

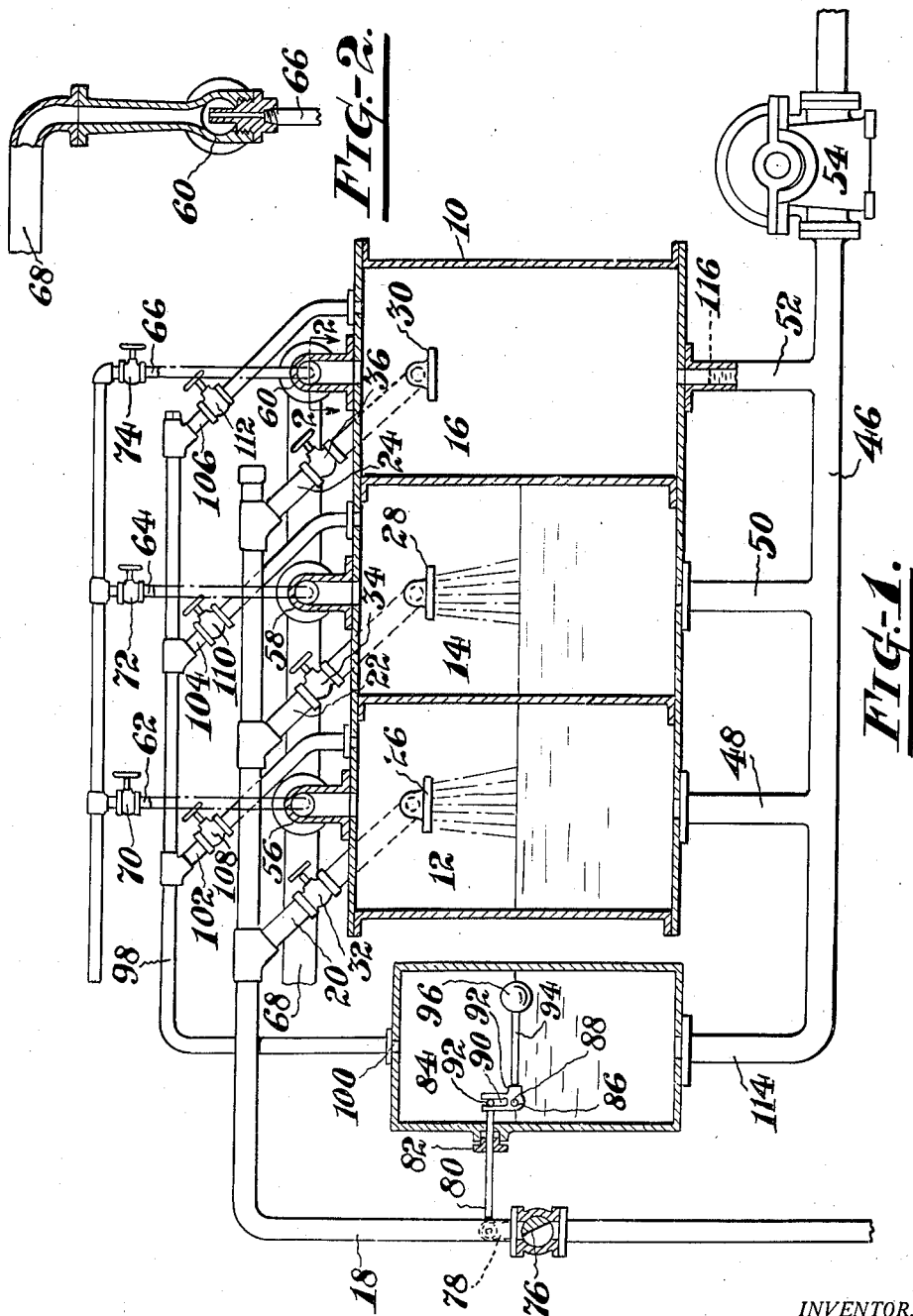
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REFRIGERATING APPARATUS AND METHOD

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REFRIGERATING APPARATUS AND METHOD

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This invention relates to refrigerating apparatus and a method of refrigeration, and more especially to a device for controlling refrigerating apparatus of the type in which a liquid refrigerating agent or medium is brought down to the required temperature by the cooling effect produced by vaporization of a part of the refrigerating agent itself.

An object of the invention is to provide mechanism for enabling refrigerating apparatus of the kind mentioned, including a plurality of evaporator compartments or chambers, each equipped with a vacuum producing device, to carry away the vaporized portion of the refrigerating medium, to perform its functions in a practical manner over a considerable range of operation.

In refrigerating systems using a non-volatile substance such as water as the refrigerating or cooling medium, an evaporator in the form of a container for water to be chilled is employed. The pressure in this evaporator is reduced to such a degree that when water is admitted thereto at a given temperature, some of the water is vaporized at once. In this way a body or mass of water in the evaporator can be cooled to the necessary extent and utilized for the intended purpose. The water vapor obtained from vaporization of part of the water must be removed from the evaporator, and this may be accomplished by a steam ejector which exhausts to a condenser wherein the discharge of the ejector is liquefied.

With an evaporator having a single chamber and steam ejector such a system will serve quite well at approximately fixed or predetermined loads, but it is quite unsuitable for operation when the load varies. Hence if such a system is built for a rated load it cannot be operated advantageously to give a reduced output, and if it is built for a small load the output cannot greatly be increased. This is due to the fact that the capacity of the steam ejector or steam jet booster, that is, the pounds of water vapor evacuated thereby at fixed suction pressure determined by the pressure in the evaporator itself, is constant; regardless of the amount of steam being used, and further it is a characteristic of the steam jet booster that its steam flow must be maintained at the rated value so long as the suction pressure (or chilled water temperature) in the evaporator and discharge or condenser pressure remains constant. Hence this type of steam jet must therefore be turned on completely, using its full rated steam consump-

tion, or completely off and rendered inoperative so long as the operating pressures remain at their normal values. But with a refrigerating system of the character described which comprises several evaporator chambers and steam ejectors, connected in multiple and adapted to work with either all of its evaporator chambers and ejectors, or less than all of said chambers and ejectors in operation, the load can be varied within quite widely separated limits and steam can be saved at varying loads, because the consumption or expenditure of power is thus regulated according to the need thereof under all conditions of practical operation.

My invention is particularly designed to be employed with refrigerating systems having several chambers for evaporating and cooling water and a corresponding number of steam ejectors, with proper connections to permit operation at full or partial capacity. A further object thereof is to provide a refrigerating system having multiple evaporator chambers and steam ejectors, with delivery means disposed in permanent free communication with said chambers and so arranged that chilled water is delivered from only the chambers of the evaporator which really are in operation and use, the water in any chamber or unit which is cut out being automatically drained therefrom, except possibly a small part thereof which may be trapped, so that said chamber remains virtually empty but sealed, until the operation thereof is resumed, and the previous level of the contents restored therein.

Another object of the invention is to provide a refrigerating system, having a water evaporator, with a suitable appliance for maintaining the water in the chamber or chambers of the evaporator which are in immediate operation at a substantially constant level, independent of the rate of outflow from the evaporator. In its preferred form this feature is so related to the evaporator that working conditions in the chamber or chambers thereof which are in operation influence said appliance and the desired effect is automatically obtained.

These and other objects and advantages of this invention are clearly set forth in the ensuing description, taken with the drawing, which shows one embodiment of the invention; and the novel features are pointed out in the appended claims. The disclosure is, however, illustrative only, as many alterations in detail can be made without departing from the prin-

ciple of the invention or exceeding its spirit or scope.

In the drawing, Figure 1 shows an outline of a refrigerating apparatus according to the invention, partly in section, and

Figure 2 is a horizontal sectional line 2—2 of Figure 1.

In the following, the numeral 10 is employed to indicate a water evaporator which is divided up by suitable inside partitions into a number of sections or compartments, three for example, indicated at 12, 14, and 16. A water supply pipe or conduit is indicated at 18, and it has branches 20, 22, and 24 leading to each of the aforesaid chambers or compartments. These branches terminate within said chambers in nozzles or sprayers 26, 28, and 30, each of suitable capacity. The pressure within any chamber of the evaporator 10 that is working will, of course, be low enough so that when water is admitted some of it will be vaporized at once and the remainder cooled to the required extent. If the temperature of the incoming water is 55° F., for instance, the system can be so designed and the pressure in the evaporator so reduced that the vaporization of a small part of the water admitted will cause the entire mass of incoming water to be cooled down to 50° F. In the branch pipes 20, 22, and 24 are admission and cut-off valves 32, 34, and 36 so that one or more of the nozzles can be shut off whenever desired.

The water thus chilled is withdrawn through a common delivery means or conduit 46 connected by risers 48, 50, and 52 to the separate compartments of the evaporator 10. To these risers the chambers discharge through outlets in the bottom. In the line of the conduit 46 I connect a pump 54 to insure the carrying off of the chilled water to a place where it is utilized to afford a cooling effect.

To remove the water vapor created by vaporization in the chambers of the evaporator, steam ejectors or evacuators 56, 58, and 60 are used. These are in the form of L-shaped tubular members which communicate at one end with the inside of the chambers of the evaporator through openings in the top, and are connected at their opposite ends to a common discharge conduit or header 68 which leads to a suitable condenser. The ejectors receive steam nozzles which are connected by branches 62, 64, and 66 to a common steam supply line and these branches 62, 64, and 66 each carry an admission and shut off valve shown at 70, 72, and 74. These ejectors, besides removing the water vapor, create by their operation the necessary high vacuum in the chambers to produce vaporization of the water therein.

If maximum output is desired, the pipes 20, 22, and 24 are all opened to admit water to the three chambers of the evaporator; and all of the steam ejectors are employed to carry away the water vapor to the condenser. The chilled water is withdrawn through the delivery pipe 46. To work at reduced capacity and supply a smaller quantity of chilled water, one or more of the chambers 12, 14, and 16 can be cut out by simply closing the valves in the water and steam branch pipes of said chamber or chambers. The drawing illustrates the chamber 16 as being out of service. For this chamber the level of the water is somewhat lower than in the other two, because the pressure therein is slightly higher; that is to say, the vacuum therein is less because the steam jet thereof is not active and the

pressure inside this compartment is therefore equal to the pressure in the condenser, which is higher than in the chambers 12 and 14. The rise in pressure in the non-operating chamber is due to the fact that this chamber is connected with the conduit 68 which receives the vapor from the other chambers. Hence, no vaporization takes place in chamber 16 but in the other two chambers the water is still vaporized as soon as it enters and the water vapor is withdrawn through the conduit 68. The chilled water is carried away as before by the conduit 46. The ejectors withdraw the water vapor from the operating chambers and compress up to the pressure in the condenser. The ejectors are therefore sometimes called thermo-compressors.

With this construction the system can be operated under a wide range of varying loads without waste of steam or power. When the system is operating at full load all three of the chambers deliver continuously to the conduit 46; but when any one or more of the chambers with its ejector is cut out, condenser pressure is exerted therein, the level of the water therein sinks and the contents are drained out. Part of the refrigerating medium is trapped at a lower level in the riser at the bottom, as shown in the chamber 16, while the other chambers continue to discharge chilled water through their risers into the conduit 46, and the water in the other chambers is not similarly exhausted.

At all times the chambers, whether in operation or not, are in permanent free communication through the riser pipes 48, 50, and 52 with the conduit 46, and no valves in any of these risers are necessary. In other words whichever chambers are active, are always connected to the conduit 46 to discharge chilled water into same, and the riser leading to the bottom of any chamber which is cut out is likewise always open and enables most of the water to be drained therefrom, or at least acts as a trap or pocket in which a part of the refrigerating medium can be retained until operation in that chamber is resumed and the water therein permitted to rise to its former level.

When a chamber is valved out, as shown at 16, the contents will be withdrawn down to a level such as is indicated at 116 in the riser 52. Some water is thus trapped in the riser, and seals the non-operating chamber at the bottom, so that the higher pressure therein cannot be transmitted to any chamber which is operating. Otherwise the remaining chambers could not function. The difference between the level 116 of the water in the riser 52 and the level of the water in the other chambers corresponds to the difference in absolute pressure within the condenser and the pressure within any operating chamber; and the risers are all of sufficient height to seal any non-operating chamber in this manner. This method of connecting the evaporator chambers through riser pipes to a common delivery conduit greatly facilitates the prompt delivery of the chilled water and its transmission to the place of use, regardless of the number of evaporator chambers operating, and constitutes a most simple and effective way of securing these results.

To govern the admission of water to the evaporator 10 through the intake pipe 18 and maintain the water at constant level in such of the chambers as are rendered operative by the opening of the water and steam admission valves, a valve 76 is mounted in the line of this conduit, 75

and connected to be actuated in the desired manner.

This valve may be a rotary valve with an outside arm 78 connected to a rod 80 which passes through a stuffing box 82 to the interior of a float tank 84. On a pivot 86 inside of this tank is mounted a lever, having an arm 88 containing a slot 90 to receive a lateral projection on the rod 80, and the other arm 94 of the lever carries a float 96. From this tank leads a header or conduit 98, communicating with the inside of the tank or vessel 84 through an opening 100 in the top and having branches 102, 104 and 106 which communicate through suitable top openings with the compartments 12, 14, and 16. In each of the branch pipes 102, 104, and 106 are valves indicated at 108, 110, and 112.

At the bottom, the vessel 84 is connected by a conduit 114 to the delivery conduit 46. The function of this vessel is to enable water to be admitted to the evaporator at a rate which is proportional to the delivery of water therefrom. The effect of connecting it as shown is to enable the water level in such of the chambers as are operative to remain constant, independent of the rate of outflow.

It is only necessary to open one of the valves 108, 110, and 112 to establish communication between the vessel 84 and one of the chambers of the evaporator wherein water is being chilled, and to cut it off from any chamber or chambers not operative. The pressure inside the tank or vessel 84 will then be the same as the pressure in the chamber or chambers to which it is connected and water will back up into the vessel 84 through the pipe 114 until it reaches a predetermined height. If the chilled water is withdrawn rapidly, the level of the water in the vessel 84 will tend to drop, and then the valve 76 will be opened further and more water can flow into the active chambers of the evaporator through the pipe 18 to increase the supply. In case the water is withdrawn from the evaporator more slowly the level of the water in the vessel 84 will tend to rise and reduce the intake of water through the pipe 18.

The float 96 and its connection to the valve 76 thus regulate the admission of water to be chilled according to the demand therefor, and since the vessel 84 is connected to the operating chambers of the evaporator above and below the top of the water therein, the action thereof is so controlled that the volume of incoming water is always kept proportional to the rate at which the water is cooled and discharged from the apparatus.

From the foregoing description it will be seen that operation of the evaporator chambers can be selectively controlled by the means consisting of the water supply pipe 18 with the branch connections and valves to the chambers, and the branched steam supply line with the valves therein. Delivery of the chilled water takes place continuously through the conduit 46, which is in permanent free connection with the bottoms of the chambers through the branch pipes or risers. Thus the chilled water is continuously passed from the chamber or chambers which are in operation, while refrigerating medium is exhausted from the remaining chamber or chambers which may be out of operation, as indicated by the chamber 16 in Figure 1, such a chamber being temporarily drained of its refrigerating liquid down to a point which will be generally below the outlet and in the riser pipe itself, which thus

acts as a trap or pocket for a part of the liquid to seal the inoperative chamber.

Also the level of the liquid in any chamber or chambers which may be in operation is maintained constant by the action of the float 96 on the valve 76, regardless of the rate of outflow of the chilled medium from the chamber or chambers which are active; and, as stated above, it is only necessary that the vessel 84 be maintained in communication with the top of one chamber wherein vaporization is effected, the bottom of this vessel being always in constant communication with the delivery conduit 46. Hence, because of the connection of the vessel 84 with any active chamber at points which are both above and below the surface of the refrigerating medium therein, the interior of the vessel 84 is subjected to both the pressure head of the liquid contents of such a chamber and to the vapor pressure therein above the liquid. The depth of the liquid in the vessel 84 is therefore determined by conditions inside of any working evaporator chamber, and the valve 76 is actuated accordingly to admit only so much water to be cooled as is required.

While I have shown and described the preferred embodiment of my invention, it is obvious that many changes in construction and arrangement of the mode of operation may be adopted in practice; and I therefore do not wish to be limited to any combination of parts except as expressly stated in the appended claims.

I claim:

1. Refrigerating apparatus comprising chambers for a refrigerating medium which is to be cooled therein, means for selectively controlling said chambers to render same operative or inoperative, and free outlet connections for said system arranged to withdraw refrigerating medium from a chamber which is inoperative and for continuously delivering the contents of a chamber in which cooling is effected.

2. Refrigerating apparatus comprising evaporator chambers for a liquid refrigerating medium, part of which is to be vaporized therein, means for controlling said chambers to enable a selected chamber to be rendered inoperative, and free outlet connections for said chambers arranged to withdraw refrigerating medium from said selected chamber and to continuously deliver the contents of any chamber wherein vaporization is effected.

3. The method of controlling refrigerating apparatus which consists in selecting one or more chambers of a group thereof, admitting a refrigerating medium to a selected chamber and cooling said medium therein, and maintaining all of said chambers in free communication at all times with common delivery means, whereby refrigerating medium in a chamber where it is not cooled is withdrawn therefrom.

4. Refrigerating apparatus comprising chambers for a liquid refrigerating medium to be cooled therein, connections for selectively controlling the operation of said chambers, common delivery means for said chambers in free communication with all of said chambers, and arranged to receive cooled medium continuously from any chamber which is operative and to withdraw refrigerating medium from a chamber which is inoperative and means for maintaining said medium in any chamber which is operative at a substantially constant level.

5. Refrigerating apparatus comprising chambers for a liquid refrigerating medium to be cooled

therein, connections for selectively controlling the operation of said chambers, means for maintaining a substantially constant level of said medium in a chamber which is operative, a common delivery conduit for said chambers, and risers freely connecting said delivery conduit at all times to the lower portions of all of said chambers.

6. Refrigerating apparatus comprising chambers to receive a liquid refrigerating medium to be cooled therein, means for selectively controlling the operation of said chambers, common delivery means in free communication at all times with all of said chambers, a vessel and connections actuated from the interior thereof to control the admission of medium to be cooled, said vessel being in communication with an operative chamber above and below the top of said medium therein to maintain said medium in said chamber at a substantially constant level.

7. Refrigerating apparatus comprising chambers to receive a liquid refrigerating medium, said chambers being arranged so that the operation thereof can be selectively controlled, common delivery means in free communication at all times with all of said chambers and connected to the lower portions thereof by separate risers, a vessel and connections from the interior thereof to control the admission of said medium to be cooled, said vessel being in communication with an operating chamber above and below the top of said medium therein to maintain said medium in said chamber at a substantially constant level.

8. Refrigerating apparatus comprising chambers for a liquid refrigerating medium to be cooled therein, said chambers being arranged for selective operation thereof, common delivery means for said chambers, valveless risers connecting said means to the lower part of each chamber, said means and said risers being in free communication at all times with said chambers, a common supply pipe having valved branches to conduct said medium to said chambers, a controlling valve for said pipe, a vessel containing a float connected to said valve, a header pipe connecting the top of said vessel through valved branch connections to the upper part of said chambers and a connection from the bottom of said vessel to said common delivery means.

9. The method of controlling refrigerating apparatus which consists in maintaining a plurality of chambers in free communication at all times with delivery means, cooling a refrigerating medium in at least one of said chambers, and sealing the outlet of the remaining chambers through the connection of the latter with said delivery means.

10. The method of operating a refrigerating apparatus which consists in selecting one or more chambers of a group thereof, cooling a refrigerating medium at a relatively low pressure in a chamber selected, permitting a higher pressure to arise in the remaining chambers, maintaining all said chambers in free communication at all times with a common delivery means, and sealing the higher pressure in said remaining chambers through the connection of said means with said remaining chambers.

11. Refrigerating apparatus comprising chambers for a liquid refrigerating medium to be cooled therein, connections for selectively controlling the operation of said chambers, delivery means arranged to withdraw said medium from a chamber which is inoperative and to receive cooling medium from the remaining chambers and means for maintaining said medium in any

chamber that is operative at a substantially constant level.

12. Refrigerating apparatus comprising a plurality of chambers for the evaporation of a refrigerant, connections from a common supply to admit a refrigerant to each chamber, free outlet connections communicating at all times with common discharge means from said chambers, vacuum-producing apparatus for each chamber having a common discharge header, and means comprising valves to regulate the refrigerating effect in each chamber by controlling the flow of refrigerant therethrough.

13. Refrigerating apparatus comprising a plurality of chambers for the evaporation of a refrigerant, connections from a common supply to admit a refrigerant to each chamber, free outlet connections communicating at all times with common discharge means from said chambers, vacuum-producing apparatus for each chamber having a common discharge header, and means comprising valves to regulate the refrigerating effect of the apparatus by stopping the evaporation in any chamber.

14. Refrigerating apparatus comprising a plurality of chambers for the evaporation of a refrigerant, connections from a common supply to admit a refrigerant to each chamber, free outlet connections communicating at all times with common discharge means from said chambers, vacuum-producing apparatus for each chamber having a common discharge header, and means to regulate the refrigerating effect of the apparatus by subjecting any chamber to higher absolute pressure than another.

15. Refrigerating apparatus comprising a plurality of evaporating chambers, a vacuum producing device for each chamber whereby a refrigerant is cooled by evaporation of a part thereof, a common header to receive the discharge of the vacuum producing devices, means to supply refrigerant to each chamber, a discharge pipe from each chamber whereby cooled refrigerant may flow freely into a common discharge conduit, and means selectively to suspend the operation of any vacuum producing device to render its chamber inoperative and to subject said chamber to the pressure of the header to discharge the refrigerant therefrom.

16. Refrigeration apparatus comprising a plurality of closed vessels arranged in parallel, means for introducing refrigerant into each vessel, means for withdrawing vapors from each vessel to maintain a vacuum therein and to cool the unvaporized refrigerant, and means providing a liquid seal between the vessels.

17. Refrigeration apparatus comprising a plurality of closed vessels arranged in parallel, each vessel being adapted to contain water as a refrigerant, means for withdrawing vapors of the water from each vessel to maintain a vacuum therein and to cool the unvaporized water, and means providing a liquid seal between the vessels.

18. Refrigeration apparatus comprising a plurality of closed vessels adapted to contain water as a refrigerant, means for withdrawing vapors of the water from each vessel to maintain a vacuum therein and to cool the unvaporized water, and means providing a liquid seal between one of said vessels and each of the other vessels.

19. In refrigerating apparatus, the combination of a plurality of evaporating chambers, a pressure-reducing means for effecting partial evaporation and cooling of liquid within each chamber, means for selectively rendering a plu-

5 rality of said pressure-reducing means operative for a relatively heavy load operation or rendering a smaller number operative for operation at a lighter load, and means for conveying liquid
10 to be cooled through said chambers including conduit means providing communication between said chambers, said conduit means being arranged to provide a liquid seal between said chambers when one of said pressure-reducing means is operative and another is not operative.

15 20. In refrigerating apparatus, a plurality of evaporating chambers, a condenser, a condenser conduit connected to the condenser, an ejector for connecting each chamber with the condenser
20 conduit in order to maintain a vacuous condition in the chamber, each ejector embodying a diffuser conduit affording communication between its associated chamber and the condenser conduit and including a motivating jet, valves for
25 interrupting or permitting the flow of motive fluid to the respective jets, means for admitting liquid to be cooled to said chambers, and means for withdrawing liquid from said chambers in parallel including a valveless sealing connection
30 providing for a pressure corresponding to the condenser pressure in a chamber whose ejector is inactive and a lower pressure in the other chamber or chambers whose ejectors are active.

21. Refrigerating apparatus comprising evaporating chambers for a liquid refrigerating medium which is to be cooled therein, means com-

prising individual vacuum producing devices having a common discharge header for controlling evaporation in said chambers, a common delivery conduit and riser pipes connecting said conduit to the lower portion of each of said chambers
5 arranged to provide a hydrostatic seal for the several chambers.

22. In a refrigerating apparatus employing water as a refrigerant, a plurality of evaporating chambers, means for placing said chambers under vacuum, means for introducing water to said chambers, means comprising a common outlet with individual risers communicating at all times with each chamber to deliver chilled water
10 therefrom, means to cut off the flow of water to any chamber, and means to reduce the degree of vacuum in said chamber, the arrangement being such that the chilled water remaining in said chamber may be discharged therefrom without disturbing the operation of the remaining
15 chambers.

23. Refrigerating apparatus comprising a plurality of evaporator chambers to contain a liquid refrigerant, a pipe to deliver said refrigerant from said chambers, and risers freely connecting
20 at all times said pipe to the lower part of said chambers and forming a trap in which some of the refrigerant can be retained to seal a chamber which is rendered inoperative.

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