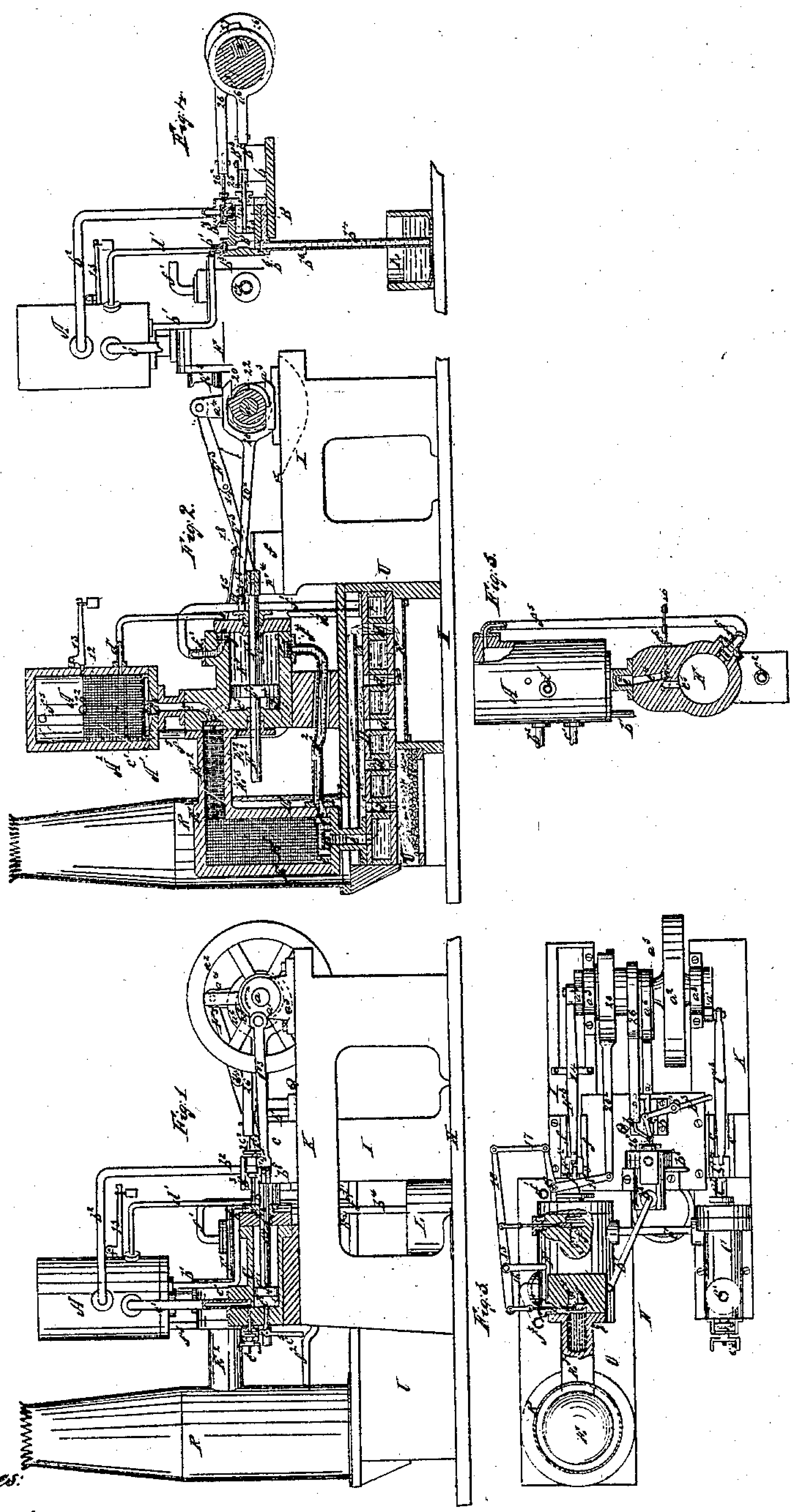
P. SHEARER.

AIR OR GAS ENGINE.

No. 33,215. Patented Sept. 3, 1861.



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PETER SHEARER, OF READING, PENNSYLVANIA.

IMPROVEMENT IN AIR OR GAS ENGINES.

Specification forming part of Letters Patent No. **33,215**, dated September 3, 1861.

To all whom it may concern:

Be it known that I, PETER SHEARER, of Reading, in the county of Berks and State of Pennsylvania, have invented a new and Improved Engine for Obtaining Motive Power by the Expansion of Air or Gases by Heat; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 represents a side elevation of the engine with the working-cylinder C, or, as I prefer to term it, the "power-cylinder," in section. Fig. 2 is a vertical section of the same parallel with Fig. 1, through the air-reservoir A, the supplementary cylinder F, and heaters D E. Fig. 3 is a plan of the same with the reservoir or cooler A removed and certain of the passages and valves belonging to the supplementary cylinder F in section. Fig. 4 is a vertical section parallel with Figs. 1 and 2 of the pump B and some of its attachments, showing also the connection of the said pump. Fig. 5 is a transverse vertical section of the supplementary cylinder F, showing its connection with the reservoir.

Similar letters of reference indicate corresponding parts in the several figures.

The principal objects of my invention are, first, to obtain the advantage which in the use of air as a motive agent results from subjecting it to a very high degree of compression before expanding it by heat—viz., economy of heat; second, to obtain the advantages resulting from the use of water as a medium through which the air acts—viz., lubrication of the wearing-surfaces and the prevention of leakage at the valves and other parts of the engine.

The principal elements of which the engine is composed consists of an air reservoir or cooler A, a pump B, the power cylinder C, and its piston C′, two heaters D and E, and what I call the "supplementary cylinder" F, containing a piston F′.

Before describing the details of these elements and their several appurtenances and connections, which may at first sight appear somewhat complex, I will endeavor to give a general idea of the most important of their several functions, as this may render the description more intelligible as it is proceeded with.

The pump B serves two purposes, viz: that of filling the reservoir A with tightly-compressed air before starting the engine, for which purpose it is worked by hand, and that of pumping water into and out of the said reservoir to cool the air which has been used, for which purpose it is operated by the engine. When the requisite pressure has been obtained in the reservoir A, a portion of air is allowed to pass in into the power-cylinder C upon both sides of the piston C′, one side of which exposes a surface to its pressure as much greater than the other side as the area of the transverse section of the piston-rod C^2. The pressure on the larger surface preponderating over that on the smaller drives the piston outward and a half-revolution of the crank-shaft a and fly-wheel a^2 is obtained. During this movement a portion of the compressed air from the reservoir A is transferred to the heater E, where it is heated rapidly to the degree required by water which has been first heated in the heater D. Before the outward stroke aforesaid is completed the air so heated begins to exert its now increasing expansive force upon the smaller surface of the piston C′, thereby producing in turn a preponderance of pressure on hat surface and so bringing back the piston after the crank has passed the dead-point, and thus completing the revolution of the crank-shaft and fly-wheel. Next, the heated air which has now expended its increased force is returned from the heater to the reservoir A and cooled by means of cold water introduced into it by the pump B without being relieved from the pressure which was first imparted to it by the said pump, and another portion of cold air is conveyed into the heater to repeat the operation. The machine is thus kept in motion by permanently maintaining the uniform pressure of the cold air upon the larger surface of the piston and alternating said pressure upon the smaller surface with an increased pressure of a portion of the air produced by heat during every revolution of the crank-shaft and fly-wheel. The supplementary cylinder F and its piston F′ are used in this operation as a pump to pump hot water from the heater D and air from the reservoir A alternately into and out of the heater E.

I will now proceed to describe the details of the engine.

H is a bed-plate, upon which are erected the heater-furnace U and the standards I and K for supporting those various working parts of the engine not supported by the said furnace. The parts supported on the furnace are the supplementary cylinder F and the reservoir A, which is supported on top of said cylinder. The parts supported entirely on the standard K are the power-cylinder C, the guides c c for the piston-rod C^2, and one of the pillow-blocks a^3 a^3 for the main shaft a. The parts supported entirely by the standard I are the guides f f for the piston-rod F^2 of the supplementary cylinder, and the other pillow-block a^3 for the main shaft. The standards I and K also support a bridge-piece Q, on which are placed the pump B and its guides b b and the post b', which forms the fulcrum of the hand-lever B^3, by which the said pump is worked to charge the reservoir A with air. The cylinders C and F and the cylinder of the pump B are arranged horizontally and parallel with each other.

The heater D, which I call the "primary" or "preparatory" heater, in which the water is heated before its introduction to the secondary heater E, may be constructed like any ordinary steam-boiler. In the drawings it is represented of the form of a parallelopipedon, having vertical flues d d, Fig. 2, through which there is an upward circulation of the gases of combustion from the fire-place of the furnace toward the chimney R. This heater is always filled with water, which circulates through it from time to time in the direction of the horizontal arrows shown in Fig. 2, from a pipe f', connecting it with the supplementary cylinder F to a pipe e', leading from it to the intermediate or secondary heater E, in which it heats the air. The primary heater always has free communication with the reservoir A by means of a pipe d', which keeps the water in the said heater under a constant pressure corresponding with that in the said reservoir, and so prevents its being converted into steam, but affords it room for expansion by heat.

The secondary heater E is of upright cylindrical form, supported on the top of the primary heater D, and arranged within the lower part of the chimney R, in which it is surrounded by the escaping products of combustion and so kept hot. This secondary heater is nearly filled with thin wire-work E', which may consist of a series of sheets of wire-gauze placed one above another or may be composed of wire arranged in any other way to present a large surface, such wire-work resting on a bridge e^2 over the pipe e' and being preferably of copper, on account of its being a good conductor of heat.

The secondary heater is connected below the bridge e^2, supporting the wire-work by a pipe f^2, with the same end of the supplementary cylinder as the pipe f', which connects said cylinder with the primary heater.

At the upper end of the pipe e' there is fitted a valve e^3, which opens by upward pressure to admit water from D to E and closes by gravitation and downward pressure to prevent the return of the water from E to D.

At the connection of the pipe f' with the cylinder F there is a slide-valve f^3, Figs. 2 and 3, which is opened by mechanism, to be hereinafter described, for the purpose of allowing water to pass from the cylinder F to the primary heater D, and at the connection of the pipe f^2 with the said cylinder there is a flap-valve f^4, which opens by upward pressure to allow the water to pass from the secondary heater into said cylinder and closing by downward pressure to prevent the return of such water to said heater.

Close to its top the secondary heater E has a horizontal neck E^2, which is bolted to the supplementary cylinder F, and which contains wire-work E^3 of similar character to E'. Between this neck and the bottom of the reservoir A there is a passage e^4, and between the said neck and the supplementary cylinder F there is a passage e^5, communicating with the said cylinder at the opposite end to the pipes f' f^2, the passage e^5 being for cold air to pass from the cylinder F to the heater E, and the passage e^4 being for heated air to pass from the heater to the reservoir A. The passages e^4 and e^5 have their ports fitted with a slide-valve e^6, Figs. 2 and 3, by which either can be opened and the other closed to the heater E. At the top of the passage e^4 there is a check-valve e^7, which opens by upward pressure to permit the heated air to pass upward from the heater E to the reservoir, but closes by its own weight to prevent the water from descending from the reservoir to the said heater.

The air reservoir or cooler A is a strong iron vessel supported on the top of the supplementary cylinder F. It may be furnished near the bottom with a perforated plate A', extending all across it for the purpose of dividing into numerous streams the heated air entering it by the pipe e^4 from the intermediate heater, that the said air may be rapidly cooled by passing through the cold water contained in it; or instead of having this plate the lower part of the said vessel may be filled with wire-work A^2, like that in the secondary heater E, for the same purpose; but in the engine represented both the perforated plate and the wire-work are shown.

Beside the aforesaid connections of the said reservoir or cooler with the primary heater D, the secondary heater E, and the supplementary cylinder F, the said reservoir or cooler is connected by a pipe f^5, Figs. 2 and 5, with the same end of the supplementary cylinder with which the passage e^5 communicates; also, by a pipe b', Figs. 1 and 4, with one end of the pump-cylinder B; also, by a pipe b^2, with a slide-valve chest B^4, whose ports communicate with the opposite end of the said pump-cylinder, and, further, by a pipe c', Fig. 1, with that end of the working-cylinder toward which the greatest area of the piston B' is exposed. At the connection of the pipe f^5 with the supplementary cylinder F there is a flap-valve f^6, which opens to admit cold air from the reservoir into the supplementary cylinder F, but closes to prevent its return. At the connection of the pipe b' with the pump B there is a flap-valve b^3, which opens outward to permit the passage of air or water from the said pump to the reservoir A, but to prevent its return to the pump by that passage. The pipe b^2 conveys the water from the reservoir back to the other end of the pump, and the reservoir contains cold compressed air above the said pipe and cold water below it. The said reservoir is also fitted in one side with an escape-valve 12, which is held closed by a lever 13, except that from time to time it is opened by the acumulation of surplus water above it in the reservoir, such accumulation being owing to the pump being so constructed that it pumps rather more water into the reservoir than it pumps out. The pipe c' is fitted at its connection with the power-cylinder C with a sliding stop-valve c^2, operated by a screw c^3 to stop and start the engine, as will be hereinafter explained.

The power-cylinder C, besides being connected with the reservoir A by the pipe c' aforesaid, is connected on the opposite side of its piston—that is to say, the side which, owing to the rod C^2, presents the smaller area—by means of a pipe c^4, with the supplementary cylinder F, the connection with the latter cylinder being on the same side of its piston as the pipes f' f^2. The said cylinder C is also fitted at the end where the pipe c' is arranged with a valve c^4, which can be opened and closed by a hand-lever c^5. This valve is closed when the engine is in operation, and is only opened for the purpose of permitting the escape from the cylinder of the water that is employed therein as a medium between the piston C' and the air that presses upon it to produce the motive-power. The piston C' is packed to the said cylinder in the manner common to the pistons of steam-engines, and its rod C^2 passes through a stuffing-box in the cylinder-head and is connected by a cross-head C^4 and connecting-rod C^3 with the driving-crank a' on the main shaft a, all in the same manner as the piston-rod of a common steam-engine.

The supplementary cylinder F, whose pipe-connections, passages, and valves have been all described, is of larger caliber than, but of about the same length as, the power-cylinder C and of smaller capacity than the air-reservoir A. It has its piston lightly packed to the cylinder and has its piston-rod F^2 extended of the same size on both sides of it and through stuffing-boxes in both cylinder-heads, as shown in Fig. 2, and therefore the same area of surface is presented by each side of the piston that there may always be the same pressure on opposite sides of it during the operation of the engine, so that the power required to drive it is only what is sufficient to overcome friction. The said rod F^2 is connected by a cross-head F^4 and connecting-rod F^3 with a crank a^4 on the main shaft a; but the said connecting-rod F^3, instead of being rigid like the connecting-rod C^3 and the connecting-rods commonly used for crank-connections, is made with a knee-joint 14 at the middle of its length, said joint being so constructed as to permit of a deflection of the said rod in an upward but not in a downward direction. This connecting-rod does not operate upon the crank a^4 to turn the shaft, but the crank acts upon the said rod to give a reciprocating movement to the piston F'. The object of the knee-joint 14 is to make the piston F' make a stroke back and forth while the piston C' makes its forward or outward stroke toward the crank-shaft, and to keep the said piston F' stationary near that end of the cylinder F which communicates with the reservoir A, as shown in Fig. 2, during the time that the piston C' is making its stroke in the opposite direction, and in order to enable this to be effected the crank a^4 is made about double the length of the power-crank a' and set at right angles to a', and a stop u is arranged in one of the guides f f to stop the cross-head from moving toward the cylinder F. After the crank a^4 in its revolution has passed a position vertically below the shaft a, the continued movement of the said crank in the direction of the arrow shown near it in Fig. 2 to the position vertically above the shaft represented in that figure merely having the effect of first bending the knee-joint 14 by striking the connecting-rod F^3 against a projection x on the standard I, and afterward straightening the said joint 14 of the connecting-rod. The continued movement of the crank a^4 from the position shown in Fig. 2 to the position vertically below the shaft produces the movement of the piston F forth and back from and to the position shown in Fig. 2.

The valves f^3 and e^6, before described, are operated to open and close simultaneously the passages f' and e^4 by means of their being connected with a lever 15, Fig. 3, which works on a fixed fulcrum 16, and which is connected by a rod 17 with one arm of an elbow-lever 18, working on a fixed fulcrum 19, the said elbow-lever having its other arm connected by a rod 20* with a cam-yoke 20, in which work two cams 21 22, fast on the shaft a, the said cam 21 operating on the upper part of the yoke to produce the necessary movement of the said passages, and the said cam 22 operating on the lower part of the yoke to produce the necessary movement of the said valves to effect the closing of the said passages. The said cams are so arranged that the opening of the aforesaid passages commences as or just before the piston F′ starts forward to the right, and that the closing of such passages is effected almost immediately after the said piston has commenced its return movement. When the passages f' and e^4 are open, the passage e^5 is closed by the valve e^6, and vice versa.

The pump B, (best shown in Fig. 4,) besides having connected with it the pipes b' and b^2, before described, has connected with it at the same end as b' an ordinary suction-pipe b^4, fitted at its connection with the pump-cylinder with an inlet-valve b^5, to admit either air or water to the pump. The lower end of this pipe dips into a water-cistern L, from which the cold water to be forced into the reservoir A at the bottom thereof through the pipe b' is drawn by the movement of the piston B′ toward the shaft a.

Before the engine starts and when the pump is required to force air into the reservoir a spigot b^6, provided to fit a hole in the pipe b^4, is removed, and the pump then draws air instead of water, and after the reservoir A has been charged with air the spigot b^6 is replaced and the pump draws water from the cistern L.

The valve-chest B^4 contains a slide-valve b^7 nearly resembling the slide-valve of a steam-engine having a cap-like cavity in its face, and working over three ports 23 24 25, of which the middle one 24 communicates with an escape-pipe b^8, leading to the atmosphere, and the two others 23 25 terminate in the cylinder B′ in a single orifice close to the opposite end of the said cylinder to that where the pipes b' b^4 are connected. This valve has a lap on one side of its cavity, which, when the valve moves to the right of Fig. 4, closes the port 24 just before it opens the port 23, and keeps 24 closed during the whole time 23 remains open and until the latter is again closed, the said valve when drawn to the right admitting water through the port 23 into the pump from the pipe b^2, but never permitting it to pass directly from said pipe to the port 24 or 25.

The pump-piston B′ is so actuated by the connection of its rod B^2 with the yoke a^6 of an eccentric a^5 on the main shaft a, and the valve b^7 is so actuated by the connection of its stem 26* with a cam yoke 26, surrounding a cam 27 on the said shaft, that the pump operates as follows: As the said piston moves to the left, the port 24 is closed and 23 opened, the latter allowing the passage of water from the reservoir or cooler A into the pump-cylinder B. This water cannot now escape from the cylinder, because its outlet-port 24 is closed, but presses against the right-hand side of the piston B′, with the pressure equal to that of the air in the reservoir or cooler A, thus assisting the progress of the said piston to the left. As the piston moves to the right, the port 23 is closed and the port 25 brought into communication with the port 24, allowing the water to escape from the cylinder by the pipe b^8. The pump is thus made to pump cold water into and out of the reservoir or cooler A, such water having an upward circulation therein and cooling the air admitted thereinto from the cylinder. The piston-rod B^2 is disconnected from the eccentric during the time of the working of the pump by the hand-lever B^3, before described, to compress the air into the reservoir A preparatory to setting the engine in operation.

Having now described the details of the engine, I will proceed to describe the leading operations that occur during a revolution of the crank-shaft when the engine is in operation. I will first suppose that the power-piston C′ has just started to the right, as represented in Fig. 1. The power-cylinder C is filled with water on both sides of the said piston, the pipe C′ supplying cold water from the reservoir A to the left of the said piston, and the pipe c^4, which is always open, allowing water to pass from the right side of the piston to the supplementary cylinder F, which is filled with hot water on the right side of its piston. The part of the cylinder F on the left of the piston F′ is partly filled with cold water and partly with air, the air being received from the upper part of the reservoir A, where air only is contained through the pipe f^5. The quantity of water which is contained in that part of the cylinder, and which remains cold, remains there permanently, the object being to afford no unnecessary space for air. The intermediate heater E is filled with air nearly down to the bottom of its wire-work E′; but the part below and the pipe f^2 are filled with hot water. The valve e^6, Figs. 2 and 3, has opened the pipe e^4 and closed that e^5. The valve f^3 has opened the pipe f', and the valve f^4 has closed by weight. The pressure from the air-reservoir A through the pipe c' on the larger surface of the power-piston C′ overcomes the pressure in the opposite surface thereof, which is exposed to a no greater degree of pressure than if directly in communication with the reservoir A, as the cylinder C communicates freely through the pipe c^4 with the cylinder F, the cylinder through the pipe f' with the heater D, and the heater through the pipe d' with the reservoir A. The pressure on the larger surface of the piston C′ thus overcoming that on the smaller causes the said piston to travel to the right, and so by giving motion to the crank a' and shaft a to cause the piston F′ also to move to the right, the latter moving at a greater velocity by reason of the greater length of its crank a^4. As the power-piston C′ advances, it drives the water before it through the pipe c^4 into the cylinder F, whence, as the piston F′ is advancing at the same time, the water is driven through the pipe f' into the primary heater D, from which the hot water, which is always contained within it, is thereby forced up through the passage e', opening the valve e^3 and passing into the secondary or intermediate heater E, displacing the heated air from among the wires E′ and heating said wires to the top of said heater. At the same time the air is forced up through the passage e^4, opening the valve e^7, and is cooled in its ascent through the water in the air reservoir or cooler A. During the time in which this takes place—viz., while the piston F′ makes its stroke to the right—a vacuum is formed behind said piston, and the valve f^6, Fig. 5, opens, allowing cold air from the reservoir A to pass through pipe f^5 and fill the said vacuum. Almost immediately after the piston F′ has completed its stroke to the right, the piston C′ having yet made but little more than half its stroke in the same direction, the valves f^3, f^6, e^3, and e^7 close, and the valve e^6 closes the passage e^4 and opens e^5. As the piston F′ travels to the left, which it does while C′ completes its stroke to the right, it forces the cold air which it has just drawn from the reservoir A into the intermediate heater E through the passage e^5, driving the hot water before it through the wire-work E³ and E′ and through the pipe f^2, opening the valve F⁴ into the vacuum which is being formed on the right of the piston F′. As the air enters and descends among the wires, it will be observed, all the exterior passages from the heater E and cylinder F, except the pipe c^4, leading to the cylinder C, are closed. The expansive force of the air among the wires is now increased by heat; but it cannot exert its increased pressure on the air-reservoir A, because the passage e^4 is closed by the valve e^6, nor on the primary heater D, because the valves e^3 and f^3 are closed but is allowed to exert it in the cylinder F through the passage e^5 and pipe f^2, still maintaining an equal pressure on both sides of the piston F′. The increased pressure is also transmitted through the pipe c^4 to that portion of the power-cylinder C on the right side of the piston, while the larger surface of the opposite side of the piston is still exposed only to the uniform pressure of compressed air in the reservoir A. As the air is entering and being heated among the wires E′ and E³, the power-piston C′ completes its stroke to the right, encountering the increasing pressure of the air which is overcome by the momentum of the fly-wheel on the crank-shaft and of other parts of the engine until its crank a' reaches its dead-point, at which point the piston F′ will arrive at the end of its return-stroke, where it will remain stationary, while the working-piston C′ is urged to the left by the increased pressure of the heated air, and at the close of the stroke in that direction the valves e^6 and f^3 are shifted back to the positions represented in Fig. 3, and before described, re-establishing communication between the right-hand end of the cylinder C and the reservoir A and primary heater D, and removing the increased ressure of the heated air from the right-hand side of the piston and causing a repetition of the above-described operation to be commenced. In the running of the engine nothing but a little water enters and issues from it. In stopping the engine, the engineer should close the valve c^2 very soon after the piston C′ starts on its stroke to the right. A vacuum will then be formed behind it and it will encounter the pressure on the smaller surface, which will be very great, as I propose to compress the air in the reservoir to a very high pressure—say one thousand pounds per square inch—and it will therefore be stopped almost instantly. In case the piston C′ should stop on its stroke to the left from any cause whatever, and the pressure of the heated air on the smaller surface of its right side be insufficient to overcome the pressure on the larger surface of its opposite side, the engineer will close the valve c^2 and open the valve c^4. The larger surface of the left side of the piston will then be relieved from pressure, the water will escape from that side of the piston, and the piston comes back to the end of its stroke to the left when the valve c^4 is closed and that c^2 opened, and the operation proceeds as before. The loss of water from the cylinder C will soon be supplied through the reservoir by the pipe c' from the pump B, which, as has been already explained, pumps a little more water into the reservoir A than out of it.

In the foregoing description I have alluded exclusively to the use of air and water; but I will now state that it may be practicable to substitute gas for air and some other liquid for water, provided always that if another liquid be pumped into the reservoir or cooler A it be allowed to cool before it can be used again to cool the air.

Air might be used instead of water in the primary heater D for the purpose of heating the wires E′ in the secondary heater E; but in that case as great an elevation of the temperature of the wires as is obtained by using water would not be practicable. It would also be necessary in that case to attach the pipe d' to the top of the reservoir A to prevent the water from running down it into the heater D, the object of this pipe being only to maintain an equilibrium between the said heater and the reservoir.

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

1. The combination of the reservoir or cooler A, the power-cylinder C and its piston C′, the supplementary cylinder F and its piston F′, and the two heaters D E, the whole applied in relation to each other to operate substantially as herein specified.

2. The combination, with the said reser-

voir, cylinders, and heaters, of the pump B, applied and operating substantially as herein set forth.

3. Combining the piston F′ of the supplementary cylinder F with the main shaft a by means of the crank a^4, of longer stroke than the driving-crank, and the jointed connecting-rod F^3, applied and operating substantially as herein set forth.

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