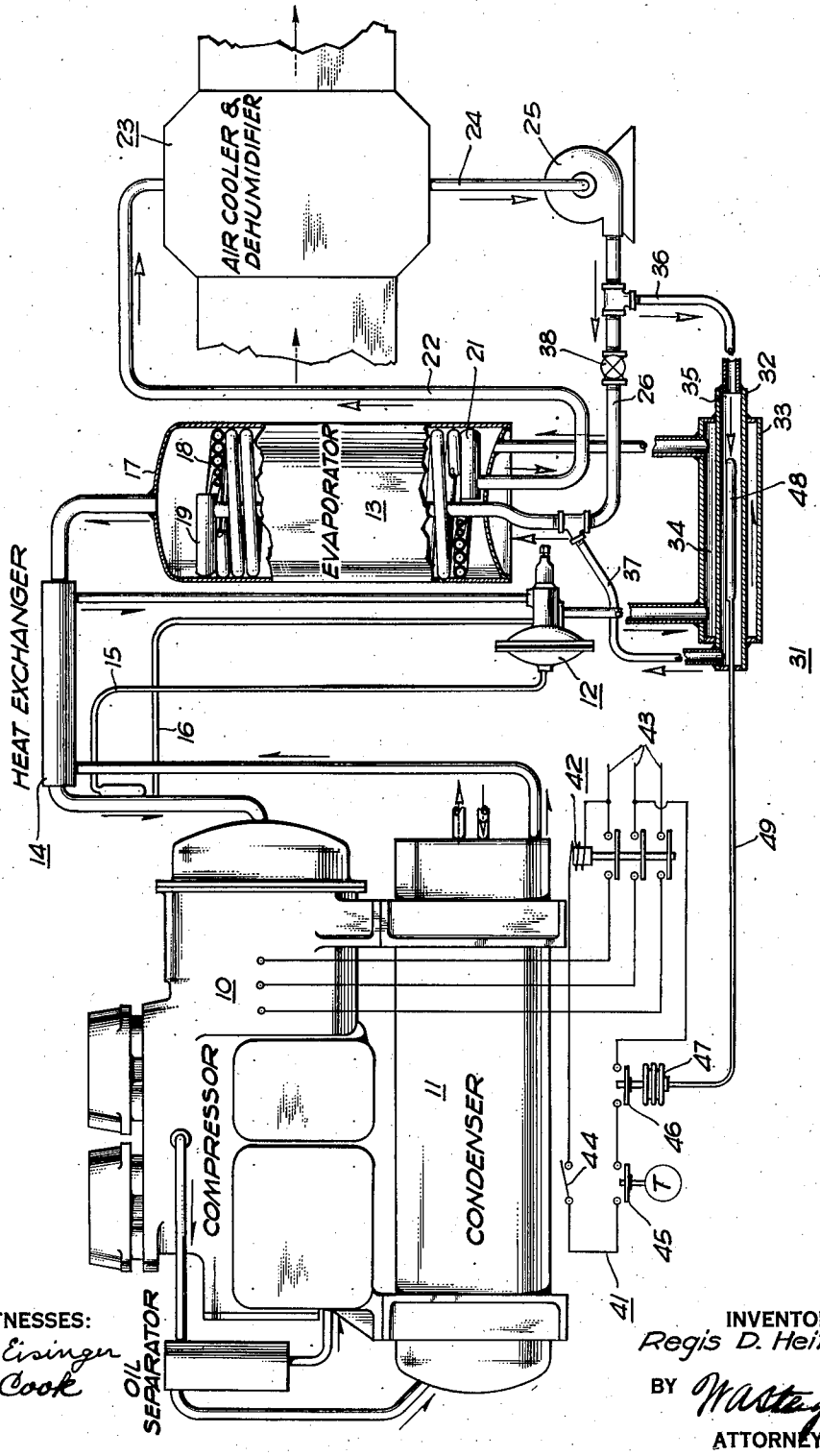
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CONTROL MECHANISM

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CONTROL MECHANISM

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My invention relates to a control mechanism, more particularly to a control mechanism for refrigerating apparatus used to cool a stream of liquid and which mechanism controls the refrigerating apparatus so as to prevent freezing of said liquid.

An object of my invention is to provide an improved control of the character set forth.

Difficulty has been experienced in obtaining a satisfactory control to prevent freezing of liquid to be cooled, particularly in the event of failure of supply or circulation of such liquid. A control which stops the compressor in response to a low refrigerant pressure or temperature in the evaporator results in short-cycling; that is, frequent stopping and starting of the compressor as the refrigerant pressure drops momentarily. This occurs particularly when the compressor is first started. Such short-cycling is undesirable, and it is unnecessary if the periods of low refrigerant pressure are of sufficiently short duration, since some period of time is required for sufficient heat flow to result in freezing. Furthermore, if water is being cooled to a low temperature, such as 33° F., it is necessary to have the refrigerant at a temperature below freezing. In such case, freezing of the water may be avoided as long as the water continues to flow, but if the flow stops, then the continued exposure of the water to the low temperature results in freezing.

Another control that has been devised includes a temperature-responsive element or control bulb located in the pipe through which the water is conveyed to or from the several tubes in which it is cooled. It has been found, however, that, although the bulb is in a water line inside the cooler, water will freeze in the tubes before the control stops the compressor.

It is an object of my invention to provide a control which avoids stopping the compressor during periods of low suction pressure that do not cause freezing of the water, and which control at the same time is reliable in stopping the compressor before any appreciable amount of freezing of water in the tubes takes place.

In accordance with my invention, I provide an auxiliary heat transfer device. I divert a small portion of the stream of liquid to be cooled and convey such diverted portion through the auxiliary heat transfer device in heat transfer relation to expanded refrigerant which is at substantially evaporator pressure and temperature. I also provide means for reducing or terminating the cooling action, as by stopping the compressor, when the temperature of the liquid to be cooled in said auxiliary heat transfer device becomes sufficiently low to indicate danger of freezing. With this arrangement, the compressor is not stopped during periods of low suction pressure which are of sufficiently short duration, since a period of time is required for sufficient heat transfer to take place in the auxiliary heat transfer device to bring the water down to a temperature near the freezing point. Also, the compressor is not stopped if the water continues to flow while the refrigerant pressure is only slightly below freezing. On the other hand, if the flow of water to be cooled should stop or if the refrigerant temperature decreases excessively, the quantity of liquid to be cooled in the auxiliary heat transfer device is sufficiently small and is cooled sufficiently rapidly so that the compressor is stopped before any appreciable amount of freezing can take place.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in accordance with the accompanying drawing, forming a part of this application, in which the single figure is a diagrammatic view of refrigerating apparatus incorporating a control mechanism in accordance with my invention.

Referring to the drawing in detail, I show a refrigerating system comprising a motor-compressor unit 10, a condenser 11, an expansion valve 12, an evaporator 13, and a heat exchanger 14 in which the liquid refrigerant is cooled by the vaporized refrigerant returning from the evaporator to the compressor. In the illustrated embodiment, the expansion valve 12 is of the type known as a thermostatic expansion valve, being operable in response to the temperature and the pressure of the vaporized refrigerant flowing from the heat exchanger 14 to the compressor, the temperature and the pressure being communicated through tubes 15 and 16, respectively.

The evaporator 13 is of the type described and claimed in the application of Edward R. Wolfert, Serial No. 192,693, filed February 26, 1938. It comprises a vertical cylindrical tank 17 and contains a coil unit 18 which preferably comprises, as shown, five helical coils disposed concentrically. The upper or inlet ends of the five coils are connected to a radially extending inlet header 19 and the lower or outlet ends are connected to a radially extending outlet header 21.

The refrigerating system may be used for cooling water or other liquid for any desired purpose. In the illustrated embodiment, it is used to cool water for an air conditioning system including

an air cooler and dehumidifier 23. Water from the outlet header 21 is conveyed to the latter through a conduit 22. The water which has been used for cooling and which has thereby been heated flows from the cooler 23 through a conduit 24 to a pump 25, from which it is conveyed through a conduit 26 to the inlet header 19.

The control to prevent freezing of water in the coils 18 comprises an auxiliary heat exchanger 31, which comprises inner and outer tubes 32 and 33. The tubes 32 and 33 form a passage 34 therebetween, and the tube 32 provides a passage 35. The passage 34 is connected in the refrigerant circuit between the expansion valve 12 and the evaporator 13, so that a mixture of liquid and vaporous refrigerant at substantially the pressure and the temperature of the evaporator 13 flows through the passage 34. A small portion of the stream of water to be cooled is diverted from the main portion flowing through the conduit 26 and is conveyed through a conduit 36, the passage 35 and a conduit 37, from which it is returned to the main portion of the stream before it enters the tank, the connection with the conduit 26 being located outside the tank 17. A valve 38 is preferably provided in the portion of the conduit 26 bypassed by the diverted portion, which valve is slightly closed, just sufficiently to provide a pressure drop to effect a small flow of water through the passage 35.

A control circuit 41 is provided for controlling the operation of the refrigerating system. In the circuit there is connected the coil of a relay 42 which controls the circuit 43 supplying electrical energy to the motor compressor unit 10. In the circuit 41, there are connected in series a manual switch 44, serving mainly for shutting down the refrigerating apparatus, an automatic switch 45 which effects the normal automatic control of the refrigerating system, and the antifreeze switch 46. The automatic switch 45 is operable in response to the value of any operating condition of apparatus which it is desired to maintain at a constant value, for example, the temperature of the air in the enclosure served by the air cooler and dehumidifier 23. The switch 46 is operable in response to the temperature of the water in the passage 35, and opens its contacts in response to a predetermined minimum temperature, for example, 33° F. The switch is provided with a bellows 47, a control bulb 48 located within the passage 35 as shown on the drawing, and a tube 49 connecting the bellows 47 and the bulb 48.

Operation

To initiate operation of the apparatus, the switch 44 is closed. The compressor is then operated intermittently under control of the automatic switch 45. In normal operation, the switch 46 is closed. The refrigerating system operates in the usual manner of such apparatus. Refrigerant is compressed by the motor compressor unit 10, condensed in the condenser 11, conveyed through the heat exchanger 14 to the expansion valve 12, wherein the flow thereof is regulated and the pressure thereof reduced. The refrigerant at reduced pressure then flows through the passage 34 of the auxiliary heat exchanger 31 and is admitted to the evaporator 13. In the latter it extracts heat from the water flowing through the coils 18 and is thereby vaporized. The vaporized refrigerant is withdrawn from the evaporator 13 and returned to the motor compressor unit through the heat exchanger 14.

The water returned from the air cooler and dehumidifier 23 flows through the conduit 24 to the pump 25, from which it is discharged through the conduit 26. A very small portion or trickle of the water flowing through the conduit 26 is diverted at a point upstream of the valve 38. The diverted portion is conveyed through the conduit 36, the passage 35 and the conduit 37 and returned to the main portion of the stream in the conduit 26 on the downstream side of the valve 38 but before the same enters the tank 17. The combined stream then flows to the inlet header 19, through the several coils 18 in parallel to the outlet header 21, and then through the conduit 22 to the air cooler and dehumidifier 23. As the water flows through the coils 18 it is cooled to the desired temperature.

The water flowing through the passage 35 is cooled by the refrigerant flowing through the passage 34 to a temperature substantially the same as or slightly higher than that to which the water is cooled in the coils 18.

In the event of any condition causing freezing of the water in the coils 18, the water in the passage 35 is first cooled to substantially the freezing point by the refrigerant flowing through the passage 34. Such a condition is most likely to be caused by failure of the supply of water to be cooled, for example, failure of the pump 25. In such case, the continued application of refrigerating effect to the water in the coils 18 continues to reduce the temperature thereof and causes freezing if the cooling action is not terminated. However, the water in the passage 35 is cooled as rapidly as that in the coils 18. Accordingly, the control bulb 48 responds to the reduced temperature and causes the switch 46 to open the control circuit 41, the latter opening the circuit 43, to the motor compressor unit. Accordingly, operation of the latter is terminated, as is also further refrigerating action in the evaporator 13, and freezing of the water in the coils 18 is avoided.

The conditions in the auxiliary heat transfer device 31 simulate the conditions existing in the evaporator 13. In the operation of the refrigerating apparatus, the suction or refrigerant pressure in the evaporator 13 may become excessively low for a short period of time and may decrease momentarily to an excessively low value. Before freezing of the water in the tubes 18 may take place, a period of time must elapse for sufficient flow of heat from the water to the refrigerant to take place. Similarly, in the auxiliary heat transfer device 31, a period of time is required for flow of heat in the water from the passage 35 to the refrigerant in the passage 34. If the low refrigerant pressure is of sufficiently short duration, the water in the tubes 18 and in the passage 35 is not reduced to a value at which the switch 46 opens its contact, so that operation of the compressor is uninterrupted. Also, it may be desired to cool the water in the tubes 18 to a temperature close to the freezing point, for example, 34°, in which case it is necessary to maintain the refrigerant at a temperature below freezing in order to provide a sufficient temperature difference to effect the heat transfer. As long as the flow of water continues uninterrupted and the temperature of the inlet water does not get too low, freezing of the water is avoided. Here again, interruption of compressor operation is avoided by the auxil-

iary heat transfer device 31 in that the flow of water through the passage 35 avoids cooling thereof to the freezing point. In either case, however, should a condition occur which would result in freezing of the water, such as failure of water supply or flow thereof, or an abnormally low temperature of the water flowing to the evaporator, then the water in the chamber 35 would be cooled sufficiently to cause interruption of the compressor.

If the water is being cooled to a temperature approximating the freezing point, then the auxiliary heat transfer device 31 must be designed to closely simulate conditions in the evaporator 13 in order to avoid uncessary and undesirable interruption of the compressor. On the other hand, if the water is being cooled to a temperature considerably above freezing and it is desired to guard primarily against freezing of the water resulting from failure of water supply or circulation, then it is merely necessary to design the device 31 so that the water in the passage 35 is cooled at least as rapidly as the water in the tubes 18.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In refrigerating apparatus, the combination of an evaporator comprising a refrigerant vessel, means including a conduit in said vessel for conveying a stream of liquid to be cooled from the exterior to the interior of said vessel and in heat transfer relation to liquid refrigerant in said vessel, means for supplying liquid refrigerant to and for withdrawing vaporized refrigerant from said container, means for diverting a small portion of said stream of liquid to be cooled at a point outside of said vessel, conveying the same in heat transfer relation to liquid refrigerant at substantially the pressure of the refrigerant in said vessel, and returning the same to said main portion at a point outside of said vessel, and means for decreasing the removal of refrigerant vapor from said vessel in response to a predetermined minimum temperature of the liquid in said diverted portion where it is in heat transfer relation to liquid refrigerant.

2. In refrigerating apparatus, the combination of an evaporator, a compressor, a condenser and expansion means connected in a refrigerant circuit, means for effecting flow of a stream of liquid to be cooled from the exterior to the interior of said evaporator and in heat transfer relation to the expanded refrigerant in the evaporator, means for diverting a small portion of said stream and conveying the same in heat transfer relation to liquid refrigerant at substantially evaporator pressure, and means for terminating operation of said compressor in response to a predetermined minimum temperature of liquid in said diverted portion at a point where it is in heat transfer relation to said liquid refrigerant.

3. Refrigerating apparatus as set forth in claim 2, wherein said diverted portion is conveyed in heat transfer relation to liquid refrigerant flowing from said expansion means to said evaporator.

4. In refrigerating apparatus, the combination of an evaporator, a compressor, a condenser, and expansion means connected in a refrigerant circuit, means for effecting flow of liquid to be cooled in heat transfer relation to the expanded refrigerant in the evaporator, an auxiliary heat exchanger having first and second passages in heat transfer relation, means for conveying expanded refrigerant from said expansion means to said evaporator through said first passage, means for conveying a small portion of said liquid to be cooled through said second passage, and means for terminating operation of said compressor in response to a predetermined minimum temperature of the liquid in said second passage.

5. Refrigerating apparatus as set forth in claim 4, wherein said small portion is diverted from the stream of liquid to be cooled, conveyed through said second passage and returned to said stream before the latter flows in heat transfer relation to expanded refrigerant in the evaporator.

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