March 11, 1941. J. L. HARRIS 2,234,250

REFRIGERATION CONTROL SYSTEM

Filed Dec. 3, 1938 2 Sheets-Sheet 1

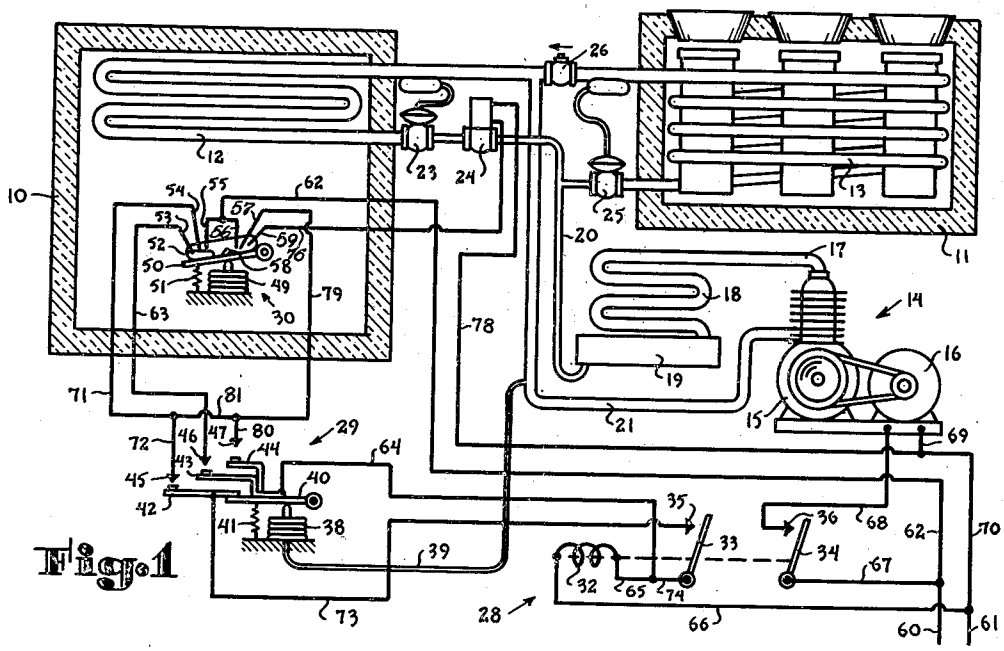


Fig. 1

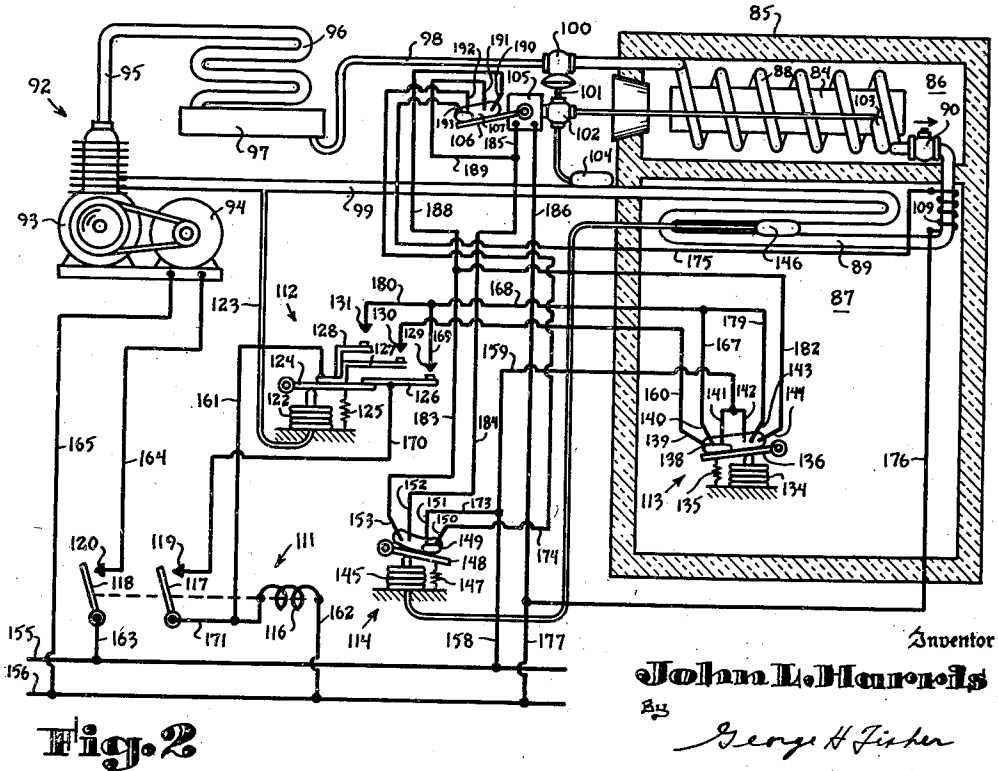


Fig. 2

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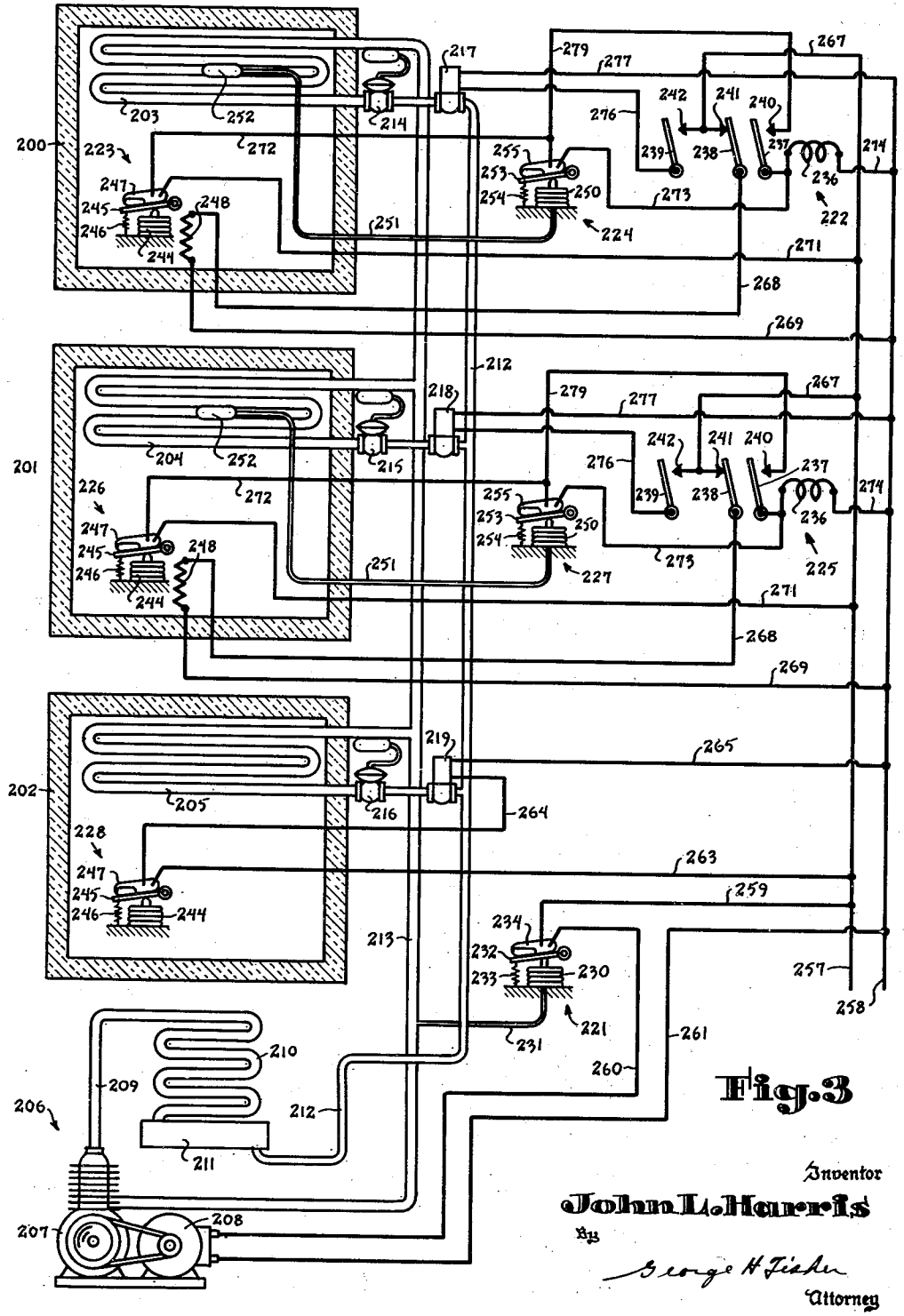


Fig. 3

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Patented Mar. 11, 1941 2,234,250

UNITED STATES PATENT OFFICE

2,234,250

REFRIGERATION CONTROL SYSTEM

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Application December 3, 1938, Serial No. 243,801

20 Claims. (Cl. 62—4)

This invention relates to control systems for a refrigerating apparatus and particularly to control systems for a refrigerating apparatus having a plurality of evaporators.

The prime object of this invention is to provide a control system for a refrigerating apparatus having a plurality of evaporators wherein refrigerant is normally supplied to one of the evaporators at all times regardless of the frost condition of the evaporator and wherein refrigerant is supplied to the other evaporator upon a demand for cooling provided the other evaporator is defrosted. In other words, this invention contemplates the control of a plurality of evaporators to give desired temperature control and to defrost those evaporators which it is desirable to defrost and not defrost the other evaporators. The evaporators which are defrosted may be utilized for cooling storage compartments, walk-in boxes or the like, while the evaporators which do not require defrosting may be utilized for cooling, freezing or hardening devices, soda fountains, water coolers, and the like.

The manners in which this sequence of operation is accomplished also form objects of this invention.

Other objects and advantages will become apparent to those skilled in the art upon reference to the accompanying specification, claims, and drawings in which

Figure 1 is a diagrammatic illustration of one form of this invention,

Figure 2 is a diagrammatic illustration of another form of the invention, and

Figure 3 is a diagrammatic illustration of still another form of the invention.

Referring now to Figure 1 a pair of fixtures to be cooled are designated at 10 and 11. The fixture 10 may be a storage compartment, walk-in box, or the like which is cooled by an evaporator 12 and fixture 11 may be a freezing or hardening chamber, a soda fountain, or the like cooled by an evaporator 13. Due to the evaporator 12 being located in an air space for cooling the same, moisture will collect and freeze upon this evaporator thereby making defrosting of this evaporator necessary. The evaporator 13 which is provided for chilling a substance which does not freeze on the coil is not subject to frosting and consequently it is unnecessary to defrost this evaporator.

Refrigerant is supplied to the evaporators 12 and 13 by a refrigerating apparatus generally designated at 14 which may comprise a compressor 15 operated by an electric motor 16. Compressed refrigerant is delivered from the compressor 15 through a high pressure line 17 to a condenser 18 and condensed refrigerant is collected in a receiver 19. Liquid refrigerant flows from the receiver 19 through a liquid line 20 to the evaporators 12 and 13 which are arranged in parallel in this embodiment of the invention. Evaporated refrigerant is withdrawn from the evaporators 12 and 13 through a suction line 21 by the compressor 15. The supply of refrigerant to the evaporator 12 is regulated by the usual thermostatic expansion valve 23 and is turned on and off by a solenoid valve 24. The supply of refrigerant to the evaporator 13 is controlled by the usual thermostatic expansion valve 25. A check valve 26 located on the discharge side of the evaporator 13 is utilized to prevent the back flow of refrigerant into the evaporator 13 during the defrosting cycle of evaporator 12.

The compressor motor 16 is controlled by a relay or starter generally designated at 28 and the relay or starter is in turn controlled by a suction pressure controller generally designated at 29 and a temperature responsive controller generally designated at 30 responsive to the temperature within the fixture 10. The temperature responsive controller 30 additionally controls the solenoid valve 24 to turn on and off the supply of refrigerant to the evaporator 12.

The relay or starter 28 may comprise an operating coil 32 for operating switch arms 33 and 34 with respect to contacts 35 and 36. When the operating coil 32 is energized the switch arms 33 and 34 are moved into engagement with the contacts 35 and 36, respectively, and when the operating coil 32 is deenergized the switch arms are moved out of engagement with their respective contacts by means of springs, gravity, or other means (not shown).

The suction pressure responsive controller 29 may comprise a bellows 38 connected by a pipe 39 to the suction pressure line 21. The bellows 38 operates a lever 40, preferably made of insulating material, against the action of an adjustable tension spring 41. The lever 40 carries contacts 42, 43, and 44, the contacts 43 and 44 being electrically connected while the contact 42 is electrically insulated from the contacts 43 and 44. The contacts 42, 43, and 44 are adapted upon a rise in suction pressure to sequentially engage stationary contacts 45, 46, and 47, respectively. Upon a decrease in suction pressure the movable contacts sequentially disengage their respective stationary contacts in a reverse order. For purposes of illustration it is assumed that upon an increase

in suction pressure contact 42 engages contact 45 at 15 lbs., contact 43 engages contact 46 at 25 lbs., and contact 44 engages contact 47 at 35 lbs. Upon a decrease in pressure contacts 44 and 47 separate at 35 lbs., contacts 43 and 46 separate at 25 lbs., and contacts 42 and 45 separate at 15 lbs. For purposes of illustration it is also assumed that the defrosting value of the suction pressure is between 25 lbs. and 35 lbs. so that it is impossible to engage the contacts 44 and 47 until the evaporator 12 has defrosted while contacts 43 and 46 may engage even though the evaporator 12 has not defrosted. Accordingly, the suction pressure responsive controller 29 may be considered a defrosted condition responsive controller.

The temperature responsive controller 30 responsive to the temperature within the fixture 10 may comprise a bellows 49 charged with a volatile fluid for operating a lever 50 against the action of an adjustable tension spring 51. The lever 50 operates a mercury switch 52 which may be of the general form shown and described in application Serial No. 167,755 filed by Harold T. Olson on October 7, 1937. The mercury switch 52 is provided with left electrodes 53, 54, and 55 and right electrodes 56, 57 and 59, the electrodes 55 and 56 being electrically connected together. The mercury switch 52 is provided with a ridge or detent 58 in the lower wall thereof to cause the mercury in the mercury switch to separate from the contacts 53, 54, and 55 before it engages the contacts 56, 57 and 59 upon an increase in temperature. Upon a decrease in temperature the ridge or detent 58 holds some of the mercury in engagement with contacts 56, 57 and 59 while the rest of the mercury engages the contacts 53, 54, and 55 until the switch 52 is tilted sufficiently far to cause the mercury to disengage the electrodes 56, 57 and 59. In this manner upon an increase in temperature the switching actions performed by the switch 52 are non-overlapping, but are overlapping upon a decrease in temperature. For a more thorough description of the sequence of operation of the mercury switch 52 reference is made to the above referred to Harold T. Olson application. For purposes of illustration it is assumed that the switch 52 is tilted to the position wherein the electrodes 56, 57 and 59 are bridged at 42° and that the switch 52 is tilted to the position wherein the electrodes 53, 54, and 55 are bridged when the temperature within the fixture 10 decreases to 40°.

Power is supplied to the compressor motor 16, the solenoid valve 24, and the control system by means of line wires 60 and 61 leading from some source of power (not shown).

Assuming now that the temperature within the fixture 10 is below 40° so that no cooling is required in the fixture 10 the switch 52 of the temperature responsive controller 30 will be in the position shown in Figure 1. When the suction pressure rises to 25 lbs. to cause the contacts 42 and 43 to engage contacts 45 and 46 a circuit is completed from the line wire 60 through wire 62, electrodes 55 and 53, wire 63, contacts 46 and 43, wires 64 and 65, operating coil 32 and wire 66 back to the other line wire 61. Completion of this circuit energizes the operating coil 32 to move the switch arms 33 and 34 into engagement with the contacts 35 and 36. Movement of the switch arm 34 into engagement with the contact 36 completes a load circuit for the compressor motor 16 which may be traced from the line wire 60 through wire 67, switch arm 34, contact 36, wire 68, compressor motor 16, and wires 69 and 70 back to the other line wire 61. Hence, whenever the relay or starter 28 is pulled in the compressor motor 16 and hence the compressor 15 is placed in operation.

Movement of the switch arm 33 into engagement with the contact 35 completes a maintaining circuit for the operating coil 32 which may be traced from the line wire 60 through wire 62, electrodes 55 and 54, wires 71 and 72, contacts 45 and 42, wire 73, contact 35, switch arm 33, wires 74 and 65, operating coil 32, and wire 66 back to the other line wire 61. Completion of this circuit maintains the operating coil 32 energized and hence the compressor 15 in operation until the suction pressure decreases to 15 lbs. to separate the contacts 42 and 45. Accordingly when the temperature responsive controller 30 within the fixture 10 is satisfied the relay or starter 28 and hence the compressor 15 are controlled by the suction pressure controller 29 to maintain the suction pressure between 15 lbs, and 25 lbs. This operation of the compressor 15 therefore supplies refrigerant to the evaporator 13 for cooling the fixture 11 but since the solenoid valve 24 associated with the evaporator 12 is closed the evaporator 12 is starved of refrigerant and therefore performs no cooling action.

Assume now that the temperature within the fixture 10 rises to 42° to tilt the switch 52 to a position to bridge the electrodes 56, 57 and 59. As pointed out above the electrodes 53, 54, and 55 are unbridged before the electrodes 56, 57 and 59 are bridged and therefore if the compressor 15 is operating at this time the unbridging of the electrodes 53, 54, and 55 stops the compressor. Bridging of the electrodes 56, 57 and 59 completes a circuit from the line wire 60 through wire 62, electrodes 56 and 59, wire 76, solenoid valve 24, and wires 78 and 70 back to the other line wire 61. Accordingly when the temperature within the fixture 10 increases to 42° the solenoid valve 24 is opened to supply refrigerant to the evaporator 12.

However, the compressor 15 cannot start until such time as the suction pressure increases to a defrosting value of 35 lbs. to close the contacts 44 and 47. When this occurs a circuit is completed from the line wire 60 through wire 62, electrodes 56 and 57, wires 79, and 80, contacts 47 and 44, wires 64 and 65, operating coil 32, and wire 66 back to the other line wire 61. Completion of this circuit pulls in the relay or starter 28 to start the compressor 15. Pulling in of the relay or starter 28 completes a maintaining circuit which may be traced from the line wire 60 through wire 62, electrodes 56 and 57, wires 79, 81, and 72, contacts 45 and 42, wire 73, contact 35, switch arm 33, wires 74 and 65, operating coil 32, and wire 66 back to the other line wire 61. Completion of this circuit maintains the relay or starter 28 pulled in until the suction pressure decreases to 15 lbs.

Accordingly, when the temperature responsive controller 30 calls for cooling, the compressor 15 is stopped if it is running and if the suction pressure is below 35 lbs., the solenoid valve 24 is opened, and when the evaporator 12 has defrosted to cause the suction pressure to rise to 35 lbs., the compressor 15 is placed in operation to supply refrigerant to the evaporator 12. The check valve 26 connected on the discharge side of the evaporator 13 prevents the back flow of refrigerant into the evaporator 13 so that the

evaporator 13 will not defrost while the evaporator 12 is defrosting.

If when the temperature responsive controller 30 is calling for cooling and the suction pressure decreases to 15 lbs. to stop the compressor 15, the compressor cannot again start until the suction pressure increases to the defrosting value of 35 lbs. whereby defrosting of the evaporator 12 is always assured.

When the temperature within the fixture 10 decreases to 40° the mercury switch tilts from the on position to the position shown in Figure 1 and as pointed out above the mercury in the mercury switch 52 engages the contacts 53, 54, and 55 before it disengages the contacts 56, 57 and 59 so that if the compressor is in operation it will be maintained in operation by the overlapping action of the mercury switch 52. When the switch 52 is tilted sufficiently far to cause the mercury to disengage the electrodes 56, 57 and 59 the solenoid valve 24 is closed to starve the evaporator 12 and hence interrupt the cooling action performed thereby. From the above it is seen that the control system of Figure 1 provides cooling at all times in the fixture 11 and also provides temperature and defrosting control for the fixture 10. In other words, the refrigerating system of Figure 1 provides a freezing or hardening action within the fixture 11 at all times and provides accurate temperature control accompanied with a defrosting action within fixture 10.

Referring now to Figure 2 a fixture to be cooled is designated at 85, this fixture being provided with a freezing chamber 86 and a storage compartment 87. An evaporator 88 located within the freezing chamber 86 cools, hardens or freezes a suitable substance located in a container 84 and an evaporator 89 located within the storage compartment 87 maintains desired temperatures within the storage compartment 87. As shown the evaporators 88 and 89 are connected in series with respect to each other, a check valve 90 being located between the evaporators to prevent the back flow of refrigerant from the evaporator 89 into the evaporator 88 during the defrosting periods.

Refrigerant is supplied to the evaporators 88 and 89 by means of a refrigerating apparatus generally designated at 92 and comprising a compressor 93 driven by an electric motor 94. Compressed refrigerant flows from the compressor 93 through a high pressure line 95 into a condenser 96 and condensed refrigerant is collected in a receiver 97. Liquid refrigerant flows from the receiver 97 through a liquid line 98 into the series connected evaporators 88 and 89 and evaporated refrigerant is withdrawn from the evaporators 88 and 89 through a suction line 99 by the compressor 93.

An expansion valve 100 regulates the supply of refrigerant to the evaporators 88 and 89, the expansion valve 100 being of the thermostatic type having a capillary tube 100 connected through a three-way valve 102 to bulbs 103 and 104. The bulb 103 is located at the discharge end of the evaporator 88 and the bulb 104 is located at the discharge end of the evaporator 89. The bulbs 103 and 104 are charged with a volatile fluid so as to operate the thermostatic expansion valve 100 in accordance with the temperature of the refrigerant leaving the evaporators. The three-way valve 102 operated by a solenoid 105 selects which bulb 103 or 104 shall control the thermostatic expansion valve 100. When the solenoid 105 is energized the thermostatic expansion valve 100 is connected to the bulb 104 to be controlled thereby so that liquid refrigerant is present in both evaporators 88 and 89 to cause both evaporators 88 and 89 to perform a cooling function. When the solenoid 105 is deenergized the valve 102 is operated to connect the bulb 103 with the thermostatic expansion valve 100 so that liquid refrigerant is present only in the evaporator 88, the refrigerant in evaporator 89 being superheated and therefore performing substantially no cooling function. The solenoid 105 operates a lever 106 which in turn operates a mercury switch 107. When the solenoid 105 is energized the switch 107 is tilted to bridge electrodes 190 and 191 and when it is deenergized, electrodes 192 and 193 are bridged. To insure that no cold gaseous refrigerant will enter the evaporator 89 when the solenoid 105 is deenergized an electric heating coil 109 located in the connection between the evaporators 88 and 89 may be utilized to heat the gaseous refrigerant flowing thereby. When the solenoid 105 is deenergized to prevent the supply of liquid refrigerant to the evaporator 89, the refrigerant therein will be superheated by this heating coil and hence the evaporator 89 will defrost.

The compressor motor 94 and hence the compressor 93 is controlled by a relay or starter generally designated at 111. The relay or starter 111 is, in turn controlled by a suction pressure responsive controller 112 and a temperature responsive controller 113 responsive to the temperature within the storage compartment 87. A temperature responsive controller 114 responsive to the temperature and hence the defrosted condition of the evaporator 89 acts in conjunction with the temperature responsive controller 113 to control the heating element 109 and the solenoid 105.

The relay or starter 111 may comprise an operating coil 116 for moving switch arms 117 and 118 into engagement with contacts 119 and 120 when energized. When the operating coil 116 is deenergized the switch arms are moved out of engagement with their respective contacts by means of springs, gravity, or other means (not shown).

The suction pressure responsive controller 112 may comprise a bellows 122 connected by a pipe 123 to the suction line 99 for operating a lever 124, preferably made of insulating material, against the action of an adjustable tension spring 125. The lever 124 sequentially operates contacts 126, 127, and 128 with respect to stationary contacts 129, 130, and 131, the contacts 127 and 128 being electrically connected together and the contact 126 being electrically insulated from the contacts 127 and 128. For purposes of illustration it is assumed that the parts are so arranged that the contacts 126 and 127 engage and disengage at 15 lbs., the contacts 127 and 130 engage and disengage at 25 lbs., and the contacts 128 and 131 engage and disengage at 35 lbs.

The temperature responsive controller 113 responsive to the temperature within the storage compartment 87 may comprise a bellows 134 charged with a volatile fluid for operating a lever 136 against the action of an adjustable tension spring 135. The lever 136 operates a mercury switch 138. The mercury switch 138 contains left electrodes 139, 140, and 141 and right electrodes 142, 143, and 144, the electrodes 141 and 142 being electrically connected together. When the temperature within the storage compartment

87 decreases to 40° electrodes 139, 140, and 141 are bridged and when the temperature increases to 42° the electrodes 142, 143, and 144 are bridged. The parts are so arranged that upon an increase in temperature the electrodes 142, 143 and 144 are bridged before the electrodes 139, 140, and 141 are unbridged and conversely upon a decrease in temperature the electrodes 139, 140, and 141 are bridged before the electrodes 142, 143, and 144 are unbridged. In other words, the switching action performed by switch 138 overlaps in both directions.

The frost condition responsive controller 114 responding to the temperature of the evaporator 89 may comprise a bellows 145 connected by a capillary tube to a bulb 146 mounted on the evaporator 89. The bulb 146 is charged with a volatile fluid so that the bellows 145 is operated in accordance with changes in temperature of the evaporator 89. The bellows 145 operates a lever 148 against the action of an adjustable tension spring 147, the lever 148 in turn operating a double ended mercury switch 149 provided with right electrodes 150 and 151 and left electrodes 152 and 153. For purposes of illustration it is assumed that the parts are so arranged that when the temperature of the evaporator 89 decreases to 30° the electrodes 151 and 150 are bridged and when the temperature increases to 34° the electrodes 152 and 153 are bridged. The parts are so arranged that the switching action performed by the switch 149 is not overlapping, that is, the electrodes 152 and 153 are unbridged before the electrodes 150 and 151 are bridged and vice versa the electrodes 150 and 151 are unbridged before the electrodes 152 and 153 are bridged.

Power is supplied to the compressor motor 94, the solenoid 105, the heating element 109, and the control system by means of line wires 155 and 156 leading from some source of power (not shown).

Assume now that the temperature within the storage compartment 87 is 40° whereupon the temperature responsive controller 113 assumes the position shown in Figure 2. The solenoid 105 is deenergized and the bulb 103 is in control of the thermostatic expansion valve 100 whereupon liquid refrigerant is supplied to the evaporator 88 but the refrigerant in the evaporator 89 is superheated so that the evaporator 89 does not perform a cooling function. When the suction pressure increases to 25 lbs. to close the contacts 126 and 129 and the contacts 127 and 130 a circuit is completed from the line wire 155 through wires 158 and 159, electrodes 141 and 139, wire 160, contacts 130 and 127, wire 161, operating coil 116, and wire 162 back to the other line wire 156. Completion of this circuit energizes the operating coil 116 to move the switch arms 117 and 118 into engagement with the contacts 119 and 120, respectively. Movement of the switch arm 118 into engagement with the contact 120 completes a circuit from the line wire 155 through wire 163, switch arm 118, contact 120, wire 164, electric motor 94, and wire 165 back to the other line wire 156. Completion of this circuit operates the compressor motor 94 and hence the compressor 93 to supply refrigerant to the evaporator 88.

Movement of the switch arm 117 into engagement with the contact 119 completes a maintaining circuit for the operating coil 116 which may be traced from the line wire 155 through wires 158 and 159, electrodes 141 and 140, wires 167, 168, and 169, contacts 129 and 126, wire 170, contact 119, switch arm 117, wire 171, operating coil 116 and wire 162 back to the other line wire 156. Completion of this circuit maintains the relay or starter 111 pulled in and the compressor 93 in operation until the suction pressure decreases to 15 lbs. By reason of the above arrangement when the temperature responsive controller 113 is satisfied the compressor 93 is operated to maintain the suction pressure between 15 lbs. and 25 lbs. to supply refrigerant to the evaporator 88. Under these conditions the expansion valve 100 is under the control of the bulb 103 so that no liquid refrigerant is supplied to the evaporator 89 and hence the evaporator 89 is not performing a cooling function.

As long as the evaporator 89 is frosted the temperature responsive controller 114 will bridge the electrodes 150 and 151 to complete a circuit from the line wire 155 through wires 158 and 173, electrodes 151 and 150, wire 174, electrodes 192 and 193 of the mercury switch 107, wire 175, heater element 109, and wires 176 and 177 back to the other line wire 156. Completion of this circuit energizes the heater element 109 to heat the refrigerant flowing to the evaporator 89 so that the refrigerant in the evaporator 89 will be superheated and hence cause defrosting of the evaporator 89. When this evaporator becomes defrosted, electrodes 150 and 151 will become unbridged for deenergizing the heating element 109.

When the temperature within the storage compartment 87 increases to 42° the electrodes 142, 143, and 144 are bridged and when the suction pressure increases to 35 lbs. a circuit is completed from the line wire 155 through wires 158 and 159, electrodes 142 and 143, wires 179, 168, and 180, contacts 131 and 128, wire 161, operating coil 116 and wire 162 back to the other line wire 156. Completion of this circuit pulls in the relay or starter 111 to operate the compressor 92. Pulling in of the relay or starter 111 completes a maintaining circuit which may be traced from the line wire 155 through wires 158 and 159, electrodes 142 and 143, wires 179, 168, and 169, contacts 129 and 126, wire 170, contact 119, switch arm 117, wire 171, operating coil 116, and wire 162 back to the other line wire 156. Accordingly when the temperature responsive controller 113 is calling for cooling the compressor 92 is controlled by the suction pressure controller 112 to maintain the suction pressure between 15 lbs. and 35 lbs. and if the compressor stops during the time that the temperature responsive controller 113 is calling for cooling, the compressor cannot be restarted until such time as the suction pressure rises to a defrosting value whereby defrosting of the evaporator 89 is assured. The check valve 90 prevents the back flow of refrigerant into the evaporator 88 during this defrosting cycle. If however the compressor 93 is in operation when the temperature responsive controller 113 is operated to call for cooling, the compressor will remain in operation by reason of the overlapping action of the mercury switch 138.

When the evaporator 89 is defrosted the temperature responsive controller 114 operates the switch 149 to bridge the electrodes 152 and 153 and a circuit is thereupon completed from the line wire 155 through wires 158 and 159, electrodes 142 and 144, wires 182 and 183, electrodes 153 and 152, wires 184 and 185, solenoid 105 and wires 186 and 177 back to the other line wire 156. Completion of this circuit energizes the solenoid 105 to shift the control of the thermostatic ex-

pansion valve 100 from the bulb 103 to the bulb 104 so that liquid refrigerant will be supplied to the evaporator 89 to cause the evaporator 89 to perform a cooling function. As pointed out above energization of the solenoid 105 bridges the electrodes 190 and 191 of the mercury switch 107 and this completes a maintaining circuit for the solenoid 105 which is independent of the electrodes 152 and 153 of the temperature responsive controller 114. This maintaining circuit may be traced from the line wire 155 through wires 158 and 159, electrodes 142 and 144, wires 182 and 188, electrodes 190 and 191 of the mercury switch 107, wires 189 and 185, solenoid 105, and wires 186 and 177 back to the other line wire 156. Completion of this circuit maintains the solenoid 105 energized as long as the temperature responsive controller 113 is calling for cooling. Energization of the solenoid 105 also unbridges the electrodes 192 and 193 to prevent energization of the heater 109 when liquid refrigerant is being supplied to the evaporator 89.

When the temperature within the storage compartment 87 decreases to 40° the mercury switch 113 is tilted to the position shown in Figure 2 and the solenoid 105 is deenergized to place the expansion valve 100 under the control of the bulb 103 to interrupt the supply of liquid refrigerant to the evaporator 89 and the compressor 93 is placed under the control of the suction pressure controller 112 to maintain the suction pressure between 15 lbs. and 25 lbs. If the temperature of the evaporator 89 is below freezing indicating that frost is present on the evaporator 89 the heating element 109 is energized to hasten the defrosting of the evaporator 89.

By reason of the control arrangement of Figure 2, when the temperature responsive controller 113 is satisfied the compressor is operated to maintain a suction pressure between 15 lbs. and 25 lbs. and the expansion valve 100 is adjusted to supply liquid refrigerant to the evaporator 88 but not to the evaporator 89 whereupon only the evaporator 88 performs a cooling function. When the temperature responsive controller 113 calls for cooling the expansion valve 100 is adjusted to supply refrigerant to the evaporator 89 provided the evaporator 89 has defrosted so that both evaporators 88 and 89 will perform a cooling function. If the compressor should cut out from a low suction pressure when refrigerant is being supplied to the evaporator 89 it cannot be restarted until the evaporator 89 has defrosted. Accordingly the arrangement of Figure 2 provides for substantially continuous cooling by the evaporator 88 and provides automatic temperature control of the evaporator 89 to maintain desired temperatures within the storage compartment 87 and to cause intermittent defrosting of the evaporator 89.

Referring now to Figure 3, three fixtures are designated at 200, 201, and 202. The fixtures 200 and 201 are cooled by evaporators 203 and 204, it being desirable to intermittently defrost the evaporators 203 and 204. The fixture 202 is cooled by an evaporator 205 and in this instance it is not desirable to intermittently defrost the evaporator 205. The fixtures 200 and 201 may be storage compartments, walk-in boxes, and the like while the fixture 202 may be a freezing or hardening compartment or the like wherein it is desirable to maintain low temperatures. Refrigerant is supplied to the evaporators 203, 204, and 205 by means of a refrigerating apparatus generally designated at 206 and which may comprise a compressor 207 operated by an electric motor 208. Compressed refrigerant flows from the compressor 206 through a high pressure line 209 into a condenser 210 and condensed refrigerant is collected in a receiver 211. Liquid refrigerant flows from the receiver 211 through a liquid line 212 to the evaporators 203, 204, and 205 arranged in parallel. Evaporated refrigerant is withdrawn from the parallel arranged evaporators 203, 204, and 205 through a suction line 213 by the compressor 207. Evaporators 203, 204, and 205 are provided with the conventional thermostatic expansion valves 214, 215, and 216, respectively, to regulate the flow of refrigerant into these evaporators. The evaporators 203, 204, and 205 are also provided with solenoid valves 217, 218, and 219, respectively, for turning on and turning off the supply of liquid refrigerant to these evaporators.

The compressor motor 208 and hence the compressor 207 is controlled by a suction pressure controller generally designated at 221 to maintain the suction pressure within desired limits. Solenoid valve 217 associated with the fixture 200 is controlled by a relay 222 which in turn is controlled by a temperature responsive controller 223 responsive to the temperature within the fixture 200 and a frost condition responsive controller 224 responsive to the temperature of the evaporator 203. In a like manner the solenoid valve 218 of the fixture 201 is controlled by a relay 225 which in turn is controlled by a temperature responsive controller 226 responsive to the temperature within the fixture 201 and a frost condition responsive controller 227 responsive to the temperature of the evaporator 204. The solenoid valve 219 for controlling the supply of refrigerant to the evaporator 205 is controlled by a temperature responsive controller 228 responsive to the temperature within the fixture 202.

The suction pressure responsive controller 221 may comprise a bellows 230 connected by a pipe 231 to the suction line 213 for operating a lever 232 against the action of an adjustable tension spring 233. The lever 232 operates a mercury switch 234 and for purposes of illustration it is assumed that the mercury switch 234 is closed when the suction pressure increases to 25 lbs. and is opened when the suction pressure decreases to 15 lbs.

The relay 222 which controls the solenoid valve 217 may comprise an operating coil 236 for operating switch arms 237, 238, and 239 with respect to contacts 240, 241, and 242, respectively. When the operating coil 236 is energized the switch arms 237 and 239 are moved into engagement with contacts 240 and 242, respectively, and the switch arm 238 is moved out of engagement with the contact 241. When the relay coil 236 is deenergized the switch arms 237 and 239 are moved out of engagement with their respective contacts 240 and 242 and the switch arm 238 is moved into engagement with the contact 241 by means of springs, gravity, or other means (not shown). The relay 225 is exactly the same as the relay 222 and therefore like reference characters for like parts have been utilized.

The temperature responsive controller 223 responsive to the temperature within the fixture 200 may comprise a bellows 244 charged with a volatile fluid for operating a lever 245 against the action of an adjustable tension spring 246. The lever 245 operates a mercury switch 247

and for purposes of illustration it is assumed that the mercury switch is tilted to a closed position when the temperature within the fixture 200 rises to 42° and is tilted to the open position as shown in Figure 3 when the temperature decreases to 40°. A heater 248 may be provided for artificially heating the thermostatic bellows 244 when the mercury switch 247 is open to provide a cold anticipating function. The construction of the temperature responsive controllers 226 and 228 is exactly the same as that of the temperature responsive controller 233 and therefore like reference characters have been utilized for like parts. As is evident, the various temperature responsive controllers may be set to maintain different temperature conditions within the various fixtures.

The defrosted condition responsive controller 224 responsive to the temperature of the evaporator 203 may comprise a bellows 250 connected by a capillary tube 251 to a bulb 252 carried by the evaporator 203. The bulb 252 is charged with a volatile fluid so that the bellows 250 is operated in accordance with the temperature of the evaporator 203. The bellows 250 operates a lever 253 against the action of an adjustable tension spring 254. The lever 253 operates a mercury switch 255 and for purposes of illustration it is assumed that the mercury switch 255 is moved to a closed position when the temperature of the evaporator increases to 34° and is moved to an open position when the temperature of the evaporator decreases to 30°. Hence the mercury switch 255 is closed when the evaporator 203 is defrosted. The construction of the frost condition responsive controller 227 associated with the fixture 201 is exactly the same as that of the frost condition responsive controller 224 and therefore like reference characters for like parts have been utilized. It is here noted that the fixture 202 is not provided with a frost condition responsive controller.

Power is supplied to the compressor motor 208, the solenoid valves 217, 218, and 219 and to the control system by means of line wires 257 and 258 leading from some source of power (not shown).

When the suction pressure increases to 25 lbs. the switch 234 of the suction pressure responsive controller 221 is closed to complete a circuit from the line wire 257 through wire 259, mercury switch 234, wire 260, compressor motor 208, and wire 261 back to the other line wire 258. Completion of this circuit operates the compressor motor 208 and hence the compressor 207 until such time as the suction pressure decreases to 15 lbs. Accordingly the compressor 207 is operated to maintain the suction pressure between 15 lbs. and 25 lbs.

When the temperature responsive controller 228 responsive to the temperature within the fixture 202 calls for cooling a circuit is completed from the line wire 257 through wire 263, mercury switch 247, wire 264, solenoid valve 219, and wire 265 back to the other line wire 258. Completion of this circuit energizes the solenoid valve 219 to supply liquid refrigerant to the evaporator 205 to cool the fixture 202. When the temperature responsive controller 228 becomes satisfied the circuit through the solenoid valve 219 is opened by the switch 247 and the solenoid valve 219 is closed to starve the evaporator 205 whereupon the cooling action thereof is interrupted. In this manner desired temperature conditions are maintained within the fixture 202.

Referring now to the control apparatus for the fixture 200 of Figure 3 it is seen that when the temperature responsive controller 223 is satisfied causing relay 222 to assume the position shown, a circuit is completed from the line wire 257 through wire 267, contact 241, switch arm 238, wire 268, auxiliary heater 248, and wire 269 back to the other line wire 258. This heater supplies auxiliary heat to the temperature responsive controller 223 to cause the temperature responsive controller 223 to assume the cut in value of 42° before the temperature of the fixture has actually risen to 42°. When the temperature of the temperature responsive controller 223 rises to 42° and when the evaporator 203 has defrosted to close the switch 255 of the frost condition responsive controller 224, a circuit is completed from the line wire 257 through wire 271, mercury switch 247, wire 272, mercury switch 255, wire 273, operating coil 236, and wire 274 back to the other line wire 258. Completion of this circuit energizes the operating coil 236 to move the switch arm 238 out of engagement with the contact 241 thereby interrupting the circuit through the auxiliary heater 248 and to move the switch arms 237 and 239 into engagement with contacts 240 and 242.

Movement of the switch arm 239 into engagement with the contact 242 completes a circuit from the line wire 257 through wire 267, contact 242, switch arm 239, wire 276, solenoid valve 217, and wire 277 back to the other line wire 258. Completion of this circuit opens the solenoid valve 217 to supply liquid refrigerant to the evaporator 203.

Movement of the switch arm 237 into engagement with the contact 240 completes a maintaining circuit for the operating coil 236 which is independent of the switch 255 of the frost condition responsive controller 224. This may be traced from the line wire 257 through wire 271, switch 247, wires 272 and 279, contact 240, switch arm 237, operating coil 236, and wire 274 back to the other line wire 258. This maintaining circuit maintains the solenoid valve 217 open until such time as the temperature within the fixture 200 decreases to 40°. Accordingly, when the temperature responsive controller 223 of the fixture 200 calls for cooling the solenoid valve 217 is opened to supply liquid refrigerant to the evaporator 203 providing the evaporator 203 has defrosted. The solenoid valve 217 is maintained opened until such time as the temperature responsive controller 223 becomes satisfied. In this manner desired temperature conditions are maintained within the fixture 200 and the evaporator 203 is defrosted every time that the solenoid valve 217 is closed.

The manner in which the relay 225 associated with the fixture 201 controls the solenoid valve 219 and the manner in which the relay 225 is controlled by the temperature responsive controller 226 and the frost condition responsive controller 227 is exactly the same as that outlined above in connection with fixture 200 and therefore like reference characters for like wiring have been utilized.

Although for purposes of illustration several forms of this invention have been disclosed, other forms thereof may become apparent to those skilled in the art upon reference to this disclosure and therefore this invention is to be limited only

by the scope of the appended claims and prior art.

I claim as my invention:

1. In a control system for a refrigerating apparatus having a compressor, first and second evaporator means, a high pressure line connecting the compressor and condenser, a liquid line connecting the condenser and the evaporator means and a suction line connecting the evaporator means and the compressor, it being desirable to defrost the second evaporator means and not the first, the combination of, valve means in the liquid line for turning on and off the supply of liquid refrigerant to the second evaporator means, thermostatic means responsive to a temperature condition produced by the second evaporator means, thermostatic means responsive to the defrosted condition of the second evaporator means, and means controlled by both thermostatic means to operate the valve means to supply liquid refrigerant to the second evaporator means upon a call for cooling only after the second evaporator means has defrosted.

2. In a control system for a refrigerating apparatus having a compressor and evaporator means, the combination of, a valve located on the inlet side of the evaporator means for turning on and off the supply of refrigerant to the evaporator means, thermostatic means responsive to a temperature condition produced by the evaporator means, thermostatic means responsive to the defrosted condition of the evaporator means, and means controlled by both thermostatic means to operate the valve means upon a call for cooling to supply refrigerant to the evaporator means only after the evaporator means has defrosted.

3. In a control system for a refrigerating apparatus having a plurality of evaporators for cooling a plurality of fixtures and a common compressor for supplying refrigerant to and withdrawing refrigerant from all of the evaporators, the combination of, valve means on the inlet side of each evaporator for controlling the supply of refrigerant to its associated evaporator, means associated with each fixture and including means responsive to the temperature of the fixture and means responsive to the temperature of the evaporator of the fixture for opening the valve means of that fixture upon a call for cooling providing the evaporator of that fixture has defrosted whereby individual temperature and defrosting control of each fixture is obtained.

4. In a control system for a refrigerating apparatus having first and second evaporators connected in series and a compressor wherein defrosting of the second evaporator is desired but not of the first, the combination of, an expansion valve for controlling the supply of refrigerant to the evaporators, control means for the expansion valve operable to maintain liquid refrigerant in the first and second evaporators or liquid refrigerant in the first evaporator and superheated refrigerant in the second evaporator, thermostatic means responsive to a temperature condition produced by the second evaporator, thermostatic means responsive to the defrosted condition of the second evaporator, and means controlled by both thermostatic means to operate the control means of the expansion valve for supplying liquid refrigerant to the second evaporator upon a call for cooling only after the second evaporator has defrosted.

5. In a control system for a refrigerating apparatus having a compressor, first and second evaporator means, a high pressure line connecting the compressor and condenser, a liquid line connecting the condenser and the evaporator means and a suction line connecting the evaporator means and the compressor, it being desirable to defrost the second evaporator means and not the first, the combination of, valve means in the liquid line for normally allowing liquid refrigerant to be supplied to the first evaporator means but for turning on and off the supply of liquid refrigerant to the second evaporator means, control means responsive to a temperature condition produced by the second evaporator means for operating the valve means to supply liquid refrigerant to the second evaporator means upon a call for cooling, and means responsive to suction pressure, operative when the valve means is operated to supply liquid refrigerant to the second evaporator means, for starting the compressor only when the suction pressure has increased to a defrosting value and for starting the compressor at a suction pressure below the defrosting value when the valve means is operated to prevent the supply of liquid refrigerant to the second evaporator means.

6. In a control system for a refrigerating apparatus having a compressor, first and second evaporator means, a high pressure line connecting the compressor and condenser, a liquid line connecting the condenser and the evaporator means and a suction line connecting the evaporator means and the compressor, it being desirable to defrost the second evaporator means and not the first, the combination of, valve means in the liquid line for normally allowing liquid refrigerant to be supplied to the first evaporator means but for turning on and off the supply of liquid refrigerant to the second evaporator means, control means responsive to a temperature condition produced by the second evaporator means for operating the valve means to supply liquid refrigerant to the second evaporator means upon a call for cooling, means responsive to suction pressure, operative when the valve means is operated to supply liquid refrigerant to the second evaporator means, for starting the compressor only when the suction pressure has increased to a defrosting value and for starting the compressor at a suction pressure below the defrosting value when the valve means is operated to prevent the supply of liquid refrigerant to the second evaporator means, and a check valve on the discharge side of the first evaporator means to prevent defrosting of the first evaporator means when the second evaporator means is defrosting.

7. In a control system for a refrigerating apparatus having a compressor, first and second evaporator means, a high pressure line connecting the compressor and condenser, a liquid line connecting the condenser and the evaporator means and a suction line connecting the evaporator means and the compressor, it being desirable to defrost the second evaporator means and not the first, the combination of, valve means in the liquid line for normally allowing liquid refrigerant to be supplied to the first evaporator means but for turning on and off the supply of liquid refrigerant to the second evaporator means, control means responsive to a temperature condition produced by the second evaporator means for operating the valve means to supply liquid refrigerant to the second evaporator means upon a call for cooling, means responsive to suction pressure and controlled by said control means upon operation of the valve means

to supply liquid refrigerant to the second evaporator means for stopping operation of the compressor until the suction pressure rises to a defrosting value whereby defrosting of the second evaporator means is provided, and a check valve on the discharge side of the first evaporator means to prevent defrosting of the first evaporator means when the second evaporator means is defrosting.

8. In a control system for a refrigerating apparatus having a compressor, first and second evaporator means, a high pressure line connecting the compressor and condenser, a liquid line connecting the condenser and the evaporator means and a suction line connecting the evaporator means and the compressor, it being desirable to defrost the second evaporator means and not the first, the combination of, valve means in the liquid line for normally allowing liquid refrigerant to be supplied to the first evaporator means but for turning on and off the supply of liquid refrigerant to the second evaporator means, control means responsive to a temperature condition produced by the second evaporator means for operating the valve means to supply liquid refrigerant to the second evaporator means upon a call for cooling, means responsive to suction pressure and controlled by said control means upon operation of the valve means to supply liquid refrigerant to the second evaporator means for stopping operation of the compressor until the suction pressure rises to a defrosting value whereby defrosting of the second evaporator means is provided, and a check valve on the discharge side of the first evaporator means to prevent defrosting of the first evaporator means when the second evaporator means is defrosting, said suction pressure responsive means operating when the valve means is operated to prevent the supply of liquid refrigerant to the second evaporator means to start the compressor when the suction pressure increases to a value below the defrosting value.

9. In a control system for a refrigerating apparatus having evaporator means and a compressor for circulating refrigerant through the evaporator means, the combination of, first control means responsive to the suction pressure of the refrigerating apparatus for starting and stopping the compressor, and second control means responsive to a temperature condition produced by the evaporator means for controlling the first control means to determine the suction pressure value at which the compressor is started.

10. In a control system for a refrigerating apparatus having evaporator means and a compressor for circulating refrigerant through the evaporator means, the combination of, means for controlling operation of the compressor, and thermostatic means responsive to a temperature condition produced by the evaporator means for controlling said compressor controlling means to stop the compressor upon a call for cooling until the evaporator means is defrosted and then starting the compressor.

11. In a control system for a refrigerating apparatus having an evaporator for performing a cooling function, a thermostatic expansion valve for controlling the flow of refrigerant through the evaporator and including a temperature bulb responsive to the temperature of the refrigerant at the outlet of the evaporator and a temperature bulb responsive to the temperature of the refrigerant intermediate the inlet and outlet of the evaporator, valve means for selectively connecting the bulbs to the thermostatic expansion valve, and means responsive to a temperature condition produced by the evaporator to control the valve means for selectively placing either temperature bulb in control of the expansion valve.

12. In a refrigerating system, the combination of, a pair of evaporators connected in series, means for circulating refrigerant through the evaporators, a heater associated with the connection between the evaporators for heating the refrigerant flowing from the first evaporator to the second evaporator, and means responsive to the temperature of the second evaporator for controlling the operation of the heater.

13. In a refrigerating system, the combination of, a pair of evaporators connected in series, means for circulating refrigerant through the evaporators, a heater associated with the connection between the evaporators for heating the refrigerant flowing from the first evaporator to the second evaporator, and means responsive to a temperature condition produced by the second evaporator for controlling the operation of the heater.

14. In a refrigerating system, the combination of, a pair of evaporators connected in series, means for circulating refrigerant through the evaporators, a heater associated with the connection between the evaporators for heating the refrigerant flowing from the first evaporator to the second evaporator, and means responsive to the temperature of the second evaporator and to a temperature condition produced by the second evaporator for controlling the operation of the heater.

15. In a refrigerating system, the combination of, an evaporator formed in two serially connected sections, means for circulating refrigerant through the evaporator, an expansion valve controlling the flow of refrigerant through the evaporator, a heater located between the sections and adapted to heat the refrigerant flowing from one section to the other, a first temperature bulb responsive to the temperature of the refrigerant at the outlet of the evaporator, a second temperature bulb responsive to the temperature of the refrigerant flowing from one section to the other, means for selectively placing either temperature bulb in control of the expansion valve, and means for energizing the heater when the second temperature bulb is placed in control of the expansion valve.

16. In a refrigerating system, in combination, a plurality of evaporators, a common compressor and condenser for supplying said evaporators with refrigerant, control apparatus for controlling the circulation of refrigerant to the evaporators to normally maintain relatively low temperatures in one evaporator and to supply effective refrigerant to another evaporator only after it has defrosted, said apparatus comprising suction pressure responsive means and an element responsive to a temperature condition produced by said other evaporator, said apparatus being operable to respond to conditions existent when said other evaporator has defrosted for causing circulation of effective refrigerant thereto, circulation of effective refrigerant to said other evaporator always being prevented when it has not defrosted, and said apparatus embodying means controlling circulation of refrigerant to said one evaporator whether frosted or defrosted.

17. In a refrigerating system, in combination, a plurality of evaporators, a common compressor and condenser for supplying said evaporators with refrigerant, control means for controlling the circulation of refrigerant to the evaporators, said control means including a device responsive to suction pressure controlling the compressor, valve mechanism controlling the supply of refrigerant to one of the evaporators, and an element responsive to a temperature condition produced by said one evaporator, said element controlling said valve mechanism to prevent admission of evaporating refrigerant to said one evaporator until it has defrosted.

18. In a refrigerating system, in combination, a source of refrigerant, an evaporator coil, valve means controlling the admission of refrigerant to the coil, said valve means including means responsive to coil temperature for varying the amount of the coil effective for refrigeration, and means responsive to a portion of said coil cooperating wth said valve means whereby said portion is made effective for refrigeration only after it has defrosted.

19. In a refrigerating system, in combination, a source of refrigerant, an evaporator coil, valve means controlling the admission of refrigerant to the coil, said valve means including means responsive to coil temperature for varying the amount of the coil effective for refrigeration, means responsive to a portion of said coil cooperating with said valve means whereby said portion is made effective for refrigeration only after it has defrosted, and means for automatically supplying heat to said portion when it is ineffective for refrigeration.

20. In a refrigerating system, in combination, a source of refrigerant, an evaporator coil, valve means controlling the admission of refrigerant to the coil, said valve means including means responsive to coil temperature for varying the amount of the coil effective for refrigeration, means responsive to a portion of said coil cooperating with said valve means whereby said portion is made effective for refrigeration only after it has defrosted, said source of refrigerant comprising a compressor, a suction pressure controller for said compressor operative at predetermined pressures, and means responsive to temperature of medium cooled by said coil portion cooperating with said controller in a manner whereby said compressor is started at a higher pressure value when said last means calls for cooling.

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