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APPARATUS FOR PREPARING POTABLE WATER

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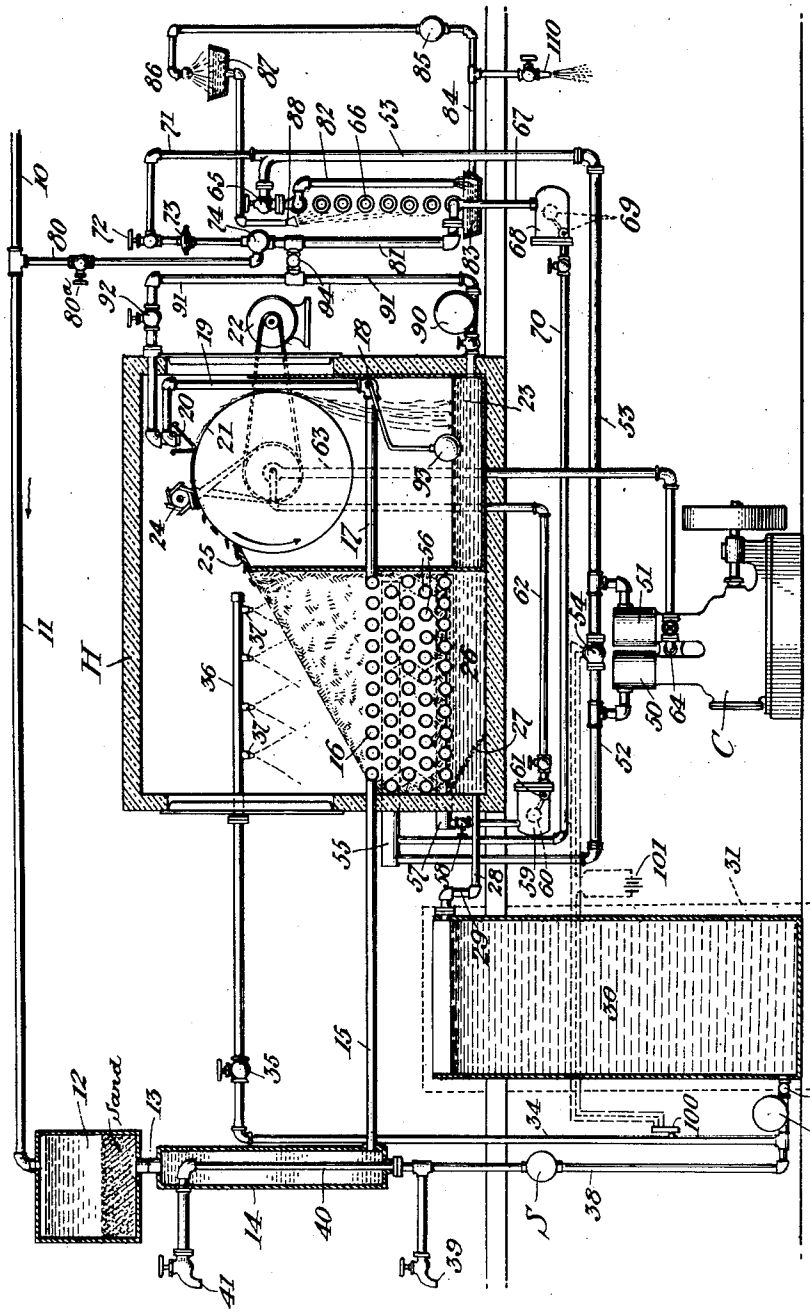

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APPARATUS FOR PREPARING POTABLE WATER

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16 Claims. (Cl. 62—124)

This invention relates to an apparatus and a process for the preparation of potable water through a freezing procedure.

One of the features of the present invention is the preparation of potable water by freezing the same to exclude impurities, through the employment of a refrigerant medium circulating through a condensing and evaporating phase, and the employment of the heat yielded by the refrigerant medium in the condensing phase for the remelting of the frozen water.

Another feature of the invention is the provision of an apparatus and a process in which the excess heat of the circulating refrigerant medium is absorbed by an auxiliary condenser which may be cooled by the waste water containing the impurities which have been excluded during freezing of the purified water.

A further feature of the present invention is the provision of control means for regulating the condensation of the circulating refrigerant medium according to the requirements of the system.

Still another feature of the present invention is the provision of a compressor-condenser-evaporator system employing a plurality of co-ordinated compressor and condenser units in which the compressor units may operate independently with independent condensers, or together so that each condenser receives and liquefies the quantity of circulating refrigerant medium which it is capable of handling.

A still further feature of the present invention is the provision of a structure which is self-contained, and which operates to recover, so far as possible and desirable, the heat produced in the system.

A further feature of the invention is the provision of a system of this type in which is provided a storage for potable water, and means are provided for controlling the operations, these control means being actuated according to the temperature of the stored water.

With these and other objects in view as will appear in the course of the following specification and claims, an illustrative form of practicing the invention is shown on the accompanying drawing.

In the drawing, a raw water inlet pipe 10 has a branch connection 11 leading to a processing device 12 which is illustrated as a filter and softener. The water in the inlet line 10 may be at the temperature of the street conduit, for example, and thus warm water may flow through the connection 13 into a heat exchanger 14 and thus pass by pipe 15 to a coil 16, and thence by a pipe 17 to a float valve 18 and by pipe 19 into a trough 20 from which it flows upon the external surface of a freezing drum 21 which is driven constantly in rotation by a motor 22. The water is delivered from trough 20 in greater volume than can be frozen by the drum and flows down to form a pool 23 beneath the drum. Owing to the well known tendency of running freezing water to purify itself by excluding dissolved and suspended substances, this flowing sheet of water deposits a film of ice upon the surface of the drum 21, while the suspended and dissolved impurities are carried away from the film, and thus water in pool 23 has a greater concentration of impurity than the water entering through pipe 19. As the drum 21 rotates, the built-up sheet of ice is carried forward beneath a chipping device 24 which breaks the sheet into fragments which are thrown and/or rolled down the chute 25 and form a pile above the cooling coil 16, and in melting pass downward through this coil until finally a pool 26 of melted and purified water is collected. A screen 27 is provided in the path of flow of this water to prevent ice particles of major size from moving therewith into the discharge pipe 28 which has a riser trap connection 29 and leads into a purified water storage tank 30 which preferably is lined with glass or other non-pervious and easily cleanable material. The tank 30 is preferably of large capacity so that its temperature varies but little. It may be provided with a heat insulating jacket 31 as shown in dotted lines. A pump 32 takes water from this tank through a shut-off valve 33 and delivers it by a riser pipe 34 past the control valve 35 to the sprayer head 36 having a plurality of individual spray units 37 by which this water is circulated over the ice, so that it is maintained at all times substantially at the freezing point. The pump 32 also delivers water through the discharge pipe 38 to the faucet 39 from which ice-cold water may be withdrawn, for example, for drinking purposes. This water may also be forced through the pipe 40 of the heat exchanger 14 and thus delivered by a faucet 41 at substantially room temperature. Thus it is possible to employ the water from faucet 41 directly for bottling without loss of the "cold" units contained in this water.

The refrigerating medium moves in cycle, in the illustrated form, from compressor to condenser, to receiver, to evaporator and back to the compressor. The compressor C is illustrated

as having two compression cylinders 50, 51, which may have equal volumes of displacement, and discharge past the usual outlet valves into the hot, compressed gas pipes 52, 53 which may be connected together through an electrically operable shut-off valve 54. The pipe 52 leads to the inlet header 55 which extends into the ice pile located above and below the water cooling coil 16, and is provided with a plurality of condensing coils 56 leading to the lower or outlet header 57 which is connected through a stop valve 58 with a receiver 59 having a float 60 therein to control its outlet valve 61 leading to the refrigerant liquid line 62 which passes the liquefied refrigerant into the drum 21, preferably through a hollow axis thereof. As the heat absorbed from the film of flowing water causes evaporation of the refrigerant medium, the gaseous refrigerant is drawn off through the suction line 63 back to a common inlet connection 64 on the compressor.

The hot compressed gas pipe 53 leads to a stop valve 65 and thence to the annular space of a double pipe condenser 66 in which the gaseous refrigerant is condensed so that liquid refrigerant may pass through pipe 67 into the receiver 68 having a float valve 69 therein for controlling the flow of liquid refrigerant by pipe 70 into the inlet manifold 55 of the other condenser. A branch 71 from pipe 53 leads through a shut-off valve 72 to a pressure operated means 73 which controls a valve 74.

A raw water branch pipe 80 leading from the main 10 connects into a water pipe 81 through shut-off valve 80*a* and through valve 74 and thence to the inner pipe of the double pipe condenser 66, from which it escapes by a discharge pipe 82 into a pond 83, from which it may be taken by a pipe 84 and pump 85 and thus passed to a cooling tower illustrated as the spray head 86 and basin 87, and thus returned to a spray 88 from which it is passed over the exterior surfaces of the double pipe condenser 66 and thus back to the pond 83.

Further, the water in pond 23 may be delivered by a pump 90 through pipe 91 and a throttling valve 92 to the trough 20 so that a circulation of water may be maintained from the pond to the drum and back again. As water is frozen by the drum, the level in pond 23 falls and the float 93 operates to open the valve 18 to admit softened water as a "make-up". The throttling valve 92 is maintained at such a point that the pressure within pipe line 91 is greater than the mains pressure in pipes 10, 80 and 81. A branch from pipe 91 leads to pipe 81 and is provided with a bleeder valve 94 so that there is a constant loss of water from pipe 91 into pipe 81. In this way, the concentration of impurities in the water collecting in pond 23 and being recirculated therefrom, may be controlled and kept below a desired maximum by thus permitting the escape of a part of this water through the bleeder valve 94, and replacing it and the water which is converted to ice upon the drum surface, by admitting further softened water at the float valve 18. The ability of this discharged impure water, which passes the bleeder valve 94, to absorb heat, is, however, being employed for the purpose of cooling refrigerant gases in the condenser 66, for example, by admixture with raw water entering from pipe 80 through the control valve 74.

The riser pipe 34 is provided with a thermostat switch 100 which operates to close one circuit at a predetermined low temperature and open a second circuit, and to open this first circuit and close the second circuit at a predetermined higher temperature, so that current from battery 101 will flow to the operating means of the electrically operable shut-off 54 to move the stop valve therein.

In operation, the pumps, compressor and motor 22 are set in motion. The pump 90 then begins circulating water from the pool 23 over the drum, and the latter causes the freezing of a gradually increasing thickness of ice upon the drum. As the level of water in pool 23 drops, float 93 operates to permit replacement water to flow through pipe 19. This replacement water comes from the main after softening, etc., and by its passage through the heat exchanger 14 is brought to a low temperature, and finally is brought to or near to the freezing point in the coil 16.

The ice chipped from the drum 21 by the cutter 24 forms a pile over the coil 16 and thus aids in cooling the water therein, and itself is melted, and passes ultimately to the storage tank 30 from which it is delivered by pump 32 and pipe 34 back over the ice. Thus the water is maintained substantially at the freezing point in tank 30. Water may be drawn from faucet 41 for bottling or other employment after advantage has been taken of its ability to absorb heat, due to its low temperature, from the incoming replacement water. If desired, a sterilizer S, for example, of the ultra-violet ray type may be employed to destroy any bacteria which may remain in the water.

If, for example, the water in tank 30 is at or near the freezing point, the flow through pipe 34 causes operation of the thermostat which closes the "minimum temperature" contact (which by construction and adjustment occurs at or near the freezing point, in such example) and thus serves to cause actuation of the valve 54 to open it so that pipes 52 and 53 are connected directly together.

As the compressor C operates, its cylinders 50, 51 deliver into the pipes 52, 53 which then constitute a manifold for the two cylinders. Hot compressed refrigerant gas may move directly to the header 55 and thus through the cooling coil 56, and also to the annular space in the double-duty condenser 66. Since the coils 56 are being cooled by the pile of ice and the water (which is substantially at the freezing point) coming from this ice, the cooling in the condenser coils 56 is more energetic than in the condenser 66, since the latter is being cooled substantially by water at room temperature. Hence, most of the gas flows into and is liquefied in the condenser coils 56, and thus passes to the receiver 59 and is delivered into the drum, evaporates therein, and returns to the compressor. Any refrigerant gas which liquefies in condenser 66 enters the receiver 68 and passes to the header 55 and thus through the coils 56, where it is, so to speak, "super-cooled" to the temperature of the refrigerant liquefied in the coils 56 and passes to the receiver 59. Since, however, the major portion of the duty of liquefying the refrigerant gas is being accomplished by the refrigerator coils 56, the ability of the pile of ice and the water melted therefrom to absorb heat is being employed in removing heat from these refrigerator coils, and conversely the heat so absorbed causes the water in the pool 26 to become relatively warmer, and thus upon mixing with the

water in tank 30, the contents of the latter are raised to above the minimum temperature established for the system by the point at which the thermostat closes the "minimum temperature" contacts. It will be noted that the flow of water through the spray nozzles 37 permits a constant circulation for this purpose.

When, however, the water flowing in pipe 34 reaches a maximum temperature which is predetermined by the setting of the thermostat 100, it causes the actuation of thermostat switch 100 so that the former or "minimum temperature" circuit is opened, and the "maximum temperature" circuit is closed and thus causes the actuation of the valve 54 into closed position. The cylinders 50, 51 of the compressor C now deliver the hot compressed refrigerant gas into pipes 52 and 53 individually, and substantially equal quantities of gas are thus delivered to the two pipes. The gas entering pipe 52 is thus brought to the header 55 and to the evaporating coils 56, and is liquefied therein and passes to the receiver 59 as before. However, the quantity of gas so delivered is smaller in proportion to the ability of the ice pile and the circulating water from nozzles 37 to absorb heat, and the water in pool 26 becomes colder and soon reaches a temperature at or near the freezing point, and hence by its mixing with the water in tank 30, owing to the circulation above described, the contents of the tank reach a low temperature at which the circulating water again causes the thermostat 100 to change from "maximum temperature" to "minimum temperature" condition. During this time, however, the other half of the gas which has entered pipe 53 is caused to condense in the double-pipe condenser 66 and thus passes to the receiver 68 and is brought to the header 55 as before, for super-cooling.

The branch pipe 80 for leading raw water to the condenser 66 has a shut-off valve 80*a* which may also be employed as a manual regulating valve for determining the quantity of water which may flow in this pipe. The automatic valve 74 which permits the entry of the water from pipe 80 to pipe 81 is controlled by a pressure device 73 actuated by the pressure prevailing in the pipe connection 53 leading to the condenser 66. If the valve 54 is closed, under the conditions above noted, the pressure in the pipe connection 53 is normally increasing gradually, owing to the inability of condenser 66 to cool the refrigerant gas as fast as it enters, and due to the fact that the float valve 69 is preventing the passage of any gaseous refrigerant through the liquid refrigerant pipe 70. For example, the condensing pressure in condenser coils 56 may be around 60 to 65 pounds while the condensing pressure in condenser 66 will depend upon the temperature of the water supply, and may be, say, from 100 to 175 pounds when valve 54 is in closed position and with water entering from pipe 80; but drops to the pressure existing in coil 56 when the valve 54 is in open position, at which pressure some condensation still occurs in condenser 66 due to low temperature of the bleeder water from the pipe 91. The volume of flow through valve 94 is relatively small and practically constant and is of insufficient quantity, even at its low temperature, to effect sufficient condensation in condenser 66 to fulfill the condensing requirements therein when valve 54 is in closed position. To overcome this lack in condensing capacity, as the pressure builds up in the condenser 66 and the pipe 53, the pressure operated device 73 causes the valve 74 to open and admit from the pipe 80 the requisite amount of additional water required. Cold water entering through 94 and mixing with water from valve 74 gives a resultant colder water than if water from valve 74 alone were used for condenser 66, and a consequent slightly lower condensing pressure than water from valve 74 alone would give; hence the reason for mixing the water from these two sources. By connecting the pipe 81 to the bottom of the condenser 66, a counter-current flow of cooling water and of refrigerant is provided, and also the water passages of condenser 66 are maintained full, in lieu of merely receiving a trickle of water as would be the case when the bleeder water were fed into the top of the condenser 66, with the valve 74 closed.

The quantity of water passing valve 74 for a given opening may be regulated by the valve 80*a* as desired.

Thus in effect, it will be noted that while owing to the heat of compression in the compressor, and from other causes, such as leakage through insulation, etc., the heat balance in the cycle comprised of compressor, condenser, and evaporator does not suffice for maintaining a cycle of operation based on the freezing and remelting of water, yet by the inclusion of a second condenser external to this cycle, the heat balance may be restored. Further, it will be noted that the present invention also provides means for automatically controlling the operation of such external condenser.

It will be understood that a system may be constructed as a self-contained and portable unit, ready for connection to current mains and to the house water pipe and waste lines. In the illustrated form, the evaporator drum, ice pile, etc. are shown as enclosed within an insulating housing H to prevent excessive heat losses in cooled portions of the cycles. In the event that a portable unit is desired, water from the house mains may be used by connecting the house mains to pipe 10.

It will be understood that the pond 83 may be of large size in a stationary plant, and that if desired a discharge 110 may be provided for wastage to a sewer. In a portable plant, the pond 83 may be a mere collecting basin, and a recirculating pump 85 and the cooling tower may be omitted.

The heat exchanger 14 operates in counter-current, as the down-coming warm water is brought into heat exchanging relation with the discharging potable water at the upper end of the exchanger in the drawing, while at the lower end of the exchanger 14 the cooled incoming impure water is in contact with the surface, which at its other side is traversed by potable water at very low temperature. Similarly, in the condenser 66, which in the illustrated form is of double pipe type, a counter-current circulation is occurring since the hot refrigerant gas is presented to a surface which is traversed at its other side by the warmest condensing water.

It is obvious that the invention is not limited solely to the constructive embodiment shown, but that it may be modified within many ways of the scope of the appended claims.

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

1. In a water purifying plant, means for com-

pressing gaseous refrigerant, two condensers for receiving the compressed gaseous refrigerant and liquefying the same, an evaporator connected to one of said condensers and providing a chilling surface, means for passing impure water over said chilling surface whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for employing the ice thus formed for cooling one said condenser, independent means for cooling the other said condenser, and devices for controlling the flow of gaseous refrigerant from said compressing means to said condensers.

2. In a water purifying plant, means for compressing gaseous refrigerant, two condensers for receiving the compressed gaseous refrigerant and liquefying the same, an evaporator connected to one of said condensers and providing a chilling surface, means for passing impure water over said chilling surface whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for employing the ice thus formed for cooling one said condenser, independent means for cooling the other said condenser including means for employing discharged water for cooling the other condenser, and devices for controlling the flow of gaseous refrigerant from said compressing means to said condensers.

3. In a water purifying apparatus, a refrigerating plant including two condensers and an evaporator, means for passing impure water over the surface of said evaporator in a circuit whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for admitting water of lesser impurity into the circuit, a bleeder valve for permitting the withdrawal of a portion of said circulating water, means for employing the ice formed on said surface for cooling one of said condensers, means for employing water withdrawn through said bleeder valve for cooling said other condenser, a water mains pipe connection for introducing mains water into said withdrawn water, and a throttle valve in said circulating system to maintain a pressure at connection of said bleeder valve with said circulating water means which is greater than the mains pressure at the outlet of said bleeder valve.

4. In a refrigerating system, two compressors, two independent condensers connected each to one of said compressors, a valve for opening and closing communication between said condensers, and separate cooling means for said condensers.

5. In a refrigerating system, two compressors, two independent condensers connected each to one of said compressors, a valve for opening and closing communication between said condensers, separate cooling means for said condensers, one of said cooling means operating to maintain one condenser at a lower temperature than the other, and means operated when the cooling effect in one said condenser drops below a predetermined point for closing said valve.

6. In a refrigerating system, two compressors, two condensers each having communication with a corresponding compressor, independent cooling means for said condensers, an evaporator, a liquid refrigerant conduit from one condenser to said evaporator, a refrigerant gas return conduit from said evaporator to the compressors, and a liquid refrigerant conduit leading from said other condenser to the inlet of said first condenser whereby said first condenser may operate to super-cool liquid refrigerant from said second condenser.

7. In a refrigerating plant, two compressors, two condensers each having individual pipe connections to a corresponding compressor, independent means for passing cooling medium over said condensers, a valve for establishing communication between said pipes, and means operated by the temperature of the cooling medium passing from one condenser for closing said valve when the said temperature rises and for opening the same when the said temperature falls.

8. A refrigerating plant as in claim 7, in which said one condenser is capable of cooling a larger quantity of gaseous refrigerant than is delivered to it by its corresponding compressor.

9. In a water purifying apparatus, two compressors, two condensers each having an individual pipe connection to a corresponding compressor, a valve through which communication may be established between said pipe connections, an evaporator, a liquid refrigerant conduit from one of said condensers to said evaporator, a gaseous refrigerant return conduit from said evaporator to said compressors, a liquid refrigerant conduit from the other said condenser to the inlet of said one condenser, means for passing impure water over the evaporator whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for employing said ice for cooling said one condenser, and means operated according to the temperature of the melted ice for closing said valve upon a rise of temperature and for opening said valve upon a fall of temperature.

10. In a water purifying and cooling apparatus, a refrigerating plant including a condenser and an evaporator, means for passing impure water over a surface of said evaporator whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for employing the ice thus formed for cooling said condenser and thereby melting the ice, and means for recirculating the water from said melted ice over said condenser and ice.

11. In a water purifying apparatus, means for providing a freezing surface, means for cooling said surface to below the freezing point of water, means for passing impure water over said surface whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, means for employing the ice thus formed for pre-cooling the impure water before its passage over said surface, and means for recirculating the melted ice over said pre-cooling means.

12. In a water purifying apparatus, means for supplying impure water, a heat exchanger, a water coil, means for providing a freezing surface, a conduit extending from said supply means through said exchanger and coil for delivering water over said surface whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity, a refrigerating plant including a compressor and condenser and means for employing condensed refrigerant for cooling said surface, means for employing the ice for cooling said coil and condenser and thereby to melt the ice, and

means for passing the melted ice through said exchanger and over the ice and around said coil and condenser.

13. In a water purifying apparatus, means for supplying impure water, a refrigerating system including two compressors, two condensers, a pipe for each condenser to connect it independently to a corresponding compressor, a valve for establishing communication between said pipes, means for providing a freezing surface, means for cooling the said surface by liquefied refrigerant from said condensers, means for passing water from said supply means over said surface whereby to form pure ice from the same and to discharge therefrom water containing a higher proportion of impurity and including a pre-cooling coil, means for employing the ice thus formed for cooling said coil and one of said condensers, a liquid refrigerant conduit extending from the other said condenser to the inlet of said one condenser, means for passing melted ice in circuit over said coil and said one condenser, and means operated according to the temperature of said melted ice for closing said valve upon rise of temperature and for opening said valve upon fall of temperature.

14. In a water purifying apparatus, an evaporator constructed as a revolving drum, means for providing a collecting pond below the drum, an ice chamber, means for removing ice from said drum and delivering it into said chamber, a compressor, a condenser connected to said compressor and located in said chamber whereby it is cooled by the ice therein, a conduit for passing melted ice from the chamber, a circulating pump and conduit for passing water from said pond and causing it to flow in a circuit over the surface of said drum and back to the pond, a conduit for passing mains water into said circuit and including a valve, and float means operated according to the liquid level in said pond for operating said valve.

15. A water purifying apparatus as in claim 14, including a water pre-cooling coil in said chamber and forming a part of said mains water conduit, a second condenser, means for withdrawing a portion of the water from said circulating conduit and passing it over said second condenser, a gaseous refrigerant conduit leading from said compressing means to said second condenser, and a liquid refrigerant conduit leading from said second condenser to the inlet of said first condenser.

16. In a water freezing apparatus, means for providing a freezing surface and including means whereby liquid refrigerant may be evaporated in proximity to said surface whereby to cool the same, a compressor for the evaporated refrigerant, a condenser for the compressed refrigerant, means for passing the condensed refrigerant to said evaporating means, circulation means for circulating water over said freezing surface, means for discharging a portion of the water from said circulation means at substantially constant volume and passing the water so discharged for cooling said condenser, means including a control valve for admitting mains water for mixing with said discharged water, and means operated according to the pressure of the compressed refrigerant for opening said valve as the pressure rises.

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