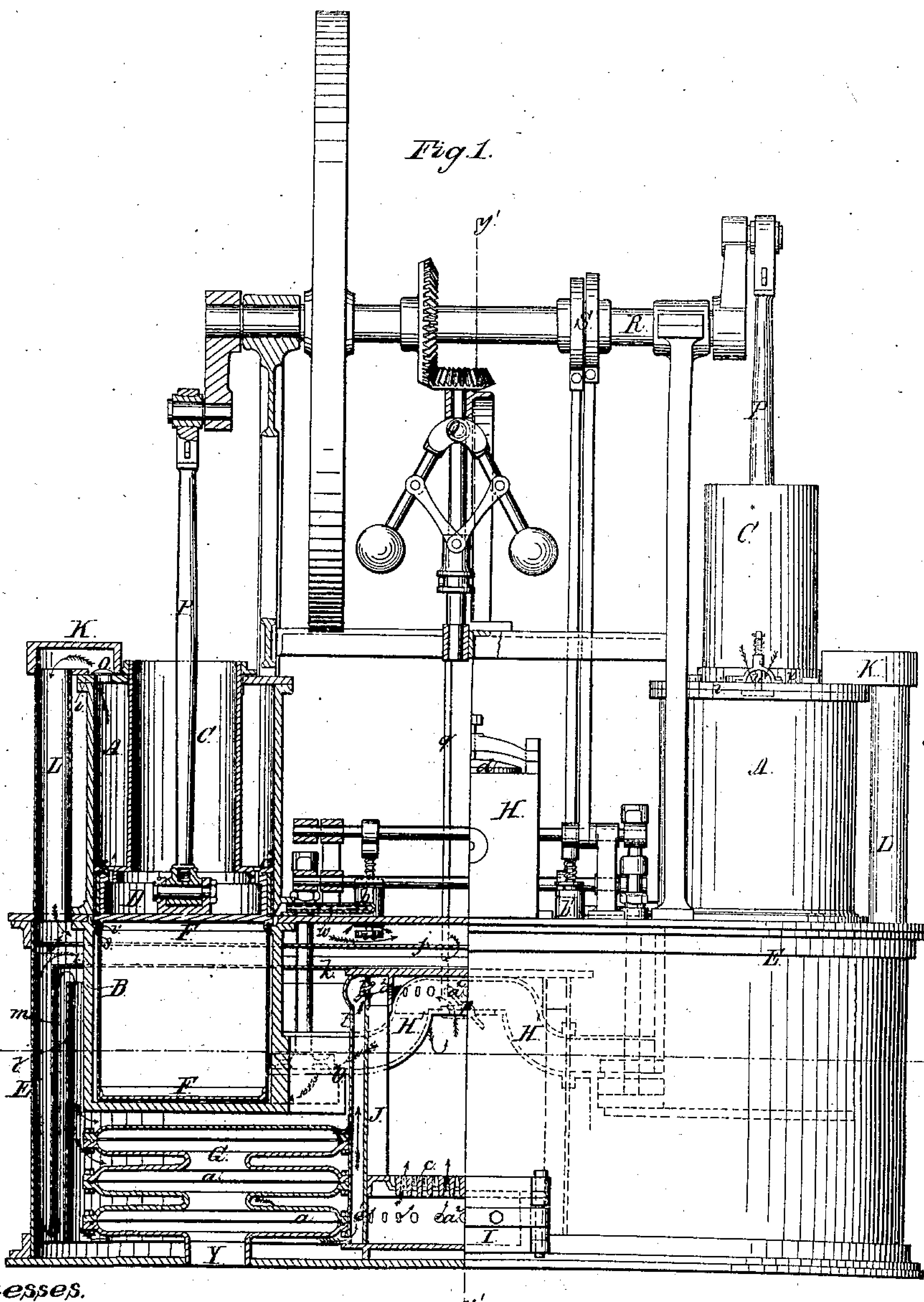
Sheet 1-3 Sheets.

P. Shaw,

Air Engine,

№ 33,799. Patented Nov. 26, 1861.

Fig. 1.



Witnesses.
J. B. Crosby
Galen Coffin

Inventor
Philander Shaw

Sheet 2 - 3 Sheets.

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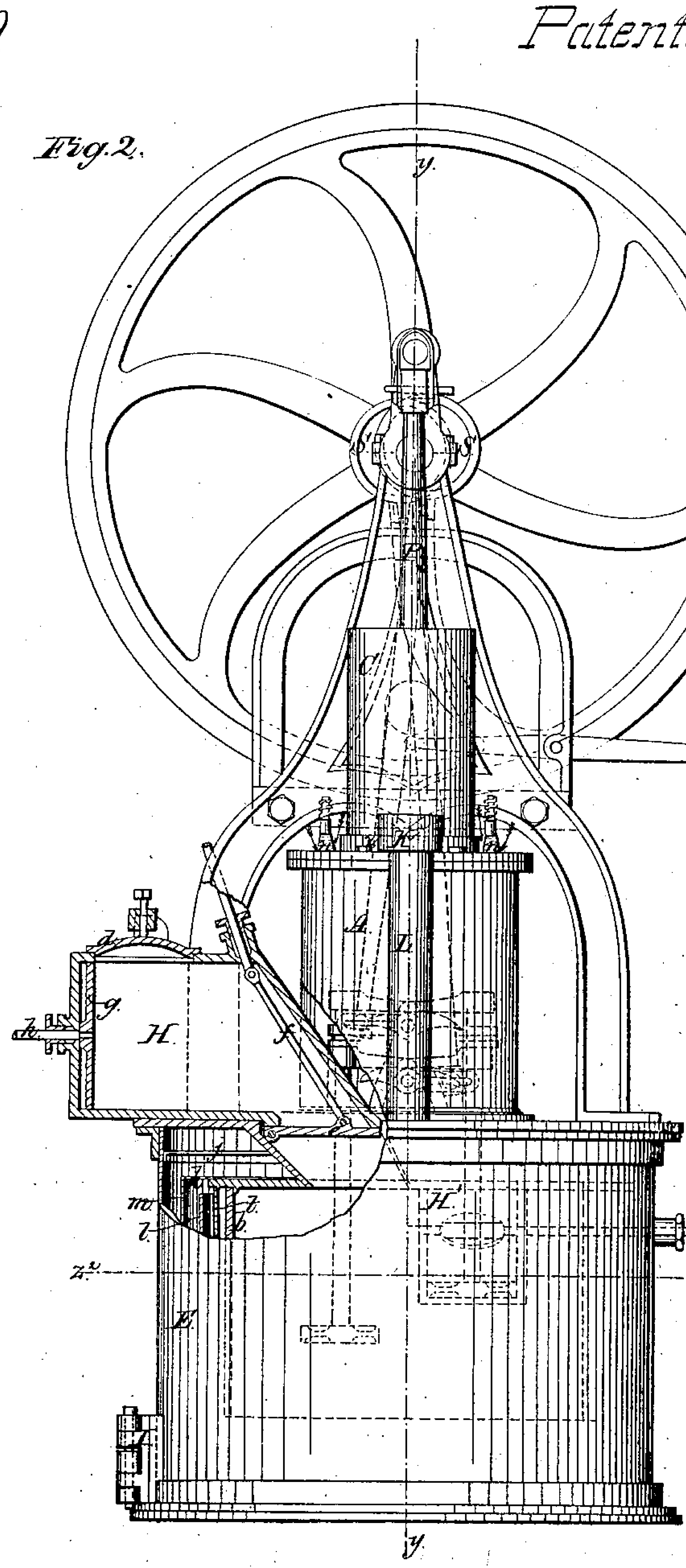
Fig. 2.



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Sheet 3 3 Sheets.

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Air Engine,

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Fig. 6.

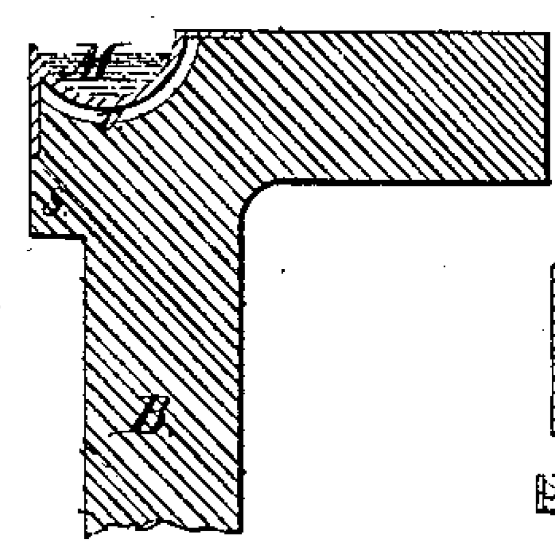


Fig. 5.

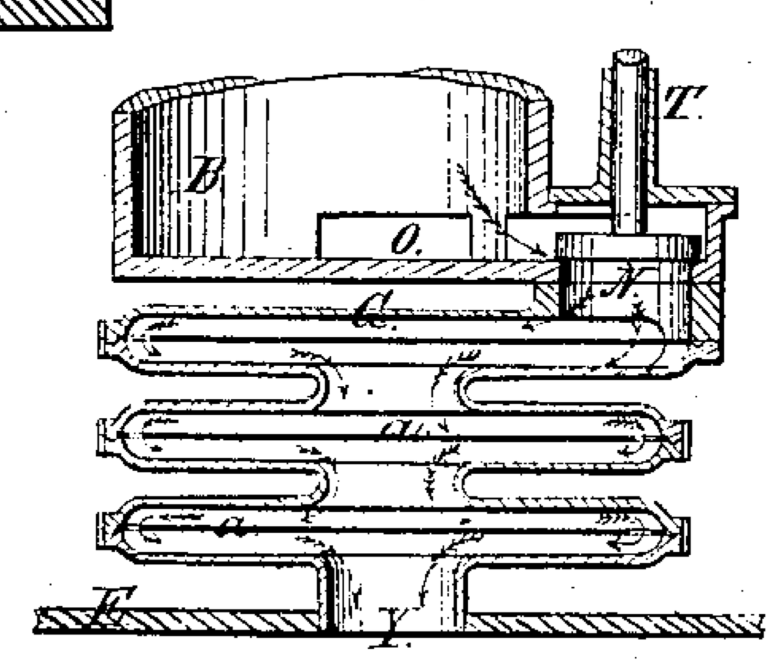


Fig. 4.

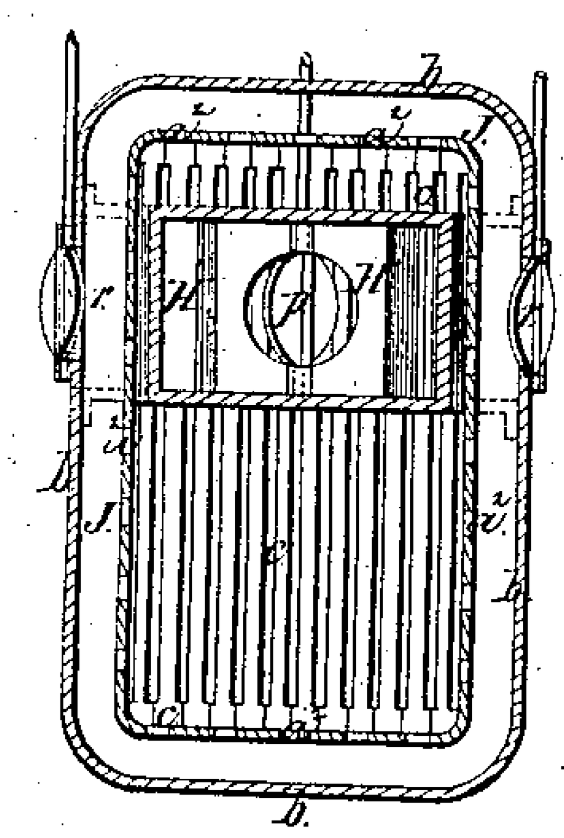
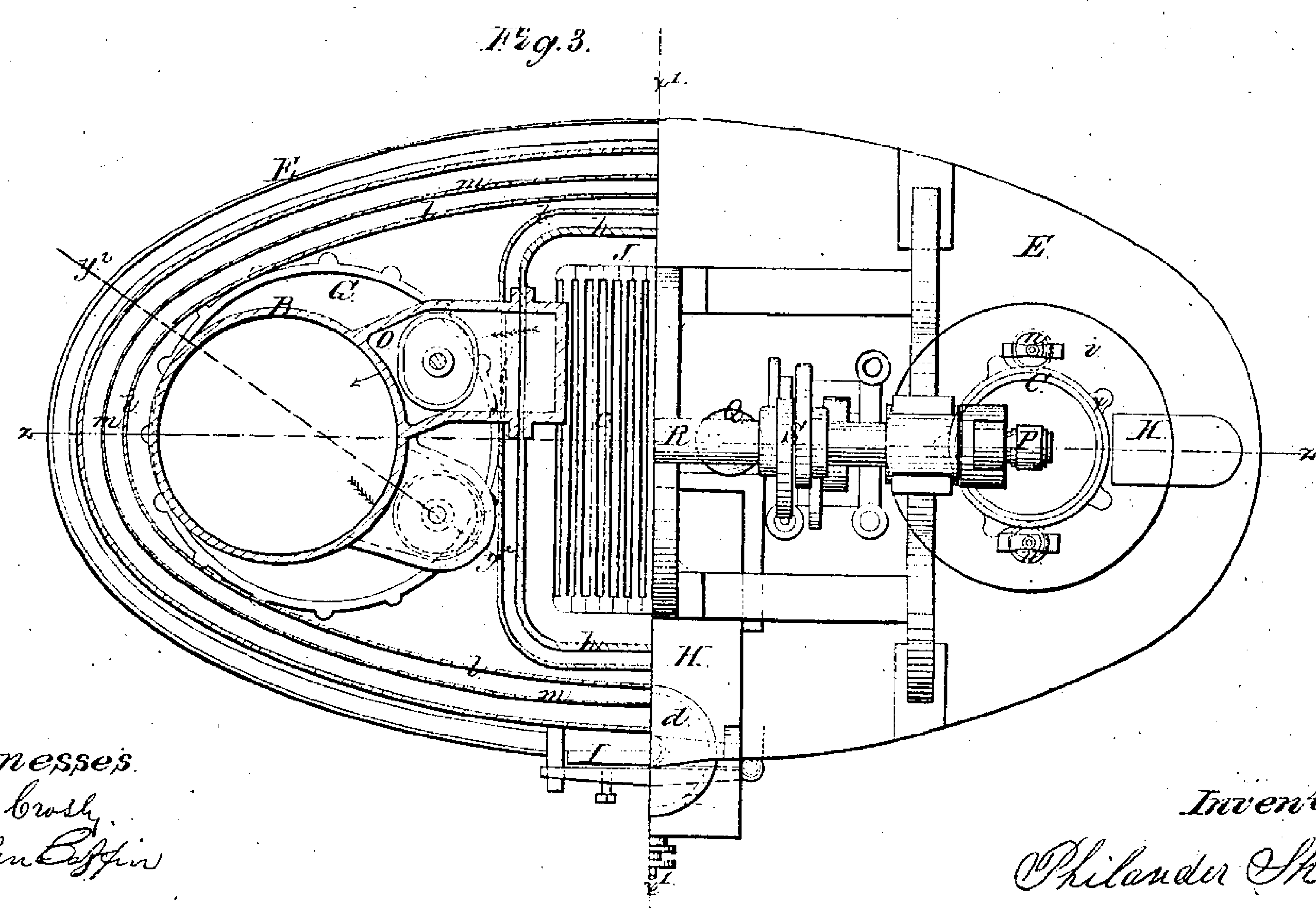


Fig. 3.



Witnesses.
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UNITED STATES PATENT OFFICE.

PHILANDER SHAW, OF BOSTON, MASSACHUSETTS.

IMPROVEMENT IN HOT-AIR ENGINES.

Specification forming part of Letters Patent No. **33,799**, dated November 26, 1861.

To all whom it may concern:

Be it known that I, PHILANDER SHAW, of Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Hot-Air or Caloric Engines; and I do hereby declare that the following, taken in connection with the drawings which accompany and form part of this specification, is a description of my invention so full and exact as to enable those skilled in the art to practice it.

The nature of my invention consists, first, in an arrangement, substantially such as herein is described and is also illustrated in the drawings, of two single-acting cylinders having their pistons coupled to a shaft having its cranks at right angles with each other, with a furnace and its accessories centrally located, or nearly so, between the said cylinders and within an air-tight casing, which forms a reservoir for compressed and heated air and is so divided by partitions and diaphragms as to receive the cool supply-air at or near the exterior of the reservoir and to guide it inward by a tortuous passage to the furnace in substantially the manner described, so that it shall absorb the heat radiated from such parts of the engine as receive the products of combustion, those parts of the engine-cylinders in which the pistons fill the bore being located outside of and upon the casing as a foundation and exposed to the atmosphere, and the other parts of the cylinders being located within the casing, so that the heat radiated therefrom shall be absorbed by the cool supply-air on its route to the furnace.

Second. In a peculiar construction and arrangement, substantially such as herein is described and is illustrated in the drawings, of the hot-air cylinder, the packed part of its piston, and a piston-trunk, which, with the necessary packing, valves, and other adjuncts, form a pump by which cold air is compressed and supplied to the furnace to be expanded by heat. The pump, being annular, is exposed, inside as well as outside, to the cooling influence of the atmosphere, and, when compressing the supply-air, being operated by the direct pressure of the expanded heated air on the engine-piston. The strain necessary to compress the supply-air is applied directly and is not transmitted through the rotative parts of the mechanism. By this annular arrangement of the pump I am enabled to reduce the height, which would otherwise be needed by my engine, by connecting the pitman direct to the engine-piston. The pitman thus vibrates within the trunk, and good facilities are had for keeping cool the joint of the pitman with the piston and for lubricating it.

Third. In a construction of the cylinder, substantially such as is herein described and is illustrated in the drawings, and more particularly detailed on Sheet No. 3, Figure 6, which consists in a groove or chamber formed around the interior of the cylinder at that part thereof where the lower edge of the closely-fitting portion of the piston comes at the lowest point in its downward stroke. This chamber receives a supply of pure cool compressed air, by means hereinafter described, for the purpose of keeping the piston-packing cool and that part of the interior surface of the cylinder against which the piston slides and to keep solid products of combustion from rising to the upper part of the cylinder with each incoming supply from the furnace. This chamber or groove also serves to receive the lubricating-fluid which escapes past the packed portion of the piston, and as much more as may be introduced therein by means of "oil-pumps," &c. Into the fluid contained in this groove the lower edge of the piston may be made to dip, and so lubricate the inner surface of the cylinder at each stroke of the piston. The groove or chamber may be made to receive an isolated circular trough to receive the oil, as shown in Fig. 6, which by means of the introduction of cool, compressed, and pure air around it prevents evaporation of the oil by conducted heat, which might occur without the use of the isolated trough.

Fourth. In the construction of an inwardly-projecting flange, as shown and described, which flange may form part of the boundary of the circular chamber before referred to, and which comes nearly but not quite into contact with the contracted and extended part of the piston for the purpose of deflecting such solid matter from the furnace as may find entrance into the cylinder along with the gaseous products of combustion and preventing the same from abrading the finished surfaces of the piston and cylinder.

Fifth. In the employment of an auxiliary valve operating to admit from the reservoir in which the air is maintained under pressure comparatively cool and compressed air into the circular groove around the cylinder and into the clearance-spaces within and connected with the cylinder for the double purpose of balancing the pressure upon the main inlet-valve into the cylinder and to maintain the finished surfaces of the piston and cylinder, where one moves upon the other, at a temperature which will not prevent lubrication.

Sixth. In regulating the speed of hot-air engines by controlling the flow of the heated compressed air and gaseous products of combustion, or the supply thereof to the engine-cylinders by means of a valve controlled by a regulator dependent upon the speed of the engine, instead of permitting such a regulator to operate a valve to open communication through which the generated pressure is permitted to escape and be lost without acting to impel the pistons.

In the drawings, Fig. 1, Sheet No. 1, illustrates in half-side elevation and in half-sectional elevation a hot-air or caloric engine embodying my invention, the section being taken in the lines *y y*, Fig. 2, and *z z*, Fig. 3. Fig. 2, Sheet No. 2, is an end elevation of the same, a part, however, being shown in section, taken in the lines *y′ y′*, Fig. 1, and *x′ x′*, Fig. 3, for the purpose of showing the fuel-feed box. Fig. 3, Sheet No. 3, illustrates the same in half-plan and in half-horizontal section, taken in the lines *z′ z′*, Fig. 1, and z^2 z^2, Fig. 2. Fig. 4, Sheet No. 4, supplement, shows a horizontal section taken through the furnace just beneath the crown-plate and cutting the supply-pipe H, so as to show fully the throttle-valve *p*. Fig. 5 is a sectional elevation taken in the line y^2 y^2, Fig. 3, of so much of the cylinder and the parts connected therewith as to illustrate how the "exhaust" escapes into the radiator or heater. Fig. 6 shows in section the groove or chamber in the cylinder, the isolated trough therein, and the inwardly-projecting flange on a scale enlarged from that used for the other figures.

Throughout all the figures of the drawings similar letters refer to similar parts.

In Figs. 1, 2, and 3, E is the casing, which, as it forms the reservoir for the compressed air and the foundation or bed-plate for the mechanism, should be so made as to be air-tight under the heat, strains, and pressure to which it is subjected, and wherever moving parts pass through it they should be carefully packed.

Centrally located in E is the furnace, lined with fire-brick J, Figs. 1, 3, and 4, and provided with grates *c*, Figs. 1 and 4, and an ash-pit, which has an air-tight door I, Figs. 1, 2, and 3, and fuel-receptacle H, Figs. 1, 2, and 3, from which fuel is fed to the fire through the top of the furnace. This fuel-box is provided with an air-tight receiving-door *d*, Figs. 1, 2, and 3, having suitable fastenings, and a valve *e*, Fig. 2, opened and closed by a link *f*, Fig. 2, and a valve-rod which passes through a packing in the fuel-box.

A piston-head *g*, with its rod *h*, (see Fig. 2,) serves to thrust the fuel forward in the fuel-box, so that it may all fall into the furnace through the aperture closed by valve *e*, Fig. 2. By this arrangement and its proper manipulation, which will be seen by inspection of the drawings, it is obvious that the fire may be replenished with fresh fuel while there is the requisite pressure within the furnace and casing needed to operate the engine without reducing the pressure or impeding the operation of the engine.

The furnace is provided with openings *a′*, Fig. 1, below the grates and with others a^2, Figs. 1 and 4, above the top of the fuel, through which air under pressure is supplied by means hereinafter to be described, which air is introduced into the space contained between the outside casing *b*, Figs. 1, 2, 3, and 4, of the furnace and the casing *t*, Figs. 1, 2, and 3, which next surrounds it. The working-cylinders, of which there are two, are located within and upon the casing and upon opposite sides of the furnace. These cylinders are single-acting—that is, the piston of each is forced upward by admitting the compressed heated air and gases from within the furnace beneath the piston, and both pistons being connected to the main shaft R, Figs. 1 and 3, by cranks at right angles with each other. The downward movement of each piston is produced by the upward movement of the other acting through the shaft in connection with the balance-wheel. Each cylinder may be described as in two sections, the upper section A, Figs. 1 and 2, standing above and outside of the casing or bed-plate and being finished inside so that a closely-fitting packed piston D, Fig. 1, may move freely therein, after the manner of steam-engine pistons within their cylinders. The lower section B, Figs. 3 and 6, is within the bed-plate or casing. This section need not be bored out or finished, as the extension part F, Fig. 1, of the piston, which plays in the lower section of the cylinder, is not intended to come into contact with it, and when at the lowest point of its downward stroke leaves an end and an annular clearance.

That part of the piston which is marked D, Fig. 1, is constructed nearly like steam-engine pistons, so far as packing is concerned, and does not need further explanation than is afforded by the drawings, Fig. 1. The piston-follower *c′*, Fig. 1, is the flange of the pipe or trunk C, Figs. 1, 2, and 3. In this trunk the connecting-rod or pitman P, Figs. 1, 2, and 3, plays, and is connected to the piston-head by a joint, as shown in Fig. 1, which is kept cool by free exposure to the atmosphere and by lubrication, for which good facilities are afforded. The trunk passes through the upper head *i*, Figs. 1, 2, and 3, of the cylinder, where it is packed with leather and guided by the gland *x*, Figs. 1, 2, and 3. The upper cylinder-head is furnished with a valve *o*, Fig. 1, which when forced open by the compression of the air in the annular space between the trunk and the upper section of the cylinder permits the said compressed air to pass into the casing through the valve-box K and pipe L, Figs. 1 and 2. It will be obvious that the piston in its ascent will compress the air in the said annular space till its density is equal to that of the gaseous contents of the casing, when further movement of the piston upward opens the outlet-valve and displaces the compressed air. The upper cylinder-head is also furnished with valves *n*, Figs. 2 and 3, the purpose of which is to open to admit air within the annular pump when the piston descends and to close and remain closed at other times. Supposing the engine to be in motion, the air which is taken in by the pumps and thrown out by each stroke of each piston passes, as is indicated by the arrows in Fig. 1, along the division-plate *j*, Figs. 1 and 2, which extends horizontally entirely across the space contained within the casing to an opening in the center of said plate; then between said plate and a second horizontal plate *k*, Figs. 1 and 2; from thence downward between the outer vertical boundary of the casing and an internal partition *m*, Figs. 1, 2, and 3, parallel with said outer boundary, and extending entirely around within the casing; then vertically upward between partitions *m* and *l*, Figs. 1, 2, and 3, into a space contained between *l* and *t*, Figs. 1, 2, and 3, whence the air passes into the furnace through apertures a', Fig. 1, and a^2, Figs. 1 and 4, the position of the dampers *r*, Figs. 1 and 4, determining what portion of the air shall pass into the furnace through the fuel and what above it.

Having described how air is compressed and forced into the furnace, I will now show how, when expanded by heat, it passes into the cylinders and is exhausted therefrom, thereby producing reciprocations of the pistons and developing the power generated by heating the air.

In the top of the furnace and passing through it to the inlet-valve boxes O, Figs. 1 and 3, is a suitably-shaped pipe h', Figs. 2 and 4, with an aperture therein opening into the furnace, which can be opened and closed by a throttle-valve *p*, Figs. 1 and 4. This valve is operated by a governor or regulator Q, Figs. 1 and 3, operating on a lever fixed to the valve-stem by means of the connection *q*, Figs. 1 and 2. The heated air, and gaseous products of combustion, mingled, pass into this pipe in amount regulated by the position of the throttle-valve, and when the inlet-valve of either cylinder is opened they pass into the cylinder and force the piston upward. The inlet-valve or valve corresponding to the steam-valve of a steam-engine closes when or before the piston has completed its upward movement. At about the time when the upward movement of the piston ceases and after the inlet-valve has been closed the exhaust-valve opens and permits the contents of the cylinder to escape and to be forced out by the descent of the piston into the open air through the passage N, Fig. 5, and the radiator or heater G, Figs. 1, 3, and 5, located in the space through which air passes on its way to be heated in the furnace. The valves shown in the drawings are of the puppet variety and are operated at proper times by lifter-tappets on the valve-rods and on rocker-shafts worked from eccentrics S, Figs. 1, 2, and 3, on the main shaft. There is nothing peculiar about the valves or valve-gear, and any other which is adapted to the ingress and egress of the heated air and known to engineers in the practice of their profession may be used for those shown, though I prefer to use valves of the puppet variety.

The form of the heater is immaterial. That shown presents a large surface for radiation, and the diaphragm-plates *a*, Figs. 1 and 5, within the heater compel a tortuous passage of the exhaust. It will be seen that the disposition of division plates and partitions before mentioned is such as to cause the gradual heating of the cold compressed air on its way from the pump to the furnace by the absorption of the heat from the radiation from the lower part of the cylinder, the conveying-pipes, heater, and boundaries of the furnace, so that the radiated heat is nearly all utilized, and the desideratum is attained of having a comparatively cool surface to the outer or exposed surface and parts of the machine. A dead-air space is formed in the casing between its base-plate and the compressed and heated air to prevent radiation of heat from the lower surface of the casing.

At the juncture of the upper and lower sections of the cylinder and at the lower edge of the close-fitting part of the piston a groove or chamber *v*, Figs. 1 and 6, is formed entirely around the cylinder. At the upper inner edge of the lower section of the cylinder is an inward projecting flange *s*, Figs. 1 and 6, which forms the bottom of the groove and extends inward from the general surface of the lower part of the cylinder, so as almost to touch the lower or extended part of the piston. The groove or chamber round the cylinder communicates with the compressed air in the upper part of the casing, where it is comparatively cool and pure. This communication is made by the means of pipe *w*, Fig. 1, which terminates in the valve-box b', Fig. 1, in which the puppet-valve *u*, Fig. 1, operates by any suitable mechanism, that shown being a wiper or arm on a rocker-shaft acting on the valve-stem to open the valve against the pressure of a spring, the reacting of which assists to close it. It will be seen that when the valve u, Fig. 1, is open air will flow into the cylinder from the casing at such spot as the valve may be located. If this valve is opened, as it should be, after the exhaust-valve closes and before the main inlet opens, all the clearances or unoccupied space in the cylinder and valve-passages will be filled with pure air, but little heated and of density equal to that within the casing and furnace.

The object of introducing air through pipe w, Fig. 1, from and at about the place and at the time mentioned is threefold. First, by rendering the pressure alike on both sides of the inlet-valve it is balanced and operated in equilibrium, by which the power necessary to work it is reduced to the minimum; second, by having the spaces in the cylinder filled with pure air that which rushes afterward into the cylinder from the furnace will not be apt to carry the solid products of combustion into the joints between the finished portions of the piston and cylinder; third, by the introduction of cool compressed air, as described, the temperature of the finished parts of the piston and cylinder which come into contact are kept sufficiently cool to admit of efficient lubrication.

The inwardly-projecting flange s, Figs. 1 and 6, serves to deflect or to render difficult the passage of any particle of solid matter coming into the cylinder with the heated air and gaseous products of combustion, and the lower edge of the packed part of the piston is made of the shape shown in Fig. 1 to aid in keeping solid matter from entering between the finished surfaces of the piston and cylinder and from abrading them.

The chamber v, Figs. 1 and 6, serves to catch the oil which passes by the piston, or lubricating matter may be injected therein by an oil-pump. A pipe provided with a stop-cock will afford means for drawing off accumulations of lubricating matter, together with such solid matter as may be deposited there, while the lower edge of the piston-packing by dipping into the oil at each downward stroke will aid in keeping the working-surfaces well lubricated.

An improvement upon the simple chamber consists in placing therein a circular oil-trough M, (see Fig. 6,) which is sustained at a little distance from the metal of the cylinder by ears placed at intervals around the trough. The current of cool air from the auxiliary valve will pass through the space around the trough, cutting off communication of the heat conducted by the metal of the cylinder and preventing evaporation and burning of the lubricating material.

In starting a fire on the grates the main inlet, exhaust, and throttle valves should be opened, as well as the ash-pit door, to establish a draft through the engine by way of the cylinder and radiator. If sufficient draft cannot be attained in this way, then the fuel-box valve e, Fig. 2, and the door d, Figs. 1, 2, and 3, should be opened and a direct upward draft thereby established, which may be conducted by a temporary funnel. When the fuel is well ignited, all the doors and valves through which air can pass to or from the casing should be closed and secured and air should be supplied by a pump to support combustion and to force and compress air within the casing, where it will be expanded from the heat generated by the burning fuel. The means by which air may be forced into the furnace while establishing a sufficient pressure therein to start the engine may be a force-pump or fan or other equivalent device operated by hand or by any other convenient and suitable power; or the main shaft of the engine itself may be rotated by suitable means, when the pumps forming part of the engine will supply the air needed in the furnace. When sufficient pressure has been generated to rotate the engine, the extraneous force may be discontinued, as the expansion of the air supplied by the pumps of the engine will continue to increase the pressure within the casing till the engine has some work applied to it to absorb the power generated.

A safety-valve may be applied to the casing and so regulated as to prevent the increase of pressure to a point which would endanger the integrity of the machine.

It should be observed that the valve-chest covers, through which pass the valve-stems, are provided with pipes T, Fig. 5, which extend through the casing for the purpose of bringing the packings of the valve-stems to a position where they are not materially affected by the heat from the furnace.

Having described my invention, what I claim as new, and desire to have secured to me by Letters Patent, is—

1. The combined arrangement, in a caloric-engine, operating substantially as herein shown and described, of the cylinders, pistons, reservoir, and furnace, the cylinders and their accessories acting together to rotate one shaft, and the cylinders being located partly within and partly without the reservoir, which contains a supply of compressed and heated air, and a furnace which heats the said supply, which, with the gaseous products of combustion, passes through the engine.

2. The combination of the finished or upper part of the cylinder with its head, piston, and trunk therewith connected, all operating together, substantially as described, and with inlet and outlet valves, and suitable packing round the said trunk to form an annular air-pump.

3. The chamber or groove around the cylinder arranged and operating, substantially as specified, at or near where the lower part of the piston comes at the termination of its downward movement.

4. The isolated oil-trough within the chamber or groove around and within the cylinder, for the specified purpose.

5. The inwardly-projecting flange s, arranged and operating substantially as shown and described.

6. Admitting into the cylinder comparatively pure and cool air from a reservoir, in which it is constantly maintained compressed, at the place and times and by suitable valve-gearing, substantially as and for the purposes specified.

PHILANDER SHAW.

Witnesses:

J. B. CROSBY,

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