(No Model.) 3 Sheets—Sheet 1.

F. B. HILL.

ICE MAKING AND REFRIGERATING APPARATUS.

No. 462,551. Patented Nov. 3, 1891.

Fig. 1.

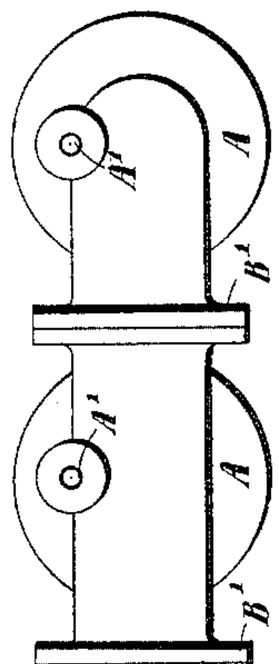


Fig. 2.

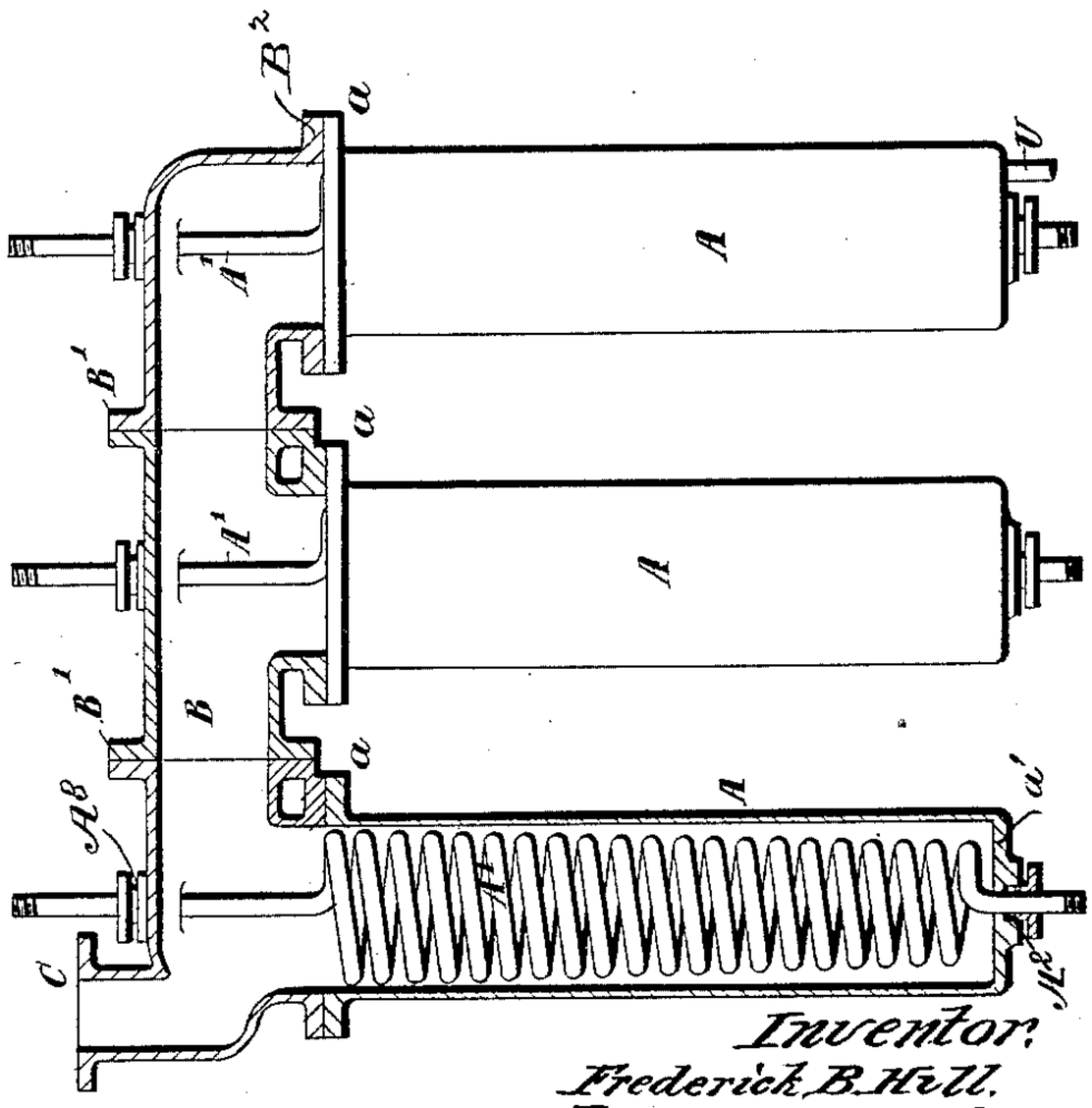


Fig. 3.

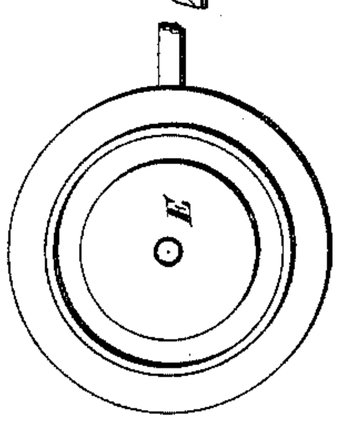


Fig. 4.

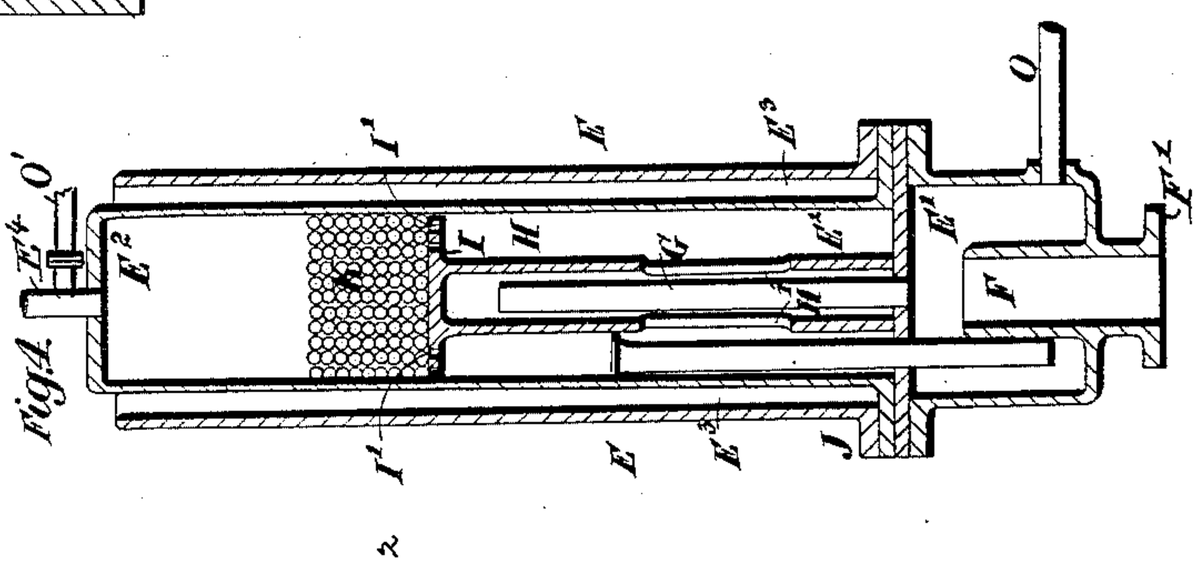
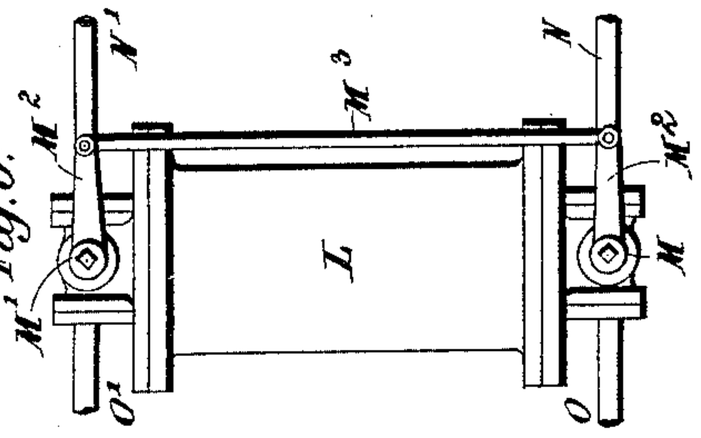


Fig. 5.

Fig. 6.



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(No Model.) 3 Sheets—Sheet 2.

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ICE MAKING AND REFRIGERATING APPARATUS.

No. 462,551. Patented Nov. 3, 1891.

Fig. 10.

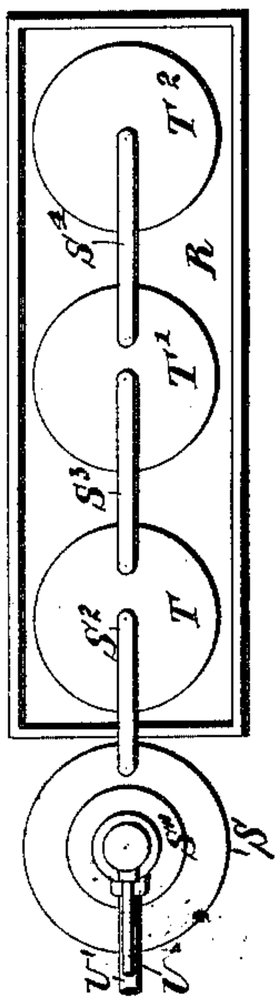


Fig. 9.

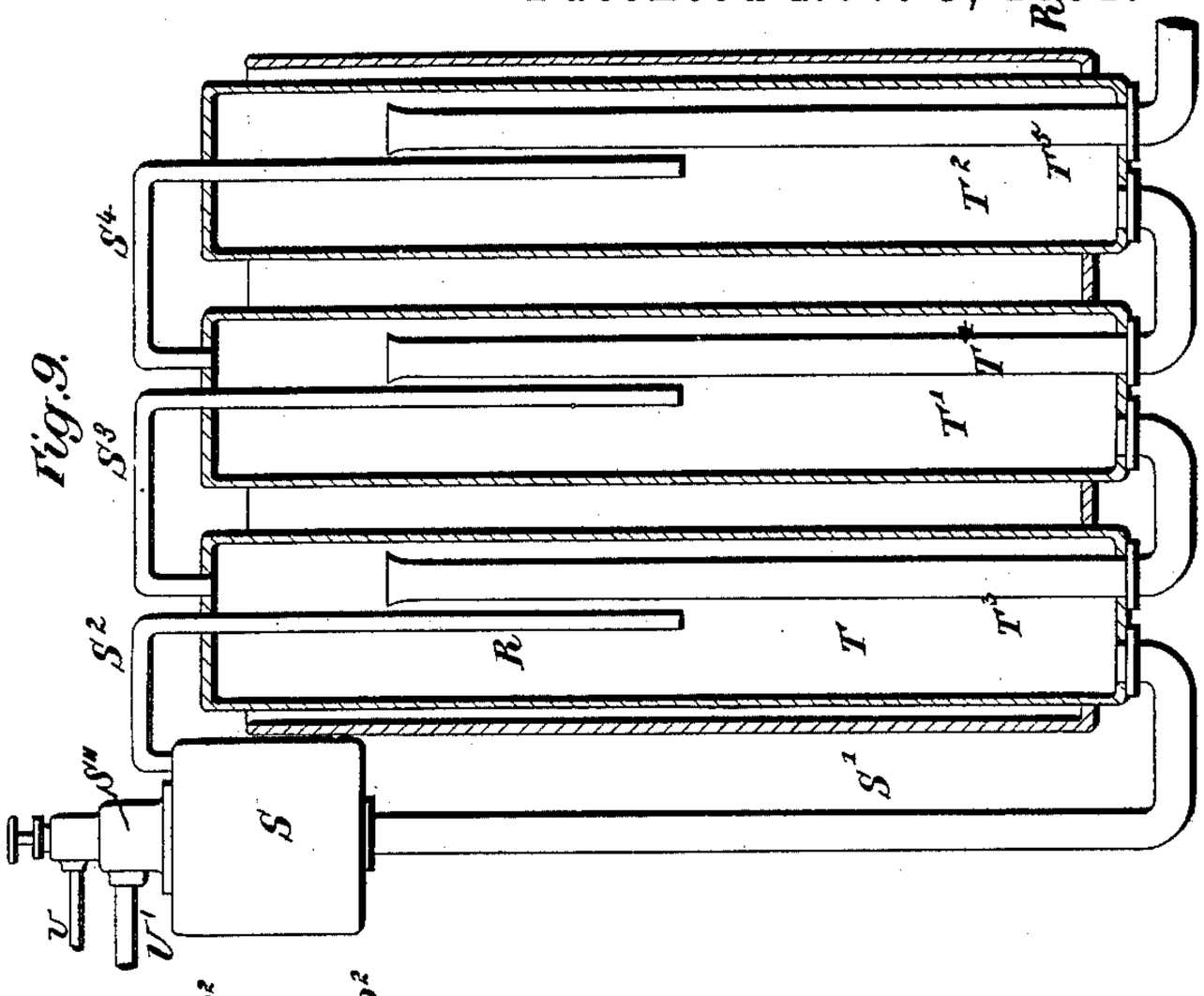


Fig. 7.

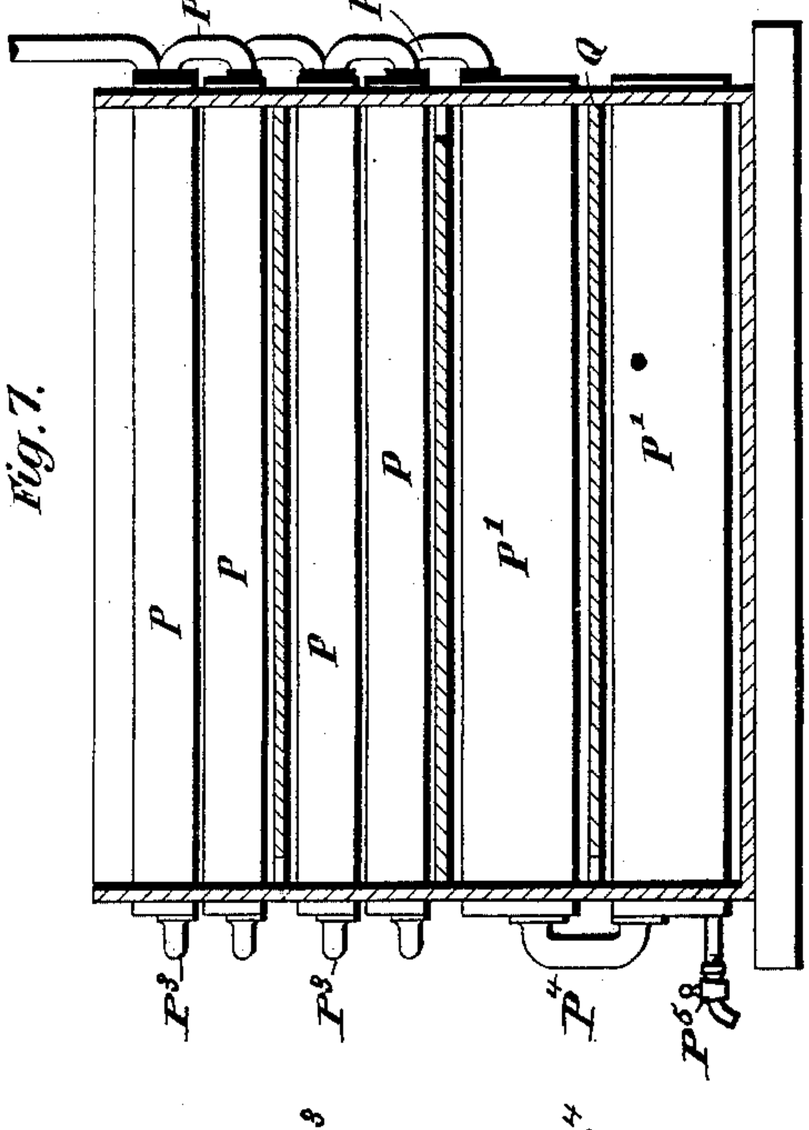
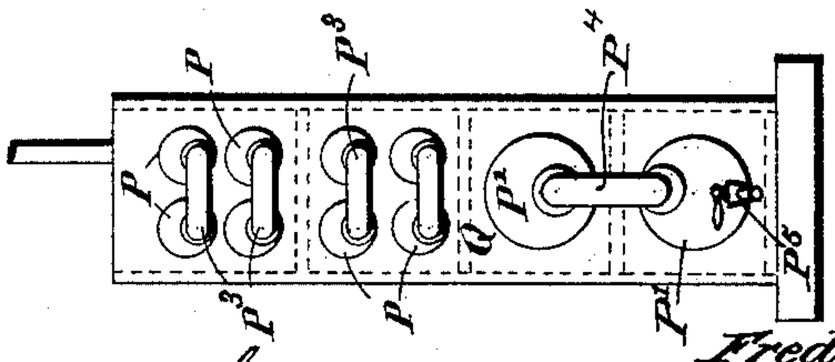


Fig. 8.



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(No Model.) 3 Sheets—Sheet 3.

F. B. HILL.

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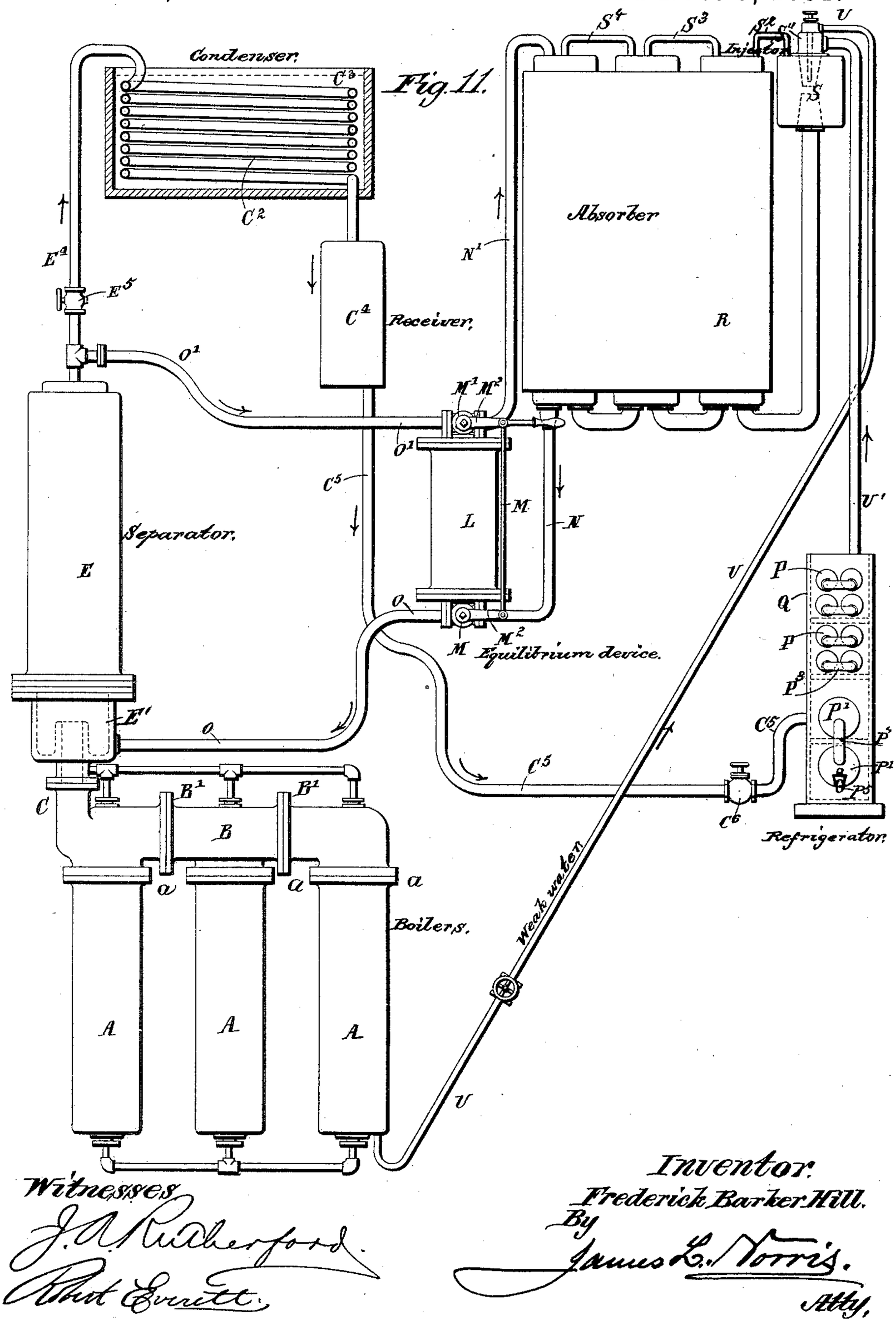
Fig. 11.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

FREDERICK BARKER HILL, OF LONDON, ENGLAND, ASSIGNOR OF THREE-FOURTHS TO JAMES SINCLAIR, OF SAME PLACE.

ICE-MAKING AND REFRIGERATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 462,551, dated November 3, 1891.

Application filed February 7, 1889. Serial No. 298,986. (No model.) Patented in England June 4, 1885, No. 6,808.

To all whom it may concern:

Be it known that I, FREDERICK BARKER HILL, engineer, a subject of the Queen of Great Britain, and a resident of London, England, have invented new and useful Improvements in Ice-Making and Refrigerating Apparatus, (for which I have obtained a patent in Great Britain, No. 6,808, dated June 4, 1885,) of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to ice-making and refrigerating apparatus wherein the cold is produced by the continuous ammonia-absorption process.

My said invention is designed to simplify the construction and increase the efficiency of such apparatus.

One feature of my invention is the combination, with the ammonia boiler or still, the cooler or condenser, and the absorber, of an equilibrium device, whereby, notwithstanding the difference between the pressure in the boiler and that in the absorber, the ammoniacal liquor can be caused to flow under the action of gravity from the said absorber to the boiler. By these means I obviate the necessity for using a pump to force the ammonia solution from the receiver back into the boiler or still.

My said invention, moreover, comprises an ammonia boiler or still built up of sections which can be readily connected or disconnected and the number of which can be increased or diminished with facility, according to the desired capacity of the boiler.

My said invention also comprises a separator or rectifier which is arranged between the boiler and the cooler or condenser, and which consists of upper and lower chambers suitably connected and having shot, pebbles, or the like arranged in the upper chamber, so that any steam or aqueous vapor carried over from the boiler with the ammonia-gas will be condensed and arrested and allowed to return to the boiler.

My said invention also comprises a refrigerator consisting of large tubes or cylinders so connected that the liquid ammonia which is admitted to one of the said tubes cylinders will flow into the other tube or cylinder, in which the weak ammoniacal solution will be collected, and smaller tubes so connected with the said large tubes that the ammonia-gas ascending from the large tubes will pass successively through the small tubes.

My said invention also comprises an absorber in which the ammoniacal liquor flows successively through a series of chambers so connected that any ammoniacal gas not absorbed in the first chamber will pass into the liquor in the second chamber, and so on.

In the accompanying drawings, Figure 1 is a plan, and Fig. 2 a front elevation, partly in vertical central section, of one form of my improved ammonia boiler or still. Fig. 3 is a front elevation, partly in vertical central section, showing another form or modification of the said boiler or still. Fig. 4 is a vertical central section, and Fig. 5 a plan, of my improved separator or rectifier. Fig. 6 is a front elevation of my improved equilibrium device. Fig. 7 is a front elevation, partly in vertical section, and Fig. 8 an end elevation, of my improved refrigerator. Fig. 9 is a front elevation, partly in vertical section, and Fig. 10 a plan, of my improved absorber; and Fig. 11 is a front elevation showing the separate parts of my refrigerating or ice-making apparatus combined.

My improved ammonia boiler or still (shown in Figs. 1 and 2) comprises wrought-iron or steel tubes A, which are closed at their lower end, and each of which is provided at its upper end with a flange *a*, the said flanges and the bottoms *a'* being united to the tubular portions, preferably by welding. By using wrought-iron or steel in the construction of the said tubes I am enabled to make them comparatively thin. Moreover, by welding the bottoms in the tubes I obviate the necessity for making joints, which would be liable to become leaky.

The tubes A are intended to contain the ammonia solution, which is heated by means of steam passed through internal coils A', or the steam is applied externally in any convenient manner—for example, by means of a jacket or casing surrounding the tube or tubes A. The chamber B for the ammonia-gas is formed in sections, which are provided with flanges B', whereby they are connected by bolts or the like, and each of which is pro-

vided with a flange B^2, to which one of the tubes A is firmly connected by bolts or other convenient means. The said chamber B is connected by a pipe C with the separator or rectifier, hereinafter described. The ends of each coil A′ are passed through suitable stuffing-boxes A^2 A^3, the former being provided in the bottom a' of the tube A, and the latter in the top of the corresponding section of the gas-chamber B.

By making the ammonia boiler or still in sections, as above described, I obtain the advantage that I am enabled to increase or diminish the capacity of the said boiler or still by simply adding thereto more sections similar to the central section shown in Figs. 1 and 2, or by removing such sections therefrom.

Another advantage afforded by my present improvements is that in the boiler or still, as well as in the other parts of my apparatus, all the joints are exposed, so that any leakage can be at once detected and stopped. This is very important, because should leakage of ammonia take place into the water-spaces such leakage might remain long undiscovered, whereas if the joints are exposed leakage can be easily detected by the smell of the ammonia.

In Fig. 3 I have shown a modified arrangement of my improved boiler or still adapted to be heated by fire, the heat being applied to the exterior of the tubes A, which are arranged in a flue D, provided with bridges or checks D′, and connected with a furnace D^2. It is evident that the flue D can be made of any suitable length to adapt it for any desired number of sections of the boiler or still, and that when one or more sections are removed the hole or holes from which they are withdrawn may be closed in any convenient manner.

The separator or rectifier E, Figs. 4 and 5, is constructed with a lower chamber E′ and an upper chamber E^2. The lower chamber E′ is provided with a tube F, which extends upward within it, and which, together with the external wall of the said chamber E′, forms an annular space for the condensed steam and for any ammoniacal liquor that may be carried with the gas into the chamber E′. The tube F is provided below the chamber E′ with a flange F′, whereby, it is connected with the pipe C of the boiler or still. The upper chamber E^2 is connected with the lower chamber E′ by a tube G, which extends upward within a hollow stem or tube H, formed on or firmly attached to a disk or diaphragm I. This disk or diaphragm is provided with perforations I′, for the purpose hereinafter specified, and divides the upper chamber E^2 into two parts. In the lower part of the said chamber E^2 the ammoniacal gas is washed and cooled and any steam from the boiler is condensed.

J is an overflow-pipe, which allows the water of condensation, when the same rises above the upper end of the said pipe, to pass from the chamber E^2 into the annular space around the tube F in the chamber E′. The tube H is provided with elongated holes H′ below the level of the liquid in the chamber E^2, which level is regulated by the height of the said overflow-pipe J. The ammoniacal gas and any aqueous vapor or steam that may be carried over with the same from the boiler pass through the tube G and through the holes H′ in the tube H into the lower part of the chamber E^2 and thence through the perforated disk or diaphragm I into the upper part of the said chamber. The upper part of the chamber E^2, above the disk or diaphragm I, is filled or partially filled with a mass of shot or pebbles K or other suitable material affording a very large surface designed to serve as a scrubber and to arrest any aqueous vapor or moisture that may pass through the perforated disk I with the ammoniacal gas and to allow the liquid to trickle down into the lower part of the chamber E^2. The liquid overflows from this chamber through the pipe J into the chamber E′, and, rising in the latter chamber, overflows through the pipe F and returns to the boiler. The upper chamber E^2 is preferably cooled by the circulation of water through a jacket or casing E^3 provided around the said chamber, or it may be cooled by the circulation of water through a coil arranged within the said chamber. The separator or rectifier E is connected by a pipe E^4 with the condenser or liquefier C^2, Fig. 11.

My improved separator or rectifier operates more efficiently than apparatus of the same kind or class heretofore constructed to free the ammonical gas from aqueous vapor or steam before the said gas passes to the condenser or liquefier.

In Fig. 6 I have shown my improved equilibrium device, which is so constructed and combined with the boiler or still and the absorber that it is at a higher level than the boiler and at a lower level than the absorber, so that the ammoniacal liquor may be allowed to fall by gravity from the absorber, in which there is a low pressure, into the boiler, in which there is a high pressure, thus obviating the necessity for employing a pump for drawing the ammoniacal liquor from the absorber and forcing it into the boiler. This device comprises a chamber L, provided with two cocks M M′, one at its upper and the other at its lower end. The plugs of these cocks are connected by a suitable link or in any other convenient manner, so that both of the said plugs must be moved simultaneously. From the last overflow-pipe of the absorber, hereinafter described, extends a pipe N, which is connected with one way or passage of the cock M. The cock M′ is connected by a pipe N′ with the upper end of the last chamber of the absorber, hereinafter described. The cocks M M′ are, moreover, connected, respectively, by pipes O O′ with the upper and lower ends of the separator or rectifier E. Therefore, when the chamber L is put in communi-

cation through the cocks M M′ and pipes N N′ with the absorber the liquid overflowing from the absorber will fall by gravity into the chamber L, the pressure in this chamber and in the absorber being in equilibrium by reason of the connection of the top and bottom of the said chamber with the said absorber. When the chamber L is filled or nearly filled with the liquid from the absorber, the cocks M M′ may be reversed, thus putting the said chamber in communication at its upper and lower ends with the separator or rectifier E, and through the latter with the boiler. The said liquid then falls by gravity from the chamber L into the boiler.

The cocks M M′ are intended to be operated by hand or by suitable mechanism. In some instances I provide the said cocks with levers M^2, coupled together by a link M^3, so that both cocks can be moved by hand by operating one of the said levers.

Other suitable devices are sometimes provided in place of the cocks M M′ for opening and closing communication between the chamber L and the boiler and between the said chamber and the absorber, for the purposes above specified.

My improved refrigerator is constructed in such a manner that the liquid ammonia, which is admitted continuously into a large tube or cylinder, will flow thence into another large tube or cylinder, and, being vaporized by its contact with the warmer surfaces of the said tubes, will pass in the form of gas through smaller tubes suitably connected with the said large tubes or cylinders. These tubes are all placed, either horizontally or vertically or in any other convenient position, in a vessel or vessels containing non-congealable liquid, such as brine, glycerine, and water, or chloride of calcium dissolved in water. The said tubes are, moreover, so arranged that their ends project through the walls of the said vessel or vessels, so that the joints of the pipes which connect the said tubes are all outside of the said vessel or vessels, and are consequently easy of access for repairs or for ascertaining whether any leakage is taking place. By placing the said tubes horizontally I obtain a very large area of evaporative surface of the liquid ammonia, and by the herein-described arrangement of the said tubes I obviate the liability to carrying over of the liquid ammonia with the gas into the absorber.

In the refrigerator shown in Figs. 7 and 8 the small tubes P are arranged in pairs above the large tubes or cylinders P′, the latter being arranged one above the other. The said tubes are placed horizontally in a tank or vessel Q, in which the non-congealable liquid is placed or through which the said liquid is circulated in the opposite direction to that of the flow of the gas through the tubes P. The tubes or cylinders P P′ are closed at their ends, preferably by plates welded therein, and are so arranged that their ends project through the walls of the tank Q for the purpose above specified. The upper tube P′ is connected with one of the lowermost tubes P, and the pairs of tubes P are connected with each other at one end by means of pipes P^2. The tubes P of each pair are, moreover, connected at the other end by pipes P^3, and the tubes or cylinders P′ are connected with each other by a pipe P^4. The upper tube or cylinder P′ is connected by a pipe C^5 with the condenser or liquefier C^2, Fig. 11. The non-congealable liquid, reduced in temperature by the vaporization of the ammonia in the tubes P P′, may be circulated among ice-boxes or otherwise utilized, as may be desired. Any water or weak ammoniacal solution in the refrigerator will collect in the lower tube or cylinder P′, and may be drawn off from time to time through a cock or valve P^5 provided for the purpose.

In the case of a small refrigerating or ice-making machine I sometimes combine with the refrigerator a device which comprises two chambers, and which can be inverted so that one chamber is considerably higher than the other. Around the tube of the refrigerator is circulated a non-congealable liquid, which is caused to flow by gravity from the upper chamber of the said device, and which is also circulated among the ice-boxes, and which then passes by gravity into the lower chamber of the said device until the upper chamber is empty, when the device is inverted and the circulation is continued, and so on.

My absorber is made up of a series of closed chambers, each of which is provided with an inlet-pipe for the passage of the gas into the same from the refrigerator or from the next preceding chamber and with an overflow-pipe which extends upward a considerable distance above the orifice of the inlet-pipe and which is connected with the lower end of the next succeeding chamber. By constructing the absorber in this manner I greatly increase its efficiency as compared with those heretofore constructed. The said absorber is shown in Figs. 9 and 10, in which R is a tank or vessel having arranged therein the closed chambers T T′ T^2, which are preferably formed of tubes having ends welded therein. S is a chamber provided with an injector S^{11} and connected by means of pipes S′ S^2 with the chamber T, the said pipe S′ serving for the admission of ammoniacal liquor to the said chamber T, and the pipe S^2 for the admission of gas to the said chamber. The injector S^{11} is connected with the boiler by a pipe U and with the refrigerator by a pipe U′. The chamber T is connected with the chamber T′ by a pipe S^3, and the said chamber T′ is connected with the chamber T^2 by a pipe S^4. The chamber T is provided with an overflow-pipe T^3, which is connected with the lower end of the chamber T′. This chamber is provided with an overflow-pipe T^4, which is connected with the lower end of the chamber T^2, and the said chamber T^2 is

provided with an overflow-pipe T^5, which is connected by the pipe N with the cock M of the equilibrium device above described. The tank or vessel R contains water for the purpose of cooling the chambers T T' T^2, or water may be circulated for this purpose through tubes or coils arranged within the said chambers. The said chambers may, if desired, be arranged horizontally instead of vertically. Moreover, the number of the said chambers may be increased or diminished, if desired.

Fig. 11 shows the separate parts of my improved apparatus combined together for use, C^2 being a worm or coil of wrought-iron tube or the like surrounded by a tank C^3, which is charged or supplied with liquid for the purpose of cooling the said coil. This coil serves as a condenser or liquefier for the ammonia.

The operation of my improved apparatus is as follows—that is to say: The boiler A is charged with a strong solution of ammonia and is heated either by means of the steam-coil A' or by direct heat, as in Fig. 3, or in any other convenient manner. The ammonia-gas thus driven off ascends through the pipe C into the separator or rectifier E, where any water-vapor is condensed and flows back to the boiler, while the gas passes on through the pipe E^4 (the cock E^5 being open) into the condensing-coil or liquefier C^2, where, by the accumulation of pressure in the apparatus combined with the cooling effect of the liquid in the tank C^3, the gas becomes liquefied and flows down the coil C^2 into the receptacle or receiver C^4. The cocks M M' are at this stage in communication with the pipes N N', respectively. On the cock C^6 being opened the liquid ammonia passes from the receiver C^4 through the pipe C^5 into the upper tube or cylinder P' of the refrigerator, where, owing to the diminution of the pressure and to its contact with the warmer surface of the said tube or cylinder, it evaporates, thereby causing the temperature of the non-congealable liquid surrounding the tubes P P' to fall considerably below zero. The liquid ammonia flows from the upper tube P' into the lower tube P', while the gas passes through the tubes P. The gaseous ammonia passes from the refrigerator through the pipe U' to the injector S^{11}, while the impoverished ammoniacal liquor from the boiler A passes up through the tube U and through the injector (forming an induced current) to absorb the gas. The ammoniacal liquor flows through the pipe S' into the chamber T of the absorber and overflows from this chamber through the pipe T^3 into the chamber T' and thence through the pipe T^4 into the chamber T^2. Any ammoniacal gas which is not absorbed in the chamber S passes through the pipe S^2 into the chamber T, beneath the surface of the liquid therein, the orifice of the said pipe S^2 being below the mouth of the overflow-pipe T^3. Any ammoniacal gas not absorbed in the chamber T passes through the pipe S^3 into the chamber T', and should any gas still remain unabsorbed it passes through the pipe S^4 into the chamber T^2, the gas first passing through and being absorbed by the weaker solution and then by the stronger solution. The ammoniacal liquor overflows from the chamber T^2 through the pipe T^5 and is conducted by the pipe N into the chamber L of the equilibrium device. When this chamber is filled or nearly filled, the cocks M M' are reversed, and the ammoniacal liquor then flows by gravity back to the boiler to be again evaporated therein.

I am aware of the existence of the following prior Letters Patent of the United States, viz: No. 215,798 to Corliss, Nos. 266,312 and 316,824 to Rankin, and No. 311,062 to Condict and Rose, and I do not claim any of the inventions described in the specifications of the said prior Letters Patent.

What I claim is—

1. In a refrigerating or ice-making apparatus, the combination, with the tubes A of the boiler or still, each of which is closed at its lower end and open at its upper end, of a gas-chamber B, extending across the upper ends of the tubes A and formed of readily separable sections which are connected with each other, and each of which has secured to its under side one of the said tubes A, so that such sections with their attached tubes A can be readily removed from or added to the boiler or still to vary its capacity, according to the amount of work which it has to perform, substantially as set forth.

2. In a refrigerating or ice-making apparatus, the combination, with the tubes A and the gas-chamber B, formed of readily separable sections, each having one of the said tubes attached to it, of heating-coils A', which are arranged within the tubes A, and each of which extends at its lower end through a stuffing-box in the closed end of the corresponding tube A and at its upper end through a stuffing-box in the top of the corresponding section of the said gas-chamber, substantially as and for the purposes set forth.

3. In a refrigerating or ice-making apparatus, a separator or rectifier consisting of a lower chamber E', connected by a tube F with the ammonia-boiler, an upper chamber E^2, divided by means of a perforated disk or diaphragm I into two compartments, of which the lower one communicates with the said chamber E', and a body or mass of shot, pebbles, or the like arranged above the said perforated disk or diaphragm, substantially as and for the purposes set forth.

4. In a refrigerating or ice-making apparatus, a rectifier comprising a lower chamber E', having an internal pipe F, an upper chamber E^2, divided by a perforated diaphragm I into two compartments, a pipe G, extending from the said chamber E' into the lower compartment of the said chamber E^2, a perforated tube surrounding the said pipe G, a mass of shot, pebbles, or the like arranged in the upper compartment of the chamber E^2,

and an overflow-pipe J, extending from the chamber E^2 into the chamber E′ and below the upper end of the pipe F, substantially as and for the purpose set forth.

5. In a refrigerating or ice-making apparatus, a rectifier comprising a lower chamber E′, having an internal pipe F, an upper chamber E^2, divided by a perforated diaphragm I into two compartments, a pipe G, extending from the said chamber E′ into the lower compartment of the said chamber E^2, a perforated tube surrounding the said pipe G, a mass of shot, pebbles, or the like arranged in the upper compartment of the chamber E^2, and an overflow-pipe J, extending from the chamber E^2 into the chamber E′ and below the upper end of the pipe F, and a jacket or casing E^3, surrounding the chamber E^2, substantially as and for the purposes set forth.

6. In a refrigerating or ice-making apparatus, a refrigerator comprising tubes or cylinders of comparatively large diameter arranged one above another in a tank or vessel and in communication with each other, the uppermost of the said tubes or cylinders having an inlet for the supply of liquid ammonia thereto, and tubes of smaller diameter in communication with each other and with the uppermost of the said large tubes or cylinders, the uppermost of the said smaller tubes having an outlet for the ammoniacal gas, the ends of the said tubes projecting through the walls of the said tank or vessel, so that all the joints are easy of access, substantially as and for the purposes set forth.

7. In a refrigerating or ice-making apparatus, a refrigerator consisting of tubes or cylinders P′, arranged one above the other and communicating with each other, an inlet-pipe C^{15} for the supply of liquid ammonia into the upper tube or cylinder, smaller tubes or cylinders P, through which the gaseous ammonia passes on leaving the upper tube or cylinder P′, and a box or casing Q, inclosing the said tubes or cylinders, substantially as and for the purposes set forth.

In testimony whereof I have hereunto signed my name in the presence of two subscribing witnesses.

FREDERICK BARKER HILL.

Witnesses:
DAVID YOUNG,
A. E. NIXON.