USES OF COMPRESSED·AIR

·ADDISON·C·RAND·

THE USES OF COMPRESSED AIR

WITH ILLUSTRATIONS

SECOND EDITION

BY

ADDISON C. RAND

NEW YORK
THE REPUBLIC PRESS

1895

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INTRODUCTION.

THIS little volume is issued to present a comprehensive account of the important uses which have been found for compressed air, within a very short period, and the utility of air as a motive power. It is not intended as a scientific exposition. The author has endeavored to describe the principal uses of air in a common sense way, and has explained, though less at length, many possible uses. A great number of carefully prepared illustrations are presented. Even among the well informed, comparatively few persons realize the diversified interests using compressed air in some form, and to many, doubtless, the contents of this book will be a revelation. Air, the simplest and most abundant element, has become a powerful factor in the arts, sciences, and manufactures. Its employment as an agent in the transfer of power is attended with absolute safety and certainty.

The most important application of compressed air in the past has been that to rock drills in tunnels and mines, and in both these fields of activity the drill has accomplished wonders within a decade. America can claim, at Hoosac Tunnel, the first general application of the rock drill, followed by the work at Hell Gate, and in all the tunnels of the Alps, and in our own and other countries. The New York Aqueduct, 30 miles in length, was made with such remarkable speed only by the use of compressed air driving the rock borers. Another instance of rapid tunnelling by the use of compressed air is cited in the work at Niagara Falls, where 7,250 feet of tunnel was excavated in the short space of six months, and it is to be observed that, in locations permitting the use of shafts at frequent intervals, a tunnel ten miles in length can be constructed as quickly as that of one mile.

This fact has a bearing upon the question of providing quick transit in cities built upon a rock foundation, inasmuch as modern engineering permits the construction of tunnels in rock with celerity, and comparatively small cost, and without large land damages. It is claimed by experts in the construction of tunnels that a deep tunnel system (which may contain a four-track railroad, to be laid in two decks, of two tracks each), can be built and lined with white glazed brick and provided with suitable shafts, within the limit of cost of two million dollars per mile, excluding the cost of surface stations.

The question of raising and lowering passengers has been practically solved at the Eldorado Station of the North Hudson County Railroad, near Wehawken, where one elevator has carried 160 passengers, making the up trip of 153 feet in 40 seconds, and the down trip in 35 seconds. Objections to an underground system, based upon the limited facility for transferring passengers to and from the railroad, is fully met by this illustration.

Against such a system the chief objections so far raised are the smoke and discomfort of the London underground tunnel, which has been cited as an obnoxious example. In view, however, of the recent improvements in electric and compressed air motors, it is obvious that this objection is no longer valid.

The marked influence of the rock drill operated by compressed air, upon the mining industry, and especially upon that of precious metals, is a matter that so far has received little attention. A study of the increase of silver production shows to a marked degree that it is coincident with the introduction of compressed air drills. The decreased cost of excavation is not, however, the only advantage obtained from the use of drills, for the increased speed with which a mine is opened up and made a factor in producing metal, is of almost equal importance.

With few exceptions, the modern method of mining cannot be as readily applied to obtaining gold as it can be to the less valuable ores, and it is significant that the increase in the production of gold has been very slight during the last twenty years. Within three years, however, the rock drill has been largely introduced in the gold mines of Johannesburg, South Africa—to the extent of about three hundred machines—and the mines are now producing at the rate of about $2,000,000 per month.

The uses of compressed air with which the public is most familiar is undoubtedly that of the air brake upon railroad cars, and of the pneumatic tire of the bicycle, both of comparatively recent adaptation.

Compressed air bids fair to find also a very wide application to pumping from artesian wells. It is much applied in atomizing crude petroleum for use under boilers, forges, etc.; other important uses of air are, seasoning wood, driving locomotives in mines, coal mining machines, underground haulage, hoisting, and street cars. There are also a multitude of other important uses, both of peace and war.

No attempt has been made in this book to discuss at length the principles of air compressing or the construction of compressors, but it should be clearly understood at the outset, that modern ingenuity in compressing air makes operations practical which formerly were forbidden. To the pages which follow, telling their own stories of scope and utility, the reader is referred, who desires to obtain even an imperfect idea of the application and usefulness of compressed air. It is more than likely, however, that there are many uses of compressed air not described in these pages, and the writer solicits from his readers detailed information regarding practical uses not herein described. It is not unlikely that the possible uses of compressed air may be added to another issue.

While most of the illustrations are from photographs made by the direction and at the expense of the writer, he is grateful to the editors of the technical press of this country (to which, with few exceptions, his investigations have been limited) for many facts, illustrations and courtesies. Among them he takes pleasure in mentioning THE RAILROAD GAZETTE, THE ENGINEERING RECORD, MINING AND ENGINEERING JOURNAL, ENGINEERING NEWS, SCIENTIFIC AMERICAN, CASSIER'S MAGAZINE, RAILWAY MASTER MECHANIC, THE RAILWAY AGE AND NORTHWESTERN RAILROADER, THE HUB. He is also indebted to many companies and individuals.

ADDISON C. RAND.

NEW YORK, March 1, 1894

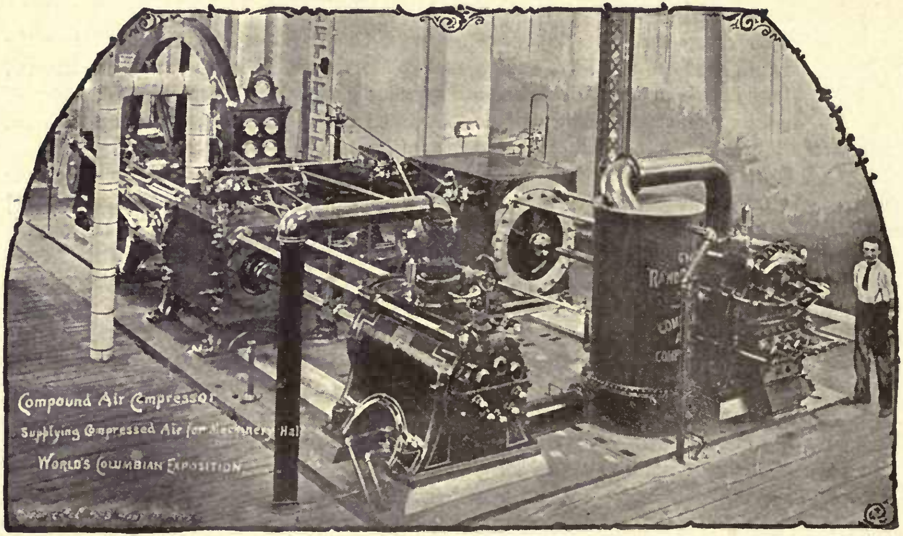
THE CONSTRUCTION OF AN AIR COMPRESSOR.

THE air compressors now in general use in the United States, and, indeed, all over the world, are fitted for surface cooling, and deliver dry air. This method is the result of long experiment and experience, and practically eliminates the physical difficulty of extremely high temperature of air attendant upon compression, which up to recent years made the practical, economical application of compressed air almost impossible.

Bearing in mind that special compressors are constructed for special requirements or localities, the modern air compressor is generally of the horizontal duplex type of steam engine, with air cylinders behind and in line with the steam cylinders, the piston rods of the latter being extended to couple to those of the air cylinders.

The operation of air compression is directly the reverse of the steam engine ; in the former the initial resistance is nothing, increasing to slightly above reservoir pressure at end of stroke ; in the latter the pressure of the boiler is only found at the beginning of the stroke, and then rapidly decreases by expansion. To equalize the variable power of steam to the variable resistance of the air, a heavy fly wheel is used, in which the power of the steam engine is stored at the beginning, to be expended on the air pistons at the end of the stroke.

While slide valve engines (provided with adjustable cut-off valves) of a substantial type, give economical and satisfactory results for good, simple working air compressors, the highest practical known economy is accomplished by a design using a cross compound condensing Corliss steam engine, driving compound air compressing cylinders, having an inter-cooler between them. The atmospheric air is brought from outside the engine house, through conduits to the first air


Compound Air Compressor
Supplying Compressed Air for Machinery Hall
World's Columbian Exposition

cylinder, where it is drawn in by the suction of the piston, through poppet inlet valves located in the cylinder heads; the returning stroke of the piston compresses it to a sufficient pressure to open the discharge poppet valves and cause it to be passed into a surface cooler, where the heat is extracted before entering the second cylinder. In this cylinder the final stage of compression is accomplished, the air then being delivered to storage tanks to be drawn off as desired.

The poppet inlet and discharge valves are constructed so as to be moved either by the air pressures, or by positive mechanical attachments, to suit requirements.

When air at very high pressure is needed, the compression is done in three or four stages, by air cylinders in suitable number and proportions. Cooling water is circulated around the air cylinders and heads, and in cases through pistons and rods.

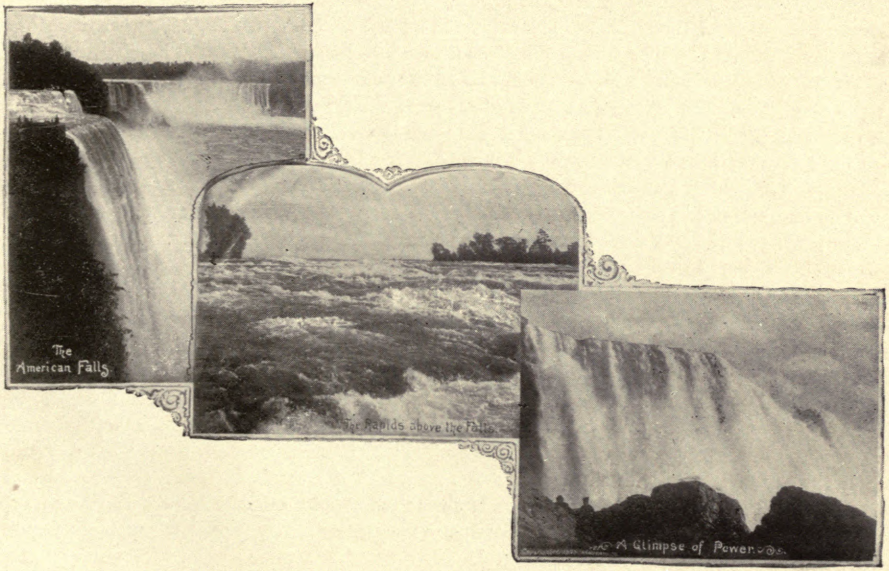
Compressors are also driven by water, electrical or other power, through direct connection or the medium of belts or gearing. The easy transmission of air through pipes for long distances, places no practical restriction upon their location, and they are frequently built of odd design to be placed in limited space on shipboard, etc., and for handling different gases.

Air compressors are built of all sizes and capacities, from a size sufficient for operating one drill, to the Mammoth. that will drive 70 at the same time.

TUNNELLING TO UTILIZE THE POWER OF NIAGARA.

CONSERVATIVE engineers agree in declaring that much more than all the horse-power now actually in use on this Continent, is contained within the narrow limits of the Niagara River. The census of 1890 made no attempt to compute the total combined steam and water power used in the United States, as was done in 1880, but it must have amounted to 4,000,000 horse power. The Niagara River represents 5,878,100 horse power, thus vastly greater than all the power in use in this country.

It has long been the dream of engineers and capitalists to utilize some of this marvelous supply of power, and though a few thousand horse power have been employed for some years by means of a crude canal, the tunnel and canals constructed by the Niagara Falls Power Company form the first elaborate attempt to chain a portion of Niagara's wonderful strength. This gigantic undertaking was made practicable by the use of rock drills operated by compressed air. With these drills a tunnel, 7,250 feet in length was constructed to form a tail race, starting from just above the water-level below the Falls, and running under the village of Niagara at a depth of 200 feet; the upper end of the tunnel being adjacent to the river bank and beneath a large tract of land owned by the Company. The grade of the tunnel is 36 feet to the mile; it is 19 feet wide and 21 feet high inside the brick work, which is of most substantial character. The sinking of the shafts was attended with many difficulties, on account of the large amount of water entering them, but when they were completed, the entire tunnel was excavated in the amazingly short period of six months, by the contractors, Messrs. Rogers & Clements. The boring was conducted in three benches, the upper one, or heading, (see cut), being driven first, and in advance. The



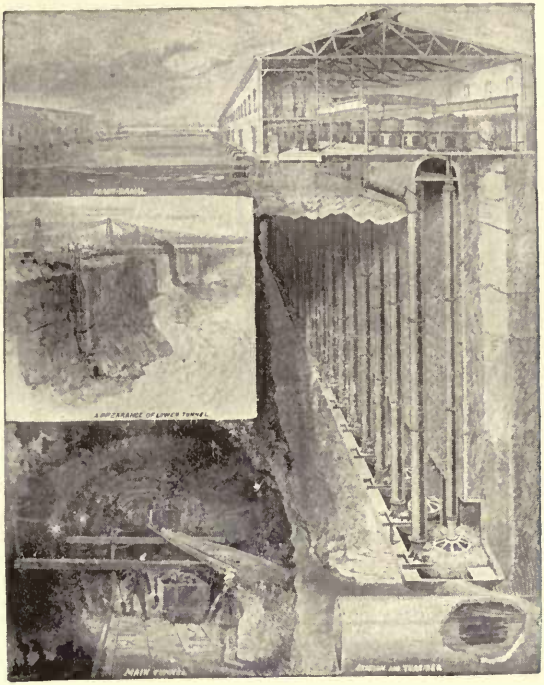
The American Falls

The Rapids above the Falls

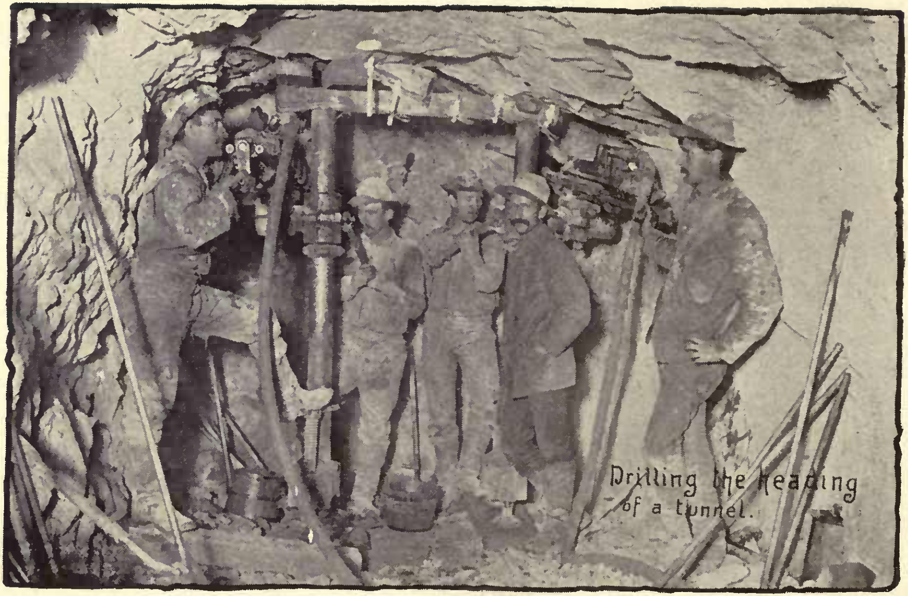
A Glimpse of Power

next bench was slightly behind, and the lowest, behind that, the general appearance of the three benches being that of three steps. The excavated matter, from the two upper benches was withdrawn over platforms, thus permitting simultaneous work at three levels without interference. The cost of the excavation alone was $400,000, and when walled and completed with arching of brick, $1,300,000. In driving this tunnel, three shafts were sunk, in order to expedite the work—the Zero shaft at the portal, extending 93 feet from the top of a ledge to the tunnel soffit ; No. 2, 2,650 feet from the portal, sunk 260 feet, and No. 3, 5,200 feet from the portal is 196 feet in depth.

The general plan of the main supply canal includes an upper reach extending 500 feet inwardly from the river, thence parallel to the river in a down-stream direction for 5,000 feet, where a lower reach 200 feet wide and 1,200 feet long connects this end with the river. These sections, adapted to different power requirements, will be connected by gates when completed. Along these reaches central power stations will be erected, obtaining their power from turbine wheels. The total horse-power which this system is expected to develop is 125,000. The power produced by the tunnel capacity is equal to the water-power of Lawrence, Lowell, Holyoke, Turner's Falls, Manchester, Bellow's Falls, Lewiston, Cohoes, Oswego, Paterson, Augusta, Ga., Minneapolis, Rochester, and Lockport, combined. But the Company is moving cautiously and begins by generating 5,000 horse-power by compressed air, and 5,000 by electricity, adding in units of 2,500 or 5,000, to whichever power proves the more profitable. It is estimated that this Company can supply the city of Buffalo with all the power it requires at a rate much below ordinary cost of steam, and that Rochester, Syracuse, and other cities throughout Central New York can be profitably supplied. It is even claimed that eventually the belts in New York City itself, 440 miles away, will be turned by the power of Niagara.

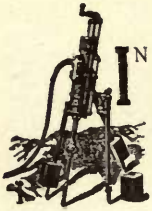


In the portion of the cut marked "main tunnel" the work of excavating the "Heading" and "first bench" is shown. The second bench being driven last is not shown. In that marked "Appearance of Lower Tunnel," the outlet is seen on the left of the picture. The other views indicate one of the proposed arrangements of water wheels.

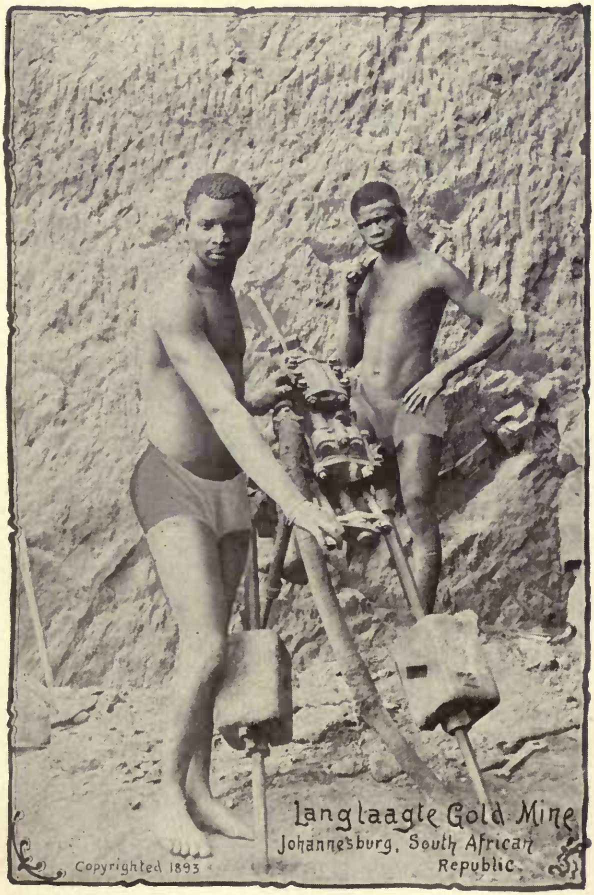


Drilling the heading of a tunnel.

DRILLING IN ROCK.



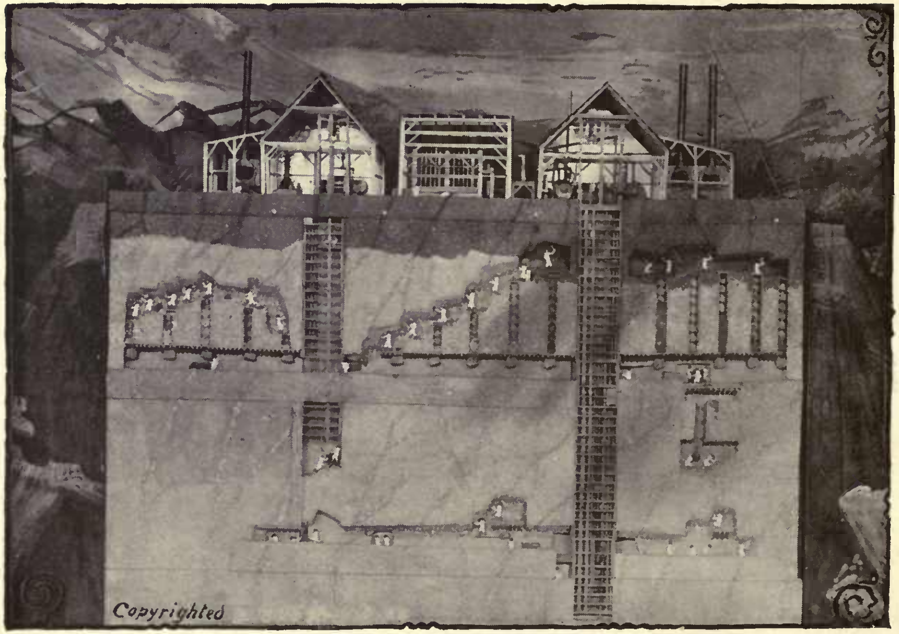
IN connection with rock work, all modern engineering is dependent upon the rock drill, which, in addition to general use in America, is found at work in the mines of Europe, Australia, South Africa, South America, Mexico, Japan, and in fact keeping pace with the advance of civilization. Perhaps a better statement is that in recent years the rock drill indicates the advance of civilization. It is estimated that one medium sized rock drill will do the work of 12 men, and will drill, depending upon the hardness of the rock, from 20 to 150 lineal feet of hole per working day. The motive power employed is compressed air or steam, though electricity has been tried. Except for outside work, where steam can be used, experience demonstrates that air is far more economical and satisfactory. The air used to drive the drills is worth in ventilation alone, nearly the cost of the fuel required to operate the compressor. The air compressor may be situated in any location convenient for steam or water power, and air, though led in piping for one or more miles through the mine or tunnel, retains most of the pressure indicated at the compressor. The successful operation of the principal iron and copper mines is largely due to the use of rock drills. The rock drill has developed the mines of South Africa in four years to a production of $24,000,000 annually, these mines being exceptionally well adapted to the use of power drills. And such modern engineering feats as the Hoosac, Mount St. Gothard and all railroad tunnels; Hell Gate, the Niagara Tunnel, the tunnels under Bergen Hill, the Palisades, and the Croton Aqueduct, were carried to success by rock drills. These machines, with the air compressing plant to operate them, are now as indispensable in tunneling, mining and excavating, as the air brake on railroad trains.


Langlaagte Gold Mine
Johannesburg, South African
Republic.
Copyrighted 1893

THE ROCK DRILL
ON TRIPOD.

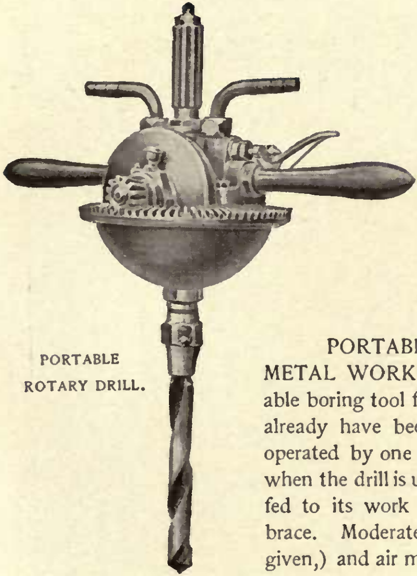
The effect of the introduction of rock drills for mining purposes is shown in Rothwell's report on The Mining Industry for 1892, p. 137. Taking the Atlantic Mine as an example, the cost sheets of different years show the cost in 1881, the year before the introduction of drills, to have been—for stoping, per fathom, 14.35, against 4.33 for 1891; for drifting, 10.08, against 4.92 for 1891. Though it is fair to state that a portion of this reduction in cost is due to the use of high explosives.

Rock drills are of varying sizes, due to the diameter and depth of holes to be drilled, mounted on tripods, columns, or shaft bars, as desired. The drilling steel, a separate and changeable piece, is an extension of the piston rod, and strikes from 400 to 800 blows on the rock per minute, depending upon the size of the machine. The mechanism is simple but strong and durable, consisting of a cylinder containing a long pis-



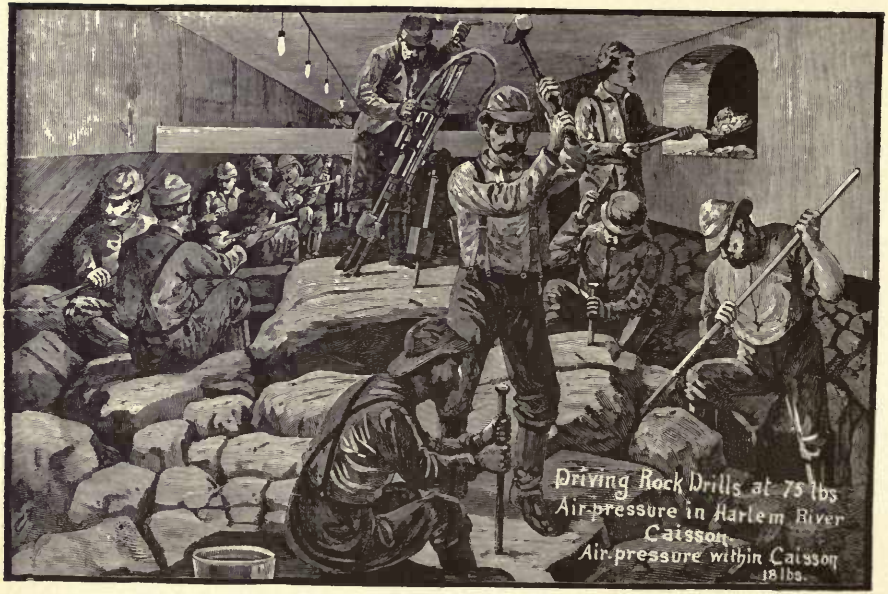
SECTION OF A MINE, SHOWING SHAFTS, DRIFTS, WINZES, SHAFT HOUSES, ETC.

ton, the extension of which carries a chuck that holds the drill steel. The valve admitting air to each end of the cylinder is operated either by mechanical or pressure connection with the main piston. A suitable device causes the piston, and thus the drill steel, to rotate while drilling, a necessary feature in drilling rock. A long practical experience has been necessary to bring the design of the rock drill to its present perfected state, as the nature of its work is most severe. Several styles of compressed air drills compete for public favor, but they do not vary essentially in principle from the above description, which may be taken as representative.



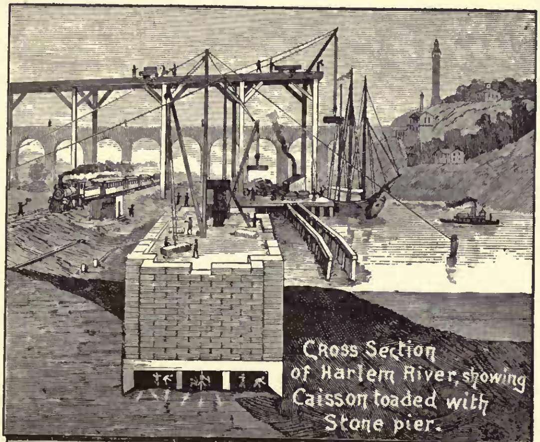
PORTABLE ROTARY DRILL.

PORTABLE COMPRESSED AIR ROTARY DRILL FOR METAL WORKING.—Compressed air is now used to operate a portable boring tool for drilling holes in metal and for reaming holes that already have been punched. For reaming, the drill is handled and operated by one man, no brace being required, which is not the case when the drill is used for drilling holes in solid plates. The drill is then fed to its work by a hand wheel between the cylinder and arm of a brace. Moderate air pressure operates this drill, (of which a picture is given,) and air may be conveyed in one-inch rubber hose.


Driving Rock Drills at 75 lbs
Air-pressure in Harlem River
Caisson.
Air-pressure within Caisson
18 lbs.

DRILLING AND WORKING IN CAISSONS.—In a closed chamber like a caisson, the replacing of foul by pure air is almost impossible by natural means, and as the condition of the men depends directly upon the purity of the air they breathe, it is of vital importance to preserve it in its normal state and prevent pollution. The bridge which spans the Harlem River at One Hundred and Eighty-First Street, New York, presented interesting engineering problems during the course of its construction, of which the most perplexing was the sinking of the caisson along an incline of rock. Borings showed that fifteen feet from the surface of the water the eastern edge of the foundation would encounter rock, sloping downward at a sharp angle toward the center of the river, while on the rock lay the soft mud of the river bed. Thus, during the greater part of its downward course, the caisson rested upon rock, mud and sand. To sink it vertically, therefore, was extremely difficult, as there was a constant tendency to shift sidewise toward the channel. Within this caisson it was found necessary to work and drill for blasting, by compressed air.

The bottom of the caisson was 54 feet wide by 104 feet long, the top being one foot less. The roof was six feet thick, and constructed of pine timbers one foot square, the layers running differently. The walls, which were three feet thick, were made also of pine. The inner portion of each wall was bevelled off to form a shoe, or cutting edge, which was nine inches wide, protected by an oak strip. The outside walls were covered with a three inch sheathing, and the interior was sheathed also. From the botton of the shoe to the top of the caisson measured 13 feet, the interior being seven feet in height. Longitudinal partitions cut the chamber into three compartments, two feet thick by five feet high, with suitable openings. The supply lock, through which passed the excavated material and all supplies, was in the center of the roof. The shaft of this lock


Cross Section
of Harlem River, showing
Caisson loaded with
Stone pier.

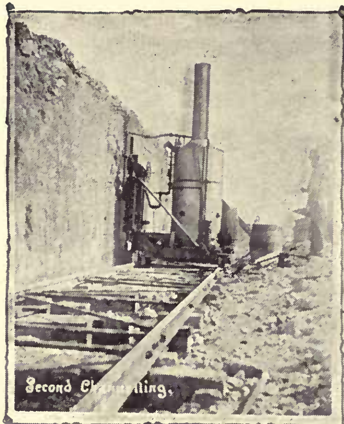

THE HARLEM BRIDGE AS IT NOW APPEARS.

was five feet in diameter and extended above the surface of the water. To the bottom of the shaft, which just entered the chamber of the caisson, was attached a rectangular air lock, provided with doors at two opposite sides, which permitted loading and unloading at once. At the botton of the shaft was a third door, and when the two inner doors were closed the pressure of the air admitted to the lock was made to equal that in the caisson, and the shaft door was then opened ; after which excavated material was hoisted to the top. The lock for the workmen was in the top of the shaft, extending through the roof. It was 12 feet by 4 feet, provided with a closed chamber at each end.

The same air compressor which supplied the pure air to the workmen within the caisson furnished also the power to operate the drills, about 75 pounds pressure being required for the drills and 18 pounds in the caisson. After each blast the loose material was extracted from about the shoe, permitting it to settle, and as the caisson descended the masonry of the pier was added on top.

DRILLING IN CANALS—THE CHICAGO DRAINAGE CANAL.—The use of compressed air to operate rock drills, hoisting engines and pumps is well nigh universal in the mines of the United States, and is elsewhere described. Its application for operating the same machines when used on the surface of the earth in rock excavations, is not as common as the economy effected by the concentration of boiler power well warrants.

There is, however, a work now under construction in the United States—a notable public work—in which most of the small engines, above referred to, to the number of over one hundred, are satisfactorily operated by compressed air. Before the erection of the compressor plant the contractors were in much doubt as to the economy of the project, but their experience has proved to be in favor of the concentration of power in this manner. The work referred

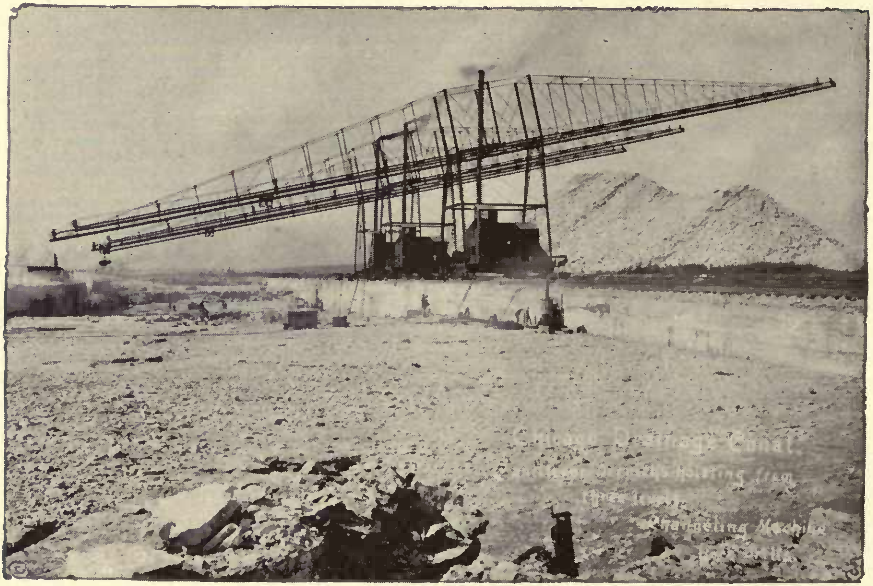


CHICAGO DRAINAGE CANAL.

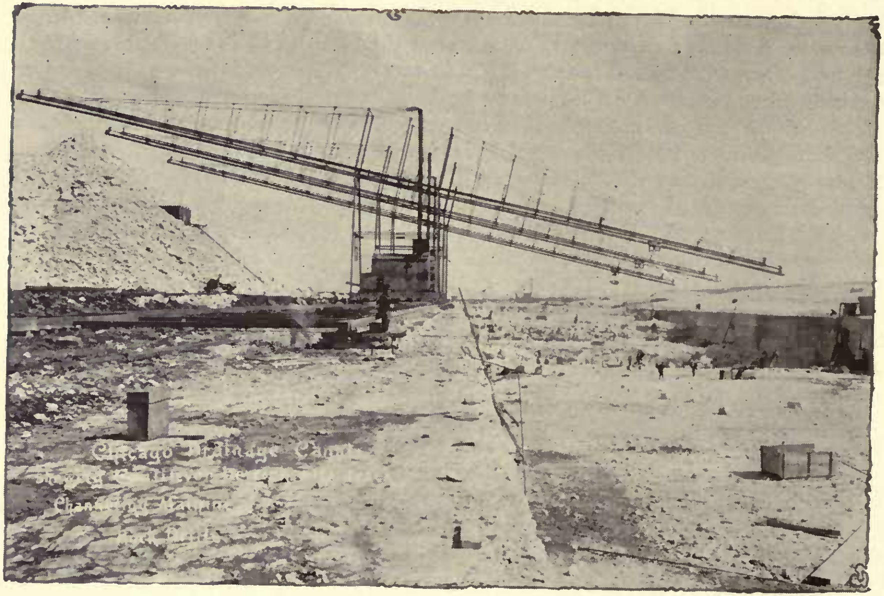
From photographs of the preliminary work.)

to, is known as the Drainage Canal of Chicago, Illinois, and while the work is one of so great magnitude that were it located in other countries it would have attracted great attention, yet it has been quietly started during the past year and the progress on a goodly portion of it has been very marked, being up to the time contracts, in the most difficult portions. The work is of so important a character that while the large engines are run by steam direct, yet compressed air is used to so great an extent as to justify a general but brief description of the work in this book. It has been the aim of the writer to give no more than a popular description of the different uses of compressed air, in so small a volume, and he will not depart from this practice in describing the Drainage Canal, pointing out briefly the general purpose and general features of its construction as seen by him in his visits, and as explained by Mr. L. E. Cooley, Civil Engineer, its most persistent projector.

The canal is primarily designed for drainage of the City of Chicago and vicinity through the Illinois and Mississippi Rivers, and ultimately to connect the Lakes with the Gulf of Mexico for the navigation of vessels, and in this its projectors are far seeing in their plans for the advancement of Chicago. The work is carried on under a law of the State of Illinois, which provides for a commission to take lands, raise money and make contracts. The cost of construction is borne by the City of Chicago. Cities less enterprising might well hesitate before assuming such a responsibility, but the former's enterprise will carry it through speedily and cheaply. The progress already made (October, 1893,) fully justifies the making of this prophecy, and the writer further prophesies that in its speedy construction it will be the forerunner of other important water-ways in the United States. In fact, it seems to him to be the " object lesson " or preparatory school for the construction of the canal at Nicaragua. The canal is now being built between Chicago and Joliet, a distance of about thirty-two miles, twelve miles of which is through rock, ten through clay, ten through a mixture of clay


Drainage Canal
Channeling Machine

and "indurated earth" and rock. In order to make this work practical it has been found necessary to excavate six miles of rock, two hundred feet wide, six feet deep, in which the Desplaines River is to be turned. This portion is about completed. The amount of rock excavation is about 14,000,000 yards, and earth about 36,000,000. The prices are moderate, but remunerative to the enterprising contractors, who have adopted modern methods and machinery. The canal, through the rock sections, is to be about one hundred and sixty feet wide and about thirty-two feet deep. The excavation is made in three benches, eleven feet each. Channels, ten feet deep, are first made by percussion channelling machines on each side of the canal, then the eleven-feet holes that have been bored about ten feet apart, are blasted and the rock lifted in kibbles and dumped at one side of the canal. When sufficient space has been cleared on the first bench, the second is channelled, drilled and blasted, and after that the third level is treated in the same manner. At one point, seen by the writer and illustrated herein, the three benches are close to each other. The means for channelling, drilling and blasting have been so improved in recent years, that this work proceeded in advance of the hoisting from the pit, and it remained for some one to devise and adapt a speedier and cheaper method of handling the rock than by carts or cars commonly used (although the latter is a speedy method for the first level.) This requirement is met in the cantilever hoisting apparatus shown in the accompanying illustrations, which was designed by the same parties that have so successfully applied a somewhat similar principle to the machinery for the transfer of iron ore from the lake boats and barges to the railroad cars at Cleveland, Ohio, and other places. This device, as adopted for the canal work, allows the use of large buckets, or kibbles, having one open side, to be so placed in relation to the broken rock as to avoid the necessity of high lifting of the rock in loading. This fact increases the work of each man in the pit about 30 to 40 per cent., as compared with the high lift to the ordinary con-

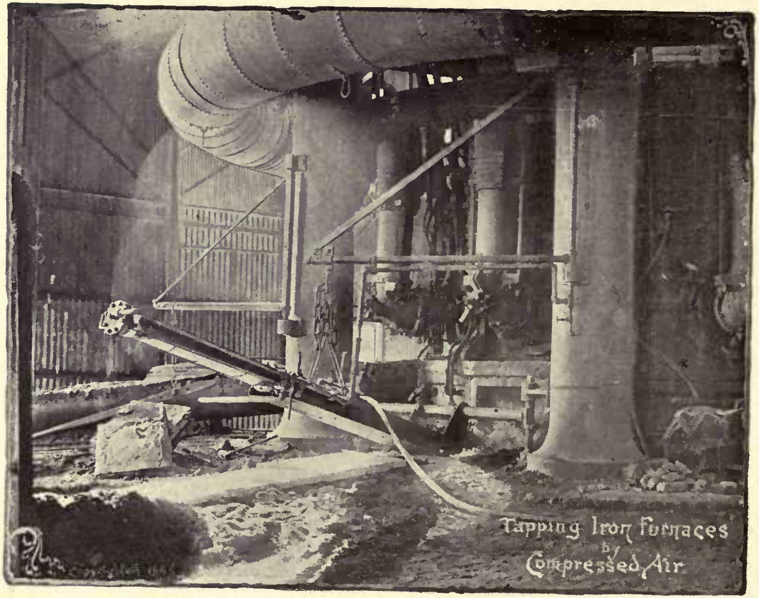

Chicago Drainage Canal

tractor's car, so that a few men make a large output of rock. The device also allows of a high dump, which is a marked advantage. At this writing, three cantilevers at one section are raising and dumping about 1,200 yards of rock in ten hours. The capacity for hoisting and dumping of the cantilever is said to be much greater than that, but it is limited by the power of the laborers to fill the buckets. The manufacturers of the cantilever express the opinion that the practical working capacity will yet be increased 40 to 50 per cent.

Perhaps it may be necessary to give a description of the cantilever, although the cut would seem to indicate its operation. Briefly, four tracks are laid laterally along one side of the canal. On these tracks are the four trucks on which rests the support of the cantilever. The motive power for moving the cantilever along the track, is inside the cantilever supports. The kibbles, when filled, are hoisted rapidly, traversed to the rear of the cantilever, and dumped. The kibble is speedily returned to the pit and another one raised. The lateral travel of the whole structure, and transverse and hoisting motion of the kibbles, controlled by one operator, enables him to lower the empty kibbles to the exact point desired.

The preliminary work of excavation was done by horses attached to carts, and by cars operated by the rope haulage system, the engines having been stationed on the bank and operated by compressed air. Page 26 illustrates the method adopted and also the channelling machine making a second cut of 11 feet. This novel method of making a rock cut canal by channelling the sides originated in the United States, and is a very important improvement, saving as it does the necessity of masonry sides where the rock is not much broken.

TAPPING IRON FURNACES BY COMPRESSED AIR DRILLS.—With the increase of furnace capacity and the enlarged "hearths" in modern furnace plants, the labor and danger



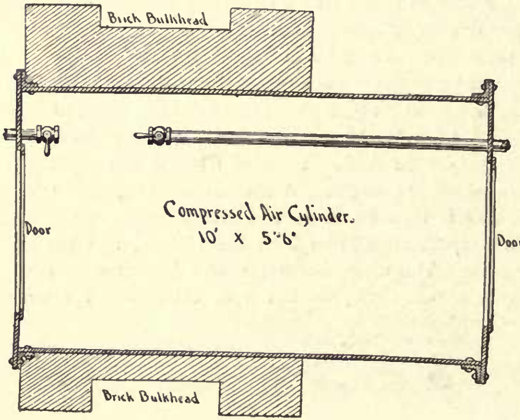
Tapping Iron Furnaces by Compressed Air

attendant upon opening and closing the tapping hole (the orifice from which the molten metal flows out), have considerably increased. In old-fashioned furnaces of small capacity these operations were speedy and unimportant. Any material, such as brick or clay, and three or four minutes of time, sufficed, but at present, fire clay and graphite are used, and instead of one ball, from three to five wheelbarrow loads are required.

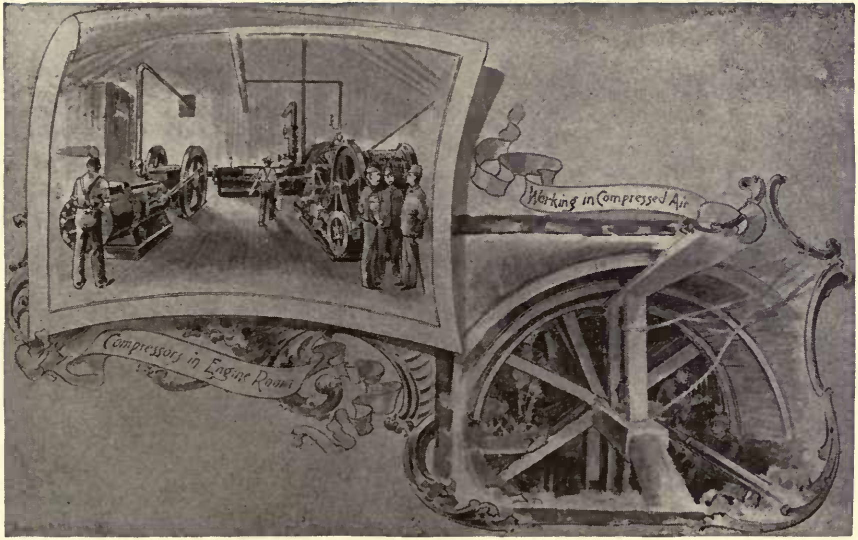
To open the furnace at casting time, one of these deeply stopped iron notches requires the labor of eight or ten men, drilling with a heavy bar for half an hour, or longer. The recent introduction of rock drills operated by steam or compressed air has resulted in a thoroughly successful method of tapping furnaces. Between two columns near the furnace, a horizontal cross bar is swung, so fitted that it can be raised or lowered ; to this bar is attached a frame consisting of two parallel irons (the other end of the frame being suspended by a chain) and upon this frame as a bed the drill travels, the latter being equipped with a tubular rod which takes the place of an ordinary hand screw, and forms the piston rod of a cylinder for feeding the drill forward or backward, as well as the pipe for admitting the air to the operating cylinder. When it is time to cast, the frame is lowered to the proper position, and the drill is then advanced and set to work. As soon as molten iron is reached, the bit of the drill is rapidly withdrawn from the taphole, and the latter now being open, the drill is swung up or aside. This method is not only a labor saving device, but it has been found that as the drill cuts a true circle, the hot iron and cinders are not so destructive.

USE OF COMPRESSED AIR IN SOFT GROUND TUNNELS.

THE importance of compressed air in caissons has already been described. Its use, however, is equally necessary in working through the decomposed rock and mud (known as soft ground tunnelling) sometimes encountered in sub-aqueous tunnels. The construction of the tunnel under the East River and Blackwell's Island, extending

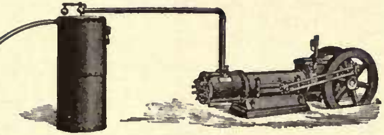


from East 71st Street, New York, to Ravenswood, L. I., presented serious engineering difficulties which have been overcome partly by ingenuity and partly by the use of air at a high pressure. The tunnel is being built in anticipation of a law excluding gas manufactories from New York City, and is designed to convey gas from the Ravenswood works to New York. It is ten feet in diameter, and when completed will be 2,500 feet in length. The work was begun about a year and a half ago by sinking a shaft at each end—that at the New York end being 141 feet in depth, that at


Working in Compressed Air
Compressors in Engine Room

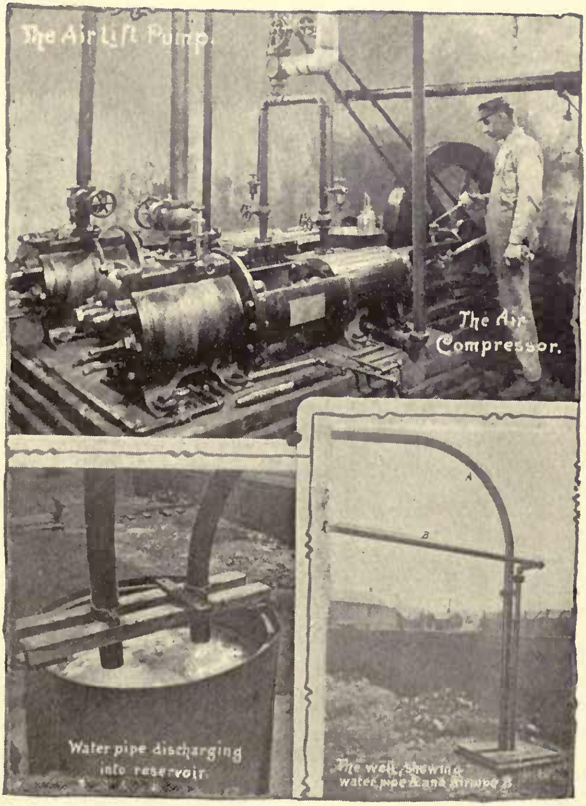
Ravenswood, 134 feet. The tunnelling began at a depth of 124 feet below the surface of the river, and 60 feet below the bed. The tunnel itself was advanced by forcing a cylindrical shield of steel plates through the soft mud. The shield is moved by twelve hydraulic jacks, with a combined power of 600 tons, and its advance packs the mud so tightly that it is readily excavated by the workmen within the shield.

The use of compressed air in this tunnel is two-fold. As in all caisson work, it is necessary to constantly replace foul air, but in this tunnel it is also necessary to employ a high pressure to aid in sustaining the walls of the tunnel during construction. The air pressure is therefore over three atmospheres (48 lbs.) In this pressure the workmen are able to remain but two hours at a time—six hours constituting a day's work, of which four hours are spent in the tunnel and two in the atmosphere. It is necessary for each workman to be examined by a physician before being employed, as the air pressure would kill any but the most robust. Four workmen have died from the effects of the pressure, due, it is claimed, to carelessness in coming too quickly from artificial pressure to the atmosphere. The change is made by means of air locks. The lock, of which a section view is given, begins in a brick bulkhead and terminates within the tunnel entrance. It is ten feet high by five and a half feet long. Atmospheric or tunnel pressure is secured by the usual arrangement of pipes and stop cocks, readily understood. The tunnel advances about five feet a day, and is now nearing completion.



THE AIR LIFT PUMP.

THE recently patented system of moving fluids automatically, consists of an air compressor and reservoir to contain the compressed air, the needed adjusting cocks, foot pieces, and the tubing to convey the compressed air and the water. The operation of the pump is so simple that it can be understood readily from the cut. Compressed air is led into the artesian well and is liberated into the lower end of the water pipe. The upward movement of the air first carries up all the water in the pipe and the air then arranges itself automatically in layers with the water, delivering the latter at the surface. The compressed air is said to form a leakless piston, expanding as the upward pressure diminishes, which completely dispenses with plunger, rods, bucket, suction, foot and discharge valves. In fact, there are no ordinary pump parts whatever. The presence of mud, sand, and other obstructions usually so troublesome to pumping machinery, does not affect the compressed air pump, as the greater power supplied forces every obstacle to the surface. The water is delivered cooled by the air expansion, and thoroughly aerated.



The Air Lift Pump.

The Air Compressor.

Water pipe discharging into reservoir.

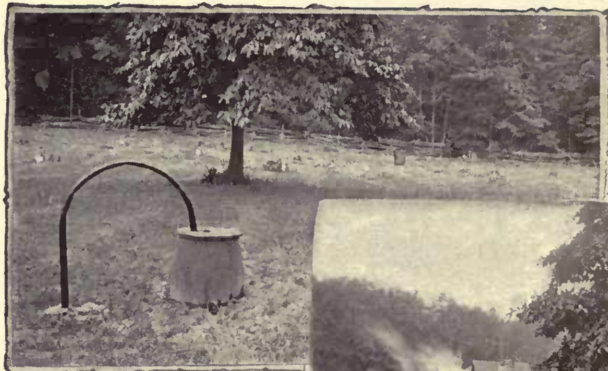
The well, showing water pipe A and air pipe B.

THE RELATION OF COMPRESSED AIR TO THE WATER SUPPLY OF CITIES AND TOWNS.—The cut showing the water works at Wayne, a suburb of Philadelphia, is an interesting exhibit of the new method of securing water by means of scattered, driven, or artesian wells, operated from a central source of power by compressed air.

The water is lifted by the method already described to a sufficient height to allow it to run back to the compressor house by gravity, where it is gathered from thirteen different wells, in some instances 2,000 feet apart. It is then forced by special means through the distributing pipes to the houses of the town. This method gives life and sparkle to the water, and oxidizes the impurities while it is being pumped. The effect of aerating water is elsewhere described at greater length. (See Aeration.)

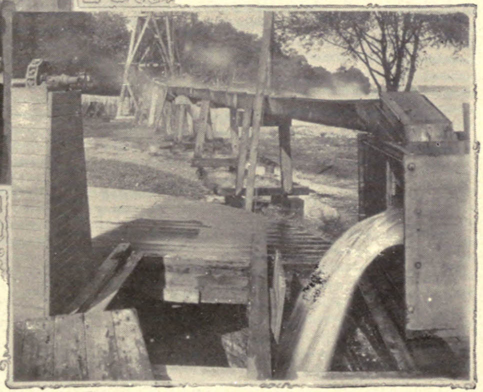
In the accompanying cut of the Wayne Water Works is shown the "picking up" of water from isolated wells in both high and low ground. In the low ground the barrel into which water is delivered by the air pressure, is shown as resting on a rough structure at sufficient height to allow the water to run back to the station house by gravity, and in the higher ground the barrel is shown as partly buried. The air pipe and return water pipes are not shown, being underground.

Pumping by compressed air has been successfully employed at Rockford, Ill., where the output of city water from Artesian wells has been enormously increased. An accompanying illustration shows part of the Rockford plant.

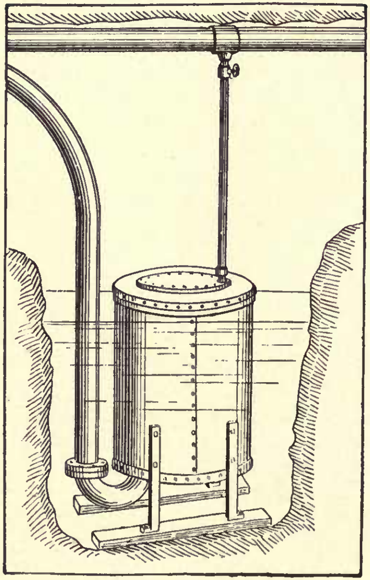


Town Water Works, Wayne, Pa.
Obtaining water from scattered wells by the Air Lift Pump.

These illustrations show two views of the discharge of a conduit leading from a flowing artesian well which was increased five-fold in its discharge by the use of the Air Lift Pump.



VIEW OF WATER WORKS
AT ROCKFORD, ILL.



THE AUTOMATIC PUMP.

A pump operated by direct air pressure has been devised to force water from wells and pits. It consists of a tank with an air valve at the top and a water valve at the bottom. The water rising in the tank carries upward a device to automatically close the water inlet and operate a valve by which compressed air is admitted. The pressure thus produced forces the water out of the tank and delivers it wherever desired. As the water descends, a device at a certain point automatically operates the air and water valves, reversing the process.

Recent improvements have been made upon the old devices, which ensure continuous and automatic action and allow of operation until the water is entirely exhausted from the swamp or pit in which the tank is placed.

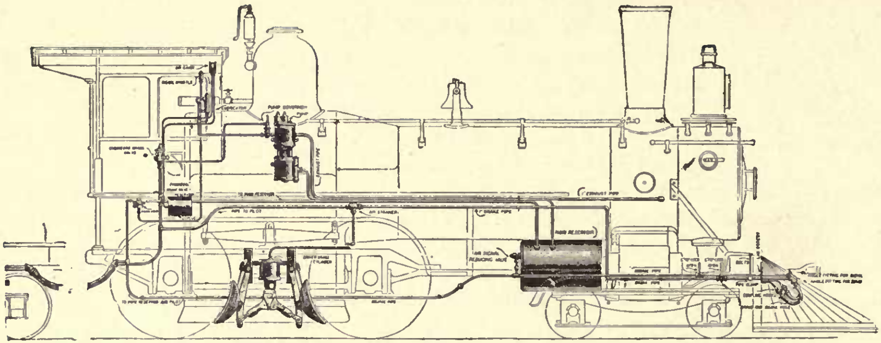
DRIVING PUMPS BY COMPRESSED AIR.—In most mines where compressed air is employed to operate drills, this power has been substituted for steam in driving pumps. A mine owner recently declared that the incidental value of compressed air in preserving timbers and walls, was alone equal to the value of steam.

THE AIR BRAKE.

WHILE there are several systems of air brakes, the perfected compressed air brake which is in most general use on railway locomotives and cars, is the Westinghouse quick action automatic brake. Compressed air, supplied by a steam engine and compressor, is stored in a main reservoir on the locomotive, and led by the main or brake pipe to the engineer's brake and equalizing discharge valve, and thence along the train, supplying the auxiliary reservoir on each car with air. From this reservoir the brake cylinder is supplied for application of the brakes.

The automatic action of the brake is due to the construction of a triple valve, which is connected with the main train pipe, to the auxiliary reservoir, and brake cylinder. It is operated by the variation of pressure in the brake pipe (1) to admit air from the auxiliary reservoir (or under certain conditions from the train pipe) to the brake cylinder. This applies the brakes, and cuts off communication from the main train pipe to the auxiliary reservoir, or (2) to restore the supply from the train pipe to the reservoir, at the same time letting the air in the brake cylinder escape, thus releasing the brakes.

The primary parts of the triple valve are a piston and a slide valve. A moderate reduction of air pressure in the train pipe causes the greater pressure of the air stored in the auxiliary reservoir to force the piston of the triple valve and its slide valve to a position which will allow the air in the auxiliary reservoir to pass directly into the brake cylinder and apply the brake. A sudden or violent reduction of air in the train pipe produces the same result, and in addition causes supplemental valves in the triple valve to open, permitting pressure from the train pipe to enter, and

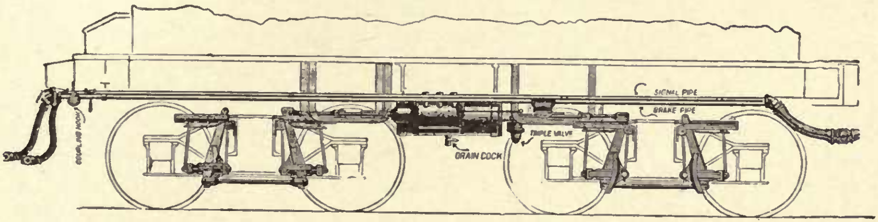


APPLICATION OF AIR BRAKE TO RAILWAY LOCOMOTIVES.

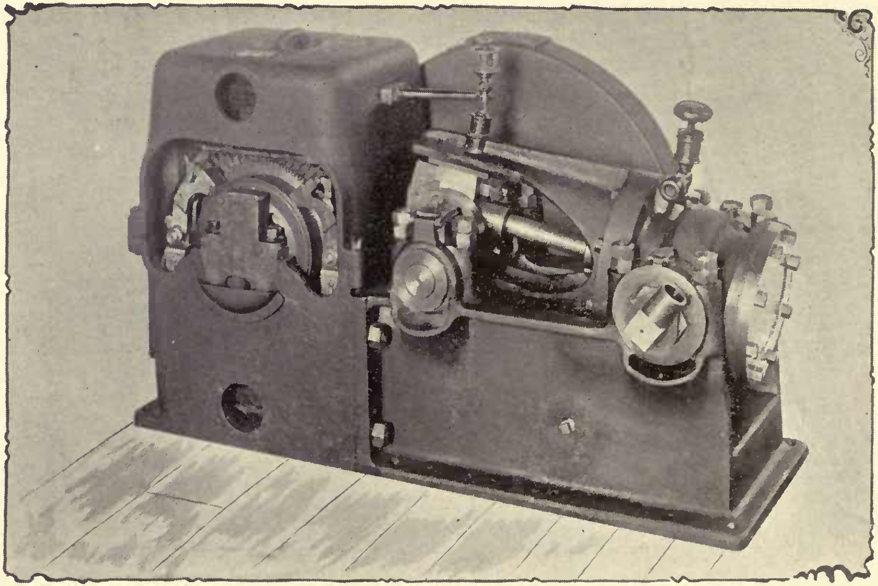
augmenting the power of the pressure derived from the auxiliary reservoir about 20 per cent., producing instantaneous action of the brakes at their highest efficiency.

As soon as the pressure in the brake pipe is restored to an amount in excess of that remaining in the auxiliary reservoir, the piston and slide valve are forced back to their normal position, opening communication from the train pipe to the auxiliary reservoir, permitting the air in the brake cylinder to escape to the atmosphere, thus releasing the brakes. If the engineer desires to apply the brakes, he moves the handle of the engineer's brake valve to the right, which first closes a port, retaining the pressure in the main reservoir, and then permits part of the air in the train pipe to escape. To release the brakes, he moves the handle to the extreme left, which permits the air to flow freely from the main reservoir into the brake pipe, restoring pressure and releasing the brakes. In every car there is a cord which, if pulled, opens a valve in the brake pipe and thus applies the brakes. The same action occurs in case the cars accidentally break apart from each other. The automatic application of the brakes by any reduction of pressure in the train pipe, forms one of the most ingenious and effective safeguards in modern railway appliances.

In the safe and effective operation of railroad brakes, compressed air stands alone. Until very recently, however, its use has been confined to steam railways, but the increasing employment of trains of high speed electric cars has required the use of the air brake. At the recent Columbian Exposition, the brakes upon the Intramural Electric Railroad were operated by air, which was compressed by individual pumps on each train, receiving power from special electric apparatus. The



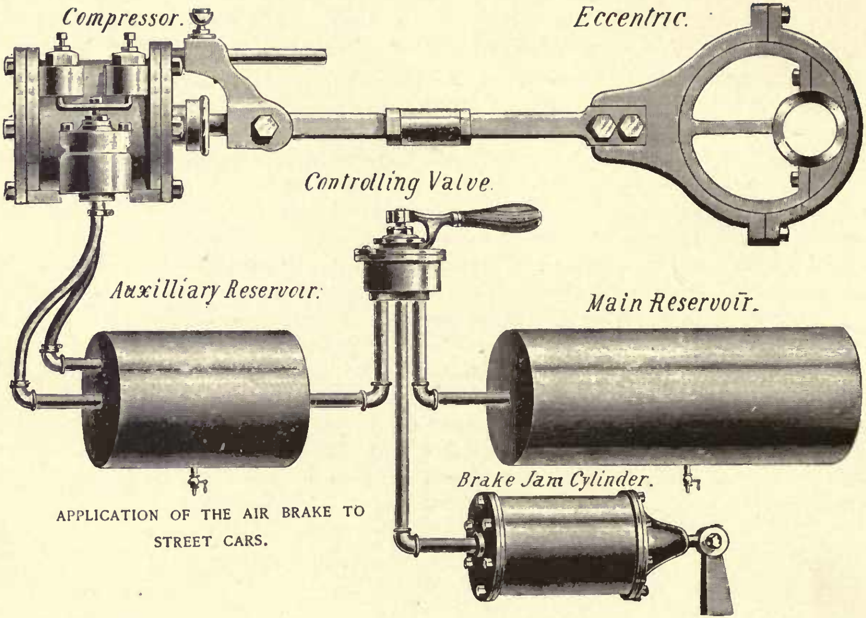
LOCOMOTIVE TENDER, SHOWING APPLICATION OF THE AIR BRAKE TO CARS.



AIR BRAKE MOTOR USED UPON THE INTRAMURAL R. R., COLUMBIAN WORLD'S FAIR, CHICAGO, ILL.

air fixtures were similar to those in general use on steam locomotives, but in place of steam fixtures an electric motor was arranged, operating automatically. Whenever the air pressure reached 60 pounds (the pressure carried) it became sufficient to operate a rheostat and check the motor, and when sufficient leakage had occurred, or the use of the brake had reduced the pressure, the motor started again, automatically.

AIR BRAKES IN STREET CAR SERVICE.—The increasing use of heavy and high speed cars in street car service, whether the motive power be electricity or cables, seems to make the application of the air brake, even to single cars, a logical necessity, as under those conditions the manual labor and attention required by the hand brake are so great that the motorman is not able to keep his car under control without the utmost exertion. The principle of the air brake has been successfully adapted to street car service. The air is compressed by attaching an eccentric to the axle of the car. About forty revolutions suffice to fill the reservoirs with air at a pressure of 32 pounds. Having attained that pressure, a governor cuts off in such manner that the piston stops working against pressure, and operates in free air as long as the reservoir gauge indicates 32 pounds pressure. The motorman applies the brake by simply turning the controlling valve, and but three pounds of the storage pressure are required for each application. When the brakes are released and the car is started again the piston once more operates against pressure to restore the reservoir pressure to 32 pounds, but by an automatic arrangement this does not begin until the car has gathered headway, and then but five turns of the wheel are required.



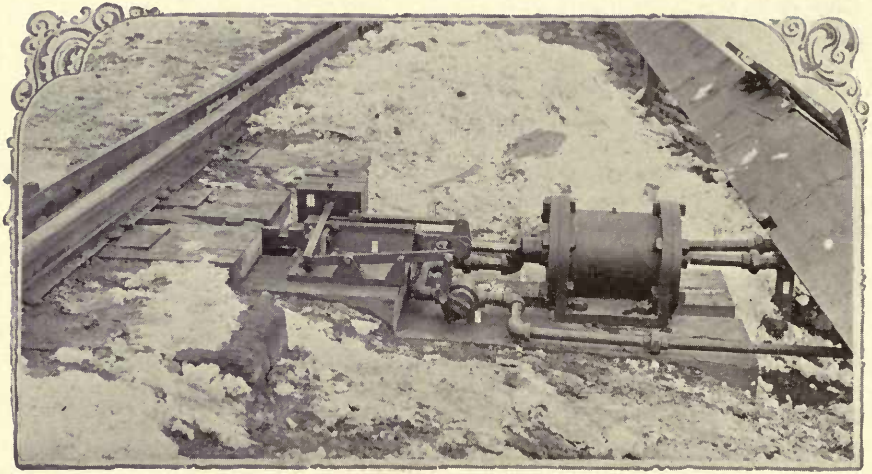
APPLICATION OF THE AIR BRAKE TO STREET CARS.

COMPRESSED AIR SAFETY APPLIANCES FOR RAILROADS.

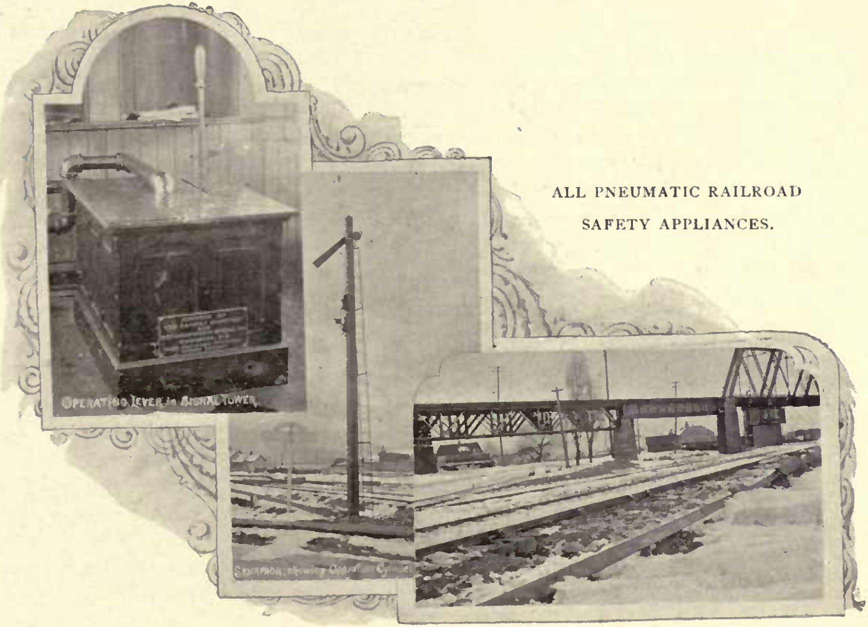
THE system of interlocking switches and signals recently introduced at Buffalo, N.Y., on the Delaware, Lackawana and Western R. R., at its crossing of the Western New York and Pennsylvania R. R., is notable for its dependence upon compressed air solely for the whole operation of signalling a switching, without the intervention of any intermediate agency. The movement of a lever at the central station admits air to pipes which lead directly from the reservoir to the cylinder moving the switch and signals. One set of pipes leads to the front end of the operating cylinder and another set to the rear end. The illustration shows the operating cylinder with its piston rod connected with the switch bar, with suitable interlocking devices.

In this illustration the switch is open, and air has been admitted to the rear end of the operating cylinder by means of the pipe 7. When the operator changes the position of the lever, the air is exhausted from pipe 7 and admitted to pipe 5 and passes to the forward end of the cylinder, and the piston is forced backward until the switch is closed. Then the locking bar 1 drops into a notch in the connecting rod which locks the switch in place. This operation of the locking bar operates the semaphore controlling valve 2. This valve being open when the switch is locked, the air passes through it to the semaphore that guards the switch and sets it to "safety."

In the reverse operation the air is exhausted from the pipe 5 and turned into the pipe 7. This forces the piston forward, the first part of the movement forcing a wedged-end bar under the locking bar 1, lifting it out of the notch, thus closing the valve.



ALL PNEUMATIC RAILROAD SAFETY APPLIANCES.



ALL PNEUMATIC RAILROAD SAFETY APPLIANCES.

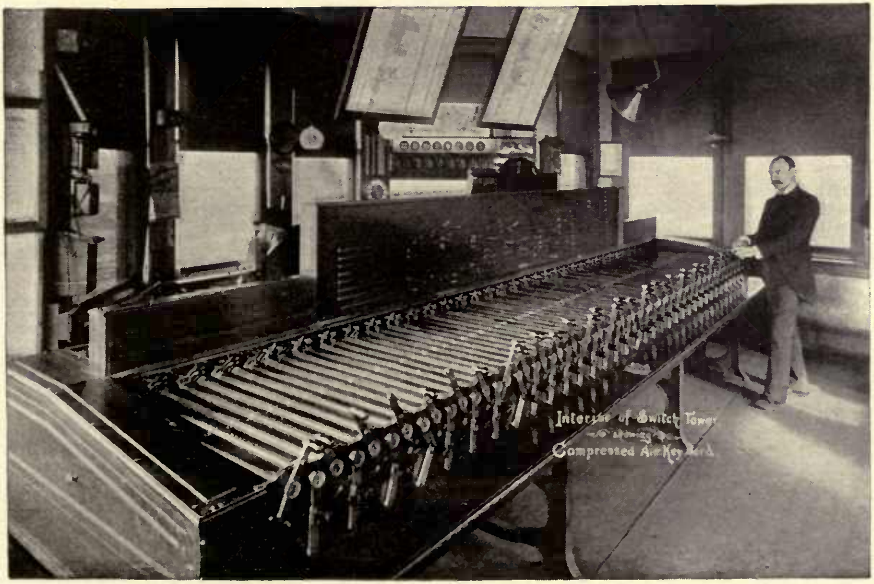
The continued movement of the piston forces the switch open. The signals are held in "safety" position by the pressure in their cylinder.

When the pressure is released a counter weight draws the signal back to "danger." It is found in practice that a comparatively low pressure of air is sufficient for operation of this system and the low pressure is thought to be favorable to the prevention of condensation and freezing.

PARTLY PNEUMATIC SWITCH AND SIGNAL SYSTEM.—The operation of railway signals and switches from a central point or tower, with the well-known interlocking features of such systems, is successfully accomplished by compressed air, in which that is the motive power, controlled by small valves, which, in turn are controlled by electro-magnets. This method has the advantage over systems operated directly by heavy levers, and rod and wire connections, in the saving of manual labor, space required in operating towers, and having no practical limit to the distance away a switch may be operated.

The air compressing plant required, is a steam generating boiler, an air compressor, and a condensing tank through which the air must pass before entering the main air pipe. This deprives the air of moisture which it may have had originally, or collected in the process of compression, and prevents its accumulation in the valves and cylinders of the system, where it might interfere with their operation.

Each signal blade is connected directly to a small compressed air cylinder, the pressure to which is controlled by a small valve, and the air supply is obtained from a cylindrical tank placed at the foot of the signal post, kept stored from the main supply pipe ; consequently, all signals have, at all times, the full pressure of compressed air right at their cylinder valves. The small pot or drilling signals are connected in like manner to a small cylinder, and operated in like manner ;


Interior of Switch Tower
Compressed Air Key

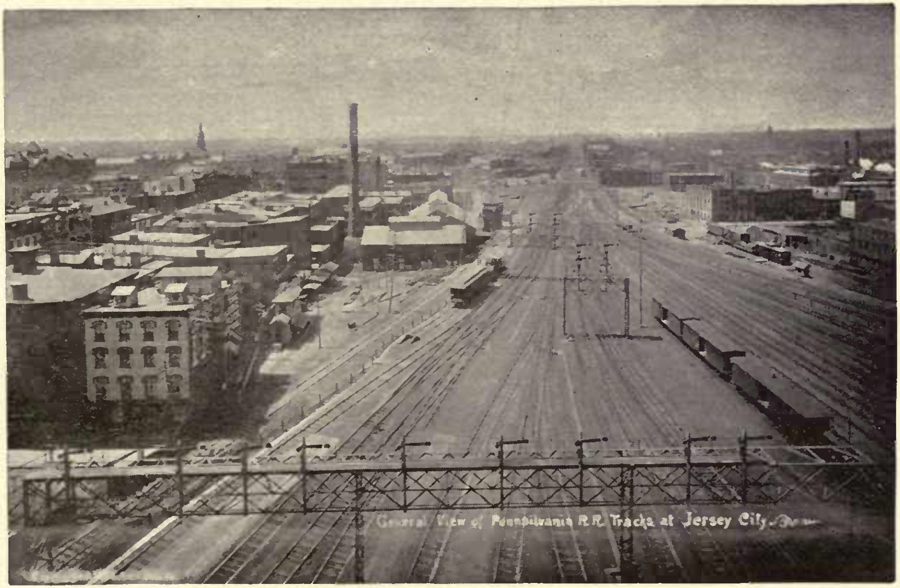
both signals standing normally at "danger" position by means of a counter weight and spiral spring respectively, and held at "safety" position only when pressure is admitted to the cylinders.

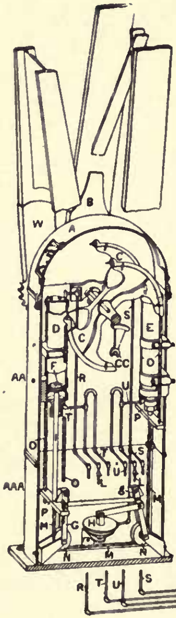
The switches with their locking attachments are controlled and operated by a long double acting cylinder secured to the ties, the air pressure being governed by a valve also operated by small compressed air pipes leading from another small controlling valve placed directly in the signal tower. In case of a long distance between the controlling and cylinder valves the small compressed air pipes are filled with water in summer and with alcohol or some non-freezing liquid in winter, which being non-compressible is moved like a solid rod, by the admission of the air upon it, and obviates the waste of air otherwise occuring each time the pipes must be filled and released, in operating the cylinder valve. Automatic means are provided for restoring the loss of water in case of leakage.

The controlling valves of these signal and switch cylinders are operated by electro-magnets, connected with a complete electrical indicating and interlocking switch board located in the signal tower, where, as in all such systems, a switch cannot be thrown until it is fully protected by the setting of the proper signals first, and then cannot be returned to place until the train that has entered upon it has passed over. (See cuts of switch tower, and tracks.)

All these operations are accomplished by the movement of small keys which instantly make or break, as desired, the electrical circuits controlling the compressed air cylinders attached to signals and switches, which in turn are acted upon immediately by the air pressure.

To cite one example of operation in a railroad yard tower in 1888, the highest number of movements in 24 hours was 1,500, and the highest number in one hour was 86, operated by one man.


General View of Pennsylvania R.R. Tracks at Jersey City.

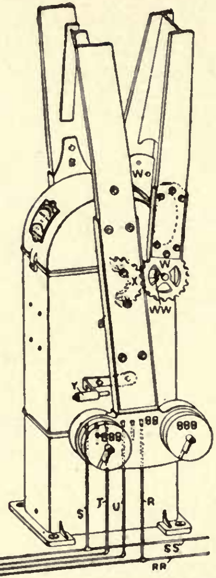


THE RAILROAD GATE.

The use of compressed air for raising and lowering the gates at crossings of railroads is now generally practiced. It is a good illustration of the substitution of air power, easily carried and applied at many and distant points, in the place of numerous mechanical devices liable to get out of order.

The cut shows the operation of the system, except the compressor, which may be operated by hand power either at the time the gates are to be raised or lowered or the power may be obtained from a reservoir of air previously compressed and kept on storage.

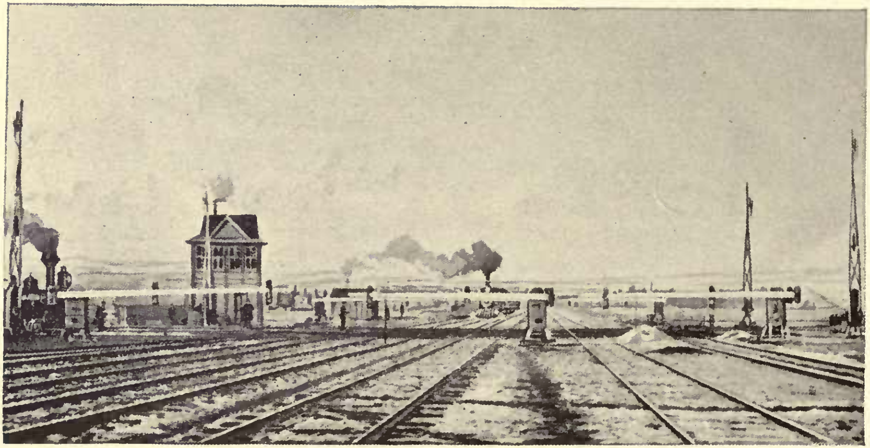
Another cut shows this system applied to the protection of a dangerous crossing of



two railroads, where the gates are closed upon one and opened for the passage of a train upon the other, by an interlocking device, making it impossible for the operator to raise the gate upon one road without closing that upon the other.

PNEUMATIC RAILWAY GATE DETAIL.

A. Cap of hollow post.
AA. Middle section of post.
AAA. Bottom section of post.
B. Gate arm casting.
BB. Cross balance casting.
BBB. Balance weight casting.
C. Chain sector.
CC. Frictionless bearing.
D. "Up" cylinder.
E. "Down" cylinder.
F. Piston head.
G.g. Locks with latch.
H. Lock diaphragm.
I. Piston rod.
L. Waste oil pipe and drip cock.
M. Chain connecting piston rods.
N. Chain sheaves.
O. Chains from piston to sector.
P. Piston cross-head.
R. Main air pipe connecting "up" cylinders in two posts.
RR. Main air pipe from "up" cylinders to pump
S. Main air pipe connecting "down" cylinders in two posts.
SS. Main air pipe from "down" cylinder to pump.
T. Tie air pipe from bottom of "up" cylinder in one to bottom of "down" cylinder in the other post.
U. Tie air pipe from bottom of "down" cylinder in one to bottom of "up" cylinder in the other post.
W. Sidewalk arm casting.
WW. Sidewalk arm pivot.
X. Sidewalk arm half gear.
Y. Bumper with spring.



COMPRESSED AIR INTERLOCKING RAILWAY GATES AT THE JUNCTION OF THE C. B. AND Q. AND CHICAGO STOCK YARDS R. RS., CHICAGO, ILL.

USES OF COMPRESSED AIR IN RAILROAD SHOPS.

SO useful have Compressed Air Hoists proved themselves in railroad shops, that they are now extensively employed over lathes, planers, drill presses and other tools, and greatly facilitate shop work. Some are permanent ; others are provided with overhead radial runs, or constructed in connection with overhead railways, the latter permitting the use of the hoist in loading or unloading all manner of freight. These hoists readily handle from 800 to 4,000 pounds ; occupy but little room, and are extremely convenient. In fact, compressed air has become such an important and useful adjunct to railroad shops and round-houses that few are now without it. Engine rooms, shops, and in many cases car yards are kept thoroughly piped, in order to equip hoists, or other compressed air appliances wherever required.

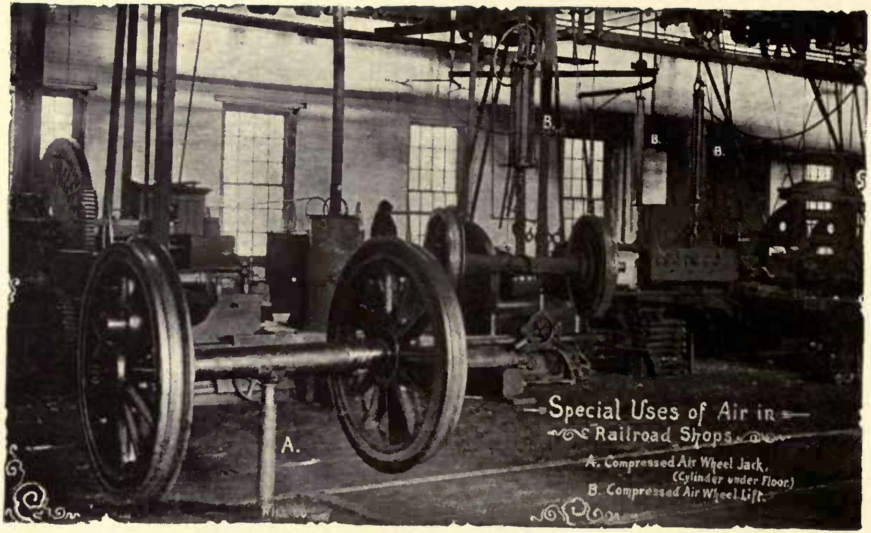
These hoists have proved themselves so valuable for all lifting purposes that their use is rapidly extending. They are much employed in cold storage warehouses to handle sides of beef.

Excellent results may be secured with a small compressed air plant. One superintendent of railroad shops, reports that two compressors with a storage capacity of about 90 cubic feet, suffice for shops caring for 85 locomotives, and also an engine house, and three hoists in the yard.

Any good quality of hose will stand moderate pressure, and can be used readily when flexible pipe is needed.

The use of hoists in shops, both from below (A) and overhead (B) is clearly shown in the cut. Hoists B are equipped with radial or track runs.

In some railway shops a compressed air punch is in operation, employed to punch holes in portions of boiler plates, which cannot be reached by an ordinary boiler shop punch. Compressed air jacks are also in constant use for car and truck work. They are applied directly to the side



Special Uses of Air in Railroad Shops.

A. Compressed Air Wheel Jack. (Cylinder under Floor.)

B. Compressed Air Wheel Lift.

sill of the car, are easily handled, and require no overhead structure or additional apparatus. One compressor supplies all the pressure required for the plant.

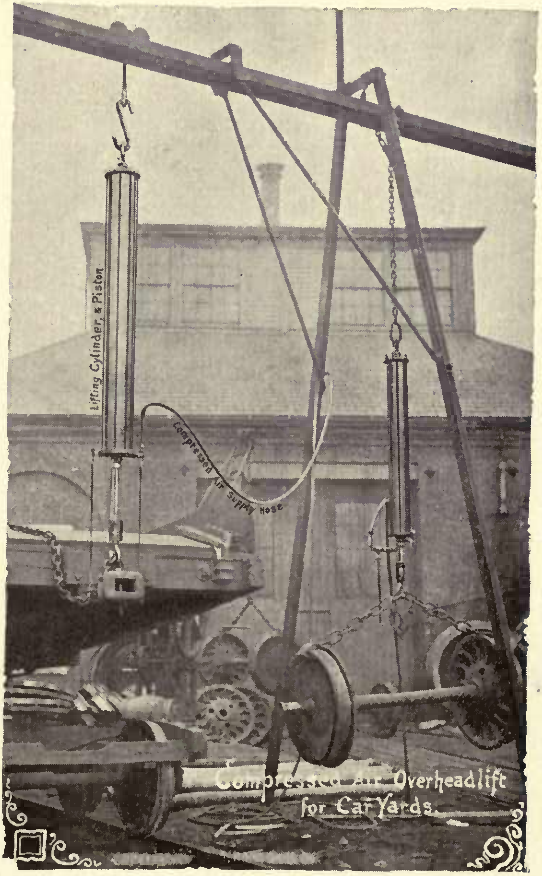
Compressed air angle iron shears are also in constant use. The only difference between the latter and compressed air punches is the actual shearing and punching parts, the frame and upper parts for each being the same. At the back, a cylinder 12 inches in diameter is mounted in a vertical position and its piston rod is attached to the long arm of a horizontal lever above it. The cylinder is designed to receive air under the piston, and a spring on the piston rod returns the parts to a normal position after the stroke is accomplished. The upward stroke is limited by a by-pass port in the side of the cylinder.

MINOR USES OF COMPRESSED AIR IN RAILROAD SHOPS.

INCREASING HEAT.—Compressed air is used in combination with gas on a blow pipe to create intense heat in small space. It is especially valuable in working upon inconveniently located parts, where fires cannot be built nor frames removed.

CLEANING STEAM PASSAGES.—In many railroad shops the steam passages and ports of new locomotives, or old ones that have been repaired, are cleaned by compressed air, instead of firing up the locomotive and using steam. The boiler is readily filled with compressed air from the shop plant, saving time, trouble, dirt, smoke and fuel. The same plant tests all parts of the air brake apparatus.

FORCING OIL FROM BARRELS.—Where oil barrels cannot be conveniently raised to the tank, compressed air may be applied to the surface of the oil, which is forced out through a hose,

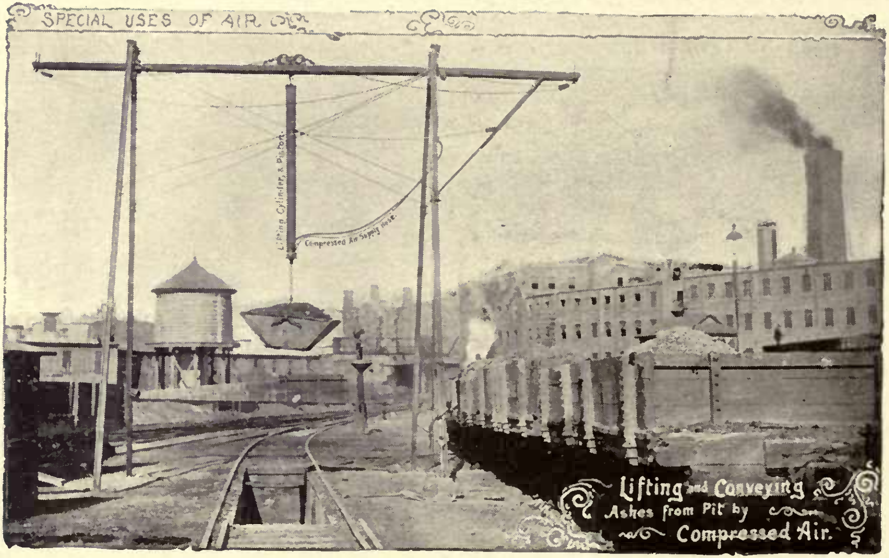

Lifting Cylinder, & Piston
Compressed Air Supply Hose
Compressed Air Overheadlift
for Car Yards.

the open end of which lies upon the bottom of the barrel. The hose passes out through the bung, at which point it is covered by a tapering sleeve, thus keeping the bung air tight. This operation is varied to drive oil from barrels through hose to any desired point. This principle is now employed by one of the sleeping-car construction companies to force up the water used in each car, and, in consequence, the water tanks are placed beneath the cars. A connection is made with the compressed air tank under the car and at the top of the water reservoir, and when the water-stop cock is open, the pressure of the air on top of the water forces it up. It is more satisfactory to employ a reducing valve between the air tank and water reservoir, the air pressure being too great for the small supply of water.

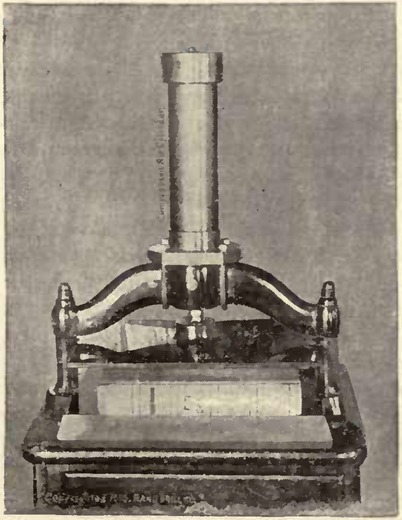
Cleaning Car Cushions.—A jet of air applied to car cushions cleans them quickly and completely, and is found to be a great saving in time and labor over the old method of beating. This method of cleaning is also frequently applied to carpets and rugs, and is widely used in London, where special machinery is employed. An extra price is obtained in that city for the careful cleaning of expensive fabrics, made possible by the compressed air process. This use of air is being constantly extended, and in some car shops cars are cleaned entirely by the application of air pressure.

Sanding Rails for Locomotives by Compressed Air.—This device distributes sand automatically upon the rails by an air blast which is put in operation when greater adhesion is required between the driving wheels and rails. The old method of delivering by valve and lever frequently resulted in too much sand or too little, in consequence of which trains were often stalled.

Compressed Gas for Car Lighting.—The recent improvements in railroad and street car lighting have come from the use of compressors, enabling the storage of considerable gas in small compass. The plant required is a small gas works located in some available place, with pipes



Lifting and Conveying Ashes from Pit by Compressed Air.



to the car yards. The plant consists of a furnace for the production of the gas, purifiers, gas holder, compressors and storage tank. From the latter the gas is drawn off to the cars, as required.

Copying Letters by Compressed Air.—The application of air to a copying press (as shown in the accompanying cut), is a serviceable device, though of course available only in the presence of a plant. The screw of a copying press is removed and an air cylinder of two inch brass tubing is substituted, attached to the original yoke of the press. The platen is returned by a spiral spring. The press is not mutilated in the least.

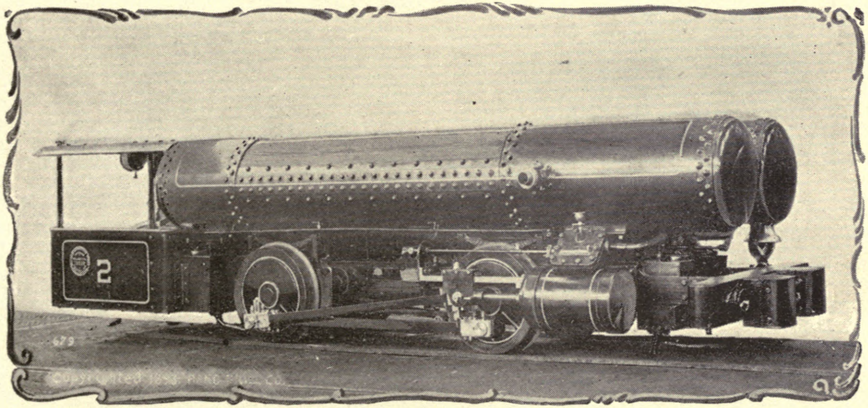
Other Minor Uses of Compressed Air are, taking the place of bellows at forges and rivet heating machines, thus dispensing with the services of blacksmiths; tripping and returning the ram of hydraulic presses; a grate shaking device; an apparatus for opening a furnace door; compressed air bell ringer motors put in operation by a touch; and drop bottom cars; to which should be added the general advantage of abating smoke, smell, dirt and heat.

COMPRESSED AIR LOCOMOTIVE.

COMPRESSED AIR offers a valuable motive power in mines where the conditions of ventilation make it inexpedient to use steam. Mines which are already supplied with compressors for ventilation can readily adapt their existing plant to the pressure required by air locomotives. A pressure of from 400 or 500 pounds to the square inch is commonly used. A compressed air locomotive is, in fact, but a storage tank on wheels, with engines equipped to convert the tank pressure into direct motion of the wheels.

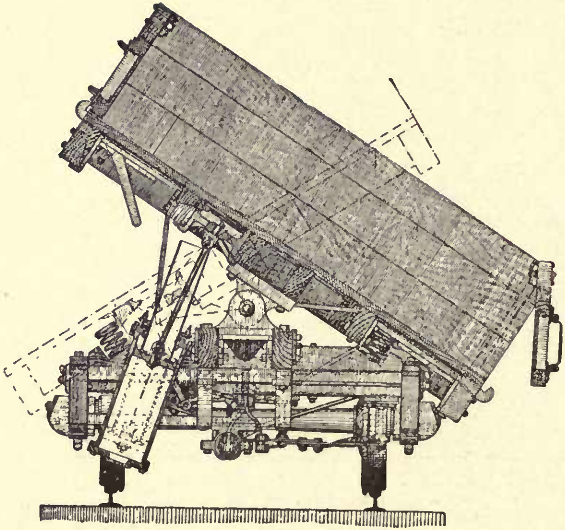
The tank is made of steel, with seams double and treble riveted. If there is any danger that the locomotive cannot carry sufficient power to perform the services required, arrangements can easily be made to replenish the tanks at stated parts of the mine, by drawing air in small pipes from the distant storage reservoir at the compressors. By this simple and convenient means compressed air can be conducted long distances with very slight loss of power.

The dimensions of the locomotive illustrated herewith are: Gauge, 3 feet; cylinders, 8 inches by 12 inches; drivers, 24 inches; weight, 15,820 pounds. Dimensions of reservoirs, R. S. 23¾ inches by 13 feet 9½ inches; L. S. 23¾ inches by 16 feet 0¼ inch. Reservoir pressure, 600 pounds per square inch; working pressure, 100 pounds per square inch.



THE COMPRESSED AIR LOCOMOTIVE.

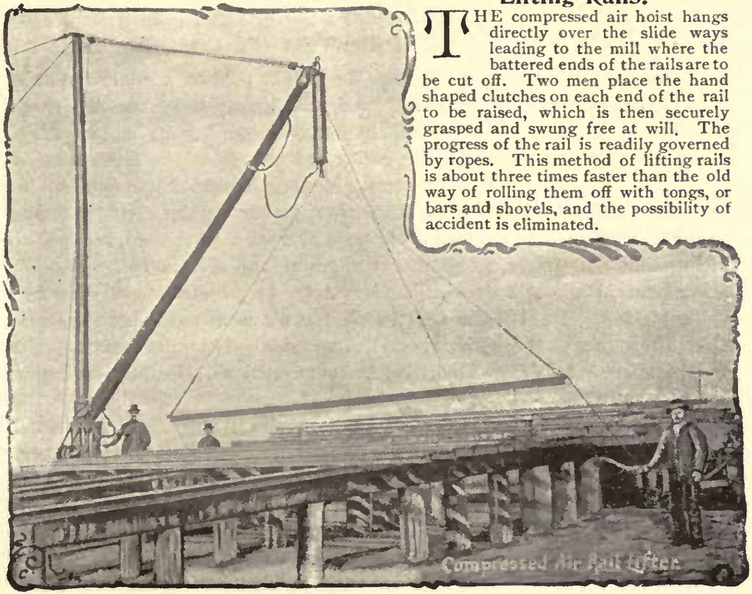
UNLOADING CARS.



A dump car has been invented recently, which is operated by compressed air from the locomotive. The air is supplied through an air cylinder and piston mounted on the truck frame of each car. Two air pipes lead from the train pipe to the dumping cylinder, one entering at the top and the other at the bottom. The piston rod is coupled directly to the body of the car. An upward stroke dumps in one direction, a downward stroke in the other. When the car is to be dumped in either direction the piston is at midstroke, and the car is in a level position; but if the car is to be dumped on one side only, the piston is adjusted to be at the bottom of the cylinder when the car body is level. A ten-inch cylinder is employed, and with 80 pounds pressure the upward push is 9,984 pounds, the downward pull 7,808 pounds. The dumping piston is operated from the locomotive, from which also the car bodies are locked and unlocked at will, by small compressed air cylinders with latch controlling pistons under each car.

Lifting Rails.

THE compressed air hoist hangs directly over the slide ways leading to the mill where the battered ends of the rails are to be cut off. Two men place the hand shaped clutches on each end of the rail to be raised, which is then securely grasped and swung free at will. The progress of the rail is readily governed by ropes. This method of lifting rails is about three times faster than the old way of rolling them off with tongs, or bars and shovels, and the possibility of accident is eliminated.



Compressed Air Rail Lifter.

STREET RAILWAY CARS OPERATED BY COMPRESSED AIR.

FOR some time compressed air has been successfully used as a motor for street railways in Nantes, France, at Nogent near Paris, and Berne, Switzerland, the air compressors at the latter place being operated by water power. Each motor carries a storage pressure of 350 pounds at Berne, and 2,000 pounds in the line recently established in the city of Paris itself. Other lines carry varying pressures between these figures. The Nogent line traverses narrow and much travelled streets, sharp curves and grades. Under these conditions the most apparent features of the Mekarski compressed air system there used, are high speed when desired, absolute control of the car, an abundance of power, and silent action.

In Chester, England, a tram-car line is operated by compressed air. The amount of air carried is 50 cubic feet. To refill the tank, while the car is in rapid motion, a plow blade is dropped which lifts a cover plate with grooves in its lower side. The groove forms a guide connecting the car attachment with device for letting in compressed air. In this way the tank can be charged almost instantly.

In any discussion of the street railway motor problem, it must be admitted that while much progress has been made during the last five years, yet a perfectly satisfactory system has not yet been found, especially for lines not doing enough business to warrant the erection of the overhead system of conducting the power.

While it is true that all eyes are turned to electricity to solve the problem, it is more than likely that another agent may be found to be more economical and reliable.

The cable car system represents an immense outlay in preparation, and constantly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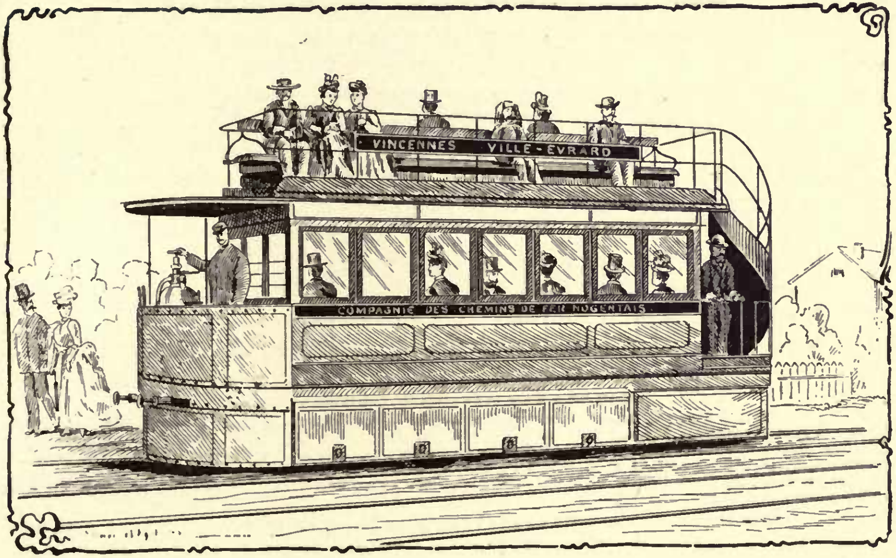
subjects the passengers to a distressing, jerky motion. The demand, however, for a system which is inexpensive and satisfactory, is increasing with the enormous expansion of towns into cities, all over the country.

By the compressed air system cars are handled easily, and quickly ; the speed varies at will, from three to twenty-five miles ; stops can be made on grades and curves without difficulty in starting again ; there is no danger, odor, noise, or other discomfort. This system is in successful use abroad and meets the approval of all citizens in the cities and towns in which it is used.

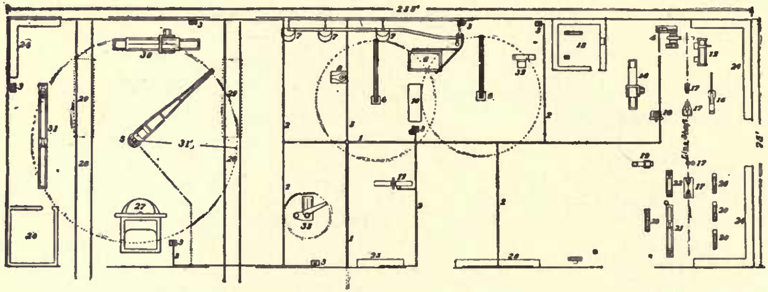
Some work has been necessary in order to adapt it to American roads, and with these changes it seems likely to prove very useful.



COMPRESSED AIR STREET CAR, NOGENT, FRANCE.

SHOP TOOLS OPERATED BY COMPRESSED AIR.

THE recent erection of a large machine shop in St. Louis, with air as the only power employed, marked a great advance in the application of compressed air.



PLAN OF A SHOP OPERATED BY COMPRESSED AIR.

1, Main Air Pipe; 2, Branch Pipes; 3, Engines for Large Tools; 4, Engine for small Tools; 5, Power Crane; 6, Hand Cranes; 7, Forges; 8, Hammer; 9, Oil Furnace; 10, No. 5 "Bull Dozer"; 11, Punching and Shearing Machine; 12, Cold Saw; 13, Tool Room; 14, Planer; 15, Shaper; 16, Horizontal Boring Machine; 17, Drill Presses; 18, Milling Machine; 19, Jumper; 20, Lathes; 21, Lathe; 23, Turret Lathe; 24, Benches; 25, Testing Benches; 26, Stock Room; 27, Boring Mill; 28, Tracks; 29, Pits under Tracks; 30, Planer; 31, Bending Roll; 32, Radial Drill.

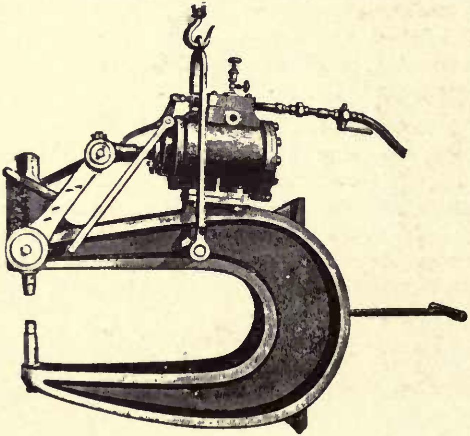
From the smallest tool grinder to a twenty ton crane, air is the motive power. A 55-horse power compressor operates the plant. The cost of installation is stated to be about equal to that of an ordinary steam plant. The air is stored in a reservoir beside the power house, and from this it is piped over the entire plant. In the machine shop the piping is overhead and serves each tool directly. The larger tools have their own engines, located against the nearest wall, or at the base of the machine. The turning of a cock starts the engine, and the same movement cuts off the supply of air when power is no longer required. By this means the tools are constantly in readiness, but consume no power when idle. The usual wilderness of shafting, expensive both in maintenance and power consumption, is entirely avoided unless the very small tools form an exception. They are grouped and run by one engine, in consequence of which a little shafting is required.

The use of compressed air, as above described, permits a saving of from 15 to 20 per cent, and improves the light, ventilation and temperature.

THE VALUE OF COMPRESSED AIR AS COMPARED WITH HYDRAULIC POWER.—A member of the Manchester (England) Association of Engineers recently declared that he had introduced an air compressor along side of hydraulic machinery for working stoking machines in the Manchester Gas Works, and found the first cost of the air compressing plant less than that of the hydraulic system, and that it was more efficient and economical in operation. The machinery in the Portsmouth (England) Dockyard is operated by compressed air, and air engines have been found more satisfactory, and less liable to breakage, than those operated by water.

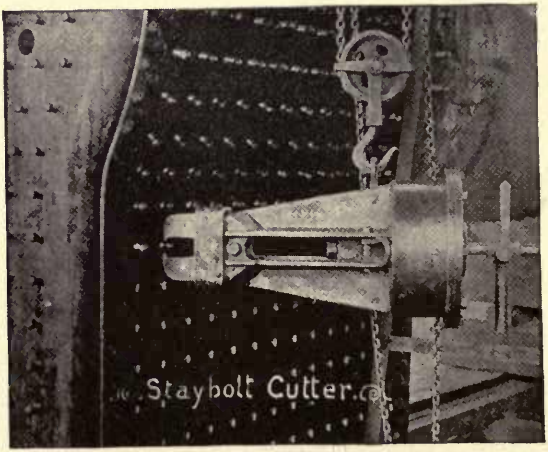
RIVETERS AND STAY-BOLT CUTTERS.

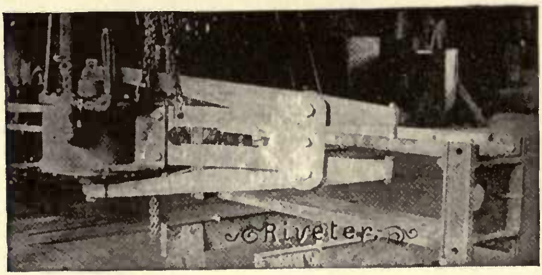
RIVETERS operated by compressed air are now generally used in bridge construction works, and in boiler, machine and railroad shops. The ease and economy with which the air riveter is handled makes it decidedly superior to steam and hydraulic riveters, in using which it is necessary to carry the work to the machine, a requirement always inconvenient and frequently difficult.



Riveting by hand is said to require three men and a boy to rivet 250 rivets per day. The compressed air riveting machine, operated by one man and two boys, will drive from three to six thousand rivets in a day.

These machines are substantially constructed. A piston rod connects two levers of different length, forming a reversed toggle joint. The lower ends of the larger links are attached to fixed centres on the frame. The end of the central short link is attached to the ram, into the lower end of which the die head is secured. By this latter arrangement any desired change in the distance between the dies is easily effected. The ram has a stroke

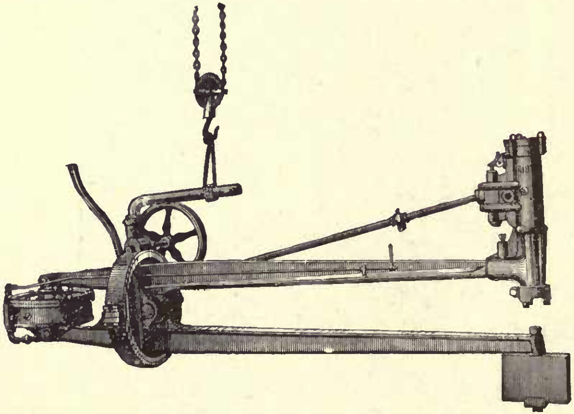




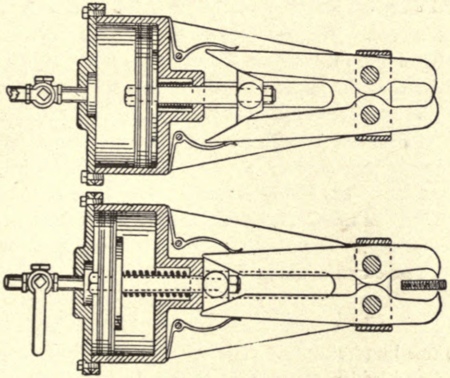
STAY BOLT CUTTER AND RIVETER IN USE IN RAILROAD SHOPS.

of $3\frac{1}{2}$ inches. These machines are balanced so that they may be operated either vertically or horizontally, as desired. Air pressure of 60 or 70 pounds is employed. Variations of this machine are used for channel-iron bridge work, and riveting boilers and tanks.

For boiler riveting, the machine proper consists of a cylinder with a hammerhead or die, attached to the end of the piston rod, capable of being easily changed to adapt the machine to rivets of different sizes. The valve is operated directly by the pressure in the cylinder and so arranged that the stroke repeats itself automatically. Another cylinder closes the long ends of the bars or arms and enables the operator to clamp the boiler plates together with a pressure of 2,000 pounds, previous to riveting, thus securing much tighter work.



The compressed air riveter has largely replaced the portable hydraulic riveter, as the use of air at 60 pounds pressure is so much more convenient than that of water under 2,500 pounds, as the latter requires cumbrous iron pipes especially jointed. This riveter is a valuable addition to railroad shops, where it is estimated that one gang of men with a compressed air riveter can do the work of four gangs working by hand. A truck can be riveted complete in twenty minutes.

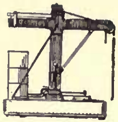


DETAIL OF STAY-BOLT CUTTER.

STAY-BOLT CUTTER.

A Stay Bolt Cutter, which does the work of twenty men, is in use in several railroad shops, the motive power being compressed air. The nippers are operated by the wedge action of the bevelled end of the cross head of the piston cylinder. This remarkable machine cuts off several hundred bolts an hour and though operated so rapidly, there is no jar or loosening of the bolts. 70 pounds pressure is sufficient to cut off one and a quarter inch bolts.

COMPRESSED AIR CRANES.

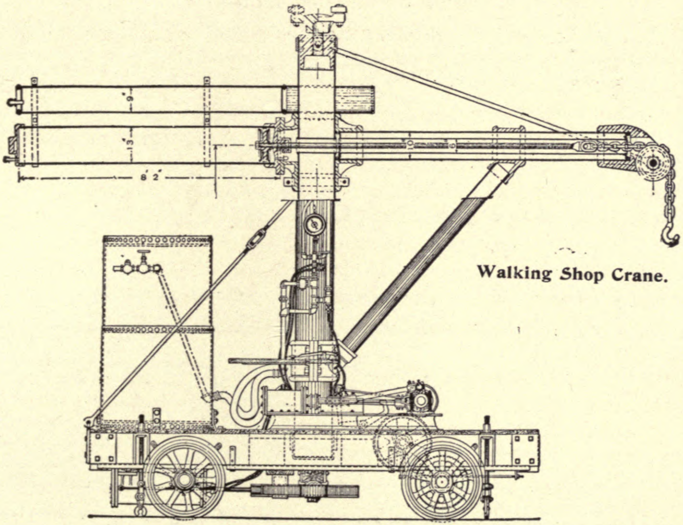


HAT machine shop is best constructed which permits the use of travelling cranes along the center of the shop, and its entire length. In this way the machines on each side are easily and quickly served. The compressed air in shop cranes is stored in a cylindrical reservoir standing on the car (as shown in the accompanying cut) and also in three horizontal tubes at the upper part of the crane. The interior of mast and jib is also used as storage space. The main reservoir of the shop crane shown, is 42 inches in diameter and 6 feet high, the diameters of the mast and jib are 13 and 10 inches. The total storage capacity is 85 cubic feet. The crane is propelled by a pair of horizontal engines, connected with a front axle by grooved friction gearing. The lifting capacity is four tons.

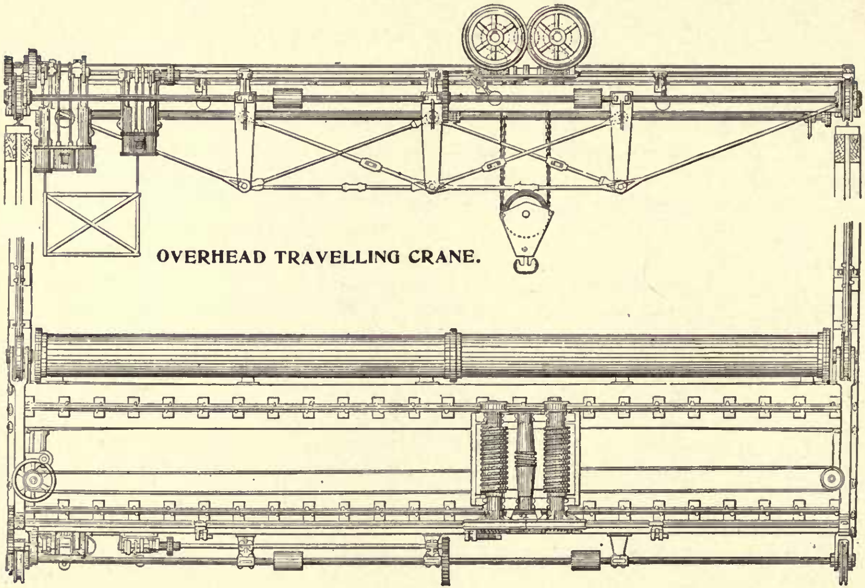
OVERHEAD COMPRESSED AIR TRAVELLING CRANES, as shown in the accompanying cut, possess the advantage of extreme simplicity. The length of travel is about 400 feet, capacity 20 tons, air pressure about 100 pounds. These cranes are easily repaired, easily controlled, noiseless and moderate in cost.

The air storage capacity is sufficiently generous to admit of considerable use without replenishing. Crane capacities vary from one to one hundred tons. The speed of hoisting varies from five to forty feet a minute, and trolley travel and bridge travel from 25 feet to 100 feet, and 50 inches to 200 inches, per minute respectively.

Compressed air is now claimed to be the best motive power for shop cranes of any kind. The air compressor required to operate them needs little attention, as the pressure of air in the receiver governs the compressor, and the air can be stored in any convenient part of the building.



Walking Shop Crane.

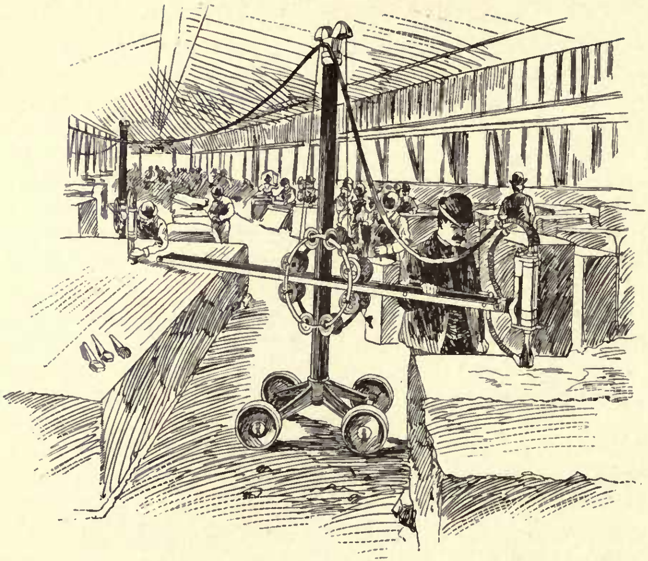


OVERHEAD TRAVELLING CRANE.

COMPRESSED AIR TOOLS.

COMPRESSED air is now successfully applied to tools of all kinds, from the roughest chisel to the most delicate instrument for carving. The operation of the tool is very simple and effective and the extraordinary results accomplished are due to the multitude and uniformity of blows which are struck while the machine is in operation. Air is forced into a reservoir by an air compressor, and from it a small tube leads the air into the end of a cylinder which is held and guided by the workman. In tools of ordinary size, the cylinder is about as large as a chisel handle. The air is led under a jacket on the cylinder to a valve by which it reaches the piston. Each advance of the piston strikes a spindle on the end of the tool, forcing it outward, the return motion being imparted by a spring. The blow of the piston is then repeated, and it is claimed that they number ten thousand a minute. A large number of compressed air tools is used in the shipyards of Cramp & Sons, the calking on war ships and other vessels being done wholly by these instruments. One compressed air calker does the work of four men. This ingenious tool has been adapted to many uses. It is effective in calking boilers, water pipes and tanks, as well as ships; heading tubes of boilers, dressing steel castings, chipping cast and wrought iron work, and also in lettering, carving and moulding granite, marble, onyx and other stones.

This tool has found a large field of usefulness in dressing granite for building and monumental purposes. In that industry modern ingenuity has offered so far no improvement over the mallet and chisel of our ancestors, but a machine has been constructed which fully meets the stone cutter's requirements. A hollow iron post on wheels holds a nicely balanced movable frame, on one end of which is a compressed air tool weighing about 50 pounds, and of great power. The

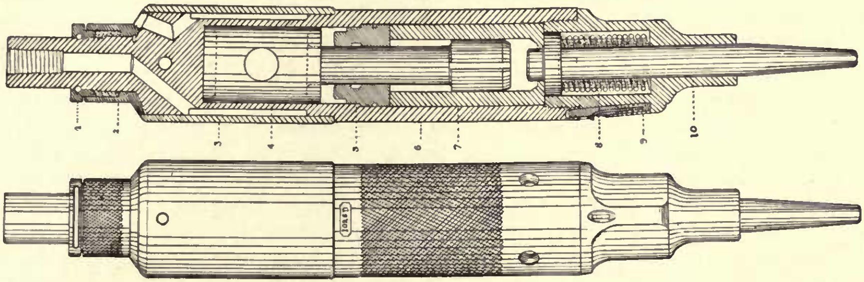


COMPRESSED AIR TOOL FOR DRESSING GRANITE.

entire machine is substantially constructed, and fitted so that it can be adjusted easily to any position. It can dress a square foot of granite in eight minutes, a task which would require one and one-half hours of hand labor.

To operate these tools, air pressure of 60 to 80 pounds is required. In addition to an extraordinary saving of labor in every instance, the absolute evenness of the blow delivered by these tools, produces better results than that of the most skilful hand labor.

Detail of Compressed Air Tool.



1.—Throttle Nut. 2.—Throttle. 3.—Jacket. 4.—Piston. 5.—Split Washer. 6.—Cylinder. 7.—Washer Sleeve. 8.—Compound Spring. 9.—Nose. 10.—Spindle.

OPERATING CLOCKS AND ENGINES IN PARIS.

IN 1870, a system of operating clocks by compressed air was instituted in Paris, France. A small central station, equipped with a compressor, was established in the Rue St. Anne, and the clocks in the system were operated from this by pulsations. The business grew slowly at first, but within the last few years has increased with extraordinary rapidity. The original station becoming inadequate, an elaborate and powerful plant was established in the suburbs of the city (Belleville) and from this upwards of 10,000 clocks, public and private, are now driven, all regulated from a standard clock in the Rue St. Anne. The operation of the clocks was originally the main object of the system, but extensive as that now is, it forms but a small part of the usefulness of compressed air in Paris. This power is obtainable anywhere in the city, subject to a meter, like gas, and can thus be used in large or small quantities, for driving engines and tools. At the central station a series of engines drive a great number of air compressors, generating, it is said, 10,000 horse power. The air is drawn in direct from the engine house, at a temperature of 70 degrees and compressed to 75 pounds. It is then led about the city in mains, which are laid beneath the streets and along the soffit of the famous Paris sewers. The mains are of cast iron, each length having plain ends, connected by an external joint of air tight India rubber packing rings. This permits a little play and assures a minimum leakage. The meter is a small double cylindrical box. The air passes by a branch through the botton of the inner box, up through it, and down outside between the two boxes, and away through a branch at the bottom opposite the entrance. The measuring apparatus is a little six armed fan with nickel or aluminum vanes placed near the bottom of the inner casing and communicating motion to clock work mechanism outside which records the number of revolutions. A reducing valve and a small heater for the motor are the only other needed parts. The heater is used to economize air by expanding it. It has been found in Paris that by using heated air the mechanical efficiency of the motor is much increased. When refrigeration is required, however, the air is not heated, in order to avail of the cooling due to expansion.

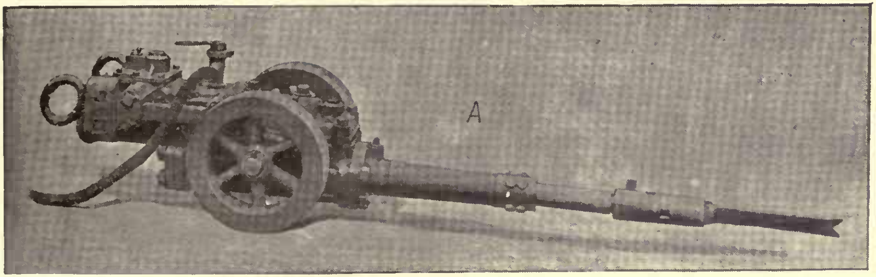
The application of compressed air which the Paris system permits, is as varied as the requirements for power. In many parts of the city this convenient and inexpensive power is used to run the dynamos to generate electricity for lighting and other purposes.

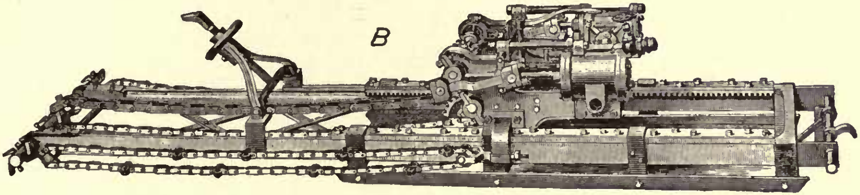
The value of the system is apparent. There is an absence of danger, and annoyance, a saving of space, reduction of insurance, and incidentally is derived the very important advantage of pure and cool air, the value of which, in some cramped shops, can scarcely be exaggerated.

It has recently been demonstrated for the French government that in case of a siege of the city of Paris, the application of half the compressed air now being generated, to refrigerating food, would preserve, at a temperature below freezing, a sufficient supply of food to last six months.

COAL MINING MACHINES OPERATED BY COMPRESSED AIR.

IT was long believed that machinery could not compete in coal mines with a pick axe, but within the past decade coal mining machines operated by compressed air have come into general use, especially in mining bituminous coal. Of these machines, one (illustration A) is small, strong and easily operated. It is from five to seven feet long, two feet high and two feet wide. It has no complicated parts, and reduces friction and power consumption to a minimum. Two men are required with each machine, one to operate, and a helper to shovel away cuttings. The machine is mounted on a platform, so pitched in front of the coal that the recoil is neutralized by gravity. The pick strikes from 200 to 210 blows a minute, and as it works under the coal the runner allows the machine to run forward down the platform, and swings the pick from side to side in its progress. The amount of compressed air required is but ten cubic feet per minute, delivered at a pressure of 75 pounds, which can easily be drawn in small pipes for a mile or more with very slight loss of power. This machine weighs about 500 pounds. Another machine (illustration B) consists of a bed frame, two feet wide by seven and a half feet long, composed of two steel channel bars firmly braced, the top plates on each forming racks with their teeth downward, into which the feed wheels of the sliding frame engage. This sliding frame consists mainly of two steel bars. At the rear of this frame a double engine is mounted, from which power is transmitted to the rack, by means of which the sliding frame is fed forward. At the front end is the cutter bar. This contains steel bits, held in place by set screws. When the cutter bar is revolved these cutters or bits cover its entire face. The cutter bar is revolved by an endless curved link steel chain, and advances mechanically as described.





SIDE VIEW—CUTTER BAR PARTLY EXTENDED.

This machine requires an operator and helper. It is taken into the mine on trucks, placed upon two boards in front of the coal and braced by front and rear jacks. The cutter bars range in length from 39 to 48 inches, and after a full cut, the bar is withdrawn by reversing the engine. It is claimed that this machine can cut 150 lineal feet face to a depth of 6 feet in ten hours.

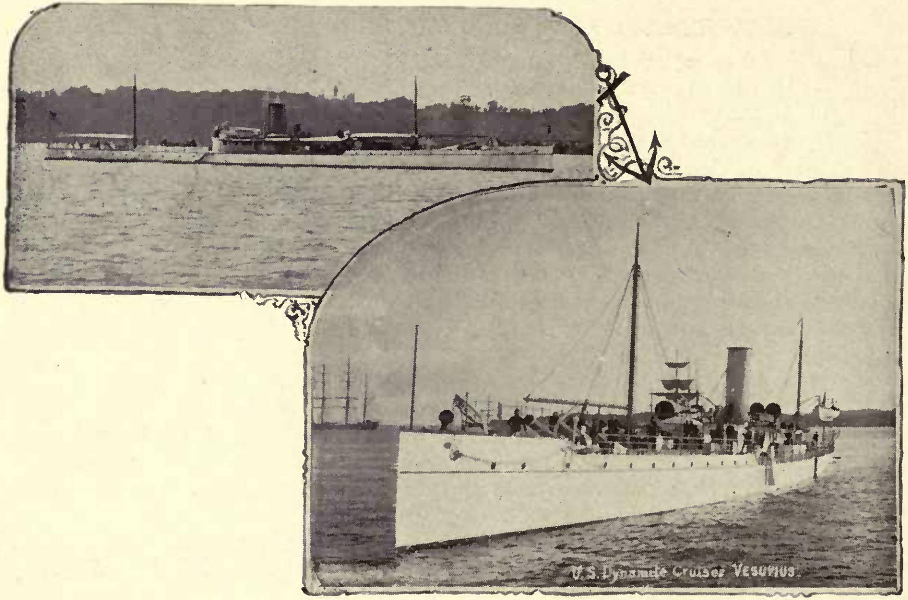
The advantages derived from operating coal mining machines by compressed air are said to be economy, better condition of coal, concentration of work, and absolutely no danger from sparks.

THE COMPRESSED AIR GUNS OF THE CRUISER VESUVIUS.

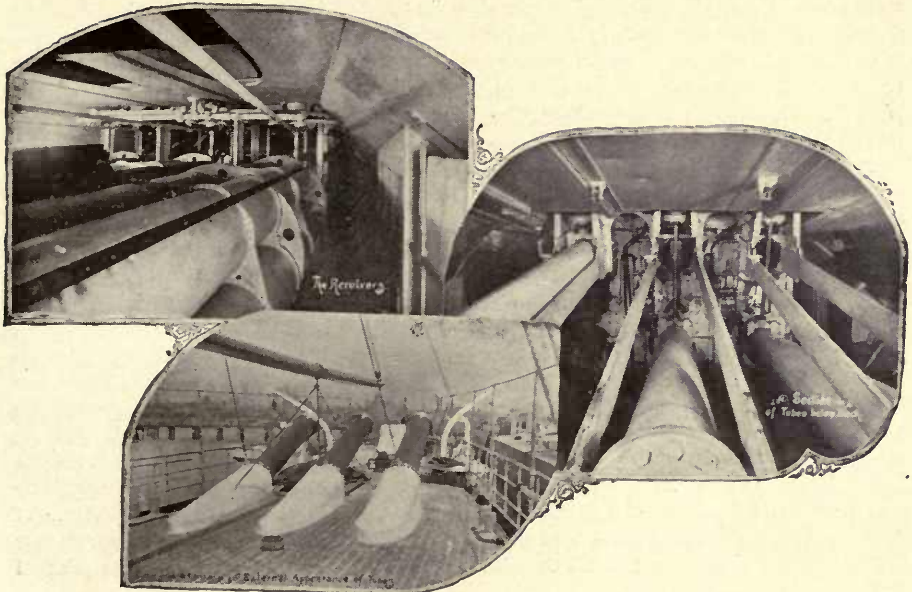
THERE is no explosive on board the Vesuvius but the gun cotton projectiles which are intended to annihilate the enemy. The power that is capable of hurling these deadly missiles more than a mile with extraordinary accuracy, is air. The Vesuvius is an unarmored cruiser of 950 tons and 4,000 horse power. She is 252 feet in length, and has a record of 21¾ knots. These facts though interesting are unimportant, and the title of the Vesuvius to fame lies in the three stationary so called pneumatic dynamite guns which project above the deck. These guns are unique and extraordinary. Each is 55 feet in length, and composed of two sections. The upper half is immovable, but the lower section can be detached and dropped to a horizontal position, where, in connection with a cylinder which then lies directly in front and in contact, this lower section resembles a huge revolver. Like an ordinary revolver, the cylinder turns, and is composed of chambers, five chambers in each cylinder and two cylinders for each gun.

To load a gun, the lower section is dropped. It then receives a cartridge from its cylinder by a mechanical adjustment, and is reconnected. At the bottom of the gun is the compressed air chamber which forms the impelling force, pressure of about 1,000 pounds being employed. As the guns are immovable and point straight from the bow, the aim is produced from the steering gear. This, with the three levers which discharge the guns, are in a conning tower which can be entered only from below deck.

The projectile weighs from 400 to 1,000 pounds, the bursting charges being from 200 to 500 pounds of gun cotton or explosive gelatine. The explosive contained in it is discharged by



U. S. Dynamite Cruiser VESUVIUS.


The Receivers

a cap which is ignited by contact with either the solid target or the water. The aim is to have the shell strike the water just short of the target and explode after it has entered the water to a depth of 10 to 15 feet. The chief dependence for successful action is against the under water hull of the enemy's ship. A perforation here is likely to prove fatal. The guns are fixed in ship at an angle of 18 degrees. The range is varied by either varying the cut off of the automatic valve or by varying the pressure used. The range of each tube is one mile for a shell carrying 500 pounds of explosives, and 3,000 yards for a shell containing 200 pounds of explosives, and within that, the distance which the shell is to traverse can be accurately adjusted by gauging the air pressure. On leaving the gun the projectile ascends sharply to a height, and then describing a curve, plunges at length sharply downward. Frequent tests have demonstrated that for stationary firing at a stationary object, the accuracy of range is remarkable.

THE COMPRESSED AIR TORPEDO GUN for sea coast defence is mounted in a similar manner to the ordinary sea coast gun, being, unlike the guns of the "Vesuvius," movable both for elevation and training. The guns are fifty feet in length. Air, compressed to 1,000 pounds per square inch, is used as the propelling charge. Five 15-inch guns are to be mounted at Sandy Hook and San Francisco for experiment. These guns can throw a shell charged with 500 pounds of high explosive a range of one mile, a shell with 200 pounds bursting charge to a range of 3,000 yards, and one containing 100 pounds to a range of 4,500 yards, an automatic valve admitting the air to the gun bore and making the cut off at any desired point, so that without changing the elevation a projectile may be dropped just out of the muzzle, or sent to the extreme range. The importance of compressed air in naval warfare has been shown recently in the purchase of the passenger steamer "El Cid," and her equipment as the Brazilian Government cruiser "Nictheroy." The principal feature of the armament was one of the movable compressed air guns above described. An opening, shaped like a horse shoe, was cut in the upper deck at the bow of the ship, and a heavy well-shaped base was erected below. Upon this the great air gun was mounted. A powerful three-stage compressor, located just behind the ships' engine room, supplied compressed air at a pressure of 1,000 pounds, the compressor being capable of doubling the pressure if desired. The air was led in heavy piping to a reservoir in the bow. Practice firing with the gun showed excellent results. The projectile is a cylinder containing gun cotton. This explosive is used because by keeping it wet it is perfectly harmless, and it can be dried out as desired for use. The method of exploding is either by impact, time fuses, or miniature electric batteries in each projectile. The latter method of discharge is regarded with much favor. The jar in starting the projectile from the gun, liberates the acid into the miniature cup. Electricity is thus generated, and the fine thread of platinum is soon heated red hot. This acts as the spark within the cartridge and explosion follows without fail, and wherever the projectile has fallen.

The result of this bold experiment in naval armament, is being watched with interest. The success of the "Nictheroy" means nothing less than a revolution in naval construction. It is only fair to state, however, that the vessel was hastily transformed from a merchant vessel, and that the time occupied in equipment was only about one month. If the experiment of throwing explosives by this system should prove, in this instance, even a moderately successful method of sea warfare then much might be expected from a system having proper elaboration and operated by a properly trained crew.

Disappearing Gun Carriages are operated successfully by compressed air. The recoil of the gun is overcome by using a compressed air buffer, in which the air pressure is 575 pounds.

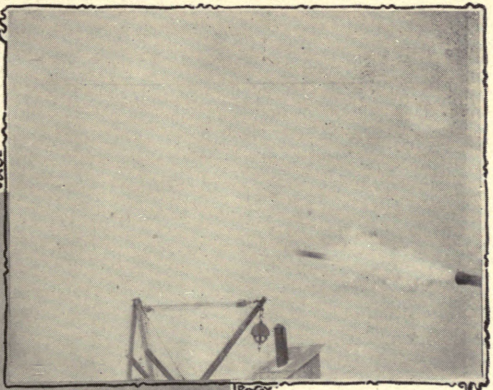
The accompanying illustrations are from instantaneous photographs, and show this gun in the act of being discharged—the projectile being caught in the act of flight. It should be understood that these cuts are prepared by the photo-engraving process direct from the photograph, and without alteration or re-touching of any kind. Their interest is unique, and may be depended upon as authentic.

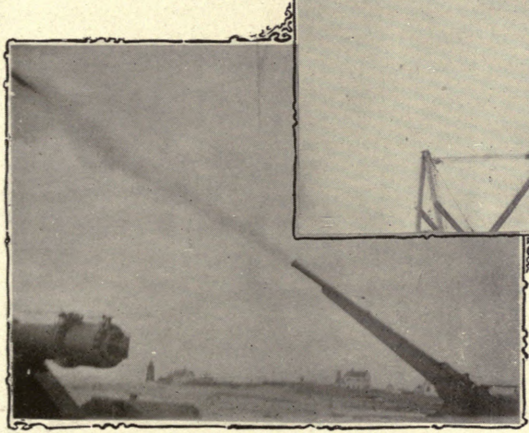
The lower picture shows the gun entire with the projectile at the extreme upper left-hand corner of the picture. The upper picture shows the muzzle of the gun only, with the projectile but a small distance from it.

The projectile here shown is of 15″ diam. x 10 ft. extreme length. Its weight is 1,100 lbs. and it carries 500 lbs. of explosive gelatine. Its range of flight is 2,400 yards and the velocity at the moment in which the picture was taken, was between 500 and 600 ft. per second. It carries the latest pattern of fuse, which has overcome all former difficulties. Its action is purely mechanical and is brought about by the shock due to the discharge of the gun and that due to the impact of the projectile against the target or water. Both these shocks are required to act in succession, in order that the fuse may act and the shells be exploded. This construction gives practically absolute security in the handling of the projectile, as no single shock of any kind is able to explode it.

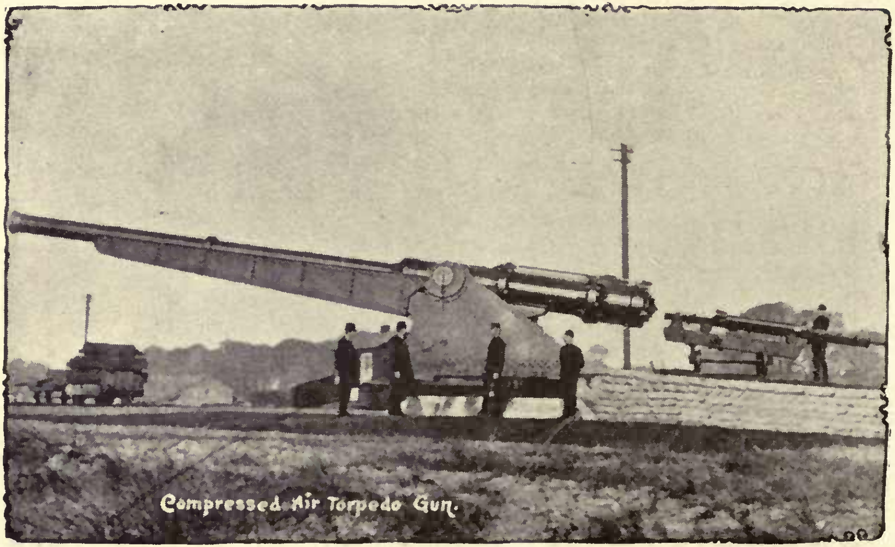
It may be added that the plant of guns at Sandy Hook, N. J., when tested under the rigid requirements of the U. S. Army, surpassed those requirements in every item—accuracy of fire, extreme range, number of shots per hour and certainty of explosion on impact. The photographs, of which these pictures are a reproduction, were made during the official test of July and August, 1893.

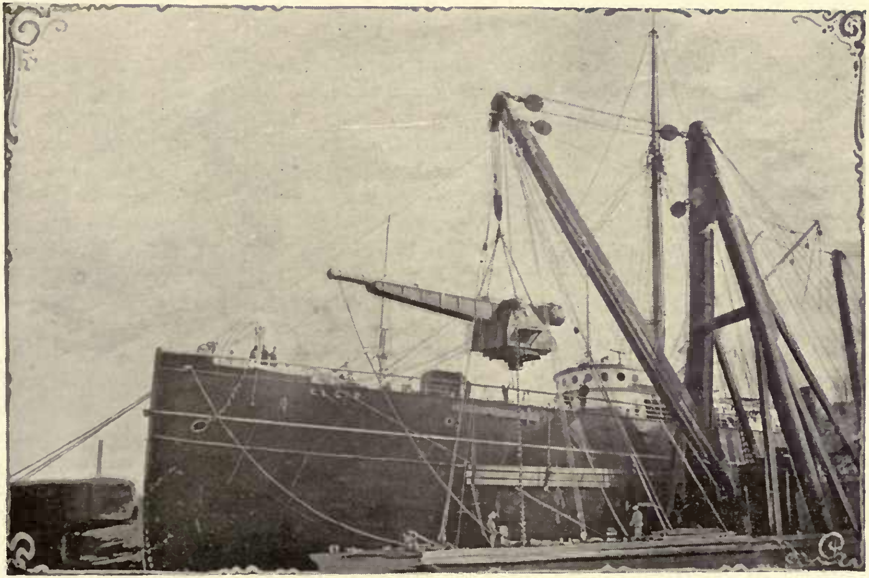
SNAP SHOTS AT THE
DYNAMITE GUN.





SHOWING PROJECTILE IN
FLIGHT.


Compressed Air Torpedo Gun.



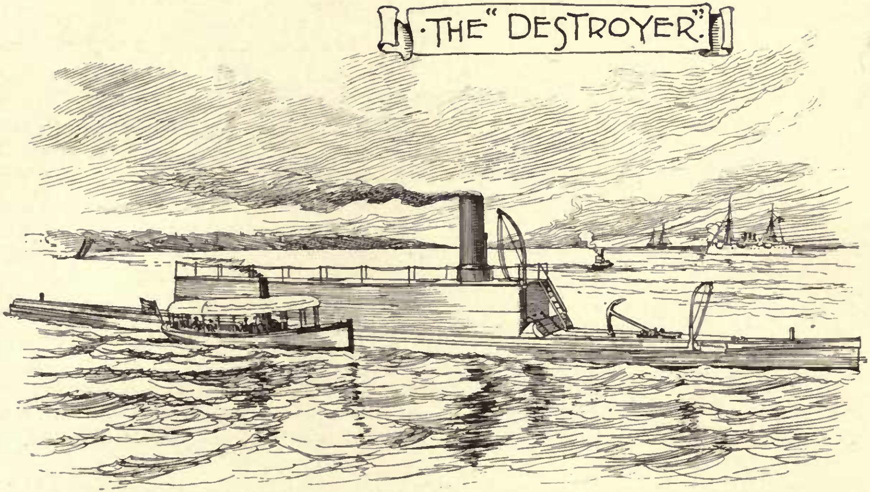
HOISTING THE COMPRESSED AIR GUN INTO PLACE ON THE NICTHEROY.
(From photograph made by the Chapman Derrick Wreckage Co.)

THE "DESTROYER."

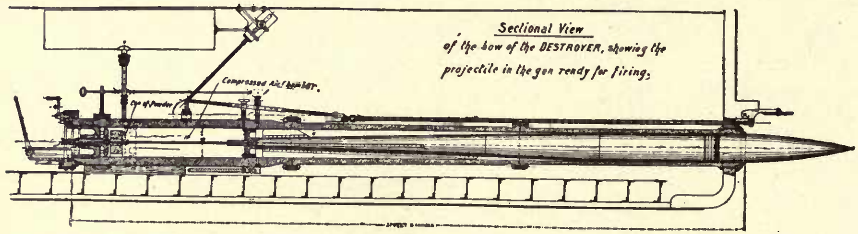
THE propulsion, both above and below the surface, of projectiles containing high explosives has become one of the serious problems of modern war-ships, and of defence construction. The "Destroyer," known as a detachable ram, is the result of many years of thought and labor on the part of the late Captain John Ericsson, the famous inventor of the "Monitor." The "Destroyer" is 130 feet in length, with 12 feet beam. Her displacement is 250 tons; draught, 10 feet. Bow and stern lines are the same, straight and exceedingly sharp. The gun is constructed of steel, with breech mechanism similar to that in high power guns. The caliber is 16 inches, length 32 feet. The gun ends at the bow of the vessel, and the end of the projectile extends beyond the bow, but is eight feet under water. The projectile is also made of steel, is 27 feet long, 16 inches in diameter, and weighs 1,525 pounds. At the front of it is the explosive, which is one-fifth of the entire weight, and is discharged by a percussion cap. The projectile is made in three sections, for convenience in handling.

In loading, the breech of the gun is opened, and the torpedo, placed on a carriage, is run into the bore of the gun, and close to the tail end of the torpedo comes the piston, then the tail rod, through which runs the electric wire used in firing, and last the powder can, containing from 20 to 40 pounds of powder. The breech is then closed; the valve that supplies the compressed air is opened, and with a pressure of 40 pounds to the square inch, the torpedo is forced to its final firing position.

The initial pressure in the gun when fired is 4,000 pounds per square inch, and the



THE "DESTROYER".

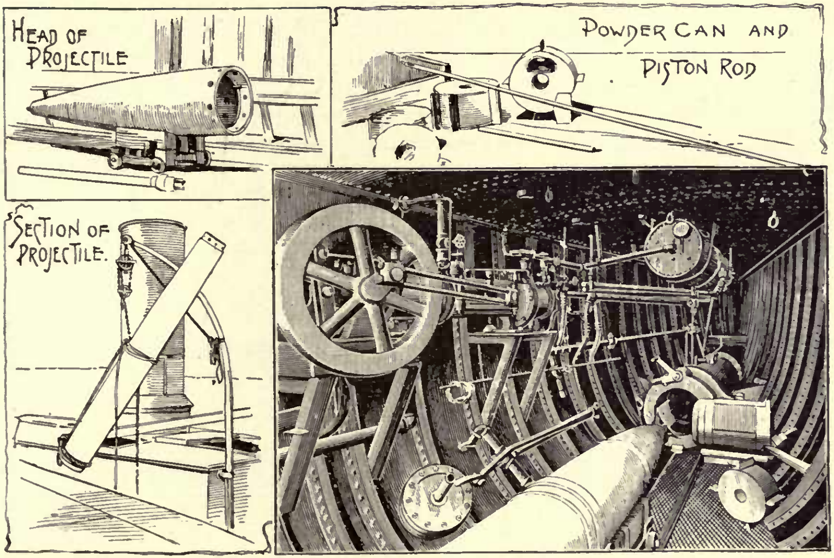


muzzle velocity is 548 feet per second. Upon reaching the water, the piston falls off; a piston is thus lost with each shot.

Immediately after the discharge of the projectile, the valve, which has hung above the cone of the projectile, and which is opened by a rod from the compressor, is shut down over the muzzle of the gun. The gun is then drained and is ready for another shot.

It should be noted that the manner of exploding the powder charge in a large air space filled with compressed air, is a radical departure from the ordinary usage. This is claimed by the owners to be of great advantage, as the air not only forms a cushion, but adds to the efficiency of the combustion of the powder.

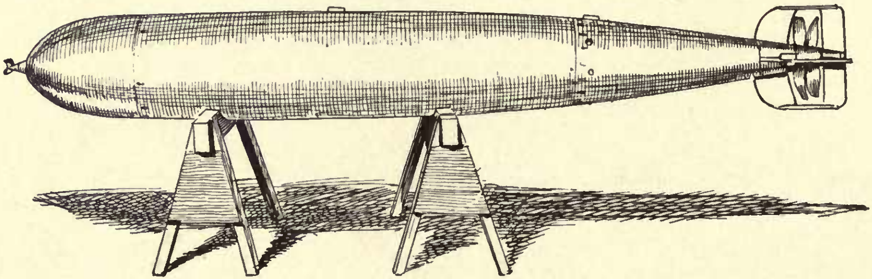
It is claimed that recent experiments with the "Destroyer" have demonstrated that it is possible to fire a sub-marine torpedo accurately a distance of 600 feet. To that distance the vertical danger space is 22 feet, and the lateral accuracy is sufficient to hit a vessel 50 feet long.



THE DESTROYER: INTERIOR OF BOW SHOWING COMPRESSOR, GUN AND PROJECTILE

LOCOMOTIVE TORPEDOES.

THE Whitehead Torpedo is now regarded as such a successful implement of war that it has been generally adopted by European nations. This torpedo is propelled by compressed air. Its length varies from 12 to 19 feet, its diameter from 13 to 15 inches. The torpedo on being discharged will travel at any length according to adjustment, at a uniform speed of 24 knots for 600 yards. Having reached the end of its travel without impact, it will either sink or rise as previously adjusted. The foremost compartment contains from 50 to 100 pounds of gun cotton. Upon striking a ship, this charge is fired by a pistol which screws into the nose of the torpedo. The point of the pistol is driven in by compact forcing the point of a steel



THE WHITEHEAD TORPEDO.

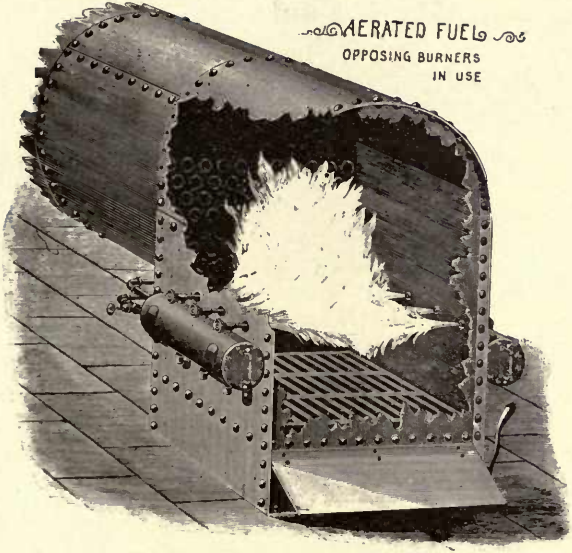
striker into a detonator. A large portion of the torpedo is devoted to an air reservoir, within which compressed air is carried to a pressure of 1,000 pounds. This operates a three cylinder engine driving two propellers revolving in opposite directions in the tail of the torpedo. The mechanism in the balance compartment works two exterior rudders, which keeps the torpedo at a uniform depth. This mechanism constitutes the secret of the invention and is sold with the right to manufacture the torpedo. The discharge is secured from a compressed air gun and may occur above or below water. This torpedo is owned and made in Austria. It is estimated by the United States Navy that each torpedo costs about $1,000.

The Navy has purchased the right to manufacture the torpedo, and they are made in Brooklyn, N. Y., under the Department supervision.

TRANSPORTATION TUBES.

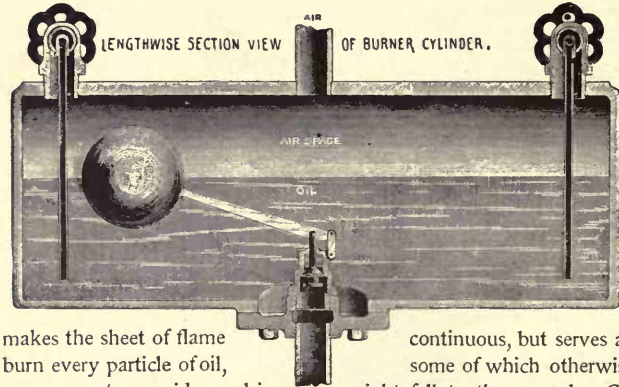
SYSTEMS of underground transportation of mail matter and packages are in general use in London, Vienna, Paris and Berlin. The motive power employed is compressed air or a vacuum. In New York City, the Western Union Telegraph Company operates an underground system for the transmission of telegrams. The central office, at Broadway and Dey Street, is connected with the main branch office at Fifth Avenue and 23d Street by four tubes—two express, two local. These tubes run under Broadway to 14th Street, thence to Fifth Avenue, and under that thoroughfare to 23d Street. The distance is just three miles, and the time consumed by a carrier in transit is seven minutes. All the principal newspaper offices are connected by a single tube, the right of way being governed by touching a button. The newspaper and exchange tubes are operated by compressed air, but vacuum is used upon the main line. The diameter of the tubes is three inches. The Philadelphia Post Office operates a short, underground tube system to a branch office. Compressed air is the power employed. Several systems of underground transit have been advocated from time to time, among them being a method of propelling balls through a tube by applying a vacuum in front and compressed air behind.

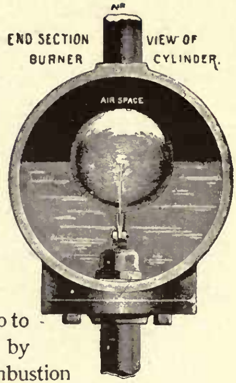
That system which will come at length into general use, must possess great simplicity, as repairs upon an underground system are both tedious and expensive.



AERATED FUEL.

THE formation of a highly combustible spray composed of petroleum and compressed air, has been found to offer a most effective, convenient and inexpensive fuel. By means of an air regulator the compressor maintains a uniform pressure of from 10 to 20 pounds to the square inch, as the case demands. The pressure upon the oil forces it out of the burners in a fine spray, which, upon being ignited, becomes a steady and powerful flame. Wherever it is possible the burners are arranged opposite each other so that on being lighted the flames mingle, an adjustment which not only





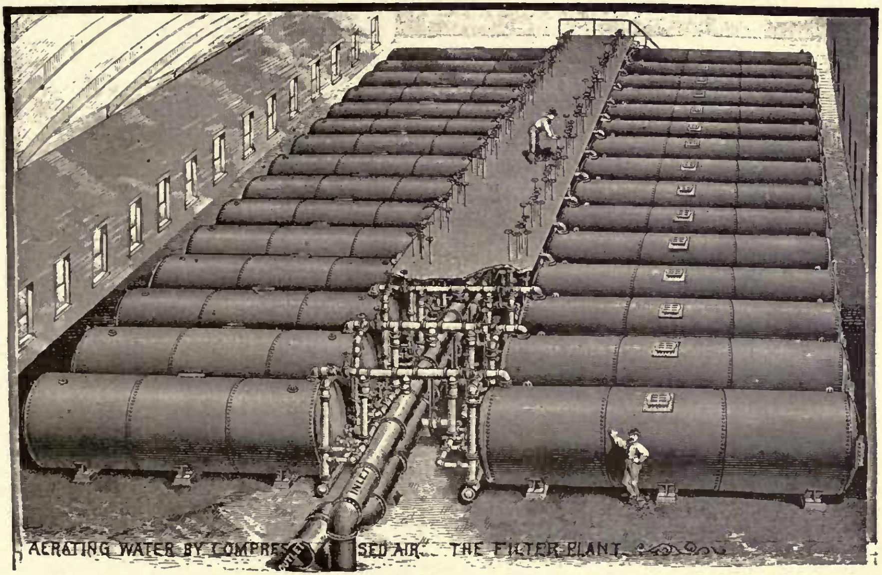
makes the sheet of flame continuous, but serves also to burn every particle of oil, some of which otherwise, by pressure or too rapid expulsion, might fall to the ground. Combustion by this method is so complete that no receptacles and drip pans are required. The oil and air valves control the amount of flame at all times, and the burners may be placed in any position. From the accompanying illustrations the mechanism will be understood readily. In each burner cylinder there is a float which keeps the oil at the proper height by automatically opening and closing a valve, thus preventing the oil from rising above the mean level established at any one factory.

The advantages of the system are said to be an absolutely even fire, at all times under instant control, thus yielding any degree of heat desired, and economy in labor and fuel. Aerated petroleum fuel is especially adapted to all kinds of iron and steel forging, tempering, welding and annealing ; making tin plate ; glass works ; furnaces ; burning lime, brick, etc. ; heating chemicals and asphalt ; japanning and oxidizing. An effective system of garbage burning by this method has also been devised. The furnace or receptacle for the garbage is placed below the level of the ground, or the floor of the building used for this purpose. In this floor are arranged movable caps covering the dump holes for the garbage, the garbage being dumped into the furnace below. There are placed at regular intervals on each side of the outside wall of the furnace a number of the burners used in this system, the number depending, of course, upon the size of the furnace. The gases which arise from the garbage are also met by burners and destroyed by the intense heat.

AERATING WATER.

WITH the rapid increase of population in towns and cities, the purity of the water supply has become more and more difficult to maintain, while scientific research has annually increased the evidence that the quality of water is the most important factor in the health of the community. It has thus become necessary for cities so located that their water supply is impure, or subject in transit to contamination, to erect filter stations where the entire supply of water as it passes to the mains may be subjected to a rigid filtering process. Careful experiment, however, has demonstrated that filtration is frequently only part of the process required to supply the community with wholesome water.

Pond water, or water drawn from sluggish sources, may contain organisms which are offensive to taste and smell, and which can be expelled only by thorough aeration. The air compressor thus has been found a most valuable adjunct to the principal systems of filtration. The filter illustrated, consists of a cylindrical steel shell built to withstand any desired pressure. The water is introduced along a conduit running the entire length of the filter just beneath the crown. It filters through 4 feet of coke and sand and passes out by cone valves. These valves are imbedded permanently in the cement floor and flush with it. They are filled with screened quartz gravel. Most impurities in the water can thus be caught, but peaty matter and certain other impurities, as well as some kinds of bacteria, require the addition to the water of a coagulant or precipitant previous to filtration. The filters used by various cities in connection with their water works vary in capacity from 100,000 gallons per 24 hours to 5,000,000, and, as an evidence of value, it is estimated that the filters at Little Rock, Ark., remove over half a ton of solid dirt and filth from every million gallons of water filtered.



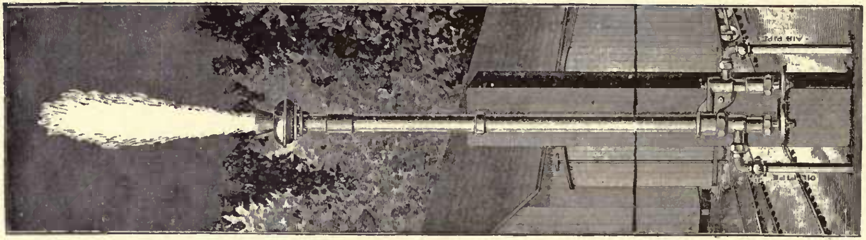
AERATING WATER BY COMPRESSED AIR. THE FILTER PLANT.

The cleansing of the filters is accomplished by flooding them in reverse; the adjustments being such that the entire force of the flood is applied to one-third of the filter at a time. The cleansing process occupies but a quarter of an hour, and is applied to each filter in the plant separately, so that while one is being cleaned the others are at work. After filtration the water is aerated. The air, sweeping through the water under pressure, scrubs and cleanses it, carrying away the gases and volatile matter, which may have made it offensive to taste and smell. In highly colored water, the dissolved oxygen is only one-seventh of the requirement, and in other water from one-third to one-quarter. The air compressor supplies this much needed deficiency by forcing air through the water in every direction ; completes the filtration and renders the water fresh, sweet and sparkling.

REFINING ASPHALT BY COMPRESSED AIR.

THE asphalt pavements which are so largely used in Paris, and many American cities, are composed of refined asphalt, often called bitumen, with oil and sand added in moderate quantities. Much of the asphalt used in the United States is obtained from the Island of Trinidad, a British possession lying about ten miles off the coast of Venezuela. The asphalt occurs as a natural phenomenon. It is found floating on the surface of a fresh water lake, about 80 feet above the sea, and probably owes its origin to vegetable matter subjected to a slow process of decay, resulting in the production of bituminous coal, from which by some action, volcanic or otherwise, the asphalt has been distilled and diffused as a pitchy substance.

In its natural state asphalt is not homogeneous, and it is too soft for satisfactory results. The crude asphalt is therefore placed in large kettles through which pass hot air or steam tubes, and for three or four days it is kept at the boiling point, during which period agitation is an absolutely necessary requirement. For this purpose compressed air is used. Pipes pierced with small holes are so arranged in the kettle that the largest distribution of air can be obtained, and through these holes air at moderate pressure is forced. During the early part of the process the air reaches the surface of the thick, black mass of asphalt, in the form of huge bubbles, but as the boiling progresses, the asphalt becomes thinner, and seethes and boils under the pressure of the air forced everywhere through the kettle. On being taken from the kettles, after cooling, the asphalt appears as a hard, black, brittle substance. It is barrelled, and is then ready for use. No other satisfactory method of stirring asphalt while boiling has been devised. The refining process must be at once thorough and inexpensive, and compressed air so perfectly fills these requirements that it has become an indispensable factor. A system somewhat resembling this is employed for agitating syrups in sugar refineries.



INCREASING THE BRILLIANCY OF LAMPS BY COMPRESSED AIR.

THERE are several methods of applying compressed air to oil, in order to increase the surface and brilliancy of the flame. One method, known as the Lucigen, atomizes the oil for illumination. Air compressed to a pressure of from 10 to 30 pounds, according to the characteristics of the oil used, forces the oil through a nozzle where oil and air mingled form a spray, which upon being ignited, yields a large, clear flame of great illuminating power, and capable of successful employment even in rain and high wind.

About one gallon of oil per hour and 60 cubic feet of free air under pressure are required to maintain a flame 5x30 inches. The illuminating power of this flame is reckoned at 1,000 candles. Lamps of this character are of much service where diffused light of great power and small expense, is required, and they are widely used in steel works, machine and railroad shops, and for open air service.

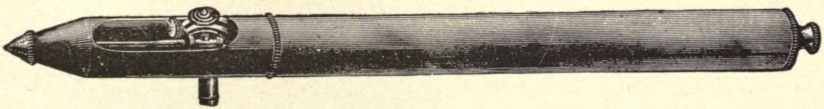
MIXING NITRO-GLYCERINE BY COMPRESSED AIR.

THE complete mixture of the acids, which, with glycerine, form this high explosive, is most thoroughly accomplished by compressed air. By this method the process is accelerated, as the air in expanding absorbes heat. The original process of delivering the glycerine in a spray has been modified, and the acid mixture is now made in a lead vat, and permitted to stand twelve hours to cool. 600 pounds of nitric acid and 1,100 pounds of sulphuric acid are used ; when cooled, the acid mixture is transferred to the nitro-gylcerine apparatus, the water circulating in it through six large lead worms and in a water jacket around it. The glycerine is then forced into the acid mixture by a specially constructed injector operated by compressed air. 240 pounds of glycerine are required for the amount of acid above mentioned, and the operation consumes an hour and a half. The thermometer is constantly watched during the process, and if it begins to rise, the operation is becoming dangerous. In that case it may be necessary to lead off the compound to a tank of water which should be in constant readiness, which will prevent any further danger. After the addition of the glycerine is complete, the mixture is led into a lead separator, where the nitro-glycerine appears at the surface, and is skimmed off in dippers, after which it is washed in water in a solution of carbonate of soda.

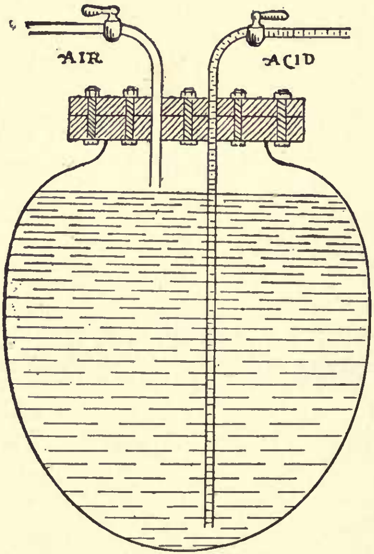
PAINTING BY COMPRESSED AIR.

REPEATED experiments in atomizing paint by compressed air, have resulted in successfully applying pigments to great surfaces; as well as perfecting the air brush, by which a marvellously delicate application of color to portraits and pictures, can be secured. These are the extremes of practically the same idea. It is needless to refer to the demand for some rapid method of painting large surfaces, to replace the expensive and laborious system of scaffolding and paint brush. The idea of atomizing paint and projecting it as a spray against a wall or surface, by using compressed air, is not new, but a practical difficulty has been presented by the thickness and weight of the paint, and the impossibility of finding hose that would withstand the action of the pigment. It has been found that by reducing the paint and heating it, these difficulties may be largely overcome, and though this device is still experimental, the Mines Building at the Columbian Exposition was painted in this way. Experiments in atomizing paint have recently been made by one of the large producers of corrugated iron, for the purpose of reducing the time and labor necessary to paint the great number of iron sheets used in the construction of iron buildings. The sheets are placed upright in a trough and the paint is led through hose to a nozzle, where it is met by moderate air pressure and forced out in the form of spray. By this device large surfaces can be successfully and quickly painted, the aeration imparting an especially high gloss.

The air brush has been perfected and is now in general use. It consists of a pencil six inches in length and half an inch in diameter, terminating in a pointed cap. The upper part of the brush is a reservoir for paint, a screw on the upper end regulating its flow into the receptacle. In the lower part of the brush there is a connection and valve for the compressed air, which is generated by a little compressor operated by the foot. Above this valve there is a button admitting air as desired, which, passing under the paint in the receptacle, is expelled at the point of the cap, carrying paint with it as a fine spray. The amount of paint actually atomized is regulated by a rod, which runs through the receptacle (see cut), and the point of which fits into the cap. The supply of paint atomized of course decreases the more tightly the rod is adjusted to the cap. This adjustment is made at will by a little thumb screw in the receptacle.



THE COMPRESSED AIR BRUSH.



RAISING ACIDS.

In the manufacture of acids, particularly the oil of vitriol, the newly formed acid is permitted to flow into an egg-shaped vat situated in the cellar of the building or partly buried in the ground. The capacity of these vats varies from 400 to 500 gallons. The application of compressed air to the surface of the acid is universally employed in chemical works and forms the only known method of pumping these liquids, as ordinary pumps cannot be applied. The acid flows into the vat through the acid pipe, as shown in the accompanying cut. When it reaches a certain height, the valve is shut, cutting off the inflow, and connection is opened with receptacles for the storage of the acid. The lid of the vat is then clamped down, being made air tight by rubber adjustment, and the valve in the air pipe is opened, and compressed air admitted to the surface of the acid in the vat. The pressure thus secured forces the liquid through the open valve to any required elevation.

In Lard Refineries, this method is employed with great success for conveying lard in process of refinement from one department to another.

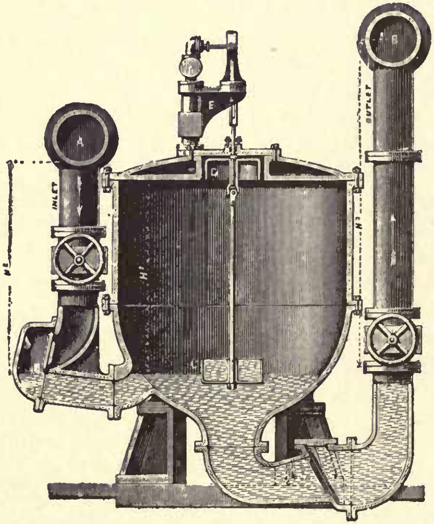
MAKING SILK FROM WOOD PULP.

IN the Consular Reports for March, 1893, Francis B. Loomis, U. S. Consul at St. Etienne, France, reports the discovery of a process for making silk from wood pulp. An important feature of this discovery is the use of compressed air. Silk from wood pulp (sometimes called cellulose silk) is the invention of Count de Chardonnet. The pulp is carefully dried in an oven and plunged in a mixture of sulphuric and nitric acids; then washed in several baths of water, and dried by alcohol. The product thus prepared is dissolved in ether and pure alcohol, and the result is collodion in viscous form.

This substance is then enclosed in a solid, air tight receptacle, furnished with a filter in the lower end. Compressed air is applied, and by the air pressure the collodion is forced through the filter, which removes all impurities, into a tube placed horizontally. This tube is armed with 300 cocks, the spouts of which are made of glass, pierced by a small hole of the diameter of the thread of a cocoon as spun by a silk worm. The spinner opens the cock and the collodion issues in a thread of extreme delicacy (it takes six to make a thread of the consistency for weaving). The glass tube is surrounded by a small reservoir of water, and as the thread issues from the aperture the water takes up the ether and alcohol. This solidifies the collodion and transforms it into a resisting, brilliant, silk-like thread.

The principal defects at present in this invention are said to be the inequality of the product, inflammability, (though this defect has been in part remedied by a bath in solution of ammonia), and the snapping of the thread. It is claimed, however, that all these difficulties can be overcome.

HYDRAULIC COMPRESSED AIR SYSTEM OF SEWERAGE.

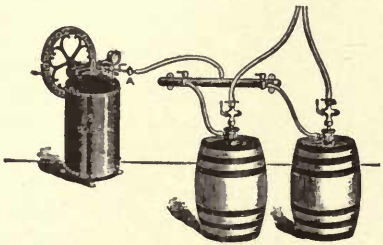


NO system of sewerage equals natural gravitation, and artificial methods of moving and expelling sewage are of course only required in cases where the town or city is so located that gravitation is not available, or too slight to be effective. In such cases, compressed air becomes an important factor, and a system has been devised by which, at moderate expense, any town or city, regardless of natural disadvantages, can be equipped with an effective and healthful compressed air sewerage system.

At a central power plant compressors generate and distribute compressed air to various stations, each station being the outfall of the district about it, and from each the sewage is automatically expelled into a main that leads to the common outlet.

The town is first divided into districts, varying according to population or formation.

At some convenient point in the district, an ejector station is erected for all the sewers in the district, which are so laid as to carry all the sewage to the station, as quickly as possible. There it falls through an inlet pipe into the compressed air ejector. As the sewage gradually rises in the ejector, it carries upward with it a little rod which at a certain height automatically closes the inlet pipe, and opens a valve in the compressed air reservoir. The air then flows into the ejector and forces the solid and liquid contents through the outlet pipe into the high level gravitation pipes or discharge mains. The air valve in the ejector remains open until practically all the sewage has been expelled, when by a reverse automatic arrangement, it is closed and the inlet opened. The advantages of this system are the reduction of working parts to the smallest number and simplest sort, and the absence of finished surfaces. It should also be noted that the ejector forms a cylinder in which the air itself is the piston and there is, therefore, no leakage, friction, slip, or clogging of machinery.



RAISING BEER BY COMPRESSED AIR.—The elevation of beer, ale, porter, etc., from kegs in the cellar is generally accomplished by compressed air, though the compressor is usually a small hand pump, or, as shown in the cut, a hand wheel compressor. These are, of course, able to produce but low pressure, the requirements in these cases being light. Instead of the hand compressor here shown, one known as the Hydro Pneumatic Pump is largely used. The air pump is operated by the hydrant pressure of the water. (See articles upon emptying acid tanks, elevating oil, etc.)

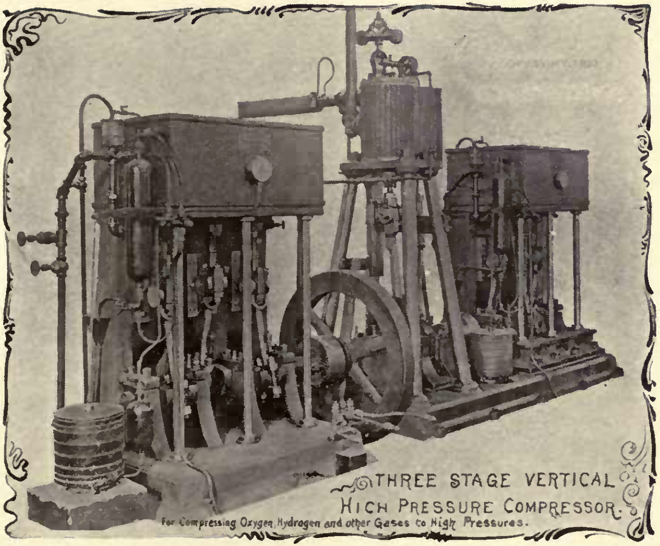
COMPRESSING OXYGEN AND OTHER GASES.

THE Brin process of producing oxygen requires no chemicals, but by using an air compressor, oxygen is extracted from the atmosphere. The process is: A retort charged with absolutely pure anhydrous oxide of barium, is raised to a temperature of 1,400° Fahrenheit. Into this retort an air compressor passes air which has been first purified by lime and caustic soda. The oxide of barium in the retort absorbs the oxygen, while permitting the nitrogen to escape, thus completely separating the two gases. When the barium oxide has become sufficiently peroxidized the compressor is reversed by an automatic arrangement, and the oxygen which has been absorbed is yielded up into vacuum and conveyed by pipes to a tank. The process is then repeated.

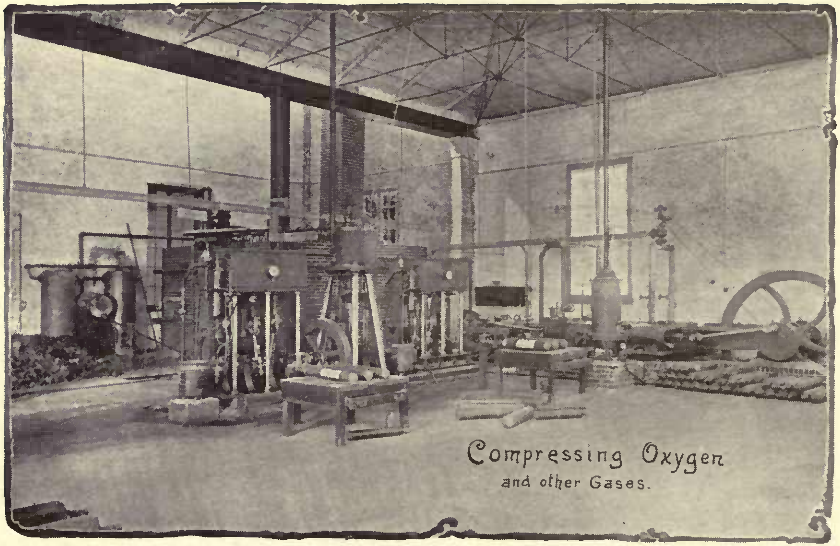
The uses for oxygen are rapidly increasing with the lessening cost of production. With hydrogen, oxygen is widely used in theatres for calcium or lime lights. It is used with hydrogen as a blow pipe, developing such enormous heat that platinum may be readily melted. It is also of extraordinary value in sustaining life in cases of pneumonia and other lung diseases.

Other uses are, thickening oil (as in the manufacture of linoleum,) eliminating sulphur from coal gas, and in aerating water, the latter having especially valuable medicinal properties for rheumatism, diabetes and dyspepsia. The manufacture of oxygen in Europe is practically controlled by one Company, which has an associate organization in this country, the New York Oxygen Company.

Pure nitrogen may be obtained by passing it through an additional barium charged retort, the operation being similar to that for oxygen. The process is purely mechanical, as the



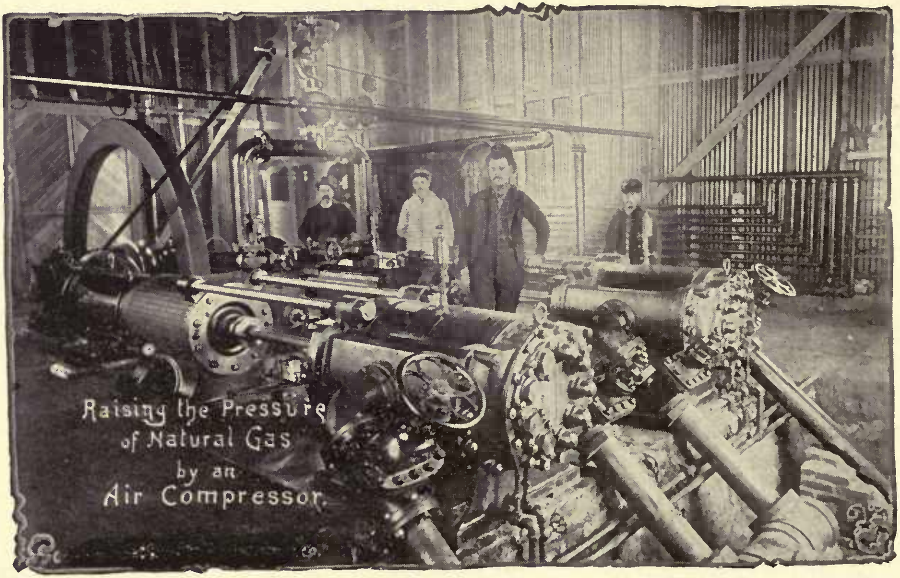
THREE STAGE VERTICAL
HIGH PRESSURE COMPRESSOR.
For Compressing Oxygen, Hydrogen and other Gases to High Pressures.



Compressing Oxygen and other Gases.

barium oxide remains unaffected, receiving and giving off like a sponge. The cost of raw material is therefore literally nothing. From the receiver, the gas is conducted to an especially constructed compressor, within which the oxygen is first compressed to about 70 pounds; a second cylinder then compresses it to 1,000 pounds, and a third to 2,000, at which pressure it is drawn off into weldless steel cylinders which contain from 10 to 100 cubic feet. These cylinders are tested by hydraulic pressure to stand 4,480 pounds, and they have been further tested, when fully charged, by dropping 700 pounds of iron upon them from a height of 35 feet, and, though bent, have retained their contents uninjured. The gas can be drawn off from a cylinder as desired, by a stop cock and key. A system of army balloons, lately devised, is based upon the use of compressed hydrogen. A large number of cylinders containing the gas highly compressed are transported upon a specially constructed wagon, accompanying the balloon corps.

RAISING THE PRESSURE OF NATURAL GAS.—When gas wells were first discovered, the natural pressure was generally so great that it was sufficient to carry the gas through pipes of moderate diameter to a distance, in some instances, of twenty miles, but as the pressure lessened, it was found necessary to put in air compressors, and by this device natural gas is now carried 100 miles from the source of supply. It is not at all improbable that in the course of time it may be found economical to make gas from the coal of the dump piles in Pennsylvania and force it through pipes to the cities far distant. The photograph shows a gas compressor now working at the Lima Natural Gas Co., Lima, Ohio.


Raising the Pressure
of Natural Gas
by an
Air Compressor.

PRESERVING TIMBER—(Vulcanizing.)

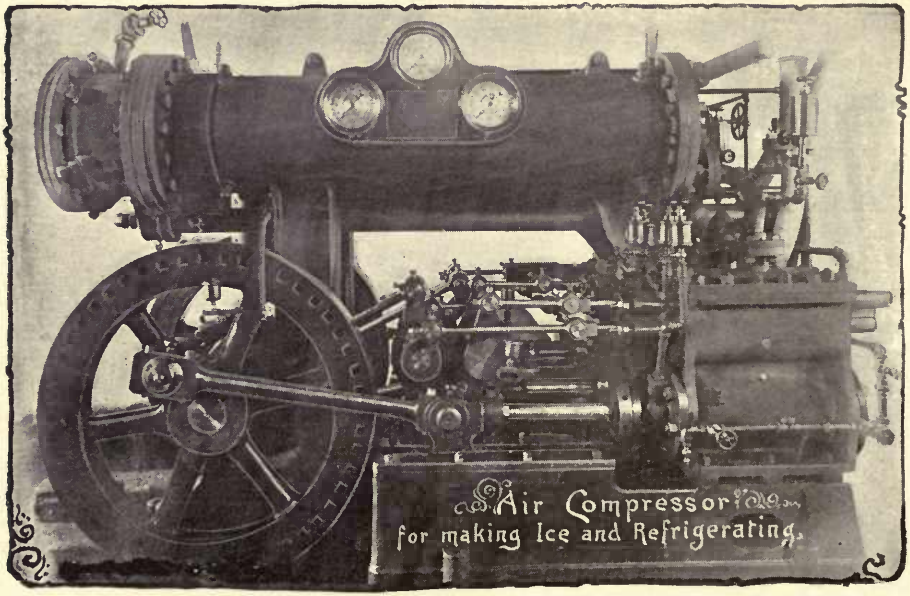
THE vulcanizing process consists of taking advantage of the highly antiseptic change produced in the sap of wood by heat; while this chemical change is in progress the application of compressed air at high pressure, prevents the escape of the sap, and it is solidified within the timber. Thus, by the application of heat and pressure for a few hours, any wood may be as perfectly seasoned as if it had lain for years under the most perfect conditions. The plant for vulcanizing consists of steel cylinders about 100 feet long and 6 feet in diameter, capable of sustaining about 200 pounds pressure. The timber to be vulcanized is run into these cylinders on cars. The cylinders are then closed, and the temperature raised to about 300 degrees by superheated steam and coils. At the same time compressed air, at a pressure of 160 pounds, is applied through a pipe entering the cylinder about midway. The heat and pressure are maintained from eight to twelve hours, and the cylinders are then permitted to cool, still under pressure. The advantages of the process are many. Decay is made impossible, by hardening the wood and retaining every preservative quality. The life of vulcanized timber is therefore unlimited, making it of extraordinary value in outdoor service such as railroad ties, telegraph poles and arms, and ship timber. The strength and resistance of wood are increased 18 per cent. by this process; cracking and warping are rendered impossible; and color and brilliancy are so much improved that vulcanized wood is now largely used in cabinet work and house finishing. By this means, also, antique oak of richest tint may be produced from green timber. The process of vulcanizing wood has already been extended to Europe, and is coming into general use at a time when the annual consumption of timber is twice the natural growth. By extending indefinitely the life of useful timber and making of value wood otherwise useless, vulcanizing may offer the ultimate solution of that troublesome problem of forest destruction.

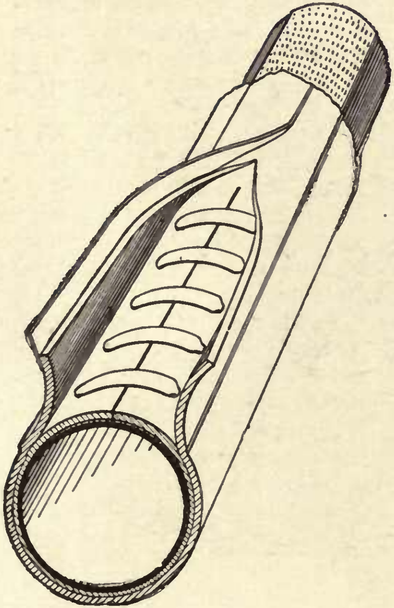
RAISING SUNKEN VESSELS BY COMPRESSED AIR.—Many methods have been devised from time to time to raise vessels, by employing compressed air, the essential feature being the adjustment of bags in or about the wreck, after which air was forced into the bags, raising the wreck by the buoyancy thus imparted. One method, employed in England in 1870, was to place pontoons about the wreck, to each of which was attached a small cylinder of compressed air. By a valve the air was permitted to expand into the pontoon, thus expelling the water, and the vessel rose.

ICE MAKING AND REFRIGERATING.

ALL refrigeration by mechanical means depends upon the fact that heat is generated by the compression of gas or air, and that if this heat be in any way absorbed, and the air be then expanded to its original pressure, the expansion will cool it in the same way that the compression heated it—the temperatures obtained in this way being many degrees below zero. The system of refrigeration which employs air instead of ammonia and other gases, has distinct advantages for many places, notably on ship board. The illustration is made from a photograph of a machine furnished to one of the flag-ships of the navy. This machine, by reason of its compactness, is specially adapted for marine use. It has three cylinders—one for steam, one for compressing, and one for expanding the air—the cranks being all on the same shaft. The system comprises the compression of the air, the absorption of the heat generated, and the expansion of the air in a cylinder similar to the steam cylinder—the air in its expansion thus doing useful work, and assisting in driving the machine. After expansion the cold air is circulated through the rooms to be cooled, in closed pipes, after which the same air is returned to the machine to be used over and over—this cycle of operations being indefinitely repeated. Any incidental leakage of air is supplied by a small auxiliary pump.

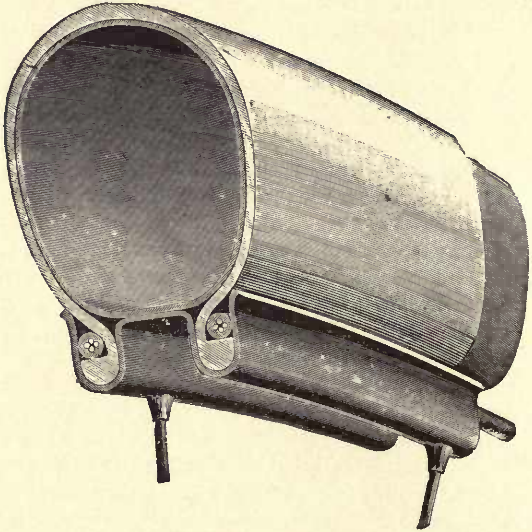
The system of refrigerating by compressed air, is meeting with great favor in many Western cities, and the practicability of piping the streets and supplying cold air for business and private requirements, has been actively discussed in St. Louis and elsewhere. Investigation in St. Louis showed that in a business quarter five miles in extent, $172,000 was annually expended for ice at $4 per ton, a figure which would make a compressed air plant a profitable investment.


Air Compressor
for making Ice and Refrigerating.



THE COMPRESSED AIR TIRE.

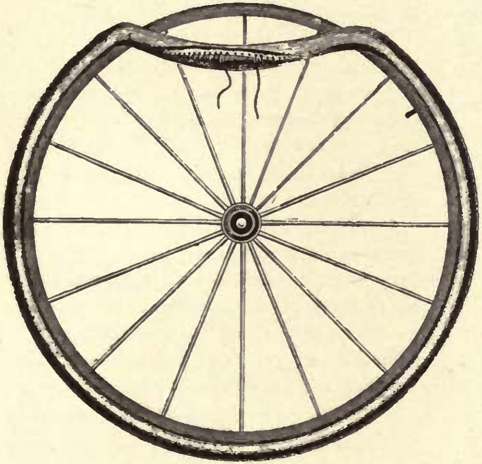
The application of compressed air to the tires of vehicles is said to be at least 50 years old, and at that time it was proposed to make them with an inner tube and cover of leather. The practical application to bicycles, however, is said to have been first made in England in the form, substantially, of an endless hose, which was cemented to the rim. In this form the tire was intended to be thick enough to withstand the cuts of sharp stones, but even though so made, punctures occurred, necessitating the return of the tire to the manufacturer, which led to the design of a detachable cover and inner tube. This is the tire now in most general use. It is said to be a French invention. The inner tube is made of pure gum elastic rubber about 1-32 of an inch thick. The tube when inflated is about 1 3-8 inches in diameter. A patch holding the projecting valve is put on one side of the tube before vulcanization. The strip of tubing is cut in suitable lengths to form the circle; one end is then inserted in the other, and they are cemented together. The outer cover is formed of layers of canvas



SECTION OF BICYCLE TIRE.

and rubber—thicker on the tread portion, and about 1¾ inches in diameter. The method of application of the tire shown in the cut on the opposite page is to lace protecting flaps over the inner tube, through slits. The cut on the this page illustrates the most recent device. This method is to fasten one side, then place the inner tube in its place, bring the cover down over it and fasten the latter to the rim by means of the binding wire.

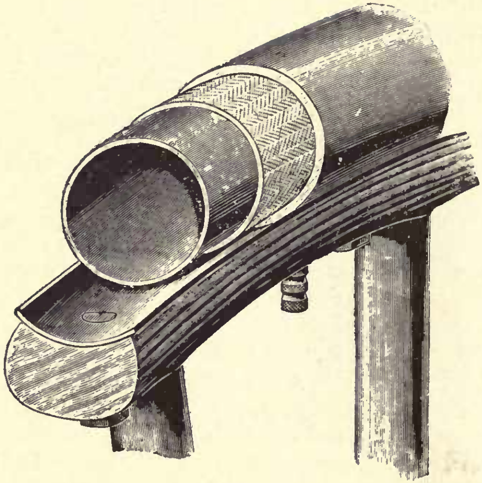
The speed made by experts upon the bicycle in races, is said to have increased within a few years' time, about 18 per cent, according to the testimony of experts, and much of this is due to improved machines and the better skill and endurance of man. But after these factors have been deducted the same experts express the opinion that 10 per cent. of the increase is due to the pneumatic tire. The same experts say that while the races upon the solid wheels produced stagnation of blood in the lower limbs, the pneumatic tire prevents any such effect. There is a notable difference in the increase of speed obtained by the pneumatic tire applied to a bicycle and to a sulky, as the estimate is made that the advantage in the latter case is about three per cent.



AIR TIRE ON A ROAD WAGON.

Experts differ greatly as to what may be called the life of a bicycle tire, but it would seem to be a safe statement to make, that when the tires are used by professionals, on the road as well as in the ring, three or four are required during the season. Perhaps the average life of a compressed air tire may be stated as about one year.

The pneumatic tire has not come into such general use for road wagons and carriages, but is used very generally on sulkies. The wagon-wheel tire is substantially the same as that already described. The illustration shows a popular pneumatic tire for road wagons. The triple tube shows the sections of the tire. The smallest section is the air tube, made of specially prepared stock, the air valve



SECTION OF A TIRE ON A ROAD WAGON.

being vulcanized to the air tube. The second section shows the restraining jacket enveloping the air tube, and made of Sea Island cotton of peculiar construction to avoid stretching. Outside of this is the wearing shoe, which, like the inner tube, is of finest material, but is not subjected to any air pressure. It is thus apparent that each section performs special service, and it is said they together form a most satisfactory and durable tire, effectually deadening cobblestone pavements and rough roads.

The principle of the pneumatic tire, has been applied even to roller skates. A Scotch manufacturer makes a skate that meets all the requirements of road travelling, and which straps or clamps to the shoe like the ordinary skate. The rollers are 3½ inches in diameter, the tires 2 inches, and the average weight of each skate 2¾ pounds. The rollers are fitted with ball bearings, and run noiselessly.

TRANSMISSION OF POWER.

SCIENTIFIC experiment has discovered but four methods of transmitting power—steam, water, compressed air and electricity: and of these, steam and water are open to serious objections. The use of compressed air distributed through the streets in Paris and Birmingham, England, has developed numerous uses not originally contemplated. New works, located near the river Seine for convenience of supplies of coal and water, have recently been erected, and the design contemplates an aggregated power equal to 25,000 horses. A major part of the power is now issued to operate engines running dynamos for electric lighting purposes scattered throughout the city. The exhaust from the engines is used for refrigerating purposes, and for ventilation when the engine is located in or near a hotel, restaurant, or theatre.

This also serves to keep the temperature above the freezing point after exhaust. An English engineer declares that a quarter of a pound of coke per hour per indicated horse power is sufficient to heat the air required in a moderate sized expansion engine, and 5 pounds of coke per hour sufficed for an engine indicating 20 horse power, enabling it to maintain the whole system at 80 per cent of proficiency.

Other uses of compressed air are—for refining silk ribbon, for removing the hose from iron mandrels in rubber hose factories, operating sand blasts, automatic fire extinguishers, increasing the pressure on hydraulic elevator tanks, and for indicators and bells in elevators, houses and shops.

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