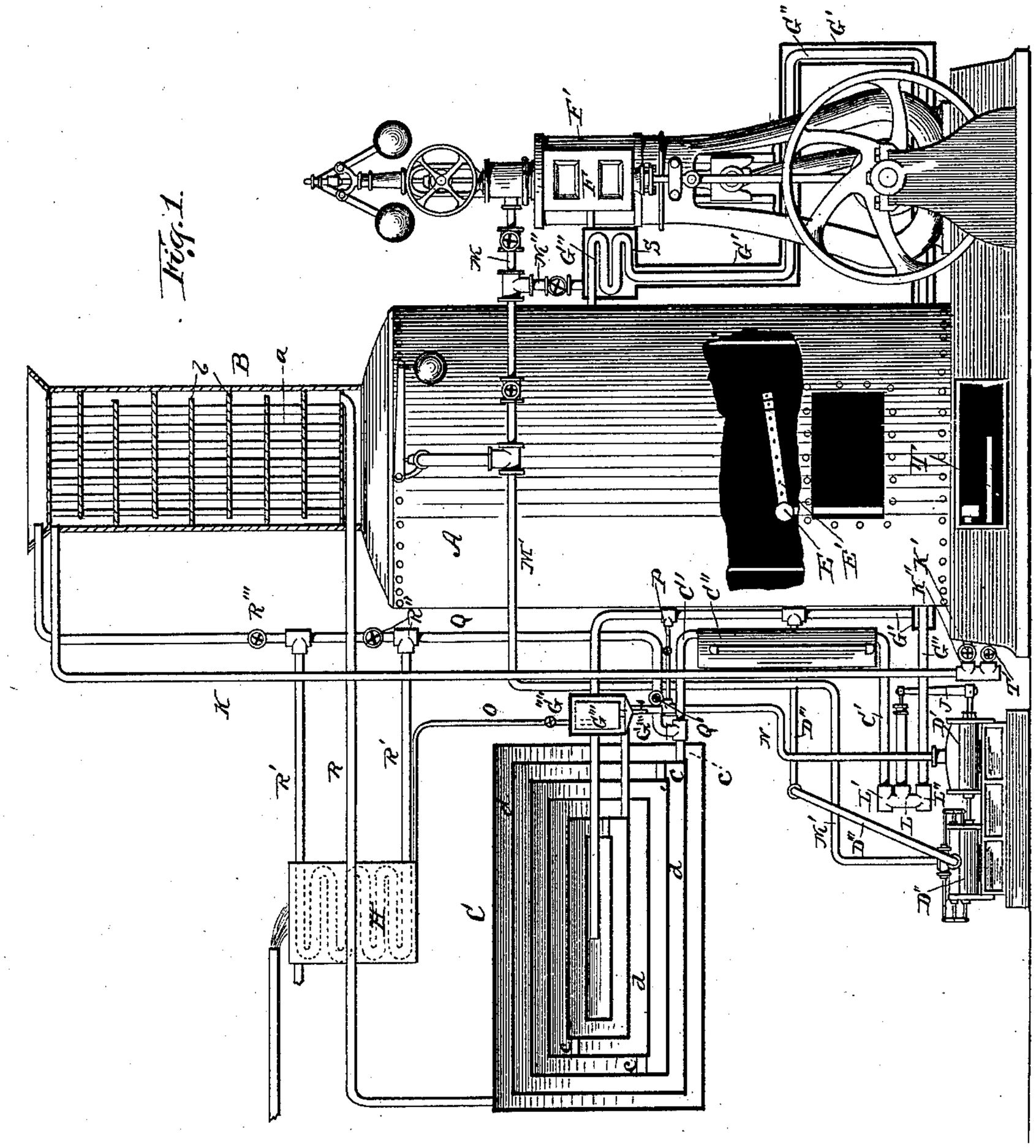
(No Model.)

2 Sheets—Sheet 1.

V. W. BLANCHARD.

HYDROCARBON FURNACE.

No. 268,176. Patented Nov. 28, 1882.



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(No Model.) 2 Sheets—Sheet 2.

V. W. BLANCHARD.

HYDROCARBON FURNACE.

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Fig. 3.

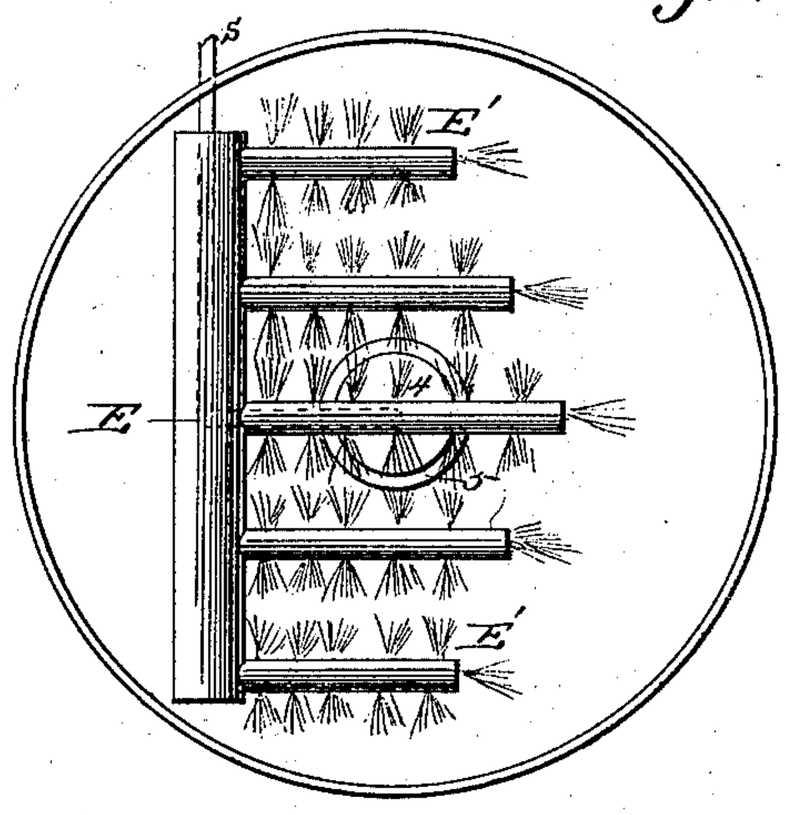
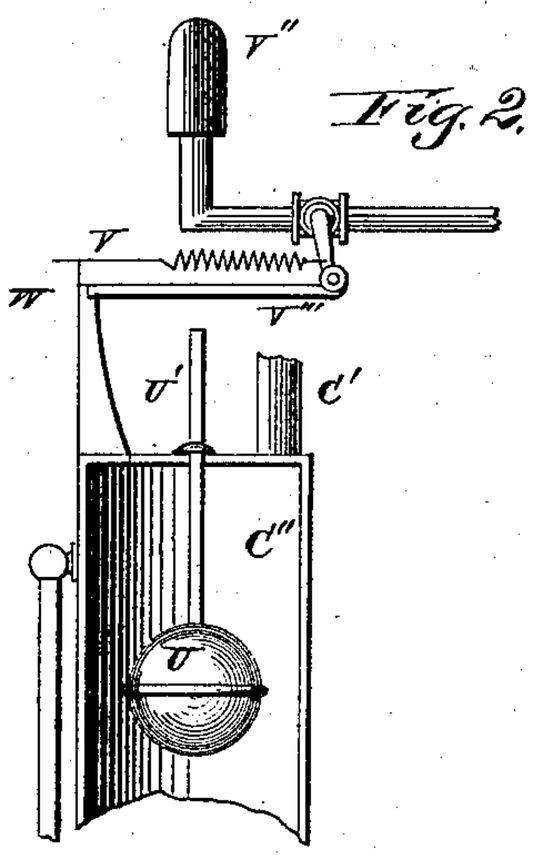


Fig. 2.



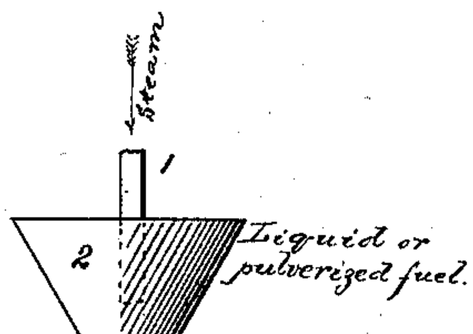


Fig. 4.

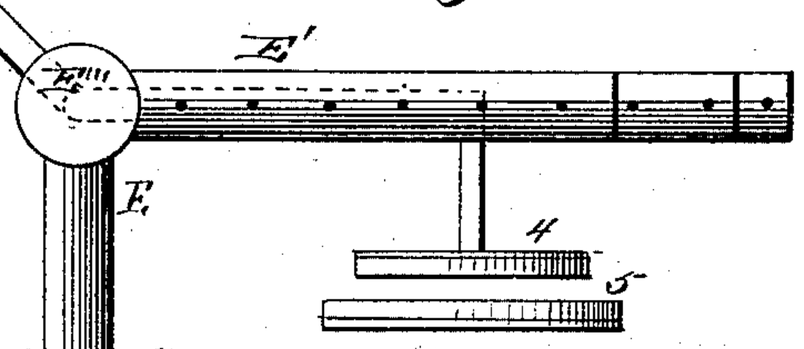
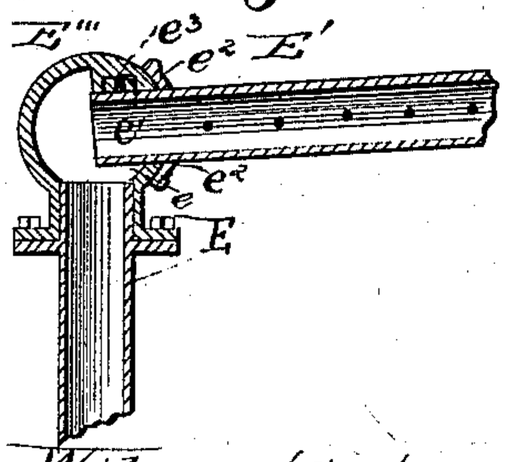


Fig. 5.



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UNITED STATES PATENT OFFICE.

VIRGIL W. BLANCHARD, OF NEW YORK, N. Y.

HYDROCARBON-FURNACE.

SPECIFICATION forming part of Letters Patent No. 268,176, dated November 28, 1882.

Application filed December 16, 1881. (No model.)

To all whom it may concern:

Be it known that I, VIRGIL W. BLANCHARD, of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Furnaces; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form part of this specification, and in which—

Figure 1 is a side view of my invention partly in section. Fig. 2 is a section through the water-reservoir C″, showing the alarm mechanism; and Figs. 3, 4, and 5 are detail views of the liquid-distributers.

This invention relates to hydrocarbon-furnaces and an apparatus for the production of steam and for other purposes; and it consists, first, in an improved furnace for general purposes in the arts, and which is designed for burning ordinary fuel—such, for instance, as wood, anthracite or bituminous coal, or for burning liquid or pulverized fuel separately or singly—in each instance realizing from the fuel which it is found desirable to use the most desirable results in the process of its combustion; second, in a combined air heater and distributer of novel construction, that may be applied to the fire or fuel chamber of any furnace, by means of which a more perfect combustion of the fuel burned on the grate-bars or dispersed above them is obtained than would be possible if it were burned by the methods now in usual practice; third, in a combined air-heater and steam-condenser that serves as a valuable auxiliary to the combined air heater and distributer within the furnace, in serving both to heat and to promote the process of combustion within the furnace and to utilize the exhaust-steam by condensing it back to water; fourth, in an air-heater of novel construction, adapted for use in connection with the aforesaid combined air-heater and steam-condenser, and with or without the air-heater within the furnace, for the purpose of a more perfect utilization of the waste gases that usually pass off through the escape-flue of the furnaces hitherto constructed; fifth, in a receptacle for the water resulting from the condensation of the exhaust-steam from the cylinder of the engine, which is so applied as to afford a suitable reservoir to the water of condensation from the combined air-heater and steam-condenser previous to its being returned by a pump to the boiler; sixth, in a water-heater of novel construction, forming a part of the steam-boiler, and so applied that when it is used in combination with a pump and the combined air-heater and steam-condenser it will return the water of condensation to the boiler at a very high temperature; seventh, in a novel device for effecting the evaporization or distillation of water by means of the heat contained in the exhaust-steam, by means of which water may be freed from impurities before it is supplied to the boiler to compensate for the waste consequent to leakage, and also the waste resulting from the motion of the piston in the cylinder of the engine; eighth, in a device by means of which steam, as well as air, may be introduced into the blast by which combustion is carried on within the furnace; ninth, in a novel arrangement of parts by which the water of condensation from the exhaust-steam is returned to the boiler at a temperature a little below the heat of the exhaust-steam as it leaves the cylinder of the engine; tenth, in such an arrangement of an air-pump, with connecting pipes and valves therefor, that the volume of air may be measured previous to its being discharged into the fuel and combustion chamber of the furnace to carry on and make complete the process of combustion in the same; eleventh, in a combination of elements whereby a partial vacuum is formed behind the piston of the steam-engine, thereby obviating the loss of power consequent on its working against the pressure of the atmosphere; twelfth, in a novel device applied to the reservoir holding the water derived from the condensation of the exhaust-steam and the steam of evaporation, so that a failure of the pump to return the water of condensation back to the boiler will cause an alarm to be sounded, thus warning the attendant of danger and preventing the explosion of the boiler in consequence of low water that attends the usual method, as will be hereinafter explained.

A designates an ordinary tubular boiler of the upright kind, and of the ordinary and usual construction. The heating-flues occupy the upper portion of this boiler. Below the flues

the water-space is seen in Fig. 1, with the aperture for the furnace-door, which opens into the fire-box, also the aperture for the door opening into the ash-pit.

The grate-bars are not shown, they being just below the fire-box aperture.

F designates the steam-chest, and F′ the vertical cylinder thereof, the governor being arranged above the cylinder and crank, the fly-wheel and its connections being arranged below the cylinder. These parts need no detailed description, as they are so well known, although they take part incidentally in my invention.

D″ designates a secondary steam chest and cylinder, receiving live or common steam from the boiler A by means of the pipe M′, and exhausting the same from the cylinder D″ by means of the pipe D‴ into the pipe G′. The office of this engine is to give motion simultaneously to the air-pump D′ and the water-pump L. It will be observed that motion is communicated from one end of the piston-rod of the air-pump D′ to the piston-rod of the water-pump L by means of the arm J. Both the air-pump D′ and the water-pump L are similar to those in general use, therefore do not require a more detailed description, the office of the former being to supply the furnace of the boiler A with air or air and steam to carry on the process of combustion of the fuel within the same after such gaseous elements have performed other offices, which will be hereinafter described, and the office of the latter to return heated water to the boiler A in the manner also hereinafter specified.

B designates a cylindrical air-heater above the boiler A. It will be observed by reference to the drawings that the said air-heater is closed at both ends, and that it is supplied with a large number of upright pipes or flues, *a*, extending its entire length. These pipes or flues *a* afford a passage for the waste gases from the top of the furnace, with which they communicate, to a suitable conductor that may be adjusted to the upper portion of the air-heater B to carry the same away. The air-heater B is a closed vessel, and is divided by horizontal diaphragms or partitions *b* into compartments which communicate with each other zigzagging by a portion of the partitions being omitted alternately, so that air or gases being introduced under pressure into the lower compartment will pass across the same and rise into the compartment next above, and thus take a tortuous or serpentine course through the heater B, as indicated by the arrows. I thus expose said gaseous elements to the effects of the heat resulting from the passage of the waste heated gases through the upright pipes or flues *a* in the most effectual manner to receive or eliminate heat from the same. It will thus be seen that with a brisk fire in the boiler-furnace the heated air or other gaseous elements introduced through the pipe R under pressure into the lowest compartment of the air-heater B will be compelled to pass to and fro in a transverse direction across said air-heater as many times as there are horizontal partitions or diaphragms *b*, and will during the passage thereof become heated by the upright pipes or flues *a* previous to its passage from said heater through the pipe K. It will be clearly seen that my manner of constructing the air-heater B serves in a high degree to transmit the heat of the waste gases passing from the top of the boiler A to the gaseous elements passing under pressure through the interior of said air-heater in the manner heretofore set forth.

C designates a cylindrical vessel composed of a series of concentric tubes, *d*, with closed extremities. The annular spaces between said tubes *d* communicate with each other in the manner hereinafter explained. The object of this vessel C is threefold, viz: first, to heat the air supplied by the air-pump D′ previous to its entering the air-heater B; second, to condense the exhaust-steam coming from the steam-chest F of the engine and the engine D″ back to water previous to its being returned to the boiler A by the pump L; and, third, to serve, if desired, as a water-heater to heat water to supply the waste resulting from a greater or less loss from running the engine, whose valve-box is lettered F, and also the engine D″. It will be seen that the annular spaces between the tubes composing the vessel C have a certain regular connection with each other, such space between two tubes connecting at their closed extremities by a tube, *c*, with a space, so that two distinct channels are formed through the vessel C, independent of each other, by the thickness of the metal forming the walls of the concentric tubes that take part in the formation of the vessel aforesaid. Hence, if at the same time the exhaust-steam from the engines F′ and D″ is introduced by a pipe into the interior cavity of the vessel C, and cold air is introduced under suitable pressure by a pipe communicating from the air-pump D′ with the annular space between the inner tube and the one that surrounds it, it will be seen that the steam and the air will traverse separate channels formed by the spaces between the concentric tubes in the vessel C and their connecting-pipes, being separated only by the thickness of the metal out of which the walls of the said tubes are formed. It therefore follows, if the vessel is of ample size, that if a sufficient volume of cold air be so introduced into it simultaneously with the exhaust-steam in the manner just described the heat of the exhaust-steam will be imparted to the current of air, separated from it by a metallic wall only sufficient to cause a condensation of the said steam to water at or near the boiling-point, while at the same time the current of air by which the condensation of the steam is produced is heated to a greater or less degree of intensity, according to its volume and the pressure used in its transmission. It will be observed that the annular spaces in the

vessel C, which constitute the steam-channels in the same, are so connected with each other by tubes as to form a descending passage, so that the water of condensation will flow by its own weight from said vessel through the pipe C′, which connects outwardly with said steam-channels. This is a very important feature of my invention. By the introduction of a stream of cold water into said channels, traversed by the steam in the combined steam-condenser and air-heater C, it is evident that less air would be required to condense the steam to water in the manner described, while at the same time the water thus introduced would become heated to a temperature the same or nearly the same as the exhaust-steam within said vessel. Thus the vessel C would serve at the same time as a water-heater and an apparatus for condensing exhaust-steam to water by means of cold water and cold air mingled in suitable proportions.

G′ designates a pipe for conveying the exhaust-steam from the cylinder of the engine F′ to the vessel C. It will be observed that in close proximity to the engine-cylinder the pipe G′ is expanded into a vessel, S, so as to allow another pipe, G″, to pass in a serpentine direction through it, and also beyond this vessel it is expanded in diameter, so as to allow the pipe G″ to pass inside of it, leaving sufficient space between the two pipes to allow a free passage of the exhaust-steam from the chest F of the engine through a part of its journey to vessel C. It will also be observed that at a certain point the pipe G″ passes out of the pipe G′, after which the pipe G″, in a diminished size, after entering and leaving the vessel G‴, communicates with the interior of the vessel C. It will also be seen that the pipe G″ enters the boiler A, and that its interior is continuous with the steam-space of the boiler to the point where said pipe is connected with the pump L, near the check-valve L″ of the latter, so that the steam-pressure in the boiler extends through pipe G″ to this check-valve. The two pipes G′ and G″ together form a water-heater, which, when it is taken in connection with the boiler A, the vessel C, and the pump L, forms an element of the greatest importance, whose function will be hereinafter set forth.

C′ designates a pipe connecting with the steam-channels in vessel C and the reservoir C″, and it will be seen that a continuation of this pipe C′ also connects the reservoir C″ and the pump L, so that a stream of water will pass by its own gravity from the steam-channels of vessel C to the pump L, passing through the reservoir C″. This reservoir C″ performs two very important offices, viz: first, to afford a reservoir to contain the water of condensation from the vessel C and prevent the steam passage in this vessel from being filled or flooded with water in case of any derangement in the working of the pump L; and, second, to serve as an element in an automatic alarm in case of a derangement in the working of the pump L, thereby calling assistance to repair the difficulty. This reservoir C″ is provided with an ordinary water-gage, so that the engineer may at a glance determine the depth of water in it. This reservoir C″ should be of sufficient size to hold for a considerable period of time the water of condensation as it flows from the vessel C in the manner above described, so that in the event of any derangement of the pump L the vessel C may not be in danger of being flooded with water, which should be conveyed into the boiler A as fast as it accumulates at the inlet-valve L′ of said pump by the action of the latter.

The letter U (see Fig. 2) represents a hollow metallic float located inside of the reservoir C″. This float is provided with a stem, U′, which passes through the top wall of the reservoir. The float U, being of thin metal and provided with a closed cavity filled with air, will always float on the surface of the water in the reservoir C″ when the water accumulates in the latter so as to rise above its upper third.

V represents a coiled spring attached to an arm of a rotary steam-valve in a pipe connected with the boiler A, said steam-valve being connected with a pipe terminating with an ordinary steam-whistle, V″, in such a manner that a release of the tension of the spring will open the steam-valve in the pipe leading to the whistle, or ring a bell, as may be desired.

V‴ represents a hinged arm attached by a proper connection to the retracted spring V, and W is a notch which will engage the free extremity of the hinged arm V‴. Now, with the spring V retracted and held in position by the free extremity of the arm V‴, resting in the notch W, it is evident that when the float U is raised by the water in the reservoir C″ to a certain height its stem will come forcibly in contact with the extremity of the hinged arm V‴ and disengage it from the notch W, which will allow spring V to actuate the steam-valve, or a valve to which it is attached, thus sounding an alarm and warning the attendant that the pump L is not returning the water of condensation to the boiler A as fast as it is received into the reservoir C″. By these means the return of the water of condensation from the boiler A is made secure, thus avoiding all danger of low water in the boiler.

G‴ represents a vessel contained within another vessel, G⁗, the space between the two vessels forming a channel that connects the two portions of the pipe G′ with each other, so that the exhaust-steam, in passing from the cylinder of the engine F′ to the interior cavity of the vessel C, will be compelled to pass around the vessel G‴, in the space between it and the exterior vessel, G⁗, thereby communicating a portion of its heat to the vessel G‴. This vessel G‴ is provided with a perforated top for the escape of steam that may be generated in it into the space that surrounds it, and also with a pipe, O, having a stop-cock, which pipe connects with a reservoir, H, of water. By op-

erating the cock in pipe O water may be admitted into the vessel G‴, which may be evaporated in the manner already described, the steam from such evaporation passing out of the perforations in the top of the vessel G‴. The bottom of this vessel G‴ is provided with a pipe directed downward through the bottom of the vessel G⁗, to which pipe a stop-cock is applied, by means of which the contents of vessel G‴ may be drawn as occasion requires. This apparatus, composed of vessels G‴ and G⁗, together with the reservoir H and the pipes and stop-cocks described, forms a very important part of my invention, in that I supply thereby pure distilled water to the boiler A to make good the waste or loss that may result from the leakage and escape of steam and water in running the engines F′ and D″. Although the cold air traversing the channels in the vessel C will condense to water the greater, if not the entire, volume of exhaust-steam passing at the same time through said vessel that will be returned to the boiler A by the pump L, as set forth, still there will be a large volume of water lost daily by leakage of the boiler and engine-cylinders, when in operation, which must be resupplied. By opening the cock in the pipe O to a greater or less degree water will be admitted to the vessel G‴, which will be readily evaporated by the heat of the exhaust-steam which surrounds said vessel in its passage from the steam-cylinders F′ and D″ to the vessel C. The steam resulting from the evaporation of this water will readily pass through the perforations in the top of the vessel G‴, and from thence pass directly into the vessel C to be condensed back to water in the manner described, and conveyed into the boiler A by means of the pump and the pipe-connections. Thus, although impure water may be admitted into the vessel G‴, only pure water will pass from said vessel in the form of steam to be conveyed to the boiler. The impurities of various kinds in the water admitted into the vessel G‴ from reservoir H may be drawn off from time to time by means of the pipes, which should be provided with stop-cocks, and which are connected with the bottom of said vessel. By these means, if the boiler A is filled with pure water, the waste or loss thereof resulting from running the engines may be supplied with pure water derived from impure water, thus effectually preventing the formation of scale or the accumulation of dirt in the boiler A. In case, however, it is not desirable in practice to evaporate the water that is admitted to the vessel G‴ from the reservoir H, by allowing this vessel to become filled with water from this reservoir H a continuous stream may then be caused to flow through the perforations in the top of the vessel G‴ into the space between the latter and the vessel G⁗ by a proper adjustment of the valve in pipe O. This water would then pass, with the exhaust-steam, into the vessel C and become heated previous to its exit therefrom. Certain impurities admitted with the water, in the manner described, into the vessel G‴ would settle to the bottom of this vessel, and could be drawn therefrom, as set forth. If it is desired to add only pure or distilled water to the boiler A from the vessel G‴, the latter vessel should not be permitted to fill with water, and the water should only be admitted into it as fast as evaporation takes place.

M and M′ represent the respective pipes, with their valves, that supply the engines with live steam from the boiler A. N designates the pipe that supplies the vessel C with cold air from the air-pump D′.

R designates the pipe that conveys the heated air from the vessel C to the air-heater B.

Q is a pipe that extends between the lower extremity of the steam-channel in the vessel C and the upper extremity of the air-heater B. By means of pipe Q an uninterrupted channel is afforded for the exhaust-steam from the cylinders of the engines to the flue-passage at the upper extremity of the air-heater B, passing through the open valve Q′ in said pipe, after its passage through the vessel C.

R′ represents a pipe connecting with the pipe Q and passing into the reservoir H. It will be seen that the pipe R′ passes to and fro a number of times in the reservoir H before it emerges to terminate in a connection with the pipe Q.

R″ is a valve closing the pipe Q, by means of which the contents passing in this pipe may be compelled to pass through the pipe R′ in the reservoir H.

R‴ is a valve by means of which the pipe Q may be closed above the junction of the pipe R′ with the latter. Now, with the reservoir H supplied with a flowing stream of cold water, it is evident that by opening valve Q′ and closing the valve R″ in the pipe Q any uncondensed steam passing from the vessel C from the two engines would immediately pass by the channel already described through the pipe R′ in the reservoir H, where said steam would be immediately condensed to water by the cold water in said reservoir, surrounding the pipe R′ in its passage through said reservoir, and it will be seen that the water of condensation in the pipe R′ in the reservoir H would flow by its own gravity through pipes Q and C′ into the reservoir C″, to be returned to the boiler A in the manner set forth.

M″ represents a pipe with a valve, connecting the pipe M with the vessel S. By opening the valve in pipe M and in the pipe M″, and also the valve Q′ and valve R‴, at the same time closing the valve R″, live steam from the boiler will pass through the pipe G′, thence around the vessel G‴ and into the steam-channels in the vessel C, and from thence pass through the pipe Q and pipe R′ into the reservoir H in said pipe R′, and from thence back into pipe Q, to be discharged into the conductor above the air-heater B. After atmospheric air has been discharged or expelled from the steam-channel last described by the

live steam from the boiler A, by closing the valve in the steam-pipe M''' and the valve R'' in the steam-pipe Q, a partial vacuum will be immediately formed in the pipe R' in reservoir H, where said pipe is exposed to the cold water flowing into and out of it. With this vacuum established in the pipe R' the pistons of the engines, when put in motion, will be relieved of the weight of the atmosphere, thereby making low-pressure engines of both and economizing the production of power. If the exhaust-steam is not entirely condensed to water by the cold air passing through the vessel C, such steam will immediately pass into the condensing-pipe in the reservoir H, where condensation cannot fail to take place. Under certain conditions the apparatus just described for establishing a vacuum behind the pistons in the engine-cylinders may be dispensed with, the condensation of the steam being carried on only in the vessel C. I desire to be understood as claiming that the condensation of steam in a pipe traversing the reservoir H is a valuable, though not an indispensable, auxiliary in my invention.

P represents a pipe provided with a stop-cock that connects the pipe G' with the pipe N. By means of this pipe and its stop-cock steam may be added, if desired, to the air by which the combustion of fuel is carried on in the furnace of the boiler A.

K is a pipe leading from the upper portion of the air-heater B to the ash-pit of the furnace of the boiler A. At the lower extremity of the pipe K it divides into two branches which enter the ash-pit of the furnace of the boiler. The lower branch, T, is provided with a valve, T', and terminates in the ash-pit by a free extremity, and the upper branch, K'', is provided with a valve, K', and after entering and passing partly across the ash-pit in a horizontal direction connects with a vertical pipe, which in turn connects at its upper extremity with a horizontal pipe, E, provided with several distributing-pipes, E', each one of which enters it at one extremity and extends across the space above the grate in the boiler-furnace. It will be observed that the heating and distributing pipes E' are so arranged at a suitable distance from each other that gases resulting from combustion rising from the burning fuel will pass directly between them in their journey to the upper part of the furnace.

The pipes E' are finely perforated at their free extremities, and are also provided with rows of perforations near their center, extending their entire length, so that any gaseous elements discharged from said perforations under pressure will pass out in jets at right angles, and into the currents of combustible gases rising from the fuel, and thereby become intimately mixed with the same, thus effectually completing the act of combustion. The horizontal pipe E and its perpendicular supporting-pipe are connected by a loose joint, E''', (shown by Fig. 5,) composed of the opening *e* in the pipe E and the entering portion *e'*, with its flanges e^2, and dowel-pins e^3. The fixed portion of the connection is maintained in the furnace of the boiler A. The pipes E' should fit by loose joints into the apertures in the horizontal pipe E, which joints are of the greatest practical utility for allowing them to be quickly removed and replaced without injury to the furnace, when it becomes necessary from any cause to substitute new pipes for those which have been injured by heat. The loose joints between pipes E and E' are of the same kind as the joint E''' above described. In some instances the pipes E' may be dispensed with, in which case the heated gaseous elements would issue directly from the apertures in the pipe E, that in the other case would be occupied by one extremity of the pipes E', instead of issuing from the perforations in said pipes, as heretofore described.

In practice I shall sometimes apply furnace-brick, or other equivalent material that is highly refractory to heat, to the upper and lower sides of the heating and distributing pipes E' for the protection of the same against the intense heat to which they are exposed.

I may adopt, as a modification of the heating and distributing apparatus above described, an apparatus similar to that described in the schedule annexed to my Letters Patent dated January 4, 1881, for dispensing liquid and pulverized fuel in horizontal directions above the grate-bars and below the air-heater in the fuel-chamber of the furnace. Said apparatus for dispensing the liquid and pulverized fuel consists (see Fig. 4) of the receptacle 2, steam-pipe 1, conducting-pipe 3, and disks 4 and 5 for the lateral dispersion of the liquid or pulverized fuel. The fuel above named, admitted into the receptacle 2, would be carried by the force of steam from the pipe 1 through the pipe 3 to the disks 4 and 5 to be dispersed horizontally above the grate-bars of the furnace and below the heating and distributing arms E'. In this case the space below the pipes E' would constitute the fuel-chamber of the furnace, while the space above the said pipes would constitute the combustion-chamber proper. I contemplate the application of such a furnace to the melting, reduction, or purification of ores, metals, or minerals, or to any other purpose in the arts, as well as for the production of steam.

In the practical operation of my invention (when it is desired to free the engines from atmospheric pressure) pure water should be introduced into the boiler A, and a fire from wood, or anthracite or bituminous coal, kindled in the furnace on its grate. After the steam-gage indicates a pressure of steam in the boiler exceeding the weight of one atmosphere the steam-valves should be opened, so as to admit live steam from the boiler into the vessel S, after which the valve Q' and the valve R''' in the pipe Q should be opened, while the valve R'' in the pipe Q should be shut. This will

afford a continuous channel for the live steam from the boiler A through the vessel S, pipe G′, the space between the vessels G‴ and G⁗, into the vessel C, and from thence through the pipes R and Q into the conductor above the air-heater B. After atmospheric air has been expelled from the channel just described by the live steam from the boiler A the valve R‴ in pipe Q should be shut. Then cold water should be introduced into the reservoir H, which will instantly condense the steam in the therein-contained portion of the pipe R′, forming a partial vacuum behind the pistons in the cylinders F′ D″.

I would here add that in practice a small stream of cold water should be kept constantly flowing into and out of the reservoir H to prevent the water therein from becoming heated. When the steam-pressure in the boiler has become sufficient the valves in pipes M M′ should be opened, and at the same time the door of the ash-pit should be securely closed. The action of the cylinder D″ will at once give motion to the air-pump D′ and the water-pump L. From the pump D′ a current of air will be forced through the pipe N, vessel C, pipe R, air-heater B, pipe K, and from the latter pipe, by its two branches, into the ash-pit beneath the grate and out of the perforations in the combined air heater and distributer above the grate; or if the heating and distributing pipes are not employed the air will be forced out of the apertures in the horizontal pipe E. Said air, in its course through vessel C and heater B, will become heated to a greater or less intensity by the exhaust-steam in the vessel C and the escaping gases from the top of the boiler passing through the heater B.

The advantage of supplying heated air beneath the furnace-grate to carry on the process of combustion of the ignited fuel above it need not be herein set forth, and also the advantage of injecting heated gaseous elements containing oxygen and hydrogen gases in jets into the combustible gases rising from the ignited fuel is well known.

It will be observed in this connection that the combined air heater and distributer, composed of a vertical pipe connecting with the horizontal pipe E and its perforated distributing-branches E′, from its position in the furnace of the boiler, serves to reheat the heated air and steam to a still greater intensity during their passage through it, whether they are discharged from the openings or apertures in pipe E or from the perforated pipes E′.

By adopting the modification of the air heater and distributer which allows the pipes E′ to be raised or lowered, as described in my aforesaid patent, the said pipes may be adjusted nearer to or farther from the ignited fuel than would be possible if the pipes were fixed permanently in one position. In this case the application of furnace-brick to the pipes E, or the incasing of each one of these pipes in a cylinder of fire-clay, might in some cases be desirable. The incasing-cylinders would be suitably perforated for the escape of the gaseous elements.

In some instances a fan might be used instead of the air-pump D′, although I prefer to use the air-pump.

As the perfect combustion of the fuel requires a certain volume of atmospheric air to every pound of carbon that the fuel may contain, when air alone is used to effect its combustion, by the use of an air-pump of a certain capacity, if the quantity of carbon in the fuel burned per hour is actually known, by giving a certain activity to the air-pump, so that from three hundred and twenty-five to three hundred and fifty cubic feet of air will be supplied in a proper manner to the furnace to every pound of carbon consumed therein per hour, an approximately perfect combustion of fuel used may be realized; but in the application of an air-pump in the manner described for measuring the amount of air supplied to a furnace per hour the air must be heated before it is discharged in the furnace, and part of this heated air must be discharged into the current of combustible gases rising from the ignited fuel on the grate, as above described.

By means of the pipe P and its valve steam may be mixed with the air that is supplied to the furnace to carry on combustion.

In case of the dispersion of liquid and pulverized fuel, as set forth, the use of a certain volume of steam mixed with the air discharged into the furnace, especially when the barometer shows unusual density of the atmosphere, would conduce to a greater economy in fuel. The exhaust-steam, after leaving the steam-chest F, comes in contact with the pipe G″ at the point at which it enters the vessel S, and near the point where the pipe G″ enters the boiler. This feature is very important, and will be particularly described hereinafter. After leaving the vessel S the exhaust-steam passes for a certain distance around the pipe G″, which is inclosed in pipe G′, and thence through this pipe to the vessel C, where it traverses a channel or channels separate from the cold-air channel only by the thickness of metal sufficient to withstand the steam-pressure. In this channel the condensation of steam to water at or below the boiling temperature is effected by the cold air, as described, while in a continuation of this same channel—viz., in the pipe R′ in the reservoir H—is a vacuum, thereby relieving the piston in the cylinder F′ of atmospheric pressure and greatly economizing power. In case that the current of cold air supplied by the air-pump D′ to the vessel C should not entirely condense to water the exhaust-steam passing to said vessel from the cylinders F′ and D″, said steam will immediately pass to the pipe R′ in the reservoir H, where its condensation must take place. Thus the reservoir H, with its pipe, becomes a valuable auxiliary to the vessel C, and should be of ample capacity to meet all of the necessary requirements.

If it should not be desired to relieve the pistons in the two engines of atmospheric pressure when in use, the valve R″, and also the valve R‴ in pipe Q, may be opened, allowing a free channel from the vessel C outward to the atmosphere. In such case the reservoir H and its pipe R′ could be dispensed with altogether.

The water of condensation will flow by its own gravity from vessel C through pipe C′ into the reservoir C″, and from thence to the force-pump L, to be returned to the boiler through the pipe G″. The reservoir C″ fulfills a very important office in my invention in supplying a vessel to contain for a considerable period of time the water of condensation flowing from the vessel C, in case of any derangement in the working of the force-pump L. This will prevent the steam-channels in the vessel C from being flooded with the water of condensation should the force-pump cease to work properly. The alarm mechanism described would warn the attendant of any danger from the above cause. This alarm mechanism may be omitted from reservoir C″, and the glass gage, with which it is provided, depended on to indicate to the eye the depth of water it may contain.

The leakage of water from the boiler may be repaired by allowing a small stream to flow into the vessel G‴ through the pipe O, which leads to the reservoir H. If the stream is only sufficient to repair the waste in the boiler A, and is in correct proportion to the size of the vessel G‴, evaporation of said water in said vessel will take place as fast as it is admitted, from the effects of the heat of the exhaust-steam passing around said vessel G‴. The steam resulting from the evaporation of said water will pass out of the perforated top of the vessel G‴ and enter the vessel C, to be condensed with the exhaust-steam. If desired, water may be so freely admitted into the vessel G‴ from reservoir H that it will pass through the perforated top of G‴ and, with the exhaust-steam, enter the vessel C. This would convert the steam-channel in vessel C into a water-heater. The water of condensation, after passing the force-pump L, enters the pipe G″, whose interior is continuous with the interior of the boiler A. It should be borne in mind that when the water enters the pipe G″ through pump L it is heated so as to be near the boiling-point, and that after entering pipe G″ it is still further heated by the exhaust-steam until it reaches the vessel S, where its temperature rises to only a few degrees below the temperature of the steam in the cylinder of the engine F.

It will be observed that in the vessel S the exhaust-steam from the cylinder F′ comes in direct contact with the water-heating pipe G″ at or near the point at which its expansion commences to take place, thus communicating to said pipe a degree of heat a little below the heat of the steam in the boiler A, and that it continues to give out heat as its expansion takes place through the entire length of the enlarged portion of pipe G′. Consequently, with the water heated to or near the boiling-point, as it passes the pump L into the pipe G″ it is evident that it will enter the boiler A in the manner specified at a temperature a few degrees below the temperature of the water therein, if the steam is not worked expansively in the cylinders of the engines. The vessel S is only a continuation and enlargement of the pipe G, and the water-heater within it is only an amplification of pipe G″.

The importance of making the interior of the pipe G″ continuous with the interior of the boiler A must not be overlooked, as water heated to a temperature that the water in said pipe acquires in the vessel S and the pipe G′ could not be readily returned by a pump or other apparatus to the boiler A. In some cases the air-heater B might be dispensed with, the heated air from the vessel C being conveyed directly to the furnace of the boiler A, and, if desired, the water-heating apparatus (composed of vessel S, pipe G″, and the pipe G′) may be dispensed with, the water being returned directly to the boiler by the pump L.

In certain patents which have been granted to me, dated respectively June 8, 1867, January 4, 1881, and April 5, 1881, several forms of air heating and distributing apparatus are described for effecting the process of combustion of combustible gases rising from the ignited fuel; but in such case a separate chamber for such combustion is required. In the present application the greatest simplicity and durability are combined in an apparatus for the same purpose without the necessity of a separate combustion-chamber to complete the process of combustion, and a great advantage is derived from the parts being easily adjusted in case of repairs.

Having thus fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The combination of the horizontal pipe E, its perpendicular pipe, the perforated distributing-pipes, and the loose joint-connections of these pipes, substantially as described.

2. The combination of the air heating and distributing device, a furnace, the vessel C, and the air-heater B, substantially as described.

3. The combination of the air heating and distributing device, arranged in the furnace above the grate, with the device 4 and 5 above the grate for dispersing liquid and pulverized fuel, substantially as described.

4. The combination of the vessel C, constructed of concentric tubes with closed extremities, forming spaces between said tubes, and the short connecting-tubes between said spaces, substantially as described.

5. The combination of the outside shell of the air-heater B, the heating-flues therein, and the transverse partitions, the latter being cut away at alternate portions of the diameter of said shell, whereby gaseous elements passing through said vessel under pressure in a zigzag

direction will absorb a large amount of heat passing through the said flues, substantially as described.

6. The combination of the air-pump D′ for measuring the volume of heated air supplied to the boiler-furnace, the air-heater at the top of the boiler, and the pipe-connections and their cocks between the said pump and heater, substantially as described.

7. The combination of the reservoir C″, the vessel C, the pump L, and the pipe-connections provided with stop-cocks, substantially as described, and for the purposes specified.

8. The combination of the reservoir C″, air-heating vessel C, and the apparatus composed of the float and stem thereof, the notch W, the hinged arm, the spring, and an alarm, substantially as and for the purpose set forth.

9. The combination of the vessel G‴, the vessel G⁗, the pipe O, its stop-cock, the reservoir H, and the air-heating vessel C, substantially as and for the purpose specified.

10. The combination of the air-heating vessel C, vessel G‴, its perforated top, the inclosing vessel G⁗, and the outlet-pipe at the bottom, provided with a stop-cock, substantially as described.

11. The combination of the steam-pipe G′ with the apparatus consisting of the vessels G‴ and G⁗, the vessel C, and the pump L, with their pipe-connections and stop-cocks, substantially as described.

12. The combination of the air-heating vessel C, the exhaust-pipe of engine F′, the vessel S, the pipe G″, the pipe G′, boiler A, and pump L, the interior of pipe G″ being continuous with the boiler, substantially as described.

13. The combination of the air-heating vessel C, the engine-cylinder F′, vessel S, pipe G″, pipe G′, and boiler A, substantially as described.

14. The water-heating device consisting of the pipes G′ G″, (with or without the vessel S,) in combination with the boiler A, pump L, reservoir C″, and vessel C, substantially as described.

15. The process consisting in heating the air by the exhaust used for carrying on the combustion of fuel and at the same time reheating the water derived from its condensation to a very high degree of temperature before the latter is returned to the boiler, substantially in the manner and for the purposes described.

16. The combination of the vessel C, (as a water-heater,) the vessels G‴ and G⁗, and pipe O with the tube G′, the air-pump, the pipe N, and reservoir H, substantially as described.

17. The combination, in a low-pressure engine, of the cylinder F, boiler A, vessel C, reservoir C″, water-pump L, air-pump D′, reservoir H, pipe R, air-heater B, and the pipes with cocks communicating with said parts, substantially as described.

In testimony that I claim the foregoing as my own I affix my signature in presence of two witnesses.

VIRGIL W. BLANCHARD.

Witnesses:

H. P. SISSON,

JOHN R. QUAIFE.