Sheet 1-2 Sheets.

P. Shearer,

Reciprocating Steam Engine,

No. 31,631, Patented Mar. 5, 1861.

Fig. 4.

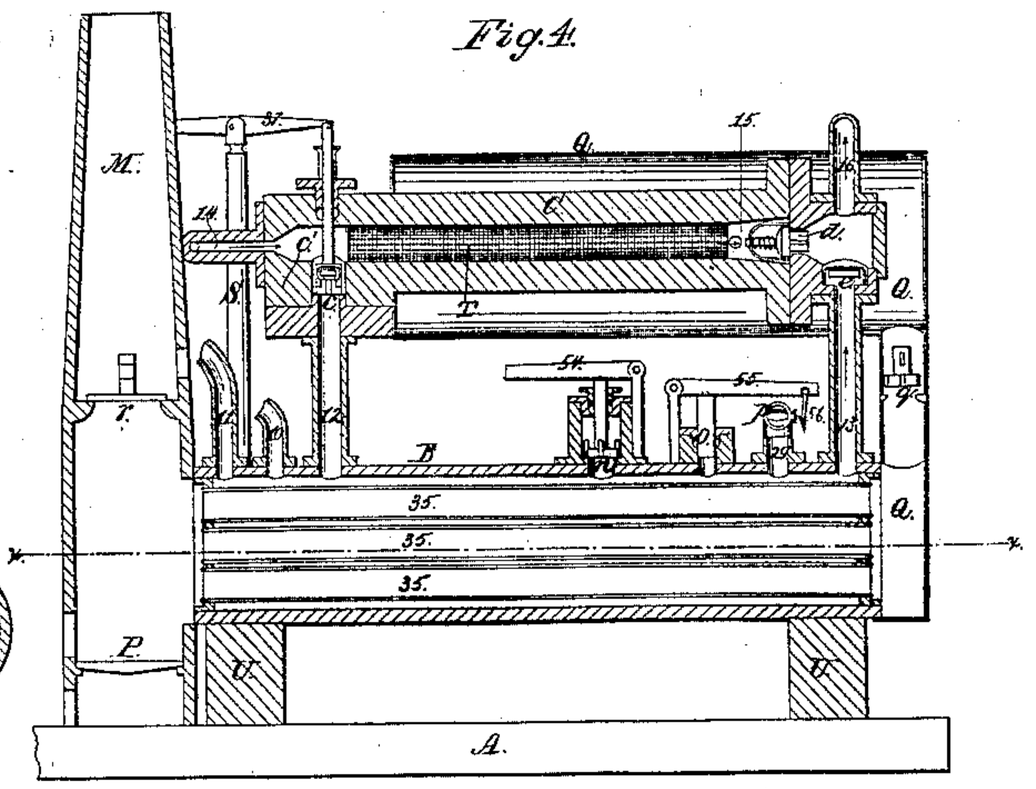


Fig. 5.

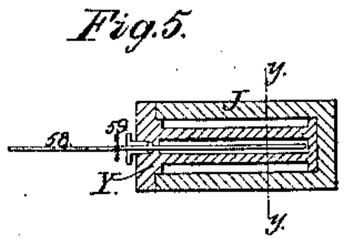


Fig. 6.

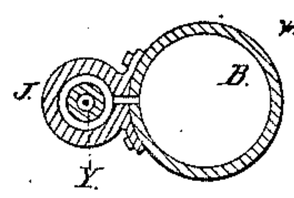
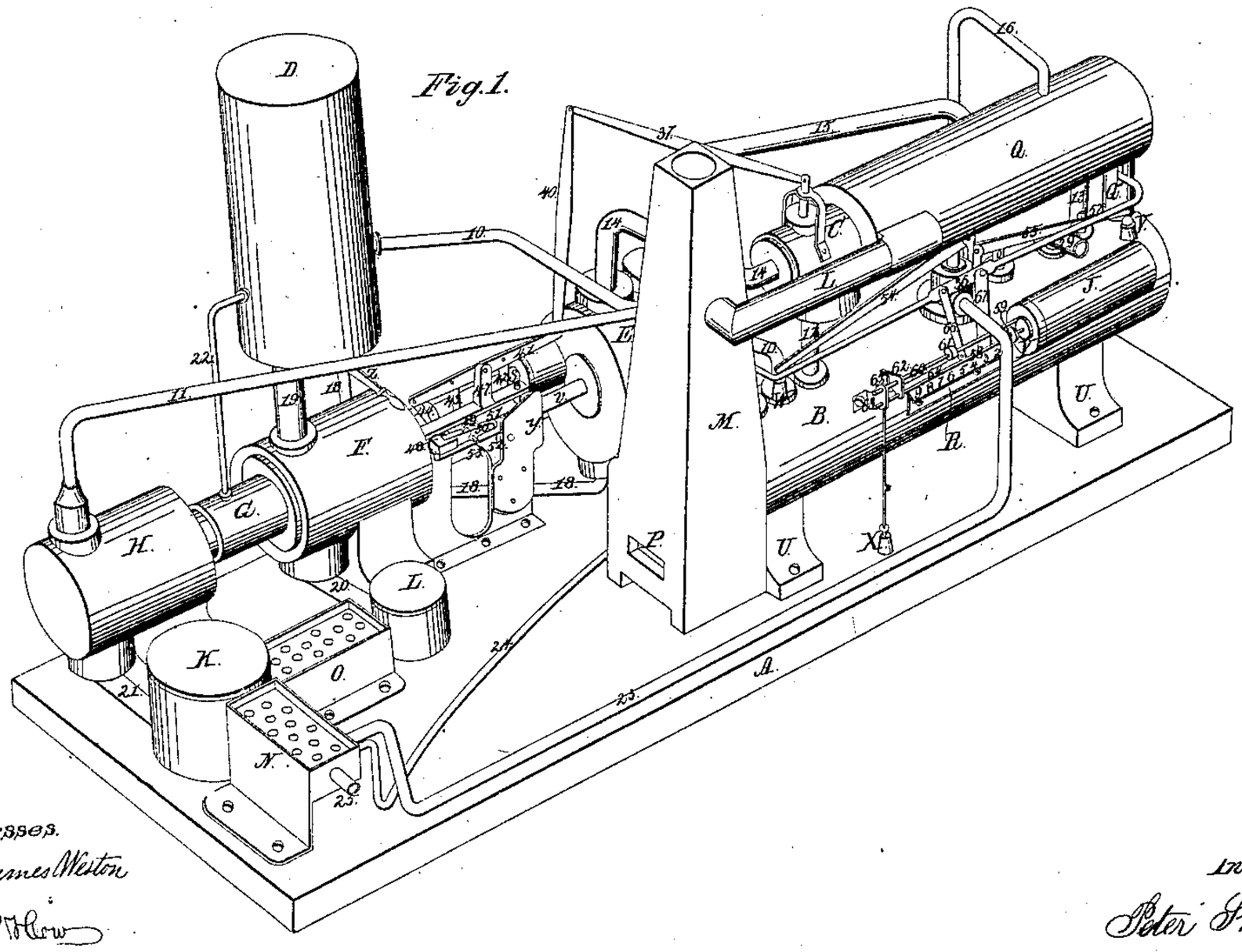


Fig. 1.



Witnesses.
H. James Weston
Thos P. Howe

Inventor.
Peter Shearer.

Sheet 2 · 2 Sheets.

P. Shearer,

Reciprocating Steam-Engine,

No. 31,631, Patented Mar. 5, 1861.

Fig. 3.

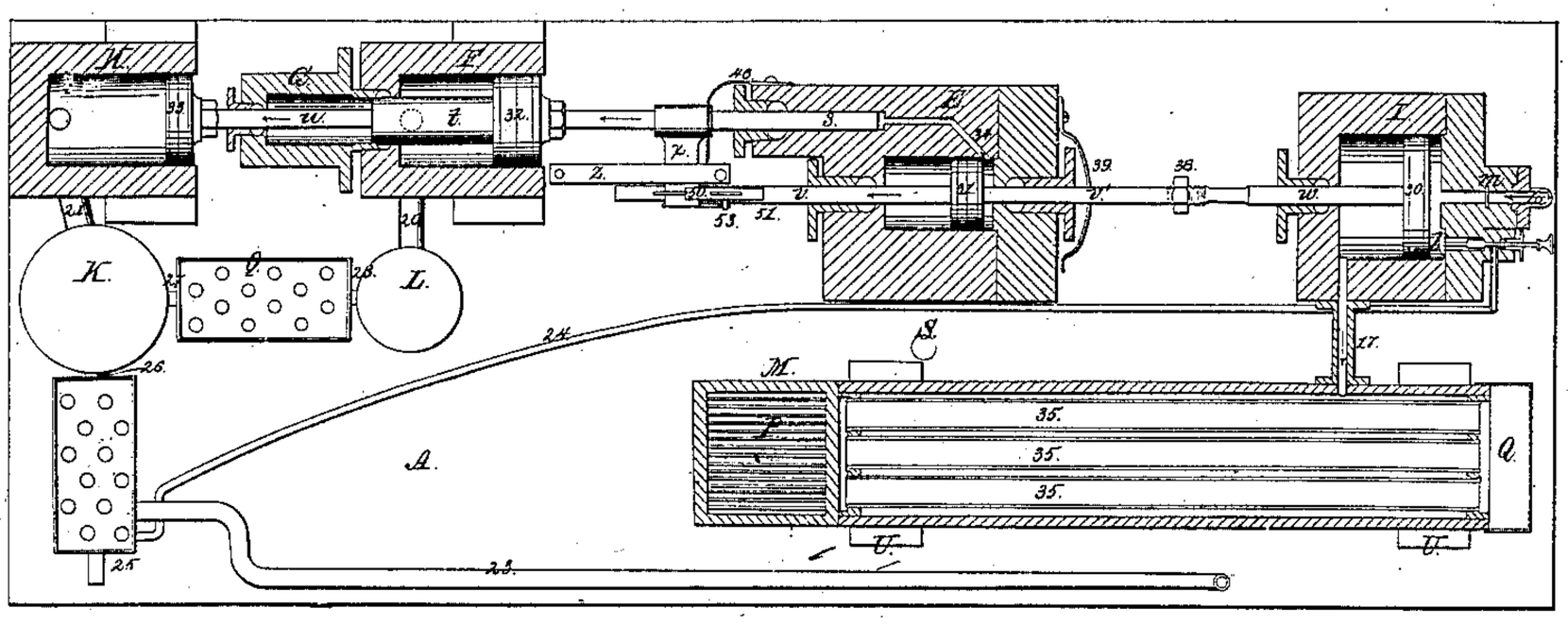


Fig. 2.

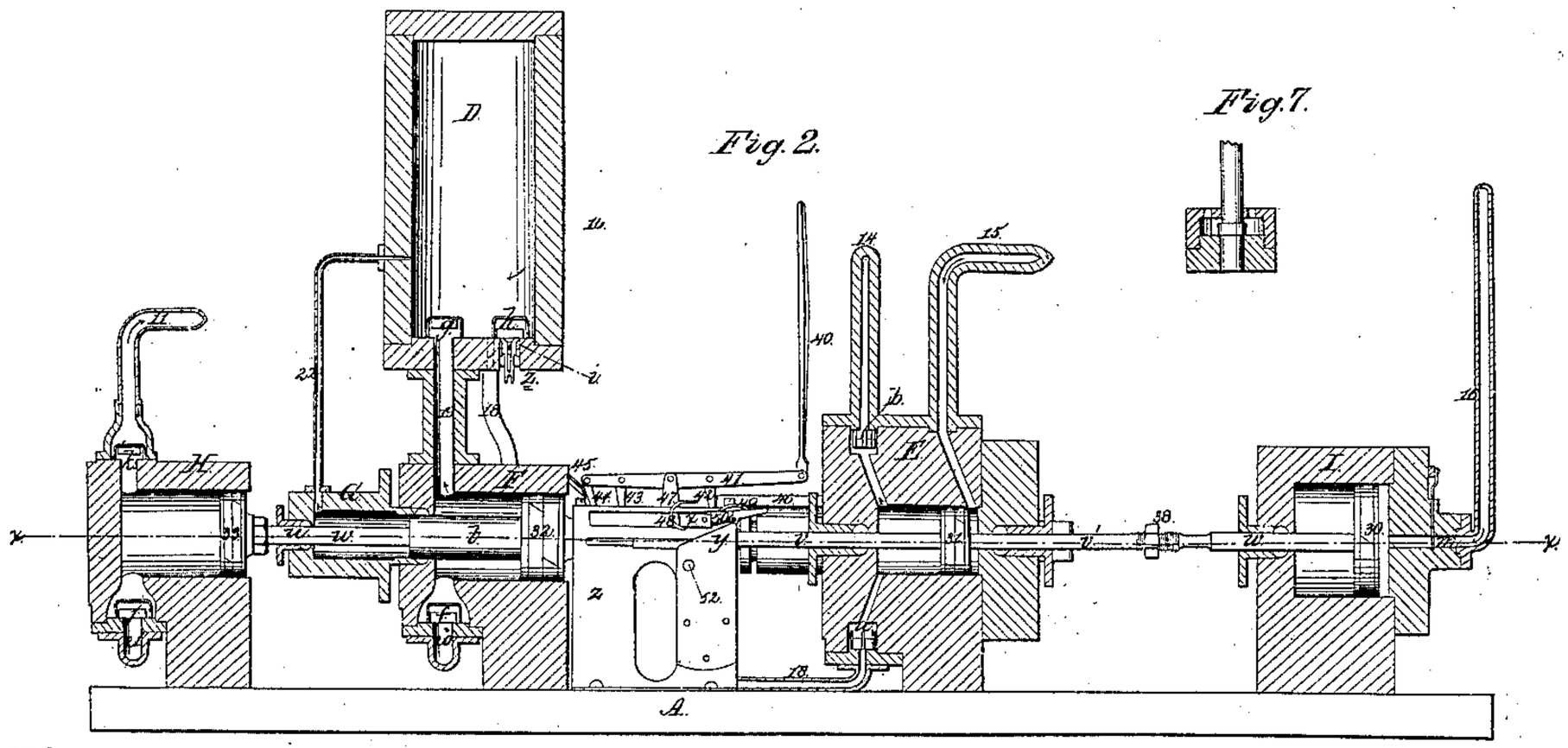


Fig. 7.

Witnesses
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Thos P Howe

Inventor.
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UNITED STATES PATENT OFFICE.

PETER SHEARER, OF READING, PENNSYLVANIA.

IMPROVED APPARATUS FOR GENERATING POWER.

Specification forming part of Letters Patent No. **31,631,** dated March 5, 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 certain Improvements in Machines for Generating Power by Means of Heat, the construction and operation of which I have described in the following specification, and illustrated in its accompanying drawings, with sufficient clearness to enable competent and skillful workmen, in the arts to which it pertains, or is most nearly allied, to make and use my invention.

My said invention consists in, first, the combination of a heater or heaters with a piston and surrounding cylinder, said cylinder being connected, as described, upon both sides of the piston to said heater or heaters, and a plunger or power-piston inclosed in another cylinder connected by an appropriate passage with the end of the cylinder previously referred to, in which cold liquid is received, to be pumped through the heater and expanded, substantially as and for the purposes hereinafter more fully set forth; second, the combination, with the heater or heaters, of an air-chamber, said air-chamber being connected by suitable passages with the heater or heaters, and provided with a pump or pumps to pump in the necessary supply of liquid, as described below; third, the combination, as described, of the auxiliary cylinder and piston with the circulating-cylinder and piston above referred to for causing the fluid to circulate through the heater and then return and give out its expansive effect for the purpose of facilitating the starting of the machine, said auxiliary cylinder being provided with valves so arranged as, in connection with the other parts, to effect the purpose stated; fourth, in the combination, in the manner described, of a thermometric regulator with the dampers in the flues and smoke-stack, when the parts are so arranged that the inordinate accumulation of heat at the heaters shall close the passage in passing through which the heat is made available, and open a valve in the smoke-stack or chimney or flue by which the heat is made to ascend without imparting its effect upon the heaters, or doing so only partially, substantially as set forth.

In the drawings, Figure 1 is an isometrical view of the machine entire. Fig. 2 is a longitudinal sectional elevation of the principal parts. Fig. 3 is a horizontal section showing the parts below the line *x x* as drawn across Figs. 2 and 4. Fig. 4 is a longitudinal vertical section showing the construction of the boiler, heater, chimney, and some other parts. Fig. 5 is a longitudinal section of the thermometric regulator. Fig. 6 is a vertical transverse section of the cylinder of the thermometric regulator and a portion of the boiler, showing the parts at the left hand of the line *y y* as drawn across Fig. 5 and illustrating the connection between this cylinder and the boiler. Fig. 7 is a sectional elevation of the valves, marked C C′ in other views, the object of this figure being to represent these parts on a larger scale.

A is a bed-plate representing the seat of certain portions of the machine.

B is a boiler used for heating liquid, resting on its feet U.

Numbers 35 represent flues in the boiler.

The boiler communicates with cylinders D through pipe 10, H through pipe 11, C through pipe 12, and I through pipes 17 and 13 and 16. It is entirely filled with liquid without leaving any space for air or steam.

M is the chimney, and P the grate, an ash-pit being underneath.

Q is a sheet-iron casing which leads from the boiler to cylinder C, inclosing the latter and conducting the products of combustion from the boiler-flues into the chimney M, above the damper *r*.

q and *r* are dampers connected together and opened and closed by lever 36, which is supported on a post, 67, fastened to the side of the boiler. When *q* is opened and *r* closed, the heat passes through the boiler and casing Q. When *q* is closed and *r* opened, the heat passes up the chimney, suspending the process of heating in the boiler.

C is a hollow cylinder, made of steel or other strong metal, capable of sustaining a pressure of many tons to the square inch. It is used for heating and expanding cold liquid pumped through it from cylinder E, with which it is connected by means of pipes 14 and 15, possessing equal strength with cylinder C. From this source the principal power of the machine is derived.

T is a net-work made of copper wires, resembling a series of sieves facing each other, through the interstices of which hot liquid and

cold liquid are alternately pumped. When the valves *c c'* are opened by the lever 37, which has S for its fulcrum, hot liquid passes from cylinder I, through pipe 16, valve *d*, wires T, and pipe 12, into the boiler B, rapidly heating the wires in cylinder C. When the valves *c c'* are closed by lever 37, valve *d* closes by a spring and outward pressure and the cold liquid enters through pipe 14 and passes out through pipe 15, being heated and expanded in its passage through the wires T.

E is a hollow cylinder made of the same material and strength as C. Into this cylinder cold liquid is pumped preparatory to heating and expansion. As piston 31 travels to the right, the cold liquid enters from cylinder D through pipe 18 at valve *a*. On the return of the piston valve *a* closes by gravity and reacting pressure, *b* opens by upward pressure, and the cold liquid passes in the direction of the arrows, through the heater C, as before explained, again entering cylinder E, through pipe 15, on the opposite side of the piston. During this operation the cold liquid heats through contact with the hot wires T and exerts its expansive power. All the external avenues to the two cylinders E and C being closed during this operation by valves *a*, *c*, *c'*, and *d*, the expanding liquid enters port 34 and pushes out the plunger *s*, which offers the only yielding resistance to the expanding force. The plunger *s* is therefore urged onward with a pressure of many tons to the square inch and transmits its power to pistons 32 and 33, driving them into their respective cylinders.

The diameter and length of stroke of plunger *s* are governed by the amount of expansion in the cylinders E and C. This depends upon the quantity and expansibility of the liquid employed and the number of degrees of temperature through which it is heated. If four hundred cubic inches of turpentine be heated from 100° to 400° Fahrenheit, they will expand about fifty cubic inches. This increase of volume will displace fifty cubic inches of the plunger. A plunger having eight square inches cross-section would therefore be moved about six inches. Now if the liquid in the cylinder produces a pressure of fifteen tons to the square inch said plunger will exert a power of one hundred and twenty tons moved six inches, equal to four horse-powers for one stroke per minute, or one hundred and sixty horse-powers for forty strokes per minute.

I is a hollow cylinder used for the purpose of operating piston 31 in part and pumping hot liquid through the heater C. It communicates with the boiler B through pipes 17, 13, and 16, and with the heater C through pipe 16. It is filled with heated liquid from the boiler, and both sides of the piston-head 30 are kept under a constant pressure of, say, one thousand pounds pressure per square inch, as will presently be more fully explained. As piston 30 is propelled to the right, in conjunction with piston 31, by a force, hereinafter explained, applied to the piston-rod *v*, the valve *e* being closed by its weight and the valves *c c'* having been opened by lever 37, the heated liquid is forced from cylinder I through pipe 16, opens valve *d*, heats the copper wires, and passes into the boiler B through pipe 12. As piston 30 returns on closing valves *c*, *c'*, and *d*, the valve *e* opens, giving passage to a new supply of hot liquid from the boiler through pipes 13 and 16 into the cylinder I. Pipe 17 serves only to keep a constant pressure on, on the left-hand side of piston-head. Piston 30 makes a return-stroke the moment the pressure is removed from rod *v*, because the superficies of the right-hand side of the piston-head exposed to pressure is greater than that of the left-hand side by the area of a cross-section of the piston-rod *w*, which enters the piston-head through a stuffing-box. The rods *v v'*, which play through stuffing-boxes in cylinder E, being of equal diameter the pressure on the two sides of piston 31 always remains equal. The adjustable nut 38 is employed to ease the concussion of the stroke by striking against the spring 39.

D is a hollow metallic cylinder, into which air is pumped by hand with the air-pump Z until it attains any desired pressure—say one thousand pounds to the square inch—the air occupying the space above pipe 10 and cold liquid below it. Said air-pump works in the head of the cylinder with a movable packing, a hole being bored through the center of the pump to admit air. As the pump descends, the air rushes up through said bore, opening the small conical valve *i* and filling the space below the valve *h*. As the pump ascends, valve *i* closes and the valve *h* is forced open, both by the compressed air and the body of the pump, when the air rises through the cold liquid and the valve *h* closes. The air is pumped into the cylinder D to its desired pressure before the liquid in the boiler is heated, and after the boiler and cylinders are all filled with liquid, D itself being filled with liquid up to pipe 10. This cylinder communicates with F through pipe 19, G through pipe 22, E through pipe 18, and with the boiler B through pipe 10, throwing said pressure of one thousand pounds upon all parts directly or indirectly connected with it. The object of keeping the boiler and the other parts of the machinery under this constant pressure is to retain the hot liquid permanently in a liquid state—in other words, to prevent it passing into steam or vapor. Therefore the pressure of the air in the cylinder D must be sufficiently great to prevent the heat applied to the boiler from generating steam, and must be determined by the boiling-point of the liquid employed and the intensity of the heat in the boiler.

F is a strong hollow metallic cylinder containing a piston, 32, propelled by the plunger *s* and used for drawing cold liquid from the cistern L through pipe 20 and pumping it into cylinder D. As the piston passes to the right, a vacuum is formed behind it, valve *g*

closes, *f* opens, and the liquid is forced up into cylinder F by atmospheric pressure. As it travels to the left *f* closes, *g* opens, and the liquid is forced up into cylinder D. The capacity of cylinder F to pump liquid must slightly exceed that of cylinder E, which it supplies through pipe 18. Pipe 10 discharges the surplus liquid into the boiler.

H is a strong hollow metallic cylinder used for drawing liquid just condensed and still hot from the cistern K through pipe 21 and pumping it into the boiler B through pipe 11. Piston 33 is connected by means of the rod *u*, Fig. 3, which runs through a steam-tight packing-box, with the plunger *t*, which is attached to piston 32, and is moved in conjunction with it by the plunger *s*. Valves *j* and *k* operate similarly to valves *f* and *g*. The solid contents of the bore of this cylinder must be determined by the power which the plunger is capable of exerting. If *s* moves with a power of one hundred and twenty tons, it will give an area of two hundred and forty square inches to pistons 32 and 33 and plunger *t* combined against a pressure of half a ton in cylinder D.

G is a hollow metallic cylinder having the form of a gland, for convenience' sake, on the side entering F to tighten the packing in the stuffing-box between the two cylinders. It communicates with D through pipe 22. Its object is to force back the plunger *s*, and with it pistons 32 and 33, so soon as *s* has completed its stroke and opened the valves *c c'* to remove the great expanding pressure in cylinders E and C. It also carries back simultaneously with *s* the piston-rod *v*, together with pistons 31 and 30, with which it is connected. The area of the plunger *t*, exposed to pressure in the cylinder G, being greater than the combined areas of the plunger *s* and piston-rod *w*, gives *t* a preponderance over both and causes it to drive them back. In order to elucidate this operation, let us for a moment advert to valves *c c'*. There is a pressure of many tons on the valve *c* when closed. In order to facilitate the opening of this valve, a smaller valve, *c'*, is placed upon it, closing a hole through the center. The face of the smaller valve has an area but little greater than the area of a transverse section of the stem by which it is operated and to which it is joined. The pressure on it is therefore comparatively small. So soon as it is opened the liquid rushes through the hole in the larger valve, *c*, restoring the equilibrium of pressure on both sides and rendering its opening less difficult. The lower valve is attached to the same stem which operates the upper valve a little above it, so that the raising of the stem by lever 37 opens the smaller and larger valves successively. Lever 37 is connected with and operated by lever 41 through the invention of link 40. To lever 41, which rests on fulcrum 47, fastened to frame *z*, are attached three depending catches, 42, 43, and 44, playing on pins in the lever. As the plunger *s* completes its stroke to the left, a projection on cross-head *x*, having an inclined plane on the right hand side and a perpendicular shoulder on the left-hand side, strikes catch 44, thereby raising the lever and opening the small valve *c'*. The great pressure in the cylinders E and C being thus removed, the plunger *t* bears back the plunger *s*. Spring 45 causes catch 44 to resume its former position. The projection on cross-head *x* strikes catch 43, elevating lever 41 still farther, and thereby opening the main valve *c*. As the stroke of the plunger is completed, said projection strikes catch 42, closing valves *c' c* in immediate succession. Spring 46 restores last-named catch to its proper place. The rod *v* is pushed into cylinder E as follows: When the plunger *s* completes its stroke to the left, or a little before, a catch, 50, pinned to cross-head *x*, which is guided in a slot in frame *z*, falls into a notch or shoulder, 51, in rod *v* and carries the rod with it on its return. When the pin 53, projecting from a joint in the center of the catch, strikes the inclined plane *y*, the catch is bent and raised, releases the rod, and resumes its proper position beyond the shoulder 51 through the action of the springs 48 and 49. The rod *v* is supported by and runs on a wheel, 52, between the inclined plane *y* and the frame *z*, and is prevented from turning by a projection guided in a slot in frame *z*.

Let us now follow the operation just described through a full stroke of the plunger and pistons and their return.

Imagine valves *c*, *c'*, *a*, *d*, *f*, and *j* closed; valves *b*, *e*, *g*, and *k* open, and pistons 30 and 31 just starting in the direction of the arrows. The liquid in I will be pumped into the boiler through pipe 17 in the direction of the arrow. Hot liquid rushes from the boiler in the direction of the arrows through 13 and 16 into the cylinder I. The cold liquid in E is pumped through pipe 14, heater C, and pipe 15, as indicated by the arrows. Expanding in its passage through the wires T, it enters port 34 in the direction of the arrow and pushes out the plunger *s*, driving pistons 32 and 33 and plunger *t* into their respective cylinders. Cold liquid in F is pumped up through pipe 19 into cylinder D, and hot liquid in H through pipe 11 into the boiler B. On completing the stroke, projection on cross head *x* strikes catch 44, opening small valve *c'*. Immediately on returning catch 43 opens main valve *c*, affording full passage to liquid. Valves *d*, *a*, *f*, and *j* open; *e*, *b*, *g*, and *k* close. The liquid enters F, G, and H through pipes 20, 22, and 21. The liquid in cylinders E and I is pumped from the right-hand side of pistons 30 and 31 through the heater C in a direction contrary to that of the arrows into the boiler B, again heating the wires T in its passage through them, and, completing the stroke, projection on cross-head *x* strikes catch 42 and closes valves *c'* and *c*, when the operation just described will be repeated.

Valve *m*, in piston I, is used only in starting the machine, it being always open when the machine works. It is opened and closed by the hand with a lever. By closing *m* the pressure on right-hand side of piston 30 is removed, and on opening valve *l* by pressing it inward the pressure on the left-hand side of piston 30 will force it to the right, driving the liquid through pipe 24 into the condenser N. On opening *m*, *l* will close from outward pressure and the pistons be driven in an opposite direction. Thus the pistons 31 and 30 can be brought back and the machine started independently of the catch 50.

The valve *n* on the boiler B is the safety-valve, loaded with weight W, attached to lever 54, which works the valve stem through a stuffing-box. This weight is made to throw said pressure of one thousand pounds on every square inch of the safety-valve, thereby regulating the pressure of the air in cylinder D. The safety-valve opens into a steam-tight cylinder, from which the liquid is conducted through pipe 23 into the condenser N.

A plunger, *o*, enters the boiler B through a stuffing-box, and is pressed down by a weight, V, attached to lever 55. As this lever sinks down it closes the valve *p* in pipe 29 by means of the link and crank 56, and as it rises it opens said valve. The object of this contrivance is to stop the working-engine, to which pipe 29 leads, when the liquid is worked off below a given pressure in the boiler. Let us suppose that the plunger *o* is loaded with a pressure on the square inch somewhat smaller than the pressure on the safety-valve *n*. It is evident that if the working-piston carries off the liquid so fast as to reduce the pressure in the boiler below the pressure resting on the plunger *o* by means of the weight V, the plunger *o* will sink into the boiler and, by closing valve *p*, arrest the flow of liquid through pipe 29 to the working-piston. So soon as the pressure in the boiler exceeds the pressure on the plunger *o* from without it raises it and opens valve *p*, giving free passage to the liquid, the guard 57 preventing the lever from rising beyond its assigned limit. This device effectually prevents the pressure in the boiler B and air-chamber D from being reduced below the point prescribed, and therefore effectually provides against the conversion of the liqnid into vapor or steam.

The working cylinder, which receives its supply from the boiler through pipe 29, is not represented in the drawings. It may be made single or double; is built in every respect like an ordinary steam-cylinder, with similar attachments and appendages, and may be applied to propel the same kinds of machinery. The liquid enters this cylinder from the boiler in a liquid state, and presses against the piston with the aforesaid pressure of one thousand pounds to the square inch. If cut off before the completion of the stroke, it will burst into steam, urging the piston still onward and maintaining a decreasing pressure to the end of the stroke, the force of the steam depending upon the temperature of the liquid at which it enters the cylinder. Thus it will be perceived the full value of the expansive force of steam or vapor will be utilized in addition to the direct force of the liquid on the working-piston. The eduction-pipe from the working-cylinder discharges the steam and the liquid which may not have been converted into steam through a pipe, whereof 25 in the drawings is a continuation, into the condenser N.

N is a hollow chest, closed on all sides, made of copper, in which the steam or vapor is condensed, and from which it passes through pipe 26 into cistern K. The circular holes in N represent copper pipes leading from a trough surrounding the top through the condenser. A constant stream of cold water is kept running through these pipes to effect the condensation of this steam or vapor. The liquid in K is still hot, and as such is pumped back into the boiler, as above described. A portion of the liquid, however, is carried from K through pipe 27 into O, which is also a cooler or condenser made precisely like N and cooled in like manner by water running through a trough and copper pipes. In O the liquid is cooled down to a still lower temperature, and is then conducted into the cistern L to supply the pump F, as aforesaid.

J is a hollow metallic cylinder, Figs. 1, 5, and 6, bolted steam-tight to the boiler B, with which it is placed in communication by means of contiguous slots cut through both cylinder and boiler to enable the hot liquid to enter the cylinder J from the boiler. A hollow metallic cylinder, Y, is inserted in J, flanged steam-tight on its head, Y being surrounded with the hot liquid and permeated by its heat. The object of the cylinder Y is to prevent the liquid in the boiler from being raised beyond a desired temperature by closing damper *q* and opening damper *r*. The hollow part of the cylinder Y contains mercury, into which a plunger, 58, enters through a steam-tight stuffing-box. The plunger is guided on the opposite side in the bracket 63, bolted on the side of the boiler, and is driven to the left as the mercury expands. A fixed collar, 59, is fastened to the plunger near the cylinder Y, which, as it traverses the figures 0 1 2 3 4, &c., on the scale R, indicates the degrees of temperature of the mercury. Said figures represent hundreds of degrees. The spaces between the figures may be subdivided into tens and units. The weight X, attached to the plunger by a cord, serves to bring it back as the temperature of the mercury falls, and also by its pressure prevents it from forming vapor. The proportions of the diameter of the plunger, of the capacity of the bore of the cylinder Y, and of the distances marked on the scale R, are determined by calculation and experiment. The expansibility of the metal of

which Y is composed will enter into the calculation. Copper will be a useful metal for this purpose, because by being a rapid conductor of heat it will enable the mercury to sympathize quickly to the heat of the liquid.

60 is a rod which plays in bracket 63 and on cylinder-head Y. On this rod is fastened an adjustable collar, 61, which can be set by means of a thumb-screw to any desired degree of temperature marked on the scale R.

62 is a fixed collar on rod 60 and guided on rod 58.

64 and 65 is a bent lever moving on a pin inserted into the side of the boiler. 66 connects this lever with lever 36. As the rod 58 travels to the left by reason of the increase of temperature of the mercury the fixed collar 59 strikes the collar 61 at the point to which it is set on the scale, carrying the rod 60 with it and causing collar 62 to strike the lever at point 65, which elevates link 66 and thereby opens damper *r* and closes damper *q*. This arrests the further heating of the liquid by cutting off the heat from the boiler and directs it up the chimney. As the temperature of the mercury in cylinder Y falls, weight X pushes back the plunger 58, releasing collar 61, and damper *r*, closing by preponderance of weight and leverage, raises damper *q*, thereby renewing the process of heating in the boiler. This thermometric governor or regulator of heat is useful as a safeguard against excessive firing.

Having thus fully described my said invention, I claim as the improvements which constitute it—

1. The combination of the cylinder E, piston 31, piston *s*, and the heater or heaters, substantially as described, the parts being so connected and arranged with reference to each other as to accomplish the result stated.

2. The combination of the air-chamber D with the heater B or other suitable device for heating fluid used for the purpose of maintaining proper and elastic pressure upon the fluid, as set forth, the heater and air-chamber being connected, as stated, or in any other appropriate manner.

3. The combination of the auxiliary cylinder I and piston 30 with the cylinder E and piston 31 for the purpose of facilitating the process of starting the machine, said pistons being connected to each other, and the cylinder I being provided with valves and other appendages, substantially as described, and accomplishing the purpose stated.

4. The combination of the thermometric regulator Y, or its equivalent, with dampers *r* and *q*, arranged in connection with the smoke-stack or chimney and the flues, substantially as described, for the purpose stated.

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