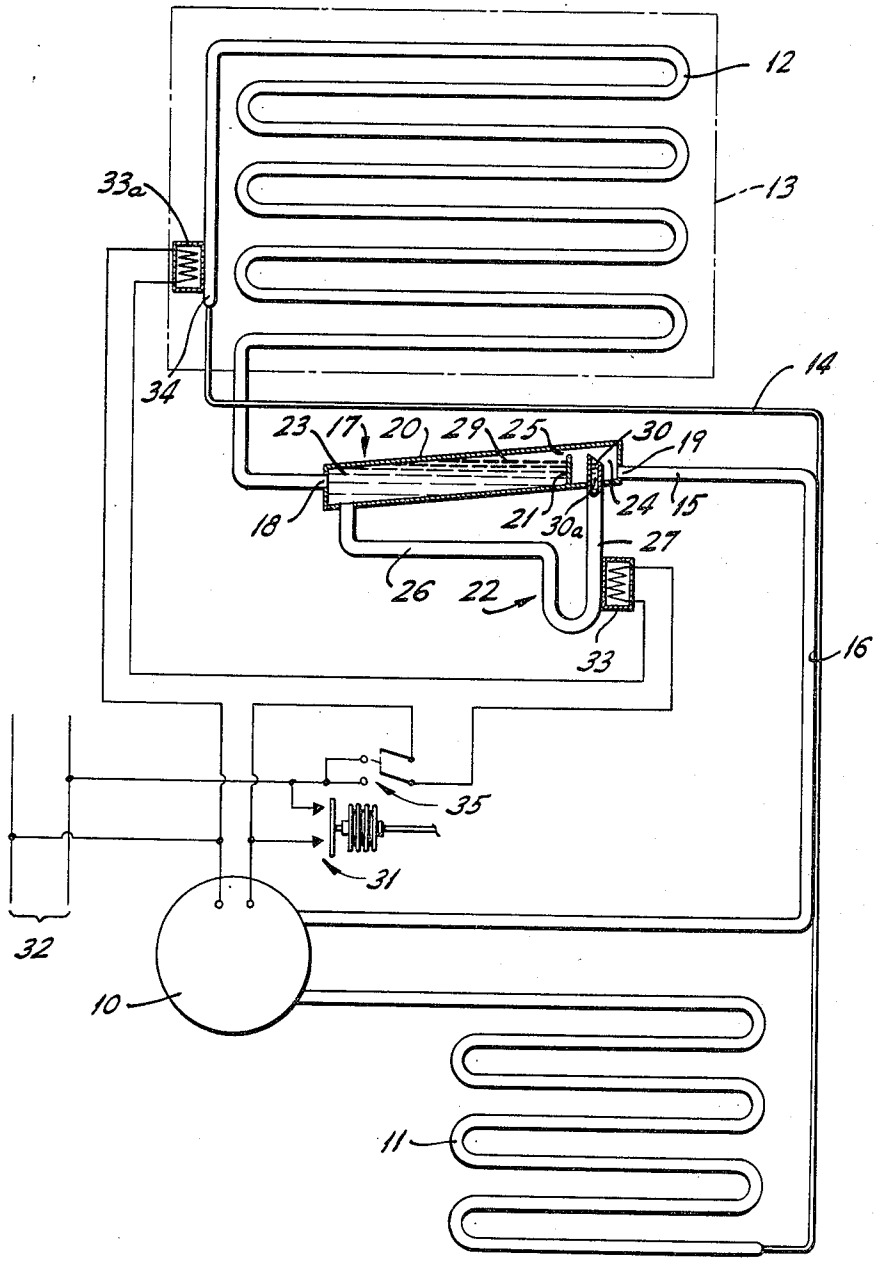
May 31, 1955 E. W. ZEARFOSS, JR 2,709,342

DEFROSTING REFRIGERATION SYSTEM

Filed Oct. 8, 1953



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United States Patent Office

2,709,342

Patented May 31, 1955

2,709,342

DEFROSTING REFRIGERATION SYSTEM

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Application October 8, 1953, Serial No. 385,017

19 Claims. (Cl. 62—4)

The present invention relates to refrigeration systems in which provision is made for selective operation of a heat exchanger either to effect cooling of its surfaces so as to produce refrigeration, or to effect heating of its surfaces to melt frost accumulated thereon.

In a general sense, the invention concerns an arrangement in which defrosting of an evaporator is accomplished by means of hot gaseous refrigerant which is admitted into the evaporator and permitted to condense therein. In a more limited sense, the invention herein disclosed and claimed has to do with improvements in a defrostable refrigeration system, which improvements principally reside in the provision of novel construction and association of component elements which co-function to create within the system a condition whereby liquid refrigerant is caused to flow out of the evaporator simultaneously with introduction of hot gaseous refrigerant into the evaporator.

Attempts have heretofore been made to attain the results contemplated by this invention. However, certain of these attempts have been unsuccessful, particularly in that there was a failure to recognize that condensate which forms in the evaporator during a defrost cycle will reevaporate in said evaporator and impede the defrosting action unless provision is made to insure the availability of sufficient refrigerant to sustain the formation of gaseous refrigerant for continuous feeding to the evaporator.

More recent developments have taken the above-noted difficulty into account, and systems have been devised in which an excess of liquid refrigerant is stored in the circulating circuit during normal or refrigerating operation. In these previous systems, the excess refrigerant is released upon initiation of a defrost cycle and, during the defrosting process, circulates through the system in such a manner that only condensation occurs in the evaporator and reevaporation takes place in the suction line and the compressor housing. Although these latter developments represent noteworthy advancements in the art, they nevertheless are still subject to certain objections not only because they required more refrigerant than is necessary for normal refrigeration, but also because they involve the utilization of special valve means to effect control of the systems.

It is an object of the present invention to provide a simplified construction and association of elements which makes it possible to effect thorough defrosting of an evaporator with unusual rapidity.

It is a further object of the invention to provide a defrostable refrigerating system in which the charge of liquid refrigerant need not exceed that required for normal refrigeration.

Another object of the invention resides in the provision of a system in which liquid refrigerant normally present in the evaporator during the refrigerating operation, as well as liquid refrigerant which results from condensation during the defrosting operation, is promptly

removed and fed to the suction line upon initiation of and throughout the defrosting process.

It is also a feature of the invention that initiation of the defrosting operation may be accomplished without the use of valves, and that simple and inexpensive means may be utilized to modify the normal flow of refrigerant within the system in order to bring about and to maintain said operation.

The invention is further characterized by the provision of a novel arrangement which, upon initiation of a defrost cycle, insures the presence of gaseous refrigerant at certain predetermined portions of the systems so as to bring about simultaneous extraction of liquid refrigerant from the evaporator and introduction of gaseous refrigerant into said evaporator.

In achievement of the above-mentioned general objectives and features, the invention employs means disposed at the outlet side of the evaporator and normally serving to trap liquid refrigerant which circulates through the evaporator to provide for normal refrigeration. In particular accordance with the invention, said means is supplied with instrumentalities which, upon initiation of and during a defrost cycle, act in a fashion similar to that of a percolator and which so affect the hydrostatic condition, existing in the system during refrigerating operation, that liquid refrigerant is caused to flow into the suction line for evaporation therein. Also, in particular accordance with the invention, the control arrangement which functions to initiate a defrost cycle by bringing about the above-stated action, further functions to convert cold liquid refrigerant which flows from the condenser and through the restrictor, into hot gaseous refrigerant, this hot gaseous refrigerant being then fed to the evaporator for condensation therein. In a practicable embodiment of the invention, the control arrangement which produces the above-noted change in hydrostatic condition and which brings about the above-mentioned change of state of the refrigerant, takes the convenient form of an electrical circuit incorporating electric heating means.

Other features, as well as the manner in which the above-stated objects and advantages are best realized, will be fully understood from the following description taken in conjunction with the accompanying drawing, the single figure of which is a diagrammatic representation of a refrigerating system embodying the present invention.

With detailed reference to the drawing, it will be seen that the illustrated embodiment of the invention includes a compressor 10, a condenser 11 and an evaporator 12, the latter being disposed in heat exchange relation with a compartment or zone diagrammatically illustrated by the broken lines identified at 13. These elements are connected in series flow circuit by means of suitable conduits and connections which include a restrictor or capillary tube 14 and a suction line 15. As is customary, and as is represented at 16, portions of said capillary tube and suction line are disposed in heat exchange relation.

As shown in the drawing, a header 17, which serves to trap refrigerant, is interposed in the system between the outlet end portion 18 of the evaporator and the inlet end portion 19 of the suction line 15. This header conveniently takes the form of an elongated tank or cylinder 20 disposed with its longitudinal axis in a generally horizontal position.

In especial accordance with the invention, the header 17 is provided with means which allows it to function, at times, as a percolator. For that purpose, said header is supplied with an internal upwardly projected wall or partition 21 and with an external downwardly projected generally U-shaped tube 22. It will be noted that, as

illustrated in the drawing, the partition **21** is disposed within the header to divide the interior thereof into a larger chamber **23** and a smaller chamber **24**, the evaporator discharging into said larger chamber and the suction line leading from said smaller chamber. It will also be noted that said partition **21** terminates at a slight distance from the upper inner surface of the header to provide a passageway **25** between said chambers. As illustrated in the drawing, one leg **26** of the U-shaped tube extends laterally for connection with a lower portion of the header **17** and for communication with said larger chamber **23** at a point adjacent the connection of said header with the outlet end portion **18** of the evaporator, and the other leg **27** of said tube extends upwardly and enters said header to communicate with said smaller chamber **24**, said other leg being projected to terminate at a point adjacent the upper inner surface of said header. According to the invention, the system is charged with a predetermined quantity of refrigerant to insure that liquid refrigerant fed through the evaporator to cool the same, will accumulate in the larger chamber **23** of said header but will not exceed a level which, as indicated at **29**, is below the passageway **25** and, as indicated at **30**, is below that end of the leg **27** which opens into the smaller chamber **24**. In this manner, liquid which fills the U-shaped tube and rises in said leg **27**, does not spill out but, due to hydrostatic forces, stops at a level corresponding to the level in said larger chamber. Accordingly, it will be understood that the leg **27** of the U-shaped tube is adapted to provide a static liquid column **30***a*.

In operation of the system so far described, compressed refrigerant from the compressor **10** enters the condenser **11** where said refrigerant liquifies. From the condenser, liquid refrigerant flows through the capillary tube **14** which subjects the refrigerant to a pressure reduction prior to its delivery to the evaporator. The refrigerant which emerges from the capillary tube circulates through the evaporator, and liquid passing out of the latter accumulates in the larger chamber **23** of the header **17**, as was hereinbefore indicated. The flash gas together with the gas resulting from evaporation of liquid within the evaporator, bubbles through the liquid and escapes by way of the passage **25** into the smaller chamber **24** of said header from which the gas is withdrawn through the suction line **15** and into the compressor for reprocessing and recirculation through the system.

As is customary, this normal operation of the system occurs cyclically in accordance with determinations of a temperature-sensitive switch device **31** which is responsive to pressure of a vaporizable fluid contained within a feeler bulb (not shown), which bulb is preferably disposed in heat exchange relation with the evaporator or with the compartment or zone to be cooled. Closing of the switch device **31** places the motor of the compressor across an electrical power supply line **32**, and thus energizes said compressor for circulating refrigerant through the system to produce refrigeration when the temperataure of the evaporator or of the air in said compartment so demands.

As was hereinbefore explained, during the above-described normal or refrigerating operation there exists in the system a hydrostatic condition by reason of which the liquid in the chamber **23** of the header **17** and in the upstanding leg **27** of the U-shaped tube **22** remains substantially at the level indicated.

In accordance with the invention, defrosting of the evaporator is initiated by unbalancing this hydrostatic condition and, simultaneously, causing liquid refrigerant to be converted to gaseous refrigerant before entering the evaporator. For that purpose, means is associated with the system to apply heat to appropriate portions thereof in order to act on the liquid within the U-shaped tube so as to unbalance the hydrostatic forces in said system, and in order to act on liquid refrigerant flowing into the evaporator so as to effect the mentioned conversion of liquid refrigerant to gaseous refrigerant.

As illustrated in the drawing, said means comprises a pair of electrical heaters, one heater **33** being disposed in heat exchange relation with a lower portion of the upstanding leg **27** of the U-shaped tube **22**, the other heater **33***a* being disposed in heat exchange relation with a refrigerant conduit portion at or adjacent to the inlet **34** of the evaporator. These heaters are controlled by actuation of a switch **35** and are conveniently connected in series and included in the electrical circuit which controls the operation of the compressor motor. As shown in the illustrated embodiment, the switch **35** is of the single-throw double-pole type and is so arranged in the electrical circuit that the compressor is energized simultaneously with energization of the heaters **33** and **33***a*, even if the switch device **31** should be open at the time said switch **35** is closed.

With initiation of a defrosting cycle, which occurs upon closing the switch **35**, heat supplied by the heater **33** and applied to the base of the liquid column in the upstanding leg **27** of the U-shaped tube vaporizes some of the liquid and, as a result, so lightens said column that liquid rises above the indicated normal level **30**. Under this condition, liquid spills out of said leg into the chamber **24** of the header and flows into the suction line **15** where said liquid evaporates. Liquid refrigerant which fails to evaporate in the suction line passes into the compressor housing, where the evaporation is completed before the refrigerant is pumped through the compressor. It will be apparent that the spilling of liquid refrigerant from the leg **27** of the U-shaped tube, causes liquid refrigerant normally trapped in the chamber **23** of the header and liquid refrigerant normally present in the evaporator to drain out, the drainage being advantageously assisted by mounting said header so as to slant slightly toward the inlet end of said U-shaped tube. Simultaneously with the action above-described, heat supplied to the heater **33***a* and applied at or adjacent the entrance to the evaporator causes liquid refrigerant which emerges from the capillary tube **14** to be converted into gaseous refrigerant. This gaseous refrigerant enters the evaporator and condenses therein by giving up heat to the evaporator surfaces, thus melting the frost accumulated thereon. The condensate which results from this condensing and defrosting process is continually withdrawn due to the continuing percolating action taking place in the U-shaped tube.

It is to be noted that the flow of liquid refrigerant out of the header and the evaporator is accelerated by the combination of the continual percolating action which takes place in the U-shaped tube and the concurrent expelling action which is brought about by the flowing of gaseous refrigerant into the evaporator. It will be appreciated that this accelerated flow of liquid refrigerant out of the evaporator is accompanied by an accelerated flow of gaseous refrigerant into the evaporator and, as a result, defrosting is accomplished much more quickly than would be the case if the out-flow of liquid refrigerant were to depend solely upon either the percolating action or the inflow of gaseous refrigerant.

It is to be understood that in practice, instead of the two heaters illustrated in the diagrammatic showing of the drawing, a single heater may be employed to apply heat at the two portions of the system as hereinbefore described. The use of a single heater is readily feasible by the simple expedient of so relating the elements of the system that said two portions are in such close proximity that a single heating structure can be mounted in heat exchange relation with both of said portions. It will also be understood that the switch **35** which controls the operation of the system for defrosting may be actuated either manually or automatically. In that latter instance any one of the several suitable arrangements which are generally known in the art may be employed. Moreover, it will be understood that, in practice, the header **17** and

its associated U-shaped tube would be enclosed in insulation, so that liquid refrigerant trapped in said header and tube is not affected by heat transfer with the ambient atmosphere.

From the foregoing description, it will be appreciated that the present invention provides a defrostable refrigerating system which is characterized by the extraordinary rapidity with which defrosting of the evaporator can be accomplished. Moreover the arrangement, including the liquid trapping header which is disposed at the outlet of the evaporator and which is associated with means to cause the flow of liquid refrigerant from said header into the suction line at the beginning of and throughout a defrosting cycle, is uniquely distinct in that it eliminates the necessity of utilizing in the system a surplus quantity of refrigerant which is stored during a refrigeration cycle and is released to flow through the system during a defrost cycle. Particularly it will be appreciated that an unusual arrangement which distinguishes the invention is the means disposed at or adjacent the outlet and the inlet sides of the evaporator to cause removal of liquid refrigerant from the evaporator simultaneously with conversion of liquid refrigerant into gaseous refrigerant for feeding to the evaporator. This unusual arrangement provides for the availability of ample liquid refrigerant for delivery to the suction line substantially instantaneously with initiation of a defrost cycle, as well as continuously throughout the defrosting process.

I claim:

1. An arrangement for controlling the operation of a defrostable refrigerating system provided with an evaporator and refrigerant circulating means adapted, under one condition of operation, to pass liquid refrigerant to said evaporator to cool the same and, under another condition of operation, to pass gaseous refrigerant to said evaporator to heat the same; said arrangement comprising: a refrigerant trap connected with the outlet of said evaporator and having a conduit portion in which liquid refrigerant accumulates in a static column which, during said one condition of operation, prevents the escape of liquid refrigerant from said trap through said conduit portion; and a control arrangement for initiating said other condition of operation and including means to apply heat to said column of liquid refrigerant in said conduit portion of said trap to provide for the presence of evaporated refrigerant within said portion to affect said column of liquid refrigerant in such manner as to cause liquid refrigerant which is present in said trap and evaporator to flow therefrom and to escape through said conduit portion.

2. An arrangement for selectively controlling the flow of refrigerant through an evaporator either to cool or to heat the same, comprising: a refrigerant receiving header connected with the outlet of the evaporator and having a portion in which liquid refrigerant accumulates after circulation through said evaporator to cool the latter; passage means leading from said portion of said header at a point normally above the level of said accumulated liquid refrigerant and providing for the escape of refrigerant which evaporates in circulating through said evaporator; conduit means leading from said portion of said header at a point normally below the level of said accumulated liquid refrigerant and having a portion for trapping liquid refrigerant in a static column which normally prevents the escape of liquid refrigerant through said conduit means; and a control arrangement including means operable to apply heat to liquid refrigerant in said portion of said conduit means to provide for the presence of evaporated refrigerant within said portion to affect said column of liquid refrigerant in such a manner that liquid refrigerant which is present in said header and evaporator flows therefrom and escapes through said conduit means, said control means being also operable to apply heat to liquid refrigerant adjacent the inlet of the evaporator to provide gaseous refrigerant for circulation and condensation in said evaporator to heat the latter.

3. An arrangement as set forth in claim 2, in which the mentioned header is internally divided to provide an inlet chamber and an outlet chamber, and in which the mentioned passage means and conduit means lead from said inlet chamber and discharge into said outlet chamber.

4. An arrangement as set forth in claim 2, in which the mentioned control means is electrically operated.

5. A defrostable refrigerating system comprising: a compressor, a condenesr, an evaporator, and conduits including a restrictor and a suction line connecting said compressor, condenser, an evaporator in series flow circuit; refrigerant passage means interposed between said evaporator and said suction line and including a substantially vertical section receiving liquid refrigerant from said evaporator and adapted normally to trap said liquid refrigerant in a static column which prevents the flow of liquid refrigerant through said passage means, control means operable to apply heat to said section at a portion where said static column of liquid refrigerant is trapped therein to affect said column of liquid refrigerant in such a manner that liquid refrigerant flows from said evaporator through said passage means and into said suction line for evaporation therein, said control means also being operable to apply heat at a portion of said system between said restrictor and said evaporator to convert liquid refrigerant into gaseous refrigerant for feeding into the evaporator; and means for operating said control means at selected times.

6. A defrostable refrigerating system as set forth in claim 5, in which the mentioned control means is electrically operated.

7. A defrostable refrigerating system as set forth in claim 5, in which the mentioned control means includes a pair of electrical heaters, one of said heaters being arranged in heat exchange relation with said portion of said section and the other of said heaters being arranged in heat exchange relation with said portion of the system.

8. A defrostable refrigerating system as set forth in claim 7, in which the two heaters are connected in series, and a switch common to both heaters simultaneously energizes said heaters.

9. A defrostable refrigerating system comprising: a compressor, a condenser, an evaporator, and conduits including a restrictor and a suction line connecting said compressor, condenser and evaporator in series flow circuit; a header divided into two chambers, one of said chambers communicating with the outlet end portion of said evaporator and the other of said chambers communicating with the inlet end portion of said suction line, said one of said chambers being adapted normally to trap liquid refrigerant flowing from said evaporator; means defining a passage leading to said other of said chambers from a point above the level of the liquid refrigerant trapped in said one of said chambers to pass evaporated refrigerant into said other of said chambers and through said suction line into said compressor; means defining a second passage leading to said other of said chambers from a point below the level of the liquid refrigerant trapped in said one of said chambers and having a generally vertical section extending into said other of said chambers to a point above said level so that liquid refrigerant in said section normally rises in a column up to a level corresponding to the level of the liquid refrigerant in said one of said chambers and is normally prevented from pasing into said other of said chambers; heat generating means arranged in heat exchange relation with said second passage and with a part of the refrigerant circulating system adjacent the entrance to said evaporator, said means being operable to cause liquid refrigerant in said section to rise above said level and to flow out of said second passage thereby providing for the flow of liquid refrigerant from said evaporator through said section and into said other of said cham-

bers for passage into said suction line to evaporate therein, said means being also operable to cause liquid refrigerant flowing from said restrictor to be converted into gaseous refrigerant for feeding into said evaporator to condense therein; and means for operating said heat generating means at selected times.

10. A defrostable refrigerating system as set forth in claim 9, in which the mentioned heat generating means is electrically operated.

11. A defrostable refrigerating system as set forth in claim 9, in which the mentioned heat generating means includes a pair of electric heaters, one of said heaters being arranged in heat exchange relation with said second passage and the other of said heaters being arranged in heat exchange relation with said part of the system adjacent the entrance to the evaporator.

12. A defrostable refrigerating system as set forth in claim 11, in which the two heaters are connected in series, and a switch common to both heaters simultaneously energizes said heaters.

13. A refrigerant circulating system selectively operable either to cool or to heat an evaporator, said system comprising: a compressor, a condenser, an evaporator and conduits including a restrictor and a suction line connecting said compressor, condenser and evaporator in series flow circuit; a header interposed between said evaporator and suction line and having an internal partition dividing the interior of said header into two chambers, said evaporator discharging into one of said chambers and said suction line leading from the other of said chambers, said one of said chambers trapping liquid refrigerant flowing from said evaporator to a predetermined normal level, said header further having two distinct passages each establishing communication between said chambers, one of said passages leading from a portion of said one of said chambers above said normal level to provide for escape of evaporated refrigerant into the other of said chambers and through said suction line into said compressor, the other of said passages leading from a portion of said one of said chambers below said level to provide for passage of liquid refrigerant into the other of said chambers, said other of said passages having a substantially vertically extended section opening in said other of said chambers above said normal level so that liquid refrigerant stands in said section up to a level corresponding to said normal level and is prevented from passing into said other of said chambers; means for applying heat to said other of said passages and to a portion of the refrigerant circulating system adjacent the connection of said evaporator with said restrictor, said heat applying means being operable to cause liquid refrigerant standing in said section to rise above said level and to flow out of said other of said passages thereby providing for the passage of liquid refrigerant from said evaporator through said chambers and into said suction line, said means being also operable to cause liquid refrigerant flowing from said restrictor to be converted into gaseous refrigerant for feeding into the evaporator; and control means for operating said heat applying means at selected times.

14. A defrostable refrigerating system as set forth in claim 13, in which the mentioned header is in the form of an elongated cylinder mounted with its longitudinal axis in a generally horizontal position, and the mentioned partition is in the form of an upwardly projected wall terminated at a distance from the upper interior surface of said header to provide the stated passage for the escape of evaporated refrigerant from said one to said other of said chambers.

15. A refrigerant circulating system as set forth in claim 13, in which the heat applying means is electrically operated.

16. A refrigerant circulating system as set forth in claim 13, in which the heat applying means includes a pair of electrical heaters, one of said heaters being arranged in heat exchange relation with said section of said other of said passages, the other of said heaters being arranged in heat exchange relation with said portion of the refrigerant circulating system adjacent the connection of said evaporator with said restrictor, and in which the mentioned control means includes a switch common to both heaters and operable to energize said heaters simultaneously.

17. A refrigerant circulating system selectively operable either to cool or to heat an evaporator, said system comprising: a compressor, a condenser, an evaporator, and conduits including a restrictor and a suction line connecting said compressor, condenser and evaporator in series flow circuit; a header interposed between said evaporator and suction line; a partition dividing the interior of said header into two chambers and having means providing a passage between said chambers, said evaporator discharging into one of said chambers and said suction line leading from the other of said chambers, said one of said chambers trapping liquid refrigerant flowing from said evaporator up to a normal level below said passageway, said passage providing for the escape of evaporated refrigerant into said other of said chambers and through said suction line into said compressor; a generally U-shaped tube depending from said header, one leg of said tube being connected with said header to pass liquid refrigerant from said one of said chambers, the other leg of said tube entering said other of said chambers and terminating at a point above said normal level so that liquid refrigerant passing into said U-shaped tube stands therein up to a level corresponding to said normal level; and heating means arranged in heat exchange relation with said other leg of said U-shaped tube and with a portion of the refrigerant circulating system adjacent the connection of said evaporator with said restrictor, said heating means being operable to create in said other leg a percolating effect which causes liquid refrigerant standing in said U-shaped tube to rise above said level and to spill into said other of said chambers thereby providing for the passage of liquid refrigerant from said evaporator through said chambers into said suction line to evaporate therein, said heating means also being operable to convert liquid refrigerant from said restrictor into gaseous refrigerant for feeding into the evaporator.

18. A refrigerant circulating system as set forth in claim 17, in which the mentioned heating means is electrically operated.

19. A refrigerant circulating system as set forth in claim 17, in which said heating means including a pair of electric heaters, one of said heaters being arranged in heat exchange relation with said other leg of said U-shaped tube, the other of said heaters being arranged in heat exchange relation with said portion of the system adjacent the connection of said evaporator with said restrictor, and switch means in electrical circuit with said heaters and operable to control energization thereof at selected times.

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