(No Model.)

4 Sheets--Sheet 1

F. E. B. BEAUMONT.

Air Engines.

No. 232,438. Patented Sept. 21, 1880.

FIG: 5.

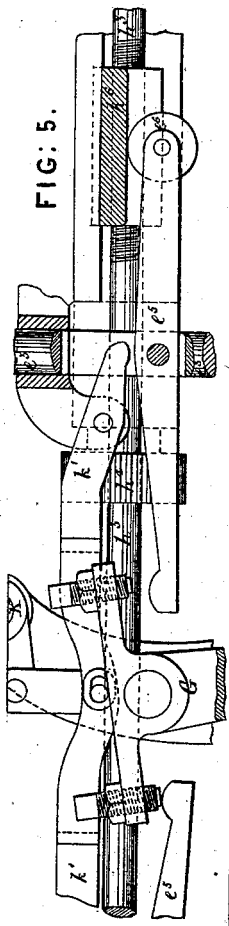
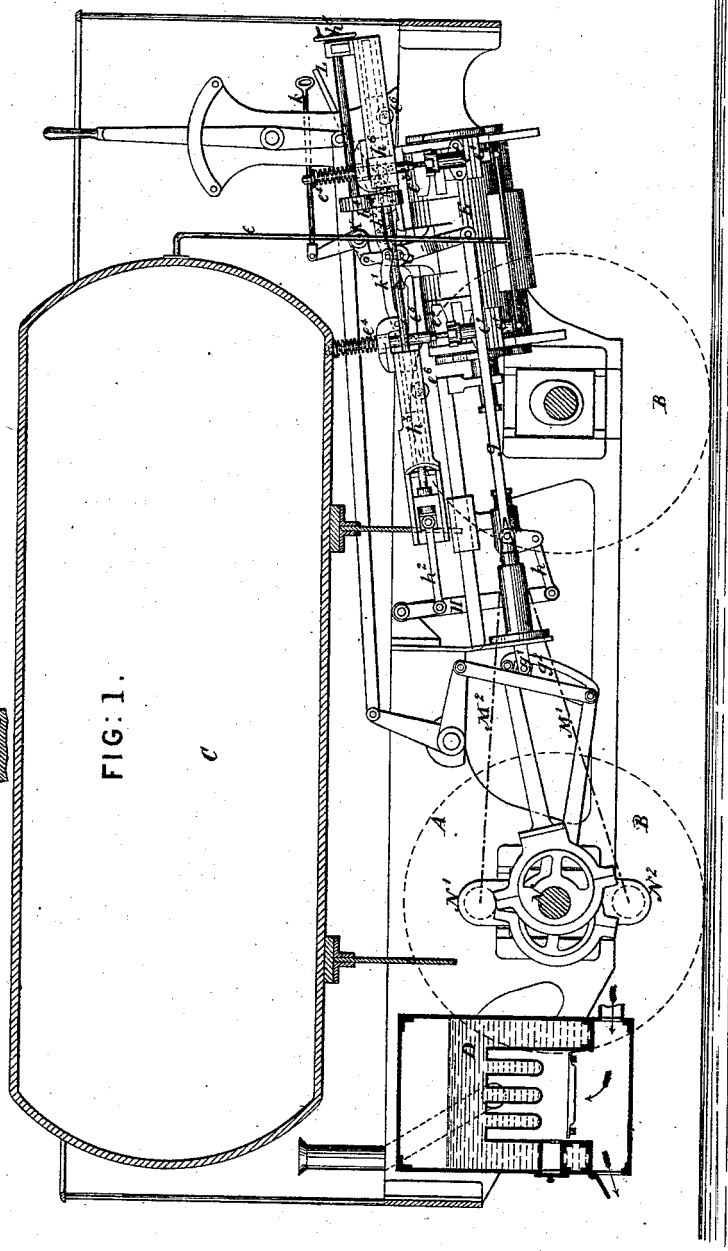


FIG: 1.



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By James L. Norris

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(No Model.)

4 Sheets—Sheet 2.

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FIG: 7.

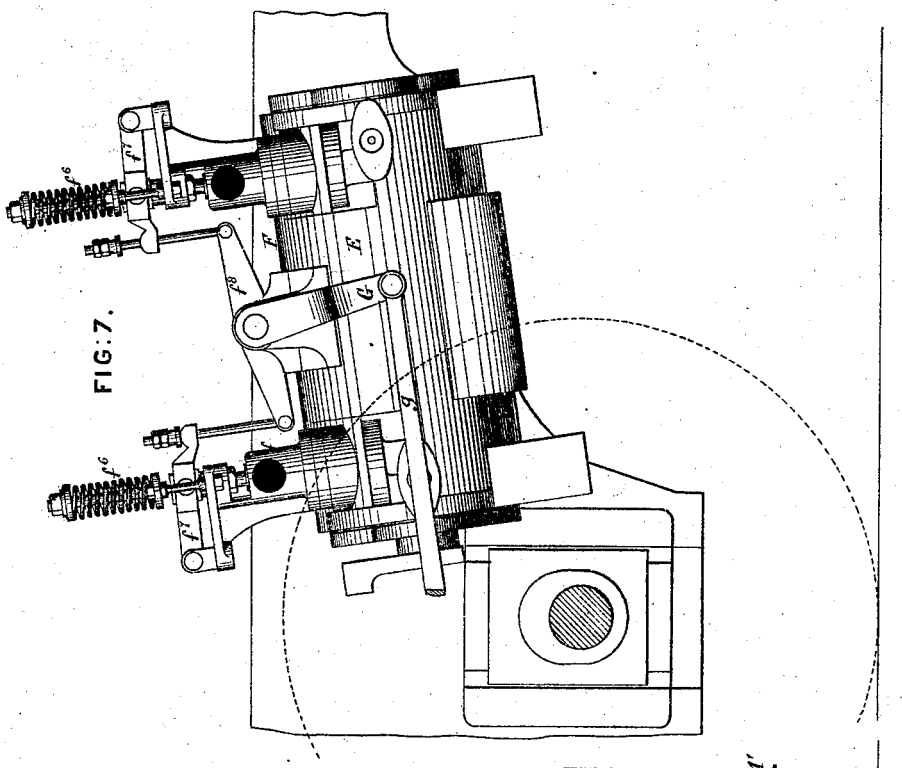
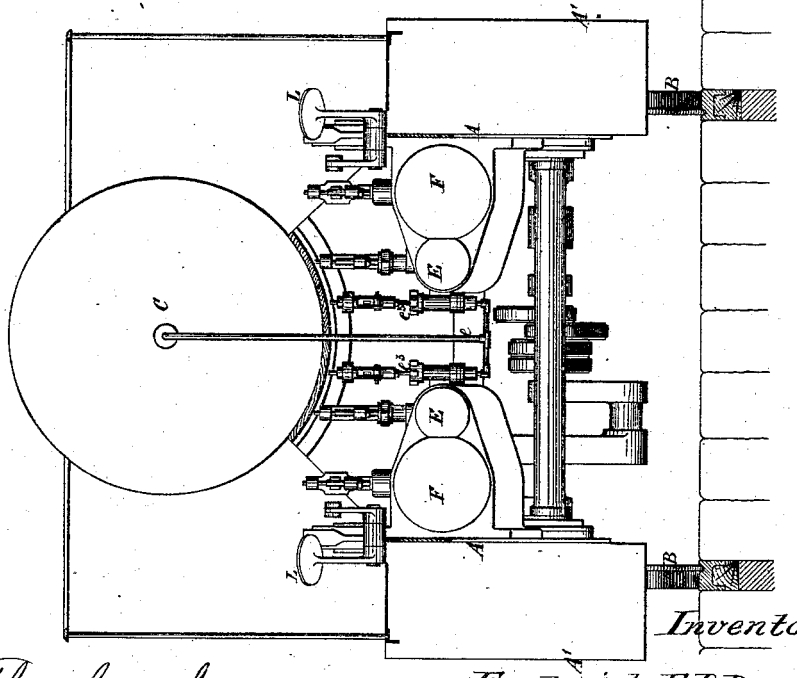


FIG: 2.



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4 Sheets--Sheet 3.

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FIG: 3

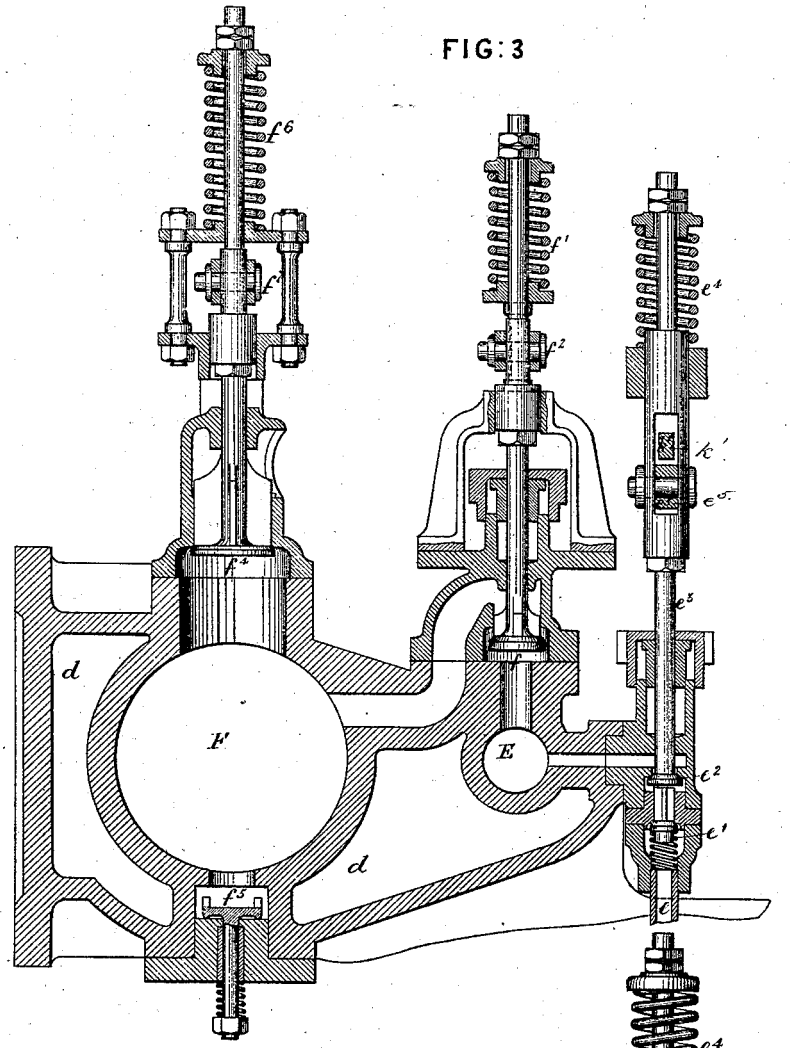
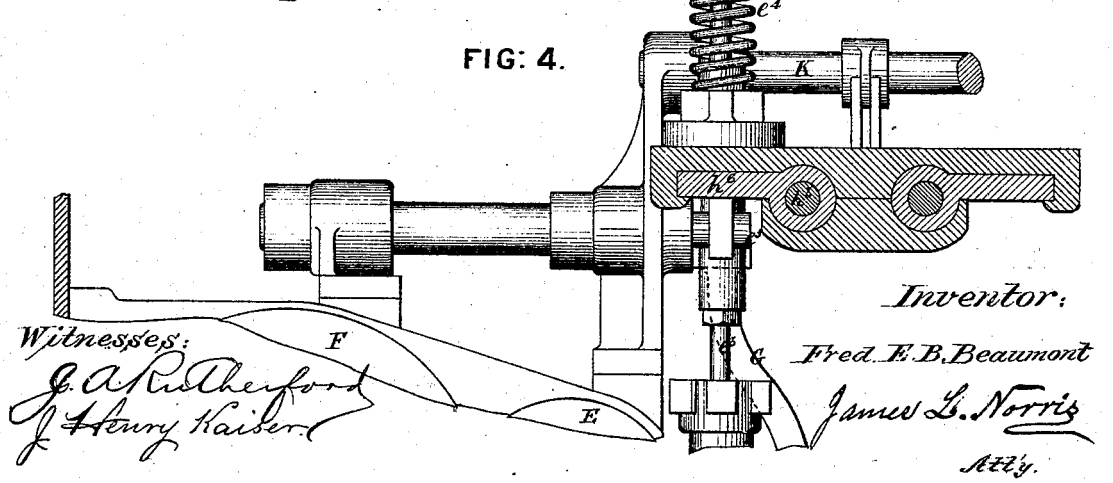


FIG: 4.



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(No Model.)

4 Sheets--Sheet 4

F. E. B. BEAUMONT.

Air Engines.

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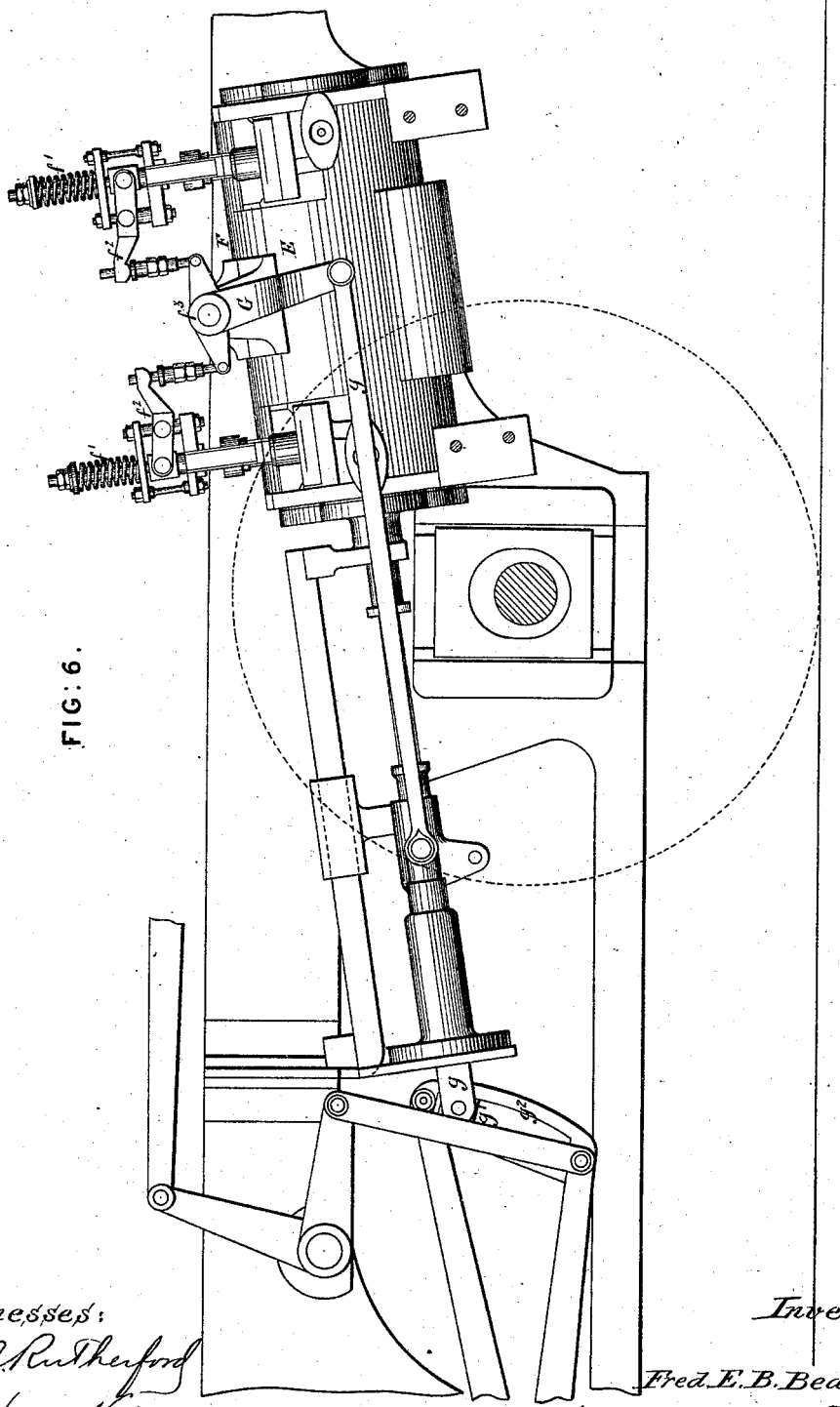

FIG: 6.

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UNITED STATES PATENT OFFICE.

FREDERICK E. B. BEAUMONT, OF WESTMINSTER, ENGLAND.

AIR-ENGINE.

SPECIFICATION forming part of Letters Patent No. 232,438, dated September 21, 1880.

Application filed August 7, 1880. (No model.) Patented in England February 7, 1880.

To all whom it may concern:

Be it known that I, FREDERICK EDWARD BLACKETT BEAUMONT, of No. 4 Broad Sanctuary, Westminster, Middlesex, England, have invented an Improved Motor-Engine worked by Compressed Air, applicable more particularly as locomotive or traction engine, for which I have obtained a patent in Great Britain, No. 535, bearing date February 7, 1880, and of which the following is a specification.

My invention relates to the construction and arrangement of a motor-engine, more particularly applicable as locomotive-engine, worked by the pressure of compressed air, which, in the case of a locomotive or traction engine, is compressed into a reservoir carried by the locomotive, and constituting a store of force sufficient to propel the locomotive over considerable distances.

In the construction and arrangement of the engine I apply certain principles whereby I am enabled to economize the expenditure of the working-fluid to regulate its action, notwithstanding considerable variations of its pressure, and also to provide for temporary energetic action when required—as, for instance, in starting the locomotive and its load from a state of rest.

As my invention is more particularly applicable for locomotive purposes I will first describe generally the character of a locomotive in which it is applied, and will then explain structural details.

Referring to the accompanying drawings, Figure 1 is a longitudinal section, and Fig. 2 an end view, of the whole locomotive. A framing, A, supported by springs on four wheels, B, carries the reservoir C, containing the compressed air and two complete engines worked by it. Each engine consists of two double-acting cylinders, one of them, E, a small cylinder, which receives for each stroke a charge of compressed air from the reservoir C, and the other, F, a larger cylinder, in which the air discharged from the smaller engine expands, performing work, and from which it is discharged as waste. The admission of air to the smaller cylinder E is regulated by an adjustable cut-off apparatus, hereinafter to be described, so that, notwithstanding considerable change of pressure in the reservoir, the engine-power can be maintained uniform, or nearly so. Thus, when the reservoir at first starting contains air at very high pressure, the cut-off is adjusted so that at each stroke the small cylinder receives a very small charge, which expands therein, propelling its piston, and afterward expands further in the larger of the two cylinders. When, on the other hand, the pressure in the reservoir has become greatly reduced by expenditure of air, the cut-off is adjusted so as to admit a larger charge into the small cylinder—that is to say, to admit air throughout a greater portion of the stroke of its piston. When the pressure in the reservoir is so far reduced that the action on the smaller piston gives very little power the supply-passages to the smaller cylinder are, by means hereinafter to be described, kept open, so that the air from the reservoir acts directly on the piston of the larger cylinder, the smaller piston in that case working idly. This arrangement can also be temporarily adopted when energetic action is required, as for starting the locomotive, the full pressure of the air in the reservoir being, throughout one stroke or more, permitted to act on the larger piston. The pistons of the two cylinders are connected in the usual way to cranks on the driving-axle, those two cranks being set opposite to one another, so that when one of the two pistons is advancing the other is retreating. By this arrangement the air discharged from each end of the small cylinder passes directly into the corresponding end of the larger cylinder, this arrangement shortening the passages from the one cylinder to the other and simplifying the valves which govern them. The other pair of cylinders, arranged in a similar manner, act on cranks on the same driving-shaft, those cranks being likewise opposite to one another, but at right angles to the cranks of the former pair of cylinders.

The driving-axle has on it two sets of eccentric-working link-motions of ordinary construction, one for each pair of cylinders, these link-motions being connected in the usual way to a hand-lever for starting, stopping, or reversing.

As the air, when it expands, performing work in the cylinders, would undergo considerable reduction in temperature and proportionate reduction of pressure, I provide means

of sustaining its temperature during its expansion. For this purpose I mount in a convenient part of the locomotive, as at D, a small boiler for generating a small quantity of steam, which is led by a pipe to hollow casings inclosing the working cylinders. The steam partly condenses in these casings, keeping the cylinders warm, and the water of condensation returns by a pipe to the boiler, to be again vaporized and circulate through the casings.

It is of advantage to lead the air discharged from the larger cylinders to the ash-pit of the boiler, which is provided with an escape-valve, so that the discharged air can, when required, be made, by closing more or less the escape-valve, to act more or less as a blast for the boiler-fire.

In order to avoid complicating the drawings I have not shown in them the air or steam pipes connected with the boiler, as their arrangement may be readily understood. The wheels B are coupled by external connecting-rods in the usual way, so that they all act as driving-wheels, and these connecting-rods, as well as the wheels, are inclosed within casings.

Having thus described generally the construction and arrangement of a locomotive according to my invention, I will now explain the arrangement and action of the valves by which the air is admitted to and emitted from the working cylinders of each engine, referring to the following detail drawings.

Fig. 3 is a transverse section through a pair of the cylinders and their valves; Fig. 4, a transverse section, and Fig. 5 a part longitudinal section, of the cut-off apparatus for the smaller cylinder; Fig. 6, a side view, showing the levers for working the valves that govern the passages from the small to the large cylinder; and Fig. 7, a side view, showing the levers which work the valves that govern the discharge from the large cylinder. In these figures E is the small cylinder, and F the large cylinder. *e* is the pipe leading from the reservoir C to each end of the small cylinder, the passage in each case being governed by a double valve, a lower valve, e', pressed up against its seat by a spring, and an upper valve, e^2, having a stem, e^3, which passes through a stuffing-box and is pressed upward by a spring, e^4.

It will be observed that the two valves e' and e^2 are not rigidly attached to one another, but that the lower one, e', is merely opened by the pressure of the upper valve upon it, the lower valve having freedom to close tightly when the upper valve seats itself. Both valves are opened by the downward movement of the stem e^3, and according as this movement is more or less prolonged a greater or less charge of compressed air will be admitted to the small cylinder E, or, in other words, the movement of the stem e^3 determines the cut off. This movement is effected and regulated in the following manner: In the stem e^3 is jointed a lever, e^5, which at one end carries a roller, e^6, and at the other end is acted on by an arm of a three-armed lever, G, which is worked by a connecting-rod, *g*, from a slide, g', moved by the eccentric link g^2.

The piston-rod of the smaller cylinder E, by means of a link, *h*, (see Fig. 1,) works a lever, H, and this lever, by means of a link, h^2, works a sliding rod, h^3. This rod is connected to the link h^2 by a swivel-joint, so that it can be caused to revolve by gearing h^4, worked from a hand-wheel, h^5. The rod h^3 is screwed over two parts of its length with right and left threads, working respectively in female threads in blocks h^6, (see Figs. 4 and 5,) which move in guides parallel to the axis of the cylinder. By turning the hand-wheel h^5, and thereby causing the rod h^3 to revolve in either direction, the two blocks h^6 can be made to approach toward each other or to recede from one another, while they also continue to reciprocate to and fro along with the rod h^3, which reciprocates in accord with the piston of the small cylinder E, but with a much smaller extent of stroke, as determined by the proportions of the lever H. The rollers e^6 bear against the under faces of the blocks h^6, and therefore if, while either of them so bears, an arm of the lever G depresses one end of the lever e^5, the middle of the lever e^5 is necessarily depressed, moving down the stem e^3 and opening the valves e^2 and e', so as to admit a charge of air to the small cylinder E. The piston of that cylinder moving causes the rod h^3 and block h^6 also to move, and when the block h^6 has moved so far that the roller e^6 no longer bears against it, then the lever e^5 is left free and the valves e' e^2 close, cutting off the supply to the cylinder E. Thus, when the hand-wheel h^5 is turned in the one direction, causing the blocks h^6 to approach toward each other, the cut-off takes place at an earlier period of each stroke of the small piston, and when the hand-wheel is turned in the opposite direction the cut-off takes place at a later period. The one hand-wheel h^5, by means of the gearing h^4, serves to turn the rods h^3 of both engines simultaneously, and thus the attendant can vary the expansion in the small cylinders to suit the state of the pressure in the reservoir C.

Besides being enabled thus to vary the expansion, the attendant can at any time, by means of a handle, *k*, keep open the supply-valves e' and e^2, rendering the small pistons idle and admitting air at the full pressure of the reservoir to act on the larger pistons. For this purpose the handle *k* is connected to a lever on a rocking shaft, K, an arm on which is linked to levers k', that engage in the stems e^3, so that when the handle *k* is pulled the four stems e^3 are simultaneously depressed, and consequently the four sets of valves e' e^2 are opened. Thus, when the pressure acting in the small cylinders is insufficient to start the locomotive the attendant, by pulling the handle *k*, can admit the air to act in the larger cylinders at its full pressure, the small pistons being for the time *in equilibrio*.

The valves *f*, whereby the air passes from the small cylinder E to the large cylinder F, are kept closed by springs *f'*, and are opened alternately by the levers f^2, acted on by the levers f^3, which are worked from the eccentric link and lever G, as shown in Fig. 6; and in like manner the valves f^4, which govern the final discharge of air from the large cylinders F, are kept closed by springs f^6 and opened alternately by the levers f^7 f^8, which are worked also from the eccentric link, as shown in Fig. 7.

It will be seen that by the different arrangement of the levers actuating the several admission-valves of each compound engine they are all enabled to be worked by one and the same shaft and the lever G.

The spaces *d* (shown in Fig. 3) constitute the casing supplied with steam, as above described, for the purpose of warming the cylinders E F and the air expanding in them.

It may happen that the expansion in the larger cylinders F is carried so far that the pressure of the air in them would be considerably below the atmospheric pressure. To provide against this the cylinder F has an aperture governed by a valve, f^5, which is kept seated by a light spring, so that should the pressure within the cylinder be below that of the atmosphere air will enter by the valves f^5.

The opposite cranks, $N' N^2$, of the driving-axle N are worked respectively by the piston-rods of the cylinders E and F, by means of connecting-rods indicated by the dotted lines $M' M^2$, Fig. 1. The brakes are worked by treadles L.

Although I have shown in the drawings an arrangement of locomotive suitable for being connected to other vehicles, such as tram-cars, it may be readily understood that the construction and arrangement could be varied so as to accommodate the reservoir and engines in or under the body of the vehicle itself, the general principles of action and arrangement of the valves and their movements remaining such as I have described them. The air-reservoir, which I have shown as a single strong vessel, may be subdivided into several smaller vessels. A convenient and strong form that has been employed is that of a number of closed tubes communicating with one another. I have mentioned steam as being employed for maintaining the temperature of the air-cylinders. In cases where the boiler is at a sufficiently high level relatively to the cylinder-casings these might merely have hot water circulating through them; or instead of water, there might be a saline solution or oil or other liquid having a boiling-point higher than water.

The pipe conveying the air from the reservoir to the cylinders may be heated by passing it through the hot casings, so as to warm the air before it begins to perform work.

Although I have described my invention as being more particularly applicable to locomotive or traction engines, yet it will be evident that it is also applicable as a motor-engine for propelling boats or for working in mines or other localities where it is necessary to convey the fluid-pressure from a distance through pipes. In the latter case, instead of having the reservoir for compressed air in immediate connection with the engine, it may be at a distance therefrom, at the locality where the air-compressing engine is situated, or the reservoir may be entirely dispensed with and the air compressed by the compressing-engine be conveyed directly therefrom through pipes to the motor-engine.

Having thus described the nature of my invention, and the best means I know of carrying it out in practice, I would have it understood that I make no general claim to the use of compressed air or other elastic fluid under high pressure for working locomotive or other motor-engines; but

I claim in respect of such engines, when they are worked as compound engines by compressed fluid acting in successive cylinders—

1. The method herein described for regulating the working power to suit variations in the pressure of the working-fluid by expansion apparatus, all constructed as shown, and applied to the fluid-cylinder, whereby the supply of working-fluid can be cut off sooner or later during each stroke, substantially as herein described.

2. The method of obtaining temporary energetic action by holding open the supply-valves of the first cylinder, so that while its piston moves *in equilibrio* the full pressure of the fluid is admitted to act on the piston of the next larger cylinder by mechanism constructed and arranged substantially as herein described.

3. The combination, with the supply-valves e' and e^2, of the lever G, worked by the eccentric link, the valve-levers e^5, with their rollers e^6, the screwed rod h^3, worked from the piston-rod, and the sliding adjustable blocks h^6, substantially as and for the purpose herein set forth.

4. In each compound engine, the combination of the one lever G and weigh-shaft worked by the eccentric link, with the arms f^3 and their links, and the several valve-levers, e^2, f^2, and f^7, substantially as and for the purpose herein set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses this 8th day of July, A. D. 1880.

F. E. B. BEAUMONT.

Witnesses:
CHAS. BERKLEY HARRIS,
J. WATT.
Clerks to Messrs. Scorer & Harris, Notaries, 17 Gracechurch Street, London.