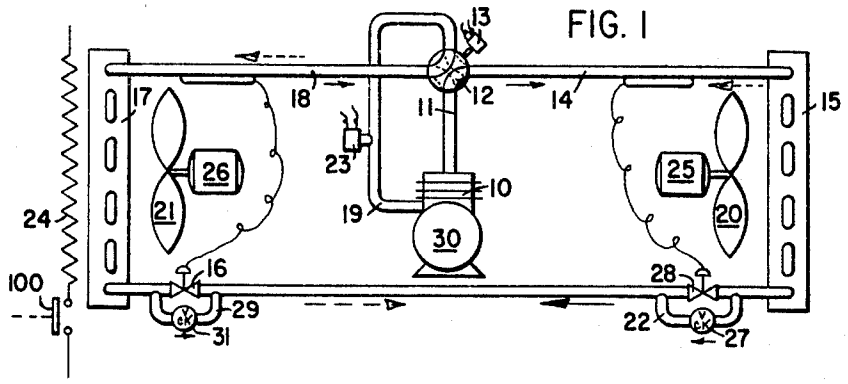
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REFRIGERATION SYSTEM DEFROST CONTROL

Filed June 14, 1965

FIG. 1



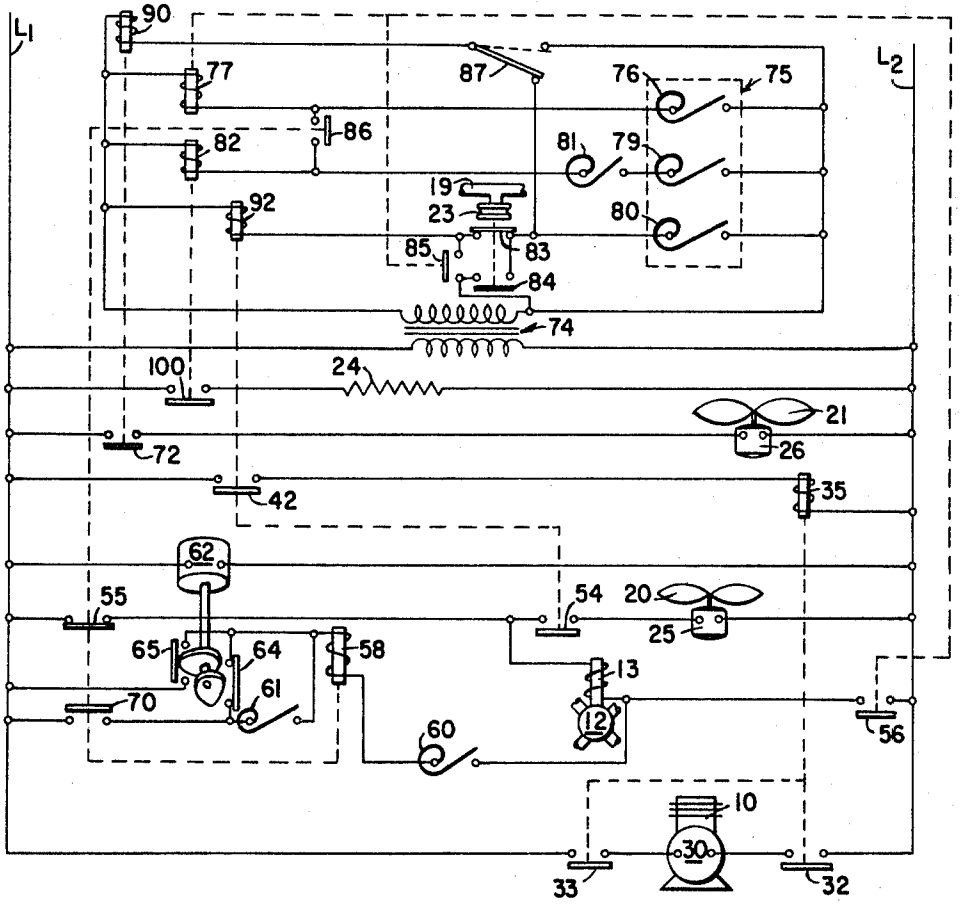


FIG. 2

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REFRIGERATION SYSTEM DEFROST CONTROL

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This invention relates to a control arrangement for refrigeration systems, and more particularly to a control arrangement for refrigeration systems operable to selectively heat and cool.

Reverse cycle refrigeration systems, commonly referred to as heat pumps, may include an arrangement for defrosting the system outdoor coil to restore system efficiency impaired through the formation of frost and ice thereon. While outdoor coil defrosting arrangements may assume various forms, a problem attendant with all forms is that of control, control of defrost initiation, duration, and termination in order that the outdoor coil may be effectively defrosted when necessary in the shortest possible time.

A usual method of defrosting the outdoor coil of a reverse cycle refrigeration system operating on the heating cycle is to revert to cooling cycle operation. By this arrangement, relatively hot gaseous refrigerant discharged from the system compressor is directed to the outdoor coil. Since operation of the system on the cooling cycle to effect removal of frost and ice from the outside coil not only interrupts the heating cycle but extracts heat from the area being conditioned, this method of defrosting the outside coil preferably is limited to as short a duration as possible.

In one defrosting arrangement, the defrost cycle duration is restricted to a predetermined timed interval. If defrost of the outdoor coil is accomplished within the predetermined timed interval, the defrost cycle is terminated. On the other hand, the timed interval may not be sufficient, under some operating circumstances, to permit the defrost cycle to completely defrost the outdoor coil. Nevertheless, this type of control arrangement terminates the defrost cycle and reverts the system to the heating cycle at the close of the timed interval. Where the outdoor coil remains partially covered with frost and/or ice, efficiency of the system is reduced. Additionally, the time required for the defrosted portions of the outdoor coil to once again become coated with frost and/or ice, due to the incomplete defrosting thereof, may be substantially lessened.

With the above discussion in mind, it is a principal object of the present invention to provide a new and improved defrost control arrangement for reverse cycle refrigeration systems.

It is a further object of the present invention to provide an improved control arrangement for a reverse cycle refrigeration system effective to guarantee a certain degree of outdoor coil defrosting during each defrost cycle.

It is an object of the present invention to provide an improved control arrangement for a reverse cycle refrigeration system having a limited duration defrost cycle effective to override the defrost control limiting means to permit continued operation on the defrost cycle until such time as a predetermined minimum defrost of the outdoor coil has been effected.

The invention relates to a control arrangement for a reverse cycle refrigeration system selectively energizable to heat and cool comprising in combination compression means, an outdoor coil and an indoor coil connected in refrigerant flow relationship to cool; means for reversing the flow of refrigerant through the indoor coil and the outdoor coil to heat; control means for regulating operation of the reversing means to defrost the outdoor coil; first condition responsive means adapted at a predetermined first outdoor coil condition to ready the control means for energization; first timing means adapted periodically to ready the control means for energization, the control means being energized upon simultaneous actuation of the first condition responsive means and the first timing means to defrost the outdoor coil; and means for regulating the duration of the outdoor coil defrosting to insure restoration of the outdoor coil to at least a predetermined second condition including second condition responsive means adapted at the predetermined second outdoor coil condition to ready the control means for deenergization, and second timing means adapted upon the expiration of a predetermined timed interval to ready the control means for deenergization, the control means being deenergized upon simultaneous actuation of the second condition responsive means and the second timing means, the first condition responsive means being effective at the occurrence of a predetermined third outdoor coil condition during the timed interval to intervene and deenergize the control means to terminate outdoor coil defrosting.

Other objects and features of the invention will be apparent from the ensuing specification and drawings in which:

FIGURE 1 is a diagrammatic view of a reverse cycle refrigeration system forming the subject of this invention; and

FIGURE 2 is a wiring diagram of an electric circuit for controlling the reverse cycle refrigeration system shown in FIGURE 1.

Referring more particularly to FIGURE 1 there is shown for the purpose of illustrating this invention an air-to-air heat pump employing a refrigeration system operable under the reverse cycle principle. In apparatus of this type a first heat transfer coil is disposed within the area to be conditioned by the heat pump and a second coil is located outside the area, usually in the ambient.

Compressor 10 discharges relatively hot gaseous refrigerant through discharge line 11 to the reversing means 12, preferably, a four-way reversing valve, which is employed for the purpose of reversing refrigerant flow through a portion of the system in order to obtain the desired heating and cooling effects. From reversing means 12, controlled by the operation of the solenoid 13 in a manner later to be described, the hot gaseous refrigerant flows during cooling cycle operation through line 14 to outdoor heat exchange coil 15 wherein condensation of the gaseous refrigerant occurs as ambient air is passed over the surface of outdoor coil 15 by fan 20.

The condensed liquid refrigerant flows from coil 15 through suitable expansion means 16 to indoor heat exchange coil 17, serving as an evaporator during the cooling cycle. Line 22 having check valve control 27 operable to permit flow in the direction shown by the solid line arrow provides a path for refrigerant flow around expansion means 28. Expansion means 16 provides the requisite pressure drop between the heat exchange coils in the refrigeration system during cooling cycle operation.

In indoor heat exchange coil 17, refrigerant is vaporized as heat is extracted from the stream of air delivered over the indoor coil by fan 21. Vaporous refrigerant so formed flows through line 18 to reversing valve 12 from whence to refrigerant flows through suction line 19 back to compressor 10 to complete the refrigerant flow cycle.

Each of the fans 20 and 21 may be driven by suitable drive mechanism, for example, electric motors 25 and 26 respectively.

To heat the area to be treated, the reversing valve 12 is

actuated to place line 18 in communication with discharge line 11. Under these circumstances, heat from the hot gaseous refrigerant flowing into coil 17 is rejected to the air within the area to be treated. The rejection of heat from the refrigerant converts the gaseous refrigerant to liquid refrigerant which flows through expansion means 28 to outdoor coil 15, which now functions as an evaporator. Line 29, having check valve control 31 therein operable to permit flow of refrigerant in the direction shown by the dotted line arrow, provides a path for refrigerant flow around expansion means 16. The vaporous refrigerant created in outdoor coil 15 as a result of heat transfer between the refrigerant and the ambient air flows through reversing valve 12 into suction line 19 back to compressor 10. Expansion means 28 provides the requisite pressure drop between heat exchange coils in the refrigeration system during heating cycle operation.

A suitable low pressure cutout control 23 may be connected to the suction line 19 by suitable connecting means. Low pressure cutout control 23 actuates a switch in the electrical circuit as will be later described.

As above noted, the refrigeration system may be incapable of providing sufficient heat to the area to be treated during heating operation, especially when the heat pump is used in geographical areas which are subject to low outdoor ambient temperatures. An auxiliary heater 24 which consists of a suitable high resistance wire through which current is adapted to be selectively passed may be used to provide supplementary heat. Thus the air, heated to a certain degree by being induced through heat exchange coil 17 by fan 21, is further heated by being passed over resistance wire 24 which is energized upon closing of switch 100.

Referring to FIGURE 2 of the drawings, a suitable source of alternating current (not shown) is adapted to supply current via leads L_1 and L_2 to a primary control circuit. It will be understood, of course, that the system can operate on three-phase current, if it is suitably modified.

The motor 30 for driving compressor 10 is energized when contacts 32, 33 are closed. A contactor coil 35 for closing contacts 32, 33 is provided. Contactor coil 35 is in series with control switch 42 across leads L_1 and L_2.

Outdoor fan motor 25 is connected in series with a control switch 54 and defrost switch 55 across leads L_1 and L_2. Reversing valve solenoid 13 is connected across leads L_1 and L_2 in series with defrost switch 55 and reversing valve switch 56.

A defrost relay coil 58 adapted when energized to initiate defrosting of outdoor heat exchange coil 15 is connected in series with reversing valve switch 56 and first defrost thermostat 60 across leads L_1 and L_2. Defrost timing motor 62 is connected in series across leads L_1 and L_2. The output shaft of defrost timing motor 62 is operatively connected by a suitable mechanism, such as cam means, to a pair of defrost timer switches 64, 65. Switch 65 is positioned in series with defrost relay coil 58 across leads L_1 and L_2. Defrost switch 70 is series connected with defrost timer switch 64 and defrost relay coil 58, defrost thermostat 60 and reversing valve switch 56 across leads L_1, L_2. A second defrost thermostat 61 is connected across defrost timer switch 64. Defrost timer switch 65, normally open, and switch 64, normally closed, are adapted to be periodically closed and opened respectively for a short duration in a predetermined sequence by the defrost timer motor driven mechanism in a manner to be more fully explained hereinafter. Indoor fan motor 26 is connected in series with indoor fan switch 72 across leads L_1 and L_2.

The secondary control circuit may be electrically connected to the primary control circuit by means of a transformer 74. Included in the secondary circuit is a room thermostat 75 comprising a two-stage heating thermostat and a single-stage cooling thermostat. The first stage of a heating thermostat 76 is in series with reversing valve relay 77. The second stage heating thermostat 79 is in series across outdoor thermostat 81 and resistance heater relay 82. When energized, relay 82 closes switch 100 to energize resistance heater 24. Defrost relay switch 86 is disposed across heating thermostats 76 and 79. Switch 86 is closed during the defrost operation to energize the resistance heater 24 in a manner to be more fully explained hereinafter.

Also provided in the secondary control circuit are fan switch 87 which may be manually moved from an automatic position shown in solid line to a continuous operating position, shown in dotted line, and indoor fan relay 90 in series therewith.

A control relay 92 is in series across the secondary circuit with first low pressure switch 83 and cooling thermostat 80. Low pressure switch 83 is normally closed. A circuit connecting second low pressure switch 84 and defrost relay switch 85 in series parallels low pressure switch 83. Closure of switches 84 and 85 bypasses low pressure actuated switch 83. Low pressure switches 83 and 84 are opened and closed respectively in response to a predetermined suction pressure as sensed by low pressure cutout control 23.

During cooling operation, the cooling thermostat 80 of the room thermostat 75 will close in response to a predetermined demand for cooling. Assuming that the indoor fan switch arm 87 is in the solid line position permitting automatic operation of indoor fan 21, indoor fan relay 90 is energized to close indoor fan relay switch 72 in the is energized to close indoor fan relay switch 72 in the primary control circuit thus energizing indoor fan motor 26.

At the same time, control relay 92 is energized to close control switches 42 and 54. A first circuit is completed via lead L_1, normally closed defrost relay switch 55, control switch 54 and lead L_2 to energize outdoor fan motor 25. A second circuit is completed via lead L_1, control switch 42, and lead L_2 to energize contactor coil 35. Contactor coil 35 closes compressor control contacts 32, 33 to energize the compressor motor 30 to drive compressor 10.

During cooling operation, compressor 10 forwards high pressure vaporized refrigerant through reversing means 12 to line 14 and outdoor coil 15. Heat is extracted from the refrigerant by the air stream passing over coil 15, condensing the refrigerant. Condensed refrigerant passes through expansion means 16 to indoor coil 17 where the refrigerant is vaporized. The vaporized refrigerant returns to compressor 10 through line 18, reversing means 12, and suction line 19.

Operation of the system on the heating cycle is initiated by closure of the first heating stage 76 of the room thermostat 75 in response to a demand for heating. Closure of first heating stage 76 energizes reversing valve relay 77 to close switches 56 and 85. Closure of reversing valve switch 56 completes a circuit from lead L_1 through defrost relay switch 55 and reversing valve switch 56 to line L_2 to energize reversing valve solenoid 13 to move reversing valve 12 to the heating position whereby refrigerant in discharge line 11 passes through line 18 to indoor heat exchange coil 17. Closure of reversing valve switch 85 energizes control relay 92 to close control switches 42 and 54. Closure of control switch 42 effects energization of compressor motor 30. Closure of control switch 54 effects energization of outdoor fan motor in the manner described heretofore.

Under the heating cycle of operation, refrigerant flows from indoor coil 17 through expansion means 28 to the outdoor coil 15. Heat rejected to the air passing over the indoor heat exchange coil warms the air being supplied to the area being conditioned. The hot vaporized refrigerant discharged from compressor 10 is condensed in the indoor coil 17. The refrigerant vaporized in outdoor coil 15 as a result of heat transfer between the refrigerant and the ambient air flows through reversing valve 12 into suction line 19 back to compressor 10.

During heating cycle operation, ambient conditions may be such that a coating of frost and/or ice forms on outdoor coil **15**. The defrost control means depicted in FIGURE 2 are operable to sense this accumulation of frost and/or ice and, in response thereto, to temporarily reverse the system to cause the system to act on the defrost cycle to remove the accumulated frost and/or ice.

Defrost timer motor **62** operates continuously. Periodically the switch actuating mechanism driven by the defrost timer motor closes defrost timer switch **65** for a brief interval. When defrost thermostat **60** senses a need for defrost and closes, a circuit is completed at the closure of defrost timer switch **65** via lead L_1, defrost timer switch **65**, defrost thermostat **60**, reversing valve switch **56** and lead L_2 to energize defrost relay **58**. Defrost relay **58** closes defrost relay switch **70** to provide, through either switch **61** or **64**, a holding circuit therefor and opens defrost relay switch **55** to deenergize reversing valve solenoid **13** and outdoor fan motor **25**. At the same time, defrost relay **58** closes defrost relay switch **86** to permit energizaiton of the auxiliary resistance heater **24** in a manner to be more fully explained hereinafter.

Deenergization of reversing valve solenoid **13** permits reversing valve **12** to move to the position shown in FIGURE 1 of the drawings whereby hot gaseous refrigerant from the compressor **10** is passed directly to outdoor coil **15** to remove frost and ice accumulated thereon.

As noted, during the defrost cycle, defrost relay switch **55** is open and outdoor fan motor **25** is accordingly deenergized. It is, however, desirable that the indoor fan be operative to provide a loaded evaporator whereby evaporator head pressure is maintained to insure the discharge of relatively hot gaseous refrigerant from the compressor. Continued operation of indoor fan **21** during the defrost cycle is assured in the following manner. The build-up of ice on outdoor coil **15** results in a drop in suction pressure. At a predetermined suction pressure, low pressure cutout **23** will open switch **83** and close switch **84**. Closure of switch **84** maintains the circuit closed through indoor fan relay **90** to keep indoor fan control switch **72** closed and the indoor fan motor **26** operating. Upon removal of the frost and ice from outdoor coil **15** defrost thermostat **60** opens to interrupt the energizing circuit to defrost relay **58** and terminate the defrost cycle.

Following a predetermined timed interval, timer motor **62** opens switch **64**. If the second defrost thermostat **61** is then open, timer switch **64** terminates the defrost cycle by interrupting the energizing circuit to defrost relay **58** although the defrost thermostat **60** may be still closed.

Defrost thermostats **60**, **61** may be arranged to close at the same outdoor coil temperature condition. Defrost thermostat **61**, however, is arranged to open at an outdoor coil temperature condition between that temperature condition at which thermostats **60**, **61** close and the outdoor coil temperature condition at which thermostat **60** opens. The temperature condition to which thermostat **61** responds represents the minimum degree of defrost removal thought necessary for acceptable system operation. Outdoor coil **15** is usually not, however, completely free of frost at the temperature condition to which second defrost thermostate **61** responds.

Upon the lapse of the predetermined timed interval at which time motor **62** opens timer switch **64**, the defrost cycle is continued under the control of second defrost thermostat **61** if outdoor coil **15** has not been defrosted to the degree represented by the temperature condition setting of thermostat **61**. The energizing circuit for defrost relay **58** in this circumstance is from lead L_1 through switch **70**, thermostats **61**, **60** and switch **56** to lead L_2. When the temperature condition of the outdoor coil **15** has reached the response setting of second defrost thermostat **61**, thermostat **61** opens to deenergize defrost relay **58** and terminate the defrost cycle.

If, during operation of the system on the heating cycle, the demand for heat exceeds that capable of being supplied by the system alone, second stage heating thermostat **79** of indoor thermostat **75** will close at a predetermined temperature. Outdoor thermostat **81** may be provided in series with the auxiliary heater relay **82** and thermostat **79**. Outdoor thermostat **81** closes in response to a predetermined outdoor temperature. Closure of both second stage heating thermostat **79** and outdoor thermostat **81** energizes auxiliary heater relay **82** to close switch **100** energizing resistance heater **24** to provide supplementary heat.

The heretofore described defrost control arrangement causes the system to revert to cooling cycle operation. During cooling cycle operation, the indoor coil **17** functions as an evaporator. It is desirable during defrost cycle that indoor fan **21** be maintained in operation. However, the air blown over the indoor coil **17** during defrost cycle operation is chilled, resulting in discomfort to occupants of the room being conditioned.

In the present heat pump control arrangement, air discharged into the room by the indoor fan **21** during the defrost cycle is tempered. This is effected by maintaining the auxiliary heater relay **82** energized during defrost cycle operation. As noted heretofore, defrost relay switch **86** is closed on the defrost cycle. Closure of switch **86** completes a circuit through first stage heating thermostat **76** and defrost relay switch **86** to energize auxiliary heater relay **82** to close switch **100** and energize resistance heater **24**.

The defrost control arrangement of the present invention insures continuation of the defrost cycle until at least a minimum outdoor coil defrost is accomplished so that the system may resume heating cycle operation with a reasonable degree of efficiency. The present control arrangement, under less critical operating circumstances, holds the defrost cycle to a predetermined timed interval thereby preventing prolonged and needless system operation on the defrost cycle.

While I have described a preferred embodiment of the invention, it will be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a control arrangement for a reverse cycle refrigeration system selectively energizable to heat and cool including compression means, an outdoor coil and an indoor coil connected in refrigerant flow relationship to cool, and means for reversing the flow of refrigerant through said indoor coil and said outdoor coil to heat, the combination comprising control means for regulating operation of said reversing means to defrost said outdoor coil; first condition responsive means adapted at a predetermined first outdoor coil condition to ready said control means for energization; first timing means adapted periodically to ready said control means for energization, said control means being energized upon simultaneous actuation of said first condition responsive means and said first timing means to defrost said outdoor coil; and means for regulating the duration of said outdoor coil defrosting to insure restoration of said outdoor coil to at least a predetermined second condition including second condition responsive means adapted at said predetermined second outdoor coil condition to ready said control means for deenergization, and second timing means adapted upon the expiration of a predetermined timed interval to ready said control for deenergization, said control means being deenergized upon simultaneous actuation of said second condition responsive means and said second timing means, said first condition responsive means being effective at the occurrence of a predetermined third outdoor coil condition during said timed interval to intervene and deenergize said control means to terminate outdoor coil defrosting.

2. The control arrangement according to claim **1** in-

cluding a circuit for energizing said defrost control means; first and second switches in said circuit; said first condition responsive means being operable when actuated to close said first switch; said first timing means being operable when actuated to momentarily close said second switch, simultaneous closure of said first and second switches completing said defrost control means energizing circuit; first and second bypass circuits each effective when completed to bypass said second switch; a switch in each of said first and second bypass circuits; said second condition responsive means being operable when actuated to open said first bypass circuit switch; said second timing means being operable when actuated to open said second bypass circuit switch, interruption of said first bypass circuit by said second condition responsive means permitting said second timing means to limit defrosting

of said outdoor coil to a duration no greater than said predetermined timed interval.

3. A control arrangement according to claim 2 including a third switch adapted to connect said first and second bypass circuits with said defrost control means energizing circuit, said defrost control means when energized closing said third switch.

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WILLIAM J. WYE, *Primary Examiner.*