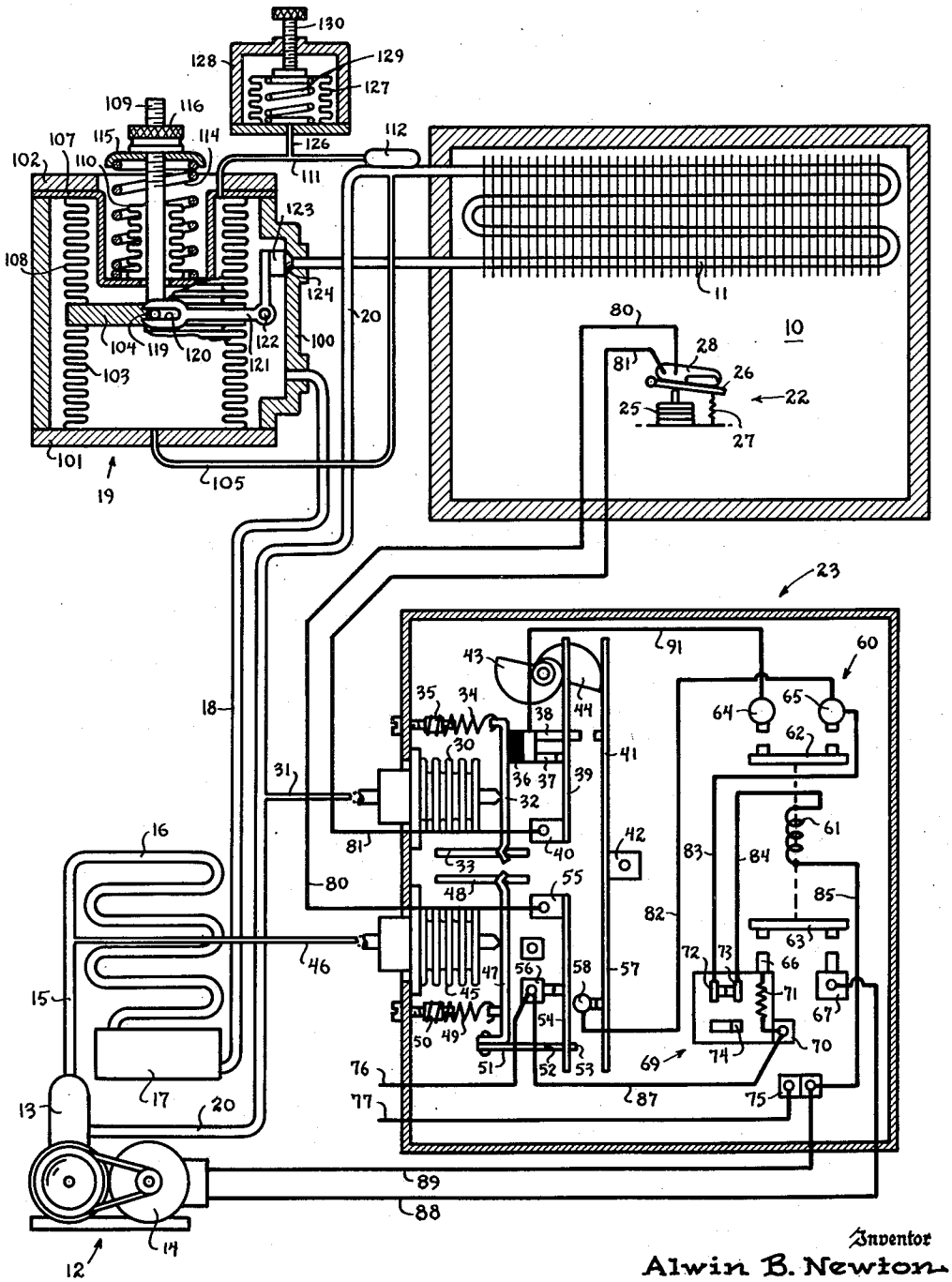
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REFRIGERATION CONTROL SYSTEM

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Inventor

Alwin B. Newton

By George H. Fisher

Attorney

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REFRIGERATION CONTROL SYSTEM

Alwin B. Newton, Minneapolis, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

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22 Claims. (Cl. 62—4)

This invention relates to a control system for a refrigerating apparatus and more particularly to a control system embodying means for automatically defrosting the evaporator of the refrigerating apparatus.

In the past, control systems have been applied to a refrigerating apparatus having an evaporator, a compressor, a condenser and a thermostatic expansion valve for stopping operation of the compressor at intervals to allow the evaporator temperature to increase above freezing for the purpose of defrosting the evaporator. However, in such systems the defrosting cycle is very often prolonged by reason of the fact that liquid refrigerant flows through the expansion valve into the evaporator and expands therein during the defrosting cycle. In addition, certain of these automatic defrosting control systems utilize the evaporator pressure as a measure of defrosting of the evaporator and in these systems the compressor is restarted after the evaporator pressure rises to a value corresponding to an evaporator temperature above freezing. If, in these systems, liquid refrigerant enters the evaporator and expands therein during the defrosting cycle, the evaporator pressure may rise to the defrosting value before the evaporator is actually defrosted with the result that the compressor may restart before defrosting of the evaporator has been completed.

It is therefore the prime object of this invention to overcome the above mentioned difficulties. In carrying out this object of the invention, I propose to so arrange and construct the expansion valve of the refrigerating apparatus to prevent the supply of liquid refrigerant to the evaporator during the defrosting cycle.

More specifically it is an object of this invention to so arrange and construct the expansion valve of the refrigerating apparatus to prevent the expansion valve from opening when the evaporator pressure rises above a predetermined value. Preferably this value corresponds to a temperature value below freezing so that at any pressure above freezing the valve will be closed whereby defrosting of the evaporator is assured. By reason of this arrangement, the evaporator pressure can never rise above the predetermined value while the compressor is operating regardless of the cooling load because the valve will close when the pressure reaches said value and this provides an additional advantage, namely, the load on the compressor motor is limited.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claims and drawing in which is diagrammatically illustrated the preferred form of this invention.

Referring now to the drawing, a compartment to be cooled is designated at 10, this compartment being cooled by means of a cooling coil in the form of an evaporator 11. Refrigerant is circulated through the evaporator 11 by means of a refrigerating apparatus generally designated at 12 and for purposes of illustration it is assumed that the refrigerant used is dichlorodifluoromethane, commonly known as Freon 12. The refrigerating apparatus may comprise a compressor 13 operated by an electric motor 14. Compressed refrigerant is discharged from the compressor 13 through a high pressure line 15 to a condenser 16. The condensed refrigerant is collected in a receiver 17 and flows through a liquid line 18 to the evaporator 11. An expansion valve generally designated at 19 is located in the liquid line 18 for regulating the flow of refrigerant to the evaporator 11. Evaporated refrigerant is withdrawn from the evaporator 11 through a suction line 20 by the compressor 13.

The compressor motor 14 and hence the compressor 13 is preferably controlled by an automatic defrosting control system and for purposes of illustration in this application this automatic defrosting control system is shown to comprise a temperature responsive controller 22 responsive to the temperature of the medium in the compartment 10 and a unitary control arrangement 23 responsive to changes in suction pressure and head pressure.

The temperature responsive controller may comprise a bellows 25 charged with a volatile fluid for operating a lever 26 against the action of an adjustable tension spring 27. The lever 26 operates a mercury switch 28 and for purposes of illustration it is assumed that when the temperature within the compartment 10 rises to 42°, the mercury switch 28 is closed and when the temperature decreases to 40°, the mercury switch 28 is opened.

The unitary control arrangement 23 may be of the type shown and described in application Serial No. 196,447, filed March 17, 1938, by Albert L. Judson and Carl G. Kronmiller. For purposes of illustration in this application, the unitary control arrangement is shown to comprise a bellows 30 connected by a pipe 31 to the suction line 20 so that the bellows 30 is operated in accordance with changes in suction or evaporator pressure. The bellows 30 operates a lever 32

fulcrumed on a fulcrum member 33 against the action of an adjustable tension spring 34. One end of the tension spring 34 is connected to the lever 32 and the other end is connected to an adjusting screw arrangement 35. By suitably adjusting the adjusting screw arrangement 35 the tension in the spring 34 may be varied and hence the pressure setting of this portion of the unitary control arrangement may be varied at will. The lever 32 carries an insulating pad 36 which in turn carries contacts 37 and 38 which are electrically connected together. The contact 37 is adapted to engage a contact member 39 carried by a terminal 40 and the contact 38 is adapted to engage a contact member 41 carried by a terminal 42. The contact members 39 and 41 are urged into engagement with concentrically mounted and independently rotated cams 43 and 44. By independently rotating the cams 43 and 44 the contact members 39 and 41 may be independently adjusted with respect to the contacts 37 and 38. For purposes of illustration, it is assumed that as the suction pressure increases the contact 37 first engages the contact member 39 at 15 pounds and then the contact 38 engages the contact member 41 at 35 pounds. Upon a decrease in suction pressure the contact 38 first disengages the contact member 41 at 35 pounds and then the contact 37 disengages the contact member 39 at 15 pounds. Since the refrigerant utilized in the system is dichlorodifluoromethane a suction pressure of 35 pounds represents an evaporator temperature of substantially 38°. Therefore the contact 37 is moved into engagement with the contact 39 only when the evaporator temperature has risen to 38° following defrosting of the evaporator.

The unitary control arrangement 23 may also comprise a bellows 45 connected by a pipe 46 to the high pressure line 15 so that the bellows 45 is operated in accordance with changes in head pressure. The bellows 45 operates a lever 47 fulcrumed on a fulcrum member 48 against the action of an adjustable tension spring 49. One end of the tension spring 49 is connected to the lever 47 and the other end is connected to an adjusting screw arrangement 50 which is utilized for adjusting the tension in the spring 49 and therefore the pressure setting of this portion of the unitary control arrangement. The lever 47 adjustably carries an abutment member 51 made of insulating material and having abutment surfaces 52 and 53. The abutment surface 52 is adapted to engage a contact member 54 carried by a terminal 55 for moving the contact member 54 out of engagement with a contact 56. The abutment surface 53 is adapted to engage a contact member 57 carried by the terminal 42 for moving the contact member 57 out of engagement with a contact 58. For purposes of illustration it is assumed that the parts are so arranged that upon an increase in head pressure the contact member 57 is first moved out of engagement with the contact 58 at 140 pounds and then the contact member 54 is moved out of engagement with the contact 56 at 185 pounds. Upon a decrease in head pressure the contact member 54 first engages the contact 56 at 185 pounds and then the contact member 57 engages the contact 58 at 140 pounds.

The unitary control arrangement 23 also includes a relay or starter generally designated at 60 which may comprise an operating coil 61 for operating bridge members 62 and 63. When the operating coil 61 is energized the bridge member 62 is moved into engagement with contacts 64 and 65 and the bridge member 63 is moved into engagement with contacts 66 and 67. When the operating coil 61 is deenergized the bridge members 62 and 63 are moved out of engagement with their respective contacts by means of springs, gravity, or other means, not shown. Also included in the unitary control arrangement 23 is an overload cut-out device generally designated at 69. This overload cut-out device is provided with a terminal 70 and a heater element 71 is connected between the terminal 70 and the contact 66. Upon an excess of current flow through the heater element 71 a thermostatic element is heated to trip a latch, not shown, for separating control contacts 72 and 73. The control contacts 72 and 73 may be reclosed by means of a manual reset lever 74. The unitary control arrangement also includes a line terminal 75. Power is supplied to the compressor motor 14 and to the control system by means of line wires 76 and 77 leading from some source of power, not shown, the line wire 76 being connected to the contact 56 and the line wire 77 being connected to the terminal 75.

With the parts in the position shown in the drawing, the temperature responsive controller 22 is satisfied, the suction pressure is somewhere between 15 pounds and 35 pounds, the head pressure is below 140 pounds and the compressor 13 is not operating. Assume now that the temperature within the compartment 10 rises to 42° and that the suction pressure rises to the defrosting value of 35 pounds. Since the head pressure is already reduced to 140 pounds, a starting circuit is completed from the line wire 76 through contact 56, contact member 54, terminal 55, wire 80, mercury switch 28, wire 81, terminal 40, contact member 39, contacts 37 and 38, contact members 41 and 57, cotnact 58, conductor 82, contact 65, conductor 83, contacts 72 and 73, conductor 84, operating coil 61, conductor 85, and terminal 75 back to the other line wire 77. Completion of this starting circuit energizes the operating coil 61 to move the bridge members 62 and 63 into engagement with their respective contacts.

Movement of the bridge member 63 into engagement with the contacts 66 and 67 completes a load circuit for the compressor motor 14 which may be traced from the line wire 76, through contact 56, conductor 87, terminal 70, heater element 71, contact 66, bridge member 63, contact 67, wire 88, compressor motor 14, wire 89, and terminal 75 back to the other line wire 77. Completion of this load circuit causes operation of the compressor motor 14 and hence the compressor 13.

Movement of the bridge member 62 into engagement with the contacts 64 and 65 completes a maintaining circuit for the operating coil 61 of the relay which is independent of the contacts 38 and 58 and the contact members 41 and 57. This maintaining circuit may be traced from the line wire 76 through contact 56, contact member 54, terminal 55, wire 80, mercury switch 28, wire 81, terminal 40, contact member 39, contact 37, conductor 91, contact 64, bridge member 62, contact 65, conductor 83, contacts 72 and 73, conductor 84, operating coil 61, conductor 85, and terminal 75 back to the other line wire 77. Completion of this circuit maintains the operating coil 61 energized and hence the compressor 13 in operation until either the temperature within the compartment 10 decreases

to 40° or the suction pressure decreases to 15 pounds or the head pressure increases to 185 pounds. When any of these contingencies occur the operating coil 61 of the relay is deenergized and the compressor 13 is stopped. The compressor 13 cannot again be restarted until the starting circuit is again established and this can occur only when the temperature within the compartment 10 rises to 42° and the suction pressure rises to the defrosting value of 35 pounds and the head pressure decreases to 140 pounds. If an overload condition should occur within the load circuit the overload cut-out 69 operates to separate the contacts 72 and 73 to deenergize the operating coil 61 and hence stop operation of the compressor 13.

From the above it is seen that the control arrangement for the compressor 13 operates to maintain the temperature within the compartment 10 between 40° and 42° and operates to automatically defrost the evaporator 11 every time that the compressor is shut down since it is impossible to restart the compressor until such time as the suction pressure has risen to the defrosting value of 35 pounds. Starting of the compressor motor against high head pressures is also prevented.

The thermostatic expansion valve 19 which regulates the flow of refrigerant to the evaporator 11 may comprise a housing 100 having a bottom plate 101 and a top plate 102. Sealed to the bottom plate 101 is a bellows 103 which is also sealed to a movable wall 104. The interior of the bellows 103 is connected by a pipe 105 to a point in the suction line 20 adjacent the outlet of the evaporator 11. The bellows 103 therefore forms a pressure operated device for moving the movable wall 104 in accordance with changes in suction pressure at the evaporator outlet and hence in accordance with pressures existing within the evaporator 11. Located between the upper plate 102 and the housing 100 is a cup shaped plate 107 to which is sealed one end of a bellows 108. The other end of the bellows 108 is sealed to the movable wall 104. A rod 109 is suitably secured to the movable wall 104 and extends upwardly through an opening in the cup shaped plate 107. A bellows 110 is sealed to the cup shaped plate 107 and the rod 109 to seal hermetically the chamber within the bellows 108. The interior of the bellows 108 is connected by a capillary tube 111 to a bulb 112 which is thermally affected by the temperature of the superheated refrigerant leaving the evaporator 11. The bellows 108, the capillary tube 111, and the bulb 112 therefore form an enclosed system which is charged with a volatile fluid so that the bellows 108 forms a pressure operated device for moving the movable wall 104 in accordance with changes in temperature of the superheated refrigerant leaving the evaporator 11.

A compression spring 114 is located between the cup shaped plate 107 and a spring retainer 115 held in place by a nut 116 screw-threadedly mounted on the rod 109. The spring 114 therefore operates to assist the bellows 103 in moving the movable wall 104 upwardly. The movable wall 104 carries a pin 119 which is located in a slot 120 of a lever 121 which is pivoted at 122. The lever 121 carries a valve element 123 cooperating with a valve seat 124. The valve element 123 and the valve seat 124 form an expansion valve for regulating the flow of refrigerant to the evaporator 11.

Upon an increase in evaporator pressure the movable wall 104 is moved upwardly to close the valve and upon an increase in temperature of the superheated refrigerant at the evaporator outlet the movable wall 104 is moved downwardly to open the valve. The spring 114 operates to assist the bellows 103 in moving the movable wall 104 upwardly so that a desired degree of superheat may be maintained at the evaporator outlet. For purposes of illustration, it is assumed that the spring 114 is so adjusted that substantially 8° of superheat are maintained at the evaporator outlet. Therefore the valve is positioned in accordance with the evaporator pressure and the temperature of the refrigerant at the evaporator outlet to maintain a substantially constant superheat of 8° at the evaporator outlet to maintain a desired amount of refrigerant in the evaporator 11.

In accordance with the principles of this invention, the enclosed system comprising the bellows 108, the capillary tube 111, and the bulb 112 is charged with a limited amount of volatile fluid so that at some temperature at the evaporator outlet all of the volatile fluid is volatilized and therefore upon an increase in temperature above this value substantially no increase in opening force of the valve is provided. For purposes of illustration it is assumed that the amount of volatile fluid contained in the enclosed system is such that all of the fluid is volatilized when the temperature of the refrigerant leaving the evaporator rises to substantially 33°. Therefore for temperatures above 33°, no additional opening force is provided. Since the superheat adjustment of the thermostatic expansion valve is such as to maintain a superheat of substantially 8°, then when the evaporator pressure increases to a value corresponding to 25°, which value for the refrigerant utilized is 25 pounds, it then becomes impossible for the expansion valve to open whenever the evaporator pressure is above 25 pounds. In other words, whenever the evaporator pressure increases above 25 pounds it is impossible for the enclosed system to open the expansion valve.

The volumetric capacity of the enclosed system may be varied to change the temperature value at which the enclosed system becomes ineffective to open the expansion valve and this change in volumetric capacity may be accomplished by connecting the capillary tube 111 through a tube 126 into a bellows 127 which is located in a housing 128. A spring 129 located within the bellows 127 urges the bellows into engagement with an adjusting screw 130. By rotating the adjusting screw 130 the volume in the bellows 127 and therefore the volumetric capacity of the enclosed system may be varied at will. By increasing the volumetric capacity of the control system the temperature at which the enclosed system becomes ineffective to further open the expansion valve may be lowered and by decreasing the volumetric capacity it may be raised. Thus if it be desired to prevent opening of the expansion valve when the evaporator pressure increases above 25 pounds corresponding to a 25° evaporator temperature and if the spring 114 is adjusted to give a 10° superheat in place of the 8° superheat referred to above, then the volumetric capacity of the enclosed system may be changed to render the enclosed system ineffective to further open the valve when the temperature of the superheated refrigerant leaving the evaporator rises to 25 plus 10 or 35°.

From the above it is seen that I have provided a control system for a refrigerating apparatus wherein the compressor which circulates refrigerant through the evaporator is stopped for the purpose of defrosting the evaporator and wherein it is impossible to open the expansion valve during this defrosting period whenever the evaporator pressure rises above a predetermined value which corresponds to a temperature value below freezing. Thus defrosting of the evaporator is hastened and the evaporator pressure will at all times correspond to the temperature of the evaporator so that at any temperature above freezing, that is, at any defrosting temperature the valve will be closed. It will therefore be impossible to restart the refrigerating apparatus until after the evaporator has actually defrosted since no refrigerant will be allowed to leak into the evaporator during the defrosting cycle to raise the pressure in the evaporator to the defrosting value before the evaporator has actually been defrosted.

Although for purposes of illustration one form of this invention has been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure and therefore this invention should be limited only by the scope of the appended claims.

I claim as my invention:

1. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and valve means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said valve means including mechanism for positively preventing flow of refrigerant to the evaporator when the evaporator is defrosting.

2. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and an expansion valve for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating and for positively preventing flow of refrigerant to the evaporator when the evaporator pressure is above a predetermined value corresponding to a temperature value below freezing.

3. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, said thermostatic expansion valve being so arranged as to positively prevent the flow of refrigerant to the evaporator while the evaporator pressure is high enough for defrosting.

4. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, said thermostatic expansion valve being so arranged as to positively prevent the flow of refrigerant to the evaporator when the evaporator pressure is above a value corresponding to a temperature value below freezing.

5. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, an expansion valve for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, and means associated with the expansion valve for causing the valve to positively prevent flow of refrigerant to the evaporator when the evaporator is defrosting.

6. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, an expansion valve for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, and means whereby the expansion valve prevents flow of refrigerant to the evaporator when the evaporator pressure is above a prede-

termined value corresponding to a temperature value below freezing.

7. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, and means associated with the thermostatic expansion valve for preventing flow of refrigerant to the evaporator when the evaporator is defrosting.

8. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, and means associated with the thermostatic expansion valve for preventing flow of refrigerant to the evaporator when the evaporator pressure is above a predetermined value corresponding to a temperature value below freezing.

9. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, said temperature operated means of the thermostatic expansion valve being so arranged as to be effective to prevent the supply of refrigerant to the evaporator when the evaporator pressure is above a predetermined value corresponding to a temperature value below freezing.

10. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means opposing said last means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet comprising an enclosed system charged with a limited amount of volatile fluid for increasing the supply of refrigerant to the evaporator upon an increase in temperature said fluid being of such amount as to become completely vaporized when the evaporator pressure is above a value corresponding to a temperature value below freezing whereby said temperature operated means develops no appreciable further pressure as the temperature of super-heated refrigerant increases and said pressure operated means keeps the valve positively closed as the evaporated temperature increases.

11. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including a valve for regulating the supply of refrigerant to the evaporator, pressure operated means responsive to the evaporator pressure for closing the valve upon an increase in pressure, and pressure operated means comprising an enclosed system charged with a limited amount of volatile fluid and responsive to the temperature of the superheated refrigerant at the evaporator outlet for opening the valve the amount of fluid being such that it becomes completely vaporized at a predetermined temperature of the superheated refrigerant whereby no appreciable further valve opening pressure is developed so that the valve remains positively closed as the evaporator pressure increases.

12. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulat-

ing means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including a valve for regulating the supply of refrigerant to the evaporator, pressure operated means responsive to the evaporator pressure for closing the valve upon an increase in pressure, pressure operated means comprising an enclosed system charged with a limited amount of volatile fluid and responsive to the temperature of the superheated refrigerant at the evaporator outlet for opening the valve the amount of fluid being such that it becomes completely vaporized at a predetermined temperature of the super-heated refrigerant whereby no appreciable further valve opening pressure is developed so that the valve remains positively closed as the evaporator pressure increases, and means for adjusting the volumetric capacity of the enclosed system to vary the evaporator conditions under which the valve remains fully closed.

13. A thermostatic expansion valve for a refrigerating apparatus having an evoparator and means for circulating refrigerant through the evaporator to be evaporated therein, comprising in combination, a valve for regulating the supply of refrigerant to the evaporator, pressure operated means responsive to the evaporator pressure for closing the valve upon an increase in pressure, pressure operated means including an enclosed system charged with a limited amount of volatile fluid and responsive to the temperature of the superheated refrigerant at the evaporator outlet for opening the valve upon an increase in pressure, the amount of fluid being such that it becomes completely vaporized at a predetermined value of the super-heated refrigerant whereby no appreciable further valve opening pressure is developed so that the valve remains positively closed as the evaporator pressure increases, and means for adjusting the volumetric capacity of the enclosed system to vary the value of the evaporator pressure at which opening of the valve is prevented.

14. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, means responsive to evaporator pressure to allow restarting of the circulating means only when the evaporator pressure rises to a value corresponding to a temperature value above freezing, and an expansion valve for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating and said expansion valve having structural characteristics whereby flow of refrigerant to the evaporator is positively prevented when the evaporator pressure is above a value corresponding to a temperature value below freezing.

15. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, means responsive to evaporator pressure to allow restarting of the circulating means only when the evaporator pressure rises to a value corresponding to a temperature value above freezing, and a thermostatic expansion valve for regulating the flow of refrigerant to the evaporator for normally maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said thermostatic expansion valve including means operated in accordance with the evaporator pressure for increasing the supply of refrigerant to the evaporator upon a decrease in pressure and means operated in accordance with the temperature of the superheated refrigerant at the evaporator outlet for increasing the supply of refrigerant to the evaporator upon an increase in temperature, said thermostatic expansion valve embodying means so arranged as to prevent the flow of refrigerant to the evaporator when the evaporator pressure is above a value corresponding to a temperature value below freezing.

16. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and control means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said control means including mechanism responsive to a condition which is a measure of evaporator temperature for positively preventing flow of refrigerant to the evaporator when its temperature exceeds a predetermined value.

17. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and control means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said control means including mechanism responsive to a condition which is a measure of evaporator temperature for positively preventing flow of refrigerant to the evaporator when its temperature exceeds a predetermined value, and means operative at a predetermined value of evaporator pressure representative of a relatively high temperature for causing the circulating means to start, said mechanism for positively preventing admission of refrigerant to the evaporator serving to avoid delay in the evaporator pressure rising to said predetermined value when the circulating means are not operating.

18. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces

the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and control means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said control means including mechanism responsive to a condition which is a measure of evaporator temperature for positively preventing flow of refrigerant to the evaporator when its temperature exceeds a predetermined value, said control means and mechanism comprising an expansion valve and an enclosed system having a thermal bulb containing a limited amount of volatile liquid, the bulb being thermally associated with the evaporator, the amount of liquid being such as to be completely vaporized at a predetermined temperature so as to develop no appreciably further pressure at higher temperature, and said expansion valve being of a type responsive to evaporator pressure and to said bulb wherein evaporator pressure urges the valve in closing direction and pressure in said bulb urges the valve in opening direction so that if the evaporator pressure increases after the pressure in the bulb reaches its maximum the valve is held positively closed.

19. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and control means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said control means including mechanism responsive to a condition which is a measure of evaporator temperature for positively preventing flow of refrigerant to the evaporator when its temperature exceeds a predetermined value, said control means and mechanism comprising an expansion valve and an enclosed system having a thermal bulb containing a limited amount of volatile liquid, the bulb being thermally associated with the evaporator, the amount of liquid being such as to be completely vaporized at a predetermined temperature so as to develop no appreciably further pressure at higher temperature, and said expansion valve being of a type responsive to evaporator pressure and to said bulb wherein evaporator pressure urges the valve in closing direction and pressure in said bulb urges the valve in opening direction so that if the evaporator pressure increases after the pressure in the bulb reaches its maximum the valve is held positively closed, and means responsive to evaporator pressure arranged to start the circulating means at a predetermined value thereof.

20. In combination, an evaporator for cooling a medium, means for circulating refrigerant through the evaporator and normally to reduce the evaporator pressure to a value which reduces the evaporator temperature below freezing, means for interrupting operation of the circulating means to allow the evaporator pressure to increase to a value corresponding to a temperature value above freezing for defrosting the evaporator, and control means for regulating the flow of refrigerant to the evaporator for maintaining a desired amount of refrigerant in the evaporator while the circulating means is operating, said control means including mechanism responsive to a condition which is a measure of evaporator temperature for positively preventing flow of refrigerant to the evaporator when its temperature exceeds a predetermined value, said control means and mechanism comprising an expansion valve and an enclosed system having a thermal bulb containing a limited amount of volatile liquid, the bulb being thermally associated with the evaporator, the amount of liquid being such as to be completely vaporized at a predetermined temperature so as to develop no appreciably further pressure at higher temperature, and said expansion valve being of a type responsive to evaporator pressure and to said bulb wherein evaporator pressure urges the valve in closing direction and pressure in said bulb urges the valve in opening direction so that if the evaporator pressure increases after the pressure in the bulb reaches its maximum the valve is held positively closed, and means for adjusting the volumetric capacity of said enclosed system.

21. In apparatus of the character described, in combination, an expansion valve for controlling a volatile fluid, means responsive to pressure of fluid after it has passed through said valve for urging the valve in closing direction, means for urging the valve in opening direction against the force of said first means, said second means comprising an enclosed system including a thermal bulb filled with a limited amount of volatile liquid, said bulb being positioned so as to respond to the temperature of said fluid after passing through the valve, the amount of said liquid being such that it becomes completely vaporized at a predetermined temperature of said fluid so that no appreciable further pressure is developed in said enclosed system and further increases in pressure of said fluid beyond the valve positively hold it in closed position.

22. In apparatus of the character described, in combination, a thermostatic expansion valve having means comprising an enclosed system having a thermal bulb filled with a limited amount of volatile liquid for producing a force urging the valve in opening direction, said bulb being responsive to temperature and the amount of liquid being such that it becomes completely vaporized at a predetermened temperature so as to develop no appreciably further opening force on the valve as the temperature increases, means for exerting a variable closing force balancing said first force on the valve, whereby if said closing force increases after said predetermined temperature is reached the valve is closed and held firmly closed.

ALWIN B. NEWTON.