No. 612,804. Patented Oct. 18, 1898.

E. W. HOWELL.

APPARATUS FOR PRODUCING ARTIFICIAL REFRIGERATION.

(Application filed July 13, 1897.)

(No Model.) 3 Sheets—Sheet 1.

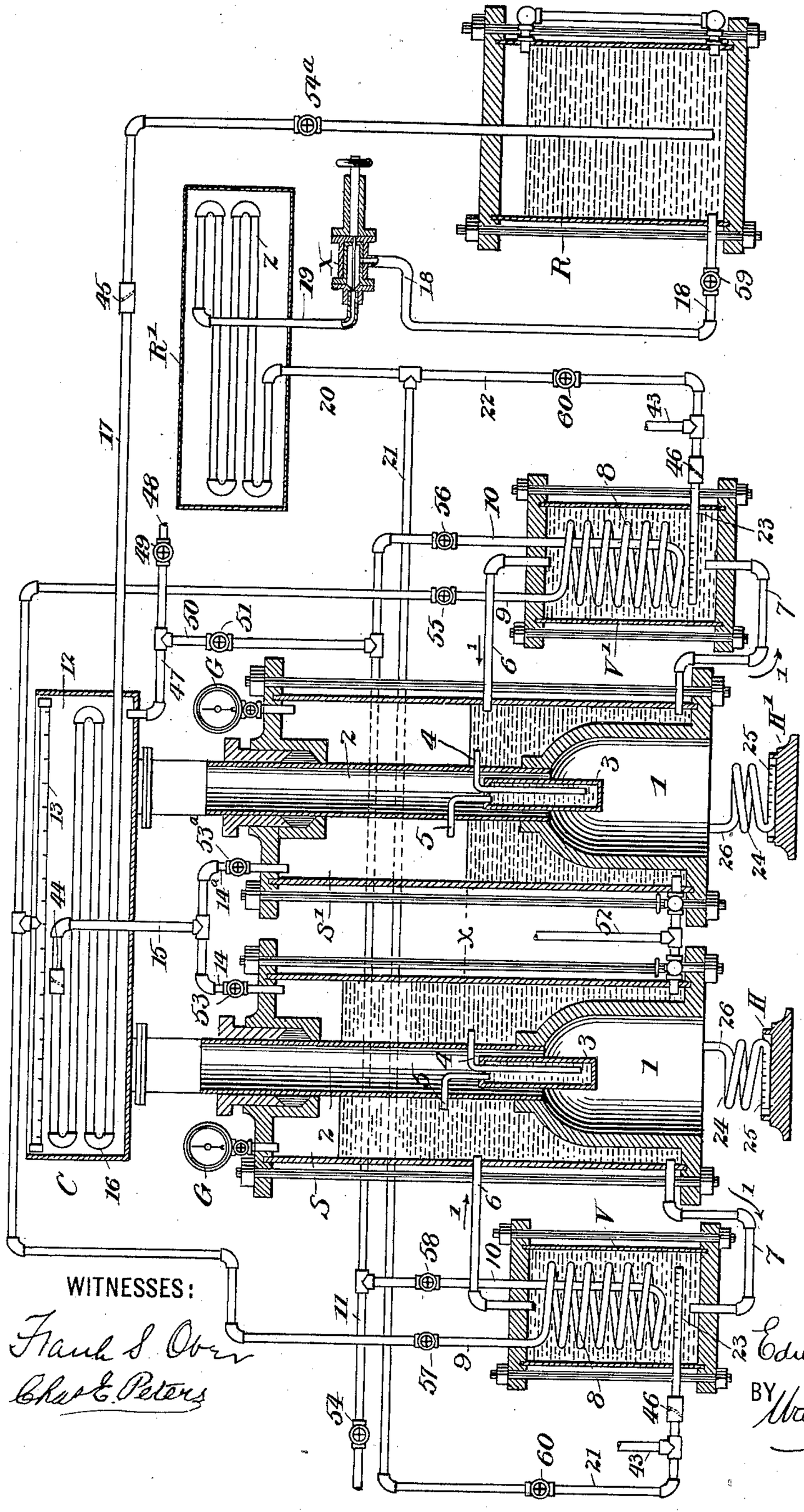

Fig. 1.

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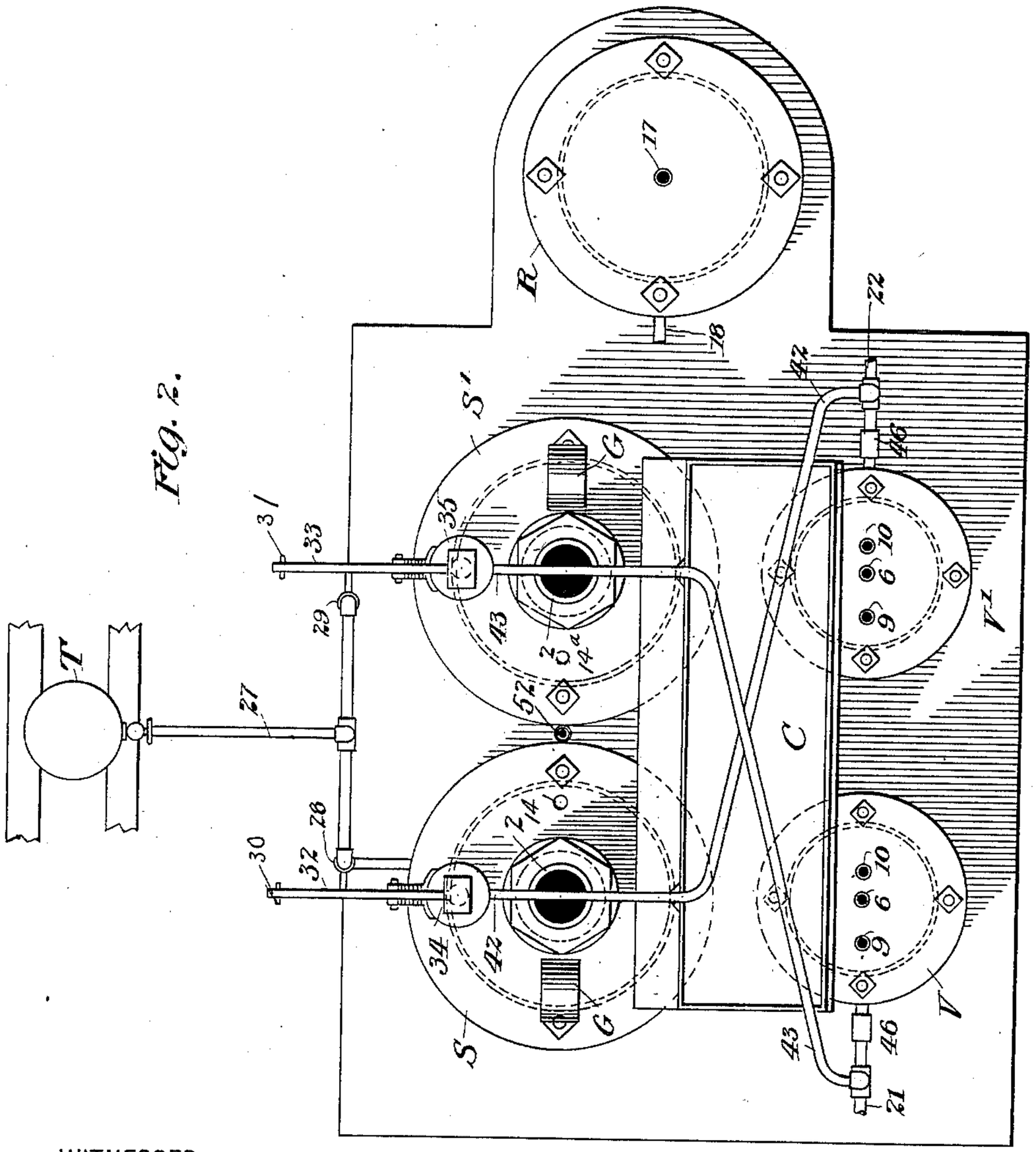
(No Model.) 3 Sheets—Sheet 2.

FIG. 2.



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(No Model.) 3 Sheets—Sheet 3.

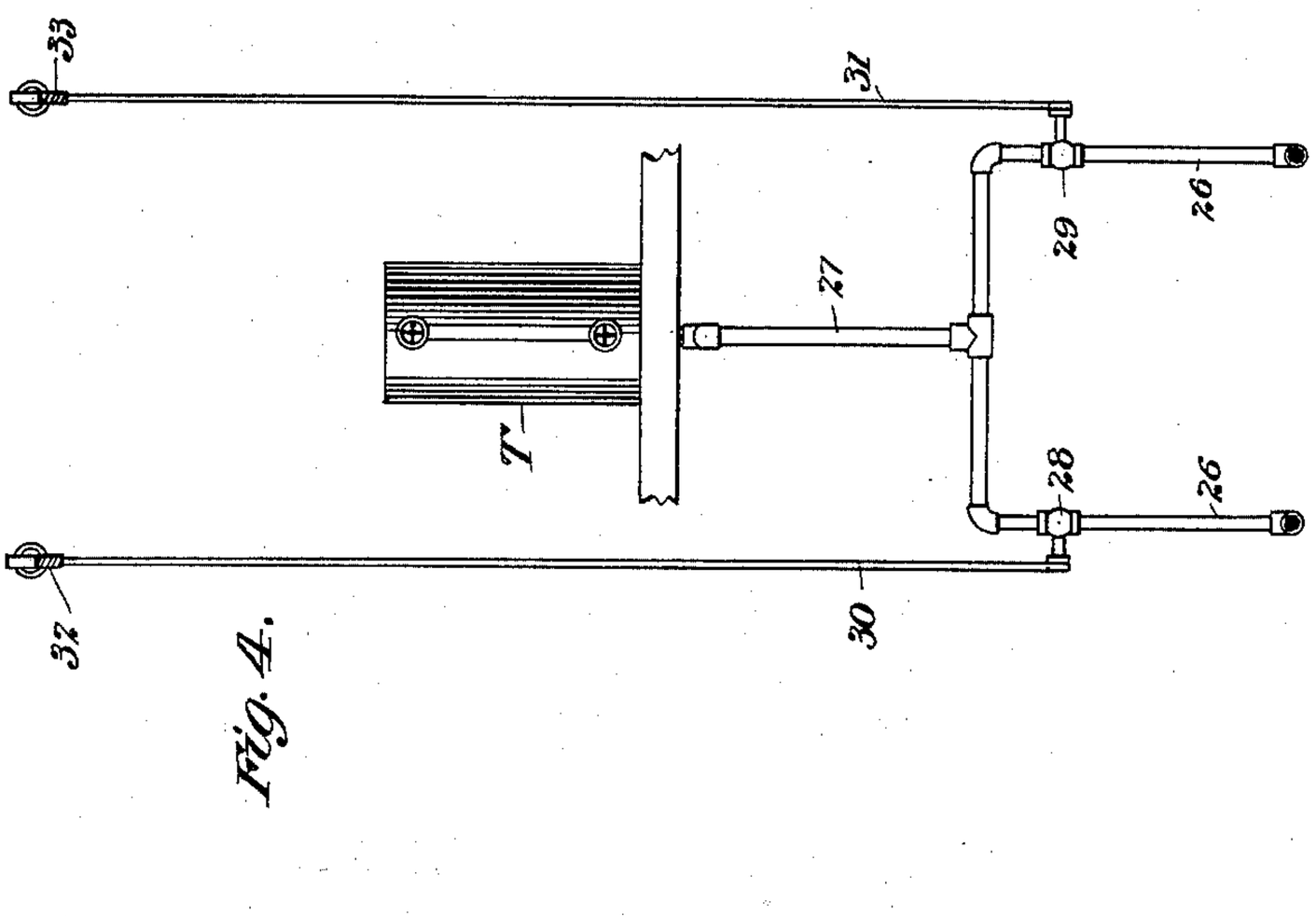

Fig. 4.

Fig. 3.

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EDWARD WELLS HOWELL, OF NEW YORK, N. Y.

APPARATUS FOR PRODUCING ARTIFICIAL REFRIGERATION.

SPECIFICATION forming part of Letters Patent No. 612,804, dated October 18, 1898.

Application filed July 13, 1897. Serial No. 644,424. (No model.)

To all whom it may concern:

Be it known that I, EDWARD WELLS HOWELL, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Automatic Circulation of Artificial Refrigerants; and I do hereby 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.

My invention relates to artificial refrigeration by the expansion of a volatile liquid or gas in proximity to the objects to be cooled or frozen, and it has particular reference to that system of producing cold artificially which consists in generating a gas from an aqueous solution of the refrigerating agent, condensing the gas to obtain an anhydrous liquid, and expanding this liquid to a vapor in the pipes forming part of the refrigerating apparatus, thereby converting sensible heat to latent and reducing the temperature of surrounding objects to the freezing-point. This is a well-known system; but in order that it may be used economically it is necessary that the gas after it has performed its refrigerating work shall be reliquefied and absorbed by the impoverished liquor from which it was derived to enrich the same preparatory to being again distilled and that this operation should be carried on indefinitely without sensible loss of the refrigerating agent.

When ammonia is the refrigerating agent, an aqueous solution is heated in a suitable vessel to distil the gas off, and this vapor is led to a condenser and condensed by cold and pressure to an anhydrous liquid, which is driven into a receiver by the pressure in the still and pipes and retained there under a pressure of about one hundred and twenty pounds to the square inch. This anhydrous liquid is forced by the pressure in the receiver through a valve into the pipes of the refrigerator, where being released from pressure it again expands into a gas and produces the cold. The expanded gas is conducted from the refrigerator to a vessel containing the spent liquor remaining after the distillation for the purpose of reënriching the same preparatory to being again distilled to furnish a fresh supply of anhydrous ammonia. Under proper conditions the spent liquor will redissolve and take up the entire volume of gas distilled out of it. The return of the gas to the spent liquor is effected in various ways. In some instances it is forced back by means of a pump; but the expense of this method makes it objectionable. Another is that known as the "absorption system," by which the expanded gas is conducted to a vessel called the "absorber," containing the spent liquor, into which the gas is discharged and taken up or absorbed by the spent liquor, the natural affinity of the water for ammonia producing an automatic intake of the gas from the pipe by which it is conducted to the vessel. In still another absorption system the return of the expanded gas to the impoverished liquor is effected by the absorptive action of the liquor alone drawing the gas over from the chamber in which the expansion takes place after the liquor cools down by the shutting off of the heat. On account of its economy the absorptive system is preferred over any system using power; but owing to certain peculiarities associated with the action of ammonia under conditions of temperature and pressure in practice the operation of this system is rendered uncertain, so that for general use it has not been regarded as entirely satisfactory.

The causes which interfere with the practical operation of the absorptive system are connected with the recovery of the gas and its re-solution by the spent liquor. When the distillation is stopped by shutting off the heat from the vessel containing the ammoniacal liquor, the bulk of the gas generated in the vessel is condensed and the anhydrous liquid is driven over into the receiver by the pressure in the still and pipes leading to the condenser; but the portion remaining in the still being absorbed by the spent liquor after it cools down sufficiently a partial vacuum is created in the upper part of the still. This vacuum, if maintained, would tend to draw over the expanded gas into the still; but for reasons which will now be explained it does not do so. In fact, the temperature is raised at first slightly, because so long as the vacuum is maintained evaporation takes place and

the water is cooled; but the water raises the temperature somewhat above that produced by evaporation. When, therefore, the expanded gas enters the still, it is brought in contact with water exceeding 60° in temperature and the refrigeration and absorption of the gas proceed very slowly and imperfectly, and the gas accumulates in the upper part of the still, destroys the vacuum, and exerts a pressure in the still, which extends into the pipes that conduct the expanded gas into the still, and, closing the check-valve, the further discharge of the vapor is interrupted. This causes an accumulation of the gas in the refrigerating-pipes, and compression taking place heat is generated, and with that refrigeration ceases. The generation of heat is extremely rapid when the escape of the expanded gas is interrupted, because the anhydrous liquid passes from the valve that admits it to the refrigerating-pipes under one hundred and twenty pounds pressure, and the expanded gas has a pressure very much greater.

From the above it will be understood that the absorbent systems heretofore known, all of which work on the same principle, are open to the same fundamental objection—viz., uncertainty of action. If the temperature of the spent liquor exceeds 60°, absorption ceases and as an automatic refrigerating system the system fails and the very reverse of the intended effect frequently ensues, heat being generated instead of cold. To guard against so disastrous a result, the constant care of highly-skilled attendants is required to watch the operation of the system and manipulate the valves when pressure in the vessel and compression in the refrigerating-pipes begin to manifest themselves. This so greatly increases the expense of the system that it offers but little advantage in the way of economy over the pumping system, and that little is offset by the danger of heating the pipes which is always present from lack of vigilance and causes which cannot always be foreseen and guarded against. That the above explanation of the causes which make the absorption system uncertain is correct is evidenced by the well-known fact that in cold weather, when the normal temperature of the spent liquor remains constant at less than 60°, no difficulty is experienced in operating the system; but at such times artificial refrigeration is not wanted. In tropical and subtropical countries such conditions are never found, and there as well as in those parts of the temperate zone where the heat of the summer months is high and prolonged the absorptive system cannot be depended on, for the reasons stated.

The object of my invention is to obviate the disadvantages heretofore connected with the practical operation of the absorption system of artificial refrigeration and to accomplish this object by means for carrying on the reliquefaction of the expanded gas and its reabsorption by the spent liquor without producing pressure and without interrupting the return of the expanded gas to the spent liquor, thereby avoiding compression of the gas in the refrigerating-pipes and the generation of heat in the refrigerator.

The invention will first be described in connection with the accompanying drawings and then specifically pointed out in the claims.

In the drawings, Figure 1 represents a sectional side elevation of the apparatus with the several parts composing it arranged in line for the purpose of clearness of illustration; Fig. 2, a plan of the apparatus with the several parts in proper relation; Fig. 3, an end elevation of the apparatus and a sectional view of the valve mechanism for automatically controlling the supply of oil to the heating apparatus under the stills, and Fig. 4 represents a front view of the oil-supply tank and the pipe and valve connection with the automatic valve mechanism.

Referring to the drawings, the letters S S′ designate two stills or generators, which may be made of steel or iron cylinders provided with strong heads and bottoms having grooves turned in them to receive the ends of the cylinders and the whole fastened together by outside bolts and nuts. The bottoms of these stills are formed with upwardly-extended arched walls, thus forming under the stills combustion-chambers 1 1. The arched walls have central openings at the top, and into these are fitted the lower ends of pipes 2 2, which extend upward and pass through stuffing-boxes in the top of the stills. These pipes carry off the products of combustion from the heat-chambers and also increase the radiating-surface inside of the stills. In the lower ends of the pipes 2 2 are located cylindrical chambers 3 3, which project downward into the combustion-chambers. These chambers are of less diameter than the pipes 2 2, so that the heat and products of combustion can pass up into the pipes and the heat circulate around them freely, and into these chambers two bent tubes 4 5 are inserted. Tubes 4 lead from near the bottom of the chambers upward through their tops, and outside of the chambers their ends are bent and carried through ammonia-tight openings in the pipes 2 2 just above the top of the chambers 3 3. Tubes 5 lead from the top of the chambers and extend to a point above the upper bent ends of tubes 4 4, where they are also bent and carried through ammonia-tight openings in the pipes 2 2. These tubes form the two legs of an inverted siphon, which are thus contrived and arranged for the purpose of conducting the liquor into and out of circulation-chambers 3 3, so that a circulation of the liquor from the stills through the chambers 3 3 and back into the stills again can be set up, as will be described more fully presently.

The letters V V′ designate two auxiliary chambers placed, respectively, outside of the stills S S′ and constructed of steel or iron

cylinders fitted with strong heads and bottoms and the whole secured together by outside bolts and nuts. These chambers are connected at the top and bottom with the inside of the stills by means of pipes 6 7, the former carried up through the top of the chamber and entering the stills below the upper siphon-tube 5 and the latter carried through the bottom of the chambers and entering the sides of the stills near their bottoms. Inside the said chambers are placed coils 8 8, the ends 9 10 of which pass out of the said chambers at the top, the former leading to the condenser C and the latter to the main water-supply pipe 11.

The condenser C consists of a tank 12, in the upper part of which is a spraying-pipe 13, joined to the pipes 9 9, that lead from the coils in the chambers V V'. Out of the heads of the stills pass pipes 14 14^a, which at a point between the stills and the condenser unite by a T-joint in a single pipe 15, which connects with the condenser-coil 16. The end of the condenser-coil passes out of the condenser-tank and thence by a pipe 17 enters a receiver R and terminates near the bottom thereof. The receiver R consists of an iron or steel cylinder fitted with a strong head and bottom fastened together by bolts and nuts. Near the bottom of the receiver a pipe 18 enters the side thereof, which leads to and connects with a valve X for regulating the admission of the refrigerating liquor to the refrigerator-coil, the influx-pipe of the coil also connecting with the said valve. The efflux end 20 of the coil passes out of the refrigerator and connects by a T-joint with two pipes 21 22, which lead, respectively, to the auxiliary chambers V V', entering the sides near the bottoms of the said chambers and terminating with the spraying-tubes 23 23.

Each of the stills has an independently-controlled heating apparatus arranged for turning the heat on and off automatically, (or otherwise, so that while one still is heating the other may be cooling.) The fuel used is preferably oil vaporized under the still at the point of combustion, and the arrangement is such as to enable the supply of oil to the heater under one still to be stopped automatically when the distillation has proceeded as far as desired, and by the same movement the valve that controls the supply of oil under the other still is opened.

The heaters are designated by the letters H H', and each consists of a coil of pipe 24, connected with a spraying-tube 25, placed in a suitable pan under the coil. A pipe 26 leads from each coil, and the two pipes 26 26 unite by a T-joint with a pipe 27, that leads to an oil-tank T, located at the back of the stills in a slightly-elevated position. The pipes 26 26 are provided with valves 28 29, respectively, and the arms of these valves are connected with the lower ends of rods 30 31, whose upper ends are pivoted to levers 32 33, fulcrumed to brackets projecting from the casings of valve-chambers 34 35, built on the heads of the stills S S', respectively. The valve-chambers 34 35 are divided by a horizontal partition 36 into two parts *a b*, the lower part *b* connecting by a passage 37 with the interior of the still and having a valve-seat 38 at the entrance to this passage. A valve-rod 39, connected with the short arm of the lever 32, passes down through a stuffing-box and the chambers *a b* and carries at its lower end in the lower compartment *b* a valve 40, and under the partition 36 it carries another valve 41, the latter under a valve-opening *d* in the partition 36. Above the partition 36 a spring *t* is coiled around the valve-rod 39 to force the rod down and close the valve 40. Pipes 42 43 lead each from the compartments *a a* of the two valve-chambers, pipe 42 connecting with the pipe 22 and pipe 43 connecting with pipe 21 just outside of the point where they enter the respective chambers V V'. The pipe 42, leading from the valve-chamber on still S, thus connects with the pipe leading into the chamber V', which is in connection with the still S', and pipe 43, connecting with the pipe leading into the chamber, connecting with still S. The purpose of this arrangement will be described presently.

The several pipes referred to are provided with suitable valves for stopping the passage of the liquor or gas. These valves will be designated when the operation of the process is described. Furthermore, certain of the pipes are provided with check-valves. Thus a check-valve 44 is placed in the first branch of the condenser-coil 16 to prevent back pressure from the coil into the pipe 15 and from thence into the still. Check-valve 45 is placed in pipe 17 to prevent back pressure from the receiver R to the condenser-coil, and the pipes 22 23 are fitted with check-valves 46 46 at a point just outside of chambers V V' to prevent the liquor in the chambers from entering the pipes 21 22.

From the tank 12 of the condenser a pipe 47 leads and connects by a T-joint with a waste-pipe 48, provided with a valve 49, and a pipe 50, provided with a valve 51, that connects with the main water-supply pipe 11.

The operation of the invention is as follows, it being understood that the description refers first to the distillation from one still S' and following this the description of the operation of returning the expanded gas to the spent liquor and its reliquefaction and reabsorption therein: At the beginning of the operation aqua-ammonia is run into the two stills S S' through a pipe 52, having branches that lead into the respective stills. The liquor flows from the stills through the pipes 7 7 into the chambers V V', filling the said chambers, and then flowing through the pipes 6 into the stills, the circulation at this point being from the bottom toward the top, as indicated by the arrows 1. The liquor also flows into the chambers 3 3 through the lower limb of the siphon and fills the same. When the cham-

bers V V′ are entirely filled and the stills are about three-fourths full, as indicated in still S, so that the ends of both siphon-pipes are below the surface of the liquor, the valves in the branches of pipe 52 are closed. No communication now exists between the two stills, and the valves in all the pipes leading to and from the chambers V V′ and the stills are closed. The heater under the still S′ is now started. The liquor in the still having passed during the filling into the circulation-chamber 3, the heat surrounding the said chamber heats up the liquor therein, which rising passes out of the upper limb 5 of the siphon, while its place is taken by the colder liquor in the still flowing into the chamber through the shorter limb 4 of the siphon. By this means a circulation of the liquor through the chamber 3 is kept up, with the result that the temperature of the liquor is quickly raised and the distillation is very rapid. At the same time that this circulation of the liquor through chamber 3 is carried on, the temperature of the liquor in the still being raised above that in the chamber V′, it passes through the pipe 6 into the top of the chamber and displaces the colder liquor at the bottom, which passes through the pipe 7 into the still. Thus a circulation of the liquor the reverse of that indicated by the arrows 1 takes place between the still and the chamber, with the result that the entire body of liquor in the still and chamber is set in motion and passes through the circulation-chamber 3, thereby being rapidly brought to a uniform temperature, and the distillation of the liquor is effected expeditiously. When the pressure of the gas in the still reaches, say, one hundred pounds, as indicated by the pressure-gage G, the valve 53ª in the pipe 14ª, leading from the still S′, is opened to allow the gas to pass into the coils in the condenser. Previous to this, however, the valve 54 in the main water-pipe 11 and valves 57 58 in the pipes 9 10, connected with the coil 8 in chamber V, had been opened and the water allowed to flow through the coil 8, whence it was conveyed by the pipe 9 to the spray-pipe 13 in the condenser, and falling in a spray on the condenser-coil cooled the same, and dropping into the tank was conveyed through the pipe 47 and discharged from the waste-pipe 48, the valve 49 being open. The gas rising through the pipe 14ª circulates through the condenser-coil 16, is condensed to liquid anhydrous ammonia, and by the pressure in the still is forced through the pipe 17 past the check-valve 45, and valve 54ª being open it is driven into the receiver R under a pressure of about one hundred and twenty pounds to the square inch. This operation is continued until the liquor in still S′ is reduced to about the point indicated by the broken line *x*—that is, until its level is just above the upper end of the siphon-tube 4 and below the upper end of siphon-tube 5—at which time enough gas has been distilled over and condensed to nearly fill the receiver R. When this point is reached, the valve 53ª is closed and the heat shut off. The valves 57 58 in pipes 9 10, leading from the coil 8 in chamber V, are now closed and the valves 55 56 in pipes 9 10, leading from the coil 8 in chamber V′, opened, so that the water flows through the coil 8 in chamber V′ for the purpose of cooling the liquor in the said chamber and still S′.

To bring about the recondensation of the gas remaining in the still and its reliquefaction by the spent liquor in the still which follows, with the result that a vacuum is formed in the upper part of the still, the receiver having been charged with the anhydrous liquor under a pressure of, say, one hundred and twenty pounds, the refrigeration can be proceeded with. The valve 59 being opened, the anhydrous liquor rushes to the valve X, which admits it, as required, to the pipes or chambers of the refrigerator, in which it expands. Immediately on its passing the valve it comes under the influence of the vacuum existing in the still S′, which by decreasing the pressure in the pipe 22, that leads from the refrigerator-coil to the chamber V′, and the pressure of the liquor in the chamber V′, permits the gas to expand rapidly and to be drawn or sucked through the pipe 22, the valve 60 in the pipe 22 being open, and thence into the chamber V′ through the perforated pipe 23 and diffused through the spent liquor in the chamber, by which it is reliquefied and reabsorbed, thus restoring the ammoniacal liquor to its original strength and recharging the still.

The reliquefaction and absorption of the gas by the liquor in chamber V′ generates heat by which the temperature of the liquor in said chamber is raised considerably above the liquor in the still S′, which was reduced by the water circulating through the coil to the temperature of the water, and further reduced, more or less, by the evaporation following the production of the vacuum in the upper part of the still. Hence when the temperature of the liquor in chamber V′ is raised it passes out of the said chamber up into the pipe 6, and thence into the colder liquor in the still, the end of the pipe being below the surface of the liquor in the still, so that the heated liquor is delivered into the body of the colder liquor. At the same time that this overflow from the chamber V′ takes place an influx from the still sets in at the bottom through the pipe 7, the colder liquor in the still thus displacing the warmer liquor in the chamber V′, and a circulation is thus established between the two bodies of liquor. The gas issuing from the perforated pipe 23 thus meets and mingles with the colder liquor flowing into the bottom of the chamber from the still, and owing to the superior liquefying and absorbing powers of the colder liquor the reliquefaction and reabsorption of the gas proceeds rapidly, and as through the circulation the entire body of spent liquor is

made to pass into the chamber V′ at the bottom and meet and mingle with the gas issuing from the pipe 23 the reliquefaction and reabsorption proceed with such rapidity that no free gas is permitted to accumulate, and hence no calculable pressure arises in the chamber or still, and the vacuum is not materially diminished. The rapid assimilation of the gas is further aided by the liquor completely filling the chamber V′, (it being maintained in this way by the higher level of the liquor in the still,) there being no space for the gas above the liquor, and the exit from the chamber being through the pipe 6 if all the gas is not absorbed in the chamber it is taken up as it flows through the pipe or by the colder water in the still, into which it is discharged from the end of the pipe 6.

By maintaining the vacuum in the upper part of the still, which can only be done by preventing the gas from rising above the surface of the spent liquor, the liquor is held up in the still and chamber and pressure from the weight of the water, against the check-valve in the pipe leading into the chamber, is relieved, whereby resistance to the escape of the expanded gas in the refrigerator-pipes is practically done away with, and thereby the expansion of the gas is greatly facilitated, back pressure in the refrigerator-pipes prevented, and the generation of heat therein virtually made impossible.

When by the decrease of anhydrous liquor in the receiver, as indicated by the glass gage, a fresh supply is required, the still S is brought into operation by setting the heater H going. The same circulation of the liquor through the chamber 3 and between the chamber V and still S is set up as heretofore described in connection with still S′, and when the distillation has proceeded as far as before stated and the pressure has reached the proper height, as indicated by the pressure-gage, the valve 53 in pipe 14 is opened and the gas allowed to enter the condenser-coil, from which the anhydrous liquor is driven to the receiver R, as heretofore described. When the distillation has proceeded far enough to reduce the body of weak liquor in still S to the level indicated in still S′, the valve 53 is closed and the valves 57 58 in pipes 9 10 opened, so that the water will flow through the chamber V to cool the spent liquor therein and in the still to form the vacuum preparatory to the return of the expanded gas from the refrigerator-pipes to the spent liquor and its reliquefaction and reabsorption therein, as heretofore described.

It is intended that the stills shall after every distillation be recharged with liquor of the original strength. Hence when the gage on one of the stills indicates that the proper quantity of the expanded gas has been returned to that still to raise the body of aqua-ammonia therein to the original volume valve 60 in the pipe leading to the chamber connected with that still is closed to stop the further influx of the gas. Thus by the process described a constant circulation of the refrigerant is obtained from the original bodies of liquor put into the two stills by operating first one and then the other.

For convenience of description the top of the liquor in still S′ is shown at the line *x*, which is the point at which distillation is intended to reduce it in both stills before the return of the expanded gas to the still last used. When the distillation takes place in still S, the liquor in that still will be reduced to the height of the line *x*, while the liquor in still S′ will be up to the level of that shown in still S. The receiver R will contain nearly the amount taken from one or the other of the stills, the difference between the quantity in the receiver and that taken from the stills being accounted for by the amount contained in the pipes, either those leading to the receiver or those between the receiver and one or the other of the chambers V V′.

The regulation of the heat under the stills is brought about in the following manner: As heretofore stated, the passages 37 in the valve-chambers 34 and 35 communicate with the inside of the respective stills. Supposing the heat to be under still S when the pressure in that still reaches, say, ninety pounds, (or more,) at which point it may be desired to check the distillation, the valve mechanism in chambers 34 and 35 being set accordingly, the pressure raises the valve 38 against the force of the spring in the chamber *a*, and thereby the lever 32 is operated and through the rod 30, which connects with the arm on the valve 28, partly closes the valve 38, checks the flow of oil to heater H, and thereby reduces the heat under the still S. When the valve 38 is lifted, the valve 41 is at the same time moved up against the partition D and closes the opening through the same and prevents the gas in chamber *b* from passing into the chamber *a;* but when the pressure decreases the valve 38 is forced down on its seat by the spring, and valve 41, being moved away from partition *d*, passes up through the opening in the partition and enters the chamber *a*, from which it passes into pipes 42, and is led thereby to the pipe 22, (see Fig. 2,) and thence into the chamber V′, where it is reliquefied and taken up by the body of weak liquor. This description of the operation of the heat-checking mechanism under still S presupposes that the liquor in chamber V′ and still S′ is being cooled, while the liquor in still S and chamber V is being distilled. It will be understood, of course, that when still S′ is being heated the valve mechanism in valve-chamber 35 operates the same as the mechanism in valve 34 to check the heat under still S′ when the pressure reaches the same point and that the gas which is led into chamber *a* when the pressure decreases and valve 38 closes passes by the pipe 43 into the pipe 21, and thence into chamber V.

In the above description ammonia has been referred to as the refrigerating agent; but it

is to be understood that the process is not limited in its application to the use of that material, as I desire to claim the process when used for the circulation of any refrigerating agent which is recoverable after doing its work in the refrigerating-chamber by being reliquefied by the residue of the liquor from which it was originally distilled or generated.

I claim—

1. In a refrigerating apparatus the combination of a still and an auxiliary chamber, forming receptacles for the liquor, pipes connecting the receptacles together at top and bottom, and a return gas-pipe that delivers into the auxiliary chamber, the receptacles being arranged to permit an uninterrupted circulation of the liquor through the pipes and receptacles by gravity alone, to facilitate and hasten the absorption of the gas, and prevent the accumulation of pressure in the receptacles, substantially as specified.

2. In apparatus for artificial refrigeration the combination of a still and an auxiliary chamber forming receptacles for the ammoniacal liquor, a return gas-pipe delivering into the auxiliary chamber and pipes leading from the top and bottom of the auxiliary chamber to the still—one entering the still near its bottom and the other entering it at a point above the auxiliary chamber the receptacles being so placed with relation to each other as to permit an uninterrupted gravity circulation between the bodies of liquor in the still and auxiliary chamber respectively through the pipes, substantially as specified.

3. In apparatus for artificial refrigeration the combination of a still and an auxiliary chamber as receptacles for the ammoniacal liquor, a return gas-pipe delivering into the auxiliary chamber pipes leading from the top and bottom of the auxiliary chamber to the still—one entering the still near its bottom and the other entering it at a point above the auxiliary chamber—the receptacles being so placed with relation to each other as to permit an uninterrupted gravity circulation and circulation between the bodies of liquor in the still and auxiliary chamber respectively through the pipes, a receiver for the anhydrous liquor, a condenser interposed between the still and the receiver and a refrigerator-coil connected by pipes provided with suitable valves with the receiver and the auxiliary chamber, substantially as and for the purpose described.

4. In apparatus for artificial refrigeration the combination of two stills, and two auxiliary chambers forming receptacles for the ammoniacal liquor, return gas-pipes delivering into each of the auxiliary chambers, pipes leading from the top and bottom of each auxiliary chamber to a still—one entering the still near its bottom and the other entering it at a point above the top of the auxiliary chamber—each of the stills and its auxiliary chamber being so placed with relation to each other as to permit of an uninterrupted gravity circulation between them through the pipes, a receiver, pipes that lead from the receiver to each of the auxiliary chambers, and a condenser connected with both stills and with the receiver by suitable pipes whereby the operation of distilling the gas and recharging the spent liquor can be carried on without interruption, the vacuum maintained in one of the stills, and the distillation can be carried on in the other when the receiver needs replenishing, substantially as described.

5. The combination, in a still, of a receptacle for the liquor, a combustion-chamber and pipe leading therefrom, a circulation-chamber placed in the pipe and combustion-chamber, and siphon-pipes leading from the circulation-chamber out into the receptacle for the liquor, substantially as described.

6. The combination, with the heating apparatus of the stills, of an oil-tank leading therefrom to branches that connect with the burners under the respective stills, a valve in the said pipe to regulate the flow of oil to the burners, upper and lower valves, mounted on valve-rods, inclosed in casings on the stills (the valve-chambers communicating with the interiors of the respective stills), the said valve-rods connected with levers which in turn are connected with the valves in the branch pipes leading to the burners, chambers above the upper valves in the casings, and pipes leading from each of these chambers to the auxiliary chambers connected with the two stills, the pipes leading from the chamber in the casing on one still leading to the auxiliary chamber connected with the other still, whereby, when the pressure in one still reaches the required height the supply of oil is automatically shut off and the burner extinguished, and the gas, which enters the valve-chamber in the casing, and is shut in there by the closing of the lower valve, is conducted back into the auxiliary chamber connected with the other still without waste, substantially as specified.

In testimony that I claim the invention above set forth I affix my signature in presence of two witnesses.

EDWARD WELLS HOWELL.

Witnesses:
FREDK. HAYNES,
MILTON C. DORNE.