(No Model.)

3 Sheets—Sheet 1.

A. K. RIDER.

AIR ENGINE.

No. 345,450. Patented July 13, 1886.

Fig. 2.

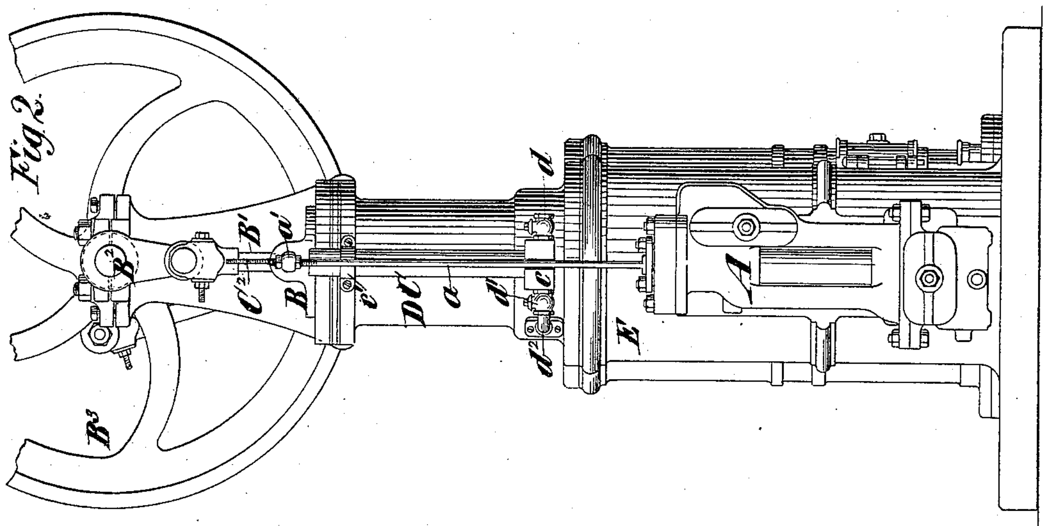
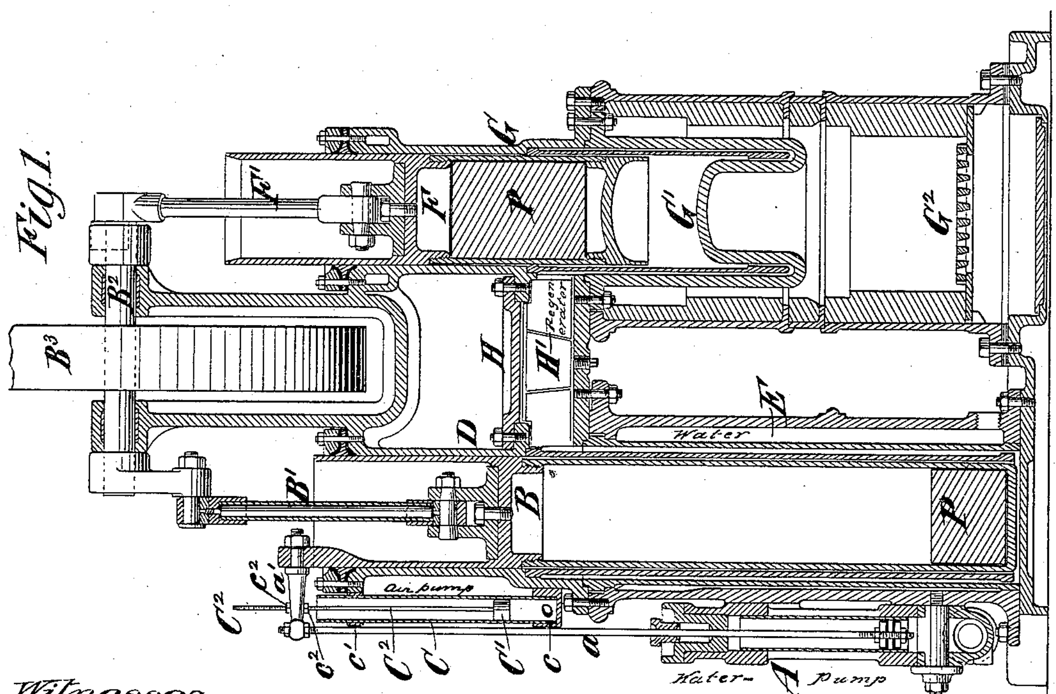


Fig. 1.



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(No Model.) 3 Sheets—Sheet 2.

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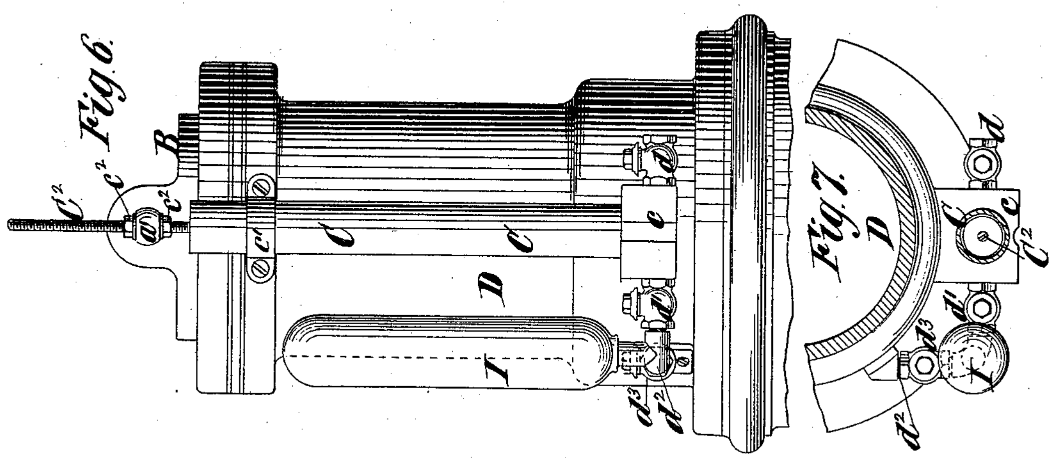

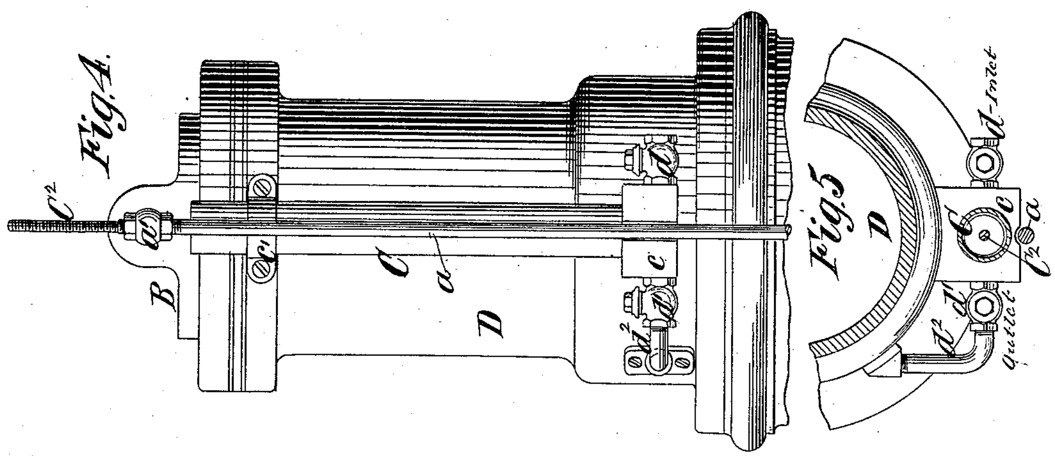

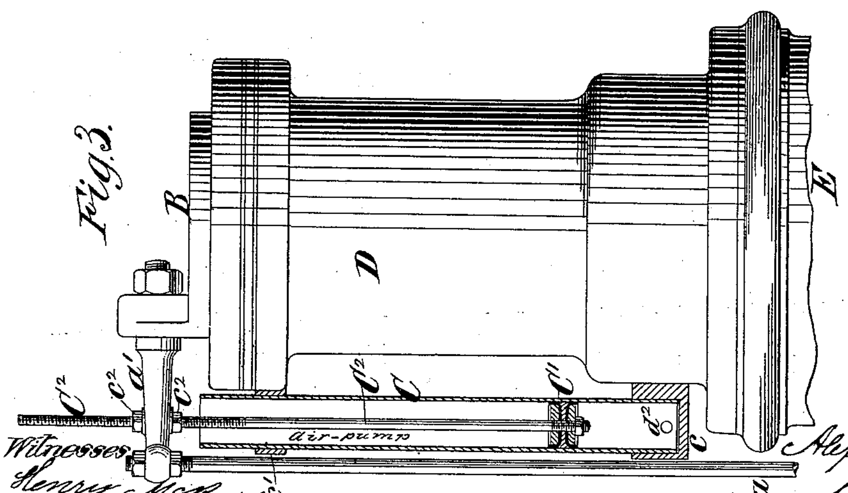

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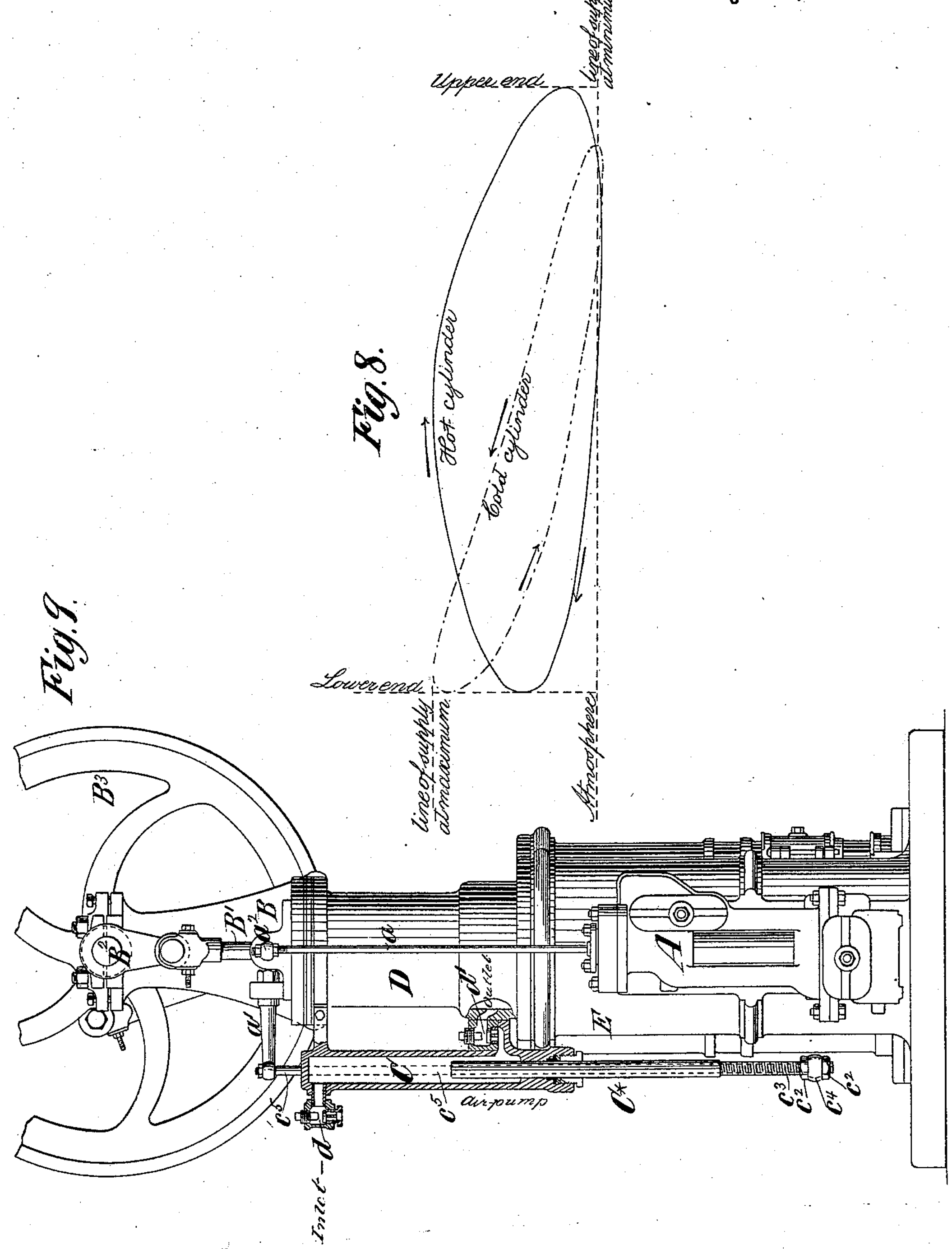

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UNITED STATES PATENT OFFICE.

ALEXANDER KIRK RIDER, OF WALDEN, NEW YORK.

AIR-ENGINE.

SPECIFICATION forming part of Letters Patent No. 345,450, dated July 13, 1886.

Application filed January 30, 1886. Serial No. 190,287. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER KIRK RIDER, of Walden, in the county of Orange and State of New York, have invented a new and useful Improvement in Air-Engines, of which the following is a specification.

My invention relates, generally, to air-engines of the class which operate in "closed cycle"—that is, using the same air over continuously, except the small portion escaping by leak; and the invention particularly relates to engines of the construction shown and described in my United States Patents No. 167,568, dated September 7, 1875, and No. 220,309, dated October 7, 1879.

The object of my invention is to increase the power of an air-engine of this class of a given size without materially increasing the cost of construction or lessening its simplicity.

The invention consists in the combination, with an air-engine acting in closed cycle, and having uncovered cylinders and pistons and an external heating device for heating the air within the engine, of an air-supply pump for maintaining the desired initial pressure of air in the engine.

The invention also consists in the combination, with an air-engine, of an air-supply pump having its clearance-space variable by adjustment to properly regulate the initial pressure in the engine.

The invention also consists in an air-engine provided with an air-supply pump, and in which the increment of pressure caused by increasing the initial pressure is wholly or partially balanced by the weight of the pistons.

The invention also consists in the combination, with an air-engine provided with the usual "suck-in" valve to prevent the minimum pressure in the engine from falling materially below the atmosphere, of an air-supply pump, whereby a sufficient pressure of air will be produced to open the suck-in valve before a partial vacuum is formed in the engine.

The term "initial pressure" is used to imply the minimum pressure of air, or that which exists within the engine at its lowest pressure.

In adapting my air-engine to use a high initial pressure of air I have found that the power developed is in direct ratio to the weight of air present in the engine, or exactly in proportion to the initial pressure in atmospheres; but an initial pressure of two or more atmospheres cannot, in this construction of engine, be used without inclosing the pistons and covering the cylinders, nor could the initial pressure be regulated heretofore so as to come to a given limit constantly. In my improved practice I do not carry the initial pressure beyond one and one-half atmospheres, which gives one and one-half times the power as compared with the same engine using an initial pressure of one atmosphere only.

In carrying out my invention I employ a single-acting air-supply pump of small capacity attached to the engine for the purpose of supplying any leak of air, and to keep up the initial pressure to the desired degree. This air-supply pump is, in its most approved form, so constructed and combined with an engine that its amount of clearance is variable and adjustable, and so that it is easy to adjust the relation between the compression and the clearance to cause the air-supply pump to throw into the engine at each revolution exactly the proper amount of air, and at the proper pressure to make up any loss of air by leak, and at the same time to keep the initial pressure or quantity of air contained in the engine constantly uniform. The regulation of the amount of clearance in the pump prevents any excess of pressure, while the comparatively large capacity of clearance insures the required quantity of air being delivered. I also employ means for balancing the increment of pressure consequent on the increased initial pressure. This is effected by weighting the pistons, which, as they reciprocate vertically, enables this to be readily done by making a greater or less portion of each piston solid; or the pistons may in other ways be given the required weight to balance as near as possible the increment of pressure by gravitation, which effectually prevents the excess of friction which would otherwise occur in the crank pins and journals.

In the accompanying drawings, Figure 1 is a vertical longitudinal section of an engine similar to those shown in my aforesaid patents, and which embodies my invention. Fig. 2 is an end elevation of the engine from the cold or compression end, showing the air-supply pump in position thereon. Fig. 3 is an elevation, on a larger scale, of a portion of the compression or cold cylinder, and also showing a vertical section of the air-supply pump with the means for adjusting its clearance. Fig. 4 is an elevation of the cold cylinder and its supply-pump on the same scale as Fig. 3. Fig. 5 is a plan and horizontal section of a portion of the cold or compression cylinder. Figs. 6 and 7 are respectively an elevation and plan of the cold cylinder and supply-pump, illustrating a modification of my invention which is designed to cause the injection of the supply of air from the pump to occur at the opposite part of the revolution of the engine from that which occurs with the arrangement of parts shown in Figs. 4 and 5. Fig. 8 represents an indicator diagram from the engine, showing the action of the suck-in valve, and also the points of delivery of the supply-pumps; and Fig. 9 is an elevation showing the suck-in valve and the air-supply pump, which is reversed in its action as compared with the pump shown in the former figures.

Similar letters of reference designate corresponding parts in all the figures.

The engine, as shown in Figs. 1 and 2, is designed for pumping water, and may be briefly described as consisting, essentially, of a hot cylinder and piston and a cold cylinder and piston, with the usual adjuncts of connecting-rods, cranks, fly-wheel, &c. The air is heated and expanded in the hot cylinder, and after it has given out its force it is returned to the cold cylinder, where it is cooled and compressed, and then returned to the hot cylinder again, to be heated and expanded, and so on indefinitely. The water-jacketed part of the cold cylinder is termed the "cooler."

A designates a water-pump, which may be of any suitable construction, and B is the cold piston, which reciprocates within the cold cylinder D. E designates the cooler, which surrounds the cold cylinder, and F designates the hot piston, which reciprocates within the hot cylinder G. The pistons B F transmit their motion through connecting-rods B′ F′ to a crank-shaft, B^2, upon which is a fly-wheel, B^3. Below the hot cylinder G is a heater, G′, into which the hot piston F projects in its downward movement, and within which the air is heated by a fire upon the grate G^2.

The cold cylinder D and the hot cylinder G^2 are connected by an air-passage, H, within which is placed the regenerator H′, which is heated by the hot air in its return to the cold cylinder, and gives up such heat to the air as it returns to the hot cylinder after cooling and compressing.

No further description of the principal parts of the engine is necessary.

The water-pump A may be bolted to the side of the cooler E, and its piston-rod *a* is connected with and operated by an arm, *a′*, projecting from the cold piston B, as shown in Fig. 3, and by an arm, a^2, as shown in Fig. 9.

The air-supply pump here shown consists, essentially, of a barrel or cylinder, C, which may consist of a piece of brass tubing, and is secured to the cold cylinder at the points *c c′*. Within this cylinder or barrel is a piston, C′, which, as here represented, is fitted with cup-leather packings, as best shown in Fig. 3, and which is operated by a piston-rod, C^2. As here represented, this rod C^2 is connected with and operated by the same arm, *a′*, which operates the rod *a* of the water-pump A. The air-supply-pump barrel or cylinder C is open at its upper end, and its lower end is fitted in a rectangular block or chest, *c*, which has inlet and outlet valves *d d′* at its opposite sides, as best shown in Figs. 4, 5, 6, and 7. The inlet-valve *d* is open to the atmosphere, and the outlet-valve *d′* is in a short curved tube, d^2, which enters the cold cylinder D, as best shown in Figs. 4, 5, 6, and 7, so as to deliver the air from the pump C into the interior of the cold cylinder D.

In order to provide for adjusting the clearance of the air-supply pump, I have represented its piston-rod C^2 as secured in the arm *a′* of the cold piston by means of jam-nuts c^2, fitted to the rod above and below said arm. This piston-rod C^2 is of such length that when the piston C′ is adjusted to its lowest position it will come to the bottom of the pump-barrel C at the end of its downward stroke, and this rod is screw-threaded for a considerable part of its length, so that the piston can be adjusted into different positions upward or downward. The pump cylinder or barrel C is made a great deal longer than the actual stroke of the pump, so as to permit a wide range of position in the length of the cylinder or barrel for the actual stroke of the pump. By this arrangement the downstroke of the pump may be completed when the piston C′ reaches the bottom of the cylinder C, or it may be completed at about one-half way down the cylinder, or in any intermediate position between these two extremes. These changes depend upon the position given to the piston by altering the acting length of the piston-rod C^2 by means of its long threaded portion and the jam-nuts c^2 above and below the arm *a′*. This construction permits the "clearance" or space below the piston C′ at the end of its downstroke to be varied and adjusted within wide limits, and as the ratio between the length of stroke and length or capacity of clearance is an exact measure of the maximum pressure obtained, the air-supply pump can thus be made to deliver the air at a uniformly accurate degree of pressure continuously without being affected by ordinary variations in the quantity of air required.

In the arrangement of parts just described the air-supply-pump delivery occurs at the end of the downstroke, which is also near the point of greatest compression in the cold cylinder of the engine. It may, however, be desirable in some cases to introduce the supply of air at the opposite extreme, or that of minimum pressure in the cold cylinder. This can be readily effected by reversing the action of the supply-pump, either by giving it reverse motion or by causing the upstroke of the supply-pump to be the delivery-stroke, as shown in Fig. 9.

In Fig. 9 the plunger C* works through a packing in the lower end of the pump-barrel C, and the lower portion of the plunger is screw-threaded, as shown at c^3, and adjustably secured by jam-nuts c^2 in an arm, c^4, with which is also connected a rod, c^5, attached to the arm a' upon the hot piston B. In this construction the air-inlet or suction valve d of the pump is at the upper closed end of the cylinder C, and the air discharge or outlet valve d' is near the lower end of the cylinder, and is similar to or is the usual suck-in valve of the engine. The construction, however, preferably used where air is to be supplied to the cold cylinder near the point of minimum pressure is that shown in Figs. 6 and 7, which is essentially the same as the construction shown in Figs. 4 and 5, with the addition of an extra check-valve, d^3, on the delivery side of the air-supply pump, and the air-reservoir I, mounted upon the air-supply pipe d^2 between the two check-valves d' d^3.

The effect and operation of the arrangement shown in Figs. 6 and 7, is, that the reservoir I becoming a large addition to the clearance of the pump, the pressure within it is not sufficiently high to cause the air to enter the engine at the point of maximum pressure, though sufficient to do so at the point of lowest pressure, and the pressure in the reservoir is kept up to any required limit by the adjustment of the position of the supply-piston, as described. The adjustment of the capacity of clearance-space may also to some extent be effected by making the reservoir I in two or more parts, so that its capacity may be changed by the use of any desired number of its parts or sections, or by increasing or diminishing its cubical contents in any other convenient manner, and in that case the regulation of the ratio of clearance can be thus effected. If a safety or blow-off valve were provided upon the reservoir I, so as to maintain therein the desired pressure, the air-supply pump might be constructed without affording provision for adjusting its clearance. In engines of this type, as usually acting in open atmosphere, it is found necessary to have a suck-in valve—that is, a valve opening inward and attached to the cold cylinder or other convenient part of the engine—the purpose of this valve being to prevent so far as possible the partial vacuum in the engine which would otherwise occur at the minimum pressure in consequence of the leaking of air occurring at the point of highest pressure. This suck-in valve, being of small size, and from its construction being comparatively heavy, in order to fulfill its office, would take an appreciable pressure to lift it, and thus an initial pressure less than the atmosphere will exist in the engine, causing a loss of power. To obviate this defect is a further object and application of my invention when applied to an engine without a sufficiently heavy piston for carrying much over one atmosphere. In this particular application of the invention the main object sought is to insure a full atmosphere or a trifle over one atmosphere in the engine at its lowest pressure, and for this purpose the supply-pump may be of the simpler construction, as shown in Fig. 9, and without means for varying its clearance.

In Fig. 9 the suck-in valve, as usually applied, is arranged at d', and constitutes the outlet or discharge valve of the pump, as before described. The operation of this construction is to cause the delivery of the supply air to occur at the time of lowest pressure in the engine, and to effectively prevent any partial vacuum in the interior of the cold cylinder. By the action of the pump shown in Fig. 9 the air will be supplied under sufficient pressure to lift the suck-in valve and increase the amount of air in the cold cylinder at the point of minimum cold pressure, whereas the suck-in valve, if the pump were not used, would not be lifted until the pressure within the cylinder had fallen materially below the atmosphere.

In Fig. 1, P P designate weights which are applied to the cold and hot pistons B F, in order to so far as practicable counterbalance the increment of upward pressure of the pistons due to carrying an initial pressure higher than one atmosphere.

As shown in Fig. 1, a portion of each piston is made solid; but this weighting may be conveniently effected by thickening the side walls of the pistons to the required extent.

I have herein described what I now consider the best and most effective means for carrying out my invention; but I would have it understood that I do not restrict myself solely to the exact construction herein set forth, but consider any modification of construction producing substantially the same results as fully within the scope of my invention.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. The combination, with an air-engine acting in closed cycle, and having uncovered cylinders and pistons, and an external heating device for heating the air within the engine, of an air-supply pump for maintaining the desired initial pressure in the engine, substantially as herein described.

2. The combination, with an air-engine, of an air-supply pump having its clearance-space variable by adjustment, substantially as herein described.

3. An air-engine provided with an air-supply pump, and in which the increment of

pressure caused by increasing the initial pressure is wholly or partially balanced by the weight of the pistons, substantially as herein described.

4. The combination, with an air engine provided with a suck-in valve to prevent the minimum pressure in the engine from falling materially below the atmosphere, of an air-supply pump, whereby a sufficient pressure of air will be produced to lift and open the suck-in valve before a partial vacuum is formed in the engine, substantially as herein described.

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