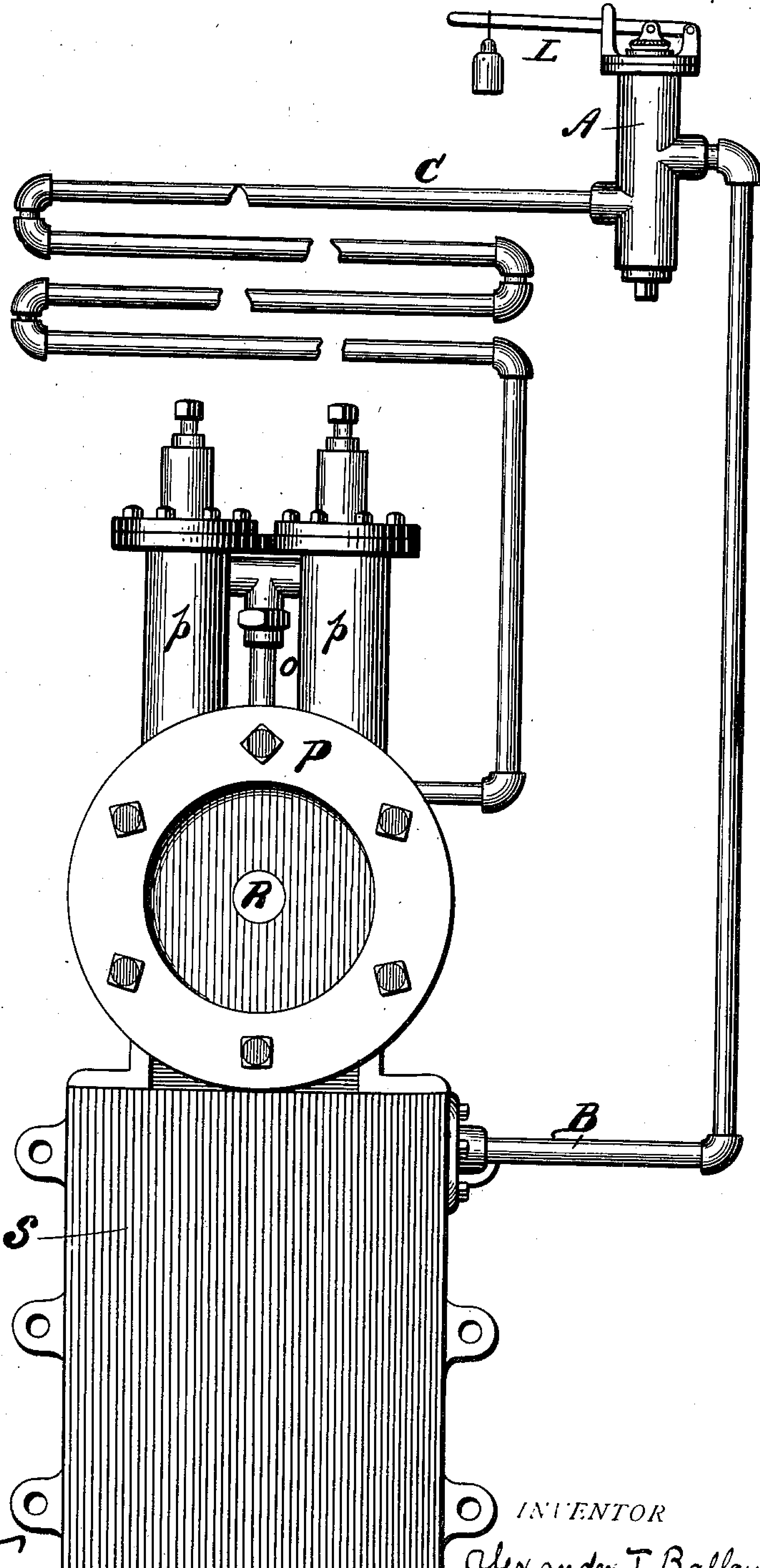
(No Model.)

3 Sheets—Sheet 1.

A. T. BALLANTINE.
ICE MACHINE.

No. 549,426.

Patented Nov. 5, 1895.



WITNESSES
P. E. Thomas
Amelia J. Williams

INVENTOR
Alexander T. Ballantine
by Geo H Lothrop, atty

(No Model.)

3 Sheets—Sheet 2.

A. T. BALLANTINE.
ICE MACHINE.

No. 549,426. Patented Nov. 5, 1895.

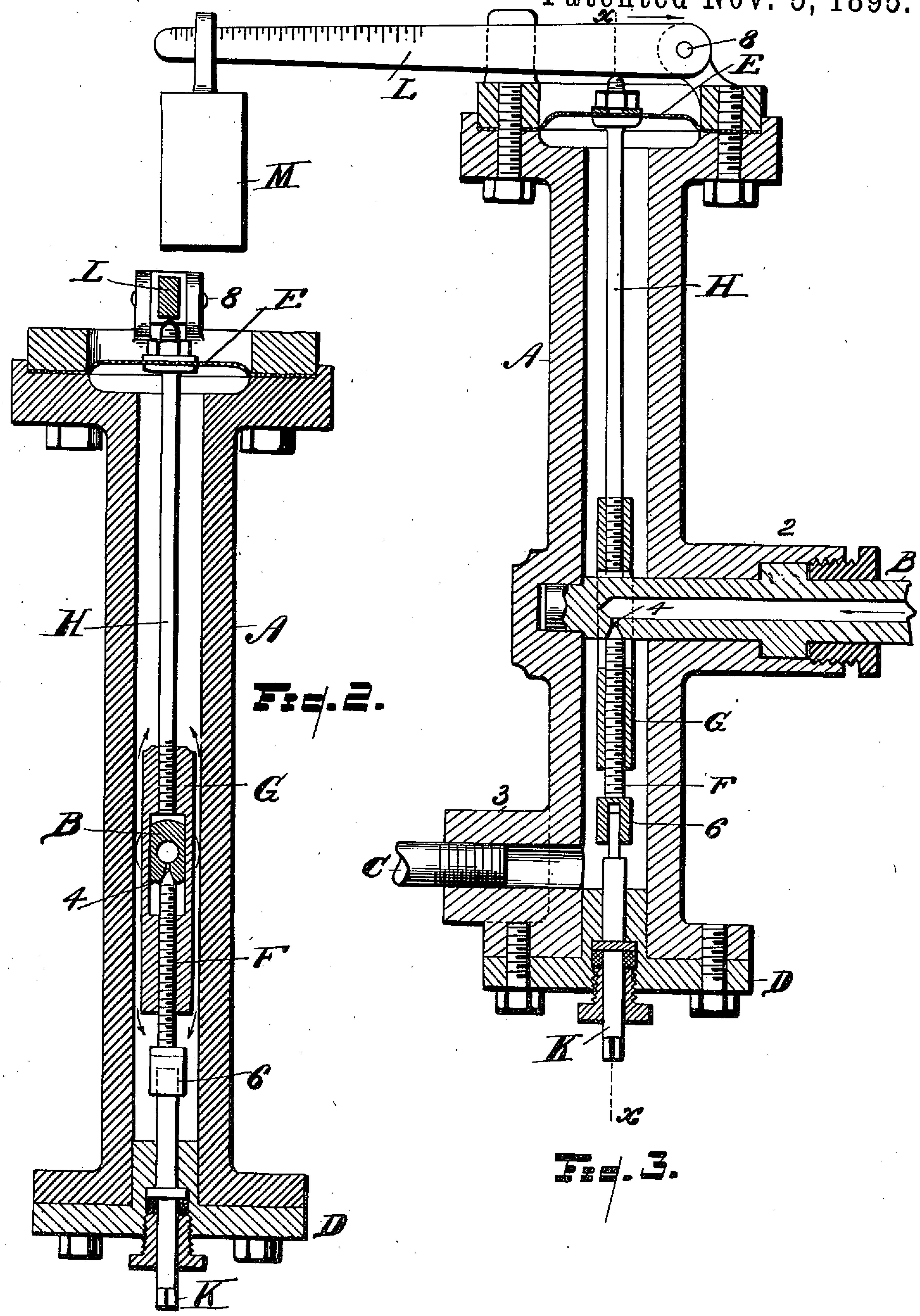


Fig. 2.

Fig. 3.

WITNESSES
H. E. Thomas
Amelia J. Williams

INVENTOR
Alexander T. Ballantine
by Geo H Lothrop, atty

(No Model.)

3 Sheets—Sheet 3.

A. T. BALLANTINE.

ICE MACHINE.

No. 549,426. Patented Nov. 5, 1895.

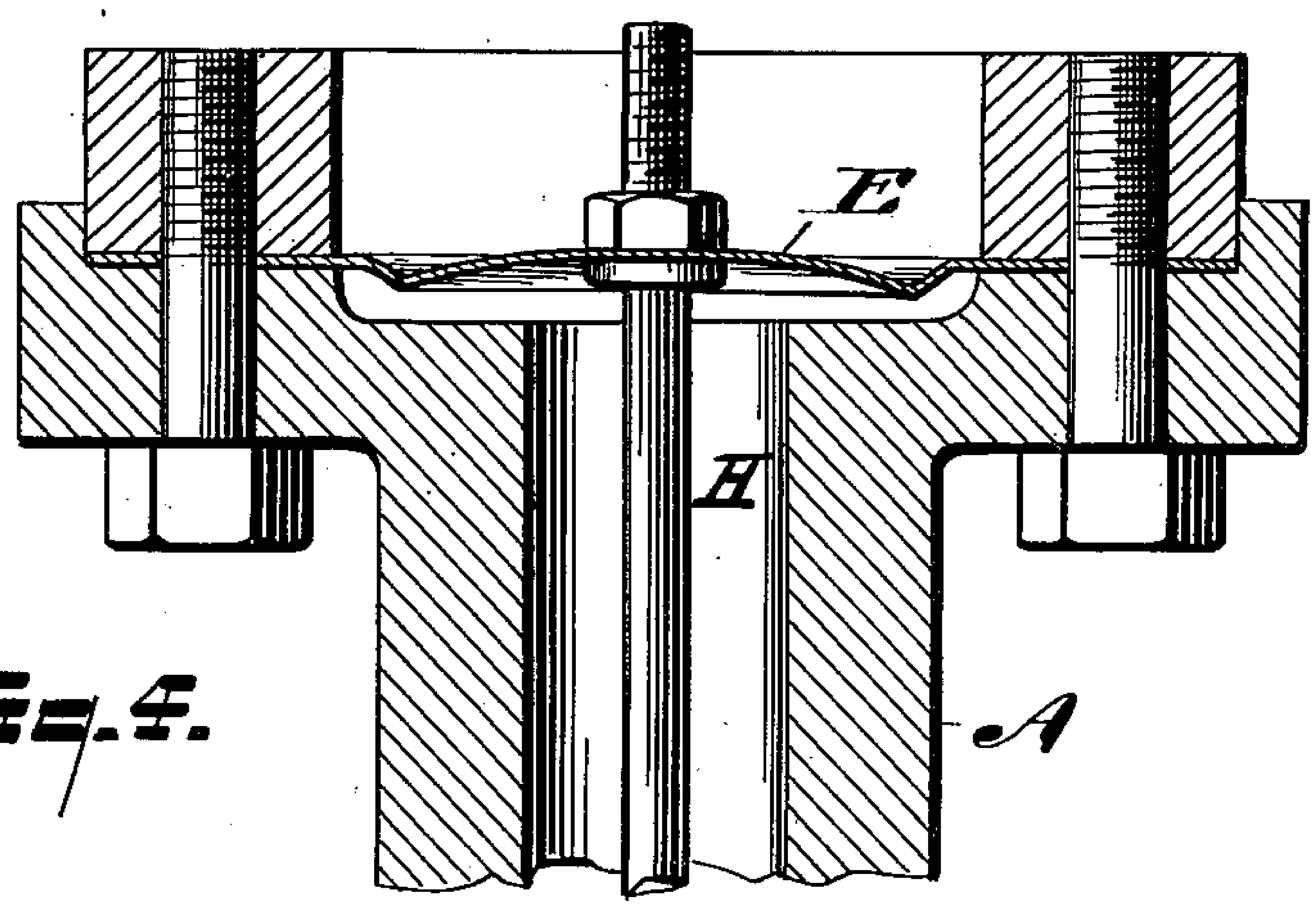


Fig. 4.

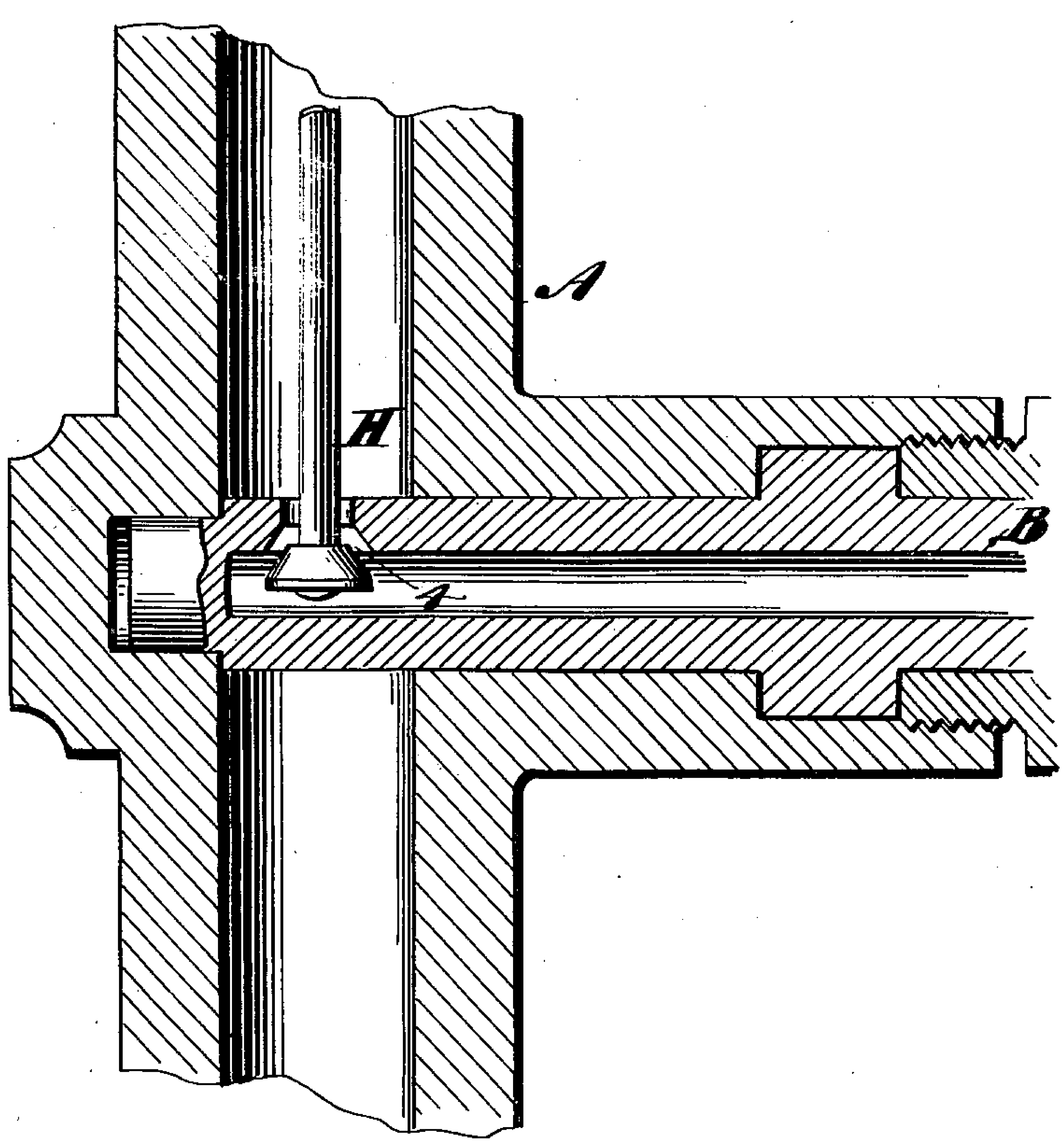


Fig. 5.

WITNESSES

S. C. Thomas

Amelia J. William

INVENTOR

Alexander T. Ballentine

by Geo H. Lothrop, atty.

UNITED STATES PATENT OFFICE.

ALEXANDER T. BALLANTINE, OF CLEVELAND, OHIO, ASSIGNOR TO THE DOMESTIFROID COMPANY, OF SAME PLACE.

ICE-MACHINE.

SPECIFICATION forming part of Letters Patent No. 549,426, dated November 5, 1895.

Application filed December 13, 1894. Serial No. 531,659. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER T. BALLANTINE, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented a new and useful Improvement in the Mode of Regulating the Expansion of Liquefied Gas in a Refrigerating and Cooling Machine and Mechanism Therefor, of which the following is a specification.

My invention consists in an improvement in cooling-machines, as hereinafter fully described and claimed.

Figure 1 is an elevation of the complete machine except the motor, and Figs. 2, 3, 4, and 5 are vertical central sections through the governing-valve.

In one known type of machine for refrigerating by the expansion of a volatile liquid, such as anhydrous ammonia, the cooling effect is produced by permitting liquid ammonia which is at high pressure to expand in the form of gas into a refrigerating-coil, drawing the expanded gas from the refrigerating-coil, and compressing it by means of a pump, cooling by water, and permitting it again to expand into the refrigerating-coil, as shown and described in my Patent No. 475,358, dated June 7, 1892.

It is evident that the continuance of this operation requires, first, that the pump must be kept in operation, and, second, that the refrigerating (or expansion) coil must at all times contain expanded gas.

My experience with this class of machines leads me to believe that the second requirement cannot be automatically met by either a valve set to admit a steady regulated feed, as in my former patent, or in Patent No. 254,203 or No. 344,310, or by a valve intended to maintain a constant pressure in the expansion-coil, such as pressure-regulating valve or temperature-regulating valves, of which Patents Nos. 135,698, 325,625, 406,775, 436,858, and 458,247 show types, because the small orifice necessarily employed soon clogs up, (probably with some saponaceous substance,) and because of their liability to flood the expansion-coil with ammonia, nor by a positively-driven intermittent feed, as by a valve operated from the moving parts of the pump, because of the irregular action of gas-pumps working against pressure.

I have discovered that by admitting a jet or spurt of ammonia to the expansion-coil when the pressure in said coil is reduced to a predetermined limit and then closing the feed-valve until the pressure is again reduced to said limit a machine of this class can be made which is automatic—viz., which will operate continuously so long as the pump is kept in motion.

P represents a pump, having cylinders *p p*, which is driven by power applied to a rock-shaft R. O represents the discharge-pipe of said pump; S, a box containing a condensing-coil and tank connected with pipe O; B, a pipe connected with said tank, and C a refrigerating or expansion coil connected at one end, through governing mechanism embodying my invention, with pipe B and at the other end with the casing of pump P. All these parts, except the governing mechanism, may be identical in construction and operation with the corresponding parts of my Patent No. 476,358, or may be of any other suitable construction, and do not need detailed description.

A governing mechanism embodying one and what I now believe to be the best form of my invention is represented in section in Figs. 2 and 3 and is as follows, and for the sake of brevity I will hereinafter indicate the compression side of the system simply as "pipe B," and the expansion or refrigerating side of the system simply as "pipe C."

A represents a tube or valve-casing closed at its lower end by a head D, into which tube (through a boss 2) leads the pipe B and out of which (through a boss 3) leads the pipe C, the joints of these connections being made gas-tight. The pipe E is closed at its inner end, and on its under side is formed a small orifice 4, which serves as a feed or supply port and a valve-seat to receive and be closed by a needle-valve F. This needle-valve F is carried in a yoke G, as I have illustrated my invention, (but of course may be guided and carried in any other suitable way,) the yoke G encircling a portion of the pipe B, being an easy way to adjust this mechanism.

H represents a valve-stem which passes through and is connected with a flexible diaphragm E, which closes the upper end of the tube A, and above this diaphragm is pivoted on pin 8 a lever L, resting on the top of the valve-stem H, and provided with an adjustable weight M, by which the pressure of said lever on the valve-stem may be regulated. The weight of the valve may take the place of this lever, but I prefer the lever or a spring.

It will be noticed that diaphragm E is slightly arched, its shape in Fig. 4 being practically identical with that of the spring bottom of an oil-can and in Figs. 2 and 3 being an upwardly-extending flat arch. This not only gives the diaphragm a sufficient play, even under considerable variations of form, so that the valve when it opens may open wide; but this form of diaphragm offers greater resistance to or works more effectively against the pressure of the lever L when it is at its highest working point—that is, when the valve is closed—than at any lower working point; so that when the valve is closed the spring action of the diaphragm will so reinforce the gas-pressure as to hold the valve closed even when the gas-pressure on the under side of the diaphragm, as it becomes reduced or lessened, is insufficient by itself to do so. The result is that when said diaphragm is pressed down it will open the valve which it governs fully and quickly, and when it is pressed up will close the valve and hold it closed until the gas-pressure is sufficiently reduced.

I have shown valve F in Figs. 2 and 3 arranged to close against the pressure in pipe B and have made its area so small in comparison with the area of diaphragm E that the pressure on said valve may be neglected, or, rather, may be treated as a mere additional weight to be raised and sustained by the pressure on diaphragm E and the spring action of said diaphragm. If, however, the action of valve F be reversed—that is, if it be made to close with and open against the pressure in pipe B, as shown in Fig. 5—then the effect of said pressure in forcing said valve to its seat and holding it there will reinforce the gas-pressure on said diaphragm and will in some cases be sufficient (when the area of the valve and valve-stem is large enough) to entirely take the place of a spring diaphragm and permit the use of any form of diaphragm which is sufficiently flexible.

The operation of my invention is as follows: I will first consider the structure of Figs. 2, 3, and 4. Assume that a gas-pressure of fifteen pounds to the square inch on the under side of diaphragm E, in addition to the resiliency of the diaphragm itself, is required to close valve F when once open. Assume that valve F is closed and there is a gas-pressure of fifteen to twenty pounds to the square inch on the under side of diaphragm E. In this case the pressure of the weighted lever L, tending to open said valve, is resisted, first, by the gas-pressure on the under side of diaphragm E, and, second, by the resistance (not merely the resilience) of the arched diaphragm. The effect of arching the diaphragm is to cause it to offer a greater resistance to lever L when in its normal form than when deformed. This may easily be tested by pressing on the arched bottom of an ordinary spring-bottom oil-can, when it will be found that more pressure is required to start the arched bottom inward than to press it farther in when started or to hold it pressed in. Of course both diaphragm E and the spring bottom of an oil-can tend by their resilience to return to their normal form when deformed, but this resilience is present in every position of the diaphragm and may be treated as merely an additional elastic force added to and acting in unison with the gas-pressure on the under side of the diaphragm. Under these conditions the action of the pump P, drawing gas from C, is to reduce the gas-pressure on the under side of diaphragm E. If my apparatus were an ordinary pressure-regulating valve, such as is shown in any of the patents above cited, as soon as the gas-pressure in C becomes reduced just below fifteen pounds to the square inch valve F would open slightly and assume such position as to permit liquid to pass through orifice 4 just fast enough to maintain a constant pressure of fifteen pounds to the square inch in C; but my apparatus does not work in this way. When the gas-pressure in C is reduced just below fifteen pounds, the valve remains closed because of the resistance (not merely the resilience) of the arched form of diaphragm. Assume that this "arch" or resilient resistance, of whatever kind it be, is equal in its effect upon lever L to a gas-pressure of three pounds to the square inch on the under side of diaphragm E. Valve F will remain tightly closed until the gas-pressure in C is reduced to twelve pounds to the square inch, when lever L will overcome the resistance of the gas-pressure in C on diaphragm E, plus the arch or other resistance of the diaphragm, and start the diaphragm inward. This instantly eliminates this particular resistance of the diaphragm, leaving only the gas-pressure in C, plus the normal resilience of the diaphragm, to oppose lever L, and the valve F is instantly opened wide. A portion of the liquid in pipe B instantly spurts violently through orifice 4 and raises the pressure in pipe C to fifteen pounds to the square inch, or more, and this pressure, acting on the under side of diaphragm E, forces said diaphragm upward and closes valve F. The valve now stays closed until the pump again reduces the pressure in pipe C as before, when the action above described is repeated.

If the valve F be made to close with the pressure in pipe B and a diaphragm be used which has no arch action and even no resilience, the operation will be as follows: As one end of the valve-stem is subject to the pressure in pipe B, there is always an unbalanced pressure equal to the pressure in B over atmospheric pressure tending to close valve F; but as this is a constantly-acting force it may be neglected just as in the previous description the resilience of the diaphragm was neglected. Assuming the same conditions as before, with valve F closed and a gas-pressure of one hundred pounds in pipe B, it is evident that the tendency of lever L to open the valve is resisted by the gas-pressure in C on diaphragm E, the unbalanced pressure on the lower end of the valve-stem, and by the unbalanced pressure on so much of the under side of valve F as equals the area of orifice 4, minus the area of the valve-stem, (which area I will hereinafter call the "valve area" for brevity,) and this unbalanced pressure is the difference between the pressures in B and C. I will now disregard the second factor in describing the operation.

When the pump has reduced the pressure in C to fifteen pounds, the weighted lever L will be resisted by a pressure of about eighty-five pounds to the square inch on the valve-area in addition to the gas-pressure on diaphragm E and valve F will remain closed. As the pump continues to reduce the pressure in C, these two forces will hold the valve closed until their sum becomes of less effect than a gas-pressure of fifteen pounds to the square inch on diaphragm E, when lever L will force the valve F open. As soon as the valve opens at all the unbalanced pressure on the valve area is reduced and the valve opens wide. A portion of the liquid in pipe B instantly spurts violently through orifice 4 and raises the pressure in pipe C to fifteen pounds to the square inch, or more, and this pressure, acting on the under side of diaphragm E, forces said diaphragm upward and closes valve F. The instant the valve closes the unbalanced pressure on the valve area again comes into play and the above-described operation is repeated.

When the valve of Fig. 5 is used with the diaphragm of Figs. 2, 3, and 4, both the arch action and unbalanced pressure on the valve area can be utilized. I prefer the mechanism shown in Figs. 3 and 4 to that shown in Fig. 5, because with the arched diaphragm I can utilize the downward arch resistance of the diaphragm to the closing of the valve by so arranging the mechanism that the diaphragm when the valve opens springs down beyond the center-line and arches downward, thus affording a resistance to closure of the valve similar to its resistance to opening. The mode of operation is therefore analogous to what would occur if valve F were arranged to be opened and closed by hand and an engineer should watch a gage on pipe C, and, when the pressure therein was reduced to a determined amount, should open the valve, admit a spurt of liquid to pipe C, and then close the valve, wait till the pressure in C was again reduced to the determined amount, and again open and close the valve; but it differs in the important particulars that my apparatus is automatic, is much quicker in its operations than a manually-operated valve would be and is always ready when the appointed time arrives.

While I prefer to use a weight or spring for the force which tends to open the valve because of cheapness of construction and ease of adjusting them to the varying limits of expansion in C, which may be required for different situations where varying degrees of temperature are desirable, it is evident that any other positive force may be substituted for the weighted lever or its equivalent—a spring. In my invention the most important feature is the manner of operation, and the particular forces employed are of secondary importance, though there is room for selection on this point in the line of economy, simplicity, ease of adjustment, and durability, and all mechanisms of like function, which will do the work under the described conditions of use, are included herein as mechanical equivalents.

It will be thus seen that the action of the pump governs the admission of ammonia into the expansion-coil, and that if the pump is irregular in its action and occasionally misses one or more strokes, which is usually the case with gas or air pumps working against pressure, the feed is correspondingly irregular, and valve F will wait until the pump has caught up with its work. This mode of operation gives the additional incidental advantage that only a small part of the expansion of the ammonia occurs at the valve, where it is injurious, and the bulk of the expansion occurs in the refrigerating coil, where it is needed, while with a pressure-regulating valve or a temperature-regulated valve (during the short time which elapses before they clog up) the expansion is mainly at the valve and freezes the clogging deposit as fast as it forms.

In practice I so regulate the valve-opening mechanism that the valve will open when the pressure in the refrigerating-coil C falls to the point which corresponds exactly or approximately to the expansion desired for the work to be done.

It will be noticed that in Fig. 2 the said tube B has its sides flattened to serve the better as a guide for said yoke, and the said yoke is suspended from the diaphgram E by a rod H, which passes through the center of the diaphragm, and is threaded in the yoke so as to be adjustable. Now in order that this valve F may be adjusted by the attendant or operator, so as to set it at any desired point, I may employ a key-rod K, which passes up through the center of the head D and is packed therein to avoid leakage and has its upper end constructed to engage in an open slot in the head 6 of the valve F. The lower or outer end of rod K is constructed to be engaged by a wrench or other device to turn it, and so, if the valve F requires setting, the operator can reach it through this rod K and turn it freely as if he could reach the rod itself directly by a suitable turning-instrument. This loose construction of the valve-head 6 enables the valve to have the necessary up-and-down movement responsive to the diaphragm E without in any manner disengaging it from the key-rod K, and hence without changing the position of said valve.

I have shown a construction of diaphragm and type of valve which I like very much, but wish to have it understood that my invention is not confined to these forms, as I believe that I am the first man to substitute an automatic intermittent irregular jet or spurt feed for a regular feed in a machine of this class and therefore the first to produce an automatic machine which will operate without attention so long as the pump runs.

I find that while the valve closing with the pressure in *b*, Fig. 5, can be used with any form of diaphragm which is sufficiently flexible it works very nicely with the arched resilient diaphragm shown in the other figures.

It is evident that when the principle of my machine is stated to good mechanics various mechanical structures can be made differing in form and appearance from those which I have chosen to illustrate my invention, but adapted to do the same work on the same principle.

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

1. In a refrigerating or cooling machine, the combination of a pump, a compression coil, an expansion coil, an intermittently operating feed valve intermediate between the two coils, a movable diaphragm or abutment subject to gas pressure on the opening of the valve, for reclosing it, a suitable mechanism, (as a spring, weight or equivalent fluid pressure,) acting in the same direction as such gas pressure and acting with greater effect when the valve is closed than when the valve is opened, and a suitable power applying mechanism, (as a weight, spring or equivalent fluid pressure,) normally constant in amount, for opening the valve, substantially as set forth.

2. In a refrigerating or cooling machine, the combination of a pump, a compression coil, an expansion coil, an intermittently operating feed valve intermediate between the two coils, a movable diaphragm or abutment subject to gas pressure, on the opening of the valve, for re-closing it, a suitable power-applying mechanism, (as a weight, spring, or equivalent fluid pressure) for opening the valve, and a counteracting mechanism, (as a spring, weight, or equivalent fluid pressure,) suitably arranged and adjusted in amount and direction for partially neutralizing, when the valve is closed, the effect of the opening mechanism, such neutralizing mechanism becoming practically inert or inoperative on the opening of the valve, substantially as set forth.

3. In a refrigerating or cooling machine, the combination of a pump, an expansion coil, an intermittently operating feed valve, intermediate between the two coils, a movable diaphragm or abutment subject to a variable, gas pressure operative in a suitable direction for seating the valve, a suitable pressure-applying mechanism supplementary thereto, and operative in the same direction, but with an increasing effect or force when the valve comes to its seat, and a suitable power-applying mechanism, (as a weight, spring or equivalent fluid pressure,) for opening the valve, substantially as set forth.

4. In combination with the compression chamber and the expansion chamber of an ammonia refrigerating or cooling machine, a valve located between said chambers, having an arched resilient diaphragm, subject to the pressure in the expansion chamber tending to close said valve, and a weight or spring tending to open said valve.

ALEXANDER T. BALLANTINE.

Witnesses:
JAMES T. SARGENT,
HARRISON B. MCGRAW.