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REFRIGERATION SYSTEM DEFROST CONTROL

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FIG. 1

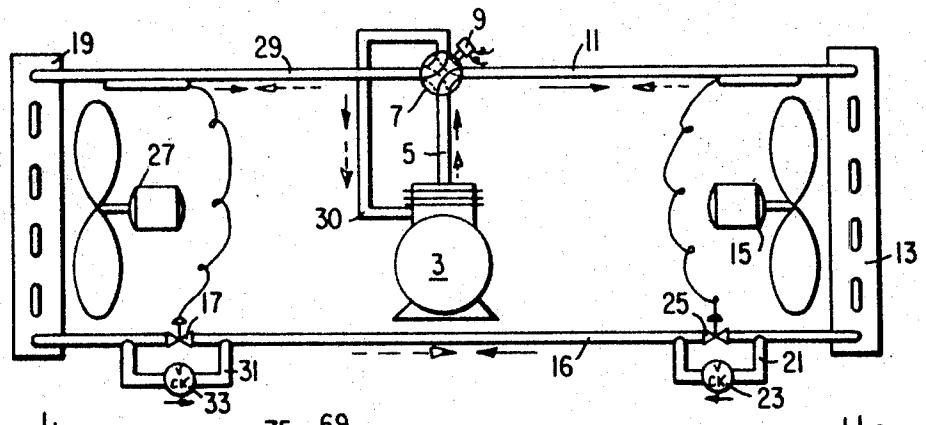
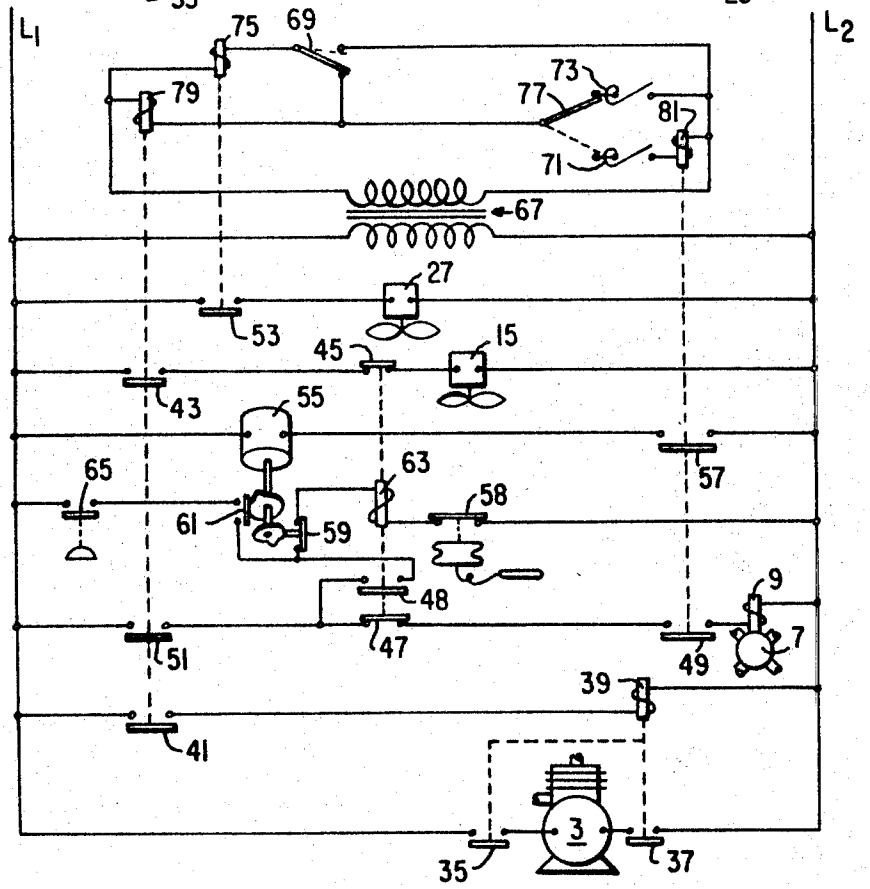


FIG. 2



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REFRIGERATION SYSTEM DEFROST CONTROL

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ABSTRACT OF THE DISCLOSURE

A control circuit for a heat pump to prevent excessive frost formation on the outside coil by initiating a defrost cycle after a timed interval in response to signals indicative of a high pressure differential of air across the outside coil and of the temperature of refrigerant in the outside coil.

BACKGROUND OF THE INVENTION

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

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

A timer may be utilized to control the initiation, duration, and termination of the defrost cycle. However, due to variable atmospheric conditions, the preselected timed interval may not be sufficient to defrost the outside coil or it may extend the defrost cycle time longer than is necessary. When the outside coil is not completely defrosted, the efficiency of the system is reduced. Additionally, the time required for the defrosted portions of the outside coil to once again become coated with frost or ice due to the incomplete defrosting thereof may be substantially lessened.

SUMMARY OF THE INVENTION

This invention relates to a defrost circuit for a reverse cycle refrigeration system having compression means, an outside coil and an inside coil arranged for refrigerant flow therebetween for cooling the inside area to be conditioned; and means for reversing the flow of refrigerant through the inside and outside coils for heating the inside area associated with the inside coil including timing means adapted periodically to close a portion of the defrost circuit, outside coil temperature responsive means adapted to close a portion of the defrost circuit, and outside coil air pressure differential responsive means to close a portion of the defrost circuit, the means for reversing the flow of refrigerant to defrost the outside coil being energized upon actuation of the timing means, the temperature responsive means and the pressure responsive means. The control arrangement is provided with means for stopping the outside fan to decrease the pressure differential across the outside coil and deactivate the pressure responsive means to provide for the

termination of the defrost cycle by deactivation of the temperature responsive means or by the timing means after a maximum preselected time interval.

BRIEF DESCRIPTION OF THE DRAWING

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.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to FIGURE 1, there is illustrated an air-to-air reverse cycle refrigeration system which is provided with a compressor **3** adapted to discharge hot gaseous refrigerant through discharge line **5**. A four way reversing valve **7**, operated by a solenoid **9** is utilized for directing refrigerant through the system to obtain the desired heating or cooling effect in the area being conditioned. When the valve **7** is positioned for cooling cycle operation as illustrated in solid lines, the gaseous refrigerant flows through line **11** to outside heat exchange coil **13** where ambient air is passed through the coil by fan **15** to condense the refrigerant therein.

The condensed liquid refrigerant flows from coil **13** through line **16** and expansion valve **17** to inside heat exchange coil **19**. A bypass line **21** having a check valve **23** is operable to permit flow in the direction shown by the solid line arrow to bypass refrigerant expansion valve **25**. Expansion valve **17** provides the requisite pressure drop between the heat exchange coils in the refrigeration system during cooling cycle operation.

Refrigerant is vaporized in heat exchange coil **19** as heat is extracted from the stream of air delivered over the coil by fan **27**. The varorous refrigerant from the coil flows through line **29** and reversing valve **7** to the compressor **3** to complete the refrigerant flow cycle.

To heat the conditioned area, the reversing valve **7** is actuated to place line **29** in communication with discharge line **5**. Under these circumstances, heat from the hot gaseous refrigerant flowing through coil **19** is rejected to the air within the conditioned area. The refrigerant which is condensed in coil **19** by heat exchange with the air passing thereover flow through line **16** and expansion valve **25** to coil **13** which functions as an evaporator during the heating cycle. Bypass line **31**, having a check valve **33** therein, permits flow of refrigerant in the direction shown by the dotted line arrow around expansion valve **17**. The refrigerant which is vaporized in coil **13** as a result of heat transfer between the refrigerant and the ambient air flowing across the coil is returned to the compressor **3** through valve **7**. The expansion valve **25** provides the requisite pressure drop between the heat exchange coils in the refrigeration system during heating cycle operation.

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. The compressor **3** is actuated when contacts **35** and **37** are closed. A contactor coil **39** for closing contacts **35** and **37** is provided in series with control switch **41** across leads L_1 and L_2.

Outside fan **15** is connected in series with a control switch **43** and defrost switch **45** across leads L_1 and L_2. Reversing valve solenoid **9** is connected across leads L_1 and L_2 in series with switch **47**, reversing valve switch **49**, and control switch **51**. Inside fan **27** is connected across leads L_1 and L_2 in series with fan switch **53**.

A defrost timing motor **55** is connected across leads L_1 and L_2 in series with switch **57**. The output shaft of

defrost timing motor 55 is operably connected by a suitable mechanism, such as cam means, to a pair of defrost timer switches 59 and 61, switch 59 being normally closed and switch 61 being normally open. Switches 59 and 61 are adapted to be periodically opened and closed respectively for a short duration in a predetermined sequence by the defrost timer motor mechanism.

A defrost relay coil 63, adapted when energized to initiate defrosting of outside heat exchange coil 13, is connected across leads L_1 and L_2 in series with defrost thermostat switch 58, outside coil air pressure differential switch 65, switch 61, and switch 59 for initial energization and in series with switches 51, 48, 59 and thermostat 58 after energization for reasons to be hereinafter explained.

A secondary control circuit, which may be electrically connected to the primary control circuit by means of a transformer 67, includes an inside fan switch 69 and heating and cooling thermostats 71 and 73 respectively. The fan switch 69 may be manually moved from an automatic position, shown in solid line, to a continuous operating position, shown in dotted line. Switch 69 has a relay coil 75 in series therewith to actuate switch 53 and fan 27. A switch 77 is provided to switch the refrigeration system between the heating and cooling modes. A relay coil 79 in series with switch 77 and either thermostat 71 or 73 is provided to actuate control switches 41, 43 and 51. A reversing valve relay coil 81 in series with switch 77 and heating thermostat 71 is adapted to actuate switch 57 and reversing valve switch 49.

During cooling operation, the cooling thermostat 73 will close in response to a predetermined demand for cooling. Assuming that the inside fan switch 69 is in the solid line position permitting automatic operation of inside fan 27, inside fan relay 75 is energized to close inside fan switch 53 in the primary control circuit thus actuating inside fan 27.

At the same time, control relay 79 is energized to close control switches 41, 43 and 51. A first circuit is completed via lead L_1, switch 43, switch 45, and lead L_2 to actuate outside fan 15. A second circuit is completed via lead L_1, control switch 41, and lead L_2 to energize contactor coil 39. Contactor coil 39 closes compressor control contacts 35 and 37 to actuate compressor 3.

During cooling operation, compressor 3 forwards high pressure vaporized refrigerant through reversing valve 7 to line 11 and outside coil 13. Heat is extracted from the refrigerant by the air stream passing over coil 13, condensing the refrigerant. Condensed refrigerant passes through expansion means 17 to inside coil 19 where the refrigerant is vaporized. The vaporized refrigerant returns to compressor 3 through line 29, reversing valve 7 and suction line 30.

To operate the system on the heating cycle, switch 77 is moved to the dotted line position to place heating thermostat 71 in the secondary circuit. The heating cycle is initiated by closure of the heating thermostat 71 in response to a predetermined demand for heating. Closure of thermostat 71 energizes reversing valve relay 81 to close switches 57 and 49. Closure of reversing valve switch 49 completes the circuit from lead L_1 through control switch 51 which is actuated by relay 79, switch 47, which is normally closed, and defrost relay switch 49 to lead L_2 to energize reversing valve solenoid 9 and move reversing valve 7 to the heating position whereby refrigerant in discharge line 5 passes through line 29 to inside heat exchange coil 19. Closure of switches 43 and 41 by relay 79 actuates outdoor fan 15 and compressor 3 in a manner described heretofore.

Under the heating cycle of operation, refrigerant flows from inside coil 19 through expansion means 25 to the outside coil 13. Heat rejected to the air passing over the inside heat exchange coil warms the air being supplied to the conditioned area. The hot vaporized refrigerant discharged from compressor 3 is condensed in inside coil 19. The refrigerant vaporized in outside coil 13 as a result of heat transfer between the refrigerant and the ambient air flows through line 11, reversing valve 7, into suction line 30, back to compressor 3.

During heating cycle operation, ambient conditions may be such that a coating of frost and/or ice forms on outside coil 13. The defrost control means illustrated 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 operate on the defrost cycle to remove the accumulated frost and/or ice.

As shown in FIGURE 2, defrost timer motor 55 operates whenever heating thermostat 71 is closed to complete the circuit through relay 81 to close timer motor switch 57. Periodically, the switch actuating mechanism driven by the defrost timer motor closes defrost timer switch 61 for a brief interval. If defrosting of the outside coil is necessary, air pressure differential switch 65 will be closed indicating a high pressure drop across outside coil 13 caused by frost formations thereon. Further, the formation of frost and/or ice on coil 13 would result in a low coil temperature which would cause defrost thermostat switch 58 to close. Under these conditions, the closure of switch 61 by timer motor 55 will complete a circuit from lead L_1 through switches 65, 61, 59, relay coil 63, defrost thermostat switch 58, to lead L_2. Relay 63 will actuate switches 47 and 48 to open switch 47 and close normally open switch 48 to maintain the circuit through relay 63 after switch 61 is opened by the switch actuating mechanism. Switch 47, which is opened by relay 63, cuts off current flow to reversing valve solenoid 9, allowing valve 7 to return to the cooling mode. Relay 63 also opens switch 45 to stop outside fan 15.

When the reversing valve 7 is in the cooling mode position, hot gaseous refrigerant from the compressor 3 is passed directly to outside coil 13 to melt the frost and ice accumulated thereon.

By stopping fan 15, air pressure differential as sensed by pressure differential switch 65 is reduced causing switch 65 to open. Ordinarily, the defrost cycle will last until the temperature of the outside coil increases sufficiently to cause defrost thermostat switch 58 to open, which cuts off current through coil 63, closing switch 47 to re-energize reversing valve solenoid 9 and return reversing valve 7 to the heating mode position. Deenergization of relay 63 also allows closure of switch 45 to actuate fan 15.

To prevent a defrost cycle period sufficient to cause discomfort in the area being conditioned, timer motor 55 will periodically open switch 59 to cut off current to relay 63, even though switch 58 is still closed, to return the system to the heating cycle.

It will be observed that the defrost cycle of the present invention is initiated after a timed interval if both the outside coil temperature and the air pressure drop across the coil indicate that defrosting of the coil is necessary. After initiation, the defrost cycle duration is controlled by the outside coil temperature unless the defrost cycle continues long enough for termination by the timer irrespective of the outside coil temperature. This sequence of operation provides for a more efficient heat pump operation than has been heretofore employed.

While we have described a preferred embodiment of the invention, it is to be understood the invention is not limited thereto.

We claim:

1. In a control arrangement for a reverse cycle refrigeration system having compression means, an outside coil adapted for passage of air thereover, refrigerant metering means and an inside coil connected in refrigerant flow relationship to provide hot, gaseous refrigerant to the outside coil upon energization of the compression means for cooling, and reversing means effective to connect the compression means, refrigerant metering means and coils in refrigerant flow relationship to provide hot gaseous refrigerant to the inside coil upon energization of the compression means for heating, a defrost circuit

for positioning the reversing valve to defrost the outside coil when the refrigeration system is connected for heating, said defrost circuit including:

temperature responsive means adapted to close in response to an outside coil temperature indicative of frost formation thereon;

pressure responsive means adapted to close in response to a pressure drop of air across the outside coil indicative of frost formation thereon;

timer means adapted for periodic closure, closure of said temperature responsive means, said pressure responsive means and said timer means completing a circuit for positioning the reversing means to provide hot gaseous refrigerant to the outside coil for defrosting the outside coil.

2. A defrost circuit according to claim **1** including actuating means adapted for energization upon closure of said temperature responsive means, said pressure responsive means and said timer means;

first means, associated with said actuating means, adapted to reduce the air flow across the outside coil upon energization of said actuating means, thereby causing said pressure responsive means to open, and

second means, associated with said actuating means in parallel with said pressure responsive means and said timer means to maintain a circuit through said temperature responsive means thereby maintaining the reversing means in a position to provide hot gaseous refrigerant to the outside coil.

3. A defrost circuit according to claim **2** further including second timer means in series with said temperature responsive means and said actuating means, said second timer means being adapted for periodic opening to

break the circuit through said actuating means, thereby opening said second means to provide an open circuit across said actuating means and said temperature responsive means irrespective of the subsequent position of said second means, thereby positioning said reversing means to provide hot gaseous refrigerant to the inside coil.

4. A method for operating a reverse cycle refrigeration system having an inside coil and an outside coil adapted to selectively heat and cool an enclosure comprising the steps of:

providing hot, gaseous refrigerant to the inside coil for heating the enclosure;

defrosting the outside coil by reversing the flow of refrigerant through the system in response to a preselected outside coil condition indicated by the temperature of the outside coil and the pressure drop of air across the outside coil, and

terminating the defrost operation of the system after a preselected time interval if the outside coil does not reach a preselected defrost termination temperature.

References Cited

UNITED STATES PATENTS

2,728,197	12/1955	Ellenberger	62—140
3,077,747	2/1963	Johnson	62—140
3,126,712	3/1964	Gebert	62—81
3,377,817	4/1968	Petranek	62—140

MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

62—140, 155, 156, 160, 234