,378.

A pneumatic carrier system employing a normally dead transmission-tube and having one or more motor-driven substation pressure creating devices.

738,546. STROKE-CHANGING MECHANISM FOR PNEUMATIC TOOLS. Julius Keller, Philadelphia, Pa. Filed Dec. 8, 1902. Serial No. 134,273.



738,576. HYDRAULIC AIR-COMPRESSOR. Joel H. Shedd, Providence, R. I., assignor to Walter C. Carr, New York, N. Y. Filed Dec. 9, 1902. Serial No. 134,470.

A hydraulic air-compressor, a series of horizontal air-bars communicating at their ends with a submerged air-chamber and means for throttling the air after it enters the air-bars from the air-chamber to secure its more even distribution throughout the length thereof, substantially as described.

738,583. PNEUMATIC MASSAGE APPARATUS. Robert Watson, Scranton, Pa., assignor of one-half to Charles A. Kram, Washington, D. C. Filed Oct. 10, 1900. Serial No. 32,566.

738,690. EXPLOSIVE-ENGINE. Jesse D. Lyon, Pittsburg, Pa. Filed Jan. 28, 1902. Serial No. 91,591.

A gas-engine, provided with a cylinder, an air-compressing chamber exterior to the cylinder and communicating with the interior thereof, exhaust-ports leading outwardly from the cylinder, and a mixture-valve chamber provided with a compressing-valve having check-controlled inlets opening into its interior, and a port leading from the compressing-chamber to the cylinder.

738,959. PNEUMATIC UNDERBLAST AND STACKER. Aart H. Van Houwelingen, Pella, Iowa. Filed May 21, 1903. Serial No. 158,164.

In combination with pneumatic stacker apparatus, an endless traveling carrier to feed the same, said endless traveling carrier comprising a lower chaff-section and an upper straw-section, said sections being angularly disposed with reference to each other, substantially as described.

739,025. INNER TUBE FOR PNEUMATIC TIRES. Theron R. Palmer, Jeannette, Pa. Filed April 14, 1903. Serial No. 152,505.

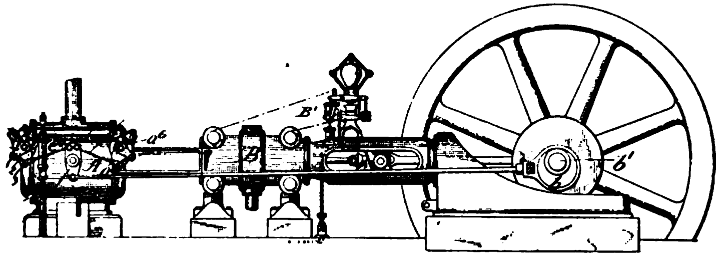
739,134. TRACKER-BOARD ATTACHMENT FOR PNEUMATIC MUSICAL INSTRUMENTS. Alfred Anderson, Cambridge, Mass. Filed May 8, 1903. Serial No. 156,228.

An automatic musical-instrument player, the combination with a tracker-board and a perforated music-sheet, of a chamber having an open bottom adapted to rest against the music-sheet, guide.

739,972. PNEUMATIC ATTACHMENT FOR CHAIRS. Gustaf B. Anderson, Chicago, Ill. Filed Dec. 30, 1901. Serial No. 87,741.

The combination with a rocking-chair provided with a downwardly-projecting pin on its seat, of a bellows located within its frame and connected near its front and rear ends to each of the rockers of the chair, said bellows comprising a pumping portion and a reservoir having an inwardly-opening valve to contact with said pin, springs located between the upper portion of the bellows and the seat of the chair, a support horizontally and rigidly secured to the bottom of the bellows and having at each of its ends rollers to rest on the floor, a hose communicating at one of its ends with the reservoir, an air-controller or hand-piece on the other end of said hose, substantially as described.

Boston, Mass., assignors to the Geo. F. Blake Mfg. Co., New York, N. Y., a Corporation of New Jersey. Filed July 25, 1901. Serial No. 69,639.



An air compressor having a cylinder, a piston, inlet-valves, the combination of a mechanism comprising a toggle for operating said valves, and a device open to the excess pressure in the receiver or reservoir for breaking the said toggle whereby the closing of said valves is retarded and a lesser amount of air than usual compressed.

An air-compressor having a cylinder, a piston and inlet-valves, the combination of a mechanism comprising a toggle for operating said valves, and a device open to the excess pressure in the reservoir or receiver for breaking said toggle whereby the closing of said valves is retarded and lesser amount of air than usual compressed, said device comprising a diaphragm which is affected by said excess pressure, and a piston operated by water-pressure, the valve for which is controlled by said diaphragm and the said valve.

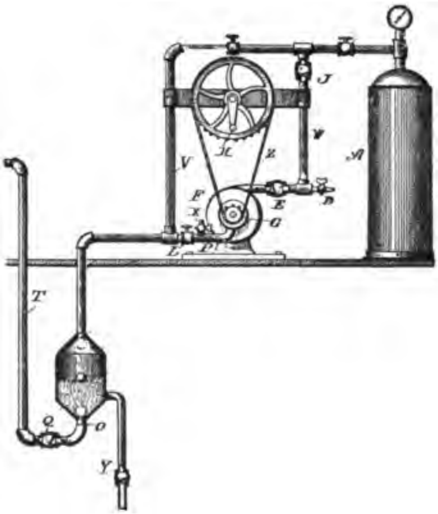
739,231. GOLD-SEPARATOR. William Snee, West Elizabeth, Pa., assignor of three-fourths to John A. Snee, Pittsburg, Pa. Filed Dec. 29, 1902. Serial No. 137,035.

A pneumatic separator, the combination of a casing having a closed hopper-shaped upper portion and a reduced lower body portion open at the bottom, a screen mounted in an opening in the side walls of said hopper-shaped portion, a feed-spout extending into the said upper portion of said casing to a point below the bottom of said screen, and a nozzle extending into said reduced portion and in alinement with said feed-spout to direct a blast of air against the powdered ore entering through said spout, substantially as described.

739,869. PNEUMATIC STACKER. John Henry, Grand Forks, N. D. Filed Dec. 22, 1902. Serial No. 136,270.

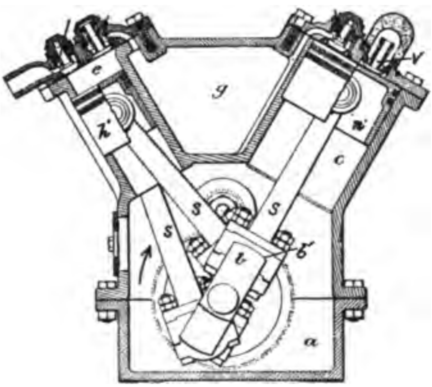
therewith, and means for discharging chaff into said pocket, of pneumatic devices communicating with said pocket for removing chaff from said pocket and discharging it, and a discharge-outlet for said pocket independent of said pneumatic devices.

739,150. PNEUMATIC WATERWORKS. Edward L. Canon, Quitman, Ga. Filed Feb. 21, 1903. Serial No. 144,393.



A pneumatic waterworks comprising a water-reservoir, an air-pressure chamber, a rotary air-pump, and a two-branched pipe with valves and air-cocks, one of said branch pipes communicating at one end with the water reservoir and the inlet for the air-pump and at its other end communicating with a pipe leading directly from the air-pressure chamber, and the other branch pipe communicating at one end with the outlet from the air-pump and at the other end with the air-pressure chamber substantially as described.

740,133. COMPRESSOR FOR AIR-BRAKE SYSTEMS. Wilhelm K. M. Hilderbrand, Gross Lichterfelde, near Berlin, Germany. Filed Apr. 2, 1901. Serial No. 54,055.



A compound air-compressor for air-brakes and the like comprising two single-acting low-pressure cylinders, two single-acting high-pressure cylinders and pistons, said low and high pressure cylinders being arranged at an angle to each other and with their axial lines converging downwardly, a crank-chamber, a crank-shaft therein, pistons and piston-rods connected with the crank-shaft, and a chamber between the cylinders at their upper ends common to the same and ports connecting said chamber with the cylinders, substantially as described.

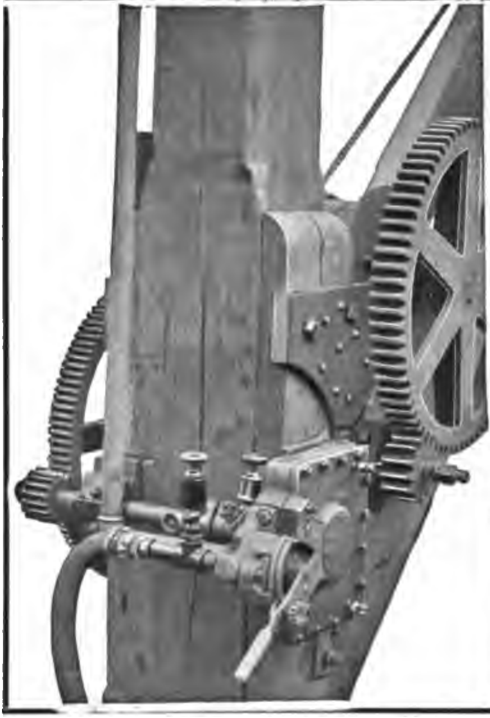
740,157. VALVE. Frederick Mertsheimer, Denver, Col. Filed Feb. 24, 1903. Serial No. 144,749.

740,186. VALVE CONSTRUCTION. Louis Schutte, Philadelphia, Pa. Filed Oct. 28, 1901. Serial No. 80,260.

740,306. AIR-BRAKE ATTACHMENT. Felipe B. O'Bannon and Frank J. Chamberlain, Albuquerque, N. Mex., assignors of one-third to George E. Lewis, Albuquerque, N. Mex.; said Chamberlain assignor of his remaining one-third to said O'Bannon. Filed Oct. 11, 1902. Serial No. 126,939.

An air-brake system, the combination with the triple-exhaust connections and the train-line, of means controlling communication between the triple exhaust and the atmosphere, and operating means therefor, said operating means comprising a cylinder having a by-pass and a piston in the cylinder, one end of said cylinder being in communication with the train-line and the other end having communication with the atmosphere, and means acting in unison with the piston to control said atmospheric communication.

740,375. MOTORMAN'S VALVE FOR AIR-BRAKES. John Shourek, Pittsburg, Pa. Filed Dec. 22, 1902. Serial No. 136,226.



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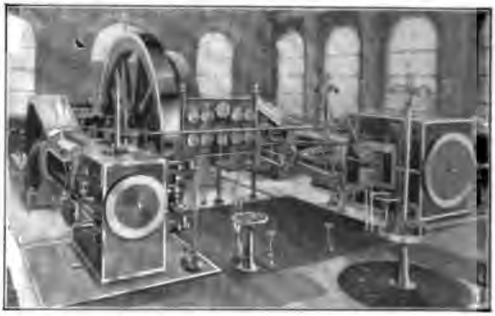

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VOL. VIII. NEW YORK, DECEMBER, 1903. No. 10.

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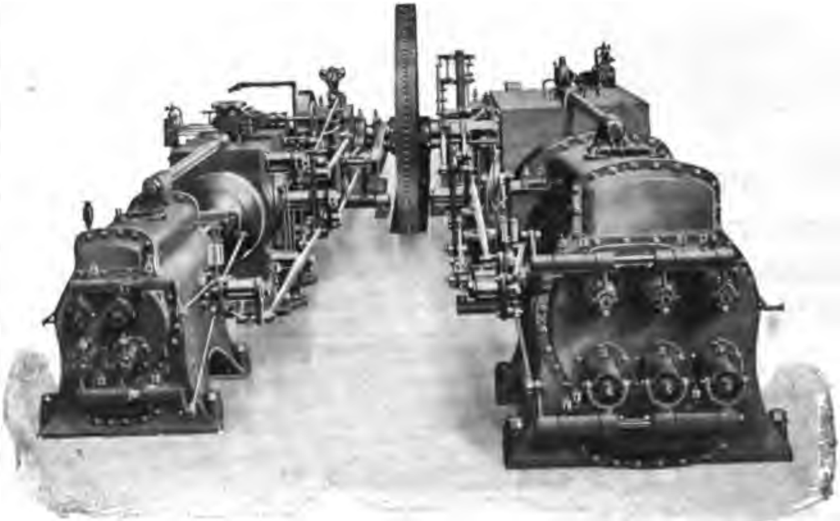

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Three Important Enterprises.

The month of November has seen important progress made in three large enterprises which promise to greatly interest the manufacturers of compressed air machinery.

Bids will be opened by the Pennsylvania Railroad Company, December 15, for its tunnels under the Hudson River. According to the specifications the shield method of subaqueous tunneling will be followed, and this will require compressed air machinery of the most advanced type.

Early last month the people of New York State voted in favor of the proposition to spend $30,000,000 for a barge canal from the Hudson River to Buffalo. The excavation which will be required will mean an increased market for rock cutting and other machinery operated by compressed air.

Then the separation of the Isthmus of Panama from Colombia makes it practically certain that the Panama Canal will be started in the near future. Here is another enterprise in which compressed air is sure to play an important part.

These three enterprises have made the month of November one of unusual moment and one which may lead to events of even greater importance.

Importance of Proper Lubricants.

COMPRESSED AIR has recently pointed out the importance of proper lubricants for use in the air cylinders of the air compressor. This very point was dwelt upon at length in the report of the commission which recently investigated the causes of miners' phthisis in the Transvaal.

Among the points to which attention was called in this report is the composition of the air received from the compressor. The danger which accompanies the use of inferior oil or oils of a low flash point is also carefully noted. Lubricants used for this purpose, it is declared, ought to be incapable of being decomposed into or giving off injurious products under the conditions they are subjected to in the air compressor. The occasional substitution of soft soap or soap-suds instead of oil, as has been pointed out several times in this publication, is recommended. All this goes to show that the demand of certain prominent compressor manufacturers, that only the highest grade of oil be used in their machines, is perfectly legitimate and proper, and that the men who attempt to save money by using an inferior grade of oil are practicing a false economy.

From this report it is shown that not only does the machine itself require lubricating oil of a high standard to keep the machine at its highest efficiency and secure proper results, but the conditions existing where compressed air is used in a confined space make it imperative that the lubricating oil used is such that it will not affect the air which men are called upon to breathe.

One of the great advantages of compressed air machinery in mines, tunnels and other operations of that nature, is that the air not only serves as a means of power transmission, but greatly assists in ventilation. It is, therefore, obligatory that the air supplied be as pure as possible. Under proper conditions there need be no trouble about this. A very important step in that direction has been proven to be the use of proper lubricating oil. The action of the Transvaal Commission is simply in accordance with the facts and has the indorsement of everyone who is interested in compressed air or compressed air machinery.

The Chaquette Pneumatic Dredge.

The Chaquette power clamshell for dredging or excavating is two semi-hemispherical shells hinged to a frame and opened and closed by a valveless cylinder horizontally placed, one end of which is hinged to the outer circumference of one shell; the piston-rod carrying an arm which is hinged to the outer circumference of the other shell.

To the piston-rod-arm are attached guide-rods which travel parallel with the piston-rod through sleeves on each side of the cylinder, to prevent buckling or undue strain on the piston-rod.

When compressed air enters that end of the cylinder nearest the centre of the frame the piston is forced inwardly and the cylinder lifts itself and travels on its guide-rods to a point over the centre of the clamshell, so that at the end of the instroke the piston-rod-arm engages the cylinder-head. By this movement the upper outer circumferences of the clamshell are drawn upward and toward each other and the jaws or cutting edges apart, in which position the latter are lower onto the material. The admission of air to the end of the cylinder farthest from the centre of the frame while the cylinder is thus elevated forces the upper outer circumferences of the shells apart and downward, the principle being that of the toggle-joint, and its lower cutting edges or "jaws" together, and, with a circular scooping movement into the material; the movement of the piston finishing as the jaws meet, to be held locked in that position until the air pressure is diminished or reversed.

(See cut of clamshell)—Fig. 1.

Forces—On the basis of a one cubic yard clamshell designed to handle iron ore, constructed heavily and weighing 6,000 pounds with a 16-inch piston and 81.3 inches of cuting edge, the forces, with 135 pounds air pressure, would be as follows for each one-half the clam:

At beginning of stroke—Due to weight of clamshell, cylinder, frame, etc., 37 pounds per linear inch. Due to 135 pounds air pressure on piston, 332 pounds per linear inch, or 369 x 81.3, equal to a force of 30,000 pounds on cutting edge of each clam.

At end of stroke—82 pounds per linear inch, or a force of 6,666 pounds on the cutting edge of each clam.

(See force diagram—Fig. 2.)

To the decreasing cutting force from the piston, being at the minimum 13,332 pounds pressure or "bite" of clam at end of stroke, is added the force due to the downward pressure of the increasing weight of material in the clam as it fills (which with iron ore, clam 70 per cent. full, is 9,000 pounds), for the reason that the arc described by the cutting edges is greater than the arc of the clamshell when closed; being so designed to prevent suction as the clam is lifted after having filled in plastic material, and to leave a clearance outside its circumference that the weight of material in the clam may assist its cutting edges beveled inwardly to draw it downwardly into material which is not plastic.

Question has arisen between engineers as to whether the forces on the cutting edges decrease as the closing progresses, the inventor taking ground that by the new application of a mechanical principle the cutting force equals at all points area of piston x air pressure, less friction.

Admitting that force on cutting edges diminishes as the clam closes, the 82 pounds per linear inch on each clam, without considering the weight of metal

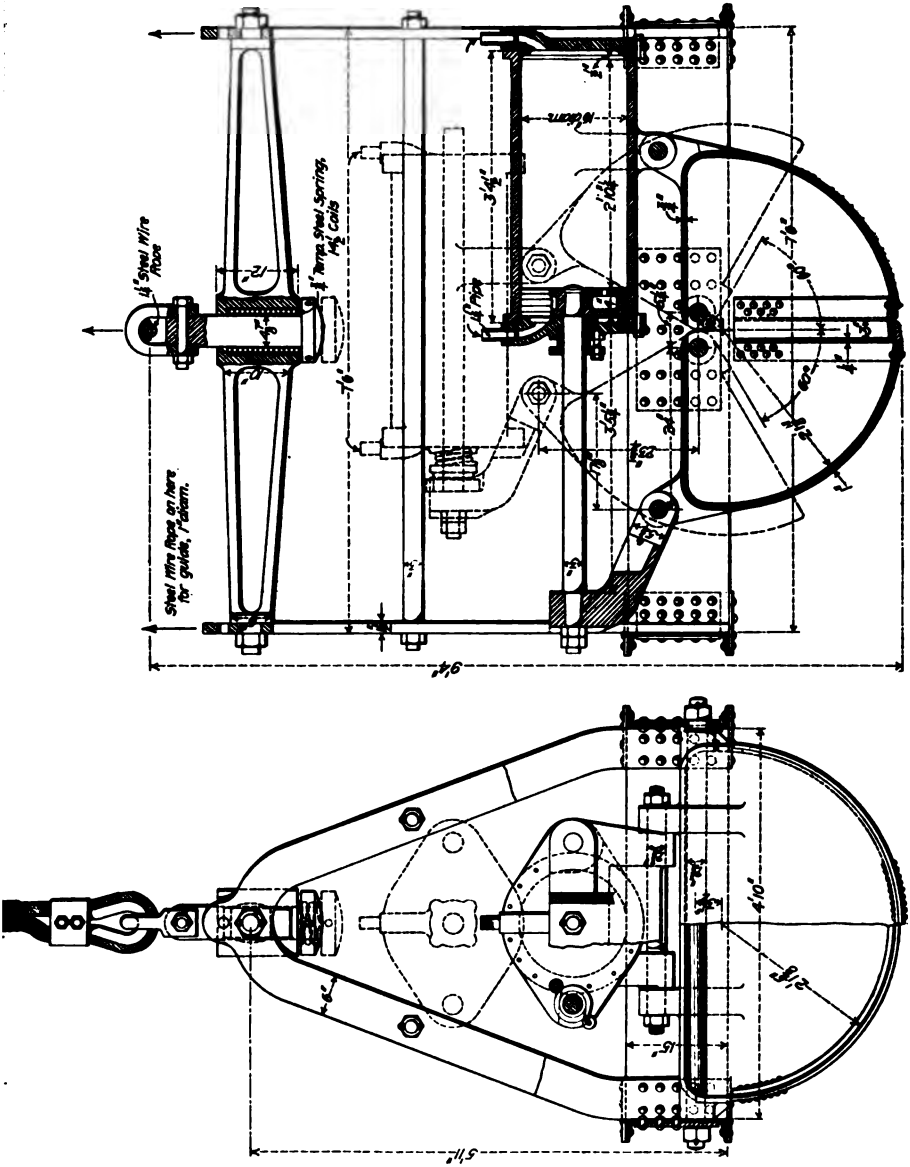


FIG. I—PNEUMATIC CLAM SHELL DREDGE.

or the load therein, will cause it to penetrate the toughest dredgeable material, which offers a resistance of about 40 pounds per linear inch, with a margin of 75 per cent. of power to spare.

If the material is not excavatable except by blasting, and the 164 pounds per linear inch will not cut it to a closing of the clam, the air pressure in the cylinder may be increased or a piston of greater area provided. If not to exceed 45 pounds per linear inch resistance is met, this would be overcome by this clamshell with an air pressure of from 40 to 68 pounds which would make its operation more economical.

Comparative Penetrating Forces—The efficiency of a present type clamshell closed by tension on one of its chains or cables leading around a sheave attached to the clam frame, vertically to a boom overhead, and then to the drum of the hoisting engine, is dependent in hard material solely on the weight of the clamshell. One weighing 6,000 pounds with 81.3 inches cutting edge would thus have with its chain slacked a power of penetration equal to 37 pounds per linear inch for each clam. But when its closing chain is made taut it lifts vertically, and each pound of pull thereon decreases the "bite" of the clam, with the result that in clay or hard material the clam lifts as it closes, the penetrating power becoming constantly less; makes a scraping across the top of such material, and comes up practically empty. Its maximum penetrating power, due to its weight, is 37 pounds per linear inch for each cutting edge at the moment of starting to close. This constantly decreases as the clam rises and closes. If during its ascent the pull on closing chain is relaxed, the jaws open and the clam loses material.

The Chaquette power-clamshell is lowered open onto the material at any depth and its single hoisting cable is slacked away so that it sags. The machine then has the penetrating power of its 6,000 pounds weight, or 37 pounds per linear inch for the cutting edge of each shell. At this moment the air enters the cylinder automatically and a pressure of 54,000 pounds reinforces the 74 pounds and drives the cutting edges, on which rest 6,000 pounds, down and into the material.

Bowlders would be encircled or gripped firmly. For removing blasted rock the renewable cutting jaws would be replaced with prongs or grapples.

If an immovable rock is caught at this moment the clam stops closing as it would at the end of its stroke, and with no greater shock. It rests on top of the obstruction and does not force itself into or become entangled underneath. It would be released by shutting off or reversing the air pressure.

The excavating force of a scoop or dipper dredge is limited by the strength of the spuds and mooring cables, and of the delicate parts of the machine itself to withstand the shock of impact with an obstruction.

The penetrating force of a chain bucket dredger depends upon the power of its engines, and the ability of the parts of its chain to withstand wear and tear and shock of impact.

Its economy is lessened by friction and the fact that when the chain is revolved rapidly a large percentage of the load in certain materials is washed away. A few years ago an English authority published a set of cylinder readings of the operation of such a machine, which proved that more than 60 per cent. of its power is wasted in friction, due principally to the many parts composing its chain. These cylinders cards were taken: (1) With engine running unattached. (2) With chain of buckets revolving in air. (3) Chain revolving in water. (4) Chain of buckets bringing up material—with the result above stated.

Operation—The pneumatic clamshell descends through an automatically moving carriage which travels on a raised structure built a suitable height for gravity discharge across and beyond one end of the float, and extending over each side of the float one-quarter of its width. If the float is equipped with two clamshells they will automatically move to the centre or extremes at the same time, thus avoiding rocking or wrenching of the float, doubling the capacity of the dredge, and effecting an economy in that if one clam becomes out of order work can be continued at reduced capacity. The number of clamshells may be multiplied to any extent; or a single clam may be worked from the boom of an existing dredge.

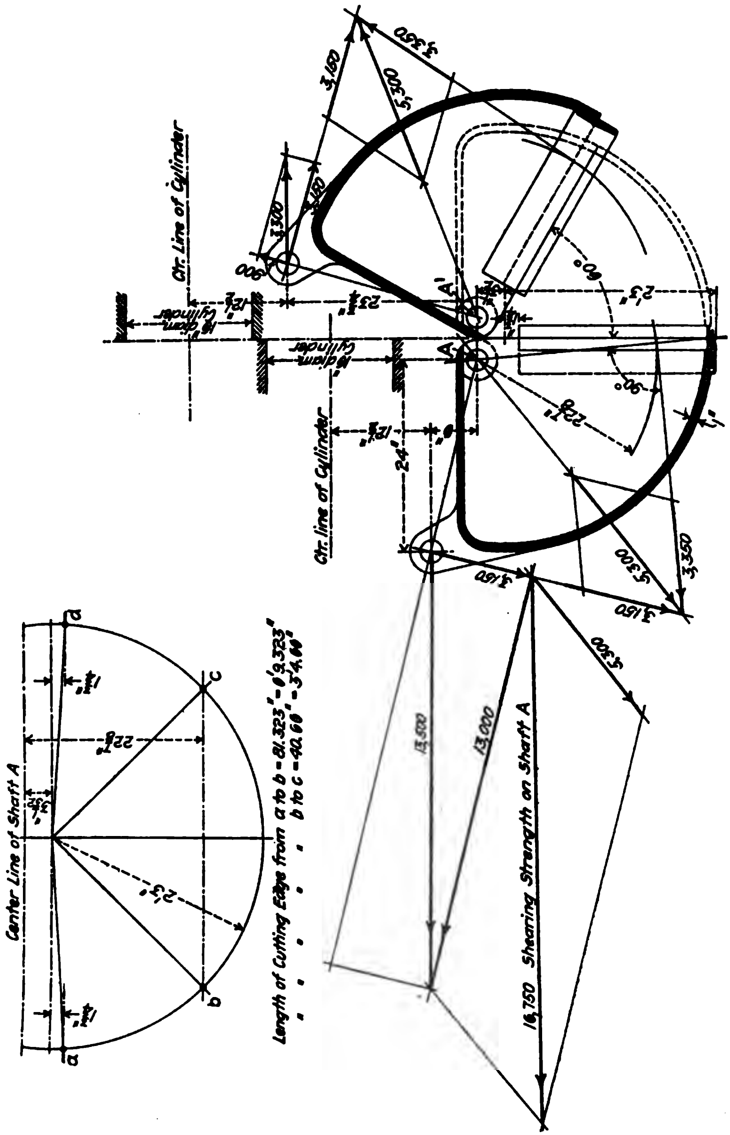


FIG. 2—DIAGRAM OF FORCES.

As the clam descends a hinged apron drops by gravity to allow its downward passage, to be engaged by its frame when the clam ascends, brought up under it and locked at an angle of 45 degrees to receive the material when discharged, which it deposits into chutes which carry it to scows on either side.

When excavating and elevating material to be washed for gold or precious metals the hinged apron is adjusted to discharge inboard into a series of flumes or sluice-boxes, after which the refuse is carried by moving aprons or agitating chains to the stern of the float and dumped.

The clam is provided with a cover. Its jaws being held tightly together by the pressure of air at the moment, it can be brought up from great depths at a high rate of speed without washing away its load.

The single air pipe is taken up by a broad sheave into which the air enters at its centres. This sheave has a movement equivalent to that of the hoisting sheave so there is no slack in the pipe, which needs little attention. This air pipe leads to a special valve attached to the frame of the clam; from which valve a connection leads to each end of the cylinder. The main or hoisting cable is attached to a slide in the centre of the frame of the clam, which slide is surrounded by a coiled spring. When the clam settles onto the material the hoisting cable is relieved of its weight. The expansion of the spring sets in operation the valve, with the result that the air closes the clam. At the height of its ascent the valve is turned automatically, and the clam discharges and is ready to descend for a new load.

To hold the clam steady and upright at any depth, and to effect an economy in the consumption of coal, cables are attached to the extremes of the clam frame, led to sheaves on the raised structure and over sheaves aft to adjustable weights, so that with soft material it is not necessary to lift more than 25 per cent. of the weight of the clam. With a clam making two trips per minute for a period of time this counterbalancing the weight of the clamshell results in a considerable saving in coal consumption. These cables take the place of poles now in use on non-power clamshells.

Economy—This is effected:

1. By the direct up and down movement of the clamshells, thus gaining the advantage of a large part of the 30 per cent. of the time of a trip now used by the present type clamshell or "dipper" in filling, and the 30 per cent. of trip required by a boom to swing and return.

2. By the certainty of bringing up a full load each trip in hard material and from any depth; at maximum hoisting speed.

3. By the saving of valuable material now lost by "washing" when coming up rapidly, or loss due to jaws of clam remaining partly open during ascent.

4. By the increase in number of trips per minute, two being the average and four possible.

5. By combining two or more dredges into one, with saving in capital expenditure and operating expenses; thus dispensing with the services of one or more crews and lessening to that extent the possibility of complications with labor.

Results—A machine of this character will do any class of dredging or excavating by reason of its adaptability. In difficult material counterbalancing sufficient only to hold the clam steady would be used, and a high air pressure maintained. Soft material being found counterbalancing weights would be added and air pressure reduced, with resultant economy.

Hence, such a dredge is general in its application, and suitable for hard or soft material at any moment; capable of excavating at any depth by the addition of a line of pipe.

Bowlders or blasted rocks would be caught and held as in a vise; and not slip away until the air was reversed.

For dredging beds of streams for gold or precious metals the clam would be lowered to engage an inch or a foot of the surface and there opened and closed to scrape such surface; or it would equally well excavate to its full capacity, and to bed-rock. Tests show it will cut into anything except solid rock, will come up 100 per cent. full of sand or gravel, and at least 80 per cent. full of tough plastic material. There is no limit to the depth at which it will work, and by it material would be elevated to any height so that it could be washed or sifted by gravity fall over flumes or sluice-boxes.

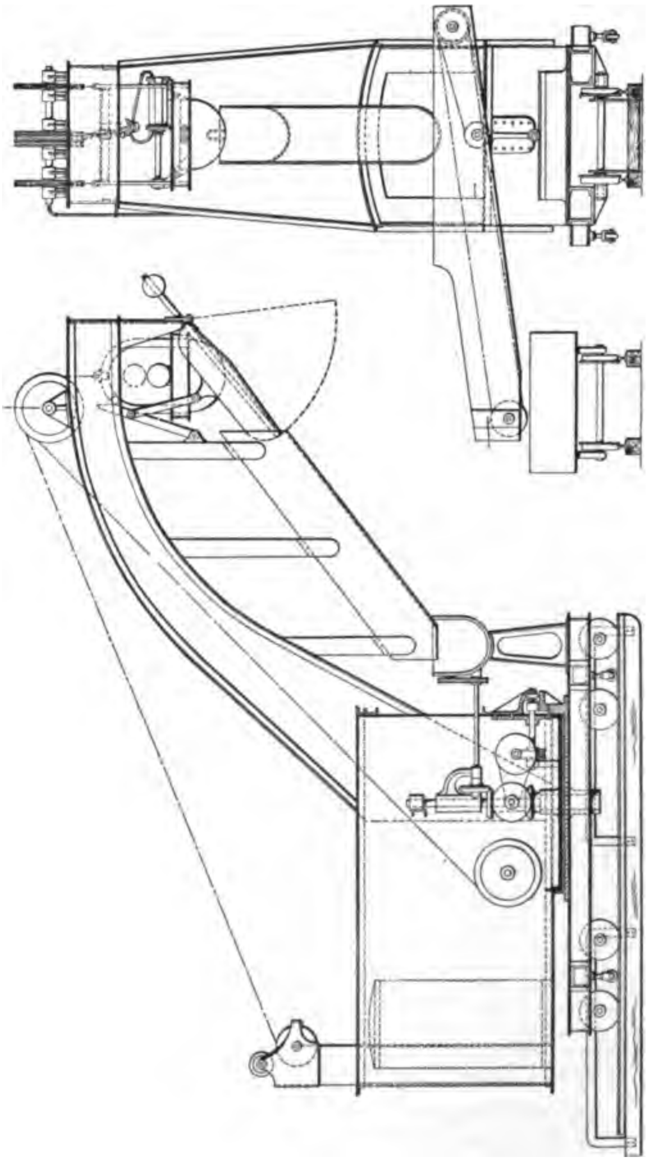


FIG. 3—ARRANGEMENT OF CHAQUETTE LAND DREDGE.

The capacity of a dredge of this design equipped with two 3 cubic yard clams, and costing complete not to exceed forty thousand dollars, would be 500 cubic yards per hour, and at a cost of operation including interest, depreciation and insurance, of less than two hundred dollars for a day of twenty hours.

The novel feature of the construction of the Chaquette Company's land dredge (Fig. 3) is the method for expeditiously moving it ahead as the work progresses; which consumes 15 per cent. of the time of operation by present methods; and for shifting it over the work.

This dredge rests upon a frame supported by trucks, the wheels or axles of which engage and carry with them when lifted a section of track about 25 per cent. longer than the wheel base. The frame also carries on each side two pneumatic or hydraulic cylinders, the piston-rods of which carry swiveling wheels to which are attached short sections of track (not shown).

When the dredge is in the position shown in Fig. 3, the short sections of track under the four cylinders are properly placed on the ground, and by the movement of a valve power is applied to the upper side of the pistons, causing the dredge to rise and lift its main track free of the surface. This track is then drawn or shoved 6 to 10 feet ahead, when the machine is allowed to settle thereon, and is in a position to work its clamshell forward that distance before another shift is made.

The length of the sections of track carried by the wheels attached to the cylinder piston-rods determines its respective lateral movements and enables it to travel curves and turn itself around.

The pneumatic clamshell applied to land excavations as in Fig. 3, works on the surface in sight of the operator, and by dumping its excavated material into a shute beneath its crane, saves a large percentage of the time used by the crane of the present type steam shovel in making its sidewise swing; and thus will average more trips and cubic yards per hour.

An application of this clamshell to land excavation is shown by the illustration, Fig. 3. The land dredge has a curved boom high enough to carry underneath a chute into which the excavated material is dropped. There is no necessity for swinging the boom, which operation takes about 30 per cent. of the time with the usual type of dredge.

C. E. Davenport.

The East River Tunnel.

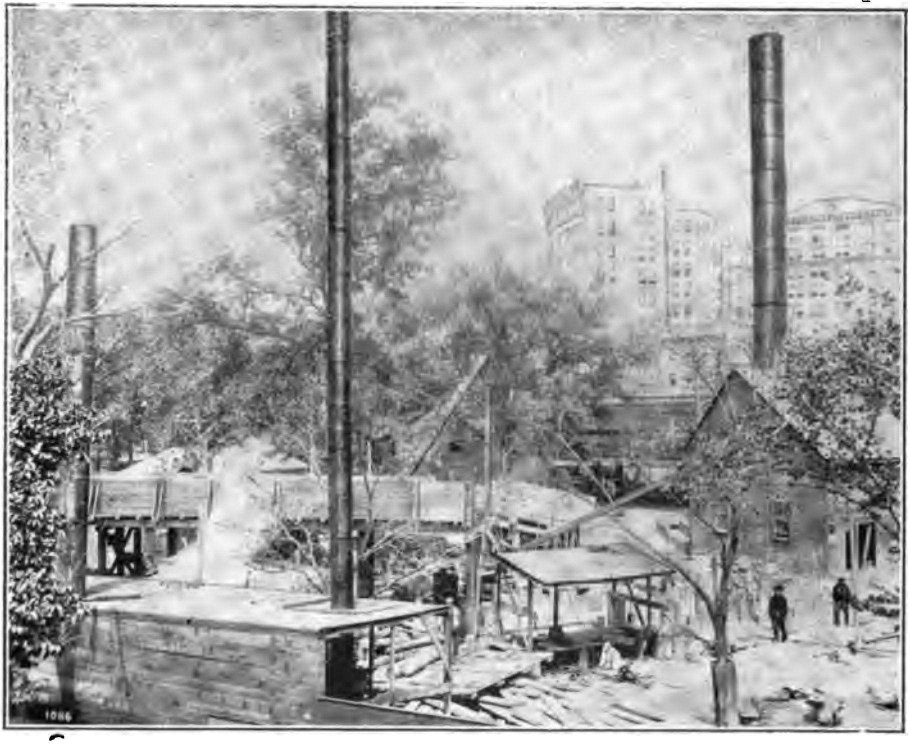
Two enterprises are now under way, both of which aim to improve the transportation facilities between Manhattan Island and the part of the Greater City of New York known as Brooklyn. One will carry its passengers above the East river on a suspension bridge while the other passes underneath that stream. Excavations for the latter have now been made at both sides of the river, and the task of digging two parallel tunnels to connect the portions of the city in question is going forward in earnest.

Particular interest is attached to this tunnel for two reasons. In its construction the most improved machinery and methods for subaqueous tunneling have been adopted and every possible advantage taken of the mistakes made in previous undertakings of this nature. While the Hudson River tunnel was started in 1874 and is not yet completed, this is the first of a series of tunnels recently planned which are to radiate from New York and improve the present very inadequate transportation facilities of America's greatest city. In the case of the others, only preliminary steps have yet been taken, but there seems to be every reason to believe that no time will be lost in their construction, and that considerably less than a decade will see them all in operation. They are really the natural outcome of public demand and not parts of any one grand scheme, yet the announcement of all these improvements has come within a comparatively short period, and the success of the first to begin active operations promises to vitally affect all the others.

The Brooklyn tunnel, as it is frequently referred to, is really a part of the great subway system which is now under construction in New York. Officially it figures simply as a part of Contract No. 2 of the subway. Contract No. 2 starts from City Hall, on Broadway, and goes southward to the Battery, then under the East River through two cast-iron tubes to Joralemon street, and below that thoroughfare to its terminus at the

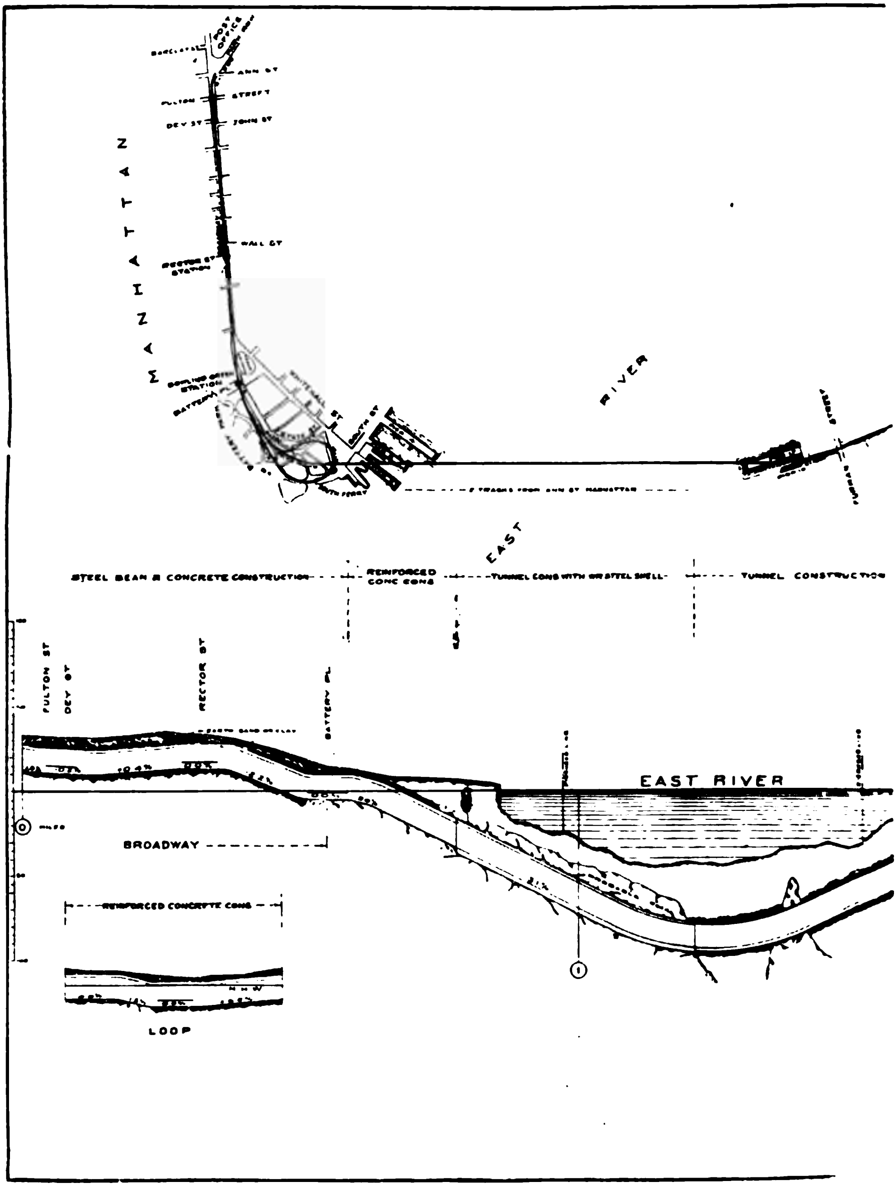
City Hall in Brooklyn. According to agreement, this section must be completed in four years, when it will be one of the most important links in the whole system. Its construction was given to the New York Tunnel Company, of which Mr. Andrew Onderdonk is the president and general manager. The construction is in charge of Walton I. Aims, chief engineer, and John Kirgan, superintendent. An excellent idea of Contract No. 2 may be obtained from the diagrams on pages 2682 and 2683. One shows the plan of the subway and tunnel, while the other gives the profile besides illustrating the construction and kind of material to be encountered. Only the tunnel under the East river will be dealt with in this article.

From the shaft in Battery Park to the one in Joralemon street, Brooklyn, it will be about 4,000 feet long. There will be, in fact, two tunnels, each 15½ feet in diameter, and running parallel to each other ten feet apart. As will be seen from the diagram, the tunnels will descend at an easy grade from either end, making the lowest point in the middle, where they will be 85 feet below water level and 35 feet below the bed of the river. At the side of Joralemon street, where the shaft has been sunk, the tunnels are 60 feet below the street. They will gradually approach the surface as the tubes near the Brooklyn City Hall.

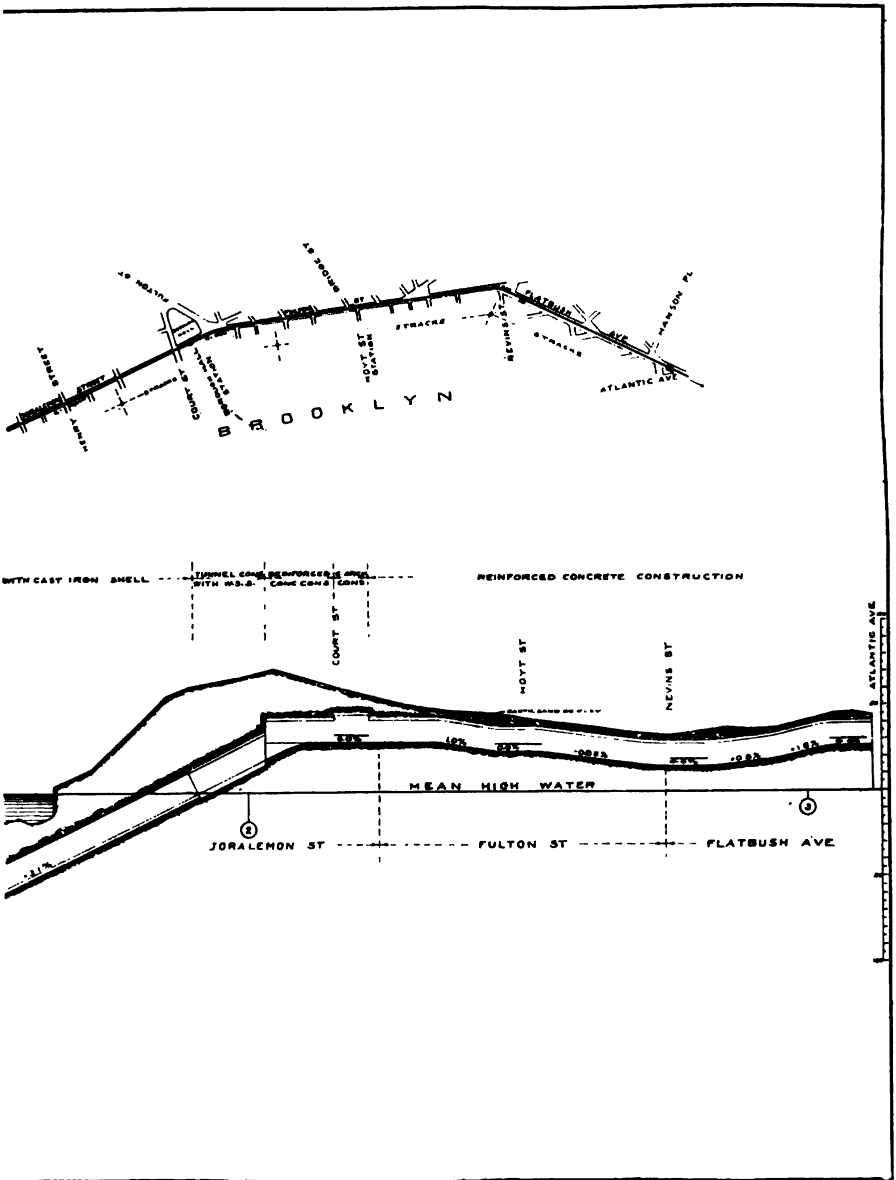


ENTRANCE TO THE SHAFT IN BATTERY PARK.

The conditions met with in the construction of these tunnels conform largely with those which have been encountered in building the Hudson River tunnel. From soundings made, it is the belief of the city engineers that the head-



PLAN AND SECTION



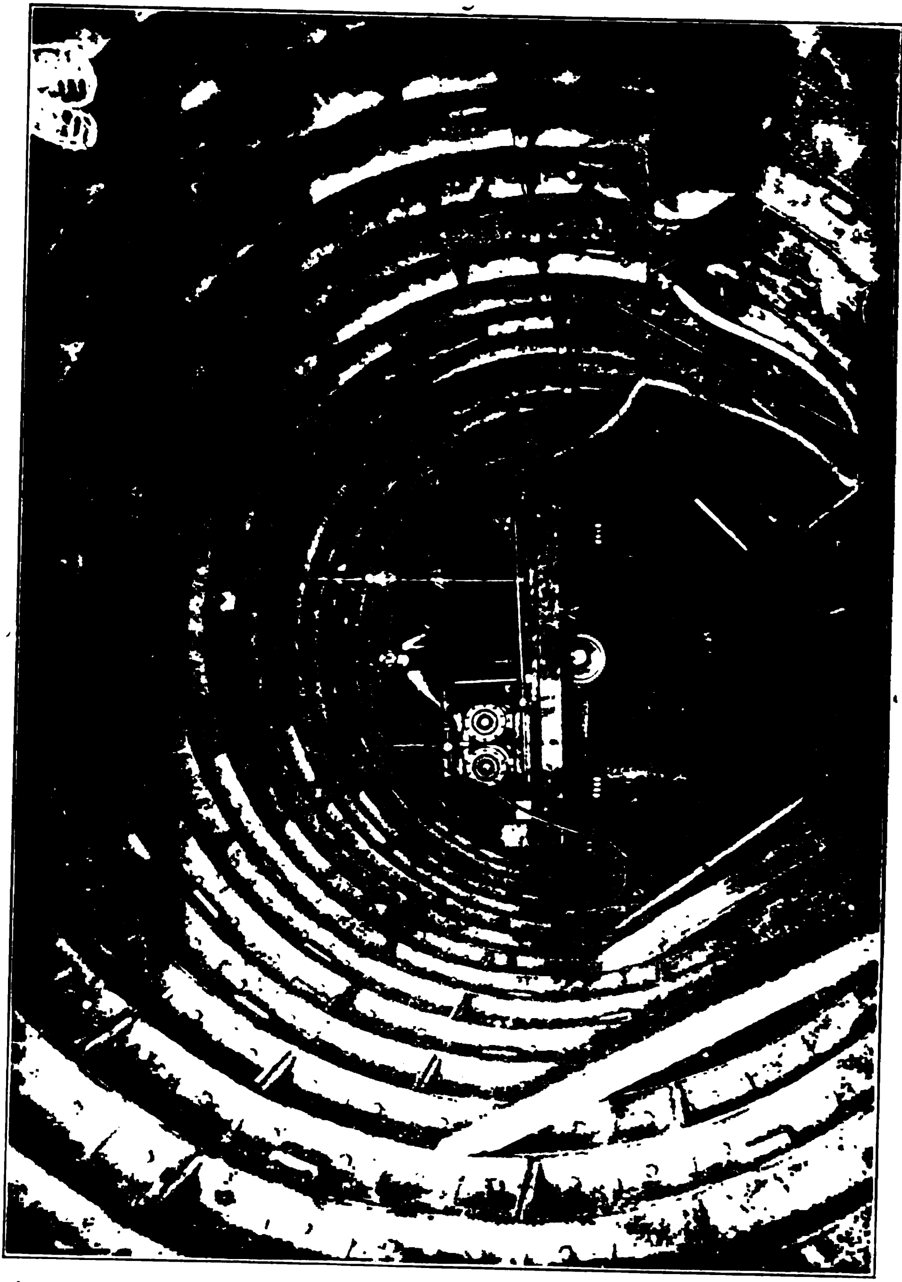
OF EAST RIVER TUNNEL.

INTERIOR OF COMPRESSOR POWER HOUSE IN BROOKLYN inches wide and 6 feet long and locked together at the top with a smaller key plate. All of the plates are flanged and bolted on the side. Inch and a quarter holes are left in the segments, and through these "grout" is forced to fill the spaces between the tube and the sides of the excavation.

It is probable that the entrance to the shaft in the Battery Park, with its accompanying little group of buildings, surrounded by a high board fence, has attracted the most attention from the public at large. Battery Park, from the early days of Manhattan when it was the parade ground for the fashionable folk of the old Dutch town, has always had a special interest for every native New Yorker. Then Castle Garden was the original opera house, the place where the once famous Jenny Lind and many other artists appeared, and hence the centre of the amusement circles of those early days. Eventually, as headquarters of the Emigration Department, its incoming crowds of foreigners made it a place strongly impressed on the memory of those who saw it as their first glimpse of the New World. Now, as a breathing spot at the point of this long drawn out city, it continues to hold the interest and affection of many. Strange buildings, an excavation and a trestlework crossing the park from the shaft to the water's edge have naturally caused more comment than would such an enterprise in any other part of the city.

ROCK DRILL IN THE HEADING UNDER EAST RIVER.

This trestle already mentioned is 400 feet long and serves as a means for disposing of the rock and other material removed from the heading. Small cars holding about one cubic yard are moved



INTERIOR OF ONE OF THE TUNNELS UNDER EAST RIVER.

Pierre P. Pullis, Photographer.

from the end of the heading to the opening of the shaft by cable. The pneumatic hoist quickly lands them on the trestle on which, with the aid of another cable, they are carried on to the water's edge, where scows are ready to receive their loads. This material is being used for building a wall on Governor's Island and filling in behind it.

For the work of excavation 14 Ingersoll-Sergeant rock drills are being used in the two headings, which start in Battery Park. From the compressor plant, which stands close to the top of the shaft, there are two 6-inch pipe lines which carry the air into the tunnel. From one, in which the air is compressed to 100 pounds per square inch, it is distributed through branch lines one, two and three inches in diameter, to the drills, the pumps which keep the tunnel free from water, and the other pumps which are to operate the hydraulic jacks for moving the shields when they are ready. The second 6-inch pipe line carries air from 15 to 25 pounds pressure for maintaining the pressure inside the air lock.

The Brooklyn end of the tunnel is equipped in much the same fashion. There are two shafts sunk in Joralemon street from which run four headings, two in either direction. The material encountered is soft and the shields, each moved by hydraulic jacks, 14 in number, are used for extending these headings. As in the other case, air is supplied to two 6-inch pipe lines, one for high pressure and the other for low pressure, and distributed to the various drills and pumps by branches of lesser diameter.

ENTRANCE TO THE SHAFT IN JORALEMON STREET, BROOKLYN.

At the Brooklyn end the small cars for carting away the debris from the headings are substituted by buckets of about the same capacity which are placed on flat cars for transportation in the headings. These buckets are hoisted out of the shaft and the contents emptied into carts which carry away the material for filling purposes.

The handling of the cast-iron segments was quite a problem, but an erector has been found which will put them in place and will hold them there while they are being bolted. This is operated by an Ingersoll-Sergeant three-cylinder engine which receives its air supply from the main pipe line.

EXCAVATING IN THE HEADING ON THE NEW YORK SIDE.

Two large compressor plants have been established in connection with building of the tunnel. One is located in Battery Park, close to the entrance of the shaft, and the other in Brooklyn, at the corner of Joralemon and Furman streets. In the latter case it is necessary to carry the air pipes five blocks under ground to the head of the shaft.

The New York plant includes two compressors, both built by the Ingersoll-Sergeant Drill Company. One is a "Straight Line" compressor with 24-inch steam cylinder, 24¼-inch air cylinder and 30-inch stroke. It has a capacity of 1,223 cubic feet of free air per minute. The other is a Corliss compound compressor with steam cylinders 22 inches and 40 inches in diameter, air cylinders 36¼ inches and 22¼ inches in diameter, and stroke 48 inches. The capacity of this compressor is 3,850 cubic feet of free air per minute. Steam for these compressors is supplied by two Hogan water tube boilers of 350 and 250 horse-power, respectively.

At the Brooklyn power-house there are three compressors which are also manufactured by the Ingersoll-Sergeant Drill Co. There are two "Straight Line" compressors similar to the one located in Battery Park. There is also a Corliss compound compressor with compound steam cylinders 24 inches and 44 inches in diameter, duplex air cylinders 24¼ inches in diameter and 48-inch stroke. The capacity of this machine is 3,208 cubic feet of free air per minute. Steam is supplied by five Ames horizontal tubular boilers of 100 horse-power each. All of these compressors are suitable for either high or low pressure and can be used interchangeably for supplying air for the air lock and for power.

Remarkably rapid progress has been made since ground was first broken. While the present progress at the New York end on the tunnels has averaged 3 feet per day, this will be considerably increased as the work progresses. From the Brooklyn side the shields are being advanced at the rate of 8 feet per day. The contractors are confident that they will have no trouble in completing the tunnel in the required time. Modern methods have been adopted in every case and the undertaking, which a few years ago would have been regarded as very hazardous, has so far been entirely free from accident.

The illustrations which accompany this article give an idea of the work which is being done and show the surroundings at both shafts as well as the compressed air power plant on both sides of the river.

Coal Cutting by Machinery.*

I have read the paper on "Coal Cutting by Machinery" by Mr. Owen Hughes, as read before the Manchester Geological Society of Great Britain, with much interest and satisfaction. It is one of the proofs that our cousins over the sea are interested in this subject, which is one of national importance and interest, and one which is destined to play an important part in the international affairs.

A few years ago Mr. Emerson Bainbridge, of Sheffield, visited America and the World's Fair at Chicago. He was entertained in New York, Chicago and Pittsburg. In an interview with the correspondent of the Sheffield *Daily Telegraph* on his return to England, he virtually stated that the Americans lead the world in the production and use of the latest improved machinery for mining methods and the cheap production of coal. Mr. Bainbridge made the speaking statement that if Great Britain did not wake up to the situation America would be mining coal and shipping it to Europe and dropping it in the English door yards more cheaply than British coal could be mined. That condition has been creeping upon England for a number of years, because the coal masters of that country have been bound, as it were, in the toils of organized labor in a most alarming degree, whose purpose it is to defeat the very object of modern invention and thus throw the country out of the competitive field.

Mr. Hughes' paper is full of interest, and, in my opinion, opens a wide field for discussion. The paper is ample evidence that the mining fraternity in England is not slumbering, but has awakened to the true situation, which was, indeed, even as Mr. Bainbridge had described. It would seem by Mr. Hughes' paper that the machine mining has indeed become a factor in England in spite of the position taken by organized labor in opposition to its introduction. Personally I am at a loss to know why men do not take hold of the machines more readily, as it is clearly indicated in Mr. Hughes' tables that the earning capacity of the men is materially increased by reason of the machine. In Mr. Hughes' first test we see that his No. 4 machine, operated by three men, produced under ordinary condition in a 4 foot 4 inch bed of coal 102 tons in four hours' time, which, at the rate of 4¼ pence, or 9 cents, per ton for undercutting would amount to 36 shillings, or $8.64, which amount, if divided amongst three machine men, would average for each, 12 shillings, or $2.88 for four hours' labor. It would appear, therefore, that if, as Mr. Hughes has said, the working conditions were ordinary, the machine men and their helpers are receiving a very high rate of pay for undercutting coal with the machine.

I can readily understand why the collier or coal loader is paid the apparently high price of 1 shilling 11¼

* The paper by Mr. Owen Hughes on the same subject, which is referred to in the text, was published in the November (1908) number of "COMPRESSED AIR."

pence, or 46 cents per ton, for his particular part of the work, because he has a very high percentage of labor to perform in addition to the actual loading of the coal into the tub. Such work as getting and fixing in position the props and cross bars for the protection of the workmen along the coal face, building pack heaps by the gateways, delivering the loaded cars at a distance of 200 yards from the coal face to the heading or haulage road, etc. All of this extra work takes time and must certainly be paid for, but in the case of the machine man, where there is a straight face of coal uninterrupted by breaks or irregularities, having been previously prepared by the collier, with no obstacles or hindrances to interfere with the constant operation of the machine driving along at a rate of 18¾ yards per hour, I fail to see why they should be paid 4¼ pence, or 9 cents per ton for this work. The coal owner has gone to great expense to prepare and furnish this facility for a high tonnage and should certainly get the benefit of it. The liberal spirit that has been exercised toward the miners both at home and abroad has often militated severely against the introduction of modern machinery. We are not exempt, however, from this same broad sense of generosity toward the miner in America, for we see by running over the statistics for 1901, we mined in one single State more than 7,000,000 tons of coal by machines on a 3½ pence, or 7 cents differential, out of which had to come the cost of operation which generally embraces

Engineers,	Fuel,
Firemen,	Interest,
Blacksmith,	Deterioration,
Pipe-fitters,	Tax,
Machine boss,	Insurance.

Where there is a good substantial daily output, the average cost per ton for the above expenses will come within the range of 1 pence, or 2 cents, per ton, which leaves a margin of 2½ pence, or 5 cents per ton in favor of machines. Even this would appear to represent a fair interest on the invesment, and on this basis there were 465 machines used in Illinois alone in 1901, and produced on an average of 70 tons per machine per shift for the entire year of 250 working days.

But, as Mr. Hughes has remarked, a reduction in the getting price is not the only advantage to be considered in machine mining. The introduction of machines is virtually the equivalent of an increased production without increasing the number of employes. This is important whether the output be great or small. The increased percentage of sound, lump coal is enough within itself to justify the use of machines, especially where coal is being mined for the domestic market; and there is a marked difference in the increased percentage of the total coal won by a machine, especially where the "room and pillar" system is used, as by the more rapid advancement the roof is held intact until all of the coal is mined out, whereas by the slow advancement of the hand pick often a large percentage of coal is irretrievably lost.

I am somewhat surprised to note the small amount of work Mr. Hughes has been able to get out of the Ingersoll percussive machine. In this country if a machine man cannot undercut as much as six or seven 12 feet headings to a depth of 4 to 4½ feet in a single shift of eight working hours, we should consider it sufficient reason for dismissal. However, I am aware that it is difficult to get the standard of the British workmen up to that of the skilled American labor.

Another interesting feature of Mr. Hughes' paper is that part which speaks of the percentage of lump coal coming from the various machines. I am not prepared to agree with him that the Champion percussive and also the Diamond disc machine will yield a greater percentage of lump coal in the same kind of work and under similar conditions than will the Ingersoll, considering conditions generally and not locally and aside from driving headings. It must be understood that the average height of the Ingersoll under cut, if made by skilled labor will probably not exceed 6 inches as against 3 inches to 4 inches with the Champion or the Diamond machine. The Ingersoll, being mounted on wheels and hence free to swing and easily directed in the hands of the skilled operator, will make at least 50 per cent. of the cuttings, large enough to pass over a 1¼ inch mesh, so that there is still 3 inches to compare with the 3 inch undercut of the Champion. The latter machine has a rotating piston; and the X drill bit, which rotates with the piston, cuts this 3-inch curfe of coal up (if it cuts in the coal) into such fine powder that it is totally spoiled for market purposes, while that cut by the two-pointed pick of the Ingersoll is much larger and worth much more as a steam fuel. Again, a cut that is only 3 inches high on the face of the coal is not sufficiently high to allow the coal to drop and roll out freely and hence must necessarily receive a larger charge of powder to blow it out. This has a tendency to fracture and shatter the coal and reduce it to slack.

The excessive use of explosives usually leaves a deposit of dust and soot, and often shows signs of powder burning. Mr. Hughes does not give any figures as to the relative percentage coming from the Champion and the Ingersoll, and my opinion is that a scientific test, made by skilled operators, would show a decided difference in favor of the two-pointed pick. Mr. Hughes may have some local conditions which would bear him out in his view in so far as it relates to his own particular mine, but generally it will not hold good. It has been well sifted and worked out in this country, where there are hundred and even thousands of machines in use, and it is well recognized by the very best authority in this country that there is a substantial difference in favor of the V-shaped cut made by the two-pointed pick. I will admit that where there is a parting at the top of the coal bed which frees the coal and lets it drop after having been under cut, without the use of explosives, the difference, as described above, would hardly exist and the two machines would probably be equal, except that in one case the coal would drop to a distance of 12 inches and roll forward, while in the other case it would drop but 3 inches and must be picked out with the hand pick, which again has a tendency to reduce it to small coal. This condition could, of course, be changed by the process of shearing or nicking.

We use a great many chain machines in this country, whose cut is practically the same as the cut made with the disc machine, and referring again to the State of Illinois, it is generally conceded in that State that there is a difference of 10 to 15 per cent. of lump coal in favor of the pick type of machine.

As regards the comparative capacity of the Ingersoll and the Champion (Mr. Hughes claims that there is no difference) it is quite common to see records of 700 square feet to 1,000 square feet of under cutting per shift with the Ingersoll machine in the hands of a skilled operator. The Champion, as I remember it, is an English-made machine, made over the patterns of the Eisbeis, which is a machine built in Duisburg, Germany. I have seen this machine, and in fact have operated it in this country, in South Wales and also in Germany. While, as Mr. Hughes said, it is easily operated after once being set up, yet it takes considerable work to set it up and tear it down again. I was not impressed favorably with the machine as an American investment, because of its limited capacity. In Germany, where they are operating on heavy pitches, it has proved of great advantage and a blessing to the coal owner and the men. On the heavy pitches the average of the Champion was estimated to me at about 15 square feet per hour. The greatest incentive in using it was that it cut out a dirty band 3 inches to 4 inches thick and located about 3 feet above the floor of the mine. It is certainly used to excellent advantage in all of the steep mines, and large numbers of them are used both for driving headings and for stoping purposes. The principal advantage in this machine, as a heading driver, is that it shears or nicks the sides of the headings and thus does away with blasting largely, and materially increases the percentage of round coal in this class of work. Its slow speed, however, would bar it from use in this country.

Mr. Hughes has recognized one matter which, though seemingly trivial, is of vital importance to mining machines, and that is, the mine officials and the heads of departments should be familiar with the details of machines, its application, limitations and operation. This is indeed very important. I think there is no question but that many of the failures can be traced to the lack of knowledge of details, not only of the machine, but of machine work generally, small matters which appear most insignificant, but combined go to make up formidable hindrances.

Mr. Hughes' experience with flanged pipe, which he recommends in preference to the screwed pipe, is rather contradictory to the experience which we have had in this country. The latter has been much more popular, and indeed much more satisfactory ,than flange pipe. It is generally considered that the screwed pipe can be put together more quickly, and when once laid and in position it is not liable to be broken or to form leakages.

There is one matter which deserves attention while discussing Mr. Hughes' paper. The question, which has proved very embarrassing and has brought forth much discussion all over the country, is of obtaining a full supply of labor at all times to blast and load the coal after the chain type of machine. It is a fact indisputable that we have more difficulty in this country in getting men to work after the chain machine, because of the narrow slot like cut made by the machine, because of a 4-inch bench of coal left on the bottom, and because of other disadvantages, which bring upon the coal loader a very large percentage of extra work, for which, it is claimed, he is not fully remunerated. The differential between the machine and hand work being virtually the same after both types of machines, it follows then that the colliers or coal loaders invariably flock to the mines where the pick machines are in use. This is a significant fact in this country, and cannot be gotten over well so long as the differential of the two types of machine remain equal. It appears that the only way out of the situation is to increase the pay of the men working after the chain machine. Several of the States have already recognized this, and have established a fair differential for loading in favor of the pick machine. In the case of one of the largest coal producing companies in the west having large numbers of chain machines of various makes, I am informed by some of the officials of that company that not one single machine is in operation, owing to the facts as stated above.

It is claimed by some of the advocates of electric mining machinery that the first cost of installing electric machines is less than compressed air, but it has been demonstrated in a multiplicity of instances that when considering plants of like capacity there is virtually no difference in the first cost. It is true, as Mr. Hughes has remarked, that care should be taken in installing a compressed air plant to the end that pipes of sufficient area should be installed so that the frictional losses should be amply taken care of, and in which case the compressed air plant will take care of its full complement of machines for almost any desirable distance.

I note Mr. Hughes' comment on the manner in which he disposed of accumulated water in the pipe line. This is a very effectual method, and in fact the one means by which the water can be readily disposed of. In this country we furnish interior receivers to be located in close proximity to the workings and between the working and the pit-mouth so that any accumulating water is deposited and trapped therein and never reaches the machine.

I can readily understand why Mr. Hughes suggests sending a machine to the surface to be overhauled when it is out of order, as the more complicated construction, such as we find in the chain and disc machines, naturally necessitates bringing them to the surface and light, where the various delicate parts can be more accessible and more accurately fitted, but with the pick type of machine we consider it quite different in this country, and never think of sending it to the surface. It usually goes into service and remains continuously at the coal face year in and year out, without the necessity of bringing it to the surface.

This is one of the peculiarities of the pick machine, and it is also one of the reasons why it will, in the long run, produce cheaper coal than the chain machine.

I am glad to read Mr. Hughes' paper on this subject, and it is to be hoped that it will bring out further discussion, as in this way only we may hope eventually, by getting the experience of our friends and neighbors, to make our system and methods more perfect and complete.

L. J. Daft.

Chicago & Northwestern Railway Air Compressor Plant.

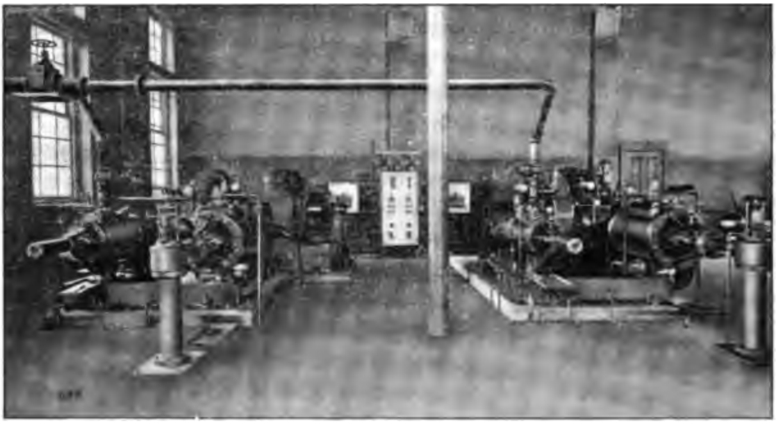
In 1893 the Union Switch & Signal Company, of Pittsburg, installed for the Chicago & Northwestern Railway an electro-pneumatic switch and signal system to control the movements of trains in the terminal station and yards at Wells and Kinzie streets, Chicago. The system to-day is much more extensive than in 1893, additions at various periods being made necessary by the constantly increasing number of train movements, due to increased business.

When this system was installed it included among the various appliances three Ingersoll-Sergeant 14-inch and 14¼-inch by 18-inch Class "A" air compressors, each having a capacity of 365 cubic feet of free air per minute. These compressors were removed from the power station, at Wells and Kinzie streets, in June, 1901, and were located farther out in the yards. At the same time two direct connected electric motor driven Class "J" Ingersoll-Sergeant compressors were installed at Wells and Kinzie streets.

The compressors are of the duplex compound type, having low pressure air cylinders 18¼ inches in diameter, with a 12-inch stroke, and high pressure air cylinders 12¼ inches in diameter, with 12-inch stroke. Each compressor is driven by an 80 h. p. compound wound 220 volt direct current motor of the General Electric type; the motor being mounted on a sub-base bolted rigidly to the compressor sub-base and connected to the compressor by means of a large cut gear and rawhide pinion.

The motor speed is 480 revolutions per minute and the compressor speed is 135 revolutions per minute; thus giving each compressor a capacity of 470 cubic feet of free air per minute, which is compressed to 100 pounds pressure.

The motors are controlled by two starting and automatic releasing rheostats, the arrangements being such that the compressors can be run at six different speeds determined, of course, by the amount of resistance inserted in the motor circuit. Each motor is protected by circuit breakers which "blow out" when the ampereage becomes too great for any cause.



AIR COMPRESSORS AT CHICAGO AND NORTHWESTERN RAILWAY STATION.

The air inlet of each compressor is equipped with an automatic choking controller, which allows only enough air to be drawn into the compressor to satisfy the demand. As its operation is gradual the load is thrown on and off the motor gently, thereby eliminating any violent fluctuation in the motor loading. When there is no demand for air there is none compressed and the motor is operated at the same speed, but under none but friction load.

The service is very exacting, and as the demand for air has increased rapidly, both compressors have been run almost continuously for 24 hours per day during the past year. After the air is compressed it is led to the aftercooler in order that any condensing moisture may be deposited. This aftercooler is rather unique and quite inexpensive. It consists of a series of panels, each panel having two large horizontal pipes into which are threaded a number of small pipes. The large pipes are capped at suitable places, so that the air must pass through the entire system. Connected to the large horizontal pipes are small receivers into which the moisture drains and can "blow off" at suitable times by opening small valves. From this aftercooler the air is led to various openings, where it is used.

The air is distributed by means of a 3-inch pipe line, which extends four and a half miles north to Gross Park and three and a half miles west to California avenue. In addition to the switches and signals, this pipe line supplies air to the passenger yards at Erie street and Ashland avenue. The loss of pressure due to transmission is about 15 pounds at Gross Park, the farthermost point. At various places in the pipe line drains are provided, so arranged that any moisture can be "blown out" at intervals.

At the California avenue freight yards are two 14-inch and 14¼-inch by 18-inch Class "A" Ingersoll-Sergeant compressors. These serve to aid those located at Wells street station.

Primarily, as stated above, the compressed air was used for the switch and signal system, but now is also used for pumping water, blowing our locomotive flues, cleaning cars, cushion and rugs, jacking up cars in yards and operating small engines connected to dynamos which furnish current to large storage batteries.

At the Wells street power-house an air lift system provides 70 gallons of water per minute from a deep well and delivers it directly to the reservoir, elevated about 25 feet above the boiler-room.

At various points between Gross Park and California avenue are located signal towers, all of which contain storage batteries to furnish current for the switch and signal system. At some of these towers there is no direct electric current available for charging the batteries. Current is made available, however, by having small Westinghouse generators direct connected to Case engines which are driven by compressed air. The engines are about 3 h. p. capacity and are located at Wells, Ada and Sangamon streets and Ashland and Grand avenues.

The severe demands made on the air compressors at present are due, in part, to the many valuable uses which has been found for the air, and serves to demonstrate what a useful power agent it is to have available.

We wish to thank Mr. A. J. Farrelly, of the Chicago & Northwestern Railway, for the information contained in this description.

Martin Metallic Flexible Joints.

There are a great variety of uses for metallic flexible joints in the place of rubber hose for steam, oil, air and water,

FIGURE I.

and we illustrate in this article two Martin metallic flexible joints which, it is claimed, give a perfectly tight flexible connection in any place where movement and vibration are occurring between connecting parts.

It will be noted in figure 1, which is called a pressure joint, that the tightness does not depend on a ground joint or abrasive wearing parts, but the ball rides in a seat of hard moulded non-metallic gaskets, which are interchangeable and self lubricating. The wear is all taken by the front gasket, as the ball is forced against this gasket when the pressure is on. When the front gasket is fully worn out and begins to leak, it can be interchanged with the rear gasket.

FIGURE 2.

These joints are made of the hardest bronze metal and as they do not depend on a ground seat to make them tight, the trouble and expense of regrinding the ball and its seat is eliminated. It is said there is no wear whatever on the joints, so that they are good for many years of usefulness.

The joint, shown on figure 2, is called the Martin liquid joint, and is used for oil, water and other liquids. It will be noticed that the two gaskets are kept in contact with the ball by means of a spring which does not come in contact with the liquids passing through it.

It is surprising the large number of uses to which these joints are put, and the wide range of movement three or four of either of these joints in connection with suitable length of iron pipe will accommodate. They are in general use for steam heat connection between locomotives and tenders, Lidgerwood unloaders, steam shovels, air lines in quarries, mines and all railroad shop and yard uses, also for high pressure work and hydraulic uses.

All sizes of these joints are manufactured by the Holland Company, 77 Jackson Blvd., Chicago, 12 Fremont street, San Francisco, Cal., or 26 Cortlandt street, New York.

Sanitary House Cleaning.*

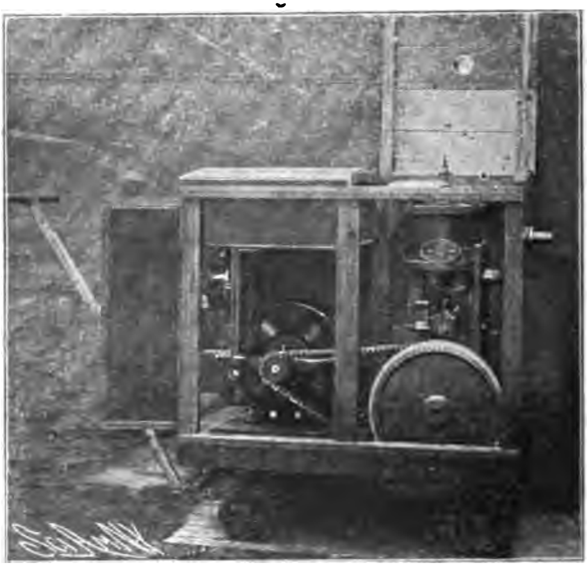
Several years ago the idea of using what might be called an air blast in cleaning fabrics suggested itself to a number of the railroad companies in this country, and since that time the seats and curtains, as well as the ceilings and walls of passenger coaches, in several systems have been freed from dust by the application of air through hose. The air has been compressed to various densities, the usual plan being to connect the tubing with apparatus attached to a yard locomotive, thus providing a portable compressor which could be placed wherever convenient. The jet from the hose pipe was directed against the surface to be cleaned. The plan was considered by no means perfect, as no means was provided for collecting the dirt, but most of the railroad companies which have employed it have preferred it to the broom method.

The idea, however, has originated a more elaborate system which has been tried in several cities with much success. The apparatus is constructed in a variety of forms, so that every kind of an object covered with fabric can be freed from the dirt which may settle into the covering. Even billiard tables, heavy carpets, and rugs are renovated, as well as upholstery, pillows, and bolsters. The air is supplied by compressors operated

* By Day Allen Willey in the *Scientific American* of October 24. Illustrations reproduced through the courtesy of the *Scientific American*.

either by steam engine or electric motor, the latter usually being preferable. The compressors are constructed in various sizes, according to the service to be performed, ranging from 50 cubic feet of free air per minute upward. As they are intended for installation in hotels, apartment houses and other large buildings where the facilties for repairs are not at hand, they are especially designed for durability and the working parts are inclosed to exclude all dust and grit, while the lubrication is automatic. This is one of the interesting features of the compressor, as no sight-feed lubricator is required. The piston rod passes through a specially constructed metallic packing box, which is self-adjusting. It is provided with an improved form of packing rings, which are carefully fitted in place, both in the piston and against the surface of the cylinder, so as to form a perfect sliding joint. The extended end of the crank shaft is provided with a gear which meshes with a pinion arranged on the armature shaft immediately above. The gear chamber and the crank chamber are connected in such a way that the gear as well as the pinion are operated in a bath of oil, which oil is also supplied automatically to the bearings at the pinion end of the motor. The gear and pinion are of the helical herring-bone type, thereby reducing the noise of operation.

If the compressor is operated by electricity the motor is usually direct-connected, taking the current from an isolated plant, or the generating set, which may be installed in the building. The motor is of the series-wound type, with formed coils of the latest pattern, and so constructed that the compressor can be started without using resistance on the motor circuit, closing the circuit in the same manner as with a knife-switch. This avoids considerable wear and tear.



A PORTABLE ELECTRICALLY-DRIVEN SUCTION PUMP FOR HOUSE CLEANING USED IN ENGLAND.

As already stated, some of the compressor plants used for supplying air for cleaning large buildings are stationary. They are generally located in the basement, for convenience.

From the air reservoir extend stand-pipes, as they might be termed, to each floor of the building. Usually they are laid along on the inside of the elevator well or air shaft. At each floor a valve is inserted in the pipe connected with a nozzle to which a hose length can be fastened like an ordinary water pipe. To supply air to the various floors it is, of course, only necessary to start the compressor and allow the air to escape through the various valves into the hose lines. These are fastened to the apparatus to be used for floor, furniture, or tapestry cleaning, and the operation can be performed as often as desired. As is well known, hotel rooms are great collectors of dust, since the doors and windows are opened so frequently and the various apartments are in such continual use. In a well-managed hotel the floor coverings of the halls, dining room and parlors are usually swept or "run over" with the carpet cleaner at least once a day, while the bedrooms are cleaned several times a week, depending upon the extent to which they are used.

CLEANING THE CHALK FROM A POOL TABLE WITH THE HAND MACHINE.

Consequently the compressor plant is apt to be almost in daily use in a building of this kind.

For the cleaning of smaller buildings, such as dwellings and offices where the installation of a plant would be too expensive, a portable system is employed. A compressor of suitable size, operated by a gasoline engine, is mounted upon a truck especially built for the purpose and hauled from house to house. Hose lines are attached to the air reservoir and extended into the building as pipe is laid in extinguishing fires, and in this way the house cleaning can be performed as often as desired without removing the furniture or even taking up the carpets if it is not desirable. It is interesting to note that the automobile has been brought into use in this service, the motor which operates the air plant being also used to propel the machine when under way. Such is the capacity of a portable plant that three men can clean every portion of an ordinary ten-room house in a day of ten hours.

CLEANING UPHOLSTERY WITH THE HAND MACHINE.

The types of apparatus for applying the air to the material vary, of course, according to the work to be performed. In the Nation-Christensen system, which has been installed in a number of large hotels and buildings, the carpet renovators are of various sizes, ranging from 12 to 36 inches in width. They consist of a steel framework which lies flat on the surface of the fabric. This is termed a hood, and contains an expanded nozzle connecting with the hose. In the bottom of the hood is a slot about 1-100 inch in width, through which the air passes in what might be termed a sheet. It is forced into the fabric at various pressures, according to the thickness of the latter and the amount of dirt which has accumulated. The usual pressure varies from 60 to 70 pounds to the square inch. This is sufficient to blow the dirt out of and from under the covering. It passes upward through two other slots into the hood, as it cannot escape outside of the machine on account of the weight on the surface. It is prevented from escaping into the air by a cloth bag which collects it but is

TESTING A RENOVATOR BY REMOVING FLOUR FROM A CARPET. THE DARK STRIPS SHOW THE PORTIONS WHICH HAVE BEEN CLEANED BY THE MACHINE.

loose enough to allow the air to pass through. The dirt settles into a pan especially designed to collect it. When filled, this can be readily removed by taking off the bag and emptied. To the renovator is attached a handle for moving it over the floor. The handle also acts as a conduit for the compressed air, the supply of which is regulated by an ordinary valve. The apparatus is usually pushed over the carpet and does its work so thoroughly that it will remove any kind of substance which can be driven out by air pressure. In several instances flour was thrown upon a rug and trod in with the feet. When the renovator was applied it apparently collected every particle of the flour, none escaping into the air.

REMOVING DUST FROM CURTAINS.

In treating lambrequins and other kinds of upholstery the hose is connected with a jointed steel tube long enough to extend to the upper portion of the apartment. The ordinary air blast is directed against the draperies and the dirt allowed to settle upon the floor and furniture. Obviously the draperies and upper portions of an apartment are the first cleaned, then the furniture and floor covering. For removing the dust from upholstered chairs, sofas, and other kinds of furniture, what might be called a hand renovator is employed. It is constructed on the same principle as the larger type with the slots for applying the air pressure and collecting the dust, and is pushed over the surface by hand. If the chair, for example, is stuffed with cotton or some other material, more power is employed to force the air through this material as well. As already stated, even billard table coverings are thoroughly cleaned of the chalk and dirt in the same way. In freeing such articles as pillows and mattresses a simple pneumatic needle is used, the air being injected with sufficient force to circulate among the feathers, straw or other stuffing and expel the dust which may have collected.

In England a vacuum-cleaner is used which depends upon a somewhat different principle. This apparatus consists essentially of a bronze suction pump driven by an electric motor. The suction pipe is connected by flexible tubing with a metal cone, which is provided with short rubber tubes disposed very much as are the bristles of a brush. Between this air brush and the pump is a hermetically sealed box, which acts as a condenser of the dust gathered up. The air which is drawn in is discharged against a baffle plate so that the larger particles of dust are precipitated. The remaining portions are filtered by passing through filtering material, the clean air being then discharged into the atmosphere. The dust collected in the box can be removed by opening a valve in the bottom of the box. The apparatus which we have described is used in many English hotels and also on the steamships of the Cunard Line.

Electro-Pneumatic Signals in England.

In connection with the new station which is approaching completion at Bolton, the Lancashire and Yorkshire Railway Company has introduced an installation of power-signalling, and the new system was brought into use recently. The system employed is that known as the "Westinghouse electro-pneumatic," which, as its name implies, depends for its action upon a combination of air and electricity. The points and signals, instead of being operated by means of rods and wires, as in the ordinary system, necessitating considerable manual power, are operated by air-motors, one of which is connected to each pair of points and each signal. The motors are driven by compressed air at a pressure of about 70 pounds per square inch, and are placed in all cases as close as possible to the points or signals which they operate. Each cylinder is provided with valves to control the inlets from the air main, and these valves are opened and closed by means of electro-magnets actuated by electric currents from the signal-box. Thus the power is applied directly at the point at which its services are required, and is subject to the central control of the signalmen. This control is exercised by means of a frame of miniature levers, similar in appearance to the levers in an ordinary interlocking frame, and made simply to open or close electrical switches, and thus to control the electrical circuits in connection with the air-valves of the cylinders. Any desired points or signals, or combination of points or of signals, can thus be operated by connecting the electrical circuits controlling the air-valves to one or more of the levers in the signal-box.

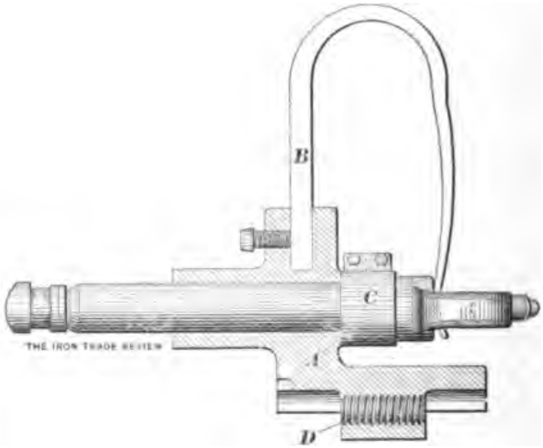
Ample measures are provided by means of auxiliary electrical circuits to guard against a signal being lowered unless the points which it controls are actually in their correct position, and in the case of facing points to ensure that they are also securely bolted in that position. An ingenious feature is what is known as the "check-locking" arrangement. This ensures that until the movement of a point or signal has been fully completed the lever in the signal-box which is concerned is checked, when about three-quarters of its stroke is accomplished. As soon as the signal or point movement, as the case may be, is properly completed, the "check-lock" is electrically removed and the signalman is enabled to pull the lever fully over. Until he has done so the mechanical locking in the frame prevents the movement of any contingent point or signal levers, which are thus held locked, until the movement of any necessary points has actually been completed. The further advantages to be obtained from the use of power-signalling are the smaller space occupied by the levers, the consequent reduction in the size of the signal-boxes, and the dispensing with rods and wires above ground. The Lancashire and Yorkshire Railway is the first company in the north of England who have applied the electro-pneumatic signalling of any size to passenger lines.—*London* (Eng.) *Daily Times*.

Another Use for the Pneumatic Hammer.

The *Iron Trade Review* for October has illustrated one of the ways in which the pneumatic hammer has been applied to another machine. This arrangement has been patented by Mr. Chas. R. McKibben, of Pittsburg, Pa. We are indebted to the *Iron Trade Review* for the illustration accompanying this article. It is described in that journal as follows:

"The carrier for the hammer is represented at A and a seat is formed in the carrier of a suitable shape to receive the hammer and to permit it to be advanced and withdrawn. A strap spring B of horseshoe type serves to hold the hammer forward in the carrier. The strap spring is rigidly mounted in the carrier A and held in place by a setscrew, the free end bearing upon a portion of the hammer. As will be seen, the strap spring B may be promptly removed and the hammer withdrawn from the carrier.

"A lug or shoulder is shown on the hammer as at C and this abuts against a spot on the carrier and limits the advance movement of the tool in the holder. A screw thread formed in the carrier at D indicates the manner in which the carrier may be adjusted and attached to a support on some suitable machine."



PNEUMATIC HAMMER AS A MACHINE DETAIL.

Air Compressor Accidents in Collieries.

The Dortmund Colliery-Boiler Inspecting Association reports two cases of accident with air compressors. In the one instance the air reservoir, which consisted of an old boiler, exploded; and the chemical examination of the pulpy residue in the bottom of this vessel, and of the pulverulent fragments of lignitic matter found in the body of the admission valve, revealed the presence of asphaltic substances; tarry bodies, paraffin, carbon, iron oxide and other inorganic substances, indicated that the oil used for lubricating the compressor had sustained a kind of dry distillation, attended with the formation of oxy-hydrogen gas. The ignition of the latter is assumed to have been effected by the high temperature, and facilitated by the presence of finely-divided metallic iron, or the admittedly high friction in the cylinders may have actually produced sparks or local super-heating. Laboratory tests showed that the lubricating oil in question (a good medium quality mineral oil, flashing at 229 and igniting at 294 degrees Cent.), when partly vaporised and mixed with air, furnished heavy hydrocarbons that yielded oxy-hydrogen gas on being mixed in the proportion of 32 per cent. with air. These results indicate the necessity for using an oil of higher burning point, the provision of a thermometer for controlling the temperature in the compressor, a valve for shutting off the air reservoir in the event of local overheating in the compressor, and the occasional testing of samples of air drawn from the reservoir and air pipes.

In the other instance, detonation occurred in the pipe leading to the air reservoir, and the safety valve on the latter began to blow off with violence. The examination of the pipes and reservoir showed the presence of a deposit of oil on the walls, and also revealed a coky residue mingled with iron oxide, the explosion being attributed to the spontaneous ignition of this oil and finely-divided iron (from the attrition of the piston and cylinder); and, in fact, the engineman stated that small outbreaks of fire had previously been detected in the pipe, a ferruginous coky residue being left in each case.—*Glueckauf* (Germany).

Laying the Dust While Drilling.

Mr. W. Wilson, of Cleator Moor, Cumberland, Eng., has recently patented in England an invention which he claims will result in the valuable improvement of rock drills operated by air or steam. There is always a certain amount of dust raised when the rock drill is at work, and this dust, besides being troublesome to the operator, has a tendency to choke the drill. Various methods of laying this dust have been devised. The object of this invention is to accomplish this by means of the air in the drill itself, so that no extra work is thrown upon the man attending the drill.

For this purpose the piston and piston rod and drill or bit are formed with a hole or way right through the same and passing axially through the bore of the piston, and entering by one end thereof into the piston rod and fitted into an enlargement of the bore thereof formed to receive it is a water tube. The rifled bar is axially bored to allow of the passage through it of the tube, and the ratchet wheel or other mechanism is correspondingly bored for the same purpose. The water tube may be fixed with the rifled bar so as to turn therewith or it may be independently fixed so as to remain stationary while the rifled bar turns. The outer end of the water tube is by means of a stuffing box, or otherwise, according to whether it is revolving or stationary, connected with a head of water or supply of water under pressure, and by a valve placed under the control of the operator, who may thus cause a sufficient stream of water to issue from the drill or bit upon the work to effectually lay or prevent the formation of dust arising from the action of the drill and at the same time clear out the hole.

A simple means of supplv water to the water tube is the following: A closed tank of water is employed, preferably fitted with a safety valve, and the upper part of this tank is by a pipe fitted with a regulating valve connected at a suitable point with the ordinary pipe supplying air or steam as the motive fluid to the cylinder. The tank is fitted with a pipe extending through the top to near the bottom thereof, and to the upper end of this pipe is connected one end of a pipe or hose, the other end of which is connected to the water tube of the drill or the pipe or hose might otherwise be connected with the tank so as to take a supply of water from the lower part thereof. By this arrangement a small proportion of the motive fluid will be conveyed into the top of the water tank, thereby creating a pressure within the tank and forcing a stream of water into and through the water tube of the drill and out at the drill or bit. The fittings are so arranged that when desired the hollow drill or bit may be substituted by an ordinary solid one and the supply of water to the water tube shut off, when the drill may be worked in the ordinary way. The water pressure apparatus may when desired be disconnected from the water tube of the drill and fitted with a spray nozzle so that the water supply may be used independently of the drill for laying dust or other purposes.

An Air Signal on An Air Brake Train Pipe.

Those who are interested in compressed air will always find something of interest in the Air-Brake Department

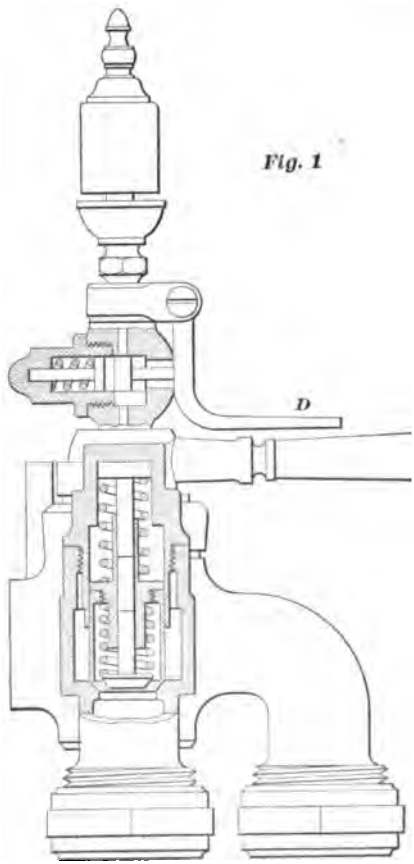
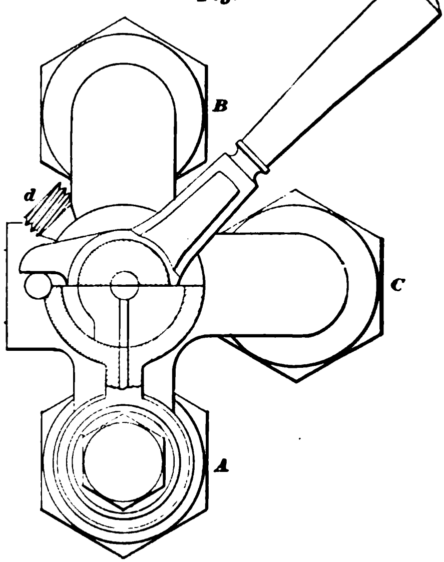


Fig. 1

of the *Railway and Locomotive Engineering*, which is conducted by F. M. Nellis. In the October number there is an interesting article on the subject "Air Signal on Air-Brake Train Pipe." Mr. Nellis writes:

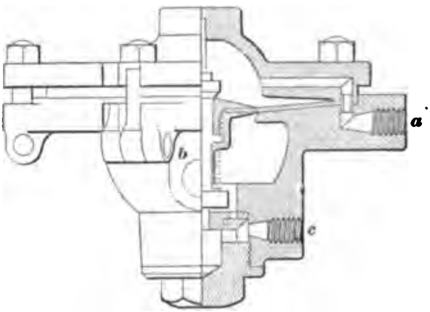
"A correspondent asks if any one has ever devised a scheme to operate the air signal on the train pipe of the air-

Fig. 2


brake. For his information and that of others we would say that as far back as 1876 Mr. Westinghouse patented an air signal to operate on the train line of the brake system. This scheme is illustrated in accompanying cuts in this department.

"To give the signals with this arrangement, a modification of the three-way cock, the brake valve then in use, was necessary. The construction of this valve is shown in Figs. 1 and 2. The connection from the main reservoir is made to the union *A*, the brake pipe is connected to the union *B*, and the branch *C* forms a discharge port. The modification consists of the introduction, in the reservoir connection, of a piston valve for limiting the diameter of the opening to the brake pipe to one-eighth of an inch at all times, except when the brakes are to be released, when this valve, by moving the handle of the three-way cock to the position shown in Fig. 2, is raised from its seat, leaving the passage unobstructed. The slightest return of the handle toward its central

Fig. 3



position reseats this valve, leaving the opening one-eighth inch as before.

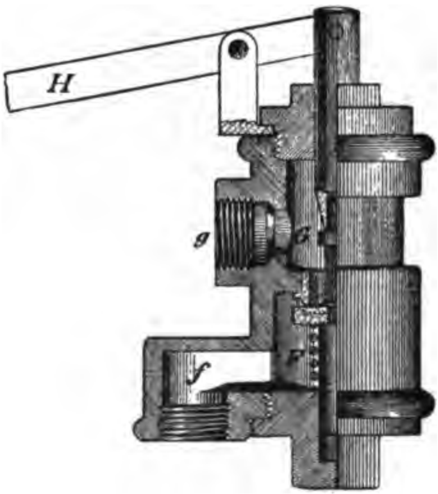
"A further modification is the small whistle and valve screwed into the top of the plug and connected by the union *d*, with the port *c*, of the diaphragm valve. The piece *D*, by opening a side port, enables the engineer to prevent the blowing of the whistle while operating the brakes. This, of course, throws the signaling device out of commission, meanwhile.

"The diaphragm valve, Fig. 3, has a port, *a*, connected to the brake pipe, through which air passes to the signal reservoir, located at some convenient point under the cab or running board, which latter is connected to the port *b*, charging it with the same pressure. A slight reduction of pressure in the train pipe causes the excess of pressure in the reservoir, acting upon the diaphragm interposed between the ports *a* and *b*, to open a valve which permits the air to pass from the reservoir to the port *c*, to the pipe connection *d*, on the three-way cock and valve to the whistle, sounding it until the equilibrium is restored on the two sides of the diaphragm.

"Fig. 4 shows the car-brake valve for application of the brakes and the giving of signals. The connection from the main brake pipe is made to the port *f*, leading into the chamber *F*. A second chamber, *G*, has a connection, *g*, leading to the atmosphere. The chambers *F* and *G* communicate through a port closed by a valve having a rubber face, which is held in its seat by a small spiral spring assisted by the air pressure. The cord extending through the car is attached to the lever *H*, and, when pulled, opens the port between the chambers *F* and *G*, discharging the air through the port *G* and into a small pipe leading through the bottom of the car. As will be seen, the signal valve is really the beginning of the present conductors' valve which is now used to apply brakes only.

"In addition to this patent held by the Westinghouse Company, a number of

Fig. 4



similar patents have been gotten out by railroad and air-brake men from time to time. Our readers will recognize the weakness of the scheme in the fact that signals cannot be given at the moment that brakes are either being applied or released, and can only be made effective at such times as the pressure in the train pipe is in equilibrium and is not flowing in or out."

Notes.

A cylinder for use in pneumatic hammers or rock drills has been patented in England by John Elliot Howard, of Eastbourne. The air is admitted through the rear end of the cylinder, and, with the aid of a tappet valve, is guided to either side of the piston at the proper time.

Mr. Irving H. Reynolds will shortly retire from the Allis-Chalmers Company, and the duties of chief engineer will be assumed by the engineers in charge of the various departments, these engineers availing themselves of the advice of Mr. Edwin Reynolds, consulting engineer of the company.

The *Mining Journal* (English) declares that in South Africa to-day machine stoping, under suitable conditions as to stope widths, is actually costing less than regular widening by hand labor. The *Mining Journal* declares that it has always maintained that machine stoping would be cheaper than hand stoping.

Among the latest English patents is a small air compressor, the inventor of which is W. J. Stevens, of Skowhegan, Me. The compressor is designed for operating air brakes on vehicles, and derives its power from the axle. It is claimed to be cheap, durable and simple, and to employ a minimum pipe system.

An interesting description of the foundry and town of Trafford City, Pa., built by the Westinghouse industries, is given in a recent number of the *Engineering Record*. As usual, compressed air figures at the power-house, where an Ingersoll-Sergeant air compressor, with combined air and steam cylinders, is in constant operation.

A new comer in the compressed air field is reported from McCloud, Cal. A pneumatic timber cutter it is called, and it is said to be the invention of an Oregon railroad employee named Young. According to the reports this machine will in five minutes cut through a tree that would require an hour's work by two men.

The attempt of the British Vacuum Cleaner Company, Ltd., to extend its business into the British Possessions seems to be meeting with considerable success. That concern has recently organized an auxiliary company to be known as the Australian Vacuum Syndicate, Ltd., which is intended to operate in Australia.

In a discussion on drilled vs. punched rivet holes in the hulls of ships, which took place at the engineering conference in London last summer, A. F. Yarrow, a prominent English engineer, declared that a service of compressed air all over the shipyard and on board each vessel under construction offered facilities for executing such work as was before unattainable. Mr. Yarrow was strongly in favor of drilled rivet holes.

The *Engineering Times*, an English publication, contained in its October number a brief description of the compressed air power plant of the Continental Compressed Air Company, which is reported to be operating some 50 engines in Norwich, Conn. This subject has already been discussed somewhat at length in COMPRESSED AIR, and several descriptions have been given of the Taylor system of hydraulic compression which is used.

The Nernst Lamp Company, of Pittsburg, Pa., has just issued a new pamphlet on the subject of the Nernst Lamp. It consists of a treatise by Mr. A. J. Wurts, the electrical engineer, who has developed the Nernst Lamp to its present practical efficiency. It contains some very valuable information and should be read with interest not only by those who are directly interested in the electric professions, but by those who are interested in the progress of American ideas.

Two new catalogs have been issued by the Ingersoll-Sergeant Drill Co. during the last month. One is a temporary edition of the Compressor Catalog and is known as 33B. It has been improved by the addition of new cuts and up-to-date descriptive tables of compressors. The other is a 32 page pamphlet, Form No. 4, illustrating the products of the Pneumatic Tool Department. There is additional information regarding the Haeseler pneumatic hammers while the piston and breast drill and the "Giv't-a-Twist" hose coupling are noted for the first time. Both of these catalogs may be obtained upon application to the Ingersoll-Sergeant Drill Co., 26 Cortlandt street, N. Y.

The *Daily Telegraph,* of London, writes: "We have not quite reached that stage of development in which liquid air will be sold as beer is to-day, but apparently that stage is approaching. In Berlin it is now being delivered to customers at the rate of two litres, roughly half a gallon, for about 1s. 6d. According to the *Energie,* published in that city, the receptacles are made of glass with double walls, the intermediate space between the walls being filled with non-conducting material and the external surface silvered to prevent radiation. One of the most fortunate circumstances which the researches of Dewar and others have brought out is that glass will endure such remarkable differences of temperature between the liquid air within and the common air without, amounting to several hundreds of degrees, and yet suffer so little from brittleness. Several minor industries are carried on in which liquid air at 1s. to 2s. a gallon would be an economic commodity."

In such an important power plant as that of the Lackawanna Steel Company it is not surprising to note that a compressor plant of considerable size is in operation. A description of these works, which appeared in the *Engineering Record,* had this to say about the compressor plant:

"The part of the station adjoining that devoted to the electrical machines contains four Ingersoll-Sergeant air compressors, each rated at 900 cubic feet of free air per minute at 100 pounds pressure. The steam end of these compressors has two 12 by 16 inch cylinders. The cylinders of the air end are compounded, with diameters of 22¼ and 14¼ inches and a stroke of 16 inches. The air valves are of the piston inlet rather than the older poppet type employed until recently on machines of this class. These compressors furnish air for the pneumatic tools in different parts of the works, for operating the bells of the blast furnaces, for starting the gas engines and for many minor purposes."

A company in Providence, R. I., has constructed a trolley water sprinkler operated by compressed air on a new principle. In the old sprinklers the compressor was driven by the axle, and at low speed the pressure was inadequate to throw the water far from the machine. The new sprinkler has a small electrically driven compressor which is entirely independent of the axle.

The pressure in the air chamber is 80 pounds, which in practice is reduced to 12 pounds on streets that are comparatively narrow. The sprinkler has, it is claimed, the power to throw the water from curb to curb on the widest avenues. The builders claim that it can wet down a street 100 feet in width.

One fault found with the machine has been that too much water is thrown near the rails. A modification of the nozzle is now expected to provide a more even distribution of the fluid. The pressure is so great that the last quart of water is ejected from a tank having a capacity of 4,500 gallons. The motorman regulates the quantity of the flow according to the speed of the sprinkler.

While not in the St. Louis Exposition grounds, the St. Louis union terminal station promises to be an exhibit of as much interest to many manufacturers and railroad men who visit that Missouri city next summer as the exposition itself. In planning to meet the greatly increased requirements which will come with the World's Fair, a complete rearrangement of the tracks, switches and signals has been necessary. The Westinghouse electro-penumatic and interlocking signal apparatus was installed at this terminal ten years ago, and was then considered one of the best and most perfect. It has continued to work satisfactorily during the decade, and now comes the installation of a much larger plant of the same make. The new interlocking machine is now in process of construction in the works of the Union Switch and Signal Company, at Swissvale, Pa. This machine will have 215 levers, 105 of which will operate 259 switches and 45 movable joint frogs; 79 will operate 164 signals and 31 will be reserved as power for future additions to the terminal tracks. There will be two smaller machines of the same design for operating the interlocking plants directing the east and west approaches to the terminal.

For sinking shafts in very soft ground or through foundations carrying a great deal of water, the pneumatic method is in some cases very successful. With this method a shaft is sunk to the wet formation, and then carried through the troublesome ground by forcing compressed air into the shaft, under sufficient pressure to hold back the water. The pressure must be maintained until the shaft has its sides lined with a metal casing, masonry, hydraulic cement or some other material impervious to water. In order that the men may go to and from their work, an appliance known as the airlock is fixed in the shaft. This is a cylindrical chamber set in the shaft, having airtight doors, one opening upward and the other downward, the air in the chamber being at the same pressure as that in the shaft. To come to the surface the workman enters the chamber, closes the lower door, lets out the compressed air, and emerges through the top door. The material is removed in the same way in the older methods, but now an auxiliary lock is used for that purpose. For admitting men and tools, etc., the lock is entered from the surface, the door closed, air pumped in up to the required pressure, and the lower door of the lock opened.—*Industrial Press.*

Many men, holding positions of importance in the engineering and other departments of prominent industrial establishments, have found themselves at a loss to know how to proceed, simply through a lack of knowledge of the fundamental principals of commercial law. An attempt to pick up this knowledge is very unsatisfactory at best unless some regular course is pursued.

The opportunity offered by the commercial law course, which has been instituted by the International Correspondence School of Law, of Scranton, Pa., is thus particularly attractive to those who are desirous of learning the rules and particulars of law that govern the various business relations.

The International Correspondence Schools are too well known to need any introduction. They have students enrolled all over the world, and the success of their various correspondence courses is well known. This new course of law has been arranged with great care and promises to be equally important. Like the other courses even a busy man can utilize his spare moments and derive much benefit from them. An interesting pamphlet of this course has recently been issued and can be obtained by writing to the International Correspondence Schools at Scranton, Pa.

The Chicago Pneumatic Tool Company has supplied the following statement from President Duntley concerning the affairs of that company: "The company has paid promptly all its interest and sinking fund charges on its bonded indebtedness. It has declared its dividends out of actual earnings, after writing off all expenses, fixed charges, and allowing liberally for depreciation of plants, etc. It has paid its dividends out of its own moneys. It does not owe a dollar of borrowed money. It has no floating indebtedness, except current monthly bills for materials and supplies, which do not exceed $48,000, and these we are ready to pay promptly when due. The company has over $1,000,000 in quick assets over and above all current liabilities, including current bills, accrued interest, dividends, etc. Its net earnings for the past nine months are $513,224. Its present business, and the outlook for the future, is satisfactory in every way. Its European business is growing faster in proportion than the local business. The company is now selling its tools and machines in every civilized country in the world, and is no longer dependent on the American trade for its business. These are facts, and the company's record shows the payment of every obligation, no borrowed money, no current indebtedness except its monthly bills, and a large surplus in quick assets. The regular annual statements will be made and published at the end of the year."

The November number of the *Engineering Magazine* contains an interesting article on the "Mechanical Equipment of Kimberly Diamond Mines," by Mr. Charles V. Allen, and shows, among the illustrations, one of compressed air drills working under ground.

Noted in the description of the new power-house of the D. Beers Company at Kimberly are the Fraser & Chalmers compressors, driven by Westinghouse electric motors. Mention is also made of the new factory of the D. Beers explosive works, which is said to be one of the best equipped in the world. Here is an air compressor operated by a 60-horse power two-stage motor.

This compressor is capable of supplying 12 pounds, or about 320 cubic feet of free air per minute, against a discharge pressure of 20 pounds per square inch. The average speed of the compressor, when working at its rated capacity, is 57 revolutions per minute. It is belted to the jack shaft driven by the motor.

The arrangement of compressor valves is unique. The only valves are of the Corliss type, and so fitted with a triple gear that only the amount of air which is required is taken into the compressor, and this automatically. This gear is so arranged as to do away with any extreme fluctuations of the motor. Further, when starting up, it allows for the motor starting up with a light load on the compressor; that is, if no trip occurs, the inlet valve remains open during the whole of the forward and return stroke, so the air is drawn in and blown back again through the same valve, and consequently no work is done. If the full capacity is required, these valves are tripped and closed exactly at the end of the suction stroke or at any other point, according to the capacity required.

Readers of Compressed Air may remember the plan of E. C. Ongley, the English engineer, to utilize the power of the tides for compressing air. This same subject is referred to by Mr. Ongley in a letter which recently appeared in the *Canadian Engineer*, in which he says: " Seeing in your valuable paper the article treating of the great power represented by the tide of the ocean, I beg to draw your attention to my invention, which proposes to produce, by the rise of the tide, compressed air, which is then stored and can be distributed for use by pipes to the places of consumption. In the June and July numbers of Compressed Air, New York, there is a description of my plan, with a sketch showing the plan proposed. I also forward *The British Inventor* for September, with a description of this arrangement. In Fundy Bay my plan would be feasible, as closed chambers in great number of great volume, forming quays, could be erected, so that several million cubic feet, or, rather, any unlimited amount of compressed air could be produced. Many thousand horse-power could be thus gained by the tide; but the compressed air could be employed not only as a motive power, but for cold storage, sand blast, etc. Central stations of compressed air could be erected at Fundy Bay and the compressed air transmitted for many miles into the country. These stations would no doubt attract industries to this part of the coast. I have as yet not been able to get my plan realized in this country; innovations are not favorably received here. Perhaps the people that live near Fundy Bay would be willing to try this plan.

" With a rise of 66 feet the compressed air would have a working pressure of nearly 30 pounds, available for small powers of one-quarter to one horse-power, using rotary engines; for higher pressure, up to 50 pounds, a second compression would have to take place, by ballasting or machinery."

The *British Inventor* recenty placed before its readers a description of an invention for producing a cheap motive power by the rise and fall of the tide. In its October issue that publication says that the distribution of compressed air has been employed over a small area for a great number of years. It is the more extensive application of compressed air this article urges. At a pressure of from 10 to 20 pounds per square inch many industries can be supplied with motive power up to say two or three horse power, as well as offering a large field for application and experiment for refrigerating and other purposes. When a suitable plant has been laid down it is estimated that thousands of workshops and other places can be provided with power at a cost of less than one penny per horse power per hour. Distributed by means of tubes of small dimension and under suitable conditions, measured by meter, air could be laid into the house for various domestic purposes in the same way as that gas and water are now distributed. Motors of the rotary engine type require exceedingly small space, work at high speed and without noise, and can be stopped and started by merely turning off or on a tap. The exhaust air has a very low temperature, and can be used for cooling and ventilating, or can be let out into the street. Sewing and other machines using comparatively little power, grinding machinery for cutlery, paint mills, etc., can be economically run by this means. Shopkeepers and householders can be supplied with a ready means of working sausage machines, coffee grinding, washing machines, and other appliances of a like nature. The absolute steadiness of the machinery renders it practical and cheap for weaving and spinning machines and heavy sewing machines. Workshops can be supplied with power with equal facility, and lathes and drilling machines, polishing and grinding tools, for mechanics, opticians, jewelers, cycle makers, etc. A serious advantage of these various means of utilizing compressed air will be recognized in that the exhaust, instead of producing a deleterious gas, as is now the case, ventilates, purifies and cools the atmosphere.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.: all communications should be written on one side of the paper only; they should be short and to the point.

ST. LOUIS, August 27, 1903.
Editor COMPRESSED AIR,
New York City, N. Y.:

DEAR SIR—I beg to submit a question on an air lift for a small pumping station, and will thank you for reply under personal cover or through the columns of valued publication. With a small compressor of about 40 cubic feet of free air per minute, about what flow of water can be expected under the following conditions, and the arrangement of piping on the "Pohle" system. Depth of well, 128 feet, distance to the surface of the water, 27 feet, lift above ground, 6 feet. What distance should the air pipe be submerged, what air pressure employed for maximum efficiency, and the flow of water in gallons that could reasonably be expected? Also the best size of water pipe to use if such materially alters the proposition.

Yours very truly,
C. P. C.

[In reply to the inquiry of "C. P. C." we must first explain that it does not state the diameter of the well, nor how cast, both of which points affect the capacity and piping. The capacity that may be expected from this compressor depends upon the lift or how much the water level falls, the strength of the well in other words. But, admitting that the regular lift of the water in the well to the point of discharge will be 55 feet. he can expect about 75 gallons per minute, and a "Pohle" air lift advertised in our columns for 3-inch water and 1¼-inch air pipe would be the best for these conditions. If the well only furnishes half this quantity, of course the pipe should be one-half the area. We would advise running the piping within a half foot of the bottom of the well. The air pressure will adjust itself. and for the above conditions it should be about 35 pounds. No throttle should be used.—ED.]

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U.S. PATENTS GRANTED OCT., 1903.

Specially prepared for COMPRESSED AIR.

740,391. PNEUMATIC-ACTION FOR SELF-PLAYING MUSICAL INSTRUMENTS. Theodore P. Brown, Worcester, Mass. Filed Mar. 8 1901. Serial No. 50,282.

740,494. VALVE. John B. Waring, East Orange, N. J., assignor, by mense assignments, to Waring Patents Company, New York, N. Y., a Corporation of New York. Filed July 1, 1901. Renewed Mar. 10, 1903. Serial No. 147,150.

740,495. REDUCING-VALVE. John B. Waring, East Orange, N. J., assignor, by mesne assignments, to Waring Patents Company, New York, N. Y., a Corporation of New York. Filed Mar. 13, 1902. Renewed Mar. 10, 1903. Serial No. 147,151.

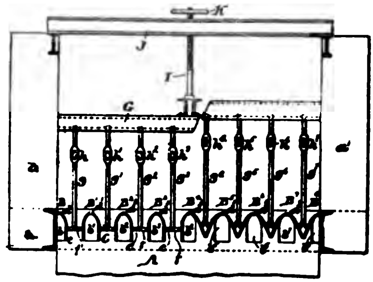
A pressure-reducing valve comprising a casing having a high-pressure chamber and a low-pressure chamber, a valve controlling the communication between said chambers, a valve-actuating piston connected with the valve and located in a chamber in the casing, the casing being provided with a passage leading to the piston-chamber at one side of the piston and having a port above the piston and another passage leading to the piston chamber at the other side of the piston and having a port above the piston, a governing device comprising a reciprocating valve controlled by the low pressure and co-operating with such ports of the casing to direct the high pressure through one or the other of the passages leading to the piston-chamber.

740,514. MUSICAL INSTRUMENT. Robert J. Bennett Chicago, Ill., assignor to Lyon & Healy, Chicago, Ill. a Corporation. Filed Feb. 8, 1898. Serial No. 669,6[illegible]6.

A musical instrument comprising a passage communicating alternately with the external air, a suction-chamber into which said passage opens, a spring-pressed pallet normally closing the entrance into said chamber, a collapsible pneumatic comunicating with said suction chamber a cam device serving as connection between the pallet and the movable side of said pneumatic whereby said pallet is easily opened when the pneumatic is collapsed and the said pneumatic easily distended when the pallet closes, a chamber in which said pneumatic is confined, means whereby said chamber is alternately subjected to air-pressure and relieved therefrom, so as to cause the pneumatic to open and close said pallet and means for exhausing the air from said pneumatic.

740,496. AIR CONDUIT FOR HYDRAULIC AIR-COMPRESSORS. William O. Webber, Boston, Mass. Filed Sept. 13, 1902. Serial No. 123,275.

A hydraulic air-compressing apparatus with a water-passage of submerged air-chambers, air inlet pipes connected to said chambers and



horizontally-disposed adjustable air-conduits leading from the chambers, and spanning the water-passage, substantially as described.

740,534. LIFTER FOR PNEUMATIC SHEET-FEEDING APPARATUS. Edward T. Cleathero, Altrincham, England. Filed Jan. 19, 1903. Serial No. 139,679.

A lifter for pneumatic sheet-feeding apparatus the combination with the mouth thereof, of plates adjustable on the lifter at the ends of the mouth, and making angles with the said mouth, and adjusting devices for varying the said angles.

740,578. PNEUMATIC TIRE. Philip Magnus, Collingwood, Victoria, Australia. Filed Mar. 30, 1903. Serial No. 150,308.

740,704. VALVE. William F. Singer, Philadelphia, Pa., assignor of one-half to George P. Carroll, Bridgeport, Conn. Filed Jan. 3, 1903. Serial No. 137,735.

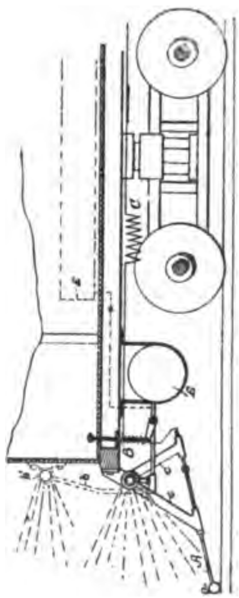
740,807. VALVE. John H. Clune, Springfield, Mass. Filed Sept. 23, 1901. Serial No. 76241.

740,808. HYDRAULIC PLANT AND VESSEL OR RESERVOIR FOR CONTAINING WATER. Carlo Coda, Pisa, Italy. Filed Apr. 27, 1903. Serial No. 154,516.

A hydraulic plant, the combination of a reservoir, a casing surrounding said reservoir at a distance therefrom forming an air-chamber around said reservoir, said reservoir being provided with openings communicating with said air-chamber, supply and delivery pipes for said reservoir, an air-pipe passing through said reservoir nearly to the top thereof, a heating-chamber underneath said reservoir, and passages through the walls of said heating-chamber communicating with said air-chamber, substantially as described.

741,020. PNEUMATIC SAFETY APPLIANCE FOR STREET-CARS, ETC. John Enright, Cleveland, Ohio. Filed Dec. 19, 1902. Serial No. 135,907.

A street or suburban car provided with a compressed-air-storage tank, an air-ejector in front of the car, controllable connections for



and between said tank and ejector whereby the amount of air supplied to said ejector may be regulated and suitable means whereby communication can be established from said tank to said ejector for the purpose of removing persons in front of the car by air-pressure.

740,993. PNEUMATIC SELF-PLAYING MUSICAL INSTRUMENT. Felix F. Schoenstein, San Francisco, Cal. Filed Mar. 25, 1903. Serial No. 149,465.

741,172. VALVE FOR HYDRAULIC AIR-COMPRESSORS. John C. Schneider, Hamburg, Germany. Filed Sept. 24, 1901. Serial No. 76,347.

A valve consisting to two disks, facing each other, one of which is mounted to turn on an axis and the other fixed, air and water inlets in the fixed disks, two hollow arms extending in opposite directions from the movable disk and communicating with ports therein, reservoirs carried at the ends of the arms, air pipes leading from the upper ends of the reservoirs to ports in said movable disk and floats in the reservoirs for closing the air-pipes.

741,261. AIR-BRAKE FOR MOTOR ROAD-VEHICLES. Hans Ledermann, Neumarkt, Germany, Filed Jan. 20, 1903. Serial No. 139,825.

In an air-brake for motor-vehicles, the combination with the brake-cylinder, of a compressed-air reservoir having a pipe thereto, a valve controlling the passage of air through said pipe, a valve controlling the exhaust of air from said cylinder, and means for successively opening and closing the first-named valve while the exhaust-valve is closed.

741,267. VALVE. Louis W. Neubling, Indianapolis, Ind., assignor of one-half to Frederick Berner. Filed Jan. 5, 1903. Serial No. 137,977.

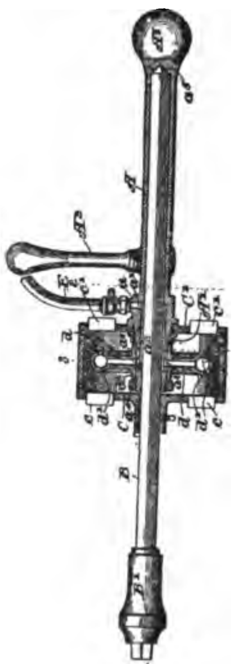
741,435. PNEUMATIC CONVEYER. Warren W. Annable, Grand Rapids, Mich., assignor to the appliance Company, Limited, Grand Rapids, Mich., a Corporation of Michigan. Filed Jan. 19, 1903. Serial No. 139,570.

741,641. VALVE. John Erwood, Chicago, Ill., assignor of one-fourth to Robert H. Walch, Chicago, Ill. Filed Feb. 20, 1903. Serial No. 144,247.

741,884. PNEUMATIC ACTION AND COUPLER FOR ORGANS. Frederick Campkin, New Haven, Conn. Filed Aug. 17, 1903. Serial No. 169,734.

741,320. PNEUMATIC TOOL. Nathan W. Fletcher, Batavia, Ill., assignor of one-half to Melville E. Dayton, Washington, D. C. Filed Dec. 15, 1902. Serial No. 135,182.

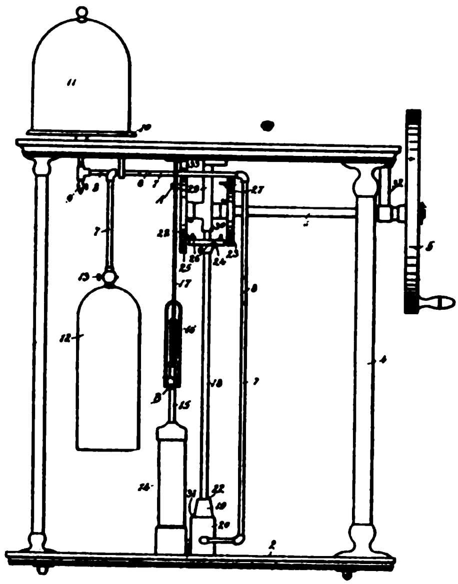
A pneumatic tool comprising connected, nonrotative and rotative parts, and an impact air motor or turbine embracing two rotative members which are rigidly connected with each other, and one of which is attached to the said rotative part, and the other of which turns on the non-rotative part, and a stationary member located between said rotative members and rigidly attached to the said non-rotative part, and means for supplying air under pressure to said non-rotative member of the motor or turbine embracing passages in said non-rotative part.



A pneumatic tool comprising a tubular stock, a rotative spindle which enters and turns in said stock, two rotative disks each provided with an annularly-arranged series of oblique surfaces, said disks being rigidly connected with each other, one of said disks being attached tö the spindle and the other turning on the said stock, an air-tube interposed between the said disks and provided with opposite jet-openings arranged to direct jets of air against the said oblique surfaces on the disks, said tube being rigidly attached to the said stock, an air-pipe attached to said stock, said air-tube being of annular form, and having the jet-orifices arranged annularly therein, and being supported from the stock by radial arms.

742,342. AIR-PUMP. George H. Mohler, Fremont, Nebr., assignor to Joseph Pascoe, Fremont, Nebr. Filed July 12, 1900. Serial No. 23,325.

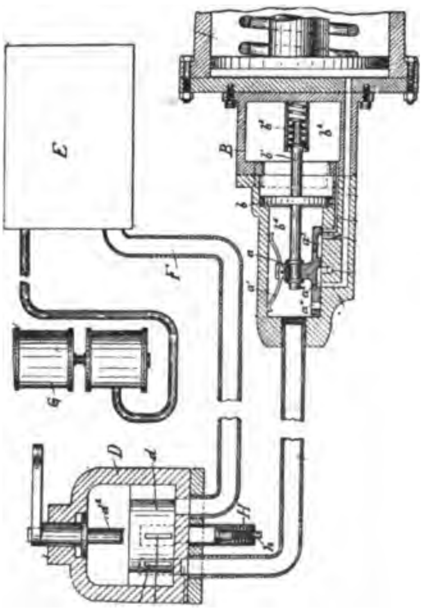
The combination with a suitable supporting-standard of a driving-shaft of two disks secured to said driving-shaft each disk being provided with a pin, said pins being at opposite points and facing toward one another, an air-pump, the piston-rod of which is in connection with one of said disks, a rock-shaft, a table secured to said rock-shaft provided with projecting lugs within the path of aforesaid pins, a valve housing in connection with said pump and provided with two escape-ways, a two-way valve within said housing, its ports or ways being adapted to come in alinement with the two escape-ways within said valve-



housing, the aforesaid rock-shaft being removably secured to said two-way valve, the pipe connecting aforesaid air-pump to said valve-housing coming in alinement with each of the aforesaid two-way valves, said two-way valves being adapted to come alternately in communication with the two escape-ways within aforesaid valve-housings, an air-exhaust receiver in pipe communication with one of said escape-ways within said valve-housing, and a compressed-air tank in pipe communication with the remaining escape-way, within said valve-housing, said instrumentalities being arranged so that aforesaid driving-shaft simultaneously operates aforesaid pump and rock-shaft to actuate said valve in such a manner that the pump exhausts air from the receiver and directs and compresses it within said compressed-air tank, as set forth.

742,386. AIR-BRAKE. John H. Bleco, Brooklyn, N. Y., assignor to Abraham B. Levy, New York, N. Y. Filed June 12, 1902. Serial No. 111,321.

A straight-air or direct-pressure brake system, the combination of one or more brake cylinders operating by straight or direct air pressure, a train-line, a controlling-valve having pressure-retaining means receiving the direct pressure of the straight air and a governing-valve also receiving the direct pressure

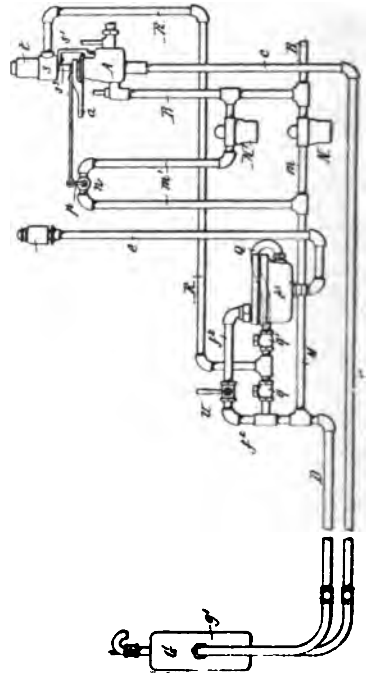


of the straight air and embodying in its structure means for venting the brake-cylinder in the immediate vicinity of said brake-cylinder, means for operating the governing-valve by reduction in the train-pipe pressure and means also operated by the governing-valve for closing communication between the train-pipe and the brake-cylinder when the brake-cylinder is being vented and thereby maintaining the air-pressure in the train-line.

742,390. PNEUMATIC CARRIER. Charles H. Burton, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Nov. 7, 1902. Serial No. 130,367.

742,491. AIR-BRAKE AND SIGNAL SYSTEM. Thomas J. Quirk, Buffalo, N. Y. Filed June 30, 1903. Serial No. 163,720.

In an air-brake and signal system, the combination with brake and signal pipes, of mechanism in connection with said pipes whereby the brakes are applied by a change of pressure in the signal-pipe, a signal device operated by an inequality of pressures acting



thereon, means for changing the pressure in said signal-pipe to operate said mechanism, and means for causing a substantially simultaneous and equal change in the pressures acting on said signal device.

742,513. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Coporation of Delaware. Filed Mar. 6, 1903. Serial No. 146,555.

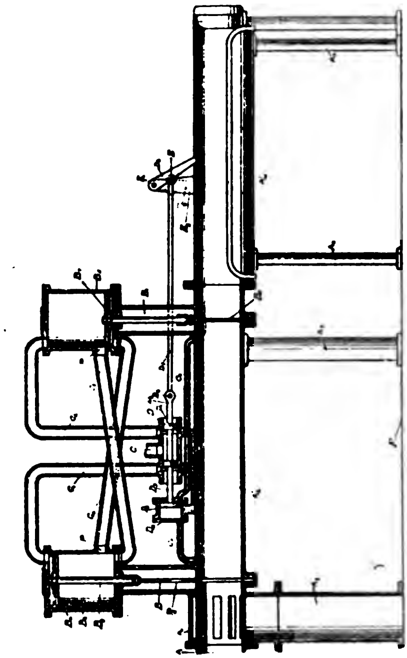
A transmission tube, a sender connected to said transmission tube, inner and outer gates normally closing said sender, means for normally producing equalization of pressure in the transmission-tube and the sender, an exhaust-port from said sender to the atmosphere normally closed, an exhaust-valve controlling said port and operated by the carrier to allow the pressure to exhaust from the sender for releasing the transmission-tube pressure on the outer gate to permit the entrance of a carrier into the sender, and means for closing said exhaust-valve after the entrance of the carrier to permit the pressure in the sender and the transmission-tube to substantially equalize on the inner gate whereby the weight of the carrier will open said inner gate and enter the transmission-tube.

742,514. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Mar. 6, 1903. Serial No. 146,556.

A pneumatic-despatch apparatus, with a transmission-tube for the carriers, a receiving terminal in communication with said transmission-tube provided with a side opening for the delivery of the carriers, a cushioning-chamber beyond said opening for stopping the carrier by compressing the air in its travel and from which the carrier returns and passes out of said side opening, an air-pressure-supply pipe in communication with said cushioning-chamber, a valve normally closing said communication, mechanism for opening said valve operated by the air compressed by the carrier to permit air from the air-supply pipe to pass into said cushioning-chamber for the cushioning of the carrier when the pressure in the supply pipe is greater than that in the cushioning-chamber, and a check-valve for closing communication between the cushioning-chamber and the air-pressure-supply pipe when the pressure in the cushioning-chamber is greater than that in the air-pressure-supply pipe.

742,516. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed May 28, 1903. Serial No. 159,(64.

A transmission-tube, a terminal communicating with said tube, an inner and an outer gate closing the same, an inner and an outer cylinder each having a piston connected to said gates, a source of air-pressure for operating said pistons, communication between said cylinders and said source of air-pressure, a valve for opening and closing said communication to each cylinder alternately, mechanism operated by the pressure in the tube for normally closing communication between said source of compressed air and the inner cylinder, mechanism operated by air compressed



by the carrier for operating said valve to open communication between said source of compressed air and the inner cylinder to close the inner gate and to close communication between said source of compressed air and the outer cylinder to open the outer gate, a connection between the inner cylinder and the outer cylinder for leading the pressure from the inner cylinder to the outer cylinder after the inner gate is closed to open the outer gate, and a connection between the outer cylinder and the inner cylinder for leading the pressure from said outer cylinder to said inner cylinder after the outer gate is closed to open the inner gate.

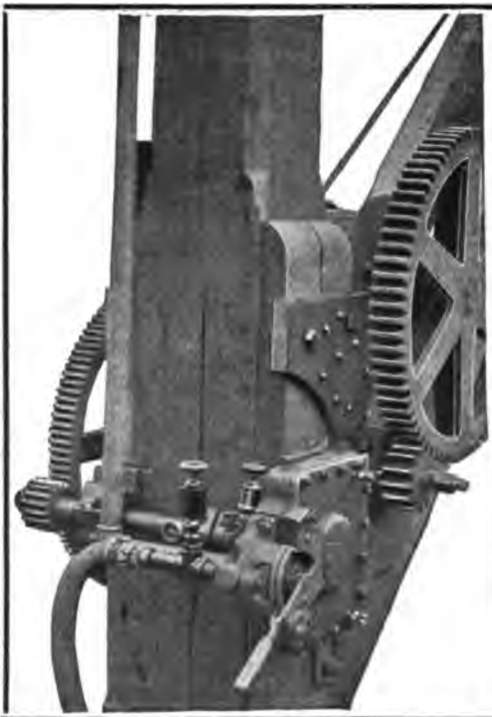
742,515. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Mar. 10, 1903. Serial No. 147,197.

A pneumatic-despatch apparatus, with a transmission-tube, a sender connected to said transmission-tube, inner and outer valves normally closing said sender, means for normally producing an equalization of pressure in the transmission-tube and the sender, an exhaust-port from said sender to the atmosphere normally closed, an exhaust-valve controlling said port, mechanism for opening said exhaust-valve to allow the pressure to escape from the sender for releasing the transmission-tube pressure on the outer valve to permit the insertion of a carrier into the sender, and mechanism for closing said exhaust-valve to permit the pressure in the sender and transmission tube to substantially equalize on the inner valve whereby the carrier by its w ight will open said inner valve and enter the transmission-tube and to hold the outer valve closed so that the pressure in the transmission-tube will not escape into the atmosphere while the inner valve is open.

742,517. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Aug. 1, 1903. Serial No. 167,818.

A pneumatic-despatch apparatus, with a transmission-tube, a sender connected to said transmission-tube, inner and outer gates normally closing said sender, means for normally producing equalization of pressure in the transmission-tube and the sender, an exhaust-port from said sender to the atmosphere normally closed, an exhaust-valve controlling said port to allow the pressure to exhaust from the sender thereby releasing the transmission tube pressure on the outer gate to permit the entrance of a carrier into the sender, means operated by the carrier for opening said exhaust-valve, a counter-weight on said exhaust-valve for closing the same after the entrance of the carrier thereby permitting the pressure in the sender and the transmission-tube to substantially equalize on the inner gate, whereby the weight of the carrier will open said inner gate and enter the transmission-tube, the pressure holding the said outer gate closed so that the air in the transmission-tube will not escape into the atmosphere, and mechanism for controlling the opening of said gates.

742,669. HOOD FOR PNEUMATIC STACKERS. John N. Kailor, Columbus, Ind., assignor to Reeves & Company, Columbus, Ind., a Corporation of Indiana. Filed June 15, 1903. Serial No. 161,561.



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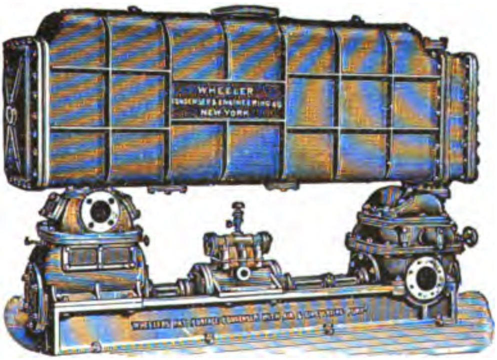

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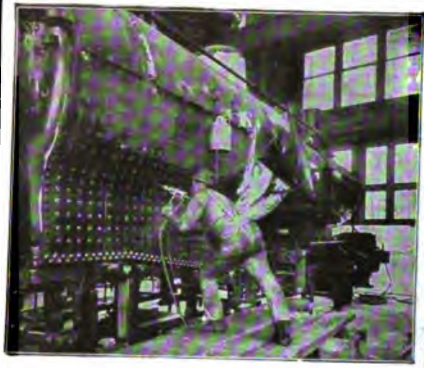

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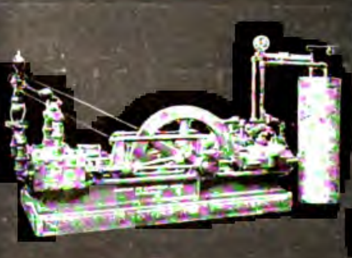

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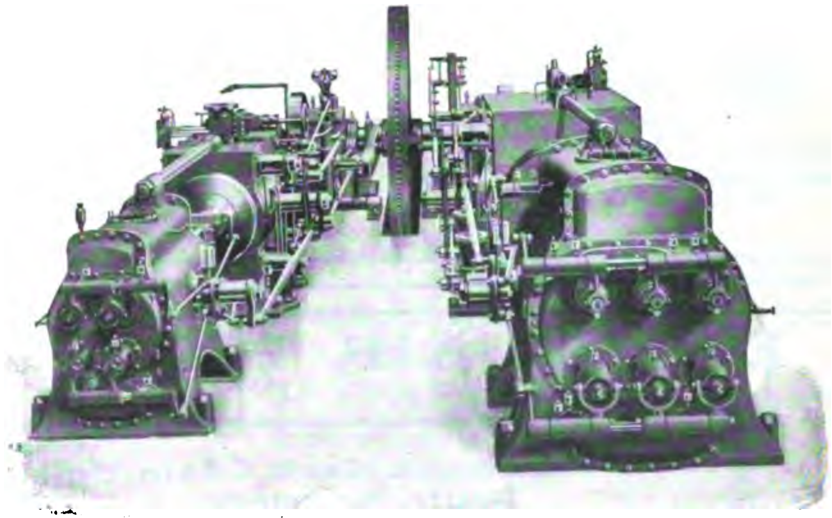

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VOL. VIII. JANUARY, 1904. NO. 11

The Pennsylvania Tunnel.

Without doubt the largest undertaking ever attempted with the assistance of compressed air is the building of the system of tunnels by which the trains of the Pennsylvania Railroad will enter the City of New York and connect with the Long Island Railroad in Brooklyn. Bids for the construction of these tunnels were opened December 15, and by the time this issue appears it is probable that the contracts will have been awarded.

The specifications provide that, unless the bidders can submit some other means which will accomplish the desired end more economically, the tunnels be driven by the shield method, which has already proven very successful in smaller subaqueous tunneling enterprises. The general belief is, however, that the tunnels will be built in the same fashion as are those of the Hudson Improvement Company under the Hudson River and the New York Tunnel Company under East River, full descriptions of which have already been published in COMPRESSED AIR.

If the specifications are followed the contractors will be operating the shields and compressed air locks in sixteen different headings at the same time. Under the Hudson River there are to be two tubes, each of which will be started simultaneously from both ends. They will require four headings. Four tunnels are to be built under the East River and these will be driven from both ends at the same time. Four more headings are called for on the Long Island side, as an examination has shown that the material for a distance of 1,600 feet east of the main shaft is very soft.

This marked increase in this class of work will result in a demand for laborers acquainted with this method of tunneling. While the high wages paid and the short hours required will undoubtedly attract many men, it will be very difficult to secure experienced and capable foremen. One of the most important requisites will naturally be a thorough knowledge of compressed air and compressed air machinery. This will have a strong tendency to encourage the workmen to look more fully into this form of power transmission and will exert a powerful influence on future undertakings of this nature.

A departure has been made in the means designed for the support of the tunnel tubes on the bed of the river. The engineers, who prepared the specifications, have decided in favor of a series of hollow iron tubes or piers which must be sunk from the headings as they progress and driven to a firm foundation. These tubes will be 27 inches in diameter and 12½ feet apart and will be filled with cement. The sinking of these tubes of uncertain length offers a new problem to be considered.

As this is one of the most important events of the year in which compressed air has figured, it will be the aim of this publication to keep its readers in close touch with the progress being made. In addition to keeping pace with the general advancement of the enterprise, we are planning to publish a series of papers dealing with the problems encountered during the construction of the tunnels.

Compressed Air for Tunneling.

The adaptability of compressed air for tunneling under a wide variety of conditions has been signally demonstrated in the construction of the Rapid Transit Subway for New York City. Where the excavation consists simply of boring a hole through the solid rock, we find compressed air used to drive the rock drills. In the open tunnel or ditch we find compressed air supplying the power for driving sheeting as well as supplying the rock drills. In the tunnels under the Hudson and East Rivers the shield method operating under air pressure has proved itself the only successful method for that particular line of subaqueous work. Now the Rapid Transit Subway contractors have found another means of utilizing it in building the tunnel under the Harlem River.

It was desirable to keep the tunnel under the Harlem River as near to the river bottom as possible so as to avoid the use of heavy grades in the tunnel approaches. The mud was, however, so thin that tunneling by the shield method was practically out of the question. A new plan was tried and with success. Two lines of sheet piling were driven parallel with the line of the tunnel and wide enough to enclose it. A strong roof of timber was constructed across from wall to wall of the piling. Then, by means of pneumatic pressure and air locks, the water and soft mud were excavated from within the tunnel caisson and the tunnel structure was constructed, partly of concrete and partly of cast-iron, within the working chamber thus provided.

Half of the tunnel was built at a time, so as not to interfere with navigation. A rectangular chamber caisson was built near the centre with the usual air locks. In this was placed the machinery for taking out the soft material of excavation. A pressure of ten pounds to the square inch was found sufficient. The leakage of air from under the roof during the work was very small. When the water had been lowered in the working chamber, the mud and other material was removed without any difficulty whatever. Then followed the construction of the tunnel itself.

Those who have watched this method of tunneling declare that it will be equally successful at any practicable depth at which it was desired to carry the excavation. Mr. McBean, one of the contractors who have been building the Harlem River tunnel, declares that this system can be used in tunneling the Hudson River, and that, owing to the fact that it would be possible to open the work at several points at once, this method would greatly expedite the work. In any event this serves to demonstrate the great value of compressed air for another method of subaqueous tunneling.

Compressed Air Locomotives for Mine Haulage.

To every mine superintendent who has charge of a growing mine must come sooner or later the problem of mechanical haulage, and the necessity of considering its installation at an early date.

With this idea in view, let us briefly go over the points to be taken care of, and consider the advantages to be gained in the event of the haulage being performed by compressed air locomotives.

To make the system of haulage a perfect one, and therefore keep down the cost per ton hauled as much as possible, every mule which heretofore has been in use should be supplanted, and the entire output collected and handled by locomotives.

The advantages to be gained by the adoption of this plan are important, and generally lead, if not always, to an increase in the tonnage, and to a decrease in the cost per ton.

We shall therefore assume that the installation contemplates the doing away with every mule now employed, and the using of the loomotives not only on the main and cross entries, but also in the chambers or rooms, for the purpose of gathering the loaded cars from the face and hauling them to the various partings or side tracks. Such being the case, the following natural conditions will have much to do with the adoption of compressed air as a motive power:

In all mines where fire damp or other dangerous gas is present in such quantities as to render the use of naked lights unwise or dangerous, more especially on the cross entries on which the working rooms are located, compressed air locomotives should be employed, as they may be used with perfect safety, and serve to mitigate any dangerous condition of this nature instead of increasing it.

In mines where the top or bottom are extremely wet, they may be operated with but little depreciation, as the working parts exposed are strong and of simple construction, and suffer but little from contact with the water.

When grades are severe, making the work of hauling the cars over them heavy, a compressed air locomotive may be overloaded far beyond its normal capacity and will remain uninjured, though this be done frequently.

In descending grades with a heavy trip, the air locomotive may be reversed and air admitted into the cylinders, thus assisting greatly the retarding effort produced by the application of the brake.

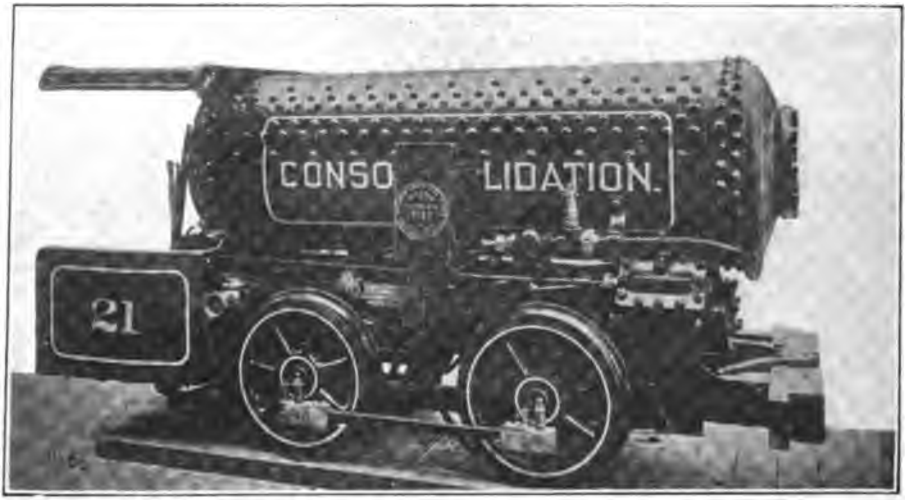


FIG. I.

In the handling of light loads at slow speed, these engines may be used continuously without any detrimental effect, the amount of air consumed decreasing as the load and speed are decreased.

In the gathering of cars from the rooms they will be found very efficient, because of their flexibility, speed and hauling capacity. For service of this kind where the cars are small and the loads to be handled light, the locomotives may be operated on wooden rails should the necessity arise. While the cost of in-talling a compressed air plant may be somewhat greater than that of other mechanical haulage, the cost of extension amounts to very little. This is obvious for the following reasons: When the main pipe line has been laid, carrying sufficient volume and pressure to enable the locomotive to make its complete round trip with one charge of air, this distance may be increased several thousand feet by simply adding a second charging station, placing it at the end of the line. The track to be used on the extension, after being laid, does not require any further outlay than would necessarily be incurred under usual conditions.

In the matter of repairs, the ease with which they can be made by almost anyone around a mine, in simpleness of construction and operation, the compressed air locomotive has many good points in its favor.

The illustrations show in Fig. 1 a room service locomotive built for the Consolidation Coal Co. and adapted for a track gauge of 3 feet. The cylinders are 5½ inches by 10 inches stroke, driving wheels 24 inches in diameter, wheel base 3 feet 2 inches. The storage capacity is provided for by one tank 31 inches inside diameter by 8 feet 3 inches in length, giving a volume of 40.5 cubic feet. The initial storage pressure is 900 pounds per square inch, the cylinder working pressure being 170 pounds per square inch. This locomotive is capable of traveling a distance of about 3,300 feet on one charge of air while exerting a tractive power of about 1,260 pounds, the point of cut-off being at one-half stroke. The over-all dimensions are: Height, 5 feet 3 inches; width, 4 feet 0 inches; length, 10 feet 0 inches; the weight in working order about 8,000 pounds.

Fig. 2.

The locomotive illustrated in Fig. 2 is one constructed for the Lehigh Valley Coal Co., having been designed for main haulage work over a track of 3 feet gauge.

The principal dimensions of this machine are as follows: Cylinders, 9 inches by 14 inches; driving wheels, 26 inches in diameter; wheel base, 5 feet 6 inches. The storage requirements are provided for by two tanks, each having an inside diameter of 34 inches, the length being 14 feet and 16 feet 6 inches, respectively, giving a total capacity of 187 cubic feet. The initial storage pressure carried is 800 pounds per square inch, the cylinder working pressure 140 pounds per square inch. The service requirements to be met call for the hauling of a train of cars weighing, including the load, approximately 65 tons, the final length of the round trip being 10,000 feet, the distance to be covered with one charge of air. The over-all dimensions are: Height, 5 feet 6 inches; width, 6 feet; length, 17 feet; the weight in working order being about 24,500 pounds.

Wisconsin University Water Works.

The proposed improvements and extension in the Wisconsin University water works consist in general of a system of tanks to furnish increased storage capacity.

Our present storage capacity is but 20,000 gallons, furnished by a large wooden tank in the attic of University Hall. This storage is too small to enable the supply to be satisfactorily maintained, especially during nights and Sundays.

The plans as now adopted and being carried out call for a storage system in which compressed air is used to maintain uniform pressure. There will be four tanks, circular in form and about 66 feet long and 8 feet in diameter. Two of these will be for water and two for air, the air tanks being placed above the water tanks and all of them in the plain brick building adjacent to the pump house. In the air tanks air will be maintained at a pressure of 100 to 150 pounds per square inch, and connecting the air tanks with the water tanks will be suitable pipes and regulating valves which will automatically introduce air into the water tanks and maintain pressure therein at about 75 pounds per square inch.

The present pumps will be operated as usual and will pump directly into these water tanks. Supposing these tanks to be full at night and the pumps not in operation, the water which is consumed will be drawn from these tanks, air being automatically introduced so as to maintain an even pressure. In the morning the pumps will be started and the water tanks again filled, and in the meantime the air that has accumulated in the water tanks will be drawn out by means of an air compressor and forced into the air tanks. The valves are so arranged that in case of fire air will be more rapidly admitted in the water tanks so as to increase the water pressure. The storage capacity of this plant will be 50,000 gallons.

The present pumps are two in number, each of about 500 gallons per minute capacity. The compressor will be duplex, single stage, of about 120 feet free air per minute capacity.

F. E. TURNEAURE,
Acting Dean, College of Engineers.

Raising Water with Compressed Air.*

This, like most all appliances for raising water, is not by any means a new invention. Papin, the great inventor of the safety valve for steam boilers, proposed to raise water by it. He said that if a closed vessel, furnished with a pipe at the bottom and filled with water, had air let into it under pressure on top of the water, the latter would pass out of the vessel to any height that may be required.

The application of compressed air to the raising of water in this country is, however, practically new, for until about six years ago we have no hesitation in saying that few had heard of the "Air-Lift Pump"; while to-day it may be found in use by scores of manufacturers, corporations, etc. It has come rapidly into use, because of its simplicity, as a means for raising water from deep wells, and is becoming popular because it affords a ready means of increasing the yield of wells that have begun to decrease in capacity.

There have been six methods employed in raising water by "Compressed Air":

1. Displacement apparatuses in which compressed air is employed at a constant pressure.
2. Displacement apparatuses in which the air is used expansively.
3. Direct-acting pumps in which a constant pressure is carried the whole length of the stroke.
4. Direct-acting pumps in which the compressed air is allowed to expand.
5. Air-lift pumps, single and combined with displacement chamber.

*By Philip R. Björling in the *Engineering Times*, London, Eng. Cuts published through the courtesy of the *Municipal Journal and Engineer*, in which it was republished.

6. Pumps operated by independent motors.

The principal reason why the compressed air method of raising water has not come to the front till recently is that air compressing has been very little studied practically, therefore, a great amount of loss in efficiency, hence great expense in working, and at the present time economy of power is a *sine qua non*. When a machine only gives an efficiency of 33 to 37 per cent. it is about time it was put on the shelf.

However, it is a very narrow view which takes in only the cost of fuel when on the same shed. Any increase in the number of wells generally affects the static pressure, but the quantity of the water cannot be determined by rules of watershed measurement, as applied to surface supplies, unless the areas and surfaces supplying the wells are already defined.

The cost of water pumping includes not only the cost of fuel, but the interest on the amount necessary to construct the plant, and to make a comparison on these lines the number of wells required to produce a certain amount of water should be figured for each system and

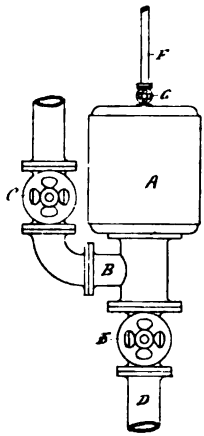


FIG. 1.

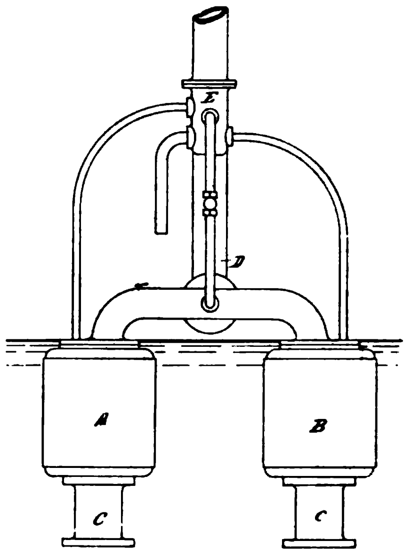


FIG. 2.

calculating the cost of pumping deep wells. The conspicuous feature in the air-lift pump is that it takes all the water a well can supply, whereas any mechanical pump only bales out a certain number of bucketfuls per minute, which experience shows is almost always less than the well can give, sometimes not over one-fifth of this.

The amount of underground water available in a well or group of wells is governed by the catchment area of source which supplies the stratum, modified by the medium through which the water circulates, and the number of wells the cost of the two plants of machinery and the interest on the two systems per year compared. This is an easy problem.

Another feature of the system, which can hardly be expressed in £ *s. d.*, but is no less important on that account, consists of the fact that the air lift has no working parts in the well. With any other system of deep well pumping occasional renewals for repairs must be made, and sooner or later something will break, leaving parts in the well which must be removed at an expense that cannot be calculated.

The great success in raising water by

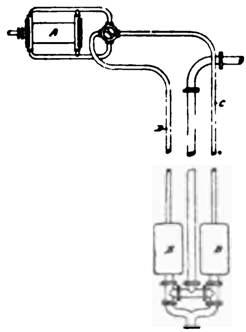
compressed air depends upon proper proportions of the various pieces of machinery, sizes of the compressor and steam cylinders, and the proper areas of the steam, air, and water pipes. For instance, if we want to compress air to 200 to 300 pounds pressure per square inch, it does not pay to perform the compression in one cylinder, a two-stage compressor must be adopted; if we do not calculate the steam cylinder area properly, and do not apply a cut-off gear

FIG. 3—"CHAPMAN" PATENT INLET OR PNEUMATIC PUMP.

for the steam engine, we will lose these again; another loss is given by too small pipes. What can we expect if we work a single cylinder engine at 100 pounds pressure per square inch, and compress the air in one cylinder to 300 pounds per square inch; and after that transmit the air to the air-lift pump by pipes so small that there is a loss of 20, 30, and even 50 per cent. by friction? That is frequently the state of affairs, and it is wondered why there is such a great amount of loss.

THE DISPLACEMENT APPARATUS IN WHICH COMPRESSED AIR IS EMPLOYED AT A CONSTANT PRESSURE.

Under this head comes the original idea of Papin. Take a tank or vessel, *A*, Fig. 1, of any description, provided with an outlet pipe, *B*, furnished with a cock, *C*, at the bottom, and a pipe, *D*, furnished with a cock, *E*, below, and another pipe, *F*, for admission of compressed air, also provided with a cock, *G*. Now, if we open the cock *C* and fill the vessel with water, turn off the cock *E*, and open the cocks *C* and *G*, admitting air under pressure through the pipe *F*, the water will be forced out of the delivery or outlet pipe, *B*, by the pressure of the air on the surface of the water in the vessel, similar to the action of the



steam in the Pulsating Steam Pump. It will be clearly seen that in this case the air is exhausted into the atmosphere at the same pressure as it was admitted into the vessel *A*. An automatic double-acting air lift is illustrated in Fig. 2. It consists of two vessels or displacement cylinders, *A* and *B*, each being provided with a suction pipe, *C* and *C*. The cylinders are placed under the lowest water level or other source. *D* is a delivery pipe or rising main, connected, by means of a branch pipe, to the cylinders. *E* is an automatic valve which distributes the compressed air to the displacement cylinders. The action of this apparatus is precisely the same as Fig. 1, except that it is double-acting, on account of the air being admitted alternately to the two cylinders by the automatic valve.

The last of this class of apparatus, the "Chapman" Patent Inlet or Pneumatic Pump, introduced into this country by the British-American Well Works, is shown in Fig. 3. This pump can be placed in a river, lake, or well, in any place of an ordinary pump for delivering water any height or distance, by the application of air under pressure, miles if necessary from the engine that puts up the air pressure. It delivers a continuous stream of water. When one of the chambers is filling, the air is forcing the water from the other to its destination.

The automatic mechanism requires no oil or attention; being inside, it is sand and dirt proof, there being no stuffing-box to adjust or stop its action. It is provided with a large strainer, which prevents foreign substances entering. Its automatic switch, that switches the air from one cylinder to the other, is non-corrosive and balanced, requiring nominally no power to operate. It performs the service of a pump without pistons or working parts that are commonly worn. The air forms the piston, hence there is no wear. This apparatus will perform all the duties of moving water that a steam pump will, without loss by condensation. It will work successfully in water whose rise and fall may vary hundreds of feet. One gallon of air will bring the same amount of water a short distance, allowing 5/8 pound of air pressure for each foot of lift.

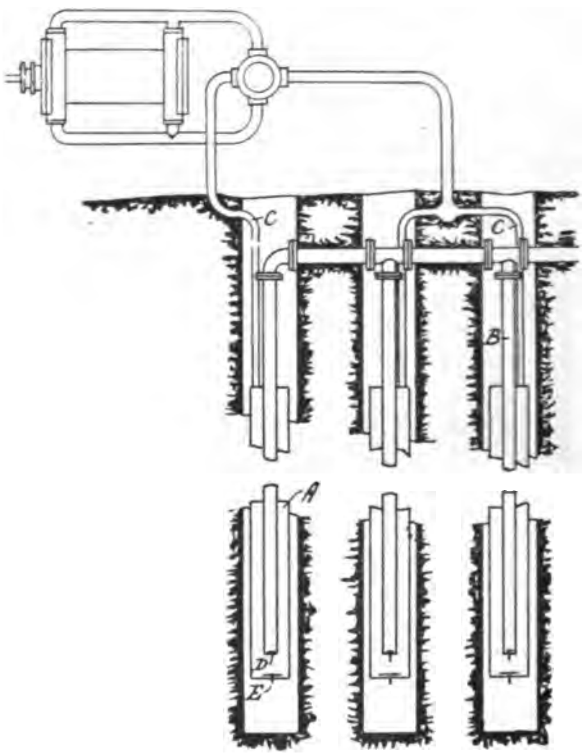


FIG. 5.

DISPLACEMENT APPARATUS IN WHICH THE AIR IS USED EXPANSIVELY.

This class of installation consists of two cylinders placed in the well or other source. The cylinders are, as in the previous examples, furnished with suction and delivery and air pipes. On the ground is fixed a double-acting air compressor and an automatic distributing valve. This arrangement is shown diagrammatically in Fig. 4. The action of the pump is as follows: As the automatic valve is shown in the diagram the air is passing from the right-hand end of the air cylinder, *A*, is in direct communication with the pump cylinder, *B*, through the pipe, *C*, and the suction or admission end of the air-compressor cylinder (the left-hand side of the piston) is through the pipe, *D*, in direct communication with the pump cylinder, *E*, so that the water is forced out of the water cylinder, *B*, up the rising main, and the air being drawn out of the pump cylinder, *E*, by the air-compressor piston, the water will rise up the suction pipe and fill the cylinder ready for being forced out when the automatic distributing valve changes its position, when the operation is reversed.

It is natural that if there are a number of wells or a number of water cylinders in each well, the air pipes can be so arranged that each end of the air-compressor cylinder can be connected with any number of water cylinders, although there ought to be the same number of cylinders for each end of the air compressor.

The "Harris" system, manufactured by the Pneumatic Engineering Company, of New York, is illustrated in Fig. 5. and shows a similar arrangement in which there are three wells worked by one single air compressor. In this the water cylinder, *A*, is very long and small in diameter, and the delivery pipe, *B*, passes nearly to the bottom of the water cylinder, and the compressed air pipe, *C*, is admitted into the top cover. Both the delivery pipe and the bottom of the cylinder are provided with valves, *D* and *E*, the former being the delivery and the latter the suction valves. The tank or cylinders are, of course, proportioned according to the capacity of the well.

Another arrangement is shown in diagram, Fig. 6. In this case the two water cylinders are placed at different levels,

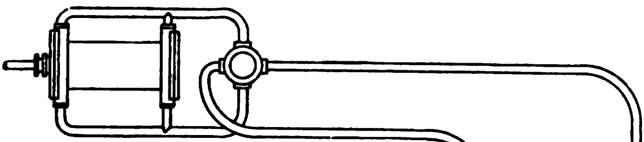
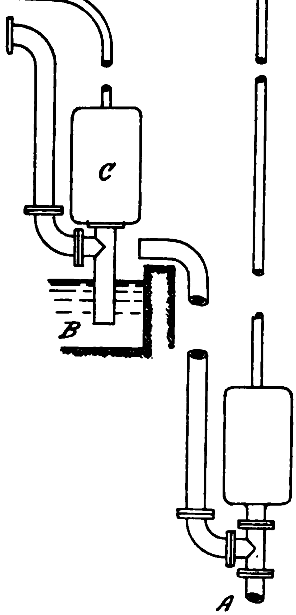



FIG. 6.

one delivering from the bottom of the well, *A*, to a sump, *B*, at a higher level, from whence cylinder *C* forces the water on the ground level. This arrangement can, of course, be multiplied to any desired extent. The air compressor and switch valve is the same as in previous examples.

Direct-acting pumps, methods 3 and 4, are so well known and do not come within the scope of this short article, therefore we must leave them for another article or to some other writer.

AIR-LIFT PUMPS, SINGLE AND COMBINED, WITH DISPLACEMENT CHAMBERS.

A sectional elevation, Fig. 7, shows one example of this class of air lift. It consists of a number of chambers (two

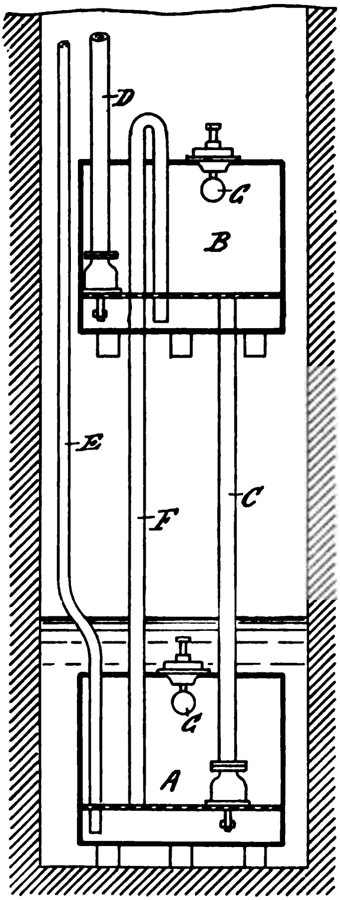


FIG. 7.

are shown in the illustration); *A* and *B* are the two chambers, the bottom one being submerged in the well, sump, or other source. *C* is the discharge pipe from the bottom chamber, and *D* the pipe from the second chamber to the ground, or to the chamber above it if there are three lifts. *E* is the air-compressor pipe to the bottom chamber, and *F* the air pipe between the chambers. *G* is a check valve in each tank which opens and puts the tank in communication with the atmosphere whenever the pressure falls to that of the atmosphere inside the tank, and immediately closing when the water rises up against it. Now, if the bottom tank, *A*, is full of water and the air is admitted, the water will be displaced and forced into the tank, *B*, but when the water is discharged from *A*, and just before the delivery pipe, *C*, is uncovered, the end of the air pipe, *E*, is uncovered, and passed up into the chamber, *B*, expanding against the water, and forces it up into the next chamber or any other source.

THE "WHEELER" AIR LIFT.

This device is shown in Fig. 8. *A* is a displacement chamber, *B* the delivery pipe or raising main, *C* the delivery valve, *D* compressed air pipe, and *E* a small air pipe, opening an air connection for the bottom of the delivery pipe. In this case the displacement is permitted to take place with low pressure, and this adds to the efficiency of the apparatus.

PUMPS OPERATED BY INDEPENDENT MOTORS.

We now come to the last class, which is no doubt the best, simplest, and cheapest if properly designed.

It is a peculiar feature of artesian wells that the conditions of no two are alike, and when this is borne in mind it will readily be understood that each well represents a problem requiring a special study.

Some makers of the air-lift pumps, to the detriment of the system, always recommend them, even when they are convinced that they are not suitable.

THE THEORY OF THE AIR-LIFT PUMP

Is best explained by reference to Fig. 9. If an open pipe, *A B*, is sunk in a vertical body of water and air is forced into its lower end, experiments have shown that the water will be raised in the pipe; the entering air current by its friction against the water carries it. It has also been found that when the air is not forced into the bottom of the pipe, but is merely allowed to escape, the water is raised in the pipe. The rise of water in the pipe is due to the lessened weight in the pipe due to the space occupied by the air bubbles. Thus, suppose the pressure at the mouth of the pipe *A B* due to the head of water outside to be 6 pounds per square inch. Now, if the air bubbles inside the pipe *A B* occupy one-third the space, and the water occupies two-thirds the space, then the pressure at the mouth of the pipe *A B* due to the weight of water inside it will be only 4 pounds per square inch. Of course, the water will rapidly flow into the pipe under these circumstances. Supposing the bubbles of air in the pipe are very small, so that they cannot rise freely through the water, we have really a mixture of the fluid. The specific gravity will be less than that of the water outside, and the water will rise because the interstices between the bubbles are too small for the water to flow down between them and exert its full head; or, on the other hand, if we go to the other extreme, and pass in air bubbles so large that they completely fill the bore of the pipe, then you will have alternate layers of air and water, as in the pipe *C D*. In this case, again, the water at the top of the pipe is shut off from communication with the lower end and cannot exert the full hydrostatic pressure there, due to its elevated position.

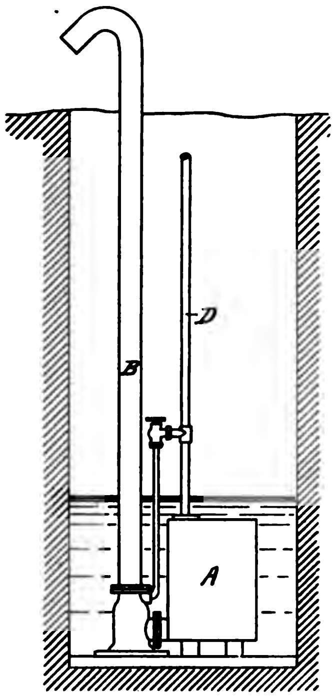


FIG. 8.

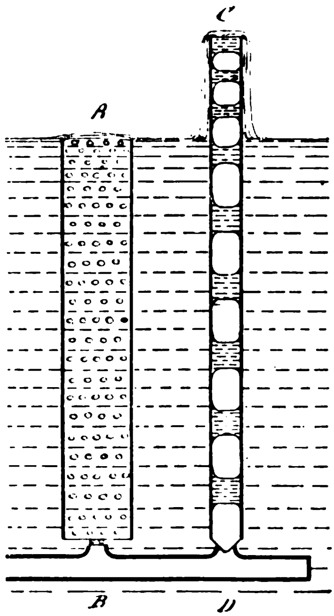


FIG. 9.

Mr. Joseph F. Frizell patented an air-lift pump in America in the year 1878. It is illustrated in Fig. 10, and was arranged in the following manner: *A* is a dam which causes a difference of level in the water above and below it. *B* is a descending shaft, with the curb *C*, built up around the mouth. The water enters the shaft *G* over a wear and is thrown into a commotion which impregnates it with air bubbles. These are carried to a sufficient depth to ensure the required pressure. In the horizontal port, *D*, of the passage, the air rises and enters the chamber *F*. and is drawn off through the pipe *H*. The water freed from air rises and returns to the stream below the dam through the ascending shaft.

Dr. Siemens invented an air-lift pump while sinking a mining shaft in the neighborhood of Berlin. The shaft was put down by the "Petsch" freezing process through about 100 feet of quicksand, but the ice melted before the sides were made watertight, and the shaft was drowned out. It was attempted to stop the flow into the shaft by putting down numerous driven wells round the shaft; but these were so small in size that it was difficult to pump from them. It occurred to Dr. Siemens, therefore, to imitate the action of gas springs, geysers and flowing oil wells by conveying compressed air to the bottom of the well casing. The German paper *Zeitschrift des Vereins Deutscher Ingenieure*, in 1885 pointed out that this system of lifting water was recommended by Loescher, of Freiberg, in a pamphlet published in 1797; but it does not appear to have been tried, except in laboratory experiments.

"The idea of such a lift (air-lift pump) is not a new one," says Professor W. H. Echols, in a paper read by him before the Philosophical Society at the University of Virginia. In "Collen's Lecture on Mining," delivered at the School of Mines, in Paris, in his description of Trigard's method of sinking a mining shaft through very aquiferous strata at Chalonnes, by means of a pneumatic cylinder, he gives the following design for expelling water and sand from the lower compartment: "The mixture of air and water in a vertical pipe forms a kind of froth having a less density than water, thus allowing it to be raised to the surface, where it flows out."

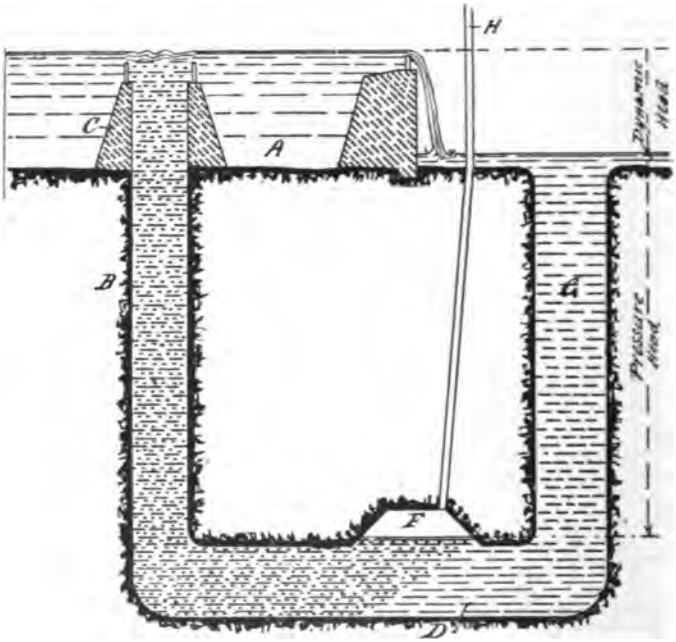


FIG. 10.

THE "POHLE" AIR-LIFT PUMP.

Manufactured by the Ingersoll-Sergeant Company, is made in three distinct methods of well piping, each different from the other, and yet working on the same principle.

Method No. 1, Fig. 11, consists of placing the air and water pipes alongside of one another in the well, connecting them at the bottom with an end pipe.

Method No. 2, Fig. 12, consists of placing a water delivery pipe into the well, the air passing down into the well through the annular space between the well casing and the water pipe.

Method No. 3, Fig. 13, consists of using the well as the water delivery pipe and simply putting an air pipe down into water surface of the pipe and the water surface inside the water pipe are at the same level; hence the vertical pressures per square inch are equal at the submerged end of the pipe, outside and inside. As the compressed air is forced into the lower end of the water pipe, it forms alternate layers with the water, so that the pressure per square inch of the column thus made up of air and water, as it rises inside of the water pipe, is less than the pressure per square inch outside of the water pipe. Owing to this difference of pressure, the water flows continually from the outside to within

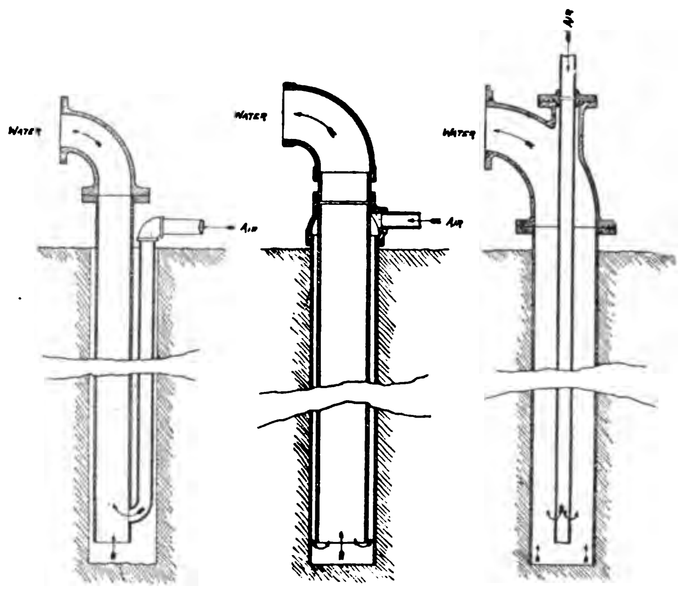


FIG. 11 FIG. 12. FIG. 13.

the well with a special device attached to the bottom through which the air escapes.

The two properly proportioned pipes are placed in position. The compressed air is forced through the air pipe into the foot piece and water pipe, and by its inherent expansive force, layers or pistons of air are formed in the water pipe, which lifts and delivers the layers of water through the end of the water delivery pipe at the surface, or a tank.

At the beginning of the operation, the the water pipe by gravity, and its ascent through the pipe is free from shocks, jar, or noise of any kind.

These air sections or strata of compressed air form watertight bodies, which in their ascent in the act of pumping permit no "slipping" or back-flow of water. As each air stratum progresses upwards to the spout, it expands on its way in proportion as the overlaying weight of water is diminished by its discharge, so that the air action, which may have been, say, 50 pounds per square inch at first, will be only 1.74 pounds when it underlies a water layer of 4 feet in length at the spout, until finally this air section when it lifts up and throws out 4 feet of water, is of the same tension as the normal atmosphere; thus

For $\frac{H}{h} = 0.5$. 50 per cent.
" " = 1.0 . 40 "
" " = 1.5 . 30 "
" " = 2.0 . 25 "

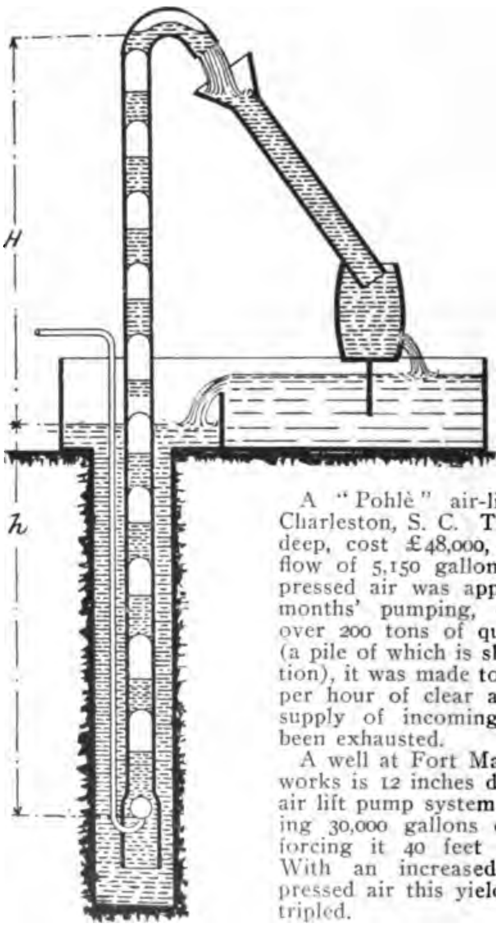


FIG. 14.

proving that this pump is a perfect expansion engine.

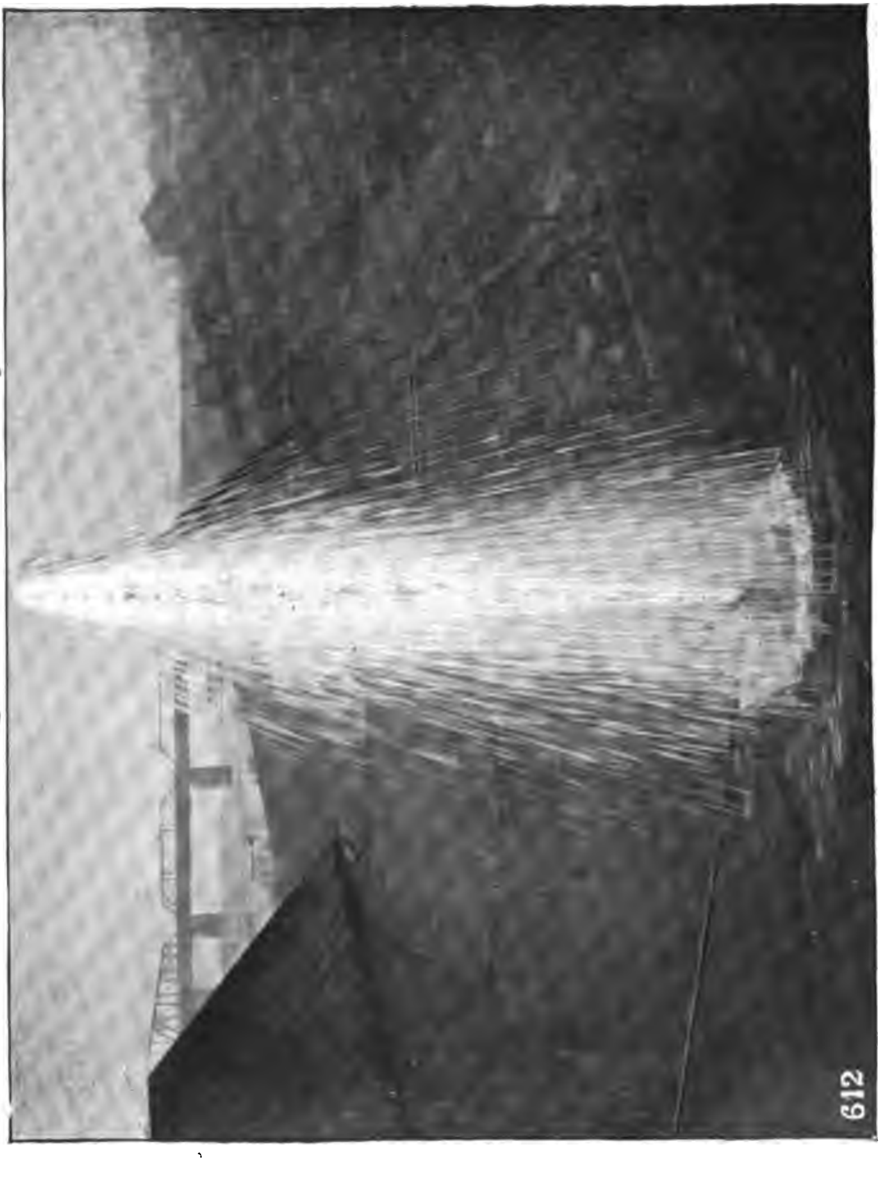
The original "Pohlè" air-lift pump tested by Professor Randall in company with Messrs. Browne and Behr is illustrated in Fig. 14. This pump showed the following efficiencies:

A "Pohlè" air-lift pump is used at Charleston, S. C. This well is 1,950 feet deep, cost £48,000, and had a natural flow of 5,150 gallons per hour. Compressed air was applied, and after two months' pumping, during which time over 200 tons of quicksand was raised (a pile of which is shown in the illustration), it was made to yield 12,500 gallons per hour of clear and pure water, the supply of incoming quicksand having been exhausted.

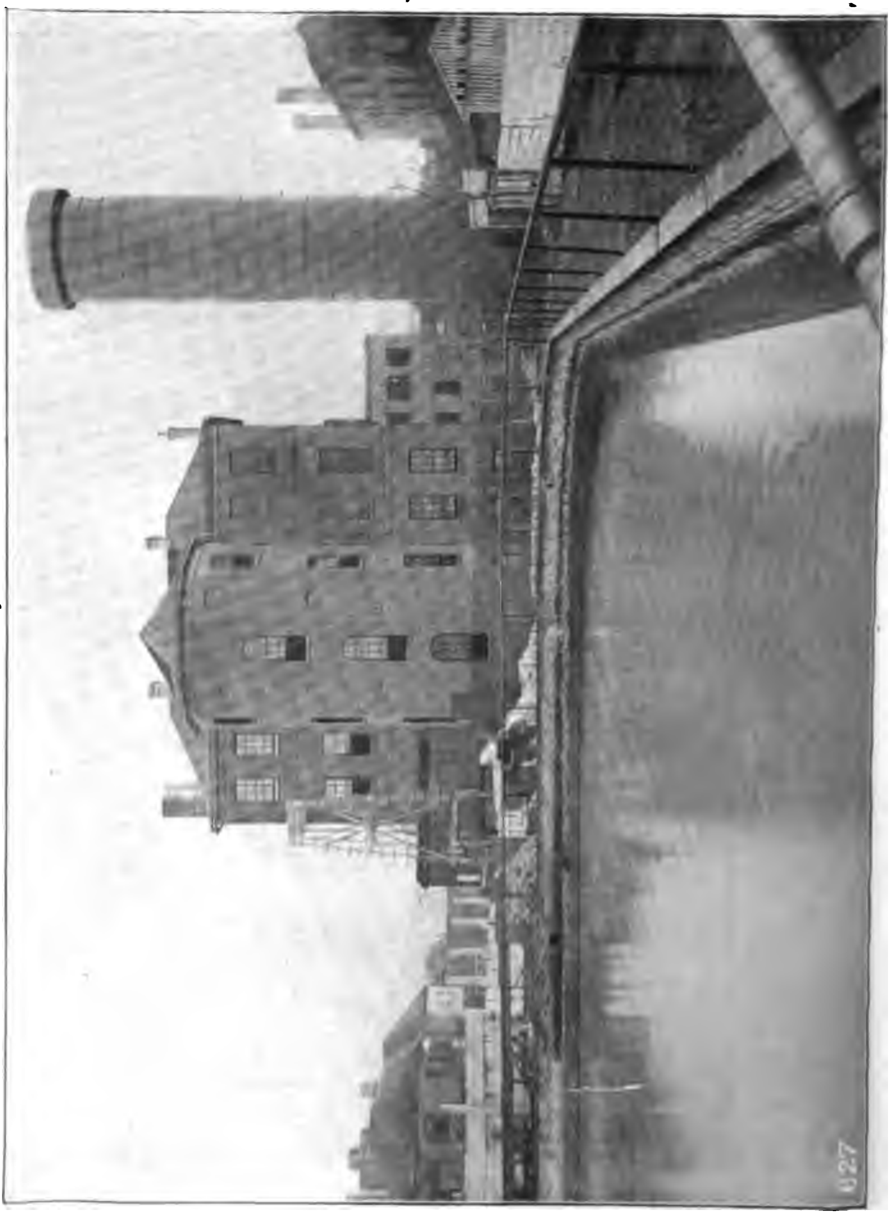
A well at Fort Madison, Iowa, waterworks is 12 inches diameter, and by the air lift pump system it is now discharging 30,000 gallons of water per hour, forcing it 40 feet above the surface. With an increased volume of compressed air this yield can be more than tripled.

THE "BACON" AIR LIFT

Is illustrated in section elevation, Fig. 17. The well head and foot piece are secured by patents. The uptake is suspended in the centre of the air pipe receiver, the lower edge of its bill-shaped attachment making a tight joint with the bell-shaped piece which is supported by the air pipe receiver.



A WELL AT FORT MADISON, IOWA, WATER WORKS.



WATER WORKS AT CHARLESTON, S. C.

In wells drilled through sand strata and having a strainer at the bottom of the well casing, the top of the uptake pipe may be closed and a sudden back pressure exerted on the well, the flow of water reversed, and the sand embedded against the strainer removed. After thoroughly cleaning a well the apparatus is adjusted to its regular duty.

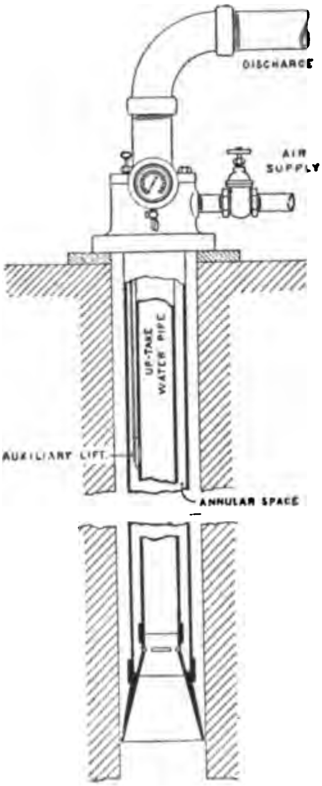


FIG. 17.

In the use of compressed air in pumping artesian wells is secured the beneficial result from aeration. The air is thoroughly mixed with the water, giving it a pure and sparkling appearance. This is a point worthy of the consideration of every brewery depending upon artesian water for brewing purposes. It is also important to factories where the employes use artesian water for drinking purposes.

Sand Blast for Castings.

Among the communications published in the October 29 issue of the *American Machinist* is one, signed "T. A. B.," which will interest readers of COMPRESSED AIR. The subject is "Sand Blasting Castings —Various Uses of Compressed Air," and reads as follows:

"Castings that are to be machined should first have the scale removed, and pickling is usually resorted to. Pickling has certain disadvantages. However much it may favor the tool, it certainly does not favor the machinist who has to breathe the dust which accompanies the cut. Pickling also takes time and sometimes has to be omitted on a 'hurry-up' job. Again, in ports and other cored work it may be essential to remove every loose particle, and pickling makes no pretense of doing this.

"There is, however, a standard method which should be used more than it is, and that is sand blasting. This is in many respects the ideal way if compressed air is available. A casting can be sand blasted 'while you wait,' and when it is done it is in perfect condition for the machinist. All scale is thoroughly removed, including that in ports and cored spaces, and there is no dust to loosen subsequently and work into cylinders, etc. I have frequently used a forming tool direct on such castings, and there is, besides, only the characteristic dirt of cast iron to endure. I do not know of a more satisfactory secondary use of compressed air in a machine shop, and, in fact, I know of one shop where a compressor was installed for this special purpose.

"This is all I started out to say, but while on the subject of compressed air I would like to mention a few more uses of it. I have used an arbor press made of an old cylinder and piston with compressed air for power. It offers an easy way of obtaining a very hot gas flame. It beats blowing through a pipe and the broken shop hand bellows as a means of removing chips. It is a satisfactory substitute for a brush in cleaning a lathe. There is at least one sprinkling system in which the pipes are filled with compressed air, the water following only when in use. The brazing fire might be mentioned as another application of compressed air and one which might be used with advantage a great deal more than it is. Sand blasting is *the* way to clean a brazed piece.

"These are a few uses of compressed air in a machine shop, and doubtless any one, on going over the list, will note many I have left out. I think that a good many shops could consider with advantage the installing of a compressor."

A Four-Stage Air Compressor for Mining Service.

A four-stage air compressor built by the Sullivan Machinery Company for the Oliver Iron Mining Company, or the United States Steel Corporation, has recently been installed at one of the largest of the Oliver Company's mines at Norway, Michigan. The machine is 30 feet in length over all, and is rated at 210 horse power. Its capacity is between 400 and 500 cubic feet of free air per minute, which it is designed to compress regularly to a pressure of 850 pounds to the square inch. It was tested to a pressure of over 1,200 pounds to the square inch. This compressor is shown in the accompanying illustration.

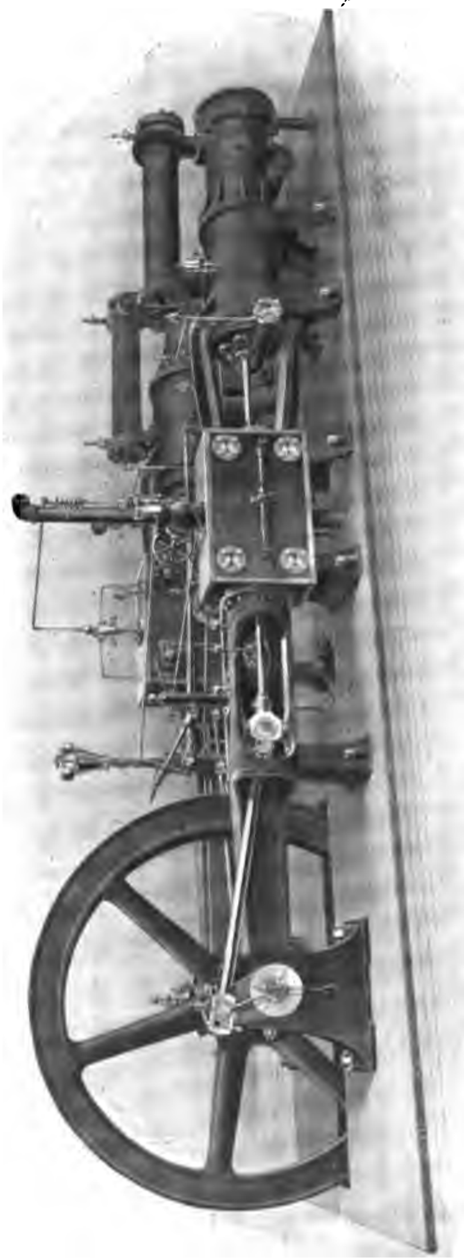
The compressor was built entirely of semi-steel, which is claimed to be much stronger and denser than ordinary cast iron. On account of the strength of the material its weight is reduced and it is therefore possible to secure a considerable saving in freight, in transporting the machine thousands of miles over a part of the country where freight rates are high. Another advantage claimed for the lightness in weight is that extra power usually required to keep in motion an unnecessarily heavy and unwieldy machine is saved. The cranks, crank shaft, connecting rods and piston rods are all made of a high grade of steel. All motion rods and pins for the valve gear are also made of steel, while the boxes and bearings for the valve gear are of phosphor bronze and are adjustable for wear. The piston rods are packed with metallic packing.

Sight feed lubricators are provided for the high and low pressure steam cylinders. The governor operates the Corliss valve gear in combination with the air pressure. The fly wheel is made sufficiently heavy to maintain a uniform speed of 10 revolutions per minute. The cross compound condensing Corliss engine built for 150 pounds boiler pressure supplies the power for operation. A reheating receiver is placed between the high and low pressure cylinders. This receiver contains a coil for reheating the steam during its passage from the high to the low pressure cylinders, and is claimed by the makers to be a feature very essential to the economy of engines of this type, especially in connection with the compressor. The cylinder lagging is made of heavy steel plate and a space of from four to five inches is allowed inside of this lagging for a magnesia covering. The lagging around the cylinder resembling a square box is filled with this non-conducting material so as to prevent loss by radiation.

This compressor is of the four-stage type, with the air cylinders so arranged that the work done in the high and low pressure steam cylinders is nearly equal. The four cylinders are single acting. In the intake and second cylinder, where the air pressure is lowest, it is compressed against the front heads. In the third and fourth cylinders, where the pressure is the greatest, the air is compressed against the back heads of the cylinders. In this way the use of stuffing boxes and piston rod packing under the heavy pressure is avoided.

The pistons in the intake and second cylinders are of the adjustable bull ring type. This kind of pistons are also used in the engine cylinders. The pistons in the third and fourth cylinders are made in the shape of a straight ram or plunger and fill the cylinder their entire length. They are also provided with a special spring packing. Special provision is made for the lubrication of these pistons and in view of the fact that they fill the cylinders their entire length the air cannot leak past them. The suction valves in the intake and second cylinder are mechanically moved. The discharge valves of the intake and second cylinders are of the poppet type and of the following design:

The valve and valve seat are located inside of a removable cage and held in place by a hand hole plate. When this hand hole plate is removed the valve cage containing the valve and seat can be removed with the hands from the recess in which they are located, without even the use of eyebolts. The pressure of the hand hole plates forms a tight



SULLIVAN FOUR-STAGE AIR COMPRESSOR.

joint between the cylinder head and the valve cage. By this method the manufacturers claim to avoid making the valve seats against part of the cylinder head, which is so annoying to keep tight when the seat becomes worn or leaky. The loose cage, valve and all, can be removed and a spare valve and cage kept on hand to be put in their place when taken out. The valve can then be ground and fitted, and be ready to take the place of the next one which becomes leaky. Where part of the cylinder head forms the valve seat, several grindings will destroy the proper shape of the seat to such an extent that when a new valve is inserted it will not always fit the seat properly. The consequences are leaky valves and valve seats.

The suction and discharge valves in the two high pressure cylinders are of the poppet type. The valves are made of nickel steel. The recess in which these cages are inserted are tapered, and the outside of the valve cage is ground to fit in these tapered recesses. The cages fit on their outside their entire length, or the thickness of the head, as it is not deemed advisable to depend on a narrow joint or shoulder for an air-tight fit under so heavy a pressure. With the smallest amount of leakage across a joint of this kind with so heavy pressure, it would soon cut away the metal, and a very small leak would impair the efficiency of the machine enormously. With these cages fitting their entire length and ground to fit like a plug cock, all danger of leakage or cutting away the metal with the high pressure is eliminated. The poppet valves in all of the cylinders are cushioned to eliminate noise or clicking.

The water jackets around the intake and the second cylinders are so designed that a body of water 3 inches in thickness circulates around the cylinder liners. The amount of water space around the third and fourth cylinders varies from 4 inches to 6 inches between the outer shell and the cylinder liner, which allows for the free and unrestricted circulation of cold water around the cylinders. The liners in the air cylinders are independent of the cylinder castings and are pressed into the outer shells with hydraulic pressure, so that in case of cutting or scoring from lack of oil, either one of these liners can be removed and new ones inserted in their place.

The flow of the air is through the mechanically moved intake valves in the front end of the forward air cylinder, located behind the low pressure steam cylinder. When compressed, it is discharged through the pipe on the side of the cylinder into the first intercooler, located below the floor line. From this intercooler it is taken into the second cylinder located on the left hand side of the machine nearest to and behind the high pressure steam cylinder. After this second compression it passes through the intercooler located on top of the second and third cylinders, and the third stage takes place after passing through this intercooler. It is then discharged through a pipe passing under the floor line from the third cylinder, and enters the intercooler located on top of the intake cylinder on the right hand side of the machine and the fourth cylinder. This intercooler is separated into two compartments, so that the air travels in the shape of a loop through the intercooler tubes and is drawn into the fourth or final cylinder where it can be compressed to a pressure as high as 1,200 pounds to the square inch. The front end of this intercooler is merely resting on the upper side of the intake cylinder. There is no connection between the intake air cylinder and this intercooler.

Copper is used exclusively in the intercoolers for circulating tubes for the cold water. The arrangement of the copper tubes in the intercooler is such that they are free to expand and contract from heat and cold without affecting the joints, so the expansion and contraction can take place without causing leakage. The speed of the machine is automatic, and varies automatically from 10 to 125 revolutions per minute. An automatic air governor acts on the automatic cut-off mechanism of the valve gear and the speed is automatically increased and decreased, according to the amount of air used.

In order to economize foundations the third and fourth cylinders may be built overhanging from the ends of the intake and second cylinders. The foundation may terminate at the back ends of the first and second air cylinders. A pedestal may then be located under the rear ends of the third and the fourth air cylinders, and a cast-iron plate on which these pedestals rest bolted to the floor.

Questions About Compressed Air.

In the English publication, *The Science and Art of Mining*, there is a department which consists of questions for miners and engineers. A series of prizes are offered for the best replies. Among the questions in a recent number was one requiring a description of the use of compressed air as a motive power. Of interest was the reply by Mr. Geo. Wood, of West Cramlington, Northumberland. It was as follows:

"Compressed air has become such a factor of importance in mining that it is very important to understand all the many uses and advantages of it. Of all considerations in mining matters of to-day. competition is so keen that decreased cost of production must be a prominent feature, and when we consider the matter we find that during the last few years vast improvements and developments have been made in compressing air so that it can be utilized for all the many purposes of mining work. In haulage compressed air cannot be excelled, as there is practically no limit to the conveyance of it, as wherever there is a road opened compressed air may be used, the power only being limited by the size of the motor.

"The earliest application of compressed air is said to have been at the Govan Colliery, near Glasgow, in 1849, where a steam engine was used to compress air to a pressure of 30 pounds per square inch, and the air was conveyed down the shaft, and to a distance of 700 yards. Since then great advancement has been made in the improvement of compressors, pipe lines, connections, motors, methods of charging, etc., until now electricity is the only power which can compete against it. Not only is compressed air invaluable as a motive power, but it is a great aid in the ventilation of mine workings, as the air given at the exhaust supplements the currents already in operation; in this way compressed air, as a motive power, can even be used when carried beyond the regular airways and range of ventilation, so reducing the risk to life and property.

"In order to compress air a steam engine is required with ordinary steam cylinders with an air cylinder. From the piston to the steam cylinder a piston rod passes through the back end, and is connected to a piston in the air cylinder. There is identity in the motion of both these, and simultaneously with the back stroke of the pistons the air cylinder is filled with air at an atmospheric pressure (15 pounds absolute) on the forward stroke of the pistons; this is compressed into about one-third, or less, space, ranging from about 45 to 60 pounds pressure per square inch. In compressing air much heat is generated, and as this cannot be retained attention is turned to the prevention of it. To accomplish this in some compressors the cylinder is surrounded with water, and sometimes water is injected into the inside of the cylinder, and the surplus water is forced out along with the air into the receiver. The use of this water is two-fold. It first cools the air, and it also fills up the space between the cylinder end and the piston, causing the whole of the air to be forced out, also the surplus water, because if any air was left in the cylinder then the air would expand to the pressure of the atmosphere, and the discharge of the air would be correspondingly reduced; the loss of work by compressed air is the taking of the heat from it.

"At Cowpen Colliery, which I visited a few days ago, a large air-compressor is in use, supplying six coal-cutting machines besides other work in haulage, with a pressure of about 80 pounds. Of course, this is not the extent of power that can be generated; in fact, a very large reserve power is expected to be utilized for this plant in a few years. The distance of the pipe line in this installation is about one mile, and the pipes are sufficiently large to allow a very large increase of energy to be conducted. This is a very important matter in the installation of air-compressors; care should be exercised to make these at the first capable of conveying sufficient air to do all the work, so that any additional cost will only come in the shape of increased compressing power and additional motors.

"Experiments have proved that if the air be re-heated before entering the engine considerable economy is obtained. This may be done by two methods, either by passing the air through hot pipes heated by a furnace fire, or by passing the compressed air through water in a boiler at a temperature depending on the pressure in the boiler. The former is called the dry method and the latter the wet or moist method of heating. Generally speaking, by this re-heating process an additional horse-power can be obtained with an expenditure of one pound of coal. As the loss of power due to the absorption of energy in the generation of heat is one of the chief defects in air compressing it can readily be seen that re-heating may be of immense importance in overcoming it.

"Allow me to itemize generally the advantages of using air-compressors:

"(1) The air may be stored to any extent or carried any distance without loss of pressure, except that due to friction and leakages.

"(2) Hand tools can be used when steam would so heat them that it would be impossible to handle them.

"(3) It can be used at any pressure, is easily generated, and its expansive qualities make it a very acceptable force.

"(4) The exhaust, instead of being detrimental, as in the case of steam, is supplementary to ventilation, and acts with beneficial effect on the workmen with its cooling and refreshing power.

"The fact that we cannot take up a paper to-day without seeing some reference to this all-important subject is sufficient evidence of the progress that compressed air is making in the commercial world generally, but to deal exhaustively with such a subject would need a whole book instead of a few lines, so that one can only state a few facts, trusting that amongst them something new and suggestive may be found."

In the same issue is a question concerning wet and dry air compressors, and which class is the more preferable. The following reply by Mr. Thomas White, of Larkhall, Scotland, is published:

"In dry air compressors no water is admitted into the cylinder, but instead the cylinder is surrounded, or nearly surrounded, by what is termed a water jacket. As a rule where the water jacket is adopted the compressor is laid over a trough containing clear, cold water. The object of the cylinder being surrounded by water is that the cooling action of the water tends to keep down the temperature of the air during the process of compression.

"The action of the dry air compressor may be briefly stated thus: The air compressor is a cylinder with proper inlet and delivery valves, and a piston for compressing the air. On the outstroke of the piston air passes through the inlet valves into the cylinder, and on the commencement of the return stroke the inlet valves close, and the air in the cylinder is compressed until it lifts the delivery valves, and is forced into the receiver.

"In wet air compressors water is introduced directly into the cylinder during the compression of the air. By the compression of the air heat is generated, therefore the object of using water in the cylinder is to absorb the heat resulting from the compression of the air. Sometimes the water may exist in volume, both before and behind the piston, washing to and fro in the compression chambers at each stroke of the piston. When this goes on for some time the water itself becomes hot from the absorption of heat from the air, and loses its power of cooling.

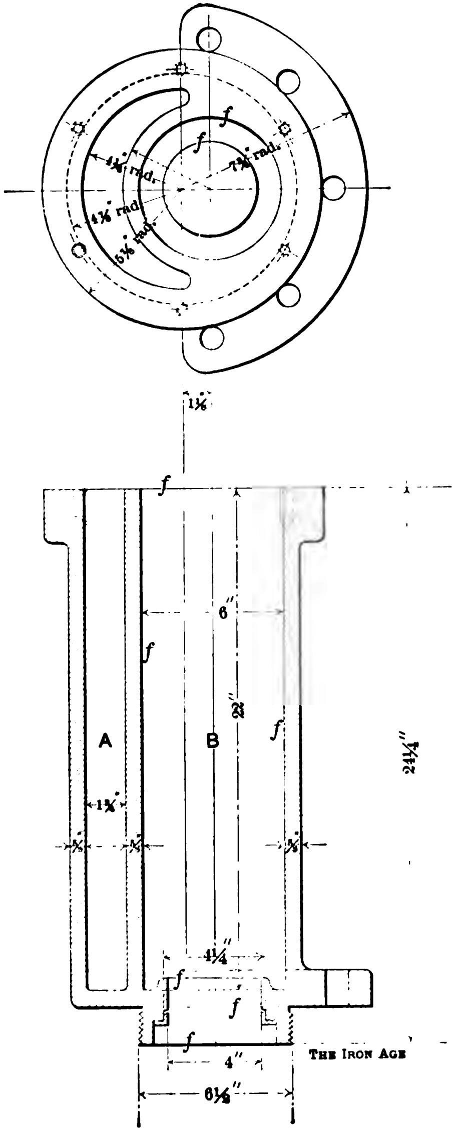
"Another and perhaps more efficient method of cooling the air is sometimes adopted by injecting a fine spray of water into the cylinder during the compression stroke.

"The wet air compressor sometimes gives very good results, but in actual practice the dry air compressor is generally preferred. An objection to the wet compressor is that the air is saturated with moisture, which has a tendency to form into ice in the exhaust parts of the motor. Again the wear and tear of the cylinder and piston is excessive, for water is a very bad lubricant itself, and oil or grease introduced for lubricating floats on the water and fails to reach the working parts.

"For a given output of the air the wet compressor must necessarily be larger than a dry one, because on account of the inertia of the water the speed at which these compressors should travel should not exceed 150 feet per minute at the surface of the water."

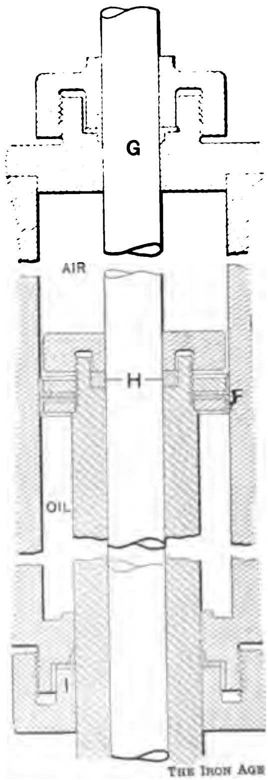
Pneumatic Reamers.

In a description of the Pennsylvania Steel Company's new plant, in an article



PLAN AND SECTIONAL VIEW OF THE CYLINDER.

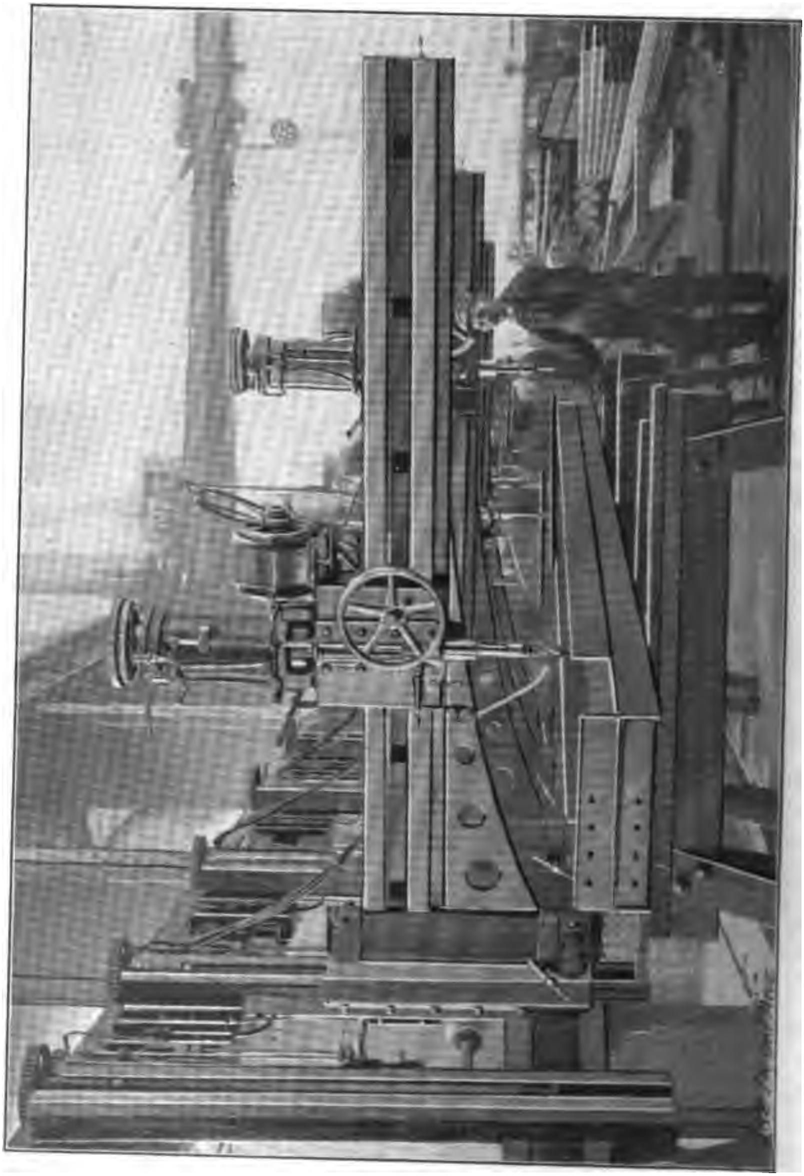
entitled "A Model Bridge and Construction Shop," the *Iron Age*, in a recent issue, describes and illustrates pneumatic reamers which are being used there to ream the rivet holes in order to insure an accurate and true bearing for the rivets. To economically perform this operation it is necessary to have an easy movable machine, as it is more advisable to shift the tool than the work. To have only one tool at work at a time would also prove expensive and cause delay.



SECTIONAL VIEW THROUGH THE CYLINDER.

These machines, which were designed under the direction of J. V. W. Reynders and built by the Baush Machine Tool Company, conform with all the required specifications.

The spindle is fitted and turned by a combined oil and air pressure, which, as expressed by the *Iron Age*, works in a closed circle. This operation is illustrated in the accompanying sectional

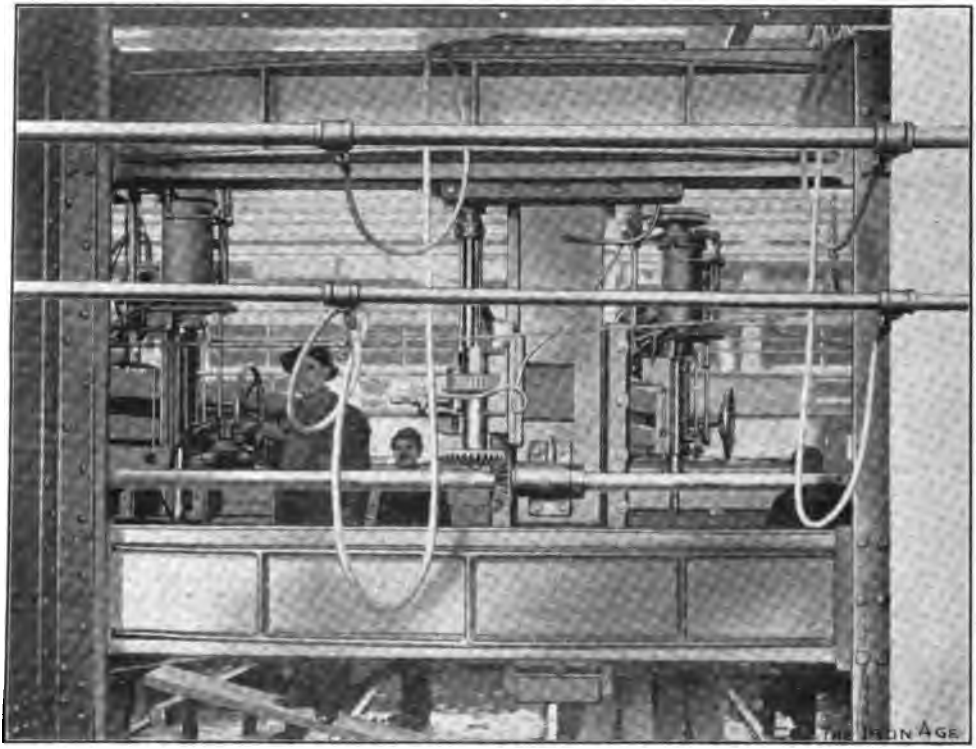


SIDE VIEW OF THE REAMERS.

illustrations which are published through the courtesy of the *Iron Age.*

The spindle terminates at its upper end in a piston which works in the cylinder B. Air is admitted on top of the piston at a suitable pressure depending on the character of the work to be done whether solid drilling or reaming, the usual pressure being about 60 pounds per square inch. Underneath the cylinders and connecting with the auxiliary chamber A by means of a regulating valve is an oil reservoir which not only regulates the feed of the drill, but also acts as a dash pot to prevent too rapid movement of the spindle after the drill has passed through the work.

The various movements are accomplished by a suitable valve arrangement in convenient reach of the operator. This provides an elastic though constant pressure on the drill resulting in the true feed which accommodates itself instantly to any variation in the resistance presented to the cutting tool due to the irregularity of punched holes or material. The machines are supported upon two horizontal beds or rails placed in the same vertical plane. Each machine can be moved in any desired position on these rails. The entire group is shifted independently and the arm raised or lowered by power.



REAR VIEW OF THE REAMERS.

The Use of Compressed Air for Operating the Contractor's Plant at the Wachusett Dam.

Some of the advantages arising from the use of compressed air on contract work were outlined editorially in our issue of June 4, 1903, and now we have the pleasure of citing an object lesson that is particularly impressive, not only by virtue of the magnitude of the work involved, but also by virtue of the excellent results that have followed the use of compressed air on so large a scale.

To generate 1,000 horse-power at a central plant, and to convey the power to some 80 different engines, is in itself impressive, but to have kept such a plant in continuous operation for a period of 32 months is a record that, so far as we know, has never been equaled on contract work. In view of this fact some details of the plant and its operation will be of especial interest to contractors having similar work to do.

In the first place, it should be stated that the power station is located between the dam and the quarry, the distance to the dam being nearly 1¼ miles, and to the quarry half a mile. Power for operating the drills, derricks, etc., is supplied by two Rand-Corliss air compressors, of 500 horsepower each. The engines are designed to operate under a steam pressure of 135 pounds, with steam cylinders 18 and 34 inches diameter for the high and low pressure, respectively and have a 42-inch stroke. The air cylinders of each compressor are 21 and 34 inches diameter for the high and low pressure, respectively. At the normal speed of 75 revolutions per minute, each compressor delivers 3,310 cubic feet per minute of free air raised to 90 pounds per square inch. The engines are so designed that either high or low pressure cylinder may be run independently. Water for the boilers is secured through a 3-inch pipe from a pond about a mile away, and condensing water is drawn from a pond alongside the power-house. The compressed air is discharged through a 10-inch pipe into a horizontal air receiver 6 feet diameter by 20 feet long, and the air is delivered to the works at the dam through an 8-inch pipe, 6,500 feet long.

At the present time the following engines and machines are being run with the air from this plant:

31 hoisting engines, about 16 horse-power each.
2 cableway engines, about 50 horse-power each.
16 No. 3 Rand drills.
3 pumps, 3 to 4 inch discharge.
1 engine on revolving screen, 10 horse-power.
1 engine in machine shop, 10 horse-power.
1 engine on mortar mixer, 10 horse-power.
1 pneumatic riveter.
1 trip hammer.
3 stone dressing machines.
10 blacksmiths' forges.
10 pneumatic plug drills.
—
80 total.

While as before stated, these machines are for the most part concentrated at two points, the dam and the quarry, still it is noteworthy that one derrick is being operated by air fully three miles away from the compressors, and the air pressure at this derrick is practically the same as at the compressors.

These 80 machines work the compressors to about two-thirds their capacity, but a few months ago when some 40 Rand drills were in operation the compressors were worked almost up to their full capacity. At no time, however, have there been many more independent machines in operation than at present.

In the quarry the rock is loaded into skips which are picked up by air-operated derricks and placed upon flat cars, where men with hose wash all dirt off the stones. The cars are hauled over a standard gauge track to the dam, where the cableway lifts the loaded skips and delivers them directly to the derricks on the dam, so that there is no manual rehandling of the stone from the time it is loaded into skips until it reaches its place on the dam.

The stone, which is a granite, breaks out irregularly and in massive blocks. Holes are often 24 feet deep, and are 3 inches diameter at top and 1¾ inches at bottom. Including delays involved in setting up the drills in difficult positions, two 24-foot holes are regarded as a fair day's work for a drill in this granite. Only a small amount of the face stone for the dam is taken from the quarry.

UP-STREAM FACE OF THE WACHUSETT DAM, SHOWING PROGRESS OF CONSTRUCTION.

For splitting or squaring up large, irregular blocks the contractors have found pneumatic plug drills especially effective. The Kotten pneumatic plug drill does not have an automatic rotating device, but the bit is turned with a wrench in the right hand of the operator. By virtue of turning the bit thus by hand, the drill mechanism is very simple and the drill is certainly effective, as 6 holes, ⅝-diameter by 3 inches deep, are readily drilled in 9 minutes.

A number of large stone surfacing machines are also operated with compressed air, but we reserve a description of their work for another issue.

Not only are all the forges of the blacksmith shop run with compressed air, but a large trip hammer is operated with the same power.

We have indicated briefly the many uses to which compressed air may be put on contract work of this character, but it should not be forgotten that not the least of its advantages over steam is the fact that licensed engineers are not required to operate an engine driven with compressed air. The contractors lay particular stress upon the ability to quickly train a man to run an engine where air is used, and the consequent freedom from the dictates of unions. Moreover, to cart the coal to a large number of separate engines would in itself be an item of great cost in the aggregate on work so widely scattered as this. Then, too, to fire up in the morning and to draw the fires at night involves not only a loss of fuel, but longer hours for the engineman, all of which is done away with where compressed air is used.

The economy in fuel that results from generating power by a few large units at a central plant is a fact universally recognized by engineers, but not so often recognized by contractors, or, if recognized, is not often used to advantage as in the plant above described. One of the reasons that in the past has led contractors to hesitate to install large central power plants has been the fear of breakdowns that would tie up the whole work. But in so reasoning the perfection of modern machinery is lost sight of. There is a good bit of wisdom in "Pudden' Head Wilson's" philosophy, where he says:

"Some say, 'Don't put all your eggs into one basket,' but I would say, 'Put all your eggs into one basket—and watch that basket.'"

This maxim holds as true of investments in machinery as of investments in stock.—*Engineering News.*

Modern Slate Quarrying.*

At all the quarries in the Festiniog district the rock is won by true mining underground, on what is known as the descending method. This system consists of a main incline tunnel running from the top of the slate bed it is intended to work down to the bottom. From this inclined tunnel, long cross tunnels are driven off left and right, which are termed floors. Each of these floors is again apportioned off with "pillars" and "chambers," the average depth of each chamber being about 50 feet, although in some cases they run as high as 80 or 90 feet.

The first operation, when a chamber has been apportioned off, is one termed "unroofing and widening." This consists of removing the rock for a thickness of about 3 feet to 4 feet over the whole surface area of the chamber, through and up to the floor above. As this work is done by miners and with high explosives it is entirely unproductive, and is, in fact, a very expensive item in underground quarrying, as, not only does it result in the waste of some hundreds of tons of good rock, through its being broken too small for slatemaking purposes, but this waste has to be cleared and tipped at a cost varying from 6d. (in a few exceptional cases) up to 1s. or more, per ton.

After the miner has completed his "unroofing" operations, the chamber is ready for the "rockman." The work of this individual is to mine the rock and send it, in the form of large blocks, to the surface, where it is taken to the mills, sawn, and dressed into roofing slates ready for the market.

In "getting" the rock the waste is very high, and owing to the depth the rock very often has to fall to the floor when blasted. For every 100 tons of rock sent to the surface for dressing into slates, about 100 ton weight is also sent

*Extracts from an article by Mr. A. Dawes in *Page's Magazine* (England) describing the Rhiwbach Slate Quarry, Blaenau, Festiniog.

up in the form of rubbish, which has to be cleared and tipped; in fact, of the total rock removed in the quarry a proportion of one ton of slates to 14 tons of rock is considered very fair, although in many cases the amount of waste is much higher even than this.

At this quarry it was decided to develop a part of the estate which had not previously been touched, and with this object, operations were commenced in a bed of slate about 300 feet to 350 feet thick, covered with a topping of peat and clay about 30 feet thick. This bed had been proved by borings some forty years ago, but no attempt had been made to work it.

The first operations were commenced in 1898, and consisted of the driving of the usual inclined tunnel, 500 yards long. In order to drain the workings and permanently dispense with pumping operations, a tunnel 842 yards long was continued from the foot of the incline to the foot of the mountain.

With a view to pressing on with the work as speedily as possible, driving was arranged for at both ends, but operations were commenced at the inclined tunnel end with an open cutting through the surface clay for a distance of about 50 yards, and then the tunnelling was commenced, still in the clay.

As the tunnel was advanced it was arched with waste ends from the dressing sheds, and for a time everything proceeded in a satisfactory manner. Owing, however, to the soft and shifting nature of the ground the arching very shortly collapsed.

Timbering was next tried, but without much success, as the timbers were constantly shifting. To overcome this difficulty the tunnel was lined for a short distance with old boiler shells 7 feet 6 inches diameter, which have answered remarkably well, for during the past four years no further difficulty has been experienced with them.

As the work proceeded, the ground became a little firmer, and timbering became possible, until the site of an old well was driven into which caused a deal of trouble and delay. This, however, was overcome in the end, and the work proceeded steadily until the solid rock was reached, when timbering became unnecessary.

Water had all along caused a deal of trouble, and to clear it pulsometers were used, which were hung in chains and provided with steam from a small vertical boiler on the surface. These worked very well, and efficiently handled the dirty water and mud.

The level had been commenced at the other end, but as this was all through solid rock, no difficulty was experienced, the water all finding its way out without mechanical assistance. As hand work did not proceed at a very rapid rate an air-compressor was erected at the quarry, and the work was thenceforward carried on with the aid of rock drills; air at 70 lbs. pressure being conveyed over the mountain to the forebreast in a line of 2-inch tubes, nearly a mile and a half in length. The rate of driving in the level was five to six yards per week.

At the inclined tunnel end serious difficulty was caused by the water, and as the forebreast had now got far from the surface a double ram pump, by Pearn, of Manchester, was put in and driven with the compressed air. The exhaust air from the cylinders was turned on to the forebreast, and very speedily cleared the place of smoke after firing. The pump was constantly moved forward as the work advanced.

The levels and gradients were carefully watched, and when the level was completed, driving up was commenced to meet the men who were going down.

When both ends met there was not the slightest difference in level between them.

The costs for driving were as follows:

FOR THE LEVEL.

	Cost per yd.		
Wages and explosives........	£2	14	7
Enginemen	0	6	0
Coal, oil and engine stores....	0	10	11
Surveying	0	1	2
Sundries	0	0	7
Giving a total cost per yard of	£3	13	3

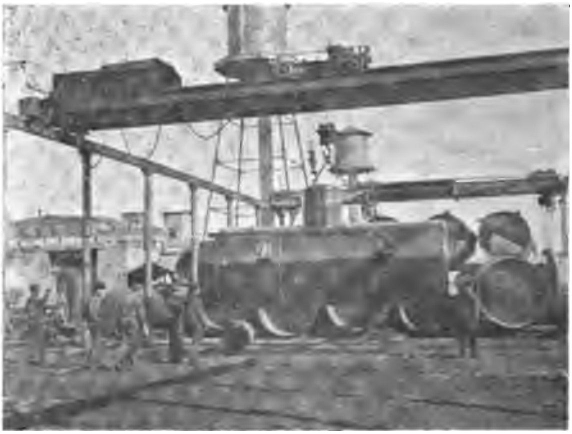
FOR THE INCLINED TUNNEL.

Wages and explosives........	£4	1	6
Enginemen, coal, oil, engine stores, surveying and sundries	0	18	8
Or a total cost per yard of..	£5	0	2

The total amount of slate rock opened out by this inclined tunnel and level is 40,000,000 tons. Of this, 16,000,000 tons are capable of producing slates of the finest quality, while 12,000,000 tons will give slates of a fair quality, the remaining 12,000,000 tons being of an inferior nature and not worth working.

A Pneumatic Traveling Crane.

The September issue of *Motive Power* contained a description of the works of the Biglow Company, New Haven, Conn. Among the illustrations was the accompanying one, which shows a pneumatic traveling crane handling a boiler. Compressed air proves a great power at that shop in handling the large boilers which are turned out there at the rate of seven a day.



PNEUMATIC TRAVELING CRANE.

A New Type of Air Compressor.*

A novel type of air compressor has been made for some time past by an English company, Messrs. Reavell & Co., Ltd., of Ipswich, England. They are now making the same type in the compound or two-stage type, a recent machine for 100 pounds pressure, being intended for one of the underground tube railways that are becoming so common. The idea of Mr. Reavell was to make a machine suitable for direct driving by an electric motor at a moderate speed, to occupy a small space and be of small weight, the latter point being secured to some extent by dispensing with the fly-wheel, as will be shown hereafter.

The general arrangement of the machine, Fig. 1, is duplex, there being two compressors, one on each end of the motor shaft. There are only two bearings, and these are of great length and carried in the uprights of the framing by means of sleeves which can be removed and replaced so that the bearing can be removed as required. On the outer ends of the shafts are placed single cranks, on each of which four connecting-rods take their bearing. The compressor frame is a hollow ring casting not unlike the field frames of an electric generator, Fig. 2. At four equal angles the frame is bored out to take the compressor cylinders. These are forced into the bored-out frame through openings on the outer circumference, which are closed by circular bolted flanges. Each cylinder is double, and consists of a first-stage cylinder 10 inches in diameter, and a tandem 5-inch second-stage cylinder. The two pistons are also cast in one piece, the connecting-rod crosshead end being at-

*By W. H. Booth, in *Mines and Minerals*. Illustrations supplied through the courtesy of *Mines and Minerals*.

tached to the first-stage piston, which forms of itself the crosshead like the piston of a gas engine. The stroke is only $4\frac{11}{16}$ inches, and the speed is 240 revolutions per minute, at which speed the compressors with their eight double cylinders will compress 300 cubic feet of free air per minute.

The large piston draws in its air through the crosshead bearing, to which the connecting-rod head forms a valve. On the complete out-stroke, the piston uncovers a ring of ports round the cylinder, and this insures that full atmospheric pressure is admitted to the cylinder at each stroke. From the first stage the air is forced through the delivery valves into a chamber which is connected by waved copper pipes to all the other first-stage delivery chambers; and, though all the cylinders are thus connected, the actual course of the air is from each cylinder across or around to the opposite second-stage cylinder. The second-stage cylinders compress the air, now cooled in the casing or tank which surrounds the cylinders and is filled by water, and discharge it into a passage which runs around the casing and is provided with three outlet ports, any one or all of which can be used at will to take off the compressed air. All the valves, both of the large and small cylinders, are alike and interchangeable, and consist of light steel cup valves in gunmetal seats. Valve capacity is given by the number of valves employed, not by change of size, and the number of spaces is reduced and chances of error are eliminated.

The accompanying diagram, Fig. 3, is a combined torque diagram of the two compressors, the diagram of each being in dotted lines. If this torque diagram be further corrected for the flywheel action of the motor armature it will become nearly circular, showing that no special flywheel is needed. This even-turning movement is due to the crank angle of 45 degrees so that there are eight deliveries of air per revolution, and, consequently, no fluctuation in the pressure of supply.

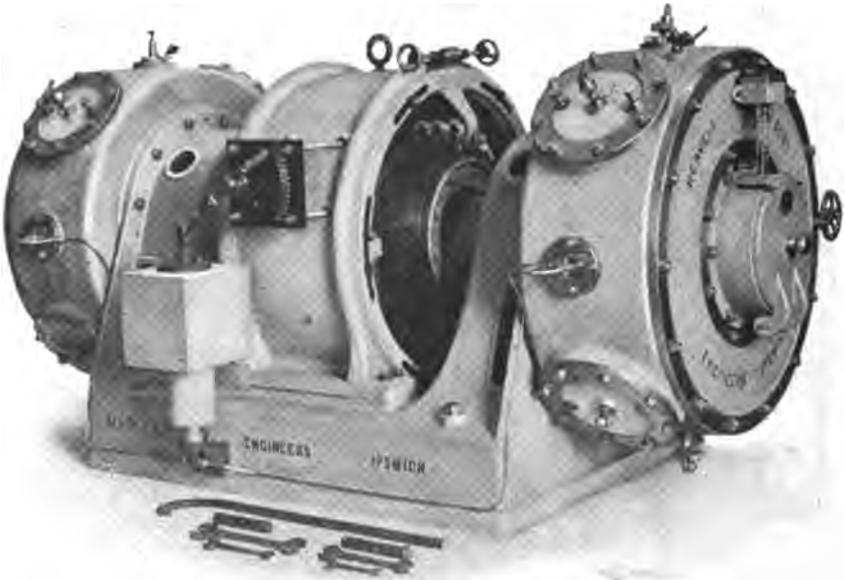


FIG. 1.

When supplying air to tools in an engineering workshop such as pneumatic hammers, tappers, air lifts, etc., it is necessary to maintain a fairly even pressure. By means of the field rheostat the speed of the motor can be regulated in the ratio of 2 : 1, and this is arranged to be done automatically. An air plunger, supplied with compressed air, is balanced by a heavy weight in a lever, one end of which is connected to the field rheostat. This device can be arranged so that for any desired range of pressure, of say 5 pounds, the motor speed will be regulated between its maximum and minimum. The reservoir pressure cannot, therefore, vary more than 5 pounds from normal. If, however, at any time even half speed of the motor delivers too much air, there can be also employed a special further device which cuts off the air supply when the pressure reaches a maximum and prevents the compressor from working to waste through the safety valve. This saves power from being needlessly wasted. If, as in mining work, the air is wanted in considerable volume at intervals only, it is better that the motor should run intermittently at full speed or be kept standing entirely.

Mr. Reavell's idea of air compression is that it is better to carry an electric cable into a mine and there drive an air compressor near to the point of use than it is to compress the air at the bank and carry the air down the mine in pipes.

The first stage of compression takes place between the two pistons. As their ratio is 4 to 1, the ratio of compression must be 3 to 1 in this stage, the second stage, of course, being what the compressor is allowed to do. The limit to which a compressor can work is determined by the ratio of its clearance capacity to its cylinder volume. If a piston has a stroke of 5 inches and a clearance of one-quarter or one-twentieth, then the maximum compression will be to increase the pressure supplied to that cylinder twentyfold. But during the latter part of the range the compression would begin to be very inefficient. Hence the use in some compressors of a jet of water to keep the clearance spaces full and render the compressor as efficient as possible.

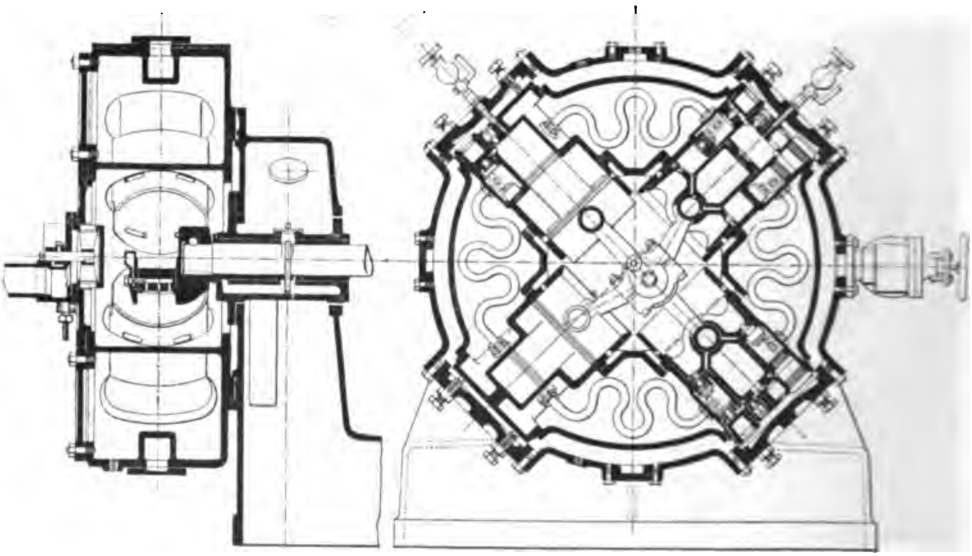


FIG. 2.

The advantage of two-stage compression is that the air heated by the first stage may be thoroughly cooled off before being subjected to the second stage. Air is so perfect a gas that nearly all the work done in compression will appear as heat and the absorption of work is thereby much increased. By dividing the whole compression into two stages with intermediate cooling, a large part of the extra work is saved. Moreover, in

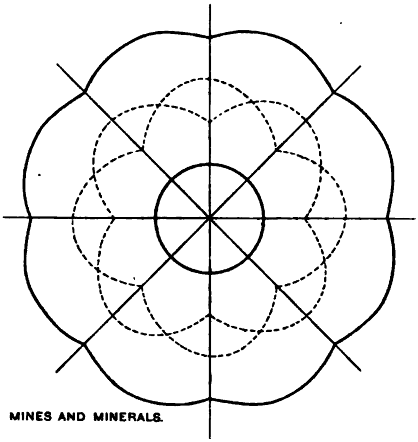


FIG. 3.

single-stage compression the pressure runs up very suddenly at the end of the stroke and this is avoided in a two-stage machine, which has the further advantage that the maximum air pressure is against a smaller piston and the risk of loss past the rings is less. The form of piston ring

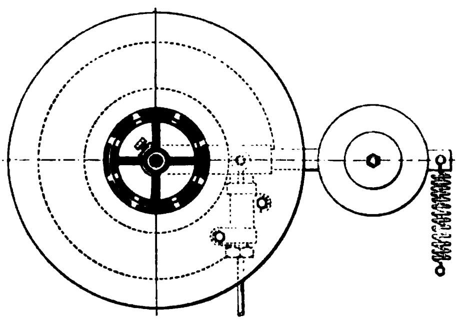


FIG. 4.

employed is one that is turned an exact fit in the cylinder and expanded by two inner rings each half as wide. The joints of the three rings are 120 degrees apart.

Similarly arranged compressors are employed to compress air to 1 ton per square inch for use in torpedoes, which, however, cannot be looked upon as comparing favorably with the use of air in workshops and in mining.

Being practically a perfect gas at all ordinary temperatures, air follows Boyle's law, which states that at any given temperature, the product of the volume and pressure of a gas is a constant quantity; or PV = a constant, or $Pv = pV$, where P and v are the pressure and volume at one time and p and V are the pressure and volume at any other time.

This is the isothermal equation and is the equation of the hyperbolic curve.

The adiabatic curve of a perfect gas is $\frac{P}{p} = \left(\frac{V}{v}\right)^{1.408}$. Assuming one volume to be unity, or say $v = 1$, there is obtained $\frac{P}{p} = \frac{V^{1.408}}{1}$, or $P = p\,V^{1.408}$.

Thus, air at 15 pounds is compressed to 90 pounds. Then $\frac{P}{p} = 6$.

What will be the relative volumes before and after compression? Here the final volume is assumed as $1 = V$.

Now $\frac{V^{1.408}}{1} = \frac{P}{p} = 6$. The logarithm of $6 = 0.77815$. This divided by $1.408 = 0.55261$, which is the logarithm of $3.57 = V$.

Thus in place of having obtained a sixfold pressure by means of six compressions, we have secured it by only 3.57, the difference being due to the heat generated by the work of compression. Thus, in compressing air, the subsequent cooling of the hot air deprives it of the pressure and it is reduced when cool to only 3.57×15, or less than 54 pounds in place of 90 pounds, and the difference must be made up by working the compressor for a longer time. Compression in a water-cooled cylinder helps to correct the evil partially, but owing to the difficulty of cooling rapidly, compressors cannot be run fast, but must allow time for cooling to take place during the stroke. Hence the gain by two-stage work.

Where air is compressed in an outside cold atmosphere and carried into a hot, deep mine, the heat of the earth is made useful in getting out of the air more than was put into it, in a sense. But this is not necessarily an argument in favor of compressing at bank, because mines which are hot may also be deep and the compressor works between wider limits of pressure. Thus in a mine 6,000 feet deep the air pressure is greater at the bottom by about 461 pounds per square foot; or say 3.2 pounds per square inch, calculated on the air measuring 13 cubic feet per pound at sea level.

If all the 6,000 feet were below sea level, the difference would exceed this figure, and it would be less where the mine depth is all above sea level. For high elevations the first or large cylinder of an air compressor must be increased to allow for the rarified atmosphere. For cases where the air is used at or near its horizon of compression, this point is of less importance, because the back pressure is so much less. But in any case it requires more cylinder capacity to get hold of an equal weight of air, and it depends on the mass of the air which works, as to the amount of work that can be done by it.

In Fig. 2 is given a cross and longitudinal section of a quadruplex, two-stage machine, showing the single crank with its oiling device, the compound cylinders, cooling pipes and water spaces, with the arrangement of bonnets and air-delivery openings. One standard and its long interchangeable bearing sleeve is also shown.

I recently tested a double quadruplex machine for efficient action. First, I tested when pumping air into a reservoir at atmospheric pressure until it attained a pressure of 82 pounds, and a volumetric efficiency of 94 per cent. was obtained. Next the reservoir, into which the air was delivered, was first pumped up to 82 pounds; it was kept at this, and air only allowed to escape through a throttle valve into the measuring vessel until this also attained 82 pounds. The volumetric efficiency of the second test was 90 per cent., showing that the clearance spaces of the machine were small. Of course, the second method of test is the only proper method, resembling the conditions of practice, the closeness of the efficiency by the two different systems of testing demonstrating this.

The use of water to fill the clearance spaces of a compressor is often found to give rise to trouble in the shape of ice in the exhaust of machines using the air. It is better, when possible, to use a dry compressor, and to do this the clearances must be small, especially when compound compression is used; in the first stage or larger cylinder, the piston must come close up to its cylinder head and the eduction valves must be close to the cylinder also and leave but little waste space.

For working with alternating current, geared motors are required, owing to the speed, and Messrs. Reavell have recently had before them a proposition for driving compressors from single-phase current at 83 periodicity. They very successfully met this problem by means of a centrifugal clutch, which allowed the motor to get quickly away and prevented the initial rush of current that is so annoying, not so much from the waste it causes as from the fluctuation of all the lamps near by. This fluctuation of lamps is overcome by a centrifugal clutch, which will allow a two-thirds full speed to be attained before it begins seriously to take up its work. As the centrifugal force varies as the square of the speed there is a margin of the ratio of $(\frac{2}{3})^2$ to $(\frac{3}{3})^2$, or say 4 to 9 as between the beginning and end of the clutch action. The outer shell of the clutch, on which the preliminary rubbing of the friction blocks is expended, is made fairly massive so as to absorb the frictionally generated heat with small rise of temperature. The compactness of these air compressors and their easy driving, point them out as particularly suited to mining work.

In Fig. 4 is shown the automatic air valve which shuts off admission when the pressure in the delivery pipes rises to a predetermined limit, thus making it possible for a compressor to continue to run without pumping to waste. This is exactly the converse of the setting of the valves of a steam engine so as to entirely prevent steam admission when a given limit of speed is attained, thereby enabling a lightly loaded engine to produce in itself a vacuum right up to the stop valve.

Air Signals for the Bengal-Nagpur Railway.

The enormous increase of goods traffic on the Bengal section of the Bengal-Nagpur Railway during the past twelve months, more especially since the opening of the Jherria coal fields to the company, has directed the attention of the management to the necessity of improving the ordinary system of manual signaling in their large yards at Kharagpur, Adra and Santragachi. The number of trains passing through the first named junction daily has been quadrupled since the increase in the coal traffic, and W. T. C. Beckett, the acting agent, anxious to maintain his company's reputation for up-to-dateness, as also to increase the efficiency of the working, addressed the home board in the fall of last year on the subject of introducing some power system of signaling, which had already been tried and proved successful on some great lines in England. The board admitted the justice of the agent's representation, and referred the matter to Sir John Wolfe Barry, the consulting engineer to the company in London, for early report.

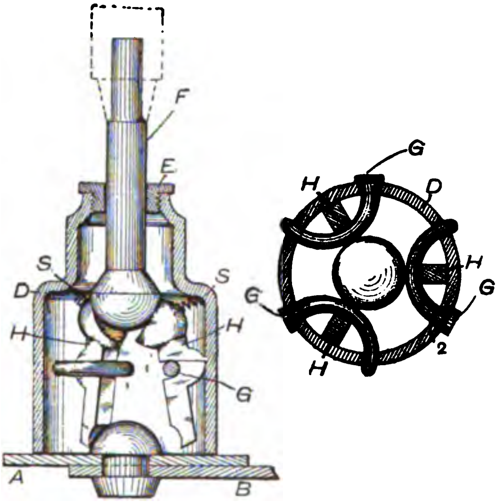
The problem did not admit of easy and offhand solution. The difference in the conditions, climatic and industrial, of India and England, had to be taken into consideration, and more than six months were passed in careful consideration and investigation before Sir John Wolfe Barry made a final recommendation. While admitting the great advantage of power over manual systems, the consulting engineer did not think that the installation of the former on the Bengal-Nagpur Railway was at present an absolute necessity; yet he was willing to concede that it might become so in the course of a few years, when the number and speed of fast passenger trains would be greatly increased. It also appealed to him that were a manual system erected in the first instance, the subsequent adoption of a power system hereafter would necessitate the scrapping of nearly the whole of the manual system machinery long before it was worn out. On these considerations, he commended the idea of a power system, pointing out that the greater initial cost would be compensated by efficiency and reduction of staff. In this view the board have concurred, and have authorized the agent in Calcutta to apply to the Government of India for sanction to equip the yards at Santragachi, Kharagpur and Adra with power systems of signaling.

The adoption of the best system for India was a matter of much consequence. Electricity is nowadays the great principle of power, and, as there are systems in operation at home in which it is used, Sir Wolfe Barry inspected the apparatus for operating points and signals, now under trial by the London and Northwestern Railway at Crewe, and the Westinghouse electro-pneumatic system, which is applied to the goods yards at Newcastle on the Northeastern Railway and at Bishopsgate goods yard on the Great Eastern Railway. He rejected both. The mechanism is elaborate and delicate and with the comparatively rough treatment it would get from the ordinary Indian operator, it would soon get out of order, and possibly collaspe. Besides, there is no electric installation at Adra or Santragachi, and its necessity might not arise for some years. Sir Wolfe Barry, therefore, fell back upon the purely pneumatic system which has given such good results at the important station at Salisbury on the London and Southwestern Railway. This system has the great merits of simplicity and strength, and can be maintained and repaired by the ordinary mechanic. Further, the air pressure being lower, there is less liability to loss of pressure from leakage due to the settlement of pipes or other causes. He accordingly recommended the adoption of the pneumatic system, selecting the tender of the British Pneumatic Company for approbation. The board has accepted the proposals, and advised their agent accordingly. The cost of installing the system at Kharagpur, Santragachi and Adra will be £29,250, or only about £5,000 more than the cheapest manual system. Considering the increase of efficiency the slight extra expenditure represents, we do not anticipate any opposition to the scheme on the part of the Government of India.—*Indian Engineering* (India).

A Rivet Calking Tool.

A tool for use in calking rivet heads in steam boiler or tank work has been invented by Patrick J. Sweeney, of Elizabeth. A recent issue of the *Engineer* contained an outline drawing of it, together with a brief description, both of which are given herewith through the courtesy of the *Engineer*.

Here *A* and *B* are the plates secured by the rivet shown, the head of which rivet is calked by placing the tool centrally over it. The stem *F* of the tool may be inserted in the plunger of a pneumatic riveting hammer and thus caused to deliver rapid blows of its convex head upon the concave heads of the calking pieces *H*. These calking pieces are pivoted upon the bent pins *G* most clearly shown in the plan view. The lower ends of these calkers are suitably shaped for their work and are forced against the head of the rivet by the outward movement of the upper end under the blows of the stem *F*. The rapid succession of blows delivered while the body of the tool is gradually rotated is designed to effect a very quick calking of the rivet head. Springs *S* are



A NOVEL RIVET CALKING TOOL.

arranged in compression between the heads of the pieces *H* and the shell *D* of the tool in such a maner that the calking points are naturally withdrawn from the head of the rivet between the blows of the stem *F*. By unscrewing the bushing *E* the stem *F* may be removed from the body *D* of the tool and, similarly, the calking pieces may be removed for sharpening or renewal by drawing out the bent retaining pins *G*. These pins *G* are held in place by split pins inserted through holes drilled in their small ends and have nothing to do, further than to retain the calking pieces in position, the pressure due to blows of the stem being taken directly by the shell *D*.

A Portable Pneumatic Tool Outfit for Railroads.*

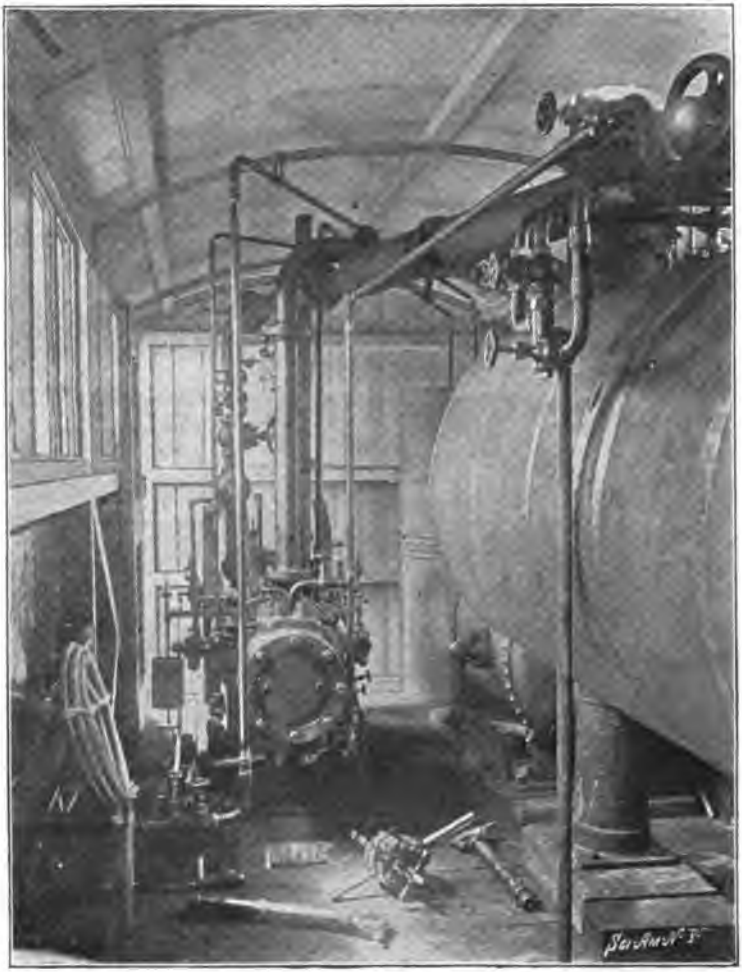
A compact and well-equipped complete portable pneumatic tool installation has recently been designed for the Great Southern & Western Railroad of Ireland by the International Pneumatic Tool Company. There are many phases of work and repairs upon a railroad for which such a pneumatic outfit is peculiarly adapted, notably the repair of bridges, relaying of the rails, and drilling operations, which can be more expeditiously and economically carried out by the aid of pneumatic tools than by the ordinary means of manual labor. The only difficulty in such work is the provision of the necessary air-compressing plant to operate the tools. The Great Southern & Western Railroad have had the car which we illustrate herewith specially constructed and fitted up with a complete installation necessary for emergency purposes.

The power for driving the air-compressing plant comprises a 12-horse-power semi-portable boiler, complete with steam injector and the other necessary fittings. The air compressor is of the horizontal straight-line, steam-driven type, with water jacket and automatic speed and pressure regulators, and it has a capacity of 134 cubic feet of free air per minute. This part of the plant is mounted on a sub-base fixed on the floor of the truck. Beneath the floor of the wagon is suspended a steel air tank. This reservoir is 6 feet in length by 2 feet 6 inches diameter, and is fitted with a flexible hose. The plant in the wagon itself also comprises a water-circulating tank, which for economy of space and weight fulfills a dual purpose—cooling the air-compressing cylinder and feed-water tank for the steam engine boiler. The pneumatic tools provided with the plant consist of two long-stroke hammers capable of closing down rivets of one inch diameter, and two pneumatic holders for use with them; two No. 2 "Little Giant" drills for boring holes up to $1\frac{1}{4}$ inches diameter, several lengths of $\frac{1}{2}$-inch metallic covered flexible hose, to enable the tools to be operated at a

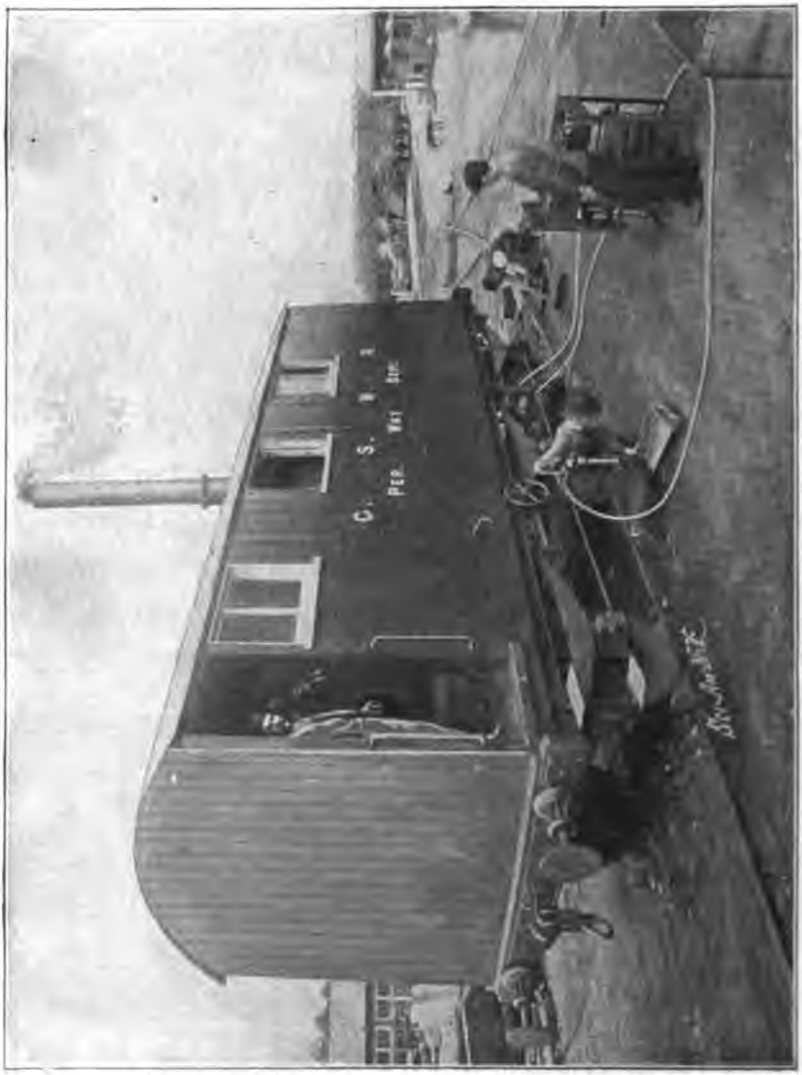
* Published in the Scientific American from its English correspondent. Illustrations supplied through the courtesy of the *Scientific American*.

distance from the vehicle, air filters, air-cocks, hose-clips, etc. The plant, which has been in operation for some weeks, has proved a great benefit for general and temporary work, both in the saving of labor, the expedition of the work in hand, and cheapening of the cost of repairing. In our illustration the plant is shown in use for bridge-repairing work, for which it is most eminently suited.

Such installations are useful in sparsely populated countries like Ireland, where either labor is difficult to obtain, or the repairs have to be carried out some distance from a center of population. The wagon containing the installation can be rapidly conveyed to the spot, and the air compressor can be set in working order en route, so that it is possible to commence operations directly the structure in need of repair is reached.



INTERIOR OF THE REPAIR-CAR, EQUIPPED WITH PNEUMATIC TOOLS.



A PORTABLE PNEUMATIC TOOL OUTFIT FOR USE IN RAILWAY-BRIDGE REPAIRING.

Notes.

The South Yorkshire Vacuum Cleaner Co., Ltd., has been registered in England with a capital of £1500. This company will carry on a business as carpet and general cleaners by the vacuum method.

The Cloud Marple Pneumatic Tool Manufacturing Company has been incorporated under the laws of New Jersey with a capital stock of $100,000. The incorporators are J. D. Cloud and Joel Marple, of Philadelphia, and Frank P. McDermitt, of Jersey City.

In the report of Second Assistant Postmaster Shallenberger, it was stated that routes were planned for a pneumatic mail tube service in New York, that the cost of construction had been estimated and plans were being made for financing the work. There are now several other lines which are in operation and this plan includes a more elaborate and complete service.

The Pullman Company have been getting all sorts of notoriety through the statements made by one of its officers that the blankets in the Pullman cars were only washed twice a year. In explanation of this statement it has since been brought out that after every trip the blankets are taken out of the car and thoroughly blown out with compressed air at 90 pounds pressure.

The control of the underground system of freight transportation for Chicago has passed into the hands of the Illinois Tunnel Company, which has been recently incorporated. In addition to gaining control of the present conduit under the streets of Chicago, this company plans to develop a particularly elaborate system of tunnels. It also will control the pneumatic tube system for conveying parcels which is now being installed.

Compressed air has been figuring in the municipal legislation of San Francisco. An ordinance was introduced in that city prohibiting the use of machinery in the streets for cleaning carpets and furniture by compressed air. This question was referred to the Merchants' Association, which reported back that this machinery was being used in Los Angeles, Portland, Milwaukee, Chicago, Springfield, Ill.; Denver or Colorado Springs, and was not considered objectionable in any of these places.

The American Air Tool Company, of Dunkirk, N. Y., has been incorporated and has elected the following officers: President, Robert J. Gross, second vice-president of the American Locomotive Company; vice-president and general manager, F. W. Smith, who holds a similar position with the United Radiator Company; secretary and treasurer, L. M. Murray. The company will manufacture pneumatic tools and machinery and carriage and wagon axles. The capital stock is $300,000.

In an article entitled "Oil Fire Furnaces," by A. M. Bell, M. I. M. E., in the November number of *Cassier's Magazine*, an application of compressed air for an oil heater is noticed. This furnace is for tube welding, bracing, annealing and type setting, and is constructed very compactly and in convenient form. A burner operated by compressed air is placed vertically at the foot of the combustive chamber and the heated gases are conducted horizontally across the opening provided for the tube end to be welded. A total of 100 tube ends per hour can, it is said, be secured.

Mr. H. F. J. Porter, who has been associated with Westinghouse interests since the first of last year, and has held the position of assistant manager of the Publishing Department, with offices in East Pittsburg and 10 Bridge street, New York, has been made second vice-president of the Nernst Lamp Company, of which enterprise Mr. George Westinghouse is president, with the duties of general manager and headquarters at Pittsburg. He assumed charge on December 1.

This appointment does not affect Mr. Porter's relations with the Publishing Department at the present time.

Several inventions which apply to compressed air machinery have recently been patented in England. Among them is a valve which is operated by the piston of an air compressor automatically and positively against the power of a spring by a projection on a connecting rod which reciprocates the piston. Another relates to air compressors in which the compound steam and air cylinders are arranged in tandem and connected by a common crank shaft. In this case the steam cylinders are controlled by balanced valves, and the air cylinders by piston valves, both operating directly upon the crank shaft, the air valves being placed laterally and obliquely on the air cylinders.

A new company to deal in compressed air machinery has just been incorporated in Connecticut. It is known as the George Miles Company, and is located at Winsted, Conn. According to the certificate of incorporation, the nature of its business is the manufacture of, selling and dealing in pneumatic specialties, air compressors, elevator drops, tubes, carriers, heaters, boilers, general iron work and business appertaining thereto. The capital stock is $50,000, and the incorporators are George Miles, of Hull, Mass.; Alfred Schoff, of Norfolk; J. Martin Sauter, of Winsted, and Davis J. McSweeney, of South Boston, Mass. No cash has been paid in on the stock, but the certificate or organization states that $20,000 has been paid in on machinery and patents.

The care of pneumatic tools is a subject that merits the attention of all purchasers of these useful appliances. The simplicity of their exterior misleads the observer into believing that they require no attention, whereas they should receive as much care as a sportsman bestows on his favorite gun. A pneumatic hammer must be kept clean and well oiled all the time, like any other high-speed tool or machine. They can be cleaned by using kerosene and should be lubricated only with sewing machine oil or some equivalent having a light body. A well kept pneumatic tool is a valuable apparatus, but one allowed to rust and become gummed with heavy oil and dirt is nothing but a nuisance. The operation of a tool of any sort in the latter condition is something no maker will guarantee.—*Engineering Record.*

The United Stated Circuit Court of Appeals has reversed the decree of the lower court in the suit of the American Compressed Air Cleaning Company, owning the Nation patent, vs. the Wisconsin Compressed Air House Cleaning Company, operating under the Thurman compressed air carpet renovating patents. The latter firm was defended by the licensor, the General Compressed Air House Cleaning Company, of St. Louis, Mo. The Court in reversing the decree granted a victory for the Thurman compressed air carpet renovators. The Court defined the Nation device as a "duster" without patentable novelty and the Thurman machine as a distinct device with characteristics peculiarly its own being a compressed air carpet renovator. This litigation has been in progress for about two years and has undoubtedly had its effect on the general use of compressed air cleaning machinery.

The manner in which the equipment of the Russian railways with American air brakes received its greatest impetus has not been widely known, and may be of interest.

A very serious accident occurred on one of the Russian State railways about the year 1895, when a hand-braked train ran into and telescoped a train that was standing on the track ahead of it, thereby killing several people, and doing a great deal of damage. At that time it was the custom of the Government Railway Department to equip only their passenger trains with the air brake, leaving the freight brakes to be applied by hand. In course of the inquiry that followed this freight train disaster, the Emperor asked the Minister of Ways and Communications to explain how it had happened, and that official stated that if the freight service also had been equipped with American automatic air brakes, the accident would not have occurred. To this the Emperor replied: "Why were they not so equipped?"

Such a reply from that Monarch was equivalent to a command; all the previous troubles in the way of lack of funds were speedily put to the vanishing test, and a Commission was formed from the Ministry of Ways and Communications to study up and recommend the best automatic air brake.

After some time this Commission decided to put to the test five companies who were competing for the five year contract for $7,000,000 worth of brakes which the Government needed at that time. They consequently invited each company to send equipments for a fifty car train, which was to be equipped with each type of brake in turn, and put through the same series of tests. As a result, the Westinghouse air brake was chosen, and as the Government contract stated that the brakes should be made in Russia, a Westinghouse factory was at once started at St. Petersburg. From the day that the report of the Commission was accepted to this, the Westinghouse Company has supplied all the rail-way brakes for the Russian Government. A statement was recently made that a large order for locomotive brakes had been given to a competing American concern, but this is erroneous. The order was for 1,000 sets of Westinghouse locomotive brakes. The policy of the Russian Government demands that all material which is to be used in connection with Government contracts must be made in Russia by a Russian company. There is no other Russian brake company in existence at the present time than the Westinghouse; none other has received a charter.

Many of the older readers of *Engineering News* will recall from their student days the illustration of a diving-bell in the old text-books on physics or "Natural Philosophy," as it was then called. The illustration showed a small craft floating on the surface of a body of water with a bell suspended from it, which looked as if it had been borrowed from a church steeple. On supports inside the bell were perched two or three persons of diminutive size, in highly uncomfortable attitudes. It is a long step from such a device to the large and elaorate "diving-bell" structure or suspended caisson used in building the Kiel dry docks, which we describe and illustrate in this issue.

It is sometimes said that the modern pneumatic caisson illustrates the principle of the diving-bell. So far as the pneumatic action is concerned this is true. The caisson, however, in all ordinary circumstances rests on the bottom, and is forced down as the work of excavation proceeds, while the true diving-bell is suspended from the surface. The Kiel caisson was thus suspended, and it is, therefore, a true application of the diving-bell. It served purely for purposes of construction and formed no part of the completed structure, as does the ordinary pneumatic caisson.

The conditions which led to the use of the suspended caisson at Kiel are rather peculiar. The docks are located partly in open water; construction "in the dry" by damming off the site was practically impossible, and the diving-bell was adopted as the sole remaining expedient for carrying out the work without concreting under water.

In respect to the method adopted, the Kiel docks contrast with the Kobe dry dock, whose construction was described in our issue of September 24, 1903. The characteristics of location and physical conditions are quite similar in the two cases, except that the Kobe dock required thorough piling to secure a satisfactory foundation, while at Kiel a natural foundation could be had; on the other hand, the Kiel docks are much larger than the Japanese structure. The Japanese engineers chose the plan of surrounding the site with a cofferdam, so as to work in the dry, if it proved possible. Yet the event forced them to do most of the work under water, depositing the concrete by the bucketful. The Kiel suspended caisson avoids this undesirable feature, and in the matter of expense it substitutes the cost of the caisson (minus the salvage) for the cost of the cofferdam. Moreover, the cofferdam must in most cases inclose the entire work; the suspended caisson need be only part of the size of the dock. As the size of the work increases, therefore, not only the uncertainty but also the cost of the cofferdam method increases as compared with the other method. On the whole, the suspended caisson seems the more satisfactory expedient; certainly it is a neater and safer system. The Kiel caisson, with its carefully developed details and its successful operation, will undoubtedly serve as a model for future cases of difficult subaqueous work.—*Engineering News.*

(The article referred to in the first paragraph will be republished in the February issue of COMPRESSED AIR.—Ed.)

INDEX.

U.S. PATENTS GRANTED NOV., 1903.

Specially prepared for COMPRESSED AIR.

742,819. PNEUMATIC-TUBE CARRIER. Maurice Anderson, Chicago, Ill. Filed Feb. 7, 1902. Serial No. 93,017.

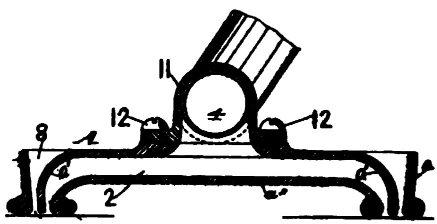
Pneumatic-tube device, comprising a tube formed so that a portion is out of line with the main tube, an opening in the tube at this point through which the carriers are discharged, a detachable supporting-piece associated with said opening and provided with a laterally-projecting part extending outwardly away from the portion of the tube bent out of line, and a valve connected with said laterally-projecting part so as to open outwardly, and a receiving device below said tube connected with said detachable supporting-piece so as to be held in place thereby.

742,831. PNEUMATIC TIRE. John R. Brunt and Richard C. Pitt, Christchurch, New Zealand. Filed Apr. 9, 1902. Serial No. 102,081.

742,834. BRAKE-OPERATING APPARATUS. Louis T. Canfield and John D. Murray, Scranton, Pa. Filed Mar. 29, 1902. Serial No. 100,525.

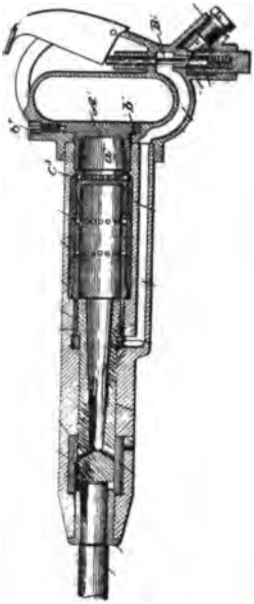
An air-brake system, an air-cylinder, a cylinder-lever provided centrally with a longitudinal slot and in operative connection with the piston rod of the said cylinder, an eccentric supported adjacent to said lever, and provided with a band, a link-bar pivoted to a stationary support and in operative connection with said eccentric-band, a pin or bolt connected with said link-bar and movable in the slot formed in said lever, and means for turning said eccentric, substantially as shown and described.

742,880. PNEUMATIC DEVICE FOR CLEANING CARPETS, FLOORS, OR THE LIKE. Augustus Lotz, San Francisco, Cal., assignor to Sanitary Compressed Air and Suction Dust Removing Company, San Francisco., Cal., a Corporation. Filed Feb. 16, 1903. Serial No. 143,553.



The combination is a pneumatic cleaning apparatus, of a casing inclosing an air chamber, said chamber communicating with a suction discharge-pipe, and having a narrow elongated slit in the bottom, adjacent to the surface passed over by the apparatus, and a wall *a* convergent in relation to the front wall of said chamber, the space between said walls being open at the top and communicating at the bottom through a narrow slit relative to and coincident in length with the opening in the bottom of said chamber.

742,934. FLUID - PRESSURE - OPERATED TOOL. Henry H. Vaughan and Charles H. Johnson, Chicago, Ill. Filed Jan. 14, 1903. Serial No. 89,751.

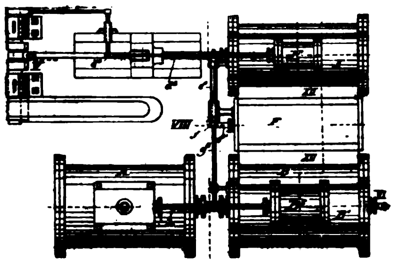


A fluid-pressure-operated tool, the combination with a cylinder, of a reciprocating piston therein, a reservoir, means for charging said reservoir prior to the admission of pressure to the working end of the cylinder and means for connecting said reservoir directly with the working end of the cylinder after the supply has been cut off, substantially as described. A fluid-pressure-operated tool, the combination with a cylinder having an open end, of a bushing fitting within said cylinder and having an exterior diameter less than the interior diameter of the cylinder around the bushing, thereby forming a storage-space between the cylinder and bushing, a partition within said bushing adjacent to one end thereof, a cap having a hollow chamber extending within the open end of said cylinder, said bushing having openings therethrough communicating with said storage-space and said chamber, and a reciprocating piston within the cylinder controlling the supply and discharge of pressure through the openings in the bushing, substantially as described.

743,109. PNEUMATIC-DESPATCH-TUBE SYSTEM. Max Stange, Chicago, Ill. Filed Jan. 17, 1903. Serial No. 139,389.

A pneumatic-tube system, the combination with a despatch-tube and its branch, one of said parts being provided with a longitudinal guide formed in the inner cylindric face thereof and which extends throughout the length of the same and a distance into the other part.

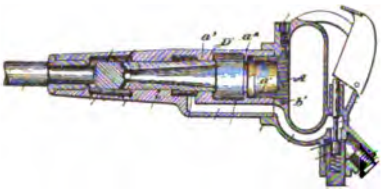
743,326. PNEUMATIC-ENGINE. William E. Peters, Allegheny, Pa. Filed Oct. 14, 1901. Serial No. 78,637.



Apparatus for utilizing an initially-generated power, the combination of a power-generating cylinder and piston, a fluid-actuating cylinder provided with a piston, connected therewith, and a working cylinder and piston, with intervening ports and valves adapted to establish communication between the fluid-actuating cylinder and the working cylinder, means for actuating said valves, consisting of an eccentric and actuating-levers with stems connected therewith adapted to be engaged by the piston of the fluid-actuating cylinder, substantially as set forth. Apparatus for utilizing an initially-generated power, the combination of a fluid-actuating cylinder provided with a reciprocating piston, means for actuating said piston, a working cylinder provided with a piston, a power-shaft and connections therewith from said piston, supply-ports for the working cylinder and valves therefor with eccentric mechanism for shifting said valves, a controlling-valve between the fluid-actuating cylinder and the working cylinder, circulating-ports between said valves and said cylinders, supplemental valves adapted to control the supply of fluid to the working cylinder, and means for actuating said valves consisting of independently-operated lever-shaft and levers, with levers provided with stems adapted to be engaged by the piston of the fluid-actuated cylinder, substantially as set forth.

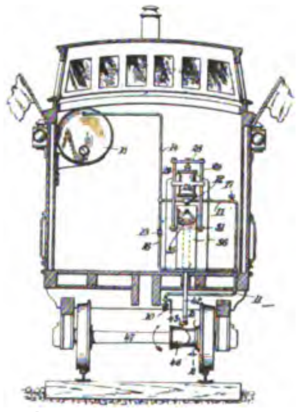
743,356. VALVE DEVICE. Charles H. Watters, Chicago, Ill. Filed Mar. 17, 1903. Serial No. 148,221.

743,389. FLUID - PRESSURE - OPERATED TOOL. Charles H. Johnson, Chicago, Ill. Filed Jan. 14, 1902. Serial No. 89,719.



A fluid-pressure-operated tool, the combination with a cylinder having the bore thereof enlarged to form a supply-chamber and a reservoir, of an annular partition between said reservoir and said supply-chamber, a hollow piston within said cylinder having ports leading from its outer surface to the interior thereof, an imperforate enlargement on said piston of a length greater than the length of said reservoir whereby said reservoir is connected with said supply-chamber prior to the admission of pressure from said supply-chamber through the ports and hollow interior of said piston to the working end of the cylinder.

743,916. AIR-BRAKE ATTACHMENT. Harlon F. Ong, Wendling, Oreg. Filed Sept. 23, 1902. Serial No. 124,513.



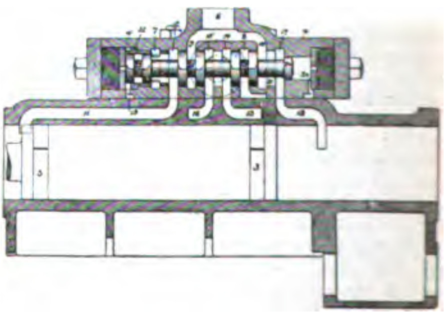
The combination with an air-brake system, of a reservoir, a pipe leading therefrom, two branch pipes communicating with the first-named pipe and with the train-pipe, a check-valve in one of said branch pipes, a valve in the other branch pipe, for the purpose specified, and means for operating the valve, such means comprising a part in connection with a mobile part of the vehicle to which the brake is applied. The combination with a fluid-pressure brake system, of an auxiliary apparatus separate from the brake system and capable of reapplying the brakes, said apparatus comprising a pressure-reservoir, a valve controlling its communication with the train-pipe and the communication of the train-pipe with the atmosphere, two devices for jointly operating the valve, the one of said devices being capable of connection with a mobile part of the vehicle to which the brake is applied, and means controlled by the train-pipe pressure for moving the first-named of said valve-operating devices in and out of connection with said mobile part of the vehicle and for actuating the other valve-operating device.

743,130. MECHANISM FOR ACCENTUATING ONE OR MORE NOTES IN MECHANICALLY-ACTUATED MUSICAL APPARATUS. Francis Young, New York, N. Y., assignor to the Aeolian Company, New York., N. Y., a Corporation of Connecticut. Filed Mar. 14, 1903. Serial No. 147,741.

743,511. VALVE. Charles E. Huxley, Quincy, Ill. Filed May 7, 1902. Serial No. 106,250.

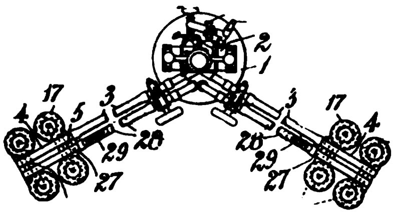
743,920. IMPACT TOOL. Thos. H. Phillips, St. Davids, Pa. Filed Sept. 2, 1902. Serial No. 121,837.

The combination is an impact-tool, of a cylinder, a piston, a valve-chest, a valve, and passages extending from the rear end of the cylinder to the valve-chest, and from the valve-chest to a point some distance from the front end of the cylinder, whereby, when the piston, in its rearward movement, uncovers said forward passage, steam will be permitted to pass directly from the front end of the cylinder to the rear end of the same, independently of any movement of the valve.



743,985. VALVE. Carl W. A. Koelkebeck, Pittsburg, Pa. Filed Jan. 20, 1900. Serial No. 2,206.

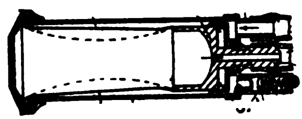
744,188. PNEUMATIC MILKING APPARATUS. Alexander Gillies, Terang, Victoria, Australia. Filed June 16, 1903. Serial No. 161,717.



A pneumatic milking apparatus, a teat-cup, consisting of a rigid casing, a flexible lining therefor, a cup at the bottom of said lining, and a cap and nut for connecting the flexible lining to the cup at the bottom thereof, said cap having a boss adapted to fit into the base of said rigid casing, substantially as described.

744,202. VALVE-GEAR. Franklin W. Jarvis, Chicago, Ill. Filed June 27, 1903. Serial No. 163,313.

744,189. TEAT-CUP FOR PNEUMATIC-MILKING APPARATUS. Alexander Gillies, Terang, Victoria, Australia. Filed June 17, 1903. Serial No. 161,941.



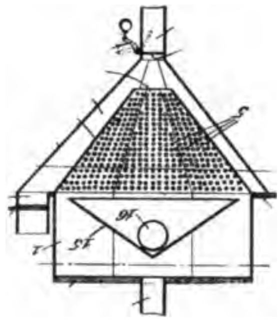
The combination with a teat-cup consisting of a rigid casing having a flexible lining, of an automatic air-inlet valve opening in the space between the lining and the casing, an intermittent suction-pipe at the base of said space, and a continuous suction-pipe at the base of the inner compartment of the teat-cup, substantially as set forth.

744,394. PROCESS OF MAKING SINGLE-TUBE PNEUMATIC TIRES. Theron R. Palmer, Jeannette, Pa. Filed June 11, 1903. Serial No. 161,027.

744,433. VALVE. Lorens Swenson and John S. Swenson, Cresco, Iowa. Filed Apr. 23, 1903. Serial No. 154,015.

744,435. PNEUMATIC TIRE. Irvin Tennant, Springfield, Ohio, assignor to Tennant Auto-Tire Company, Springfield, Ohio, a Corporation of New Jersey. Filed Apr. 17, 1902. Serial No. 103,253.

744,390. PNEUMATIC GRADER. William S. Osborne and Elwin C. Bryant, St. Louis, Mo. Filed July 19, 1901. Serial No. 68,936.

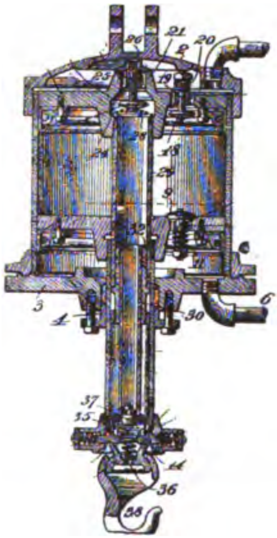


The combination with a casing comprising a surrounding wall, a top wall spanning the space inclosed by said surrounding wall and provided with an inlet-opening for the material to be acted upon, and a perforated, inverted pyramidal portion having its upper portion connected to said surrounding wall and its lower end provided with a discharge-opening, of a pyramidal spreader in said casing with its bottom above said perforated portion and its apex below and in line with said inlet-opening for the material, an imperforate, inverted, pyramidal casing-wall about said perforated portion and spaced therefrom to produce an air-space, said imperforate wall having a discharge-opening at its lower end and said opening at the lower end of said perforated portion discharging into said air-space, an over-balanced valve closing said opening at the lower end of said imperforate wall, means for closing the upper end of said air-space above said perforated portion, an air-inlet leading from atmosphere directly to said air-space, and an eduction-pipe leading from the interior of said pyramidal spreader to a point outside of the apparatus; substantially as described.

744,436. PNEUMATIC TIRE. Irvin Tennant, Springfield, Ohio, assignor to Tennant Auto-Tire Company, Springfield, Ohio, a Corporation of New Jersey. Original application filed June 25, 1903, Serial No. 163,000. Divided and this application filed Aug. 19, 1903. Serial No. 170,019.

744,630. PNEUMATIC TOY. George Schneider, Baltimore, Md., assignor to the George Schneider Manufacturing Company of Baltimore City, a Corporation of Maryland. Filed Feb. 28, 1903. Serial No. 145,489.

744,611. PNEUMATIC HOIST. Charles H. Reeder, St. Louis, Mo. Filed Dec. 8, 1902. Serial No. 134,453.

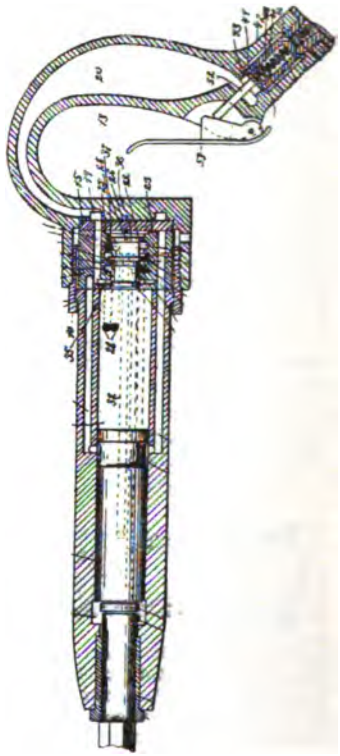


The combination of a cylinder, upper and lower load-lifting pistons arranged to operate in said cylinder, a piston rod carried by said lower piston and a piston-rod carried by said upper piston arranged to operate telescopically in the piston-rod of said lower piston, substantially as set forth.

744,814. PNEUMATIC DESPATCH SYSTEM. Kenneth E. Stuart, Philadelphia, Pa. Filed June 10, 1902. Serial No. 110,972.

A pneumatic-despatch system including two or more stations having selective mechanism adapted to be actuated by selective heads on the carriers for determining the course of the carriers at said stations, the combination of selective fingers forming part of said mechanism and extending into the tube in the path of the carriers to varying distances and at varying distances from the centre of said tube with a system of carriers having selective heads formed with circular finger-engaging faces of varying depth and of varying diameters.

745,239. PNEUMATIC TOOL. Charles B. Richards, Cleveland, Ohio, assignor to the Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Filed Feb. 20, 1902. Serial No. 94,922.



In a pneumatic tool, the combination with a plunger-cylinder having inlet and exhaust at the outer end and inlet at its inner end and exhaust, a short distance from its inner end, and a plunger reciprocating within said cylinder and formed with an air-distributing groove, of a distributing-valve chamber having one end communicating with the inner end of the cylinder, a distributing-valve in said chamber, and registering ports and channels in the cylinder respectively communicating with the air-supply and with the other end of the valve-chamber to be connected by the groove in the plunger on its outward stroke to admit live air to the other end of the valve-chamber to throw the valve in one direction, the valve being thrown in the opposite direction by the compression of the air by the returning plunger at the inner end of the cylinder against the valve, substantially as set forth.

744,815. SENDER FOR PNEUMATIC-DESPATCH TUBES. Kenneth E. Stuart, Philadelphia, Pa. Filed July 8, 1902. Serial No. 114,762.

As a sender for pneumatic tubes, a mouthpiece, a sliding gate or gates normally closing said mouthpiece at some distance from its outer edge, means for closing and keeping the gate closed, and a gate-actuating device consisting of one or more inclines extending from the wall of the mouthpiece inward therein to the edge or edges of the gates and serving to open the gates when thrust backward by a carrier.

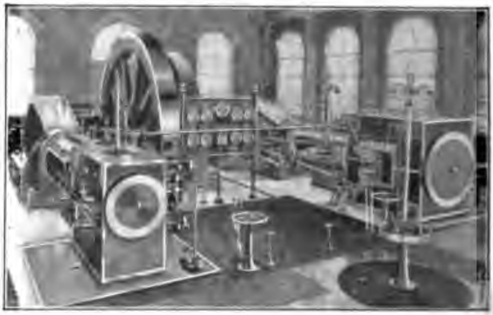
744,916. FLUID-COMPRESSOR VALVE. Fred. D. Holdsworth, Claremont, N. H., assignor to Sullivan Machine Company, Chicago, Ill., a Corporation of New Hampshire. Filed Aug. 18, 1902. Serial No. 120,084.

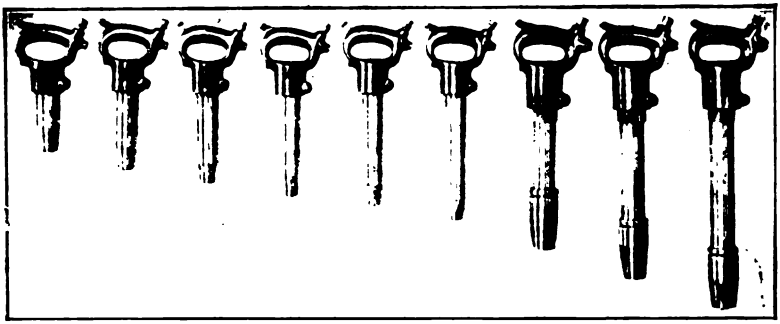
In a fluid-compressor, the combination with a valve, of mechanism for moving the same, and yielding means which is both compressible and extensible secured to both said valve and its moving mechanism and forming a connection therebetween, whereby said valve is positively but yieldingly moved in both directions and is governed by the difference in pressure on its faces and irrespective of the position of the moving mechanism.

745,040. PNEUMATIC TIRE. Thomas J. Cooper, Paterson, N. J. Filed Mar. 25, 1903. Serial No. 149,493.

745,099. VALVE. Andrew C. Fambrough, Sonora, Tex., assignor of one-half to Alonzo J. Swearingen, Sonora, Tex. Filed May 12, 1903. Serial No. 156,797.

745,300. MACHINE FOR MAKING PNEUMATIC TIRES. Uzziel P. Smith, Chicago, Ill. Filed Nov. 25, 1902. Serial No. 132,760.





Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VIII. NEW YORK, FEBRUARY, 1904. NO. 12.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
C. B. MORSE, - - - - - Managing Editor
J. E. QUINTERO, - - - - - - Treasurer

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Compressed Air Cleaning.

Some people have been horrified at the statement made by an official of the Pullman Company that the blankets in the sleeping cars of that company are washed but twice a year. If the cleaning of these blankets was confined to these two baths the public might have cause for complaint. As it is the blankets receive a cleaning at the end of every trip that is far more effective than would be the ordinary visit to the washtub. At the end of every journey they are removed from the car and "blown out" with a blast of air under high pressure.

The effectiveness of cleaning with air under compression is not appreciated by many. Experience, however, has demonstrated to those who have looked into the subject that it is of great value in securing proper sanitary conditions. As a matter of fact, the principle has been in successful use for hundreds of years. Who can name the first man or woman to hang a fabric out of doors to "air?" The fabric is freshened and purified as is possible by no other means. If these desirable results can be accomplished by the wind, which is really air under a slight pressure, how much more advantageous is a blast of air more powerful than the strongest hurricane, but under complete control?

In the case of "airing" by the wind the impurities are either carried away or oxidized as the air finds its way through the tiny spaces between the fibres or threads. A blast of air under heavy pressure accomplishes the same end, but in a much quicker time. Then, too, it possesses the advantages of a brush, and any material substances are brushed or blown away by power which is strong enough to carry particles several ounces in weight. The blast finds its way into the very fibres carrying the oxidizing process to a greater length and cleaning the cloth or fabric even more thoroughly than if it were given a bath in soapsuds. In fact, the powerful stream of air gives an "air scrubbing" which brushes, cleans and aerates the fabric, all in one process.

COMPRESSED AIR has described a number of methods of cleaning by compressed air, but they are dependent upon the same basic principle, that of passing a moving column of air around or through the articles to be cleaned, and as we have already noted, this principle is almost as old as man.

A Lesson of the Chicago Theatre Disaster.

A terrible disaster at the Iroquois Theatre, Chicago, has drawn public attention to every variety of safety appliances which will help to prevent a repetition of Chicago's awful experience.

Many suggestions have been made, some of which are excellent and will, doubtless, be adopted. Among these various methods it is not surprising that compressed air is included. A novel idea, however, in which that method of power transmission figures is advanced by a correspondent of the New York *Sun*, who, over the anonymous signature of "An Actor," writes as follows:

"*To the Editor of The Sun:* SIR—There is a simple device in use upon every railway in this country which could be adopted for use in theatres and public halls in such a way as to preclude the possibility of locked doors and non-falling fireproof curtains in times of emergency. This is the air brake, operated from a central station and controlled by levers in various parts of each car in every train. By a few simple changes in this mechanism it could be arranged so that a compressing or exhausting engine in the machine room of the theatre would not only unlock but force open every door in the auditorium of any theatre. At the same time the pneumatic power could force the asbestos curtain down—not merely release it for a fall, but actually force it to the stage floor; and while this was being done another division of the mechanism could turn up every exit light and any number of emergency lanterns that might be provided.

"Such a machine could be controlled by buttons or cords in the auditorium, one at every seat, or one at every row of seats. Any spectator could, by pressing a button or by pulling a cord, at one act lower the fireproof curtain, open every exit and turn on every light in the house, regardless of what was going forward on the stage. By the use of such machines one of the principal causes of panic and its terrible consequences would be averted, for nothing is more terrifying to an audience than the darkness of a theatre auditorium in time of peril."

If any system to accomplish automatically all the desired ends at the same time is adopted, there is no reason why compressed air cannot play a most important part. While this suggestion to utilize the air brake of the steam railway is feasible a more simple method similar to that used to close the bulkhead doors on a warship would be preferable. Instead of closing the doors the same principle could be applied to open the exits and to lower the asbestos curtain, adjust the skylights and whatever else was necessary in case of fire This system could be easily controlled at various points behind the scenes and in the auditorium.

There is common sense in "An Actor's" suggestion, although the device would require important changes before it was adapted to the very different conditions. As long as human agency is depended on in case of emergency there is bound to come a time when a misunderstanding or a sudden unexplainable fear will change the best laid plans. Of all the methods of power transmission there is none more reliable than the air itself. Compressed air's advantage in that direction has long been recognized and for that reason it is used to accomplish certain results where failure would mean serious, if not fatal disaster. There is no reason why it cannot be put to practical use in theatres to prevent another such catastrophe.

Sawing by Compressed Air.

Considerable attention has been drawn to a new invention recently appearing in the west which introduces the use of compressed air for operating a saw. This appliance is known as the Redfield pneumatic engine and frame and is built by the Ashland Iron Works, of Ashland, Ore. This is adapted for operating drag saws for cutting logs, cord wood, heavy timber and for general use in timber and log camps, displacing hand power equipment, now generally used. Compressed air to operate the engine and saw can be obtained by using a steam, belt, gasoline or electric driven compressor or by an ordinary locomotive air pump attached to the boiler of any logging or portable engine.

The pneumatic engine is capable of making from 125 to 150 strokes per minute, depending on the pressure of air used. At 60 pounds pressure it will develop 2½ horse-power. The engine weighs 50 pounds, being constructed almost entirely of brass and steel tubing. It is claimed for the valve motion, which is of an entirely new design, that it has no complicated valves or parts to get out of order and that it is very simple and easy of adjustment. The frame is made of machine steel and wood and though light in weight is strong and durable.

The makers declare that one man with one of these machines can easily cut 10 cords of 2-foot wood per day, or 50,000 feet in logs, reducing the present labor expense at least 50 per cent. The first machine constructed was given a trial in the woods by the McCloud River Lumber Company, of McCloud, Cal. It proved so satisfactory after a thorough test that an order for a number was placed.

The accompanying illustrations serve to show the constructive details of a 2½ by 30-inch pneumatic engine and 16-inch frame. Figure No. 1 shows a vertical longitudinal section on centre line of engine, and Figure No. 2 is a general drawing of the engine and frame complete.

THE PNEUMATIC SAW AT WORK.

Referring to Figure No. 1.

It will be seen that the engine consists of a cylinder *I* made of solid drawn brass tubing, in which is the piston and tubular piston rod *Il*; two brass cylinder heads *K* and *Kl* with their respective valve chambers, ports and passages; a tubular valve *H* provided at the rear end

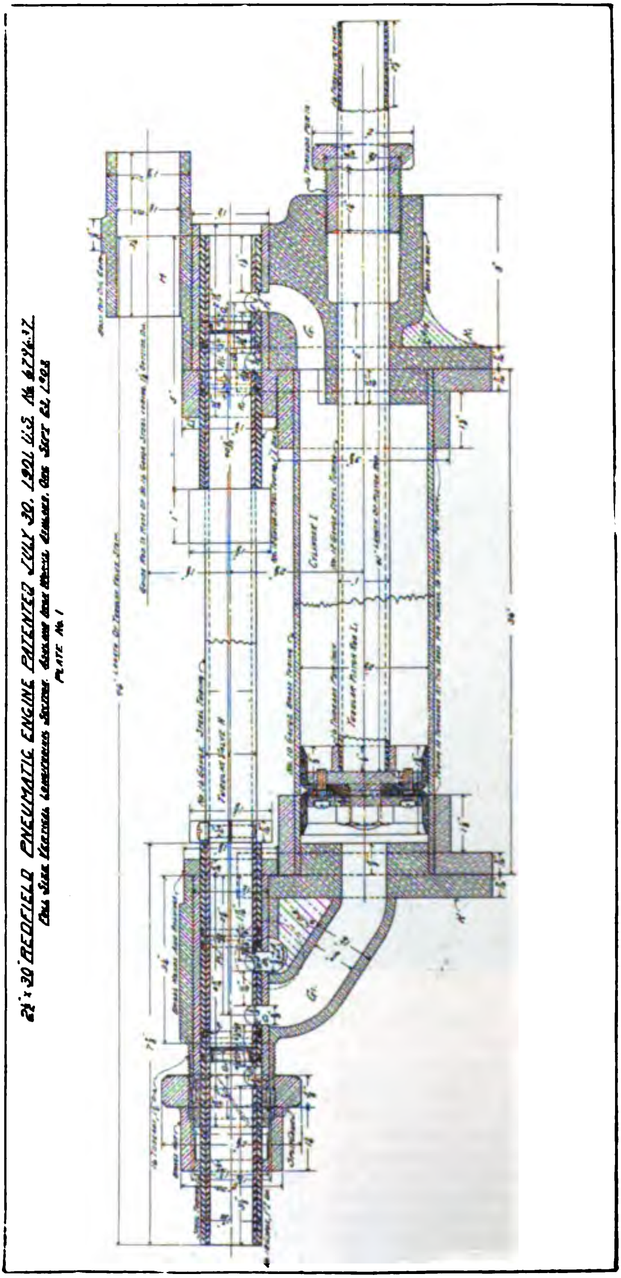

FIGURE NO. I.

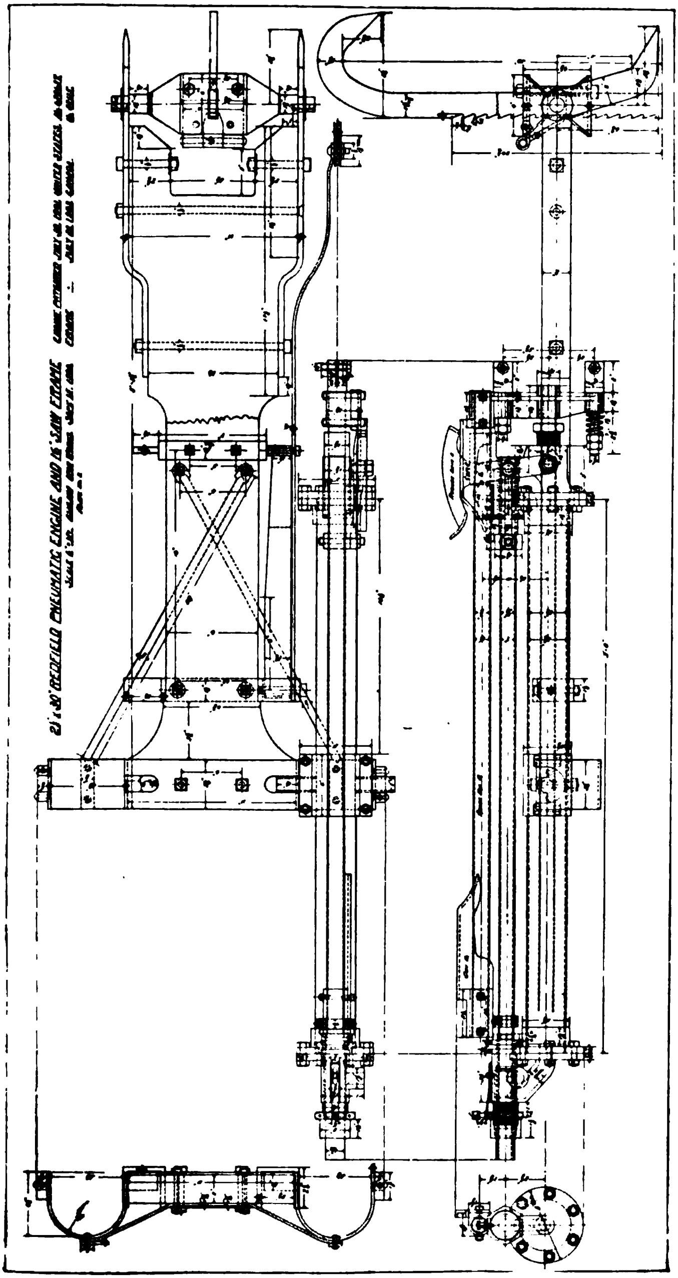

FIGURE NO. 2.

with the ports *B*, *C* and *D*, with a dividing wall or bridge *O* between ports *C* and *D*, and two sets of snap rings *P* and *Pl*, and also provided at the forward end with the ports *E* and *F*, and the bridge *Q* and the snap rings *R* and *R*; the guide *M* is a part of the forward cylinder head, and serves as a guide for a tubular guide rod which is not shown on this plate, but which is connected with the crosshead on the main piston rod and actuates the tubular valve and also serves to keep the crosshead and attached saw in a vertical position.

Referring to Figure No. 2.

On the front cylinder head is a rocker arm *A* which is connected to the tubular valve by means of the connecting rod shown on drawing, and as the piston moves backward and forward the guide rod *R* on which is fastened the cams *B* and *Bl* also moves backward and forward being attached to the crosshead, and as the piston approaches either end of its stroke the cams *B* and *Bl* alternately come in contact with the rocker arm *A* causing it to oscillate and transmit its motion to the tubular valve which controls the distribution of the air to the cylinder.

Referring again to Figure No. 1 the modus operandi is as follows:

The piston being at the beginning of its forward stroke, the valve will be in the position shown on the drawing, and the air which is conveyed to the cylinder through a hose from the supply reservoir, enters the back cylinder head *K* through the air supply chamber *A*, thence through port *Bl* of the valve chamber bushing and port *B* of the valve to the inside of the tubular valve *H* and passes through port *C* and *Cl* and passage *G* to the cylinder. The piston now moves forward and the forward end is open to the atmosphere through passage *G* and port *Fl* and *F*. As the piston approaches the end of its forward stroke the cam *Bl* shown on Plate No. 2 comes in contact with the rocker arm *A*, moving it and the tubular valve ahead, bringing port *E* of the tubular valve *H* in communication with port *Fl* of the valve chamber bushing *Ll*, also port *C* of the rear end in communication with port *Bl* and port *D* in communication with port *Gl*. Air is now supplied to the forward end of the cylinder through ports *Bl* and *C* thence through the tubular valve *H*, the ports *E* and *Fl* and the passage *G*. As the port *D* is in communication with port *Gl*, the exhaust takes place through passage *Gl*, ports *Cl* and *D*, and out through the open end of the tubular valve *H*.

The function of the bridges *O* and *Q* and the snap rings *P* and *Pl* and *R* and *Rl* will be readily understood and needs no further explanation. The split cone *J* around the tubular valve *H* on the rear head is adjusted by means of the brass nut shown on the drawing and serves the purpose of causing an even extension to the tubular valve, thereby avoiding any possible movement of the tubular valve in the way of slipping and to prevent any movement of the valve except at the proper time.

The Stanley Heading Machine.

I have read an abstract of the paper by Mr. F. C. Swallow, of the Nuneaton Colliery in Warwickshire, England, which was read before the Institution of Mining Engineers, September 2, 1903, and subsequently published in the *Colliery Guardian*, September 11, 1903. The abstract is very interesting and brings out a number of features in connection with the application of the machine as described in the paper.

Let it be understood that the Nuneaton Colliery, which is located near the town of Nuneaton, is owned and operated by Mr. Stanley, who is also the owner and proprietor of the Stanley heading machine. It would seem natural, therefore, that in getting data for a paper of this kind, he would gather it from machines working under the most favorable conditions. But for the benefit of the public it might have been better had he given general results, taken from all of the machines during the period of seven weeks.

From a table recording the coal cut per shift by one annular groove machine it shows a distance of 1,169 running feet in seven weeks with one machine, cutting out a single heading 5½ feet in diameter. If this machine worked one eight-hour shift every 24 hours, it aggregates 42 working shifts, and averages 27.88 running feet per shift, and all of the coal coming out of the heading was loaded on a single track, using but one car at a time, and, we presume, was mostly handled by one man. 27.88 running feet represents an output of about 20 tons of coal per shift, and it would appear that this amount of coal will require a good man to handle and work it from a point where it is dislodged by the cutter head, back past the heading machine, and finally into the car.

It might be well to mention that the mere shoveling of the coal back and into the car is not all the work that is to be done, and for the benefit of the readers of COMPRESSED AIR, it will be well to consider a few of the details in connection with the application of the machine and the work connected with it. The machine itself is very large, long and heavy, and when set up and ready for operation takes up most of the space in the circular heading, and leaves but little room for a man to pass by and to attend to his work of getting the coal back past the machine. This in itself requires a great deal of manual labor. But this is not all. The cutter head makes an annular's groove, say three inches wide, leaving a very heavy core in the center, which, if it does not fall of its own weight, must be picked down with a hand pick by the helper. This work, together with that of getting the coal back past the machine represents an enormous amount of labor, and we are at a loss to understand how one man can accomplish so much.

The cutter head on the machine is carried forward by a central column with a screw feed, and is so constructed as to enable it to cut the groove three feet forward without stopping the machine. At this point, however, all of the coal must be cleaned up and passed back behind the machine, and the cutter head drawn back a distance of three feet, and the whole machine moved forward against the face of the heading, when the same operation is repeated, so that in a distance of 27 feet, the machine has got to be shifted forward nine times, and anchored or made substantially fast and tight at each move so that it will stand up to the work ahead of it without working backwards.

I have had some little experience with the Stanley heading machine and know something of its application and limitation. I know that the machine is rapid when being operated under favorable conditions. But where the conditions are not in every way favorable, it is a very slow and expensive machine to use. In order to use this machine to the best advantage and economy, the coal bed in which it is operated should be thicker than the cutter head is high, so that all of the cutting would be done in the coal, and at the same time leaving a coal roof. If the coal is harder at the top than it is at the bottom, the machine has a tendency to work downward, and if it is harder in the bottom than in the top, it then has a tendency to climb up, and thus gets out of line with the heading. When once out of line, there is hardly any way of getting it back into position, except by digging the machine out, leveling up the bottom and again starting it in line. Such a condition often requires two or three men for a day or two to get the machine out and lined up and ready to start anew.

So it would appear that the Stanley machine, while it may have done remarkably well in Mr. Stanley's mine in Nuneaton, cannot do so under all conditions. It is a machine which can only be applied successfully under ideal conditions, as is virtually brought out in Mr. Swallow's paper: for he states that if the heading was to be "driven with a Stanley heading machine 5½ feet in diameter, it should be driven under the spire coal, which forms a very tough roof, and there is thus about 22 inches of coal left undisturbed."

I do not wish the reader to infer that I am in any way prejudiced against the Stanley or any other machine which can be used in any way to advantage in developing or operating coal mines, and I feel certain that the Stanley header has been doing good work in England, especially where the conditions are favorable to its use, and where rapid development is so essential. I believe it is conceded that this machine is better adapted to driving air courses than haulage ways, as by reason of the circular heading, which is only 5½ feet in diameter, it is not large enough to be used as a haulage way.

We have tried this machine in a number of places in the United States, and it has been found that the conditions necessary for its successful use are so rare that it has fallen entirely into disuse.

L. J. DAFT.

Compressed Air Locomotives, Built by the American Locomotive Company.

A solution of the problem of mine haulage has been attempted variously by animal power, compressed air, electricity and steam. Of these methods, compressed air is easily first from the standpoint of convenience, safety and economy; convenience in always being ready for work when the air supply is adequate, safe in places that would bar the steam or electric engine, owing to danger from fire or explosion from mine gases, and economical from the fact that there is no loss due to condensation as with steam, nor leakage as with electricity; the pressure when once stored, suffering no loss of energy, until having passed through the cylinders of the engine. The passing of animal power in mines is rapidly taking place, although mules are used in combination with air to some extent where air has not been provided to cover the needs of the entire plant. Under such conditions, the air motor is not seen at its best, but the compressor duty is correspondingly low. An additional advantage is had by the re-heating of air before admission to cylinders, but this refinement is not regarded with favor for mine work in general.

The American Locomotive Company has long made a specialty of air locomotives for use in and about mines, ore plants and furnaces. They are built of different sizes and types, of which two representative machines are illustrated herewith. The six-wheel engine has two storage tanks, thirty inches in diameter, in which is carried 170 cubic feet of air at 600 pounds pressure per square inch. Under these larger tanks and connecting with them by a reducing valve is an auxiliary tank ten inches in diameter which carries a working pressure of 140 pounds per square inch. This pressure is used in plain slide valve cylinders, and is controlled by a shifting link motion. In fact, the engines are identical with those in which steam is used. To overcome refrigeration at the exhaust, the exhaust openings, which are between the frame (as there are no exhaust pipes), are contracted so as to furnish just enough heat to keep expanded air above freezing point, which it does without material back pressure in the cylinders. This motor is designed for heavy work, and will exert a drawbar pull of 6,000 pounds. This is equivalent under ordinary conditions of average mine track to a hauling capacity on level, of 318 net tons of 2,000 pounds. On a grade of 3 per cent., 60 net tons, and on a grade of 6 per cent., 28 net tons. The following general description will be of interest in connection with half tones:

GENERAL DIMENSIONS.

Of 6-wheel Air Locomotive.

Diameter of cylinders..	9 in.
Stroke of piston......	16 in.
Diameter of driving wheels	26 in.
Total wheel base.......	7 ft.
Total length over bumpers	21 ft. 10¾ in.
Total height...........	5 ft. 1 in.
Total width............	5 ft. 9 in.
Storage capacity for air	170 cu. ft.
Storage pressure.......	600 lbs. per sq. in.
Auxiliary and working pressure	140 lbs. per sq. in.
Weight	30,600 lbs.

A smaller engine of the double tank type is made for use on sharp curves where the above described engine is not available. This machine is carried on four wheels, having a wheel base of 5 feet 3 inches. The cylinders are 9 by 14 inches, wheels 26 inches in diameter, the tanks 27 inches in diameter and the weight 22,100 pounds. The tractive power of this machine is 5,000 pounds. Capacity in net tons on level equals 267. On 3 per cent. grade, 53 tons, and on 6 per cent. grade, 25 tons.

The smallest motor is also of the 4-wheel design, but has ten-inch Mannesmann seamless steel tubes to furnish storage capacity of air. This construction permits of the reduction of height necessary in restricted spaces, such as chambers and inside workings of low head way. The storage capacity of the tubes is forty cubic feet of air at 700 pounds pressure per square inch. As in the case of the large machines there is a small auxiliary tank which is connected to the tube storage system by reducing valve which supplies to the cylinders a working pressure of 125 pounds per square inch. The valves are controlled by a Walschaert valve gear which is substituted for the link motion for want of room under the machine, and because of the accessibility of its parts for inspection. These small machines, like the mules, go down in a mine practically for life, and any scheme that facilitates repairs in case of break down, is of first importance. They are good for drawbar effort of 3,000 pounds, which gives a capacity on levels of 160 net tons; on 3 per cent. grade, 32 net tons, and on 6 per cent grade, 15 net tons. The height and width are such as make these little motors available for use in situations where it is impossible to use animal power. The accompanying half tone and description convey a clear idea of the low workings these machines can be used in.

GENERAL DIMENSIONS.

Of small 4-wheel Air Locomotive.

Diameter of cylinders..	7 in.
Stroke of piston.......	14 in.
Diameter of driving wheels	24 in.
Total wheel base......	4 ft. 3 in.
Total length..........	12 ft. 3 in.
Total height...........	2 ft. 11 in.
Total width...........	6 ft. 4 in.
Storage capacity for air	40 cu. ft.
Storage pressure.......	700 lbs. per sq.in.
Auxiliary and working pressure	125 lbs. per sq. in.
Weight	13,100 lbs.

The American Locomotive Company has furnished many of these compressed air locomotives to the Pennsylvania Coal Company, the Delaware & Hudson Company and others, where results of the most satisfactory character are being obtained by their use.

Air Compressors.*

As compressed air is coming into general use, it is essential that steam engineers should have a general knowledge of the principles governing its compression, application and lubrication of the air-compressing cylinders.

The use of compressed air is not the result of recent discovery; rather than this we can trace its use as far back as two thousand years before the Christian era, when it was used in connection with forges and blast furnaces for reduction of metals and forging of same.

In 1653, we find the first record of compressed air being used as a transmitter of power. At that time Denys Papin developed the use of water for compressing air and forcing it to a distance to perform work.

From the time of the experiment mentioned to the present patents too numerous to mention have been issued for devices to be used in connection with compressing air. In 1829, a patent was issued to Wm. Mann on a compound or two-stage compressor, which was probably the first of its kind. With this machine came the first suggestion of water-cooling or inter-cooling, which proper[illegible] claimed not only to effect greater economy, but also to decrease strain on the machine as well as to admit of lighter construction of compressors.

Further progress along this line was made about 1873 by means of water jets or sprays for inter-cooling, leading to the present-day methods of water-jacketing and inter-cooling systems, which have reached a degree of perfection that admits of but little further improvement except in details of construction.

The precise limit of the compressibility of air at ordinary temperature is as yet an unknown quantity. It has been compressed to 14,000 pounds per square inch in experiments for blasting rock, and there seems to be no reason to doubt the assertion that any pressure may be obtained within the limit of safety in strength of metals to hold the pressure.

Even in these days of investigation and enlightenment we find many intelligent engineers who will not consider the claims of compressed air as a means of power transmission, because of a belief that its use means a great loss in economy. A little impartial investigation will, however, show that its value is unique in that it is always and instantly ready to do work at full capacity, and that it can be easily controlled at any required pressure.

The compression of air from a lower to a higher pressure results in the conversion of energy into heat; the temperature increases with pressure, but not in the same ratio. Tables have been published giving the rise in temperature for various pressures, but in actual practice these temperatures are not attained, for the reason that in the economical operation of air compressors it is imperative that temperatures be kept as low as possible. In order to do this the heads and barrels of compressors are provided with jackets through which water circulates to absorb the heat of compression.

Where the air is compressed in more than one cylinder the temperature is still further reduced by passing it through inter-coolers on its way from one cylinder to the other.

These inter-coolers consist of chambers or cylinders of cast iron, connecting the discharge of one compressing cylinder to the inlet of the other. They contain a number of small tubes through

*Paper read by M. E. St[illegible]ver before Ohio, No. 58, National Association of Stationary Engineers, at Columbus, Nov. 5, 1908.

which the air passes, and over which water is kept circulating.

With the two-stage type of compressor the air is compressed to from 30 to 40 pounds pressure in the first cylinder, and then passes to the second cylinder, where its pressure is raised to from 100 to 150 pounds. Machines are constructed of the three and four stage type for pressures from 600 to 4,000 pounds.

In a single-cylinder machine taking air at 60 degrees F. and compressing it to 100 pounds, the air at discharge will be, theoretically, 485 degrees F.; but the cooling water of the jackets will absorb much of the heat and lower the temperature considerably, depending on the speed of the compressor and temperature and amount of cooling water.

In a two-stage machine with compression to 30 or 40 pounds, the discharge from the first cylinder will be from 200 to 250 degrees F. In passing through the inter-cooler its temperature will be reduced to 80 or 90 degrees F.; the second cylinder raises the pressure to 100 or 150 pounds, with a final temperature of from 200 to 275 degrees F. The same process is followed with the three or four stage machines.

In lubricating the interior of an air compressor cylinder conditions will be found different from those existing in a steam engine cylinder. In the former the heat is dry, while in the latter moisture is always present. Moisture has a tendency to wash oil from the surfaces, whereas with a dry heat the oil adheres to the surfaces better, with the result that a given amount of oil will give better and longer service in the air cylinder than in a steam engine cylinder, both being of equal size.

Owing to the intense heat, the oil used in an air-compressing cylinder must be of such a nature that it will not deposit a coating of carbon or burnt oil in and around the discharge valves of the compressor. If of too low flash test, the oil, on reaching the interior of compressor, will vaporize and pass off with the air without affording any lubrication to the wearing surfaces. If the oil is too dense, or is compounded with animal or vegetable oils, it will have a tendency to adhere to the discharge valves and passages, and will gradually change to a hard, brittle crust or layer of carbon, which in time will completely choke up the passages and render the valves inoperative.

It has been found by numerous experiments that, where the temperature of the air reaches 350 degrees F. to 400 degrees F., a pure petroleum oil of from 500 degrees to 530 degrees flash test and of medium viscosity, will give the most satisfactory results. When the temperature does not rise to over 300 degrees F., a more limpid oil and of lower flash test can be used, say of 400 degrees to 425 degrees flash test.

It is very important that the air suction or intake pipe be so placed that air can be had that is free from dust and dirt, as any such substance will adhere to the oily surfaces of the compressor and in time interfere with the proper working of the valves. Complaint is often made about the quality of oil, when the real trouble is due to dirty air.

Most cases of complaint about the formation of coke or carbon deposits come from users of single-cylinder compressors of small size and of the spring valve type. These machines are often worked above rated capacity; the air temperature goes above 400 degrees F., and the tendency of the attendants is to use too much oil, in which case the surplus oil gathers around the valves and passages and causes the trouble. For a cylinder 12 inches in diameter or less, a half a gill of oil per ten or twelve hours should be sufficient. If the valves are mechanically operated a slightly greater amount may be necessary.

The Concrete Dry-Dock at Kiel, Germany: Subaqueous Construction by Floating Pneumatic Caisson.

The docking facilities of the German navy at the government yard at Kiel, Germany, have quite recently been extended by the construction of a very large fixed dry-dock. The dock, which is double (having two dock chambers side by side), lies for the greater part of its length in open water, and consists of a solid concrete basin resting upon the clay subsoil of the harbor bottom without special foundation. The peculiarities of the location made the work of construction an exceedingly difficult problem; indeed, all ordinary methods were inapplicable or excessively costly. A wholly new plan of working was therefore devised, and with it the work has been successfully carried to virtual completion. The central feature of the method is the use of what is in effect a huge diving-bell—a great rectangular pneumatic caisson suspended over the work by a supporting framework carried on pontoons. This caisson formed a pneumatic working chamber in which the far as is necessary for a full understanding of the work.

Conditions Affecting the Work.—The dock is intended to accommodate in either chamber the largest vessel of the German navy, at all stages of water and even under conditions when such a vessel exceeds its normal draft, as in case of injury. The large amount

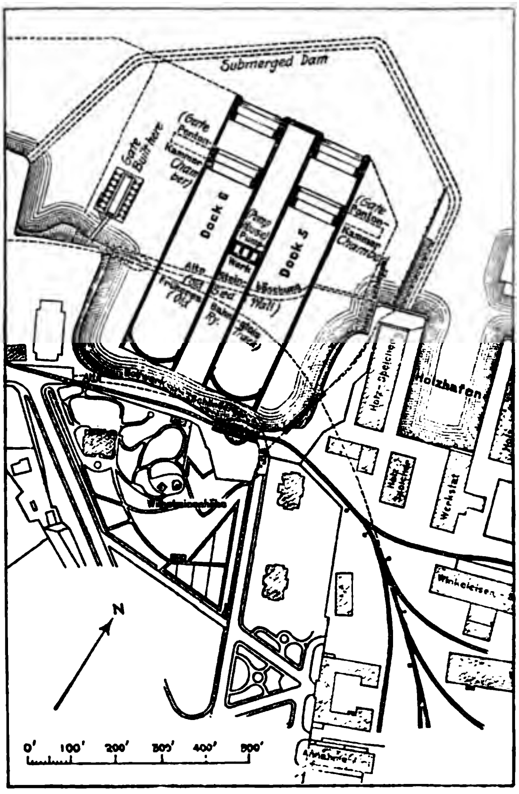

FIG. I—LOCATION PLAN OF NEW CONCRETE DRY-DOCK AT KIEL, GERMANY.

concreting was carried on under air pressure, the site having been previously prepared for the concreting by dredging. The work is sufficiently remarkable to merit close study, and to this end we give herewith a description and drawings of the construction plant and an outline of the method of working. The dry-dock itself we describe only as of dredging which would be required for a floating dry-dock in Kiel harbor, and the greater operating cost, rendered a floating dock inadvisable. Local conditions restricted a fixed dock to the site indicated in Fig. 1, which represents a ground plan of the location adopted. A bluff rising some distance back of the old shore line limited the inshore length of the docks, and the remaining portion therefore projects out into the harbor.

There is practically no tide at Kiel, but considerable variations of water level are caused by continued winds; variations up to 3 feet above and below normal are not rare. The normal depth of water at the outer end of the dock site is 25 to 40 feet. The subsoil consists of sand and gravel, bearing clay in the upper layers; farther down is a stratum of compact sand overlying good blue clay. Over the sand and gravel is a considerable depth of very soft mud, which forms the immediate harbor bottom. The depth of satisfactory foundation strata—sand and clay—is from 40 to 70 feet below water level, at the outer end of the site; the overlying strata are in general strongly water-bearing. Under these conditions any method of cofferdam construction seemed out of the question. Recourse was therefore had to the pneumatic process, using the suspended caisson to be described farther on.

The dock has no special foundation, but rests directly on the clay subsoil. The dimensions of each of the two dock chambers are: Length inside, 574 feet (175 m.); top width of entrance, 98.4 feet (30 m.); depth, 36.9 feet (11.25 m.) at the entrance, and 6 inches less in the chamber itself. The length of 574 feet is defined by a gate notch close to the extreme outer end of the dock. Some distance inside of this is another gate notch, giving a length of 459 feet, and this is the one intended for regular use. The gate is a horizontally sliding gate, working in a gate chamber extending out from the dock, as indicated in Fig. 1. This chamber is at the 459-foot gate notch, and to use the second, or 574-foot notch, it is necessary to float the gate (constructed as a caisson gate) and transfer it to the outer notch. It should be said that the actual end of the dock constitutes still a third gate notch, for purposes of construction only.

The two dock chambers, each a complete dry-dock in itself, lie side by side, separated by a clear distance of 75 feet, corresponding to 209.9 feet between the longitudinal axes of the two chambers. At the front, or outer end, of the docks this space is closed off by a wall connecting the side walls of the two docks and carried up to the same height. About in the middle of the length of the docks, and in the space between them, is the single pump house serving both dock chambers. The rear, or landward, wall

FIG. 2—CROSS SECTIONS THROUGH GATE-CHAMBER AND PUMP-HOUSE.

of each dock chamber is arched outward in a vertical plane, and the side walls are carried a short distance beyond this arch to facilitate a future landward extension of the dock.

The principal features of the design of the docks will be clear from the preceding, together with Fig. 2, showing a part cross-section through the gate chamber of one dock and the pump house. The flat bottom and the slight splay of the sides should be noted. The material is concrete throughout, except that the gate notches, the entrance, and the bottom of the dock chamber are faced with granite, while the side walls are faced with brick and stepped with basalt. The great thickness of the bottom of the dock, 17 feet, as shown in Fig. 2, was thought necessary on account of the existence of springs in the strata on which the dock rests.

Method and Course of Construction.—In Fig. 1 is shown a broken line indicating the original shore line at the site, protected by a stone sea wall; the site landward of this wall could be excavated largely in the dry. The remainder of the space covered by the dock had to be excavated down to the solid foundation stratum by dredging. Previous to the dredging, however, it was necessary to protect the space to be excavated from continued inflow of the soft mud which covered the bottom, the mud being sufficiently liquid to flow in toward any depression which might be dredged in it. For this purpose a submarine dam or earth embankment was constructed on the line indicated in Fig. 1, completely enclosing the building site. It was formed simply by dumping earth from scows over the desired location of the dam. The mud was soft enough to allow the earth to penetrate through it under the weight of the superincumbent layers, so as to finally reach down to the sound subsoil, and thus form a complete barrier for the mud. The embankment was carried up to Elev. — 13 feet, and was made 15 to 20 feet wide on top, with natural side slopes. It was deep enough below the water surface not to interfere with the floating equipment used in the construction.

The under-water excavation, which was begun as soon as the dam was completed, proceeded in three successive stages, to 17 feet, 33 feet and 60 feet depth, respectively. The latter depth was required only over small areas, near the outer end of the dock, the general elevation of the foundation being — 54 feet. For excavating the third stage it was necessary to reconstruct one of the dredges by lengthening the ladder. This was done by fixing an extension boom in guides attached to the ladder; the main winch was replaced by one of greater power and an auxiliary winch installed to handle the extension arm. The buckets in this dredge were considerably wider than the wheels of the lower head, so as to clear the latter even when lateral swaying took place. The dredge thus reconstructed is said to have worked without trouble up to the full 60-foot depth, taking out 700 to 2,000 cubic yards (according to the nature of the material) per day of 20 hours.

While the excavation was in progress, the large floating caisson by which the main part of the construction was to be carried out was built on ways in the ship yard, launched and equipped for work. This caisson will be described farther on in this article; in order to describe its manner of use we may mention here that it was simply a rectangular steel box, closed on top and open at the bottom, 138 feet long by 46 feet wide, and 16½ feet high. The lower half of the caisson formed a working chamber, while the upper half constituted a closed tank for water ballast. The caisson was hung by steel rods from a framework erected between two large pontoons, one on each longitudinal side of the caisson, and was raised or lowered by means of the rods. The supporting frame between the pontoons was covered by a working platform from where air-locked wells composed of riveted steel pipes led down to the working chamber. Fig. 3 gives a view of the structure.

In operation, the caisson was placed with its axis transverse to the axis of the dock, extending entirely across one dock chamber, and covering a space of about 46 feet lengthwise of the dock. The caisson was lowered to the bottom (its unbalanced weight being still carried by the rods), and the bottom as left by the dredge was cleaned of the remaining mud. When solid ground was reached, the concreting was begun, and carried up to a height of about 3 feet. The caisson was then raised sufficiently to clear the concrete, shifted lengthwise of the dock to a new position directly adjoining, and lowered again to the desired depth; the process of cleaning the bottom and placing a layer of concrete was repeated exactly as in the first position. By continuing this process, the whole area of the first dock chamber was covered with a layer of concrete, crossed, however, by a series of depressions where the cutting edges of the caisson had been. In placing a second layer of concrete in an exactly similar manner, the caisson was shifted so that the cutting edges did not come over the depressions left the first time, but these latter came in the space covered by the layers thus formed. It will be noted that in addition to the depressions left by the cutting edges in each position of the caisson, extending through an entire layer of concrete, a series of shallow grooves is shown in the top layer. These grooves were formed 6 inches deep in the top of each layer, to receive the cutting edges of the caisson when placing the next layer; this ensured that the level of the previously-finished concrete was

FIG. 3—VIEW OF MAIN CAISSON IN OPERATION.

working chamber, and could thus be filled with concrete, forming part of the second layer. In order to do this without concreting under water (since these depressions were below the new level of the cutting edges), the ends of each depression were first closed off by a dam of concrete, and the water was then pumped out of the trough so formed, leaving it dry and ready for the fresh concrete.

Fig. 4 represents the succession of always above the level of the cutting edges, and hence above the level of the water, except in the deep grooves, which were concreted as described above.

A cross-section through one dock chamber, shaded to show the course of the concreting, is presented in Fig. 5. The dark hatching indicates the layers of concrete placed by the large caisson. Most of this concrete was a trass-lime concrete; Portland cement was added only when low temperature rendered the trass mixture too slow in setting. The lowest layer, shaded darker than the others in Fig. 5, was made of full cement concrete; this layer rested on a bed of broken stone, by which the clay bottom was leveled up. The trass concrete was made chiefly with gravel, this being considerably cheaper than broken stone. Where special strength was required, however, as in the layers forming the floor of the chamber, and in the middle of the bottom for its full depth, broken granite was used as the aggregate in place of gravel. The average costs of gravel concrete and stone concrete, ready mixed, but not in place, are stated to have been $2.65 and $3.30 per cubic yard, respectively.

By reference to Fig. 5 it will be seen that the work done by means of the large caisson (as indicated by dark hatching) extends up to Elev. — 10.2 feet only. To use the caisson above this level would have required nearly complete emergence of the caisson, so that its entire weight would have to be carried on the pontoons. Even if the structure were made sufficiently strong for this purpose, the caisson in that position would have been so unwieldy as to very greatly increase the cost of placing the concrete in the upper sections of the walls. A much smaller and simpler caisson was therefore constructed especially for this work, and by its use the walls were carried up to Elev. + 1.6 feet, from where the remainder of the walls. to Elev. + 11.3 feet, could be constructed in the open air.

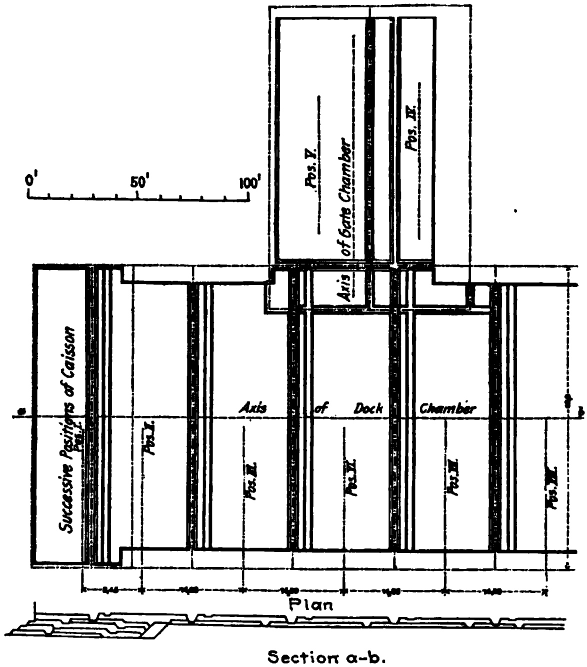

FIG. 4—ARRANGEMENT OF SINGLE SECTIONS OF CONCRETE.

The small caisson, which is shown in Figs. 10, 11 and 12, and will be described farther on, has a pneumatic chamber wide enough (23 feet) to straddle the dock wall, and 33 feet long, with a height of 6½ feet, which can be increased by lengthening the cutting edges downward by stop-logs (see Fig. 12). The concreting is done in layers of 24 inches, placing two layers in each single setting of the caisson, from Elev. — 10.2 feet to Elev. + 1.6 feet. In order to get the caisson around the corners of the wall, it was necessary to leave an open space at one side of each corner, as indicated in Fig. 7. These spaces being made long enough to accommodate the caisson lengthways, they could be concreted in a subsequent setting of the caisson, leaving only a narrow vertical slot through the wall at each end of the open space, under the cutting edges. These slots were molded in dove-tail, and were filled with concrete after the caisson work was completed.

The stone and brick interior lining of the dock was placed after the walls were finished; for this purpose the gate was placed against the outer gate notch (formed by the end wall itself, as already mentioned) and the dock pumped out. The pump house, or rather a portion of it, was built simultaneously with the first dock chamber, and was temporarily walled off at the end facing the second dock, so that pumps could be installed and the first dock made ready for use while the second was being built.

The method and course of construction of the second dock was precisely similar to that followed in building the first dock, outlined above. We may note here that the first dock was finally completed and put into service at the end of 1902; at that period the under-water construction of the second dock was completed and only the lining and equipping remained to be done.

Main Caisson.—The size of the structure was limited by the requirement that it should be able to pass through the Kiel ship canal, so that it might be available for work in the Baltic Sea. The caisson proper is, as already noted, 46 feet wide and 138 long (14 x 42 m.) and 16.4 feet deep from roof to cutting edges. Structurally it is composed of a number of transverse girder frames, 8.2 feet deep, braced together by longitudinal frames, and sheeted with a tight steel-plate skin, forming a closed box 8.2 feet deep. The sides of this box are extended downward, braced by triangular brackets on the main frames, to form an air chamber open on the bottom and 8.2 feet high. The box-shaped upper half of the caisson is subdivided by two transverse bulkheads, and the three chambers thus formed are adapted to receive water as ballast. For more accurate adjustment of the buoyancy of the caisson, a closed cylinder of about 125 cubic yards capacity is provided, running longitudinally through the ballast chambers. This cylinder may receive or discharge ballast independent of the main chambers. Compressed air is used to force the water out of chambers and cylinder when the buoyancy of the caisson is to be increased. When the caisson is wholly submerged, and the working chamber is full of air, the caisson has a remaining positive buoyancy even when the ballast chambers are completely filled with water. Fixed ballast sufficient to just neutralize this remaining buoyancy is placed in the pockets of the cutting edges and on the roof of the working chamber in the shape of concrete, pig-iron and old rails.

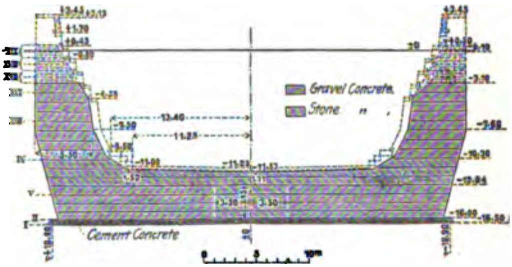

FIG. 5—COURSING OF CONCRETE IN ONE DOCK-CHAMBER.

The two pontoons which carry the supporting structure are simply flat-bottomed steel scows, about 150 feet long by 20 feet wide, which are placed parallel to each other a sufficient distance apart to admit the width of the caisson between them. They carry an overhead steel supporting framework which spans the space between them and firmly ties the two pontoons together. The top of this framework carries a traveling gantry crane fitted with two 10-ton trolleys, which controls the entire area of the working platforms below, and serves to handle all heavy material and parts. Two working platforms are suspended from the framework; the lower one, extending over the full area of the caisson, serves for communicating with the working chamber through the several air-locked wells, and in general for all the open-air work except handling the materials for concrete, which latter work is done on the upper and smaller platform.

The framework connecting the pontoons also serves as attachment for the suspender rods, by which the unbalanced weight of the caisson is carried and by which the caisson is raised or lowered to any desired position. There are twenty of these rods, one at each side of the caisson at each of the main girders of the overhead framework. They are composed of short lengths connected together by link and pin couplings. The upper length of each rod is threaded and works in a nut supported in a heavy chair. The upper end of the screw is hung to the plunger rod of a vertical hydraulic jack. The twenty jacks are the means by which the caisson is moved vertically, and the nuts on the threaded sections of the suspender rods serve only as a governing mechanism for the jacks. When the desired position of the caisson has been reached, however, the jacks are placed out of service by shutting off the pressure water, and the load of the suspender rods then rests entirely on the nuts. The arrangement is reported to have worked perfectly; it wholly eliminates the objectionable feature of nuts rotating under load, and secures a uniform distribution of load between the various suspenders.

The nut and valve mechanism, to which a great part of the success of the caisson is attributed, are shown in some detail in Fig. 6, which is somewhat diagrammatic, however. The main nut has a vertical play of about 1¼ inches in its pedestal. Its outer circumference forms a spur gear, which meshes with a pinion (not shown in Fig. 6) driven from the shaft of a constant-speed motor. A transverse groove in the nut engages the forked end of a lever which is linked to the valve that controls the admission of water to the jack cylinder. This valve and its casing are shown in section to the right. Splined to the nut is also a bevel gear which meshes with a pinion on a hand-crank. By this the nut may be rotated manually when the motor drive is out of order. When the hydraulic jack is not in service the nut rests directly on the pedestal. This brings the stem of the valve into its highest position, and as may be seen from the section of the valve, this po-

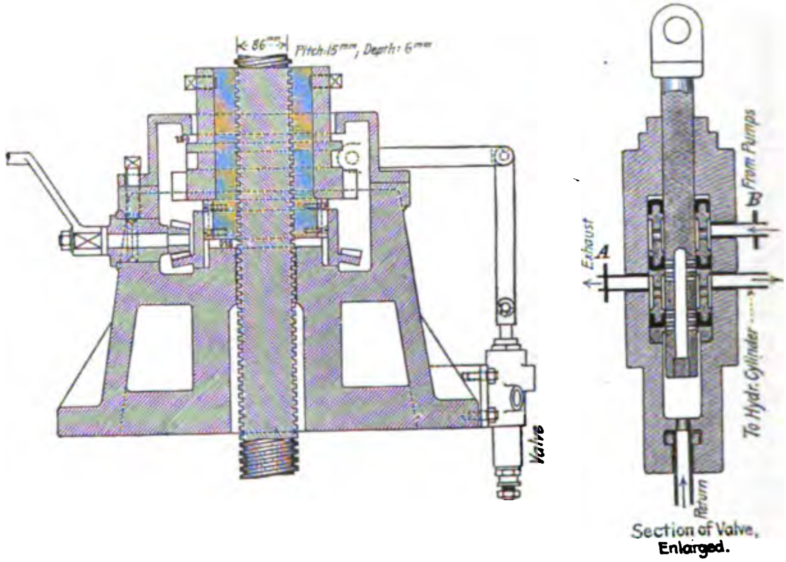

FIG. 6—VALVE MECHANISM FOR HYDRAULIC JACK.

sition admits water below the plunger of the hydraulic jack as soon as the cock *B* in the supply pipe is opened. The suspender rod then begins to rise and carries the nut upward with it. When the mean position is reached, water is shut off from the cylinder; this position is represented in the section of the valve, in Fig. 6. If, however, the nut is rotated, and thereby screwed downward on the rod as the lifting proceeds, it will hold the valve open. By rotating the nut in the opposite direction, screwing it upward on the rod, water is exhausted from the cylinder through the pipe in the bottom of the valve, and the suspender rod is lowered. When the desired motion, either raising or lowering, is completed, the pumps are stopped, and the jacks then gradually settle down until the nut of each suspender rests on its pedestal and thus takes the load of the rod. In this position the valve is open to admit pressure water as soon as the pumps are started.

The jacks have a range of motion of about 8 feet. In normal operation they raise or lower at a rate of 1½ inches per minute. Four 5 horse-power reversible induction motors are provided for rotating the nuts, one motor for five suspenders. For raising or lowering a longer distance than the stroke of the jack, the suspenders must be lengthened by inserting an additional section. This may be done even when raising or lowering the caisson, and the lengthening may be in progress on four suspenders simultaneously, the remaining sixteen being ample to carry the load. For this purpose the nut on each suspender is made in two concentric halves, the inner being the nut proper, while the outer one carries the operating gear; the two sections may be disconnected by loosening the set screws that connect them. When any nut is thus disconnected, its outer shell may be rotated by the motor without moving the nut, and the corresponding jack will then remain out of action while the remaining jacks lift the caisson and take the load off the suspender in question. It is then a simple matter to disconnect the screw portion from the suspender proper, actuate the nut by the hand gearing, so as to set the jack in action and raise the screw, and finally when the screw is in its topmost position insert a new length of suspender.

It remains to mention that each jack cylinder has a safety valve set at 100 atmospheres, corresponding to a load of about 19 tons per jack. If this load is exceeded, the safety valve allows the water to escape and the suspender settles to bearing on its nut. The latter is then held by its friction so that it cannot be rotated until the load is reduced to the capacity limit of the jack.

The pressure water is supplied by a triplex pump driven by an induction motor of 15 horse-power. A 4-gallon accumulator serves as storage reservoir, and by its position automatically starts or stops the pump. The liquid used is water mixed with about 30 per cent. of glycerine.

There are seven vertical shafts or wells connecting the working platform with the chamber of the caisson; the shafts are composed of riveted steel pipe and are made in sections so that lengths may be added or removed as the caisson is raised or lowered. The weight added or removed in this way is balanced by pumping water into or out of the cylindrical ballast tank in the upper half of the caisson. Of the seven wells, four are utilized for materials, two are for persons, and one for concrete. All the shafts have air locks at the upper end, and air-tight doors at the lower end for closing the working chamber when the shafts are being shortened or lengthened. Of the four material shafts two are fitted with motor-driven elevators, while the other two merely have covers at top and bottom, constituting a full length air-lock for handling long timbers, etc., into the working chamber.

The concrete shaft forms a simple chute with lining tube, down which the concrete falls. The chute is kept full of concrete, and two laterally-extending hoppers at the lower end permit its contents to be tapped off as needed into buckets running on overhead trolleys in the working chamber of the caisson. The upper end of the chute is fitted with a double hopper, both compartments of which discharge into the inner tube of the shaft. The two compartments are filled alternately, and each has an air-tight trap door at top and bottom, so that one compartment may be filled while the other discharges into the chute. The upper and lower door of each compartment are interlocked, so that only one can be open at any one time. The small air lock at the side of the top end of the chute serves to admit two laborers into the space just beside the hopper, for operating the bottom trap doors of the hopper compartments.

The two shafts for workmen are each fitted with a head, constituting a double air lock. The smaller chamber will contain four persons, while both chambers can accommodate up to twelve at one time. The valves for admitting air are specially designed needle-valves, in which the amount of port opening depends on the difference in pressure across the valve, so that at the beginning of equalization a much smaller opening is presented than toward the end of the operation. They are proportioned to give a pressure increase or decrease at the rate of 0.1 atmosphere per minute. This full rate is employed in the operation of locking in, while when locking out a second valve admits fresh compressed air at half this rate, so that the effective rate of locking out is only 0.05 atmospheres per minute. The use of these automatic valves makes it impossible for workmen to lock in or out at a dangerously rapid rate. Special cocks of ordinary construction are provided for special purposes, but these are arranged to be operated only by foremen or inspectors.

The two shafts containing the two material elevators are located side by side, so that the two hoisting skips could be counterbalanced through their connection to the same hoisting-motor shaft. This shaft drives by worm-gearing a lifting sheave over the centre of each well, and a sprocket chain attached to the skip passes over this sheave. The slack in the chain is taken up in a three-part rigging held taut by a weight, this rigging and weight being contained in a small air-tight auxiliary well at the side of the main well. The hoisting motor is automatically shut off, and a magnetic brake applied, when either skip nears its highest position. To draw it up so that its bottom plate forms an air-tight seal against the bottom ring of the air lock, a hand hoist is thrown into gear by a foot lever, which latter also releases the magnetic brake. The hoisting motor is a 20 horse-power induction motor, but direct current is required for the magnetic brake.

The skip is a simple skeleton frame carrying a horizontal track rail, on which runs a trolley carrying the bucket. When the skip is in its upper or lower position, the trolley track registers with a similar overhead track respectively on the working platform and in the caisson chamber. The bucket is thus quickly run out and a new one run into the elevator. The bottom of the skip bears a horizontal plate, slightly smaller than the well, whose upturned edges in the upper position of the skip make a tight seal against an angle-iron ring riveted to the skin of the well.

For handling buckets of earth, concrete and other material in the caisson, a series of trolley tracks, communicating by turntables, is hung to the roof of the working chamber, on which buckets may be run to or from any part of the working chamber and any of the wells. Similar overhead tracks are provided on the lower working platform for handling the buckets of the material elevators. On this platform are also installed three batch concrete mixers, each holding about 1.6 cubic yards, which discharge into small dump cars running to the concrete chute.

The remaining mechanical equipment of the caisson structure comprises a chain-and-bucket elevator on one side of the structure for raising mortar from lighters alongside to the upper platform; three 1-ton electric jib-cranes on the other side for hoisting gravel, broken stone, etc., to the concrete platform; four air pumps, each driven by a 30 horse-power induction motor, installed in the hold of one of the two pontoons; the 10-ton electric gantry (already mentioned) on the top of the supporting framework; and the necessary air piping, etc., for supplying the working chamber and ballast chambers and for blowing out water, mud, etc., from the working chamber. It is interesting to note that the chain-and-bucket elevator for mortar showed such rapid wear that it was soon replaced by a simple hoist.

Power was supplied to the structure by three electric cables leading from a temporary power station on shore. Two of these are duplicate three-phase cables supplying current at 330 volts to the various motors on board, while the third

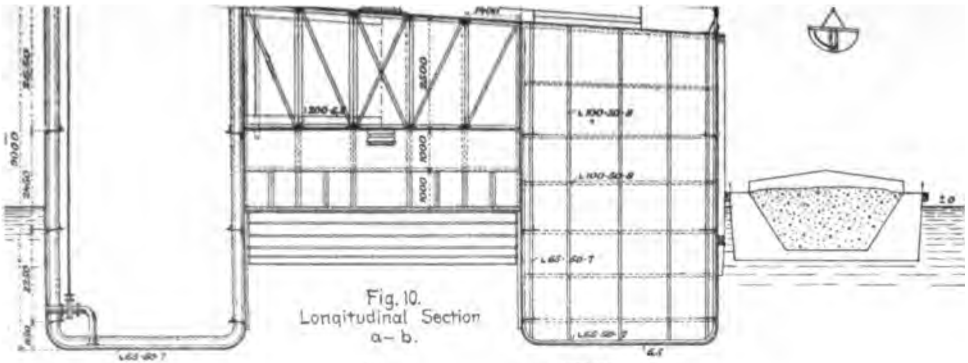

Fig. 10.
Longitudinal Section
a–b.

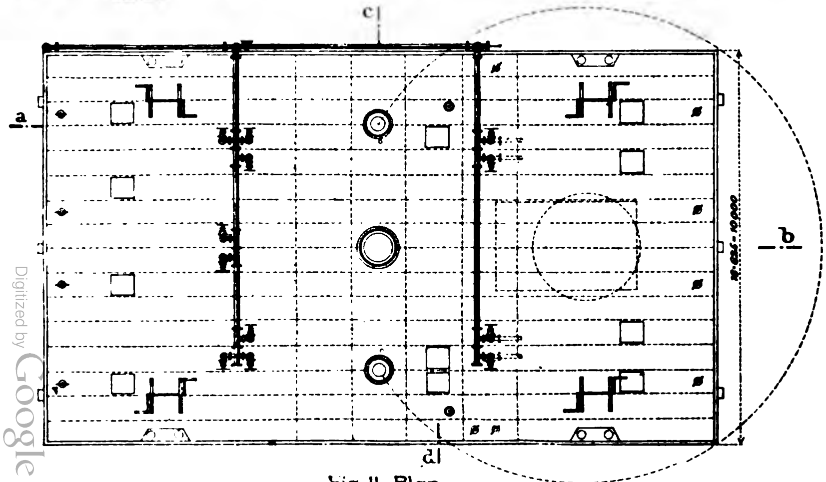

Fig. 11. Plan.

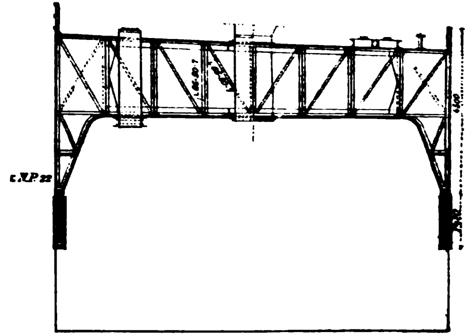

Fig. 12.
Cross Section.

FIGS. 10, 11 AND 12—PLAN AND SECTIONS OF SMALL CAISSON.

supplied direct-current at 110 volts for lighting and for the magnetic brake of the material elevators. The cables were hung to buoys about 100 feet apart in such a manner as to swing clear of the bottom. About 250 horse-power were required for power and 10 to 15 horse-power for lighting. Incandescent lamps (16 candle-power) were used in the working chamber and air locks, while both arcs and incandescents were used on the platforms.

SECONDARY CAISSON.—This is sufficiently shown by the drawings, Figs. 10, 11 and 12, and need not be described at length. It differs in general principle from the main caisson in having the pontoon portion and the caisson portion rigidly combined in a single structure. The pontoons and the upper half of the caisson constitute ballast chambers. The

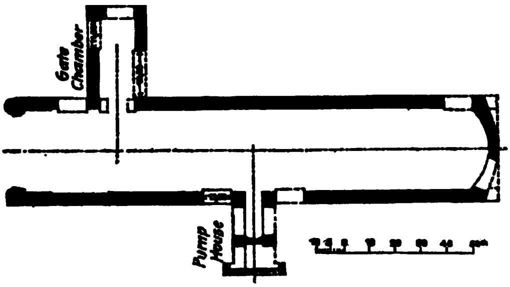

FIG. 7—PLAN OF ONE DOCK-CHAMBER, SHOWING METHOD OF CONCRETING WITH SMALL CAISSON.

horizontal dimensions of the working chamber are 33 feet by 23 feet, and its normal height is 6½ feet. This may be increased, however, by inserting stop-logs in channel frames at each end of the caisson, as shown in the drawings. Three air-locked wells lead from the deck of the structure to the working chamber, two for concrete and one for workmen. The concrete chute was, of course, much simpler than that of the main caisson; the well was simply fitted with interlocked trap doors at top and bottom, and thus formed a full length air lock, into which the concrete was dumped from the deck, and from which it dropped into the working chamber.

This smaller structure did not carry a concrete-mixing plant, but was supplied with concrete already prepared elsewhere, by lighters. An electric jib crane of 2 tons capacity, on the deck of the structure, served to handle the concrete and other materials.

CONCRETE.—As the amount of concrete in this double dock reached the figure of 200,000 cubic yards, all but 15,000 cubic yards of which was placed under air pressure, it may be recognized that the arrangements for preparing the concrete with a minimum of handling at the caisson demanded careful attention. The fact that but little Portland cement was used, practically all the concrete being made with trass, makes the plant radically different from those that are used in American practice.

The plant was established at a point along the harbor shore about a mile distant from the building site. The trass rock was brought to this place in vessels, and after unloading went through crushers, which broke it to a 2-inch size. The quicklime, also received by vessel, was slaked in a series of pits. Sand, obtained from the bank directly at the mixing plant, went through two rotating screens, which separated it into sand, gravel and stones. The stones were broken for use in mixing the concrete, and both gravel and broken stone were shipped to the caisson in scows. The mortar was prepared at the mixing plant in a set of eight rotating-pan edge-runner mills, in the following manner: The broken stone trass was first charged into the mills and ground for a few minutes; then the slaked lime was added and ground well into the trass; finally the proper amount of sand was added and the whole mass ground up together, water being added when required. The finished mortar was shoveled into dump cars running out on a pier, where they discharged into scows. At the caisson the scows were run directly alongside and the mortar unloaded by the hoist already described.

The edge-runner mills required about ten minutes running per batch. The maximum daily demand occurred when both the main and the auxiliary caisson were at work, and amounted to 300 cubic yards of mortar, corresponding to about 600 cubic yards of concrete; this amount could be turned out by the plant in about 17 hours of work. The proportions used in making up this mortar were determined from a series of tests of various mixtures, resulting in the selection of a mixture of 5 parts lime, 6 parts ground trass rock, and 8 parts sand, by volume. This mortar, tested after 16 days (48 hours in air and 14 days in water), gave a tensile strength of 175 to 225 pounds per square inch, and after 28 days 285 to 315 pounds per square inch. At temperatures near freezing, such trass mortar or concrete made from it sets too slowly, and under those conditions about 10 per cent. of Portland cement was added to the mortar to make it quicker in setting.

The concrete was mixed in the proportion of 1 part of mortar, by volume, to 2 parts of gravel or stone, making about 2.2 parts of concrete. The broken stone was obtained in part by crushing the large stones screened out of the bank sand, and in part directly from granite quarries in the neighborhood. The gravel, which was obtained from the bank sand by screening varied in size from ⅛-inch to 2 inches diameter.

COSTS.—The cost of the two caissons, including all equipment and accessories and the mortar-making plant, amounted to 850,000 marks, or about $200,000. The operating cost, including interest and depreciation on the plant, wages and repairs, was about $30 per working hour, or something less than $720 per day. The cost of the concrete, which was the principal material used in the work, amounted to about $2.65 per cubic yard for gravel concrete and $3.30 per cubic yard for stone concrete. It is calculated that the cost of putting the concrete in place amounted to about $3.25 for concreting in the caisson, against about $1 for concreting in the open air. The price paid for the dredging, in depths up to a maximum of 68 feet, varied from 11 cents to 36 cents per cubic yard, depending upon depth and nature of material.

The preceding article has been prepared from a full description of the work given by Messrs. Franzius and Mönch, the engineers in charge for the government, in the official journal of the German Ministry of Public Works, the *Zeitschrift fur Bauwesen.*

The contractors for the entire construction were Ph. Holzmann & Co., of Frankfort a. M. To this firm is due the credit of suggesting the use of the floating caisson and working out the whole scheme of attack.—*Engineering News.*

Power Signaling on English Railways.

The *Illustrated Scientific News,* an English publication, contained in its January issue an article on "Power-Signaling on English Railways" by Cyril Hall. In the course of the article Mr. Hall says:

"It is the electro-pneumatic signal which has the greatest vogue in this country. Of the several schemes which we shall endeavor to describe—all of which have points in their favor—the Westinghouse is the best known and longest tried. The Westinghouse electro-pneumatic system has passed the experimental stage, and though, of course, it is being improved year by year, and is being continually adapted to different modes of working on various railway systems, it may justly claim to be responsible for the introduction of practical power-signaling into England. From motives of space we shall be obliged to deal with the Westinghouse system in a separate article.

"In 1901, Mr. Sam Fay, who was then superintendent of the line of the London and South-Western Railway, recommended to his Directors, as the outcome of an American tour, that the British Pneumatic Railway Signal Company's apparatus should be installed on the South-Western line at Grateley, an important junction on the Exeter main line. This is a system of inter-locked signals and points operated by low-pressure air. Some of the main characteristics of this system are that it requires a low air-pressure—about 15 pounds to the square inch; that except when a lever is being actually used to operate points or signals this pressure is withdrawn, and the apparatus and conduit pipes are subject only to atmospheric pressure; that, since the final stroke of the lever in the frame is automatic, it is only the admission of air that requires the attention of the operator, and much heavy manual labor is thus abolished. Moreover, since an indication or "return" is always given, it follows that in this system, as in others, the signalman can devote more attention to the opening and closing of his sections, and need not be anxious concerning the failure of a certain signal to work. The cardinal provision is made that in case of absence or failure of the power—which seems remote—an affected semaphore will return to the "danger" position. Positive application of power is in every case necessary to move a signal or switch.

"The increased safety and quick action of the pneumatic movement has induced the Board of Trade to sanction a valuable increase in the distance over which signals and facing points may be worked. The L. and S. W. Ry. have, in addition to the Grateley installation, pneumatically worked signals at several other places on their line, including busy sections at East and West Staines. One great advantage arising out of the saving of labor is the more thorough concentration of lever frames, in many cases one cabin taking the place of two or more necessary for the old mechanical system. The essentials of the British Pneumatic Signal Company's apparatus may be said to consist of a diaphragm valve, main valve, and indicating valve attached to the operating bar or lever, air compressors and reservoirs, and the switch and signal movements. The necessary power can be supplied by a small gas or oil engine.

"As already mentioned, when 'track circuit' is employed, the safety and efficiency of the pneumatic system is considerably increased. Since the maintenance costs no more than that required for the electric treadle, and the effect of replacing a lever and holding it in the normal or 'back' position by the passing train renders the train to a certain extent independent of the signalman, or, in other words, protects itself, this will be readily understood.

"Owing to the small insulating resistance of the track itself, the electro-motive force has to be very low, and is never greater than 1.5 volts. Thus there is little leakage. The current on the track, unlike the air, is always operating. In the British Pneumatic Company's system all the circuits are kept separate, so the failure of one circuit will not interrupt the others. This is a point which, in some all-electric systems, has not received much attention, as cases have been known of a single leakage locking up a whole machine. The electrical relay, the electro-pneumatic valve, and the electro-pneumatic cut-off valve are the vitals of the track circuit when used with the low pressure pneumatic. The relay consists of an electro-magnet, which, when energized, attracts an armature. To this armature is attached a circuit closer spring, and whether this is open or closed, thus making or breaking the circuit, depends on whether the magnet is energized or not. The electro-pneumatic valve consists of a simple electro-magnet, on the top of which is fastened a valve. This and the electro-pneumatic cut-off valve are very similar in construction, but their functions are totally opposite. The electro-pneumatic valve is so designed that when the magnet is energized and the armature lifted, the ports in the cylinder are open to admit air through the valve, and when the magnet is de-energized these ports are closed.

"The action of the electro-pneumatic cut-off valve is, as has been mentioned, exactly opposite to this, and in the first-named condition the ports are closed, and when the magnet is de-energized, the ports are open for the passage of air."

Caisson Disease.

The sudden death of an inspector upon emerging from a caisson of the Manhattan Bridge has called public attention in New York City to the danger attending such work as now conducted. This death has been preceded by the deaths of four laborers upon the same work; and, now that the work is nearly completed, the Board of Health has been roused to investigate the cause and the possible remedy.

In our issue of September 5, 1901, the occurrence and treatment of caisson disease were discussed at length, and we do not purpose repeating what was then said further than to call attention to the fact that caisson work in this country has been done at the expense of far too many lives. A brief summary of the loss of life on some of the important works where compressed air has been used may serve to emphasize the danger.

In the East River Gas Tunnel, where the greatest depth below water was 120 feet, there were four deaths among the 15 men who suffered from the "bends," and this in spite of the fact that all workmen underwent a careful physical examination before admission to the air lock.

On the Eads Bridge, at St. Louis, Mo., a depth of 110 feet was reached at the cost of eight lives. There were 77 cases of caisson disease on this work, in spite of physical examinations and the use of stimulants.

On the Brooklyn Bridge work, where the maximum air pressure was 36 pounds, there were three deaths out of 110 cases of the "bends," of which 13 were so serious as to be accompanied by paralysis.

On the Williamsburg Bridge, just completed over the East river, New York, although a depth of 100 feet was reached, only a few mild cases of caisson disease were developed. The only precautionary measures used were to provide a warm room, baths for the men upon leaving the caisson, and to supply them with plenty of strong coffee.

Including the Manhattan Bridge, now under way, we have a record of 20 deaths on five large contracts involving the use of compressed air at great depths. Taking no account of the suffering and physical injury to some hundreds of workers, this is a record that deserves the serious consideration of engineers and contractors. Cannot the number of deaths and the suffering on future work of this character be lessened? and if so, how?

In this issue we publish an illustrated article descriptive of the automatic air valves used in caisson work on the dry-docks at Kiel, Germany. The object of such a valve is to make it impossible for workmen to pass through the air lock in so short a time as to cause serious risk of injury as is now the common practice in this country. The automatic valve is so constructed that after entering the lock from above the men cannot leave it for a period of 20 minutes, during which time the air pressure is gradually increasing until it equals the pressure in the working chamber below. In coming out of the working chamber the men remain in the air lock for 40 minutes, during which time the pressure is gradually reduced until it equals that of the atmosphere. It is a well-known fact that rapid locking out is far more injurious to the men that locking in, hence the difference in time at which the automatic valves are set to work.

If each man works two shifts a day it is obvious that two hours are daily lost in locking in and out; but is not the purchase of good health and safety worth the price? The men, it is true, will not voluntarily submit to so much "lost" time, hence the necessity of some such automatic device that is beyond the control of those in the lock. The contractor will not voluntarily use a safety device that the men themselves would object to, hence the necessity of prescribing the device in specifications if it is to be used at all. This is in fact the nib of our argument. Engineers who have the drawing of specifications for deep compressed air work should specify, for one thing, a minimum time to be consumed in locking in and out. If the engineer has neglected to do so, looking upon the handling of the men as beyond his province, then the Board of Health appears to be the only authority that can compel action to insure the safety and well-being of the men.

We have not spoken of the treatment that men should receive once they show symptoms of caisson disease, but among the most rational and thus far the most effective, is a compressed air hospital, which is in fact a small air lock into which the patient is placed, and left under air pressure until the pains subside. This "hospital" might well be required in the specifications for caisson work where high pressures are to be used, in view of the practical certainty that there will be a number of sufferers from the "bends," regardless of every precaution.

In closing this brief summary, we may add that were such precautions taken as have been suggested, they would in all probability so reduce the suffering and the mortality as to reduce the rates of wages now demanded by workers in compressed air, and thus eventually reduce the cost of engineering structures involving caisson work.—*Engineering News.*

[The article referred to, on the caisson work at the Kiel Dry Dock, Germany, will be published in a coming issue of COMPRESSED AIR.—ED.]

Compressed Air in Glass Blowing.

Mention has already been made in COMPRESSED AIR of the introduction of compressed air in the bottle-making industry. After following for centuries the old method of blowing bottles "by hand," the trade expression for using men's lung power for that purpose, it has been discovered that far better results and greater economies may be obtained by using air mechanically compressed for making the cheap and middle grades of bottles. Experiments along this line have been conducted for some time and have been uniformly successful. This method is now in satisfactory operation at the Alton, Ill., plant of the Illinois Glass Co., which is considered one of the largest and most progressive shops of its kind.

By the old method the requisite amount of molten glass was drawn on the end of the blow pipe through a small opening in the furnace. After it was worked to the proper shape and cooled to the required temperature it was placed in the mould and blown into the desired form by lung power.

The machine, which has been designed to take the place of the man, will blow wide-mouthed bottles of all sizes with the aid of compressed air. The moulds are of cast iron divided longitudinally and hinged on one side so they may be opened and the bottle removed.

One of the chief difficulties was to secure perfect shapes of uniform thickness. To overcome this it was found necessary to keep the moulds at a uniform temperature, which was discovered only after careful experimenting. An ingenious method of retaining the desired temperature of the mould has been devised, currents of air being circulated through it to carry off the surplus heat as necessity requires. It was found that should the mould be a little too cold the glass was chilled and failed to flow freely or fill the form completely. When the mould was too warm the result was that the glass adhered to it, resulting in defective spots.

The supply of compressed air for blowing the machine-made bottles is secured from an electric-driven Ingersoll-Sergeant air compressor, having a capacity of nearly 1,000 cubic feet of free air per minute. This machine compresses to a pressure of 85 pounds to the square inch. This plant is fully equipped with an electric power transmission system, so that the electric-driven air compressor can be operated without difficulty and at little additional cost.

A Portable Electric Driven Air Compressor.

In a recent article in the *Engineering Magazine* on the subject, "Electric Power in the Mines of Europe," there is a description of an unusual type of an electric driven air compressor. This is in use by the Schückert Company, a German concern. As the illustration shows, it consists of an air compressor, driven by an electric motor, and a compressed air reservoir arranged to run on rails and to be thus moved to the scene of action. Short lengths of hose carry the air from the reservoir to the drills. In a mine equipped with the electric current this means is used to utilize the electricity and still secure the advantages which can be gained through the use of compressed air.

Frost Trouble with Compressed Air Apparatus.*

Every one who has had to do with compressed air machinery knows that when the temperature descends to the neighborhood of 35 or 40 degrees F. he will begin to have trouble. This trouble generally takes the form of a closing of the exhaust ports with a mass

*By Forrest E. Cardullo, in *The Engineer*; reprinted with illustration through the courtesy of *The Canadian Engineer*.

of snow and ice; but it will often be found that valves stick from frost gathering on their rubbing surfaces, and pistons and stuffing boxes bind from the formation of ice.

One cubic foot of air at a temperature of 40 degrees F. will contain just 3 grains of moisture as vapor, and no more. It matters not whether the air pressure be 1 pound or 100 pounds, if there be any more moisture than 3 grains per cubic foot it will condense as water and not remain as vapor unless the temperature be raised above 40 degrees F. Suppose now that we have an air compressor delivering air at 30 pounds gauge. It must compress three cubic feet of free air into one of compressed air, and if each of these three held 3 grains of moisture at a temperature of 40 degrees F., after compression, one cubic foot will contain 9 grains of moisture.

Air heats on compression, so that this moisture will leave the compressor in the form of vapor, the air being able to hold it in that state on account of the higher temperature. This heated and moisture-laden air leaves the compressor and enters a long line of cold pipes, where it is quickly cooled to its original 40 degrees temperature, and every cubic foot of it has 6 grains of moisture to deposit. The larger part of this water remains in the pipes, but some of it is borne along with the air current in the form of tiny globules, enters the drill or motor, and passes out with the exhaust.

Five or six grains per cubic foot seems a small quantity, but with even the smallest size compressors it amounts to 4 or 5 gallons a day. If the temperature falls to 32 degrees or below, the water in the lines quickly freezes, stopping the air supply, if it does nothing more serious. Care must be taken while erecting the lines to have the drip-cocks at all the low points, through which every day or two the accumulation of water may be blown out. This simple and inexpensive expedient will save much trouble from broken and leaking lines, due to freezing and water hammer, and will increase the capacity of the line by allowing the air the full area of the pipe, where it would otherwise have only a half or a quarter of the area, the remainder being full of water.

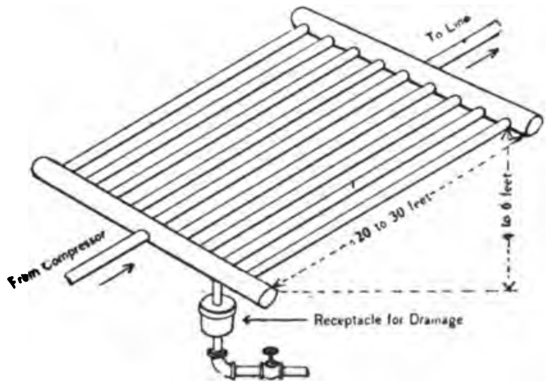

FIGURE NO. I.

Air cools so fast on expansion that it precipitates moisture, which, however, gives very little trouble, for it is frozen almost the instant it forms. So instead of forming chunks of ice in the exhaust it is blown out in the form of extremely minute ice crystals. On the other hand, when the air carries moisture in the form of mist or spray it is deposited as water, and then frozen where it is deposited. The moisture that gives the trouble, then, is the moisture that may be removed by cooling the air back to the temperature of the atmosphere before it is sent to the motors.

Many compressors are equipped with water after-coolers for this purpose, but when the temperature of the cooling water is higher than that of the atmosphere they are more or less inefficient. For some classes of work they are also too cumbersome, expensive, and liable to freeze or get out of order. An after-cooler, which meets the requirements of out-door winter work, and is much more efficient in all temperatures below 38 or 40 degrees than any water cooler can possibly be, is illustrated in Fig. 1. It consists of two manifolds connected by lengths of 1½ or 2-inch pipe. The air enters at the lower manifold and passes up the incline, depositing its moisture, which runs back and settles in the spill pot A, attached to the lower manifold. It will not readily freeze up, because the air parts with most of its moisture before being cooled to the freezing point, and what little is deposited after that is accommodated by the ample pipe section. A number of pipes are necessary in order that the air may have ample time to cool, and may not have to pass through them with such velocity as to carry some of the water with it.

A cooler of this type can be "built with a monkey wrench" from second-hand pipe and fittings. The threads should be liberally smeared with asphaltum varnish before making up the joints, and leaks will be unknown. For air work, asphaltum varnish is infinitely superior to red or white lead, graphite, or any other joint cement in ordinary use. In case a receiver or storage tank is used it is better to connect the cooler between the compressor and tanks, that the air may have additional time and opportunity to deposit its moisture. In case the cooler does become clogged with ice, as is possible in extreme weather, it being out of doors, a torch or small bonfire may be used with perfect safety. It will, however, take a long period of very cold weather to freeze it enough to make that necessary.

Compressed Air as a Motive Power Underground.*

Compressed air is particularly adapted as a motive power underground. It improves the ventilation of a mine; cools hot places when the machines are working; it can be kept in storage and suffers no loss. There is, however, a great loss shown by numerous experiments between the power required to compress air and the work got out of the rock drill or motor. It is now generally accepted that not more than 30 to 35 per cent. efficiency can be procured; in other words, it takes 3 h.p. at the compressor to develop 1 h.p. at the motor. One of the principal reasons of this loss of efficiency is the generation of heat by compression. This heat is entirely lost, or produces no useful effect, and, as previously stated, represents exactly the same amount of work. The heating of the air during compression causes a serious loss in another way, because by raising the temperature of a gas one degree we increase its bulk one volume in 460, or if we compressed 460 cubic feet of air and raised the temperature from 60 degrees F. to 300 degrees F. (which represents the temperature of air at a pressure of 90 pounds per square inch), we would have done work upon 700 cubic feet of air instead of 460 cubic feet, or nearly one-third more work done than if the temperature remained constant.

When the air leaves the compressor cylinder the radiation of the heat commences, and the air soon cools down to the original temperature, 60 degrees F.; and what was 700 cubic feet again becomes 460 cubic feet. Most of those who have been working with a rock-drill or air-winch, may have noticed how cold the exhaust chambers were when working. This is caused by the sudden expansion of the air. This also represents a loss of work, owing to our inability to get as much expansion out of the cold compressed air as we would have done had it remained at the temperature due to compression. To minimize these losses as far as possible has been the constant endeavor of builders of air compressors.

The principal means adopted to reduce the temperature is the water jacket. By this means it has been estimated that two-fifths of the temperature due to compression is absorbed by the water circulating around the air cylinder. You will now see the necessity of having a rapid circulation of water through the water jacket. The high temperature would also have a most injurious effect

*An abstract, prepared by the *Queensland Government Mining Journal* (Australia), of a paper read before the Monkland Improvement and Debating Society, Gympie, by T. G. Oliver, manager, 2 North Columbia Smithfield, Gympie.

upon the packing of the piston rods, the lubrication of the cylinder, and valves of the air compressor. It would also expand the air entering from the atmosphere to a much greater extent, and thus the air compressed would be less in bulk when it had cooled down in the receiver and pipes leading into the mine. This reduced volume would therefore represent proportionally a smaller amount of work got out for the large amount put in. We know that the efficiency of a machine is reckoned by the difference between the work got out and the work put in. We will take, for instance, a common pressure on Gympie—100 pounds per square inch. It has been proved by experiment that with air compressed adiabetically to 100 pounds pressure, the temperature would be 482 degrees F., but by cooling it with water jacketing, the temperature is reduced to 314 degrees, or by almost a third.

A nice little experiment may be performed by any one which will prove conclusively to them the great heat generated by compressing air. It was used for kindling fires before friction matches came into use. Get an apparatus consisting of an iron barrel with a bore three-eighths inch in diameter and eight or nine inches deep; make a steel piston the required length and accurately fitted and perfectly air tight, but so that it will move easily when lubricated. The end of the plunger has a small cavity and a collar eight inches from the bottom, to prevent it striking the bottom of the bore hole. A piece of tinder is placed in the cavity of the plunger and inserted in the barrel. Then by a sudden movement you push the plunger home. withdraw it quickly. and you will find your punk on fire, by the sudden evolution of the temperature to a red heat, caused by the compression of the air in the cylinder before the insertion of the plunger.

The most approved method of reducing the loss of power caused by the rise in temperature by single stage compression is to compress it into two or three stages, and complete cooling between each stage–that is, in two or three cylinders, with the pressure increasing in each cylinder, with an intercooler between. For pressures approaching or over 100 pounds per square inch, compound compression is being almost universally adopted. Even for pressures of four atmospheres the extra first cost of a stage compressor will pay for itself in a short time, because you have seen that the temperature increases rapidly as the pressure increases. This is obviated by compound pressure, because the diameter of the cylinder is so proportioned as to divide the work of compression equally between the cylinders. The cylinders, like those of single stage compressors, are provided with water jackets, and are connected by an intercooler. Free air is admitted into the low pressure cylinder, then forced into the intercooler; there the heat of compression is removed before it is taken on its journey by the next cylinder.

The advantage of compound over single stage compression lies in the reduction of work due to loss of heat, since the resistance due to compression is directly proportional to changes of temperature. We also have a cooler cylinder which does not expand the air so quickly; hence a larger volume would be compressed by each stroke of the piston. There would also be less chance of the oil carbonizing; therefore we would have better lubrication in the air cylinder.

There are two other fertile causes of loss of efficiency in air compressors. These are losses caused by the friction of the air traveling through pipes of insufficient diameter, and clearance losses. The loss due to friction in pipes of insufficient diameter is very great. In a test which I made a few weeks ago, rather more than 1,800 feet from the receiver on the surface, 1,400 feet of this length being 2-inch pipes, and 400 feet 1-inch, I found a loss of 30 pounds pressure at the drill, with 100 pounds pressure at the surface receiver; with 80 pounds receiver pressure the loss was 25 pounds at the drill. The speed the air would have to travel through a 1-inch pipe to supply a 3½-inch drill would most certainly cause it to be wire drawn. Knowing the great friction caused by this velocity, I considered it advisable to substitute 2-inch pipes right up to the drill. With these pipes I made similar tests under similar conditions to those that were made on the 1-inch pipe, and found that the loss was, with 105 pounds receiver pressure, 10 pounds at the drill, with 100 pounds, 9 pounds loss, and with 85 pounds, 7 pounds loss at the drill. Our drills are 3½-inch cylinder, and a 6-inch stroke now allows an effective piston area. After deducting the area of the piston rod in one end and the rifle bar in the other, of 7¾ square inches, and a stroke of 6 inches and 300 blows per minute, we see that each blow struck by the drill would use 93 cubic inches of air. That would be the effective piston area multiplied by twice the length of stroke, and this multiplied by the number of blows (300) per minute, would give the number of cubic inches of air required per minute. From this it will be seen that there is 27,900 cubic inches of air used per minute, and as the inch pipes are only .7854 of an inch in area, the air would have to travel at a speed of 35,523 lineal inches per minute, or nearly 50 feet per second. This proves that there must be an enormous loss from pipes of insufficient diameter, as the friction increases not directly as the velocity, but as the square of the velocity.

In addition to the friction, there are losses in bends, elbows, and T pieces. With 2-inch pipes under the same conditions, the air would travel only 12 feet per second. A few weeks ago I saw, in one of the compressed air systems on Gympie, four elbows and a T piece in about a dozen feet of air pipe. According to what has been said, in laying pipes they should be able to deliver a little more than the drills are capable of taking out, and at the same speed. All abrupt turns, such as elbows and T pieces, should be avoided, and wherever possible bends substituted; also all joints should be well made.

Another and very effective way of reducing friction in the pipes would be to have a receiver underground near to the drills or other machine. By putting in a concrete wall in any drained crosscut, level, etc., they could be utilized for this purpose. It would serve to settle all moisture in the air, also maintain a steady pressure on the machines using the air. They can be made more cheaply than an iron receiver, are several times larger, becoming as it were accumulators of power while the machines are stopped, and even if a slight mishap occurred to the compressor on top, the machines could go on working.

The loss from clearance is more a loss of volume than of power. We must first of all understand what clearance loss means. In making a compressor it is undesirable that the piston should strike the cylinder cover every stroke, but unless this were done there would be still air between the piston and cover. This is practically what takes place in most compressors at the present time. There is always a space between the piston and cover which is filled with air at a pressure 2 or 3 pounds in excess of the gauge pressure. When the stroke is reversed, this air expands again to atmospheric pressure before the piston commences to draw in air from the atmosphere; but, as I said before, this is more a loss of volume than a loss of work, because all the work put in in compressing this air is again given out by expansion. There are several other sources of loss, which can only be remedied by the designers of the compressor and by the makers having only good and reliable workmanship put into the machines. Some of these losses may be caused by the springs being too strong. As a matter of fact, in machines with spring delivery valves there is always 2 or 3 pounds more pressure in the cylinder than is shown by the gauge, caused by the lift of the valve against the spring. Mechanically worked suction valves are now being adopted in most of the larger compressing plants. The delivery valves should likewise be nicely adjusted and of sufficient area. They should immediately open or close according as the piston pressure reaches the receiver pressure or descends below it.

In spite of these drawbacks the use of compressed air for mining purposes is largely on the increase. It has the advantage of not losing either power or volume by condensation during transmission. It can be conveyed into any part of the mine without inconvenience, and readily split up. The exhaust also improves the ventilation in immediate surroundings of the machine, but it is not appreciable many feet away; it also cools down quickly a hot end or rise.

To summarize, a compressor, in order that the speed should not be excessive, should be larger than the requirements.

The pipe line should be of sufficient capacity. There should be a receiver on top in order to cool the air before traveling through the pipes, so that a large percentage of the moisture may settle there instead of in the pipes. A receiver, such as previously described, should be at every level, and nothing but the best of workmanship employed during the construction of the compressor and receiver, and the best of material used.

Having thus got the air at sufficient pressure to be serviceable, we will now consider the methods of its application to our calling as miners. The rock-drill, the air-winch for hauling up inclines and winzes, and the underground locomotive for hauling the ore along the levels, appear to be the principal methods of applying it.

The rock-drill stands out prominently as the most important method of its application. As a self-acting power machine for rock-drilling it is the outcome of the last half century. The first patent for a self-acting percussive rock-drill was taken out by Couch in 1849. This was improved by Fowle, Ingersoll, Rand, Sargeant, and others, until its construction has been brought to its present perfect form. Over 100,000 rock-drills are now in use in mining, tunneling, and quarrying, and this fact alone should prove their usefulness. No modern up-to-date mine is considered thoroughly equipped unless it has its compressor and rock-drill plant, because by their aid the development and work of a mine can be carried on more expeditiously and economically. There are a great number of different makes of machines before the mining public at the present time, and each one claims to be more efficient than the others. I am not prepared at the present time to discuss the qualities of the different drills, but in my opinion the best drill would be the one that is simplest in design and construction, with strength in every part, combined with lightness, in order that there should be a minimum risk of accidents, consequently stoppages of the machine; with a maximum ease in rigging and unrigging. The columns and bars upon which it is rigged should be easily put up or taken down, and should give a wide range to the machine. It should also give the greatest amount of boring footage for the air used. To work drills so that we may have the greatest efficiency—that is, the greatest amount of work out of them for the work put into the compressor—they should, as far as possible, be kept constantly boring, or in other words, should have two or three faces to work, so that as soon as one face is bored out, the machine can be unrigged, and immediately removed and set up in another face. This is the usual practice on Gympie.

The amount of boring that can be done by a machine on Gympie is variously estimated, but at the 2 North Columbia and Smithfield, with a 3½-inch Little Hercules rock-drill, in very hard, semi-crystalline calcerous greywacke, with an average of 70 pounds pressure of air—allowing five hours out of the eight for effective work—after deducting the time required for rigging the machine, changing its position for different parts of the face, changing blunt drills for sharp ones, etc., I find we can bore on an average 35 feet. This would represent, at the average of 250 blows per minute, and 10 blows to make a complete rotation, a cut slightly less than one-sixteenth of an inch. That would be theoretically, but practically the cut would be much deeper, because we know that in starting a hole the full force is not given to the blow, while many blows may be given at the full strength of the stroke. When this is done, there is a certain amount of cushioning by the air; therefore we see that a number of the blows struck are not very effective. I think that from 75 to 80 per cent. of the full stroke of the piston is the most effective length of stroke. Of course, there are many places where much larger footage can be done, but we are all aware that 30 feet in one place might possibly be a great deal better work than 40 feet would be in another; a great deal depends on the class of rock.

It is now being acknowledged that for most cases machine work is much cheaper than hand labor, the harder the rock the more pronounced the difference between the two classes of work. For instance, take the ground above referred to. In stoping, one miner was considered to have done fairly well if he bored from 3 to 4 feet per day. At that rate it would require about 10 men with single-hand hammers to bore as much as one machine; and at the local rate of wages for both classes of work this would be as £4 3s. 4d. to 19s. 2d. Add to machine rate £2 for compressor and other extra charges, which is a very wide margin, we still have a balance of £1 4s. 2d. per day in favor of the machine. There is another consideration that must not be lost sight of, and that is that one 4-feet machine-hole in a stope will break from 50 to 100 per cent. more rock than two holes 2 feet deep each; therefore we would have, in addition to the saving of £1 4s. 2d. about two-thirds more rock broken. This refers principally to where the rock is hard and tight. There are many places on Gympie where it is cheaper for hand labor to be employed, because the rock is considerably softer; therefore fewer holes could be bored off a rig with a machine, and in an awkward place a good deal of time is taken up in rigging. Two men with hammers could do nearly as much boring and could bring down with their holes as much rock as the timbers can stand. There is also less likelihood of the surrounding rock being loosened, thereby making it safer for the men, which is the principal consideration in mining operations.

The use of air-winches is generally forced upon us by meeting with cross-courses or other dislocators. No manager likes to use them, as they are always a source of expense. Locomotives driven by compressed air are being extensively adopted in large mines, more particularly those that are opened by an adit tunnel, or in coal-mines. There are many other interesting facts in connection with compressed air I would like to speak of, but I think I have trespassed too far already on your good nature, but at some future date, if it is your wish, we may have another chat on this interesting and familiar subject; familiar it ought to be, as without it we would soon cease to exist.

Car Heating by Steam Mixed with Air; Eastern Railway of France.

After an extensive series of experiments, the Eastern Railway of France has adopted a car-heating system in which a mixture of compressed air and steam is used, and this system is described in the November issue of the "Revue Generale des Chemins de Fer" by Mr. Lancrenon, chief engineer of motive power and machinery of the Eastern Railway.

The subject of heating cars from the engine was first taken up in connection with the long suburban trains at Paris, where the use of portable foot warmers was a nuisance, and stoves gave rise to universal complaint. A system of steam heating then in use had iron cylinders in the car with a single opening for the entrance of steam, and the escape of water of condensation. This was not satisfactory and could not be used for trains of over 10 or 12 cars, while the suburban trains have as many as 24 cars, many of them being double-deck cars (with both decks inclosed). The steam-heating system was also objectionable in that it heated the air of the car without warming the feet of the passengers. On considering the problem, Mr. Lancrenon conceived the idea of using a mixture of steam with air from the brake pump and distributing this by a system of pipes with traps or blow-offs at the ends.

Along the whole length of the trains extends a train pipe, the admission of steam and air to which is controlled by the engineman on the locomotive. On each car the train pipe connects at the front end with a chamber from which run three small pipes, which are looped along the floors of the several compartments, and are covered with metal plates, these plates being put in front of the transverse seats, so as to form foot warmers. At the rear end of the car the pipes enter a chamber fitted with a trap to discharge air and the water of condensation. One, two or three pipes may be used, according to the severity of the weather.

With a long steam pipe closed at the ends by a trap, pockets of water are liable to occur and prevent the proper flow of steam to the end of the pipe, but by admitting a certain proportion of compressed air, the rate of flow is increased sufficiently to keep any water moving constantly towards the discharge end. This combination of air and steam has made it practicable to use long pipes of small diameter, laid horizontally, and having numerous elbows. As the car body tilts on curves, etc., these elbows form low points for the collection of water, and this gave rise to considerable trouble when steam alone was used, but since the adoption of the combination system no trouble has been experienced. Owing to the more rapid current, also, the initial heating of the cars is much more rapid than when steam alone is used.

In a test with a train of 19 cars, the train pipe was charged with steam at 8.8 pounds pressure, and when the pipes were filled and the cars heated the gauge on the train pipe showed 1.65 pounds. All the traps were closed, only a little water escaping, and no steam was visible for the entire length of the train. Air at 8 to 10 pounds pressure was then admitted, and in 30 to 40 seconds the gauge on the train pipe showed a pressure which rose to over 4½ pounds. The traps then opened, discharging water in plenty and some moist air. This lowered the gauge pressure to 3½ pounds, which remained constant. In another test with 30 four-wheel cars (130 compartments), it was not possible to fill the pipes when steam alone was supplied, and air at about 10 lbs. pressure was admitted. When the pipes were all filled and the cars warmed, the air was shut off, and with 4½ pounds steam pressure at the head end, the pressure at the rear end was only 1½ pounds. Air at 10 pounds was again admitted, when the gauge rose to 3⅓ pounds, but when the traps opened it fell to 2¾ pounds.

For the train pipe coupling rubber hose and metallic tubes with flexible joints have been used, but the latter have now superseded the rubber hose. For coupling to the cars of foreign railways, to the train pipes of freight cars run in passenger service (and having no heater pipes), and to the fixed steam pipes for heating trains at stations, a flexible tubing is used composed of spirally-coiled strips of steel. These, however, are inferior to the metal tubing with flexible joints.

Mr. Lancrenon states that the combination heating system above described has been adopted also for the Paris suburban trains of the Western Railway, and for the Paris-Bordeaux trains of the Orleans Railway. The system will be put in service on these lines during the present winter.—*Engineering News.*

Air Spray for Fruit Trees.

In a recent description in the *Rural New Yorker* as to the best means for spraying fruit trees, A. T. Erwin, of the Iowa Experiment Station, writes as follows:

"As to what form of power is best, I would recommend some type of machine using compressed air. From our experience this type of machine is simpler in operation, and more satisfactory than gasoline. These machines are operated upon a very simple and effective principle. A sprocket is attached to the rear wheel and a chain connects this with an air pump which forces air into a small storage tank or receiver. In driving to the orchard a pressure upwards of 150 pounds is readily formed, and this gives a steady, even pressure, a finely divided spray and a uniform flow and distribution. In the spring the ground is usually soft, and the load should be as light as possible. An equipment of this kind will add about 300 pounds additional to the load. The lightest type of gasoline engine with which I am acquainted weighs double this amount. Some of them are also upright in position and tend to make the load topheavy, and are inconvenient to use on steep hillsides. In my experience the gasoline engine requires a good solid foundation or base to rest upon. It is very apt to prove whimsical and go on a strike almost any time on a spray tank. Steam sprayers I never used.

"The second question. how many fruit trees should a farmer have in order to justify him in buying a power sprayer, is not easily answered. I can reply to this best, perhaps, by indicating the capacity of this type of machine, and its comparison with a hand pump will indicate its profit, and hence enable him to answer for himself as to which he can use to better advantage.

"Last spring the horticultural department of the Iowa Experiment Station purchased a sprayer which is operated upon compressed air principles already described. A pressure of 80 to 100 pounds did excellent and rapid work. A part of the time the ground was soft, and it was necessary to attach the mud claws to prevent the wheels slipping when the pressure ran high. The orchard in which this machine was used contained 70 acres, the original planting being 25 years old, and planted two rods apart. About 10 years later the interspaces were filled in one way with apple and plum trees. The season was an unusually wet one and the land hilly, and under these conditions our best record was 12 acres per day of 12 hours' work. Two men did the work, one man driving and operating one line of hose. Both sides were sprayed at the same time. Sufficient power was maintained once the tanks were charged in driving from tree to tree to do the work. The five-barrel tank proved too heavy for the soft ground and in a hilly country. Were we purchasing again I should secure a three-barrel capacity tank instead.

"I believe that a compressed air sprayer can cover from one-half to two-thirds more ground than a hand machine, and do it much better. The spray is more finely divided, which increases its efficiency, hence requires less material, and the ground is covered very much more rapidly. I should estimate that the grower of 20 acres, or perhaps less, would profit by the expenditure in this type of machine."

Notes.

The January issue of *Cassier's Magazine* contains a description of the Chamonix Electric Railway in Switzerland. In the description of the cars it is explained that the power for working the compressed operating gear and also for the brakes is derived from a motor-driven air compressor in the luggage compartment behind the driver.

The Post Office Department at St. Louis, Mo., expects to have a new and complete pneumatic tube service installed by February 1. This pneumatic tube system promises to attract more than the usual attention, as it will be in operation during the St. Louis Exposition and, therefore, will be seen by people from all over the world.

Another application of the pneumatic hammer has been made in England, where it has been tried successfully for breaking up roads which have heretofore been absolutely pulled to pieces by hand labor. The chisel was fitted into an ordinary pneumatic hammer, the piston of which made 400 strokes per minute. By means of an air cushion the recoil was practically overcome. The power was produced by a motor-driven compressor.

The North-Eastern Railway Company has introduced a large installation of electro-pneumatic signalling on its Sunderland and North Shields line at Harton Colliery. This is the first instance of its adoption for the passenger traffic of the North-Eastern Railway. In order to ascertain the relative merits of the three power signalling systems now engaging the attention of British railway officers, the North-Eastern Company will shortly lay an experimental installation of low-pressure air signalling at Paragon Station, Hull.—London (Eng.) *Daily Globe*.

In an article on "The Limits and Possibilities of Deep Mining," by E. H. Robertson, in the European edition of the *Engineering Magazine*, Mr. Robertson says:

"The use of compressed air machines and drills in the mine is of much value in reducing the heat, and no doubt this will be an important factor in favor of the adoption of compressed air rather than electricity in deep mining. Liquid air has been suggested as a means of replenishing quickly the atmosphere in the working place and may ultimately prove of value."

The efficiency of compressed air in operating pumps underground in mines is greatly increased by reheating the air at a point near the pumps. This is usually possible where the ventilation is sufficiently good. A compound direct-acting pump, heated sufficiently to prevent freezing, will pump double the amount of water with the use of a given amount of air that a single-acting pump will. Freezing of a mine pump may often be prevented by arranging a drip from a pipe so that a small stream of mine water will fall upon the exhaust opening. This usually keeps the temperature at a point somewhat above freezing. A large exhaust opening is also necessary, and may be kept from clogging with ice much easier than a small one.—*Pacific Coast Miner*.

Particularly complete is the mechanical plant at the Broadway-Maiden Lane Building, New York. The compressed air equipment is of a somewhat unusual nature. Two Westinghouse locomotive type compressors are mounted on the wall in the elevator pump room and serve to supply air needed for the pressure tanks of the heating system, and for cleaning purposes. The compressors are arranged to work in parallel or in series, as desired, and are connected with a receiver 5 feet high and 24 inches in diameter. A line of piping is carried in the elevator wells to a point near the ninth floor, and to this outline is connected 150 feet of hose, so that all parts of the elevator well above and below can be reached and the grill work readily cleaned, which is done once a week. Compressed air is also used for blowing off the dust on the blower tubes, this being done about twice a week.

In the building of the Williamsburg Bridge across the East River, connecting two of the boroughs of Greater New York, compressed air has proved invaluable for operating the riveters. There were 22 riveting gangs of four men each, which drove an average of 150 rivets per gang in eight hours. About 25 per cent. of these rivets are 1 inch in diameter and nearly all the remainder are ⅞ of an inch. They were driven by Philadelphia and Cleveland pneumatic hammers, operated by air at 100 pounds pressure. The air was compressed by a 200-H. P. Ingersoll-Sergeant compressor plant at the Brooklyn approach, which also supplied air for riveting the upper part of the New York approach. The delivery pipe was 6 inches in diameter with a two foot expansion loop at each quarter point of the main span. It was reduced to 2½ inches diameter at the New York approach and was provided with 2-inch tee bolts and manifolders with four connections for flexible hose at points about 50 feet apart.

A compressed air haulage plant has recently been installed by the Encampment Smelting Company at its mine at Rudefeha, Carbon County, Wyo. The locomotive is of the H. K. Porter type, with cylinders 5 inches by 10 inches and capable of hauling a load of 25 tons on a 2 per cent. grade, which is the heaviest in the mine. This tunnel is about 2,000 feet long, the grade sloping from the mine to the ore bins on the outside. The power is supplied by a Norwalk compressor with a capacity of 65 cubic feet of free air per minute, compressing to 850 pounds. The compressor is belt-driven from a Buffalo self-contained automatic engine.

Compressed air for the rock drills is supplied by a Laidlow Dunn-Gordon duplex compound compressor with Meyers cut-off valve gear, which is also located in the power house. Twenty-five rock drills of the Sullivan type, with 2¾ inch and 3¼ inch cylinders, are used in the different levels and stopes. It is expected in the near future to install a diamond drill equipment which will also be operated by compressed air.

At the power-house No. 2 of the Niagara Falls Power Company compressed air is used to operate the brakes for the turbines and also for cleaning purposes. To supply the compressed air a two-stage Ingersoll-Sergeant air compressor is located in a special lateral chamber at the bottom of the well-pit. It is driven by a Pelton water wheel 7 feet in diameter, which is fed from a 36-inch steel main. The wheel is designed to develop 38 horse-power at 120 revolutions per minute and under a head of 127 feet. The compressor has a capacity of 120 cubic feet of free air per minute compressed to 140 pounds per square inch. The air pressure desired is maintained automatically by controlling the air inlet and the flow at the nozzle of the Pelton wheel. The system contains a receiver 4 feet in diameter and 8 feet high, located at the turbine. A system of pipe extends to each chamber so that hose may be attached for conducting the air as desired. A smaller plant is located at Power House No. 1, and arrangements are made so that the two may be connected if necessary.

There seems to be some question as to who was the originator of the scheme of painting the buildings of the World's Fair with the assistance of compressed air. The Boston *Sunday Globe* recently published a portrait of Frank D. Millet, the artist, who was born at Mattapoisett, Mass., November 3, 1846. Concerning Mr. Millet's connection with this work, the *Globe* says:

"He had charge of the art work of the World's Fair at Chicago, and when the question of painting the building came up it was found there was not time enough to do it in the regular way, so he invented a machine to do the job.

"He took a gas pipe about a foot long, pounded flat at one end so as to leave an opening about an inch across and wide enough to insert a sort of perforated cardboard. This he attached to a long piece of hose, the other end of which he dipped into a barrel of paint. An electric motor then pumped air and paint through the hose. The force of the air scattered the paint in a fine spray.

"It worked like a charm and the work was done on time. This method has since become popular in painting shops, etc. It does the work of forty or more painters."

A remarkable piece of engineering was completed in September in Cranston, R. I. The chimney of the Narragansett Brewery, 192 feet in height, owing to undermining by water, was so badly out of plumb (leaning nearly four feet toward the east) that its falling seemed assured. The fate of an $8,000 chimney seemed to be imminent and certain. J. H. Gerhard, civil engineer, of Cranston, R. I., undertook to straighten this rival of the leaning tower of Pisa. The plan devised by Mr. Gerhard was a simple one. One course of bricks three-quarters of the way through the chimney was removed from the west side, and its place was taken by wedges of oak. An 8-foot bed of concrete was then laid against the foundation on the east side. Two holes were cut in the east side of the chimney, and in these were inserted 22-inch steel beams 25 feet in length. These were used as levers to tip the 192-foot chimney toward the west. The wooden wedges were gradually burned out by a gas flame driven into the oak by compressed air. The chimney, as the wood was burned away, gradually approached the perpendicular line, the movement averaging about 6 inches a day. When the chimney was straight, the space occupied by the brick was filled and the steel beams were buried in concrete after the removal of the jack screws. This has obviated the necessity of moving the boiler house to another location.—*Brick.*

Another pneumatic power hammer has been placed on the English market by the makers, the William Graham & Sons Engineer Company, of London. This hammer is made in various sizes and is specially designed to deal with light and heavy forgings in iron or steel. The hammer head or ram has a rectangular section and has no piston rod, which is replaced by the ram itself, the object being to obviate any possibility of breakage of piston rods through crystallization. The head is lifted up by the exhaust in the cylinder and is driven down by compressed air. The force of the blow is regulated by a rotary cut-off valve which controls the admission of the air to the cylinder. This valve is oscillated by a lever moving over a mark to indicate whether the valve is open or shut. A second or controlling lever is provided for controlling the piston valve. This second or controlling lever is lifted to its uppermost position and the recording lift is moved to shut. Then the air is exhausted from the cylinder and the head drawn up and held stationary. By opening the regulating valve according to the desired force of the blow and then moving the controlling lever to its horizontal position, the hammer head is set in motion and gives blow after blow until the controlling lever is put back in its former position. The combined vacuum and compression pump is separated from the main hammer so that the hammer may be placed in any position irrespective of the location of the driving power, the required connection being made by cast iron, wrought iron or flexible piping.

In a paper "Railroad Shop Tools," which appeared in the December number of the *Railway Master Mechanic*, Chas. H. Fitch refers to the Kennedy pneumatic bull dozer or "pneumatic blacksmith" as a favorite tool at the Burnside shops of the Illinois Central Railroad. This machine is made by the Featherstone Foundry and Machine Company, of Chicago. It has a great range of work and is said to combine heavy power with quick action. It has been used to make boiler braces, valve yokes, wrecking chain hooks, heavy equalizing beams and all other forms that can be produced with a two-cam press.

The resisting frame extends like the head of a T so as to give place for a large die. There are two cylinders giving ramming movements in two directions at right angles, an end upsetting and a side closing movement. The turning of an air cock applies the rams, while their withdrawal is governed by another. The claim is made that the dies can be changed in three minutes, ready for new work even of a complicated character. The strokes are adjustable to any requirement. The dies are of two kinds, one coupled to the piston rod of the main cylinder and the other in the form of gripping or forming blocks operated by the lower cylinders.

By placing liners over the face of the dies in forming pipe clamps, 25 different sizes of clamps have been forged in one minute. A valve yoke has been forged in five minutes and a locomotive main rod strap weighing 236 pounds in 47 seconds. Rollers are used at the corner of the dies which facilitates the movement and justification of the work. The usual air pressure carried is 125 pounds per square inch. These forging machines are made with cylinders 16 inches, 20 inches and 24 inches in diameter.

New York theatre-goers have been attracted by Mr. Proctor's ingenious method of outlining the policy at his theatres. The Proctor plan, he calls it, and explains it as follows:

"The Proctor plan just consists in taking care of the Proctor audiences at the Proctor theatres; that is to say, it is a part of the Proctor plan to furnish each auditor with a clean, wholesome show and plenty of it; with courteous attention from the moment one enters the door until one leaves it; with pleasant and agreeable surroundings for old and young, and finally to leave all comers with the impression that they have received more than their money's worth, which in all cases is really a fact."

This doubtless explains how the Proctor playhouses are getting such a large share of patronage.

Our supply of copies of "Compressed Air" for November, 1902, is exhausted and we still have a demand for them for binding. Readers of this paper who have copies of this number which they do not care to preserve will confer a great favor upon the editor by mailing them to "Compressed Air," 26 Cortlandt Street, New York. We shall be glad to pay the regular price for them.

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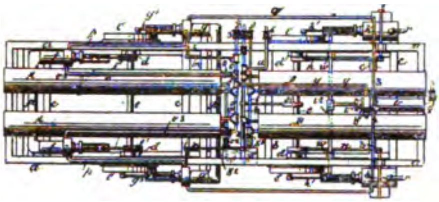
U.S. PATENTS GRANTED DEC., 1903.

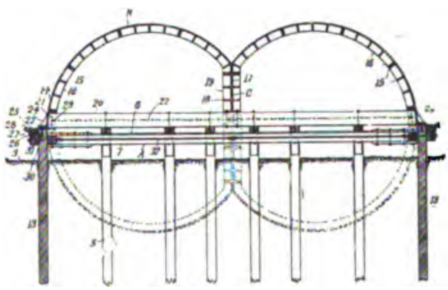
Specially prepared for COMPRESSED AIR.

745,373. UTILIZATION OF COMPRESSED AIR. Robert Nutty, New York, N. Y. Filed Dec. 17, 1898. Serial No. 699,600.



An engine, one or more operating-tanks connected directly to said engine, and adapted to contain propulsive gas or fluid under pressure, in combination with one or more auxiliary or feed tanks adapted to contain a similar gas or fluid under a higher initial pressure than that in the operating-tanks, and a body of water contained in the said auxiliary tanks; a valved pipe connecting the operating and the feed tanks; whereby the gas or fluid withdrawn from said operating-tanks to run said engine is replaced by water from said feed-tanks; and means for heating said water during its passage through said pipe; substantially as described.

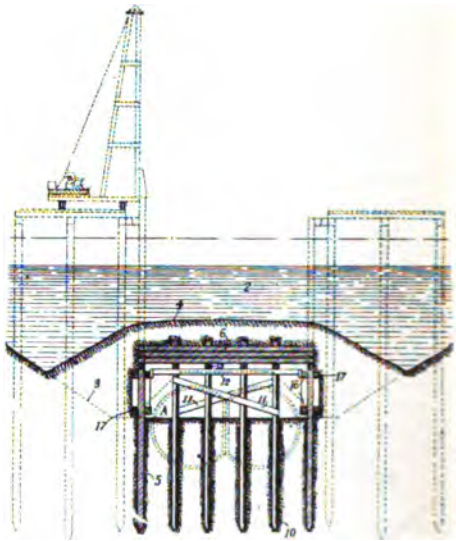
745,456. SUBAQUEOUS TUNNEL. Duncan D. McBean, New York, N. Y. Filed Oct. 22, 1903. Serial No. 178,054.



In tunnel construction, a subaqueous working-chamber, comprising the tunnel roof and walls surrounding the site.

The method of building a tunnel under water, consisting in driving foundation-piles along the site, and impervious sectional walls around the same to bed-rock or to a depth lower than the bottom of the tunnel or its foundation when completed, then cutting off said piles and walls at a depth below the top of the tunnel when completed, then seating the previously-constructed roof thereon in permanent position, then unwatering the chamber so formed, then excavating the necessary material and completing the tunnel within the same.

745,457. SUBAQUEOUS TUNNEL. Duncan D. McBean, New York, N. Y. Filed Oct. 28, 1903. Serial No. 178,950.

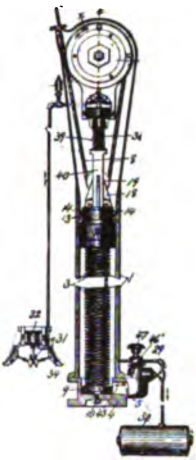


A subaqueous tunnel structure having partially-inclosing side walls secured or anchored thereto and seated on bed-rock or penetrating other material to a depth below the tunnel structure.

745,501. VALVE. Wilhelm Kuhlmann, Offenbach-on-the-Main, Germany. Filed Jan. 14, 1902. Serial No. 89,838.

745,502. COMBINED TROLLEY AND AIR-BRAKE CONTROLLER. James Kynoch, Toronto, Canada, assignor, by mesne assignments, to International Trolley Controller Company, Buffalo, N. Y., a Corporation of New York. Filed Apr. 20, 1903. Serial No. 153,522.

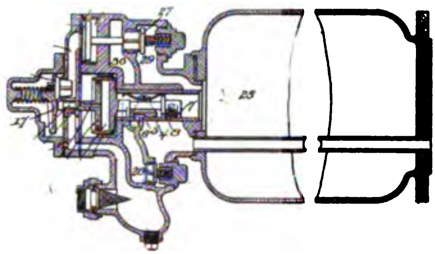
In combination with a trolley-arm-operating cord, mechanism operatively connected to the cord and brought into action by a sudden tensioning of the cord whereby the trolley is drawn from the wire, a conduit for compressed air connected to return the mechanism to its normal position, and manually-operated means for controlling the flow of compressed air through the conduit.



A cylinder and a piston movable therein, a valve-chamber having inlet and exhaust ports and communicating with the cylinder, a valve normally closing the inlet and adapted to be operated manually to close the exhaust-port, whereby when the inlet is opened the exhaust-port is closed and *vice versa*, a spring operatively connected to move the piston in one direction, a detent for holding the piston against the action of the spring, a trolley-arm-operating cord operatively connected to trip the detent when the cord is suddenly tensioned, and a compressed-air conduit connected to the inlet and whereby when the valve is open the compressed air returns the piston against the action of the spring.

745,735. AIR-BRAKE. Milton H. Neff, Watertown, N. Y., assignor to New York Air Brake Company, a Corporation of New Jersey. Filed May 21, 1903. Serial No. 158,136.

The combination with the train-pipe, auxiliary reservoir, and brake-cylinder of an air-brake apparatus; of a train-pipe vent-valve for permitting air to escape from the train-pipe; a brake-cylinder supply-duct from the auxiliary reservoir to the brake-cylinder, and valve controlling said duct; and means actuated by the air escaping from train-pipe when vented for actuating said valve in the brake-cylinder supply-duct; and a motor-piston for the train-pipe vent-valve exposed

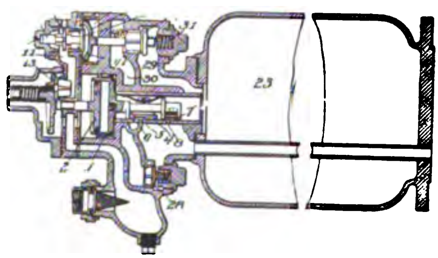


to train-pipe pressure on one side and to pressure of air confined in a small chamber at the other side; a duct connecting the said small chamber with the space containing train-pipe air; and means for closing said duct in response to a sudden reduction in train-pipe pressure.

745,827. VALVE. Ernest B. Hack, Denver, Colo., assignor to the American Filter Press Extraction Company, Denver, Colo., a Corporation of Colorado. Filed Jan. 19, 1903. Serial No. 139,713.

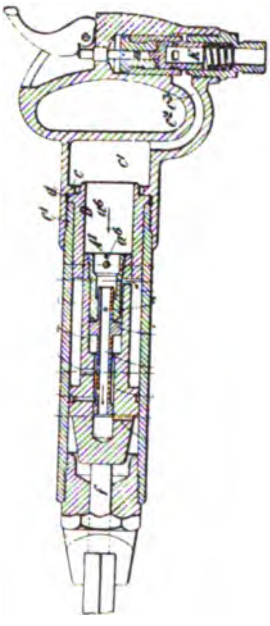
745,878. PNEUMATIC-TIRE PROTECTOR. George E. Mentel and Simon N. Mentel, Springfield, Ohio. Filed Oct. 1, 1903. Serial No. 175,281.

745,934. AIR-BRAKE. Charles W. Valentine, Watertown, N. Y., assignor to New York Air Brake Company, a Corporation of New Jersey. Filed May 21, 1903. Serial No. 158,122.



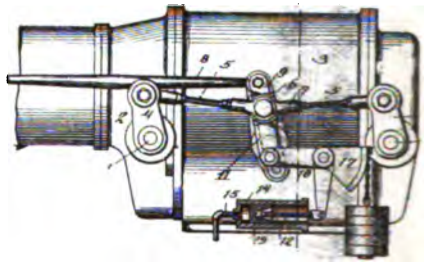
The combination with the train-pipe, auxiliary reservoir, and brake-cylinder of an air-brake apparatus; of a train-pipe vent-valve for permitting air to escape from the train-pipe; a brake-cylinder supply-duct from the auxiliary reservoir to the brake-cylinder and valve controlliduct; means actuated by the air escaping from the train-pipe when vented for actuating the valve in the brake-cylinder supply-duct; and means for entrapping a portion of said escaping train-pipe air, whereby the valve in the brake-cylinder supply-duct is retained open after the flow of air from train-pipe has ceased, substantially as and for the purpose described.

745,900. PNEUMATICALLY-OPERATED PERCUSSIVE TOOL. Walter Payton, Richmond, England. Filed Apr. 7, 1903. Serial No. 151,540.



A pneumatic percussive tool, the combination with the casing constituting the working cylinder, of a piston, a sliding tubular valve in said piston, the forward end of which is of a greater diameter than its rearward end and is constantly exposed to the pressure of the motive fluid, an enlargement or collar on said valve working in a chamber in the piston and having its forward side constantly open to the exhaust-chamber and means whereby the rearward side of said collar is subjected to the fluid-pressure when the piston is at one end of its stroke and is open to the exhaust when the piston is at the end of its stroke for the purpose specified.

746,032. VALVE OPERATING AND CONTROLLING MECHANISM. Hugh V. Conrad, New York, N. Y., assignor to Rand Drill Company, New York, N. Y., a Corporation of New York. Filed Feb. 26, 1902. Serial No. 95,690.



An air-compressor, the combination with a cylinder of reciprocating admission-valves arranged in their reciprocation to alternately admit fluid for compression to opposite ends of the cylinder, and a rocking operating-lever for transmitting such reciprocating movement to said valves, of links normally connecting said valves to said rocking lever at a point therein having the necessary throw to produce the aforesaid reciprocation, and means for shifting the point of such connection to a point nearer the center of oscillation of said rocking lever, at which point the valves will not receive an operative throw.

746,107. AIR-BRAKE SYSTEM. Harry R. Kuhn, Homestead, Pa. Filed Mar. 16, 1903. Serial No. 147,969.

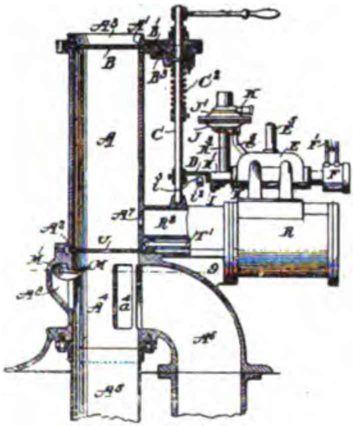
A device of the character described, the combination of the valve-body and rotarily-mounted part therein having an eccentric portion adapted to operate within an opening on an extension of the valve contained therein, and the eccentric part being so positioned that in one position said valve is permitted to close and in the other position said valve is not permitted to close.

746,207. REPAIR DEVICE FOR PNEUMATIC TIRES. John R. Vosburgh, Johnstown, N. Y. Filed Sept. 10, 1903. Serial No. 172,635.

746,279. PNEUMATIC SEAT-POST FOR BICYCLES. Edward Brougham, Brandon, Canada. Filed Sept. 2, 1902. Serial No. 121,765.

A pneumatic-cushion saddle-post comprising an outer tubular member closed at one end, a post telescoping within said outer member, and a cylindrical capsule interposed between the inner end of the inner member and said closed end of the outer member, and having a tubular air-valve projecting concentrically through a hole in the latter, whereby a pump may be externally applied, said capsule having a rigid head at its other end and resilient sides.

746,266. SENDING DEVICE FOR PNEUMATIC TUBES. Birney C. Batcheller, Philadelphia, Pa. Filed Oct. 11, 1900. Serial No. 32,682.



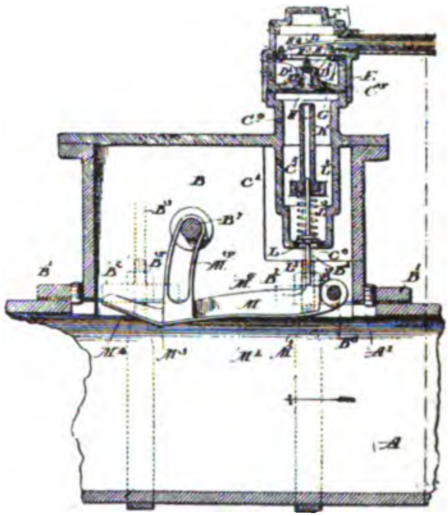
A sending device for a pneumatic-tube system, a tube-section A in registry with the end of the despatch-tube in combination with an end gate and an inner gate for closing the tube-section, means for first admitting compressed air to the tube-section and then opening the inner gate arranged to be set in operation by the closing of the end gate, an automatic lock arranged to prevent the opening of the inner gate when engaged, a time escapement arranged to disengage said lock a determined time after the inner gate has closed after opening, and means for first closing the inner gate and then opening the end gate arranged to be set in operation by the exit of a carrier from the tube-section.

746,545. VALVE. Siegfried Mertens, Charlottenburg, Germany. Filed Nov. 24, 1902. Serial No. 132,618.

746,651. PNEUMATIC LAYING-OFF APPARATUS FOR CYLINDER PRINTING-MACHINES. Wilhelm M. Rockstroh, Klein Sedlitz, Germany. Filed Apr. 16, 1902. Serial No. 103,216.

A pneumatic laying-off apparatus for cylinder-presses comprising oscillating levers, a suction-pipe carried thereby and provided with apertures, and a series of rings adjustably mounted on the pipe and provided with apertures adapted to register with the apertures of the suction-pipe, a shaft passing through the pipe, pinions on said shaft and segmental racks carried by the arms and with which racks the said pinions engage.

746,267. PNEUMATIC-DESPATCH APPARATUS. Birney C. Batcheller, Philadelphia, Pa. Filed Mar. 29, 1901. Renewed Apr. 23, 1903. Serial No. 154,028.



In a pneumatic-despatch system, a pivoted finger normally extending into a pneumatic tube and having its carrier-containing face M formed as described to impart to the finger under the pressure.

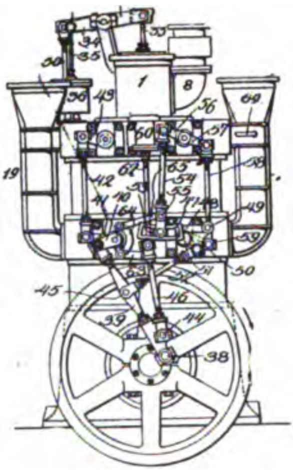
746,884. VALVE. Alonzo Sharp, Troy, N. Y., assignor to Adams Laundry Machine Company, Troy, N. Y., a Corporation. Filed Apr. 12, 1902. Serial No. 102,511.

746,955. VALVE. Lyman O. Goodwin, North Andover, Mass., assignor of one-half to George L. Wright, North Andover, Mass. Filed Apr. 26, 1901. Serial No. 57,589.

746,969. SAFETY DEVICE FOR AIR-BRAKES. John H. Luckey, New York, N. Y. Filed July 15, 1903. Serial No. 165,634.

A safety device for air-brake apparatus, comprising a branch pipe communicating with the train-line pipe and with the atmosphere, said branch pipe having a valve interposed in its lower portion and seating in opposition to the pressure of the air in the branch pipe, and a lever connected with said valve and solely depressible by a foot-pedal.

746,745. VALVE-GEAR FOR FLUID-COMPRESSORS. Francis M. Rites, Ithaca, N. Y., assignor to Ralph Baggaley, Pittsburg, Pa. Filed Mar. 5, 1903. Serial No. 146,363.



A fluid-compressor, the combination with a discharge-valve, a link, a sliding block thereon and means connected to said block for operating said valve, of a movable guide for said link pivotally connected to it, means for oscillating said link about its guide, other means for moving said guide during the oscillation of the link, and automatic fluid-pressure-governing means, actuated by variation in relation of pressure reached in the compressor to pressure of the receiver, for adjusting the position of the block on the link.

A fluid-compressor, the combination with separate admission and discharge valves, separate wrist-plates for said admission and discharge valves, and means for driving said valves from their respective wrist-plates, the means for driving the discharge-valves comprising valve-arms, and rods connecting said arms to points on the discharge-valve wrist-plate which move in directions approximating right angles with respect to their respective rods, during closed positions of the corresponding valves, and in directions approximating parallelism with respect to their respective rods, in open positions of the corresponding valves, of mechanism for driving said wrist-plates comprising a crank-pin, a pitman therefor, and means connecting said pitman to each of said wrist-plates.

747,124. PNEUMATIC ELEVATOR. Chester Bradford, Indianapolis, Ind. Filed June 9, 1902. Serial No. 110,814.

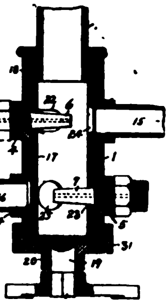
The combination, in a pneumatic elevator, of two conductor portions, one of which extends from and forms a continuation of the other but at an angle therewith whereby a change of direction is secured, a telescopic elbow composed of two portions and uniting said two conductor portions whereby the angle between them may be varied, a turn-table carrying one elbow portion, a swinging frame pivotally mounted on said turn-table and carrying the other elbow portion and also carrying the conductor portion which is adapted to be varied in position, a trussed mast extending up from said turn-table, a stay-brace extending from the mast-truss strut to the turn-table arms, and a tackle running from said mast to and supporting the conductor portion carried by the swinging frame.

747,251. PNEUMATIC STRAW-STACKER. Harry W. Smith and Martin F. Smith, Glanford township, county of Wentworth, Canada, assignors, by direct and mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Dec. 5, 1901. Serial No. 84,819.

A pneumatic stacker, a fan, in combination with a fan-housing located at one side of the end of a machine; a slanting board hinged to the side of the machine and extending over to the inner side of the top of the housing; and a triangular piece fitted underneath the forward end of the said board to close off the space between it and the fan-housing, substantially as described.

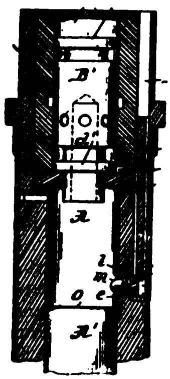
A pneumatic stacker, a substantially vertical pipe divided into two parts sleeved one within the other, in combination with a circular track or ring surrounding the upper part of the pipe; means for supporting the said track or ring from a stationary part of the apparatus; a ring connected with and encircling the upper part of the pipe; one or more rollers journaled at one side of the said ring and engaging the upper side of the track; one or more rollers journaled at the other side of the said ring and engaging the under side of the said track; an elbow formed of telescopic sections formed at the upper of the two parts of the discharge-pipe and bending outwardly above the rollers engaging the upper side of the track; means connected with the ring secured to the pipe for collapsing or extending the elbow, substantially as described.

747,308. PNEUMATIC TRACK-SANDER. James W. Thomas, Baltimore, Md., assignor to John J. Morgan, Baltimore, Md. Filed Sept. 17, 1903. Serial No. 173,522.



A pneumatic track-sander comprising a casing having an opening for communication with the sand-reservoir, an opening for communication with the forward sand-discharge pipe, an opening for communication with the rear sand-discharge pipe, and two openings for communication with the two air-delivery pipes; a sleeve fitted in the said casing and having two ports adapted to register with the sand-discharge pipes; and means for rotating said sleeve.

747,336. PNEUMATIC TOOL. William H. Soley, Philadelphia, Pa., assignor, by mesne assignments, of one-half to Thomas H. Dallett Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Aug. 1, 1902. Serial No. 117,934.

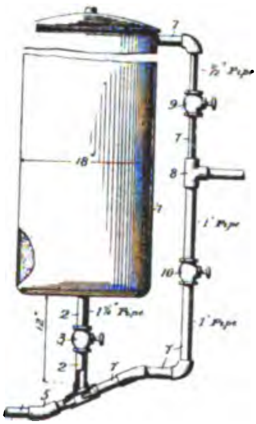


A pneumatic tool, in combination, with the piston-chamber and piston therein and valve-chamber and valve therein, of a lateral passage opening into the piston-chamber at the upper portion thereof, a passage connected with the air-supply and a passage from the valve-chamber opening into said lateral passage, an auxiliary valve in said lateral passage, said auxiliary valve having a passage in constant communication with the live air, circumferential-grooved-portion orifices in said portion extending into said passage and a projecting portion adapted to extend within the piston-chamber, said auxiliary valve being moved in one direction by the live air and in the other direction by the piston in its movement.

747,001. PNEUMATIC TIRE. Edward H. Seddon, Brooklands, England. Filed Mar. 17, 1903. Serial No. 148,160.

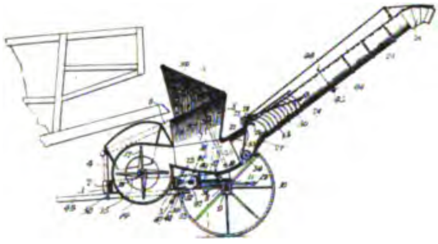
747,339. VALVE. William Wright, New York, N. Y.; Mary E. Wright, administratrix of said William Wright, deceased. Filed Mar. 19, 1903. Serial No. 148,472.

747,396. SAND-BLAST APPARATUS. Neal Farnham, Chicago, Ill. Filed Apr. 10, 1903. Serial No. 151,998.



A sand-blast apparatus comprising the tank, the discharge-pipe leading from it, to the sand- carrying hose, the compressed-air-supply pipe opening into the upper part of the tank and having the upper and lower controlling-valves, the inclined coupling between the sand-carrying hose, the compressed-air-supply pipe and the discharge-pipe from the tank, and the air-blast nozzle having its point of discharge in the inclined coupling beneath the mouth of the discharge-pipe from the tank, substantially as described.

747,397. PNEUMATIC STRAW-STACKER. Samuel D. Felsing, Crookston, Minn. Filed Mar. 5, 1903. Serial No. 146,373.



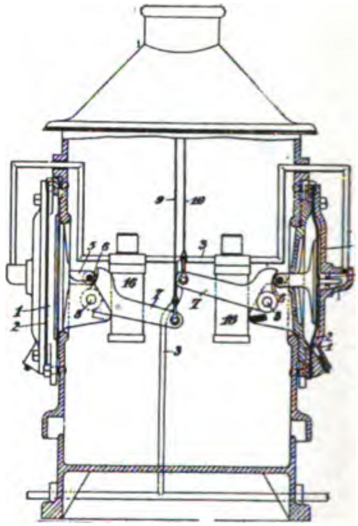
A pneumatic straw-stacker, the combination of a hopper, means for forcing a blast of air into said hopper, and an extension forming an air-trunk connected flexibly with said hopper, the latter and the air-trunk having segmental, overlapping parts concentric with the pivot whereby said parts are connected.

747,468. VALVE. Joseph W. Nethery, Indianapolis, Ind., assignor to the Nethery Hydraulic Valve Company, Indianapolis, Ind., a Corporation of New Jersey. Filed Nov. 8, 1901. Serial No. 81,545.

747,551. AUTOPNEUMATIC MUSIC-PLAYING INSTRUMENT. George W. Haywood, Meriden, Conn., assignor to Wilcox & White Company, Meriden, Conn., a Corporation of Connecticut. Filed June 1, 1903. Serial No. 159,450.

In combination, for the purpose set forth, a wind way-passage, means for inducing a wind-current therethrough, a valve for controlling said passage, a regulator-pneumatic device internally communicating with said windway-passage, and having a movable member with a connection for moving said valve, a tension-spring for said pneumatic, and an extraneous operating means connected with said pneumatic for temporarily applying force thereto in accord with or in opposition to the normal action of the tension-spring.

747,432. PNEUMATIC RAILWAY SIGNALING APPARATUS. Ernest C. Irving, Westminster, England, assignor of one-half to John Patrick O'Donnell, Westminster, Middlesex county, England. Filed Apr. 3, 1903. Serial No. 150,959.

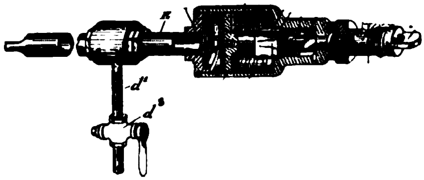


In pneumatic railway-signaling, a flexible diaphragm, a casing inclosing said diaphragm and adapted to be attached to a signal-post, a plate and (or) rod in operative connection with the diaphragm, guides for said rod in the casing, a friction-roller on one end of said rod, a lever pivoted on the diaphragm-casing, one end of said lever being adapted to be operated on by the friction-roller, a wire connecting the other end of said lever to the signal-arm, and means for admitting the motive fluid to and exhausting it from the diaphragm, all substantially as described with reference to the drawings annexed.

747,565. PNEUMATIC FLUE-CUTTER. John T. McGrath, Fort Gratiot, Mich. Filed Sept. 5, 1902. Serial No. 122,235.

A flue-cutter, the combination with the casing having a radially-movable cutter, of a spindle rotatably mounted in the casing, adapted when rotated to force said cutter outwardly, a reciprocating piston within the casing, and means whereby the reciprocation of the piston imparts rotary movement to said spindle, substantially as described.

A flue-cutter, the combination with the rotatable casing, the central spindle extending therethrough and having spiral grooves formed therein and a cutting wheel adjusted and sup-



ported by the spindle, of a cylinder attached to or forming part of the casing and having an air-inlet pipe and an outer rectangular recess, a piston located within the cylinder and provided with a stem having a rectangular end having a central orifice designed to receive the spiral-grooved end of the spindle, balls located in the spiral grooves and set-screws designed to extend through the square portion of the stem and having cup-shape inner ends designed to receive and hold the balls in position and a spring located between the piston and the end of the cylinder, as and for the purpose specified.

747,599. SELECTIVE DEVICE FOR PNEUMATIC-DESPATCH TUBE SYSTEMS. Edmond A. Fordyce, Chicago, Ill. Filed Feb. 14, 1902. Serial No. 94,143.

A despatch-tube system, the combination with a main tube and a series of branch tubes leading therefrom, of switches located at the junctions of the several branch tubes with the main tube, pivoted triggers disposed across the path of travel of the carriers in advance of said switches, pivoted tripping-levers disposed alongside said triggers and having projections extending to varying distances beyond the transverse planes of the triggers, switch-operating arms pivoted to and advanced by said tripping-levers into engaging relation to their respective switches, connections between the triggers and their respective switch-operating arms for raising the latter, and a series of carriers having graduated holes in their heads to co-operate with the graduated projections of the tripping-levers, substantially as described.

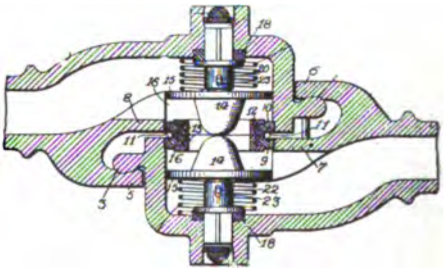
747,656. PRESSURE-RETAINING VALVE. Francis P. Skeffington, Spokane, Wash. Filed Aug. 3, 1903. Serial No. 168,055.

An air-brake system, the combination with an automatic pressure-retaining valve connected to the auxiliary reservoir and the triple-valve exhaust, of a bleed-valve controlling and in communication with the pressure-retaining valve and the auxiliary reservoir.

747,724. AUTOMATIC SWITCH. Oliver Jordan, Lowell, Mass. Filed Oct. 10, 1903. Serial No. 176,551.

A device of the class described, the combination with a main duct, of a branch duct leading therefrom, a normally closed and locked switch disposed between said ducts, means operable by a carrier for releasing the switch, and means for automatically opening the switch.

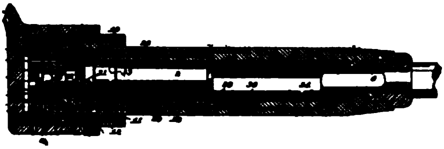
747,733. COUPLING FOR AIR-PIPES. Harry C. Lafferty, Allegheny, Pa. Filed Sept. 24, 1903. Serial No. 174,395.



A coupler comprising two sections formed with alining openings, a gasket carried by each of the sections extending in said openings and having their outer faces in engagement with each other, a valve arranged in each of said sections, the opposite faces of said gasket forming seats for said valves, auxiliary valves carried by the stems of the first-named valves, with ports arranged in alinement with said openings, said auxiliary valve closing said ports, and foraminous caps at the outer ends of said ports.

747,751. PNEUMATIC HAMMER. Albert C. Murphy, East St. Louis, Ill., assignor to Standard Railway Equipment Company, a Corporation of Illinois. Filed May 17, 1901. Serial No. 60,693.

A pneumatic hammer comprising a cylinder having ports for the admission and release of air, a piston in said cylinder and a valve for controlling the admission and release of air, said valve being of the differential-piston type and having its smaller end exposed to constant pressure and having a groove in its smaller diameter arranged to communicate at all times with a main



release-port and to communicate alternately with the respective ends of the cylinder, the cylinder having a supplemental exhaust-port located in the forward portion thereof in position to be uncovered by the piston shortly before the completion of its return stroke, and said piston having also a port communicating with the larger end of the valve-chamber and arranged to be uncovered by the piston simultaneously with the supplemental exhaust-port, substantially as described.

747,752. PNEUMATIC HAMMER. Albert C. Murphy, St. Louis, Mo., assignor to Standard Railway Equipment Company, a Corporation of Illinois. Filed Sept. 16, 1901. Renewed Nov. 2, 1903. Serial No. 179,636.

A pneumatic hammer having ports for the admission and release of pressure and a piston-valve arranged to control with the admission-ports and the release-ports and having ends of equal area, the ends of the valve-chamber being in communication with the ends of the cylinder respectively beyond the release-ports and the cylinder, substantially as described.

A pneumatic hammer comprising a valve having cylindrical end portions of equal area and an intermediate groove, said hammer having ports communicating with the source of pressure and opening into the valve-chamber in position to be controlled by the front and rear ends of the valve respectively and having three ports opening into the valve-chamber in position to register with the groove in the valve, the end ports of said three communicating with the cylinder near the front and rear ends thereof respectively and being in position to be alternately closed by the ends of the valve, and the intermediate port being permanently open to the groove of the valve and to the atmosphere, and said hammer having ports opening into the respective ends of the valve-

chamber beyond the limit of movement of the valve and communicating with the cylinder nearer the ends thereof than the ports which communicate with the valve-groove, substantially as described.

747,817. AIR-BRAKE COUPLING. Rudolph W. Wilke, Auburn Park, and Mathias Bauer, South Englewood, Ill. Filed June 23, 1903. Serial No. 162,703.

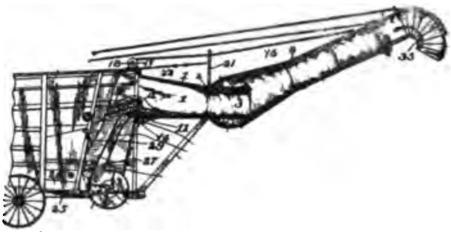
An air-brake coupling comprising a casing having an air-outlet, a flexible gasket seated around said opening within said casing and having an annular flange projecting therefrom, a metal gasket seated on said flexible gasket, an annular flange on said metal gasket entering the opening in said flexible gasket to hold said metal gasket centered, a chamfered valve-seat in said metal gasket, an air-escape groove in said valve-seat, a removable cap mounted in the opposite wall of the coupling, projections on said cap bearing upon said metal gasket to hold same compressed on said flexible gasket, a central cylindrical chamber in said cap, a valve controlling the air-outlet and having a stem entering said chamber in said cap, a spring interposed between said cap and said valve for normally holding the latter on its seat, a projection at the other end of said valve projecting through the air-outlet, an enlarged head on said projection of smaller diameter than the air-outlet and a flat end and rounded edges on said head, said head projecting only slightly beyond the free end of the flange of the flexible washer and serving as a cam to be engaged by a similar head on the other coupling member when coupled therewith to open said valve, substantially as and for the purpose set forth.

747,987. PNEUMATIC CONVEYER ATTACHMENT FOR FEED-CUTTERS. Leo J. Lee, Stark, Wis. Filed June 9, 1903. Serial No. 160,771.

The combination of a feed-cutter, a fan-casing having closed end walls and with the discharge leading tangentially from one side and adapted to receive the material from the cutter tangentially at the opposite side, the fan-blades curved radially and adapted to receive the material upon their concave sides and discharge it from their convex sides, and an extension conveyer-spout rotatively connected to said discharge, substantially as specified.

747,896. PNEUMATIC STRAW-STACKER. Joseph K. Sharpe, Jr., Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Sept. 28, 1901. Serial No. 76,876.

The combination, with a threshing-machine, of a pneumatic straw-stacker trunk or chute attached to and inclosing the rear upper portion thereof where it will receive the straw direct from the straw-floor of the separator, and a blast-fan located below said trunk or chute and provided with an



air-conduit leading therefrom and arranged to discharge into the rear end of the straw-stacker trunk or chute just above the substantially horizontal floor of the straw-chamber therein.

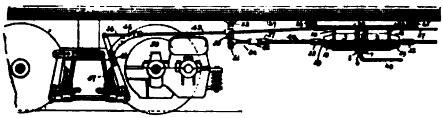
747,982. VALVE. John E. Kordick and Edward Sulgrove, Bridgewater, Iowa. Filed Sept. 5, 1903. Serial No. 172,084.

748,070. PNEUMATIC STACKER. John Henry, Grand Forks, N. D. Filed Mar. 6, 1902. Serial No. 96,984.

A pneumatic stacker, the combination with a straw-conveying tube and means for forcing a blast of air therethrough, of a straw-receiving chamber having a contracted portion communicating with the conveyer-tube and means for directing a blast of air from the side of said chamber toward the contracted outlet thereof.

748,192. VALVE. John Knowles, Colorado Springs, Colo. Filed Mar. 24, 1903. Serial No. 149,329.

748,302. DUPLEX AIR-BRAKE SYSTEM. William H. Nightingale, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Dec. 8, 1902. Serial No. 134,224.

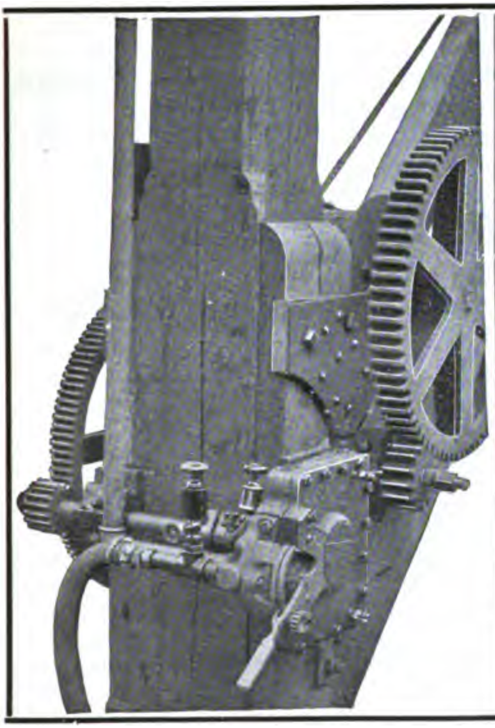


A brake, duplex cylinders having a separable central connection with means to attach each cylinder and the connection independently to the car, an air-passage to the connection, a partition in the passage and a port at each side of the partition leading into each of the duplex cylinders aforesaid.

748,405. APPARATUS FOR AERATING LIQUIDS. Kenneth S. Murray, Westminster, England. Filed Mar. 3, 1903. Serial No. 146,601.

748,498. AIR-PUMP. Martin E. Harmstead, Burlington, N. J., assignor of one-half to Joseph J. Sleeper, Philadelphia, Pa. Filed Oct. 29, 1901. Serial No. 80,408.

A device of the character described, a drum, a hollow axis therefor, a fluid partly filling the drum air-inlets, pipes communicating with the interior of the drum upon opposite sides of said fluid, aid means concentric with said shaft for forming communication alternately between one or the other of said pipes and the interior of said hollow shaft as the drum is oscillated in opposite directions whereby the direction of flow of the air is automatically controlled a... ...rsed...



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