

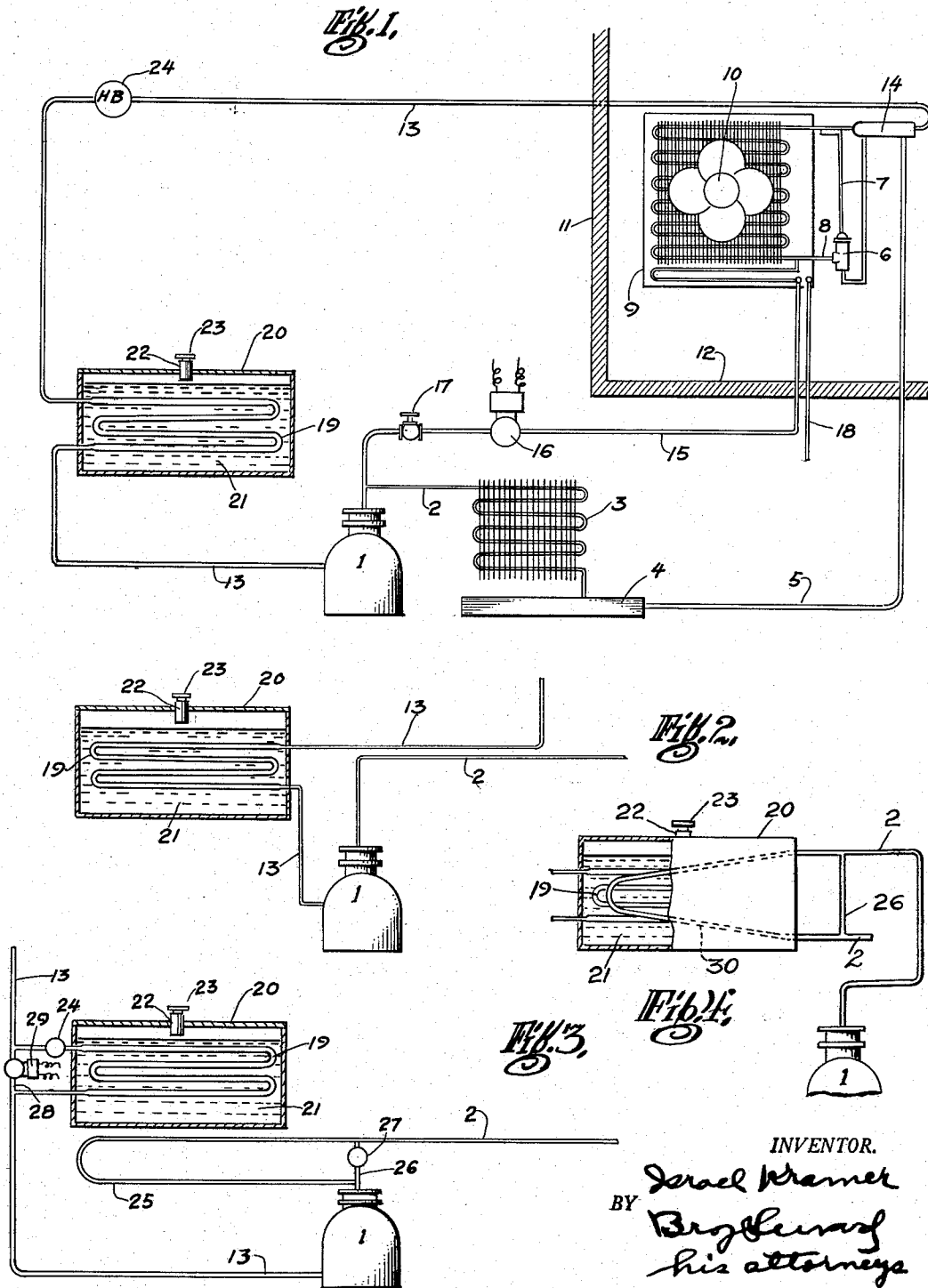
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REFRIGERATING SYSTEM WITH HOT GAS DEFROSTING MEANS

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REFRIGERATING SYSTEM WITH HOT GAS DEFROSTING MEANS

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This invention relates to a refrigerating system with hot gas defrosting means and, generally speaking, is directed to improvements on the system disclosed in my United States Patent 2,440,146, issued April 20, 1948.

An object is to adapt the system to the use of what is now commonly known in this industry as a "low temperature" compressor, and also to provide means for preventing overloading of the compressor motor during periods when the evaporator is being defrosted.

Another object is to simplify the construction of and greatly reduce the size and cost of the means for re-evaporating refrigerant returning to the compressor from the evaporator especially during defrosting periods.

Another object is to provide reevaporating means in which a coil, or the like, is immersed in a liquid which may freeze during defrosting operations and thus give up its heat of fusion to the coil and the refrigerant flowing therethrough for extremely rapid and thorough vaporizing of the latter.

Another object is to provide such reevaporating means in which the liquid that is frozen during defrosting periods will be melted during normal refrigerating periods.

Another object is to provide such reevaporating means in which the liquid may be sealed in a container in which the coil, or the like, is positioned so as to incur no loss of liquid and thus require no replenishing for an indefinite time.

Another object is to provide a system of this character in which the flow of hot refrigerant gas from the compressor discharge is used to warm the suction conduit through which the refrigerant is returning from evaporator to compressor and/or to warm to a regulatable degree the container for the liquid in which the reevaporating coil, or the like, is positioned, and/or the liquid itself.

Another object is to provide means to cause the refrigerant returning from evaporator to compressor to bypass the reevaporating means and its associated pressure reducing device, during refrigerating cycles, for the purpose of reducing friction pressure loss and avoiding excessive super heating of the refrigerant.

A further object is to provide certain improvements in the form, construction and arrangement of the parts whereby the above named and other objects inherent in the invention may be effectively attained.

While the subject matter of the above named U. S. Patent 2,440,146 has enjoyed marked commercial success, especially in the low temperature field of refrigeration, there has been a requirement to include in such a system a heat storage means of considerable size in order to provide adequate heat for rapid defrosting of the evaporator. Also, there has recently been a rapidly increasing commercial use of hermetically sealed compressors and compressors commonly referred to as the "low temperature" type, which, for the sake of economy, have been provided with motors of such low power as to be subject to overloading if the compressor crank case pressure should exceed a certain degree, which may be exemplified as approxi-

2

mately ten pounds per square inch when using a refrigerant such as Freon 12, and the system of the above named patent has been found to lack perfect adaptability for use in connection with such compressors chiefly because it does not embody means positively and unfailingly to prevent overloading of the compressor motor due to crank case pressure exceeding designed limits. It is, of course, possible so to adjust the ratio of the drive between the compressor motor and the compressor, if the parts are accessible, that the motor will to a large extent resist the effect of excessive crank case pressure, but this is not practicable in the case of the hermetically sealed compressors in which the compressor and its motor are permanently sealed in an envelope or casing. The present invention is calculated to eliminate the difficulties just mentioned by providing a system which is ideally adapted to the embodiment of hermetically sealed and low temperature compressors, and also presents its own characteristic features of desirability.

Practical embodiments of the invention are represented in the accompanying drawings, in which:

Fig. 1 represents diagrammatically the layout of a system according to the present invention;

Fig. 2 represents diagrammatically and in detail a modification of one feature of the system shown in Fig. 1;

Fig. 3 similarly represents a second modification thereof; and

Fig. 4 represents a third modification.

Turning to the showing of Fig. 1, the compressor is denoted by 1 and is driven in any approved manner by its motor, not shown, which may be of the kind commonly employed in connection with the above mentioned "low temperature" compressors, and the compressor and its motor may be of the hermetically sealed type if desired. The discharge of the compressor is connected by a conduit 2 with a condenser 3, the outlet of which latter communicates with a receiver 4; both the condenser and receiver being of any approved form either constructed separately or combined as a unit. The outlet of the receiver communicates by a refrigerant supply conduit 5 with any suitable form of pressure reducing device such, for instance, as a thermostatic expansion valve 6, which latter is controlled by the usual feeler bulb and capillary tube denoted generally by 7. The valve 6 is connected by a conduit 8 with an evaporator 9 that is fitted with the usual fan and fan motor denoted collectively by 10; the said evaporator being usually located within a refrigeration chamber, two walls of which are shown and marked 11, 12.

The outlet of the evaporator 9 communicates with a suction conduit 13, and portions of the supply conduit 5 and suction conduit 13 lie adjacent each other within a heat exchanger for elevating the temperature of the refrigerant outflowing from the evaporator through the suction conduit 13. The said heat exchanger 14 may be of any approved construction, which is well understood by those skilled in this industry, and the same is true of the expansion valve 6 and evaporator 9.

The discharge of compressor 1 is also directly connected by a conduit 15 with the inlet of the evaporator 9, as through the usual drip pan (not shown), for the purpose of defrosting the evaporator coil at intervals, as is well understood in this industry; and a solenoid valve 16 is positioned in conduit 15, the opening and closing of the said valve being suitably controlled, as by an electric timer (not shown because the arrangement is so well known in this field) for the purpose of initiating and terminating defrosting operations at desired times. Or, the electric timer may be used to initiate the defrosting, and a pressurestat or thermostat responsive to pressure or temperature at the outlet of the evaporator be used to terminate the same; or other suitable means for the same

3

purpose could be employed. A manual valve 17 may be installed in conduit 15 between the compressor and solenoid valve 16 for shutting the defrosting conduit when servicing the system. A drain pipe 18 is provided, as usual, for removal of the defrosting water from the drip pan of the evaporator.

The suction conduit 13, of course, leads from the outlet of evaporator 9 to the inlet of compressor 1, and a portion of the said conduit is formed into a reevaporating coil 19 which is located within a comparatively small container or tank 20, that may conveniently be rectangular in shape and composed of steel or other appropriate material. The points at which the suction conduit enters and leaves the container 20 are suitably sealed, as by stuffing boxes or the like, for liquid tightness. If desired, the coil 19 may be formed separately from and be connected to the suction conduit 13, and it may be manifolded or not. In all cases, the pipes of the coil should be of larger cross section than the suction conduit to minimize internal friction during refrigerating cycles of the system.

The container is largely filled with a freezable liquid, denoted by 21, such as water with or without any suitable freezing depressant, such, for instance, as denatured alcohol; while a filler neck 22 is tightly fitted in the top of the container and provided with a sealing screw plug or cap 23. The neck 22 projects downwardly a short distance into the container for regulating the height of the liquid therein. The liquid should be of such nature or composition that it will freeze during defrosting cycles at a temperature above that which corresponds to the maximum crank case pressure which the compressor motor will bear without overloading and ceasing to operate, and which will melt during the normal refrigerating cycles. As the container or tank 20 is preferably sealed, there will be no loss of the liquid 21 and hence no occasion for replenishing the same although it is possible, of course, to unseal the plug or cap 23 and inject additional liquid.

Interposed in the suction conduit 13 between the evaporator 9 and the container 20 with its reevaporating coil 19 is an adjustable automatic valve 24 which is marked in Fig. 1 with the letters "HB" to indicate that it is of the type well known to this industry for a long time as a "hold back" valve, the essential function of which is to throttle or control the flow of fluid therethrough so as to reduce the pressure thereof to a degree not higher than that at which the valve has been adjusted to close which, in the present case, and with the use of Freon 12 as a refrigerant, would be approximately ten pounds per square inch; which pressure would not be exceeded at any point from the valve 24 on through to the intake of the compressor 1, thereby preventing stoppage of the compressor motor due to overloading engendered by excessive crank case pressure. It will be understood that the ten pounds pressure just instanced is for the purpose of illustration inasmuch as the pressure at which the valve 24 should be adjusted to close will be determined by the crank case pressure which the compressor motor can withstand without ceasing to operate due to overload, and this will vary in accordance with conditions such as the power of the motor and the ratio of its driving connection to the compressor.

In operation during refrigerating cycles the hot gas from the compressor discharge passes through the condenser 3 where it is liquefied and then deposited in the receiver 4, from which latter the refrigerant, still under pressure, traverses the supply conduit 5 and enters the thermostatic expansion valve 6 where its temperature is reduced and it flows through the evaporator 9 to perform its chilling effect within the refrigeration chamber 11, 12, all as is usual and well understood in the refrigeration field. In passing through the evaporator, the refrigerant is largely, if not entirely, vaporized and flows through the suction conduit back to the inlet of compressor 1, for recompression and repetition of the refrigerating cycle. As the refrigerant flowing back to the compressor through

4

the suction conduit is largely in gaseous form it flows freely through hold back valve 24, and also through the reevaporating coil 19 in the container or tank 20 while retaining its form as a gas and, therefore, is readily subject to recompression by the compressor 1.

When the accumulation of frost on the evaporator calls for a defrosting cycle, the solenoid valve 16 is opened by its control and the hot gas flows from the compressor discharge through conduit 15 to the evaporator and, in passing through the latter, melts the frost thereon. This action condenses the gas and it flows from the evaporator largely in the form of liquid. When the latter reaches the hold back valve 24 the latter throttles the flow to establish and maintain a pressure from the outlet of the said valve to the compressor crank case which is no higher than the compressor motor will bear without ceasing to operate. Thus, in effect, the valve 24 then serves as an expansion valve greatly to reduce both pressure and temperature of the liquid refrigerant. This low temperature fluid flows through the reevaporator coil 19 and freezes the liquid 21 in the container or tank 20, and the latent heat of fusion thus generated serves thoroughly to reevaporate the refrigerant liquid so that it passes to the compressor inlet as a gas susceptible to compression without danger of hampering the operation of or damaging the latter, as would be the case if liquid refrigerant entered its inlet. Furthermore, the reduced pressure of the refrigerant, due to the action of hold back valve 24, prevents overload on the compressor motor.

The effectiveness of the reevaporator 19, 20, 21, may be illustrated by noting that, if the liquid 21 is water, it will give up to the coil 19, which it surrounds or bathes, approximately 144 B. t. u.'s per pound of water, at 32° F. to ice at 32° F., thus making it practicable to have the container 20 of small size with a marked saving in expense of construction and space. Similarly, the reevaporated refrigerant is supplied to the compressor at such elevated temperature as greatly to add to the potency of defrosting cycles which completely defrost the evaporator in a few minutes. Again, no insulation is required for the container or tank 20, as the outer surface thereof usually does not cool to the dew point.

Following each defrosting cycle, the solenoid valve 16 is automatically closed and the system returns to a refrigeration cycle in which the refrigerant that has been vaporized in the evaporator 9 and has thus been elevated in temperature, flows to the reevaporating coil 19 and melts the ice coating thereon. This action is augmented by the function of heat exchanger 14 which, through the juxtapositioning of the refrigerant supply conduit 5 and the suction conduit 13, serves to elevate the temperature of the refrigerant flowing through the latter from the evaporator to the reevaporator, and the result is not only to melt the ice surrounding the coil 19 in container 20, but also to raise the temperature of the melt, and hence the container, sufficiently to maintain the temperature of the latter above the dew point of the ambient air and prevent, or at least minimize, sweating of the container during the brief duration of each defrosting operation.

It has hereinabove been indicated that, instead of using plain water as the liquid 21 within the container or tank 20, a solution having a lower freezing point than water may be employed, and this is desirable when the general level of refrigerant temperature during the refrigerating cycle in the system is lower than is commonly the case. However, the solution 21 in container 20 should always have a freezing temperature which is higher than that which corresponds to the maximum crank case pressure which the compressor motor will bear without ceasing to operate, for which pressure at its outlet the hold back valve 24 is set or adjusted. It may be added that, when such a liquid having a freezing point lower than water is used, the ice formed therefrom during defrosting periods can be melted at a lower temperature during refrigerating

5

cycles than is the case when plain water is used in the container 20.

The modification illustrated in Fig. 2 is the same as Fig. 1 except that, instead of relying upon the heat exchanger 14 for elevating the temperature of the refrigerant flowing from the evaporator 9 through the suction conduit 13, a portion of the hot gas conduit 2 leading from the compressor discharge is positioned in heat exchange relation with a portion of the suction conduit 13 near the point at which the latter enters the reevaporator container or tank 20. The fact that the conduits illustrated in Fig. 2 are arranged somewhat differently from the showing of Fig. 1 is merely for convenience in illustration and is not functional other than in respect to the heat exchange relation between conduits 2 and 13 just mentioned.

The modification represented in Fig. 3 differs from the showings of Figs. 1 and 2 in several respects. The hot gas conduit 2 is here formed with a loop 25 of which a portion extends in heat exchange relation with the container 20 for the purpose of elevating its temperature and that of the liquid therewithin. The heating effect of this portion of the hot gas conduit is made regulatable by a by-pass pipe 26 that interconnects the loop of the conduit at two points near the compressor discharge and is fitted with a valve 27, which may be manual or automatic, such as solenoid or thermostatically controlled. It will be seen that the closing of valve 27 will compel all the hot discharge gas to traverse the loop 25 with maximum heating effect upon the container 20; while partial opening of the valve will permit part of the hot gas to flow to the condenser 3 without passing through loop 25 and thus lessen the heating effect upon the container 20; and full opening of the valve will more sharply reduce such heating effect. In place of the valve 27, the amount of refrigerant flow through loop 25 may be adjusted by varying the relative internal cross-sectional size of the loop and pipe 26; the larger the relative size of the latter the lesser the flow through the loop. And similar adjustments can be obtained by installing orifices of varying sizes in the by-pass 26.

This modified form of the invention shown in Fig. 3, also includes an arrangement whereby the suction line refrigerant may be caused to by-pass both the hold back valve 24 and reevaporator 19, 20, 21, in returning from evaporator 9 to compressor 1. This is obtained by locating valve 24 close to the container 20, and inserting a bridging tube 28 which interconnects points of the suction conduit 13 in such a manner as to cut out both the valve 24 and coil 19. In the tube 28 is positioned a valve 29, which may be of any suitable automatic type, such as solenoid controlled, and connected so as to be open during refrigerating cycles of the system and closed during defrosting cycles. In this way the friction pressure drop due to passage through valve 24 and coil 19 will be eliminated during refrigerating cycles, as will also an undesirable degree of superheating of the refrigerant gas stream; while, during defrosting periods, the refrigerant will be compelled to traverse both the valve 24 and coil 19 for complete reevaporation as heretofore explained. By the elimination of friction pressure drop due to passage through valve 24 and coil 19, lessening of compressor capacity is avoided; while the elimination of an undesirable degree of superheating escapes deleterious effect upon lubrication and excessively high compressor discharge temperature. The tendency to an undesirable degree of superheating of the refrigerant is often noticeable in systems where the suction conduit 13 is long and where back pressure is low. Thus, this provision of the form of the invention set forth in Fig. 3, notably increases the refrigerating efficiency of the system, and also promotes safety in operation. It likewise permits the maximum of heat input to the reevaporator 19, 20, 21, during refrigerating cycles, without undesirably superheating the suction gas stream, which enhances its effectiveness

6

during defrosting and permits the use of reevaporating means of small size. Should conditions so dictate, the suction conduit 13, may be insulated.

It is realized that the opening of valve 29 in Fig. 3 brings two portions of the suction conduit, i. e., tube 28 and coil 19, into parallelism for the flow of refrigerant with the major portion passing through tube 28 due mainly to the effect of valve 24. The differential in the flow through the two courses will be determined by the setting or adjustment of valve 24 which, indeed, may be set to inhibit all flow through coil 19 during refrigerating cycles, while permitting such flow during defrosting cycles when valve 29 is closed. Under such conditions, the coil 19 will not functionally constitute a portion of the suction conduit when refrigerating as it does in the forms of the invention shown in Figs. 1 and 2. Nevertheless, structurally, the coil 19 is connected as part of the suction conduit in all forms of the invention in readiness for functional activity. Thus, when in the claims I refer to the liquid container as enclosing a portion of the suction conduit, I intend the language to be generically construed so as to cover all forms of the invention.

In Fig. 4, the showing of Fig. 3 is modified by changing the shape of the hot gas line loop, here marked 30, and positioning it in a non-horizontal (preferably vertical) plane within the container 20 with the points at which the loop enters and leaves the container suitably sealed for liquid tightness. The change in shape of the loop consists essentially in adopting a formation, such as the V-shape shown, whereby the sides of the loop flare away from its end so as to induce thermosiphonic action therewithin which automatically regulates the flow of hot gas therethrough according to the temperature of the liquid 21 in the container, and eliminates the provision of valve 27 or any kind of restricting device in the by-pass pipe 26. By this automatic thermosiphonic action, the lower the temperature of the liquid 21, the greater the flow of hot gas through loop 30, and vice versa. In other words, the greater the temperature differential between the liquid in the container and the hot gas from the compressor, the greater the thermosiphonic urge for the flow of gas through the loop 30 rather than through the by-pass pipe 26; so that the action is automatically self-regulating without the necessity of providing any valve or equivalent device. A similar functional performance is obtainable by locating the loop 30 in heat exchange relation with the exterior of either vertical side or end of the container 20.

Referring to all the embodiments of the invention, it will be observed that, according to the principle of operation, ice, as distinguished from frost, is formed on the reevaporator coil 19 during defrosting periods when the frost coating is being removed from the evaporator 9; while, during refrigerating periods, the ice on reevaporator coil 19 is being melted as the coating of frost accumulates on evaporator 9. This cyclic succession is of notable value in respect to efficiency. It may be added that the system attains to a high degree all the objectives hereinbefore mentioned and is desirable not only from the point of view of its functioning, but also in regard to the item of economy in expense and space, particularly with respect to the reevaporator unit 19, 20, 21. Should it be desired, provision may be made for heating the liquid 21 in container 20 by any well known or appropriate means, such, for instance, as an electric heater or a steam or hot water coil.

It will be understood that various changes may be resorted to in the form, construction, material and arrangement of the several parts without departing from the spirit or scope of the invention; and hence I do not intend to be limited to details herein shown or described, except as the same may be included in the claims or be required by disclosures of the prior art.

What I claim is:

1. In a refrigerating system including motor driven

compressor, condenser, evaporator, a supply conduit connecting condenser with evaporator, a suction conduit connecting evaporator with compressor, and a hot gas defrosting conduit connecting compressor discharge with evaporator, means positioned in the suction conduit between evaporator and compressor for reevaporating liquid refrigerant flowing from evaporator to compressor during defrosting cycles of the system, said reevaporating means comprising, a liquid container enclosing a portion of the suction conduit, a liquid within the container which bathes the said portion of the suction conduit and is adapted to freeze and impart thereto latent heat of fusion which serves to vaporize liquid refrigerant within said portion of the suction conduit, and a refrigerant pressure and temperature reducing device positioned in the suction conduit between the evaporator and the reevaporating means and adapted to lower the temperature of the refrigerant to a degree adequate to freeze at least part of the liquid within the container.

2. A system as defined in claim 1, in which the liquid in the container is freezable at a temperature above that which corresponds to the maximum compressor crank case pressure at which the compressor motor will continue to function.

3. A system as defined in claim 2, in which the frozen liquid in the container is meltable by the refrigerant flowing through the suction conduit during refrigerating cycles of the system.

4. A system as defined in claim 1, in which the liquid within the container is freezable at a temperature above that which corresponds to the maximum compressor crank case pressure at which the compressor motor will continue to function, and which also embodies means for elevating the temperature of the liquid in the container during refrigerating cycles of the system.

5. A system as defined in claim 4, which also embodies means for regulating the amount of heat supplied

to the liquid in the container for elevating its temperature.

6. A system as defined in claim 5, in which the said regulating means is constructed and arranged for functioning thermosiphonically in response to the existing temperature differential between the liquid in the container and the heat supplied.

7. A system as defined in claim 1, which also embodies valve controlled means connected with the suction conduit and adapted to by-pass said pressure and temperature reducing device to lessen friction pressure drop of the refrigerant.

8. A system as defined in claim 1, which also embodies valve controlled means connected with the suction conduit and adapted to by-pass said reevaporating means to avoid superheating of the refrigerant.

9. A system as defined in claim 1, which also embodies valve controlled means connected with the suction conduit and adapted to by-pass both said pressure and temperature reducing device and the reevaporating means to lessen friction pressure drop and superheating of the refrigerant.

10. A system as defined in claim 1, in which the compressor is of the low temperature type.

11. A system as defined in claim 1, in which the liquid in the container has a freezing point lower than water.

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