(No Model.) 4 Sheets—Sheet 1.

# O. H. CASTLE.

## ICE MACHINE.

No. 338,482. Patented Mar. 23, 1886.

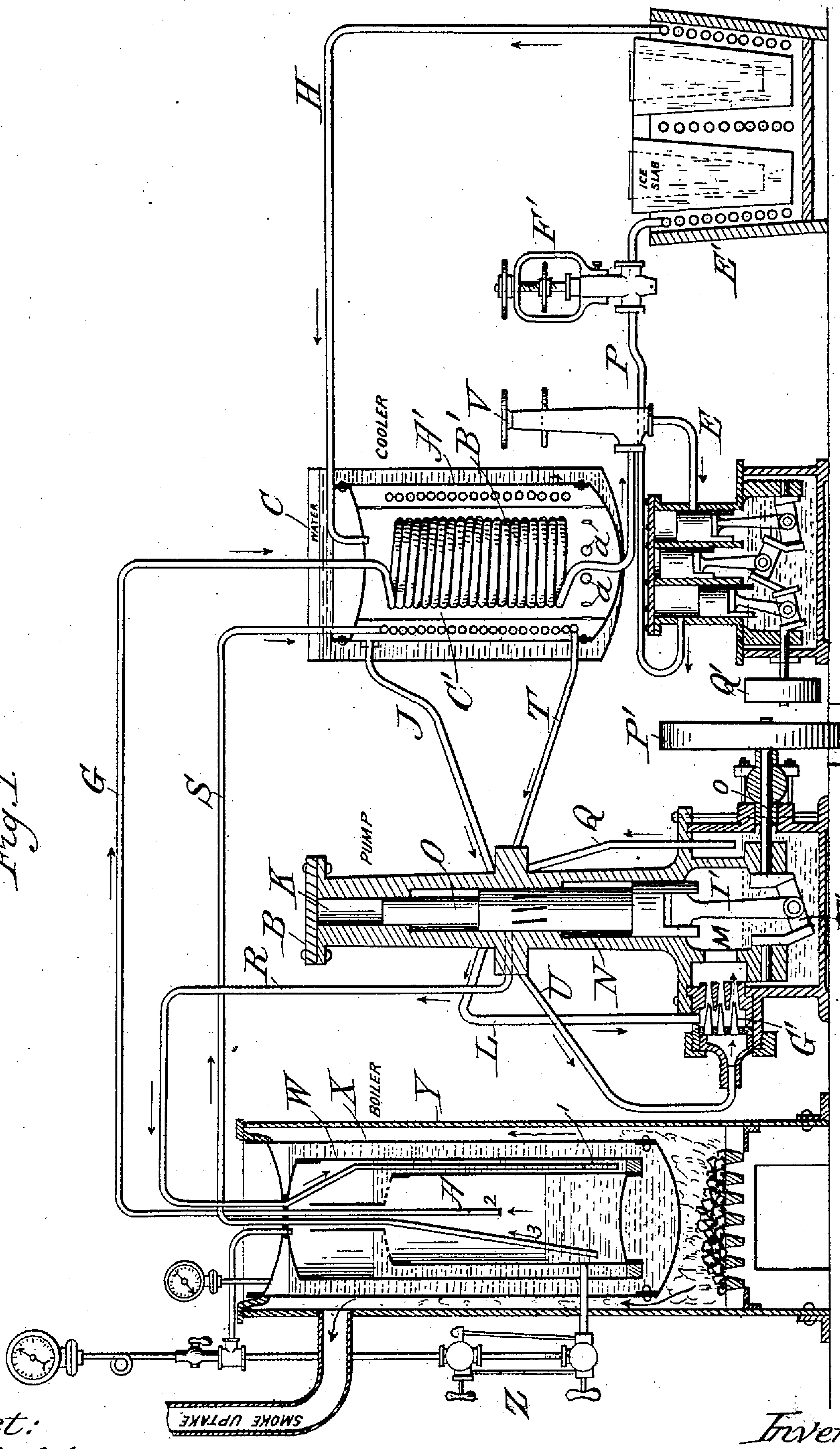


Fig. 1.

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## ICE MACHINE.

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*Fig. 2.*

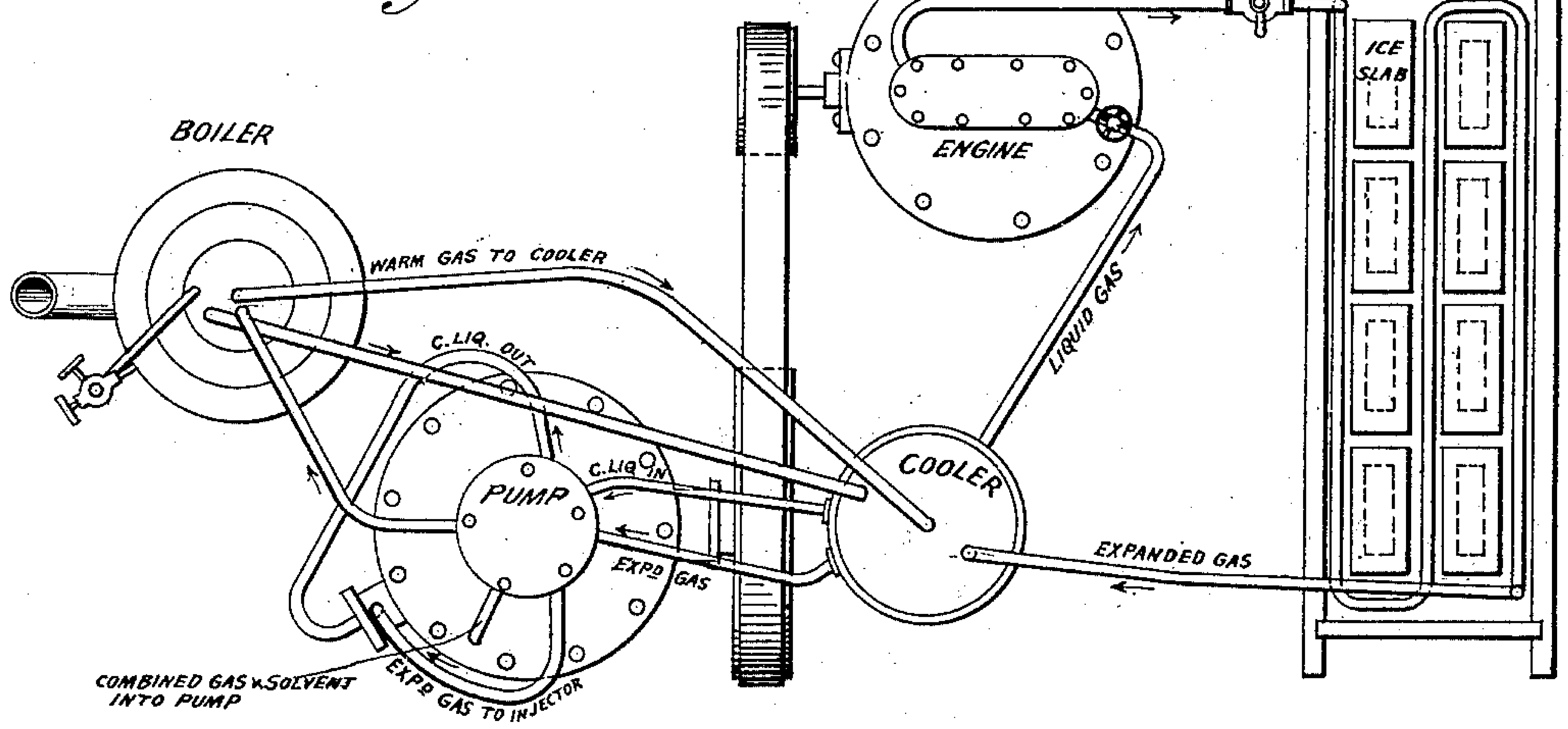



*Fig. 10.*

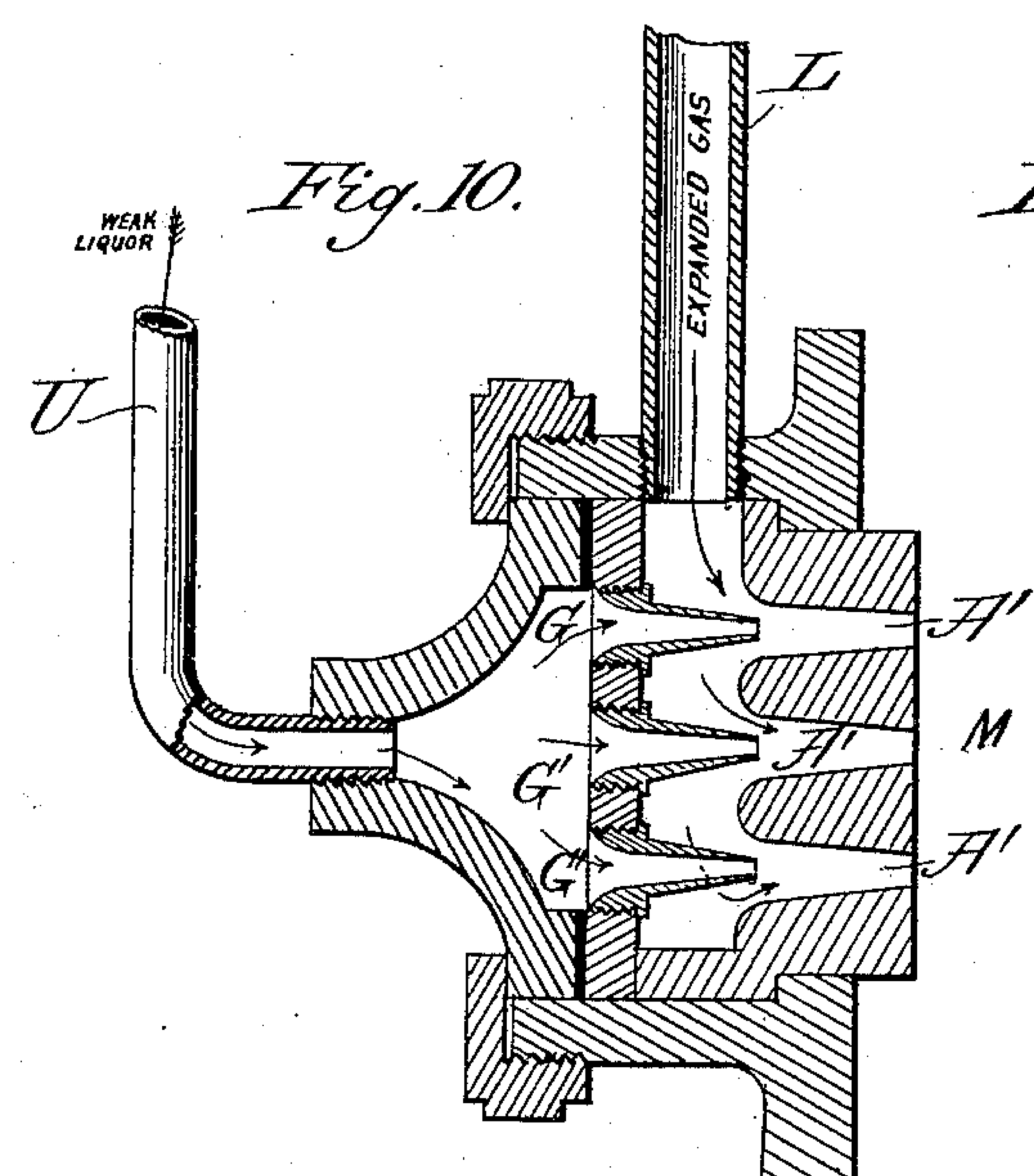
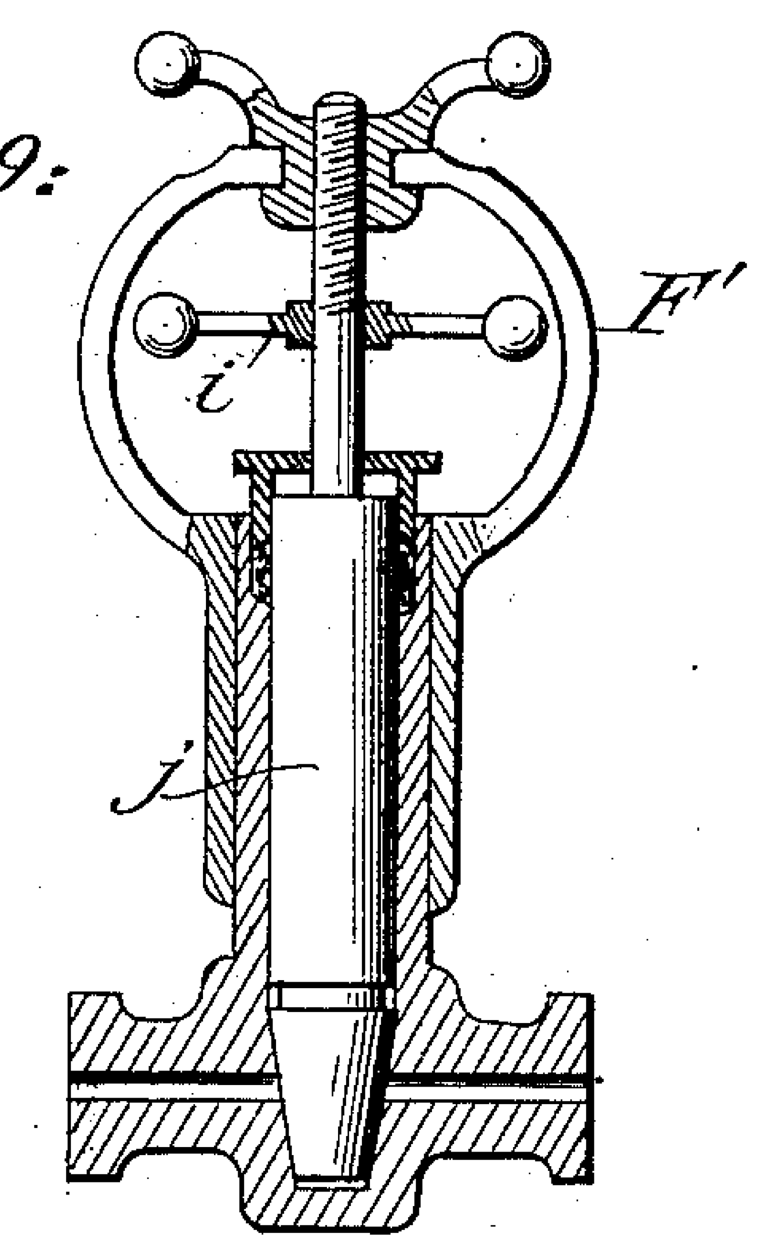



*Fig. 9:*

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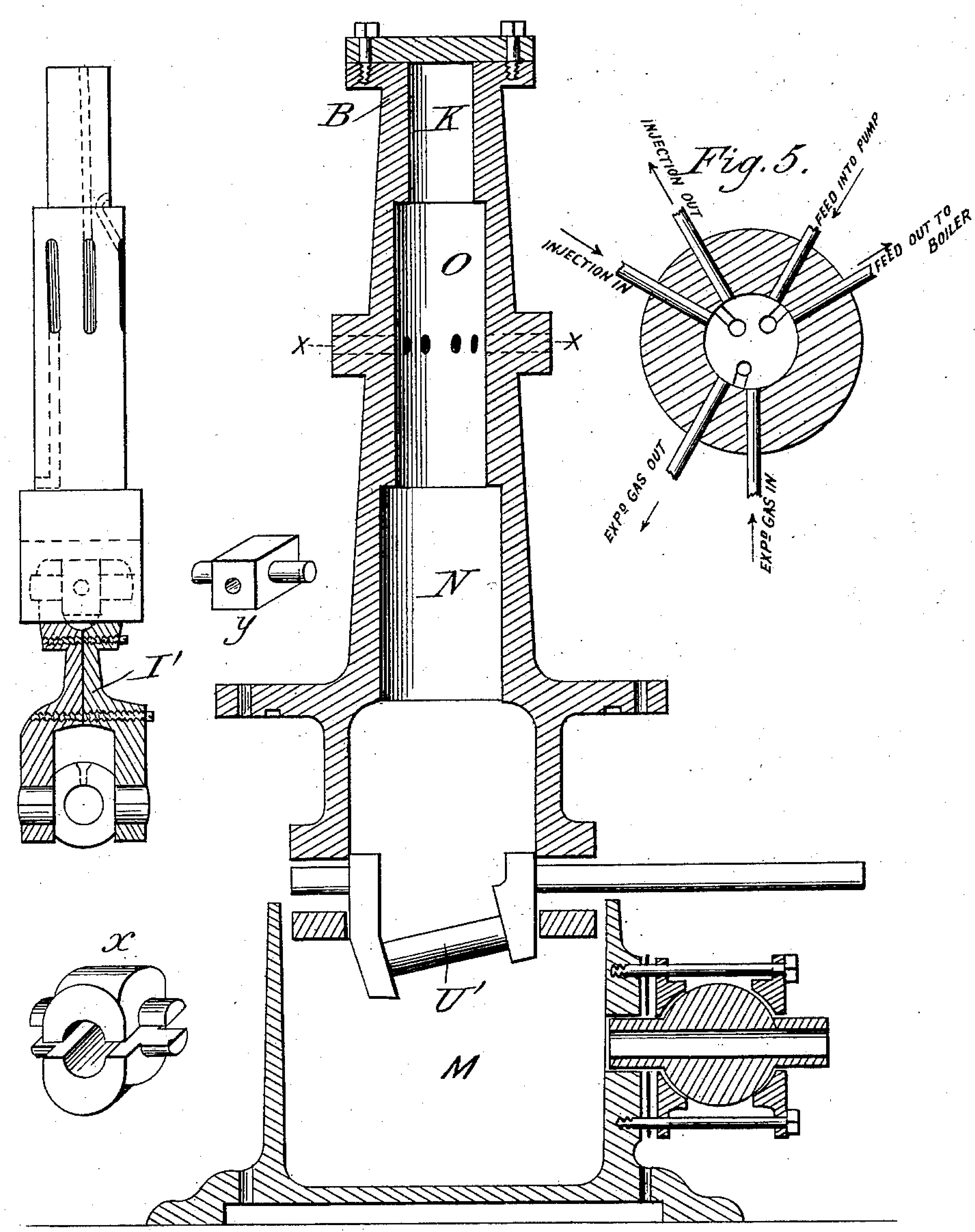
ICE MACHINE.

No. 338,482. Patented Mar. 23, 1886.

Fig. 4. Fig. 3.

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4 Sheets—Sheet 4.

# O. H. CASTLE.

## ICE MACHINE.

No. 338,482.

Patented Mar. 23, 1886.

*Fig. 8.*

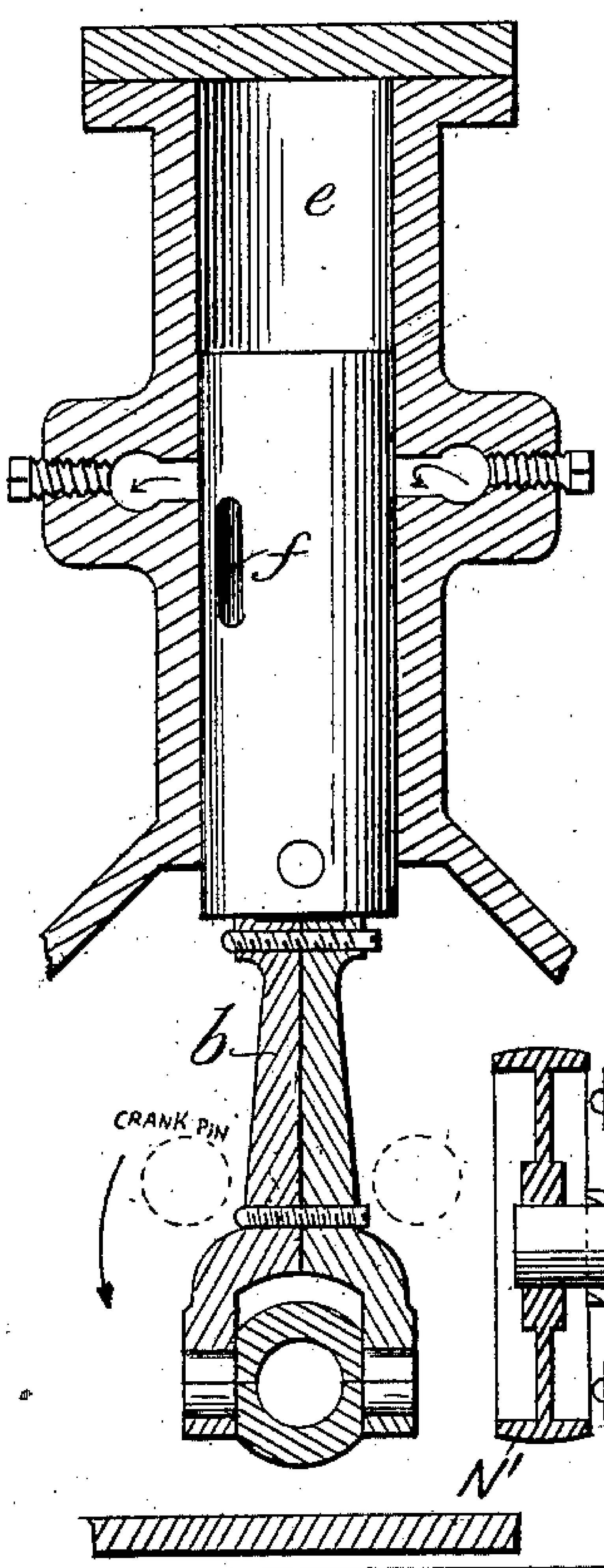



*Fig. 6.*

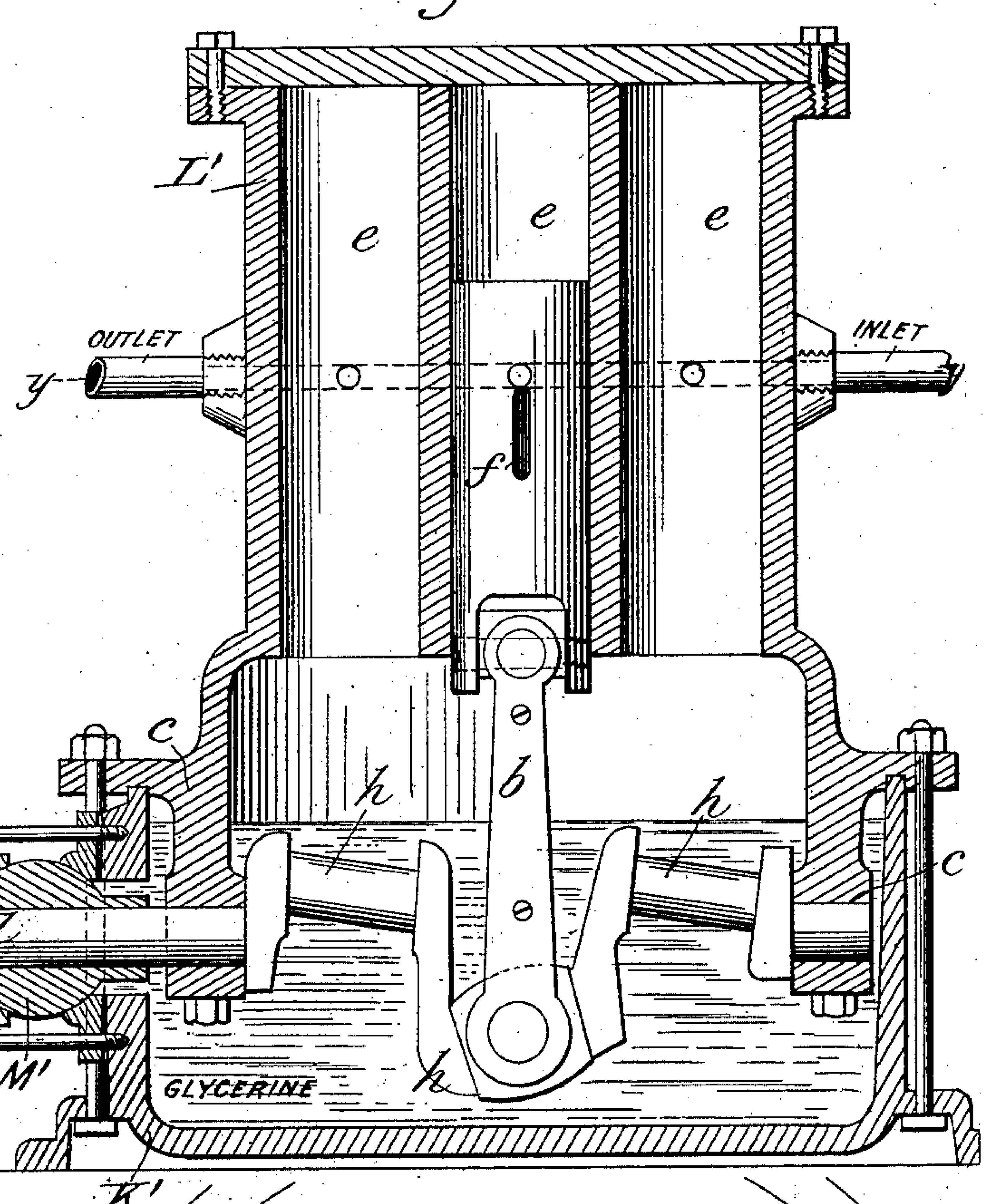
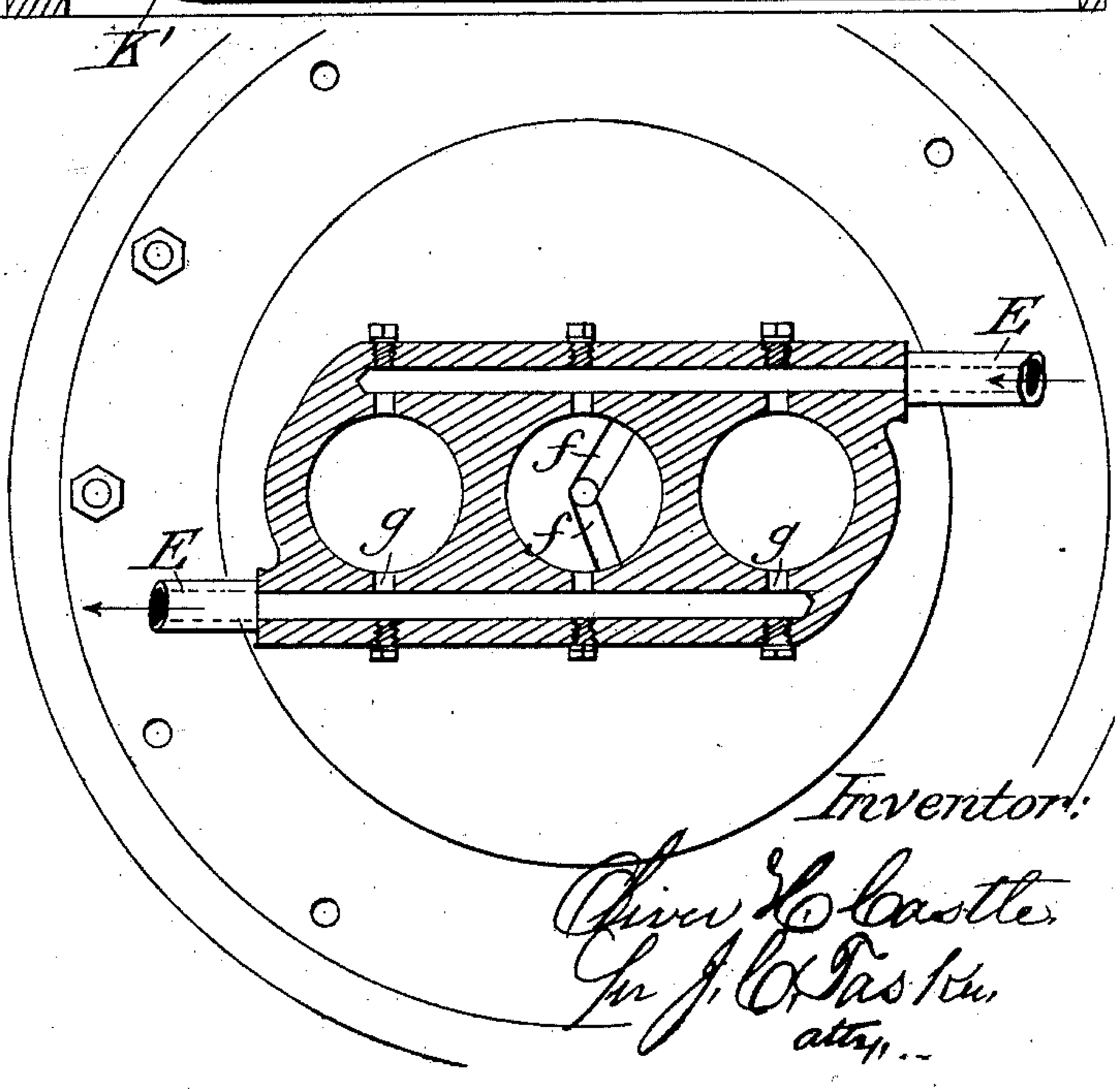



*Fig. 7.*

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# UNITED STATES PATENT OFFICE.

OLIVER H. CASTLE, OF INDIANAPOLIS, INDIANA.

## ICE-MACHINE.

SPECIFICATION forming part of Letters Patent No. 338,482, dated March 23, 1886.

Application filed June 13, 1885. Serial No. 168,572. (No model.)

*To all whom it may concern:*

Be it known that I, OLIVER H. CASTLE, a citizen of the United States, residing at Indianapolis, in the county of Marion and State of Indiana, have invented a certain new and useful Improvements in Ice-Machines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

This invention relates to an improvement in an apparatus for making ice; and it consists of a construction and arrangement of parts, which will hereinafter be specifically set forth and claimed.

It is well known that many and various methods have been employed heretofore in the making of ice. Various freezing agents—such as water, ether, ammonia, benzole, &c.—have been employed, of which, probably, the most successful is ammonia, and among the most successful and prominent refrigerating methods are the two known, respectively, as the "compression" method and the "absorption" method. The former of these uses anhydrous ammonia, the gas of which is compressed into a liquid surrounded by water or other agent to take up the heat set free by the compression. Then the gas is expanded again through suitable coils or chambers, taking up all the heat, and permitting the water in the refrigerating-box to form into ice. After the expanded gas has performed its cooling functions, it is again taken up by the compression-pump and liquefied. The latter, or absorption method, uses aqua-ammonia, and provides a retort or boiler, in which aqua-ammonia, about twenty-six per cent. of purity, is placed. The addition of heat causes the ammonia-gas to leave the water in which it is contained. At the boiling-point of water (212° Fahrenheit) all but two per cent. of the ammonia-gas will be driven from the water, and a pressure of about one hundred and fifty pounds is generated in the boiler or retort. This gas in its present extremely hot condition is led through pipe-coils, which are surrounded by water, the function of the water being to subtract from the gas its heat until the temperature of said gas has been reduced to a sufficiently low degree to allow the pressure behind it to cause it to liquefy. This liquid is cooled to ordinary temperatures—say, 60° Fahrenheit—when it is led to the refrigerating-coils, and the gas expanded in them in precisely the same way as in the compression system—that is to say, if the gas is expanded in the coils fifty times its original volume it becomes fifty times colder than before, or the temperature is $\frac{1}{50}$ of 60°, which is less than 2° above the zero-point, or 30° below freezing. This is the principle of the cooling. In the absorption system the expanded gas is led into a chamber which contains the weak aqua-ammonia that came hot from the boiler and passed through suitable coils surrounded by water. The weak liquor is cooled to ordinary temperatures when it is led into this chamber, into which the gas is admitted. The gas will then be readily absorbed by the cooled weak liquor. From this chamber it is pumped back again into the boiler, and this same cycle of operations is repeated continuously; but upon a close observation and comparison of these two leading methods of ice manufacture certain defects are patent, which it is my purpose to remedy by the process to be described in this application.

It is seen in the use of the absorption system that ice is produced at a less cost than by the other method; but at the same time the process is not always reliable or continuous, since the conditions for freezing sometimes reverse themselves, as when in the freezing-coils, which should always be colder than the medium to be frozen, in practice sometimes become heated. The compression system is markedly more expensive in operation; but it has the great advantage, also, of being at all times reliable, inasmuch as its machinery is usually actuated by the power from a steam-engine.

The object of my invention, therefore, is to combine the economy of the one system with the reliability of the other, and this result I attain by means of a mechanism which forms the subject of this application.

Some of the points of novelty shown in the drawings and used in my process are, first, an improved boiler or retort so constructed that its operations may proceed continuously and without requiring constant attendance; second, a cooler for substracting the heat from the hot products of the boiler, as well as from the water to be frozen; third, the application of the pressure generated within the boiler and adjacent machinery as a motive power to drive the pump which forces a combined gas and solvent back into the boiler, and also pumps and raises water for cooling and other purposes; fourth, the use of an improved form of pump with its attachments; and, fifth, in an improved method of increasing the product of an outfit in a given time.

In the annexed drawings, illustrating the machine which I use, Figure 1 is a vertical section of the entire machine. Fig. 2 is a top view showing the various pipe-connections of the different parts. Fig. 3 is a vertical section of the pump. Fig. 4 is an upright view of the pump-plunger. Fig. 5 is a section on line *x x* of Fig. 3. Fig. 6 is a vertical section of the engine. Fig. 7 is a horizontal section of the same on line *y y* of Fig. 6. Fig. 8 is a detail section of one piston. Fig. 9 shows in section the improved valve used with my machine. Fig. 10 is a section of a portion of the pump.

A represents the middle chamber of the several chambers which are comprised in my boiler of improved construction. It contains the vapor-gas. The chamber situated next to chamber A, and forming an annular space around it, may be denominated the "boiler" proper, W, and into it, through the pipe numbered 1, is pumped the enriched aqua-ammonia, which empties near the bottom of the boiler, the extremity of the pipe 1 being situated close to this bottom. Around this chamber is situated the water-space X. The whole arrangement, further, is contained within a wall or casing, Y, provided with furnace-grate bars, ash-space, &c., at the bottom, and suitable flues for the escape of smoke, &c. It will be seen that the boiler proper or chamber, W, is suspended within the outside water-heating space, X, by being attached at its upper end to the said casing X in any convenient manner, as represented in the drawings in Fig. 1, and is kept steady by means of lugs, (not shown,) which are situated at proper places within the annular space, and it is intended that the outside water-boiler, X, should have no outlet for the escape of steam unless it be through a safety-valve to be attached in any approved place and mode, for it is my purpose to supply sufficient heat to the boiler to create from one to five pounds pressure of steam, which pressure may, if desired, be made to operate, through a diaphragm, to open and close a damper in the pipe or uptake. If there is no loss of water or steam, there will be no need of a feed-pump and attachments. Thus the boiler is always ready to operate, and needs no care other than a fire underneath it to keep the water hot and the steam at a low pressure, thereby greatly saving in the amount of fuel needed to perform a given duty.

The enriched aqua-ammonia, which is pumped into the boiler through the pipes designated by R and 1, and which empties near the bottom of said boiler, rises as it begins to absorb heat until it reaches and falls through openings in the top head of the central chamber. This inside head and shell, A, need not be as tight or as heavy as if it were subject to as great an amount of pressure as the outer shell; hence a saving of material may be effected by making it light and less cumbersome in construction and operation. In falling, the gases separate from the poor or weak liquor, which goes to the bottom of central chamber, A, while the gases collect above the liquor in the same chamber. For convenience, a water or gage glass, Z, is attached to show the height of the weak liquor inside the central chamber, A; also, it is customary to provide the water-boiler with a pressure-gage; also, the ammonia-boiler. These gages are shown in Fig. 1.

The gas collected above the weak liquor in chamber A is conveyed thence through the pipe marked 2 and lettered G to the cooler C and into the central coil of pipe B within the cooler. The weak liquor collected within the chamber A is taken thence through a pipe, 3, which, after exit from the boiler, is lettered S, and which also leads to the cooler C, but into an outside coil of pipe. All these pipes 1, 2, and 3, proceeding from the boiler, pass upward through the head thereof; but pipes 2 and 3 pass up through a small tube attached to the top of the central chamber-head, allowing free communication between central and upper gas-spaces.

In all ice-machines with which I am familiar, and which operate upon the absorption plan, the pressure is created with such a high degree of heat that a greater or less amount of steam is driven over with the ammonia-gas. This steam condenses into water, which mingles with the liquid ammonia and is carried forward with it; but the anhydrous quality of the ammonia is lessened in proportion to the amount of water added. Then as the liquid ammonia is expanded into the coils for refrigeration or ice-making purposes the water contained in it is liable to be deposited within such coils, and has heretofore in other machines caused stoppage of cooling operations, so that it was found necessary to pass hot gas through the pipes, in order to blow out this water and free them of the obstruction.

In my improved boiler I propose to use, as above stated, a strong solution of aqua-ammonia, and then to introduce a certain amount of the liquid ammonia into the boiler, which, while the boiler is cold, will float upon the aqua-ammonia by reason of its being of a less specific gravity. This liquid ammonia at ordinary temperatures has a pressure of one hundred pounds per square inch; but if the amount of such liquid is proportioned to the volume of space into which it is placed it follows that any desired constant pressure can be had at ordinary temperatures, and if it be heated to any degree below the boiling-point of water an enormous pressure can be created within the boiler, and such gas under this pressure can be conveyed from the boiler without carrying with it any water-vapor, which clogs the pipes and is so injurious to the ice-making process; but, again, in order that the outer or water boiler may operate its regulating mechanism by means of the steam-pressure within, it is found necessary to heat the water to as high a temperature as 212° Fahrenheit, for a less temperature will not afford the required pressure. But we have already seen that this high temperature interferes with the protection of the pure anhydrous gas which it is desired to secure. To overcome this difficuly I find it most convenient to introduce into the water in the boiler an agent which will reduce the boiling-point without at the same time reducing the amount of pressure obtainable at the boiling-point of water. Alcohol and ether are such agents, and I therefore preferably use the one or the other of them. Another advantage to be gained by this mode of producing pressure is that the pressure upon the inner boiler-case be increased, since the outside shell will sustain a portion of it.

C represents a cooler which serves a threefold purpose—viz., to diminish the temperature of the heated gas which comes from the boiler, to diminish the temperature of the poor liquor, and to partially cool the water which is to be frozen preparatory to its being further cooled and completely solidified in the ice-making cans. This cooler is constructed to form a chamber, A′, having inside an annular diaphragm or ring of sheet metal, C′, and this chamber A′ is itself placed within a metallic or other case which contains the water to be cooled preparatory to its being conducted to the freezing-cans. The heated gas coming from the boiler through pipe G enters the cooler through a hole in the top through which said pipe passes, and it is then carried through the central coil, B′; but before the gas reaches the bottom of the coil it has become liquefied, owing to the pressure behind it. The pipe H, which enters the interior chamber, C′, of the cooler, leads from the coils of pipe which surround the ice-making cans, and conveys through it the highly-expanded gas after it has been used to freeze the water in said cans. This expanded gas, which is very cold, enters, therefore, the chamber C′ and cools the heated gas which is passing through the coil B′. It will then pass outward at the bottom of this chamber through openings *a a* into the surrounding chamber A′, which contains pipes carrying the poor liquor which comes from the boiler through pipe S. The gas will pass upward within this annular chamber and cool the hot weak liquor. It will then find an outlet for itself at the top of this chamber through the pipe J, where it will emerge and pass to the space K of the compressing-pump, by which it is forced through pipe L into injectors, and thence to the receiving-chamber M, which contains the combined gas and solvent, the weak liquor, the cool expanded gas passing through the water contained in the outer annular space around said chamber. The gas which becomes liquefied within the central coil is then conducted to the engine, and as soon as the valve V is opened it flashes into vapor and propels the engine, which in turn drives the pump through a belt-connection. The gas exhausts into the channel or pipe E, whence it is conducted by pipe P to the refrigerating-coils about the ice-cans E′. The water in the cooler C is conveyed thereto and thence to the cams for freezing by suitable pipes. (Not shown.) The gas after leaving the coils about the ice-can mounts upward through pipe H, as above described.

As has already been seen, the application of heat to the liquid within the boiler A caused the same to separate into two substances which compose it—viz., a gas and a weak liquor. We have thus far in our description described the circle of operations through which the gas passes from its exit from the boiler to its arrival within the pump. We next pursue the course taken by the weak liquor, and shall see how it will ultimately be recombined with the gas, and how the solvent will again be carried into the boiler for the repetition of the same cycle of operations. The weak liquor finds an exit from the central chamber, A, through the pipe 3, by which, together with the pipe S, it is conveyed directly into the outer coil of pipes in the cooler or that coil which is contained within the annular chamber A′. Having passed through this coil, it leaves it at the lower end at a temperature of about 50° Fahrenheit, and is carried by pipe T to the pump and to the space O of the pump, where it exerts the same pressure upon the pump as the other portion of the same liquor within the boiler does upon the boiler, and has a tendency to move the piston downward. On the upward stroke of the pump the cold weak liquor is forced out through the pipe U to a point where it reaches and passes through one or more injector-shaped nozzles at G′. Through these it passes into the main and larger injectors, H′, (see Fig. 10,) and into the receiving-chamber M. It will be observed that the weak liquor and the expanded gas coming through different pipes from the pump will meet and commingle in the larger injectors through which they are both driven into the receiving-chamber M. The gas combines with the cold liquor, making it hot and reducing the volumes of both. As the pump-plunger goes upward, the gas and water spaces are diminished and the receiving-chamber is increased, thus compelling the combined gas and solvent to seek the enlarged chamber. In this chamber the crank-shaft J′ and rod I′ move, and their combined movements serve to more effectually commingle the gas and solvent by shaking them well up, splashing and exposing a large amount of liquid surface to take up the gas, for it is a well-known principle that gas will absorb much more readily when well shaken than when not. From this chamber M the liquor, again enriched by its combination with the gas, is led by the pipe Q up into the pump-space N, and under the action of the pump it is driven out through the pipe R and emptied through pipe 1 at the bottom of the chamber W in like manner as it was first introduced, as heretofore explained. These are the courses and operations that the gas and the weak liquor pass through continually, being at first disunited under the action of heat, then the gas changing to a liquid, and back again to a gas, then expanding and finally recombining with the liquor, and presenting the combination once more to the disuniting influence of heat.

It is usual in ice-machines operating on the absorption plan to convey the cold weak liquor to the condensing-chamber by a pipe leading from the boiler so this liquor will be under the boiler-pressure when it enters the condensing-chamber; but it requires constant attention to keep the valve in proper regulation for working. Thus unequal volumes of cold liquor are exposed to varying volumes of the expanded gas. Consequently there is a great fluctuation in the amount of gas that will be absorbed by the absorbent. This is sometimes great, and at other times reduces so much as to entirely cease. My improved machine and method take away all this uncertainty, and afford a means whereby a fixed volume of gas is to be absorbed by a fixed volume of the absorbent which has been properly cooled. In other words, if the liquor does not absorb the gas sufficiently and so effect a combination of the two, it is forced to absorb and combine by pressure. The more pressure the gas is under and the colder the weak liquor the greater will be the volume of gas taken up by the absorbent.

It remains to describe the construction and operation of the engine and the pump which I use in the manufacture of ice.

Figs. 6, 7, and 8 indicate the details of construction of my engine and represent it with a vertical single-acting three-trunk piston. There are but two main castings—the base K′ and the cylinder-casting L′. The cylinder is triple, and constructed to allow the entrance of three pistons. Its casting contains the flange below, to which the base K′ is fastened by means of bolts passing through holes in the flange of the base and projecting upward around the outside of the base and through holes in the flange of the cylinder-casting. The boxes or bearings *c* for the three-throw crank-shaft *d* are preferably cast with the cylinder-casting and have the half boxes or caps bolted on. Into each of the three cylinder-bores *e* are fitted solid trunk-pistons adapted to move freely up and down yet fitting sufficiently close to prevent leakage, and the greater length of the pistons to the throw of the crank permits a lighter piston to be made with a less amount of wear than if the pistons were of shorter stroke. Into these solid pistons are drilled and cut two slots, each meeting a central hole, *g*, which acts as a port for the incoming gas on the one side, and as an exit-port for the outgoing gas near the opposite side. This is readily seen by reference to Fig. 7 and the arrows of direction which are there shown. The gas entering at E passes onward until it meets the ports *g g g*, where it enters into the slots of the several pistons, and emerging through ports *g g g* opposite it will pass out through E and pursue its course in the manner already described. The trunk-piston is oscillated from side to side as the crank-wrist *h* changes angles relatively into a position directly opposite combined with the reciprocating movement of the piston, so that the slots are brought into alternate communication with the passage E on the one side and the passage E on the other side, which causes the gas to enter through one port, press against the upper surface, and push the pistons downward and cause a movement of the crank *d*. This arrangement does not need a fly-wheel, and will start at once as soon as the gas is admitted. Each part of the cylinder and each piston and connecting-rod are constructed on the same plan, so the crank-shaft, with its angular crank-wrists, makes all the movements in their proper times. In Fig. 6 one of the journal-boxes for the shaft *d* is made of some length, and is constructed with a spherical shape externally, the purpose being to provide a long bearing for the crank-shaft. Gum or other packing is used between the flanges and the spherical joint, which are bolted together, so that a tight box is provided.

The combination of the long bearing with a shallow-threaded shaft will permit oil or glycerine to pass back into the cylinder-casing, and leakage under pressure will be prevented.

Figs. 3, 4, and 5 represent my improved pump to be used in ice-making. B designates the external casing. It will readily be seen that the plan of construction of the pump is the same as that of the engine just described, as it combines several pump-spaces and is driven by a single crank-shaft having the crank-wrist set at an angle with its line of bearings, such arrangement being for the purpose of imparting to the plungers the same oscillations and reciprocations that a like mechanism in the engine imparts to the pistons within the cylinder-casing; also, the pump is provided with ports which lead to and from the pump-spaces according as the plunger rises and falls. Fig. 5 is a section through the pump on the line *x x* of Fig. 3, and exhibits the arrangement of the outlet and inlet pipes, showing how they are brought into communication with the central pump-space. Fig. 3 shows the pump having three spaces of different diameters, K, O, and N, and Fig. 4 represents a plunger having different diameters at different parts of its length and adapted to move within the spaces of the pump. The plunger has a rod, I′, attached to it at one end, and at the other to a crank-wrist, by which the proper motions are given to the plunger.

It is unnecessary to repeat here the particular space to and from which each pipe leads, as this has already been indicated in speaking of the courses of the gas and weak liquor through the pipe system.

Fig. 10 represents the injector-condenser used in connection with the pump. The cold weak liquor enters through the pipe U, and is forced by the pump through injector-shaped nozzles into larger nozzles. In so doing it carries with it a large amount of gas, at the same time itself condensing, and the combined product of gas and liquor is brought under the plunger in the space M. Thus the pump reunites the two constituents of the elementary substance with which we started in the boiler, and which have since their exit from the boiler pursued separate courses and performed separate duties.

Fig. 9 represents the improved valve F′, which I use in my machine and which is located on the pipe P between the valve V and the ice-freezing cans, and it is used to regulate the flow of the expanded gas coming from the engine to the cans where it is to perform its cooling function. The valve is operated by a hand-screw, *i*, at the top, which raises or lowers a rod or piston, *j*, fitting tightly within a cylindrical casing, and having its lower end so fashioned as to open or close a pipe passed through the base of the valve-casing.

In practice it has been found that when water is placed in the cans of the refrigerating-box to be frozen that the outer surface is frozen first, and that the freezing process proceeds downwardly toward the middle. After about two-thirds of the water has been frozen, it is found that it requires about twice as long to freeze the remaining one-third as it did originally to freeze the two-thirds or the one-third on each side. This is evidently due to the fact that all the heat subtracted from the water had to pass through the encircling layers of ice. I propose to remedy this by suspending within each can a slab of ice of, say, one-third the thickness of the can. Then when the outer thirds of the water are frozen the inner cake of ice will be frozen fast and solid in the middle. These cakes of ice for this purpose can easily be supplied from another machine.

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

1. In a machine for ice-making, a condensable gas retort or boiler consisting of the chambers A, W, and X, contained the one within the other, the outer one, as X, being adapted to hold water for heating, the next one, as W, being suspended therein and adapted to hold the saturated solution of condensable gas and its solvent, and the central one, A, communicating at the top with the chamber W and adapted to hold the separated gas and weak liquid, and this triple-chambered arrangement being situated within a wall or casing, Y, which has the accompaniments of a furnace for heating the substance within the boiler, all substantially as and for the purpose specified.

2. In a machine for making ice, a condensable gas retort or boiler consisting of three or more chambers contained one within the other, the middle chamber suspended within the outer, and the central chamber mounted within the middle one by attachment to its bottom, and provided at the top with a greater or less number of perforations and with a tubular passage-way communicating with the said middle chamber, substantially as shown and described.

3. In an ice-making machine, a condensable gas retort or boiler consisting of three or more chambers contained one within the other, the whole being combined with a furnace, the central chamber, as A, being provided with a water-gage, Z, for showing the height of the liquor within the same, and the other chambers being each provided with pressure-gages, substantially as shown, and for the purpose specified.

4. In an ice-making machine, a closed chamber or cooler, C, containing two or more coils of pipe, through which gas and weak liquor coming from the boiler may pass and be cooled preparatory to their further use in water-freezing, substantially as shown and described.

5. In an ice-making machine, the cooler C, having an outer annular casing which contains water to be cooled, a second chamber, A′, containing a coil of pipe, and a third chamber formed by a loose shell or annular diaphragm, C, communicating with the next chamber by apertures *a a*, near the bottom, containing a pipe-coil, and filled with the expanded and cool gas by means of a pipe, H, entering at the top, substantially as shown, and for the purpose specified.

6. In an ice-machine, the combination, with a chambered boiler, substantially as described, of an inlet-pipe, R, entering the top head of the boiler and having its extremity situated near the bottom of the chamber W, and outlet-pipes 2 3 G S, extending outward from the inner chamber, W, through the top head of the boiler, whereby the gas and liquor separated by heat may be conveyed away, as specified and shown.

7. In an ice-making machine, the combination of a boiler having three or more chambers, W, X, and A, situated within an inclosing-wall, Y, a cooler, C, having interior chambers, A′ and C′, pipes R, leading into the boiler, and pipes S and G, leading from the boiler to the cooler, substantially as shown and described, and for the purpose specified.

8. In an ice-making machine, a three-cylinder engine having trunk-pistons which fit the bores *e e e* of the cylinder L′, and are actuated by rods *b*, connected with a three-throw crank-shaft, having crank-wrists *h* inclined at

an angle with the line of bearings, said pistons being provided with ports $f$, adapted to be closed and unclosed by the oscillations and reciprocations of the pistons, whereby the exit and inlet pipes E E communicate with these ports and admit the vapor or gas which drives the engine, substantially as shown and described.

9. In a machine for the manufacture of ice, a vapor-engine constructed of two castings, K′ and L′, one of which, L′, contains the cylinder-bores, and the other forming an oil-receptacle into which the crank dips each revolution, said two castings being bolted together by bolts passing through their flanges, substantially as shown and described.

10. In a machine for the manufacture of ice, a crank-shaft having the center line of its crank-wrists set at an angle to the line of bearings, the divergence of the central line of the wrist from the axial line of the bearings being regulated to conform to the amount of oscillation necessary to be given the piston to allow its ports to be opened and closed in the manner and for the purpose specified.

11. In a machine for making ice, an engine adapted to be driven by the vapor-gas of the freezing agent, connected with a cooler, C, by a pipe, E, provided with valve V, for admitting the gas to the engine, substantially as shown and described.

12. In a machine for making ice, the engine driven by vapor-gas, consisting of the combination of the triple-bored cylinder-casting L′, having outlet and inlet passages E E for the gas, the basal casting K′, having a space for the lubricant, crank-bearings $c$ $c$, the three cylinders provided with the ports $f$, the crank-shaft $d$, having crank-wrists $h$, set at an angle to the axial line of shaft-bearings, and the connecting-rods $b$, formed in two parts, substantially as and for the purpose specified.

13. In a machine for making ice, the combination of a chambered boiler, a cooler, C, connected with said boiler by means of pipes G and S, and an engine connected with the cooler by a pipe, E, through which gas is transmitted from the boiler to drive it, substantially as shown and described.

14. In a machine for making ice, a pump, B, having internal pump-spaces, K O N, of different diameters, and a plunger constructed to fit said spaces actuated by rod I′, driven by a crank-shaft having the angularly-set crank-wrist J′, said plunger being provided with inlet and outlet ports to correspond with the passages in the pump-casing itself, substantially as and for the purpose described.

15. In a machine for making ice, the combination, with a pump, as described, of the pipes R, U, and L, leading from the pump, and pipes J, T, and Q, leading to said spaces from other parts of the apparatus, substantially as shown and described.

16. In an ice-making machine, the combination, with a pump, as described, of a lower chamber, M, provided with injector-shaped nozzles communicating with pipe U, and larger injector-shaped nozzles communicating with a pipe, L, whereby the gas and weak liquor coming from pump-spaces through said pipes must be reunited and discharged within this chamber, which is also provided with an exit-pipe, Q, substantially as shown and described.

17. In an ice-making machine, an apartment provided with two sets of injector-shaped nozzles, those of one set being larger than those of the other, whereby gas and liquid entering under pressure must combine within the chamber, substantially as shown and described.

18. In an ice-making machine, a chambered boiler whose water-space is filled with a liquid composed of water and alcohol, whose boiling-point is less than water, so that when the composition is heated to its boiling-point gas only may be carried forward from the supercharged central chamber, thus leaving all vapors of the water behind, substantially as and for the purpose specified.

19. In a machine for making ice, a boiler or retort, W, containing a condensable gas and the solvent therefor, said solvent being charged with such condensable gas to the greatest quantity that may be dissolved or taken up by it, provided with a pipe, 1, for further introducing into such boiler or retort a sufficient amount of such condensed liquefied gas as will result in producing at ordinary temperatures a pressure of several atmospheres, substantially as and for the purpose set forth.

20. In an ice-making machine, a chambered boiler, as described, having a chamber, W, containing a saturated solution of the condensable gas and its solvent, and the further addition in sufficient quantities of the condensed or liquid gas, so that the resulting pressure at ordinary temperatures may be sufficient to cause a pump or engine to operate for a time without the addition of heat as a previous requirement to the movement of such pump or engine, substantially as shown and described.

21. In an ice-making machine, a boiler or retort constructed so that the rich aqua-ammonia shall enter at or near the bottom, coming at once in contact with a warm heating-surface and rising gradually as the enriched aqua-ammonia keeps coming in and heated portions rise until it is discharged through numerous openings in the cover or top of the central chamber and with the interior gas-space therein contained, substantially as and for the purpose specified.

22. In an ice-making machine, a boiler constructed with a condensable gas chamber or retort having an envelope of hot water or other heating medium adapted to be heated directly by a furnace and so arranged that the same supply of water may be used continuously without requiring further additional quantities, substantially as and for the purpose specified.

23. In an ice-making machine, a trunk-piston for use in a pump of peculiar construction, as described, provided with ports and

with a forked connecting-rod, I′, made in two parts and so arranged as to permit its ends to surround the trunnions of a crank-box, *x*, also in halves, and a piston wrist-box having trunnions *y*, so as to regulate the oscillation of the piston, substantially as and for the purpose set forth.

24. In an ice-making machine, the combination of pipe P and valve F′, consisting, essentially, of hand-screw *i* and rod *j*, liquid packed by capillary attraction, the same being for the purpose of controlling the supply of expanded gas in the refrigerating-cans, substantially as described.

25. In an ice-making machine, a box, E′, for the insertion of freezing-cans adapted to be used with small slabs of ice, which are placed in the middle portion of the freezing water of each can, substantially as shown, and for the purpose specified.

26. In an ice-making machine, the combination of a chambered boiler, a furnace, a cooler, a pump, an engine, and a water-freezing box, substantially as described, and for the purpose specified.

27. In an ice-making machine, the combination of the boiler having chambers W X A and outer wall, Y, the pump B, connected with chamber W by a pipe, R, the cooler C, containing two or more pipe-coils connecting with chamber A of the boiler, the engine connecting with the cooler by the pipe E and driven by the gas coming through said pipe E, said engine driving the pump B, the refrigerating-box E, containing ice-cans and connected with the engine by a pipe, P, through which the flow of the gas is controlled by a valve, F′, and pipe H, leading from box E′ to cooler C, substantially as shown and described.

28. In a machine for ice-making, the combination of the pump B, having internal pump-spaces, K, O, and N, plunger, connecting-rod I, crank-shaft *o*, band-wheel P′, and the engine for driving the same, having in its construction two castings, L′ K′, and three pistons fitting into as many cylinder-bores and actuating a crank-shaft, *d*, having band-wheel Q′, which connects a belt with the band-wheel P′, substantially as and for the purpose set forth.

29. In an ice-machine, the combination of a pump and plunger, having spaces O and N adapted and so proportioned that the weak liquor passing from O is exposed to a given cooling-surface produced by the fixed volume of gas from the engine-cylinders, and which volume of gas is in turn absorbed by the fixed cooled weaked liquor registered by the pump-space O and the combined product taken by the pump-space N and returned to the boiler A, substantially as specified.

30. In an ice-machine, the combination of a central chambered boiler and pump-spaces O and N, and gas-space K, adapted and so proportioned that the products received from the boiler by spaces O and K are taken by space N, when combined as an enriched solvent, and returned back to the boiler, so as to maintain it at all times in working condition, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

OLIVER H. CASTLE.

Witnesses:
J. W. KEALING,
BEN F. DAVIS.