REFRIGERATING AND DEFROSTING SYSTEM

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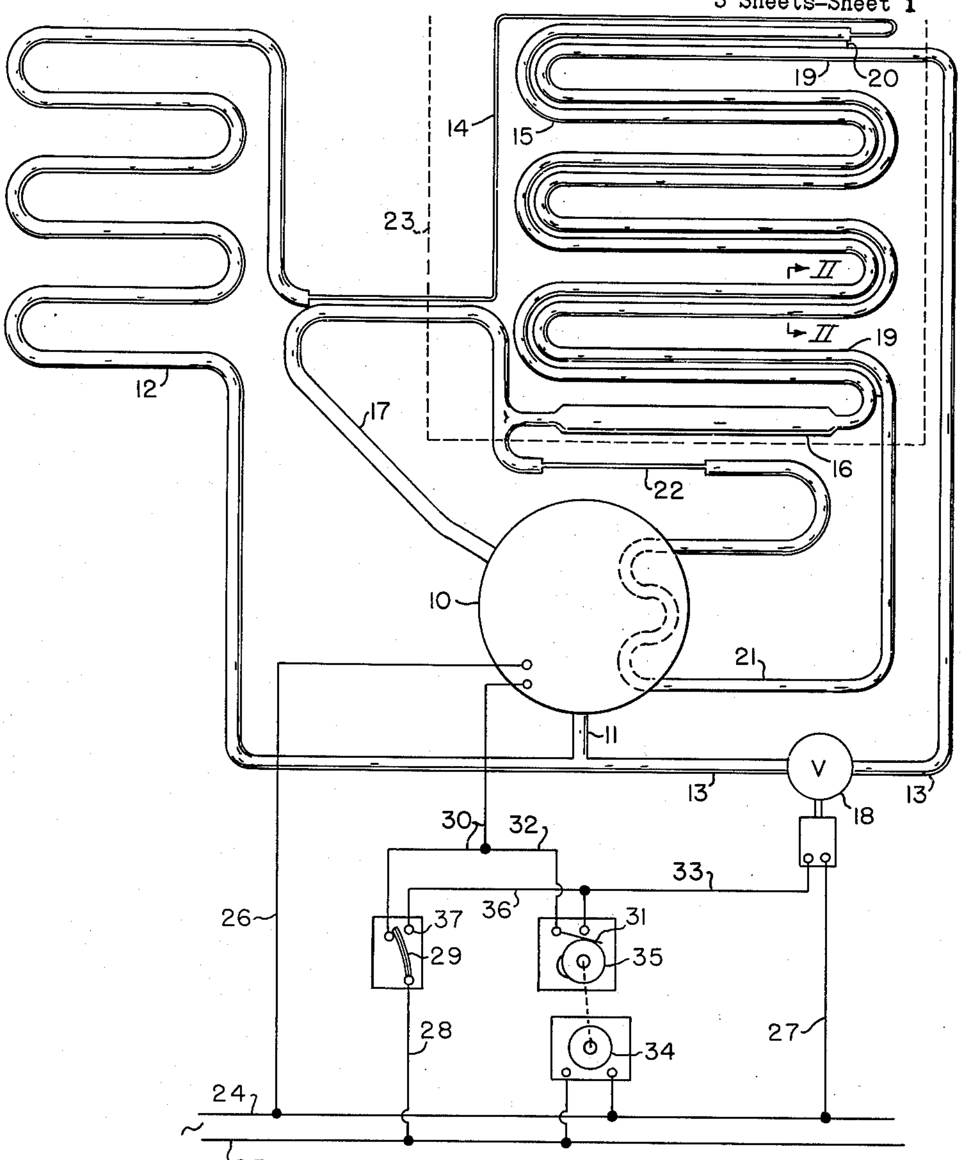

Fig I

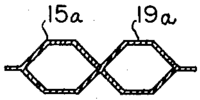

Fig III

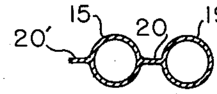

Fig II

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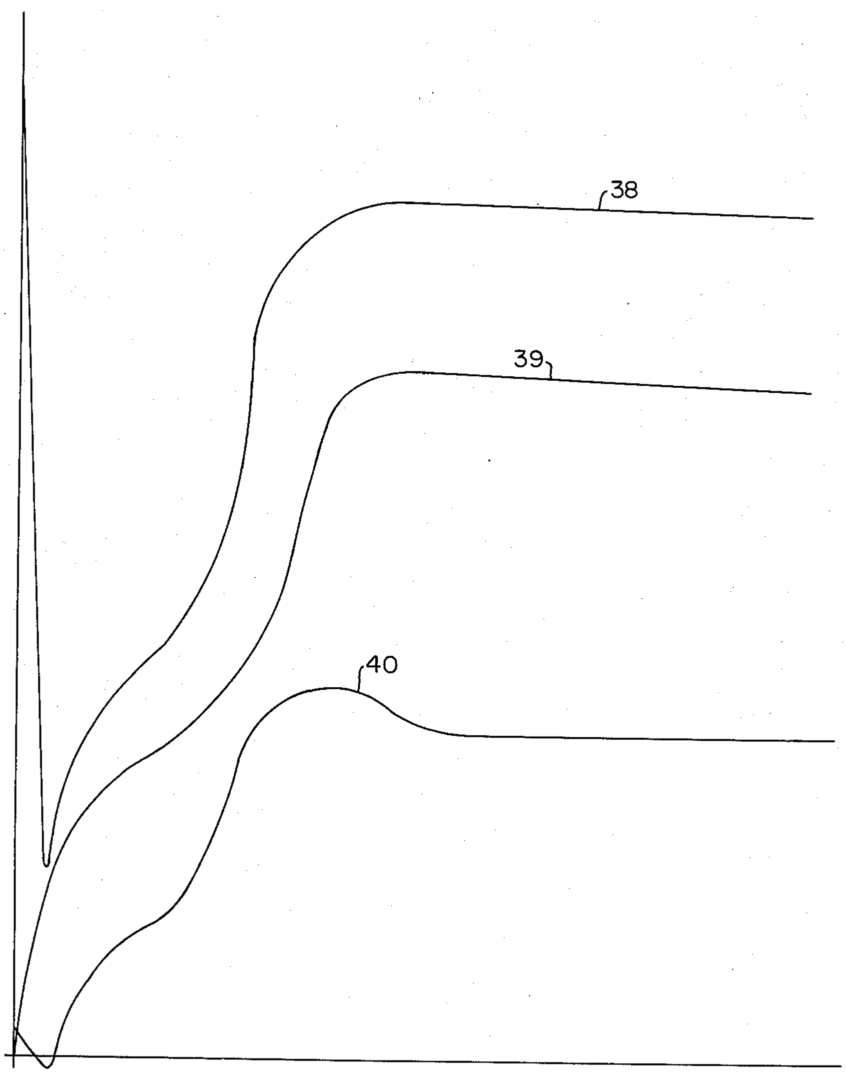

Fig. IV

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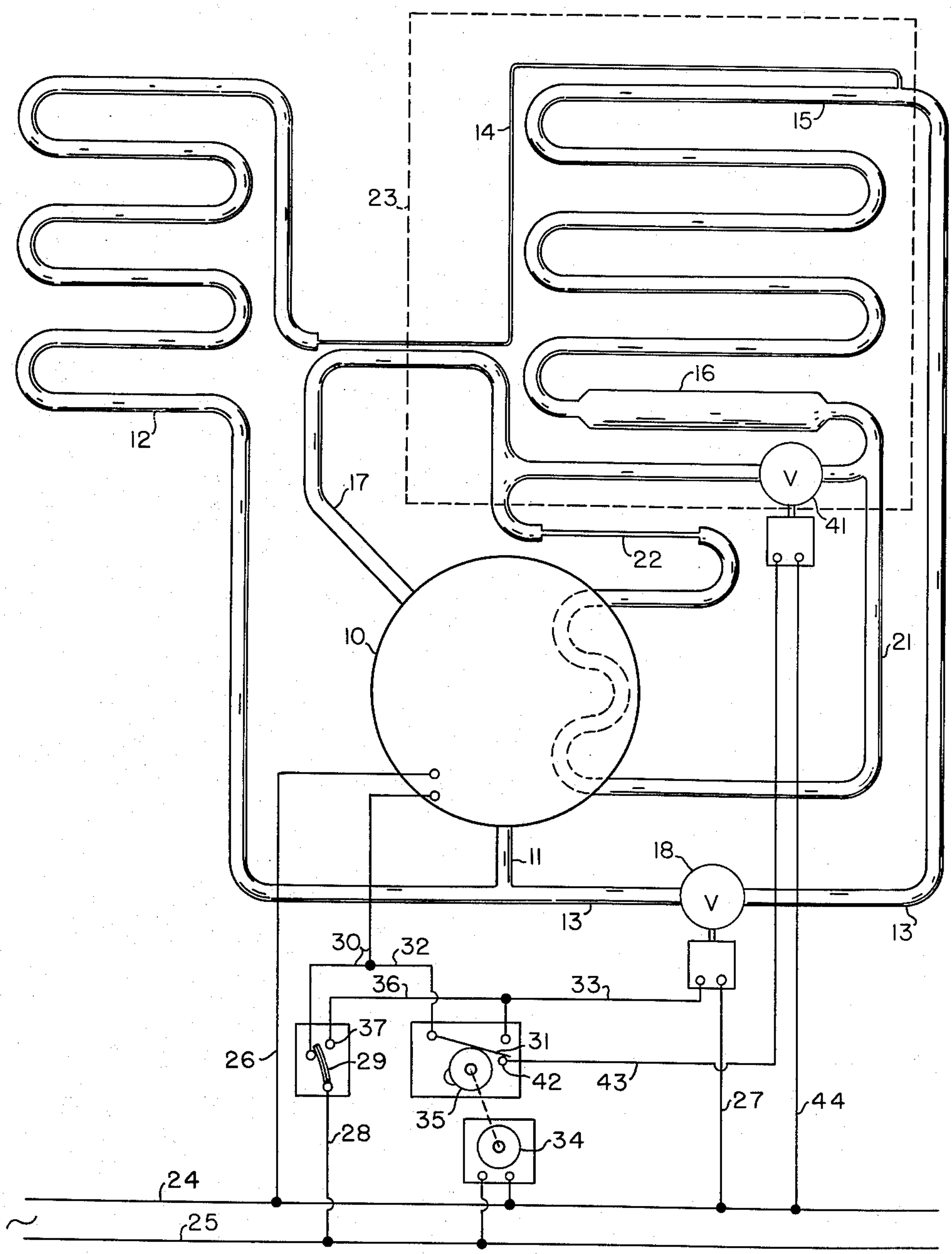

Fig V

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REFRIGERATING AND DEFROSTING SYSTEM

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This invention relates to a refrigerating system having an evaporator that requires periodic defrosting, and more particularly to an improved system for periodic defrosting of such evaporator.

The evaporator of a refrigerating system is used to absorb heat from a space to be refrigerated, and such absorption of heat is accomplished by introducing into the evaporator a liquefied refrigerant which vaporizes in the evaporator to produce the required cooling effect. The refrigerating cycle is completed by the use of a compressor which withdraws vaporized refrigerant from the evaporator, compresses the vaporized refrigerant and passes the compressed refrigerant into a condenser in which it is cooled and thus reliquefied and from which it flows through a restricted passage into the evaporator. By virtue of this restricted passage, the pressure is much higher in the condenser than in the evaporator, so that the refrigerant will be liquefied in the condenser and will be evaporated in the evaporator.

In a completely automatic refrigerating system, it is necessary periodically to melt the frost that accumulates on the exterior of the evaporator. Such defrosting of the evaporator can be accomplished by shutting off the refrigerating system until the frost has melted, but it is preferable to accomplish defrosting by supplying heat to the evaporator so as to melt the frost quickly and thus reduce the time during which refrigeration is discontinued.

One method which has been widely used for heating an evaporator periodically to defrost it is the "hot gas" method of defrosting. That method has been accomplished heretofore by providing a bypass line which leads from the discharge side of the compressor directly to the evaporator and which contains a valve that is open during the defrosting operation and is closed at other times. During a hot gas defrosting operation as practiced heretofore, the evaporator is heated by running the compressor while the valve is open in the bypass leading from the discharge side of the compressor to the evaporator, so that the hot gas leaving the compressor passes directly through the evaporator and back to the compressor, and thus heats the evaporator to melt the frost thereon. It is customary to control such a hot gas defrosting operation by means of a timer or other control device which starts the defrosting operation after the refrigerating system has been operating for a sufficient period of time to cause a substantial accumulation of frost on the evaporator. The control device holds the bypass valve open, with the compressor running, for a period of time sufficient to melt the frost from the evaporator, and then closes the bypass valve as normal operation of the refrigerating system is resumed.

One difficulty that is encountered in the operation of hot gas defrosting systems heretofore known, which is obviated by the present invention, is that the pressure of the refrigerant entering the compressor rises to an excessive value near the end of a defrosting operation. The type of compressor that is ordinarily used in a

domestic refrigerating system is designed to move large volumes of gas at low pressures and tends to overheat if there is a substantial increase in the pressure and thus in the density of the gas entering the compressor. Such a compressor, when electrically driven, is usually connected in series with a safety switch that opens the circuit to stop the compressor when an overload is encountered and then recloses to restart the compressor. Even though the opening and closing of such a safety switch may permit a hot gas defrosting operation to be completed in spite of the tendency of the refrigerant pressure to become excessive, the defrosting operation is then unduly prolonged and the starting and stopping of the compressor near the end of the defrosting operation may cause a housewife to become alarmed and to call a serviceman.

The principal object of the invention is to provide an improved refrigerating and defrosting system that obviates the disadvantages of the hot gas defrosting systems heretofore known. More specific objects and advantages are apparent from the following description, which is intended to disclose and illustrate the invention but not to limit its scope.

Fig. I of the drawings is a diagram showing a preferred form of a refrigerating and defrosting system embodying the invention.

Fig. II is a fragmentary sectional view taken along the line II—II of Fig. I.

Fig. III is a fragmentary sectional view showing an alternative construction that may be used in place of the construction shown in Fig. II.

Fig. IV is a graph showing the variation during the defrosting operation of the pressure at three points in the system of Fig. I.

Fig. V is a diagram showing a modified system embodying the invention.

In the system of Fig. I, a compressor **10** is provided with a discharge line **11** which is connected both to a condenser **12** and to a bypass **13**. The condenser **12** in turn is connected to a capillary tube **14** which may consist, for example, of 13 feet of tubing having an internal diameter of .031 inch. The capillary tube **14** leads to an evaporator **15**, which is shown in Fig. I in the form of a serpentine tube. At the end of the evaporator **15** is an enlarged section forming an accumulator **16** in which liquefied refrigerant may collect. The accumulator **16** is connected to a suction line **17** that leads back to the compressor **10**.

The bypass **13** includes a solenoid valve **18** which is open during the defrosting operation. A novel feature of the system illustrated in Fig. I is that the bypass **13** does not lead directly to the evaporator **15**, but instead leads to a defrosting tube **19** which runs parallel and adjacent to the tubing that forms the evaporator **15**. Preferably, the defrosting tube **19** and the evaporator tube **15** consist of a single extruded section that is composed of two tubular portions **15** and **19** and a connecting fin **20**. The evaporator tube **15** may be provided with an additional fin **20'** (shown only in Fig. II) to increase the surface area through which heat is absorbed during the refrigerating operation. The evaporator tube **15** and the defrosting tube **19** are not necessarily of equal diameter, and it is often advantageous to use a smaller defrosting tube (for example, a defrosting tube having an internal diameter of 1/4 inch when the evaporator tube has an internal diameter of 5/16 inch). The defrosting tube **19** preferably leads to a reheating tube **21**, which may be heated, for example, by passing through the compressor **10** as illustrated in Fig. I. A compressor manufactured for use in household refrigerators or freezers often is provided with a passage known as an "oil-cooler loop," and such passage is commonly connected in series with the condenser so that the refrigerant flows through such passage after being partially cooled in the condenser. The compressor 10 illustrated in Fig. I embodies such as passage, but in this case the passage is not connected in series with the condenser but instead forms part of the reheating tube 21.

Also provided in the system illustrated in Fig. I is a restriction 22, which preferably follows the reheating tube 21, and may consist, for example, of 1 foot of tubing having an internal diameter of .07 inch. The restriction 22 leads into the suction line 17.

The dashed line 23 indicates what portions of the system are enclosed in the compartment or cabinet to be refrigerated.

In many domestic refrigerators the evaporator, instead of consisting of a serpentine tube, is a rolled forged aluminum structure. Fig. III illustrates the use, in the system of Fig. I, of a rolled forged aluminum structure in which the defrosting tube 19*a* and the evaporator tube 15*a* are arranged side by side.

The electrical system illustrated in Fig. I includes line wires 24 and 25, one side of the compressor 10 being permanently connected to the line wire 24 by means of a conductor 26, and one side of the solenoid valve 18 being permanently connected to the line wire 24 by means of a conductor 27. Connected to the other line wire 25 by means of a conductor 28 is a thermostatic element 29 which is illustrated in Fig. I as a bi-metallic switch. The thermostatic element 29 is so located that it is responsive to the temperature in the refrigerated compartment indicated by the dashed line 23. Whenever the temperature in the refrigerated compartment is above a predetermined upper limit, the thermostatic element 29 is in its left-hand position as illustrated in Fig. I. In this position, the thermostatic element completes a circuit from the conductor 28 to a conductor 30 so as to connect the compressor 10 across the line wires 24 and 25 to keep the compressor running.

During the normal refrigerating cycle of the system illustrated in Fig. I, the compressor 10 runs until the evaporation of the refrigeration in the evaporator tube 15 has reduced the temperature in the refrigerated compartment to a predetermined lower limit. When the temperature falls to such lower limit, the thermostatic element 29 moves to the right so as to open the circuit between the conductors 28 and 30. While this circuit is open, the compressor 10 remains at rest, and the temperature in the refrigerated compartment gradually rises as the supply of liquefied refrigerant in the evaporator tube 15 and the accumulator 16 is exhausted by continued evaporation. Then when the temperature reaches the predetermined upper limit hereinbefore mentioned, the thermostatic element 29 moves to its left-hand position, and a new refrigerating cycle begins.

In the system of Fig. I a switch 31 is provided to energize and thus open the solenoid valve 18 while the compressor 10 is running. When closed, the switch 31 completes a circuit from the conductor 30 through conductors 32 and 33 to the solenoid valve 18. A control device is used to hold the switch 31 closed during each defrosting operation. Such a control device may be operated in any desired manner to close the switch 31 when a substantial layer of frost has accumulated on the evaporator 15, and then to reopen the switch 31 when the layer of frost has melted. The control device may operate by temperature sensing to detect the accumulation of a substantial layer of frost on the evaporator tube and to detect the disappearance of frost by melting, but for the sake of simplicity Fig. I shows a simple timer motor 34 which is permanently connected across the line wires 24 and 25 and therefore runs continuously, and which drives a timing cam 35. The timing of the defrosting operation may be varied to meet different operating conditions, but in a typical case the timing cam 35 may operate at such a speed that the switch 31 alternately remains closed for approximately 20 minutes and remains open for several hours. Another advantageous feature of the system of Fig. I is the presence of a conductor 36 which, through the conductor 33, connects the solenoid valve 18 to a contact 37 associated with the thermostatic element 29. Whenever the thermostatic element 29 is in its right-hand position, it completes a circuit from the conductor 28 through the contact 37 and the conductors 36 and 33 to the solenoid valve 18. Thus, the solenoid valve 18 not only remains open during the defrosting operation but also remains open whenever the compressor 10 is not running. If the thermostatic element 29 happens to be in its right-hand position, with the solenoid valve 18 open, at the moment when the switch 31 is closed by the timing cam 35, the closing of the switch 31 starts the compressor running by energizing the compressor through the conductors 36, 32, and 30. The significance of this feature is as follows:

The presence of the contact 37 in the conductor 36 becomes important in case the thermostatic element 29 happens to be in its right-hand position at the moment when switch 31 is closed by the timing contact 35. In that case, if the contact 37 and the conductor 36 were not present, the defrosting operation would not begin until a thermostatic element 29 had moved to its left-hand position, and the defrosting interval provided by the timing cam 35 would have to be long enough to permit defrosting to be completed. In the absence of the contact 37 and the conductor 36, two extreme conditions could occur. One such extreme condition would occur if the thermostatic element had moved to its right-hand position just before the switch 31 was closed by the timing cam 35, and the other such extreme condition would occur if the thermostatic element had moved to its left-hand position just before the switch 31 was closed. As a practical matter it would be necessary under such circumstances to design the timing cam 35 to provide a relatively long defrosting interval so as to permit defrosting to be completed in case the thermostatic element had moved to its right-hand position just before the switch 31 was closed by the timing cam.

Thus, if the contact 37 and the conductor 36 were not present the timing cam 35 would have to be designed to provide a relatively long defrosting interval that would prove to be excessive whenever the switch 31 happened to be closed by the timing cam just after the thermostatic element had moved to its left-hand position. Whenever the defrosting interval thus proved to be successive spoilage of food products under refrigeration would be liable to occur, particularly if the refrigeration system were being used with a home freezer, which is intended to keep its contents in a frozen condition.

The operation of the system illustrated in Fig. I may be summarized as follows:

After the switch 31 is closed by the timing cam 35, both the compressor 10 and the solenoid valve 18 are energized, so that the compressor 10 is running and the solenoid valve 18 is open. The defrosting operation then proceeds as the compressor forces the hot compressed refrigerant through the bypass 13 to the defrosting tube 19. Heat is conducted from the defrosting tube 19 to the evaporator tube 15 to melt the layer of frost, and the timing cam 35 keeps the switch 31 closed for a period just long enough to complete the melting of the layer of frost. The required period is always the same because the compressor 10 is running and the solenoid valve 18 is open immediately after the switch 31 closes.

The restriction 22 performs an important function in the operation of the system shown in Fig. I. If it were not for the restriction 22, the pressure of the refrigerant would tend to rise to an excessive value near the end of the defrosting operation, so as to cause the overloading of the compressor which commonly occurs in prior hot gas defrosting methods.

As the refrigerant passes through the restriction 22 during the defrosting operation, a reduction in the pressure of the refrigerant takes place, so as to reduce the pressure in the suction line and thus avoid overloading of the compressor. It should be noted, however, that the restriction 22, as hereinbefore described, consists of a length of tubing that is substantially shorter and has a substantially greater internal diameter than the capillary tube 14. Because of the relatively large internal diameter and the relatively short length of the restriction 22, the reduction in the pressure of the refrigerant passing through the restriction is moderated to reduce the refrigerating effect of such reduction in pressure, so as to avoid chilling the suction line 17 substantially below room temperature. If the reduction in pressure of the refrigerant passing through the restriction 22 were sufficient to cause the suction line to be chilled substantially below room temperature, excessive sweating or frosting of the suction line would occur during the defrosting operation.

As a further precaution against chilling of the suction line during the defrosting operation, the refrigerant that passes through the restriction 22 is heated in the system illustrated in Fig. I. It has been discovered that much better results are obtained during the defrosting operation if the refrigerant is heated before it passes through the restriction 22 than if it is heated after it passes through the restriction 22. If in a system such as that illustrated in Fig. I the refrigerant were not reheated before it passed through the restriction 22 during the defrosting operation, the pressure of the refrigerant entering the restriction 22 would be relatively low during all but the last part of the defrosting operation, because of the chilling action of the layer of frost, so that the rate of flow of the refrigerant through the restriction 22 would be very low and the defrosting therefore would be very slow. In the system of Fig. I, the reheating of the refrigerant just before it enters the restriction 22 causes the pressure of the refrigerant entering the restriction to be considerably higher and causes the defrosting to take place considerably faster than would be the case in the absence of such reheating.

Fig. IV is a graph showing how the pressure of the refrigerant varies during a typical defrosting operation, at three points in the system of Fig. I, time being plotted on the horizontal axis and pressure being plotted on the vertical axis. The upper curve 38 shows the pressure in the discharge line 11; the intermediate curve 39 shows the pressure of the refrigerant entering the restriction 22; and the lower curve 40 shows the pressure in the suction line 17. The curves 38 and 39 represent substantial gauge pressures ranging as high as several atmospheres, and the curves 38 and 39 are plotted on the same scale of pressure. The suction line pressure represented by the curve 40 is a relatively slight pressure and is plotted on a scale that is substantially larger than the scale of pressure on which the curves 38 and 39 are plotted.

At the start of the defrosting operation plotted in Fig. IV, the compressor 10 is running so that the discharge line pressure 38 is relatively high and the suction line pressure 40 is relatively low. As the solenoid valve 18 opens, the discharge line pressure 38 drops sharply because of rapid condensation of the refrigerant in the defrosting tube 19. The suction line pressure 40 drops also as the pressure in the condenser 12 falls while the refrigerant expands from the condenser into the defrosting tube 19. As the defrosting operation proceeds, all three of the pressures rise. It should be noted that each of the three pressure curves turns upward at an intermediate point in the rising portion of the curve. Such upturn in each curve may be due to the fact that the frost melts away from direct contact with the evaporator tube 15 and the defrosting tube 19.

The important point brought out in Fig. IV is that all three of the curves level off during the defrosting operation, so that the suction line pressure 40 does not reach a value high enough to cause overloading of the compressor. Such leveling off is due to the action of the restriction 22 as hereinbefore described.

The system illustrated in Fig. V differs from the system of Fig. I in the following respects:

The bypass 13 is connected directly to the evaporator tube 15, and there is no separate defrosting tube as in the system of Fig. I. A solenoid valve 41 is interposed between the accumulator 16 and the suction line 17, and the reheating tube 21 is connected to a point between the accumulator 16 and the solenoid valve 41. The switch 31 is provided with an additional contact 42 which is connected with the conductor 32 whenever the switch 31 is not in position to produce a defrosting operation.

The operation of the system illustrated in Fig. V may be summarized as follows:

The solenoid valve 41 has no function when the compressor 10 is not running, but whenever the compressor is running during a normal refrigerating cycle the solenoid valve is open because it is energized through the conductor 28, the thermostatic element 29, the conductors 30 and 32, the switch 31 and the conductors 43 and 44. Thus during a normal refrigerating cycle the system of Fig. V functions in the same manner as the system of Fig. I.

During a defrosting operation, the timing cam 35 holds the switch 31 in such a position that the solenoid valve 41 is de-energized and closed, so that the hot gas flowing through the bypass 13 passes through the evaporator tube 15, the accumulator 16 and the reheating tube 21 and thereafter follows the same path as in the system of Fig. I.

The distinction between the system of Fig. I and the system of Fig. V resides in the fact that in the system of Fig. I a separate defrosting tube 19 is provided to conduct the hot refrigerant in heat exchange relationship with the evaporator tube during the defrosting operation, whereas in the system of Fig. V the hot refrigerant, during the defrosting operation, is led through the evaporator tube itself. At the same time, it is necessary that the hot refrigerant, during the defrosting operation, pass through the restriction 22 before entering the suction line 17. Since the refrigerant cannot be caused to pass through such a restriction during the normal refrigerating cycle, it is necessary in the system of Fig. V to provide a bypass in the form of the solenoid valve 41 which is open during a normal refrigerating cycle, and is closed during a defrosting operation to cause the hot refrigerant to pass through the restriction 22. Various other embodiments of the invention may be devised to meet various requirements.

We claim:

1. In a refrigerating and defrost system, in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; by-pass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor.

2. In a refrigerating and defrost system, in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor; said bypass means comprising a defrost coil adjacent said evaporator and bypass valve means controlling the flow of refrigerant to said defrost coil.

3. In a refrigerating and defrost system, in combina-

tion, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor; said bypass means comprising a defrost coil adjacent said evaporator and bypass valve means controlling the flow of refrigerant to said defrost coil; said bypass valve being selectively opened by a timing control means.

4. In a refrigerating and defrost system, in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor; said bypass means including a bypass valve selectively opened and closed by a timing control means.

5. In a refrigerating and defrost system, in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor; said reheating means including means disposing said refrigerant in heat exchange relationship with the heat dissipated by said compressor.

6. In a refrigerating and defrost system, in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for reheating said bypass refrigerant after said heat exchange operation; and second restriction means returning said reheated bypass refrigerant to said compressor; said bypass means comprising a defrost coil adjacent said evaporator and bypass valve means controlling the flow of refrigerant to said defrost coil; said reheating means including means disposing said refrigerant in heat exchange relationship with the heat dissipated by said compressor.

7. In a refrigerating and defrost system in combination, a compressor, a condenser, a refrigeration restriction, and an evaporator operatively connected for circulating refrigerant; bypass means for selectively applying hot refrigerant from said compressor in heat exchange relationship with said evaporator; means for heating said bypass refrigerant after said heat exchange operation; and second restriction means returning said heated bypass refrigerant to said compressor; said second restriction means being of larger internal diameter and thus offering less resistance to the flow of refrigerant therethrough than said first-mentioned restriction means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,247,950	Kucher	July 1, 1941
2,384,210	Sunday	Sept. 4, 1945
2,430,960	Soling	Nov. 18, 1947
2,801,523	Hansen	Aug. 6, 1957
2,876,630	Boling	Mar. 10, 1959
2,882,696	Herrmann	Apr. 21, 1959
2,895,307	Nonamaque	July 21, 1959
2,907,181	Nonamaque	Oct. 6, 1959
2,907,184	Schumacher	Oct. 6, 1959
2,909,907	Swanson	Oct. 27, 1959
2,928,256	Nonamaque	Mar. 15, 1960