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REFRIGERATION SYSTEM CONTROL

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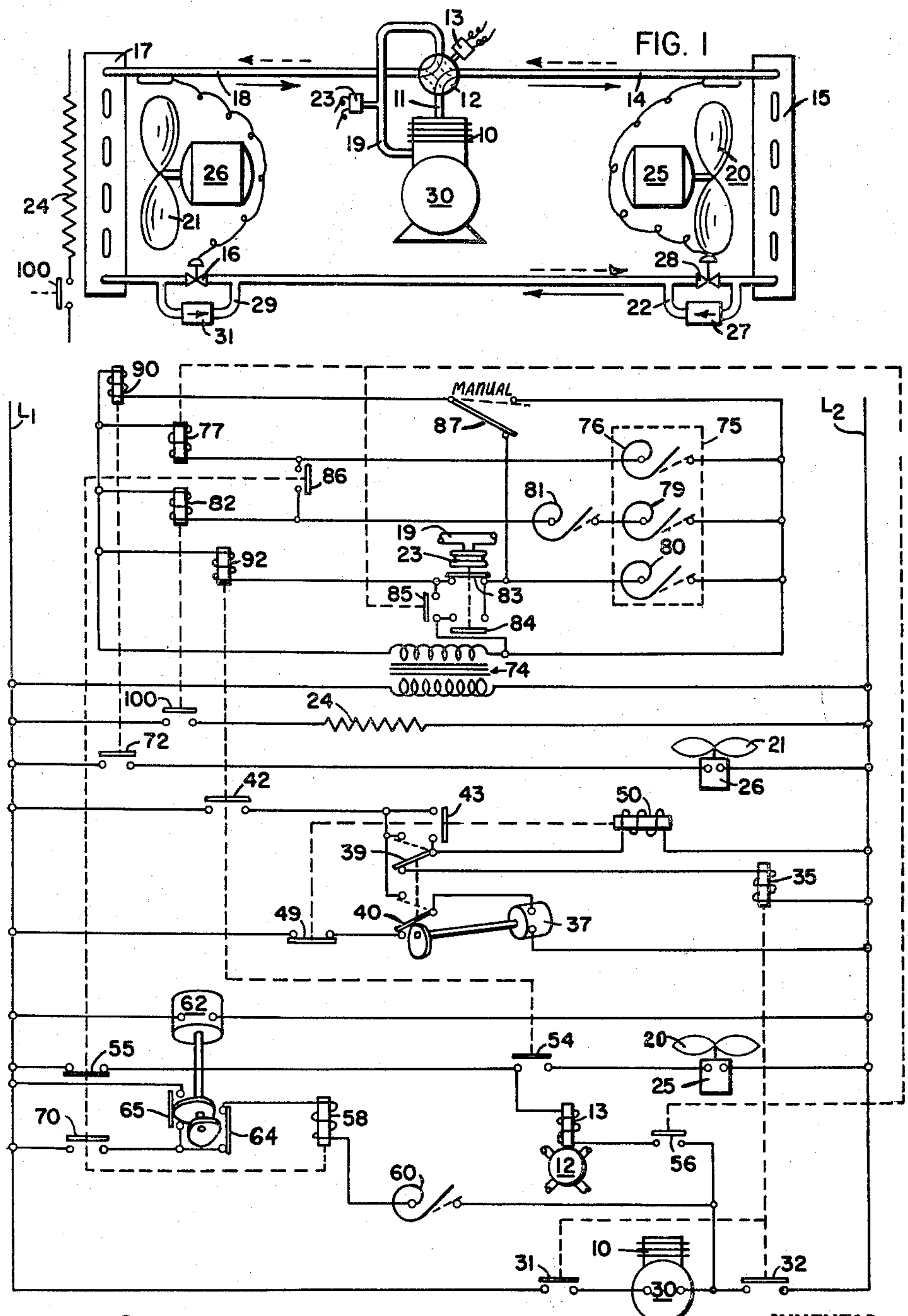

FIG. 2

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REFRIGERATION SYSTEM 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. However, operation of the system on the cooling cycle to effect removal of frost and ice from the outside coil interrupts the heating cycle and extracts heat from the area being conditioned. In systems which utilize this method for defrosting the outdoor coil, the system may start up on the defrost or cooling cycle in response to a demand for heat. This is undesirable and unnecessary.

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 a control arrangement and method of control for a reverse cycle refrigeration system effective to prevent start-up of the system on the cooling or defrost cycle in response to a demand for heat.

It is an additional object of the present invention to provide an improved control arrangement and method of control for a reverse cycle refrigeration system effective to prevent the defrost controlling mechanism from assuming a defrost initiating position while the system compressor is inoperative.

This invention relates to a control arrangement for a reverse cycle refrigeration system having compression means, an outdooor coil, refrigerant metering means, and an indoor coil connected in refrigerant flow relationship operable upon energization of the compression means to cool, and reverse means effective to connect the compression means, indoor coil, refrigerant metering means, and outdoor coil in refrigerant flow relationship operable upon energization of the compression means to heat, comprising in combination means for defrosting the outdoor coil including first means actuated in response to a predetermined outdoor coil condition to ready the defrosting means for operation, second means periodically actuated to ready the defrosting means for operation, the defrosting means being responsive to the simultaneous actuation of the first and second means to defrost the outdoor coil, the second means being adapted to terminate outdoor coil defrost after a predetermined time interval, the first means intervening to terminate outdoor coil defrost during the predetermined time interval in response to a second outdoor coil condition, and means for rendering the defrosting means inoperable in response to de-energization of the compression means to prevent start-up of the system on the defrost cycle when the compression means is energized.

The invention further relates to a method of operating a reverse cycle refrigeration system selectively energizable to heat and cool an enclosure having means for removing frost accumulated on the outdoor coil in which the steps consist in sensing outdoor coil conditions, periodically closing a switch for a relatively short interval, actuating the frost removing means on the occurrence of an outdoor coil condition during closure of the switch, bypassing the switch to maintain actuation of the frost removing means upon opening of the switch at the expiration of the relatively short interval, sensing energization of the system compressor, and limiting actuation of the frost removing means to periods when the system compressor is energized to prevent start-up of the system on the defrost cycle.

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. The 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 the 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 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. 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 L1 and L2 to a primary control circuit. It will be understood 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 31 and 32 are closed. A contactor coil 35 for closing contacts 31 and 32 is provided.

A timer motor 37 for controlling energization of compressor motor 30 in response to a demand for heating or cooling is provided. Timer motor 37 drives a suitable switch actuating mechanism, such as cam means operative to move timer switches 39 and 40 between the position shown in solid lines in FIGURE 2 of the drawings and that shown in dotted lines. Timer switch 39, when in the solid line position, connects contactor coil 35 in series with control switch 42 and switch 43 across leads L1 and L2. Timer switch 40, when in the solid line position, connects timer motor 37 in series with switch 49 across leads L1 and L2. A relay coil 50 for closing switch 43 and opening switch 49 is provided parallel to contactor coil 35 across leads L1 and L2 in series with control switch 42 and switch 43. Timer switch 39, when in the dotted line position, bypasses switch 43. Timer switch 40, when in the dotted line position, connects timing motor 37 in series with control switch 42 across leads L1 and L2.

Outdoor fan motor 25 is connected in series with a control switch 54 and defrost switch 55 across leads L1 and L2. Reversing valve solenoid 13 is connected across leads L1 and L2 in series with defrost switch 55 and reversing valve switch 56.

A defrost relay coil 58 adapted when energized to initiate defrosting of outdoor coil 15 is connected in series with defrost thermostat 60 across leads L1 and L2. Defrost timing motor 62 is connected in series across leads L1 and L2. 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 positioned in series with defrost relay coil 58 across leads L1 and L2. Defrost switch 70 parallels defrost timer switch 65 and is connected across leads L1 and L2 in series with defrost timer switch 64, defrost relay coil 58, and defrost thermostat 60. Defrost timer switch 65, normally open, and defrost 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 L1 and L2.

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 a first low pressure switch 83 and cooling thermostat 80. Low pressure switch 83 is normally closed. A circuit connecting a 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 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.

Operation

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 thereof, indoor fan relay 90 is energized to close indoor fan relay switch 72 in the primary control circuit thus energizing indoor fan motor 26.

At the same time fan control relay 92 is energized to close control switches 42 and 54. A first circuit is completed via lead L1, normally closed defrost relay switch 55, control switch 54 and lead L2 to energize outdoor fan motor 25. A second circuit is completed via lead L1, control switch 42, timer switch 39, in dotted line position, and lead L2 to energize relay coil 50. Relay coil 50 closes switch 43 and opens switch 49. A third circuit is completed via lead L1, control switch 42, timer switch 40 and lead L2 to energize the timer motor 37. After a predetermined interval, the switch actuating mechanism driven by timer motor 37 moves timer switches 39 and 40 to the solid line position.

Movement of timer switch 39 to the solid line position completes a circuit from lead L1 through control switch 42 and switch 43 to lead L2 to energize contactor coil 35. Contactor coil 35 closes compressor control contacts 31 and 32 to energize the compressor motor 30 to drive compressor 10. Movement of timer switch 40 to the solid line position places timer motor 37 in series with switch 49, now open, to de-energize the timer motor.

During cooling operation, compressor 10 forwards high pressure vaporized refrigerant through reversing means 12 to line 14 and outdoor heat exchange coil 15. Heat is extracted from the refrigerant by the air stream passing over coil 15, condensing the refrigerant. Condensed refrigerant passes through metering means 16 to indoor heat exchange 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 L1 through defrost relay switch 55, reversing valve switch 56, and compressor control switch 32 to line L2 to energize reversing valve solenoid 13 to move reversing valve 12 to the heating position upon energization of compressor 10 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 after a predetermined interval of time as described heretofore. 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 refrigerant metering means 16 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 L1, defrost timer switches 64 and 65, defrost thermostat 60, compressor control switch 32, and lead L2 to energize defrost relay 58. Defrost relay 58 closes defrost relay switch 70 to provide a holding circuit therefor and opens defrost relay switch 55 to de-energize reversing valve solenoid 13 and outdoor fan motor 25. At the same time, defrost relay 58 closes defrost relay switch 86 to permit energization of the auxiliary resistance heater 24 in a manner to be more fully explained hereinafter.

De-energization 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 de-energized. 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 through indoor fan relay 90 to keep indoor fan control switch 72 and the indoor fan motor 26 operating.

Upon removal of the frost and ice from outdoor coil 15, defrost thermostat 60 opens. Additionally, normally closed timer switch 64 is opened for a brief interval by the defrost timer motor driven switch actuating mechanism within a predetermined time after closure of timer switch 65. If defrost thermostat 60 opens within the predetermined time before timer switch 64 opens, defrost relay 58 is de-energized to terminate the defrost cycle in a manner to be described hereinafter. Should defrost thermostat 60 not open within the predetermined time before timer switch 64 is opened by the defrost timer motor 62, the opening of timer switch 64 de-energizes defrost relay 58 to terminate the defrost cycle. De-energization of defrost relay 58 upon the opening of either defrost thermostat 60 or defrost timer switch 64, permits defrost relay switch 55 to close completing a circuit from lead L1 through switch 55, reversing valve switch 56, and compressor control switch 32 to lead L2 to energize reversing valve solenoid 13 to move reversing valve 12 to the heating position. A circuit is completed from the lead L1 through defrost relay switch 55 and control switch 54 to lead L2 to energize outdoor fan motor 25.

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. In series with the auxiliary heater relay 82 and thermostat 79 is an outdoor thermostat 81. 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 heater relay 82 to close switch 100 and energize resistance heater 24.

By the novel control arrangement shown in FIGURE 2 of the drawings, the control circuitry for the defrost cycle is made dependent for its energization upon actuation of the system compressor. This dependency is effected by the positioning of compressor control switch 32 in series with the energizing circuit for defrost relay 58 and reversing valve solenoid 13. With this arrangement should the defrost timer motor-driven switch 65 and defrost thermostat 60 simultaneously close while the unit is shut down, the defrost relay coil 58 is not energized to close the holding switch 70 to lock the defrost control circuitry in defrost initiating condition. The unit therefore will not, upon closure of the first stage heating thermostat 76 in response to a demand for heat, start up on the defrost or cooling cycle.

It is understood that while the defrost control circuitry including defrost relay 58 and reversing valve solenoid 13 are illustrated in series with compressor control switch 32, the defrost control circuitry may be placed in series with the compressor control switch 31.

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 in the scope of the following claims.

I claim:

1. In a control arrangement for a reverse cycle refrigeration system having compression means, an outdoor

coil, refrigerant metering means, and an indoor coil connected in refrigerant flow relationship operable upon energization of the compression means to cool, reversing means effective to connect the compression means, indoor coil, refrigerant metering means, and outdoor coil in refrigerant flow relationship operable upon energization of the compression means to heat, the combination of means for defrosting the outdoor coil including first means actuated in response to a predetermined outdoor coil condition to ready said defrosting means for operation and second means periodically actuated to ready said defrosting means for operation, said defrosting means being responsive to the substantially simultaneous actuation of said first and second means to defrost said outdoor coil, said second means being adapted to terminate outdoor coil defrost after a predetermined time interval, said first means intervening to terminate outdoor coil defrost during said predetermined time interval in response to a second outdoor coil condition, and means for regulating said defrosting means in response to energization of said compression means to prevent start-up of the system on the defrost cycle.

2. The control arrangement according to claim 1 including a circuit for energizing said compression means, a circuit for energizing said defrosting means having first and second switches, actuation of said first means closing

said first switch, actuation of said second means closing said second switch, said regulating means including switch means for interrupting said compression means and defrosting means energizing circuits to de-energize said compression means and prevent completion of said defrosting means energizing circuit on closure of said first and second switches during de-energization of said compression means.

3. The control arrangement according to claim 2 in which said defrosting means energizing circuit includes a third switch, said second means being operable to open said third switch within said predetermined time interval following closure of said first switch to terminate outdoor coil defrost.

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