

Aug. 19, 1958

R. H. MERRICK

2,847,833

DEFROST CONTROL FOR REFRIGERATION SYSTEMS

Filed Sept. 1, 1955

2 Sheets-Sheet 2

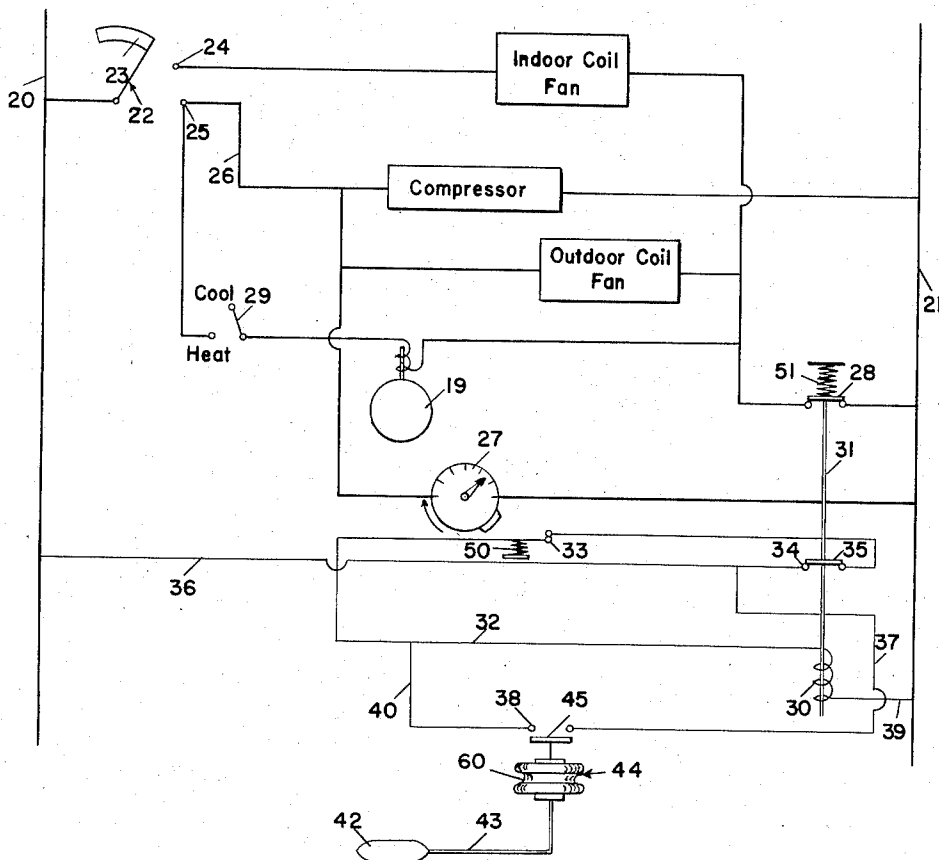


FIG. 3

INVENTOR.
RICHARD H. MERRICK.

BY

Herman Seid

ATTORNEY.

1

2,847,833

DEFROST CONTROL FOR REFRIGERATION
SYSTEMS

Richard H. Merrick, East Syracuse, N. Y., assignor to
Carrier Corporation, Syracuse, N. Y., a corporation
of Delaware

Application September 1, 1955, Serial No. 531,903

6 Claims. (Cl. 62-155)

This invention relates broadly to air conditioning equipment. More specifically, this invention relates to air conditioning equipment including a refrigeration system operable under the well known reverse cycle principle, wherein, the system can be utilized to either heat or cool air for use within an enclosure.

In air conditioning apparatus of the kind under consideration, one of the problems most often encountered when the apparatus is operated on the heating cycle involves the disposal of frost from the heat extracting or absorbing coil. Consider for example, an air conditioning unit of the type known as a room cooler adapted to be mounted in the window of a room to be supplied with the conditioned air. The refrigeration system employed in the air conditioning unit is arranged within a window so that the high side of the refrigeration system is located outside the building, and the low side is situated inside the confines of the room. Under this arrangement, the heat, that is rejected to a cooling medium such as air in the condenser, flows, under the influence of a fan, through a path located wholly outside of the building. When the air conditioning unit described above operates to supply heat to the enclosure the flow of refrigerant through the system is reversed so that the inside coil, normally functioning as the evaporator coil of the refrigeration system when the air conditioning system is operating on a cooling cycle, functions as a condenser, and the outside coil normally operating as the condenser when the unit is operating under the cooling cycle, operates as an evaporator. In many cases the temperature of the outside coil falls below 32° F., the freezing temperature of water. It will be appreciated that under these circumstances the outside coil on the unit of the type described above may acquire a substantial coating of frost in a relatively short period of time. This occurs when the moisture from the air flowing in heat exchange relation with the outside coil, now functioning as an evaporator, deposits on the surface of the coil and freezes.

Heretofore it has been suggested that a defrost control arrangement operative under the influence of a timer mechanism be used to periodically initiate the defrosting action. Under these circumstances, at predetermined intervals and for a prescribed length of time the air conditioning unit is operated on a defrost cycle. The primary disadvantages with this arrangement are the institution of a defrost cycle of a predetermined length without regard for the condition of the coil. It is well known that a number of factors contribute to the formation of a coating of frost on the heat exchange coil. The operating temperature of the evaporator and the moisture con-

2

tent of the air stream are among two of the principal factors. Consequently when the factors vary from the original defrost design values, a fixed interval timer defrost action may be too short to completely remove the frost, or it may be longer than necessary or not needed at all resulting in inefficient operation.

This invention contemplates the use of a timer mechanism for initiating the defrosting action, however, the action of the timer is modified by a thermostat sensing the temperature of the refrigerant in the coil to be defrosted or the temperature of some other element such as the coil proper. The action of the thermostat eliminates or nullifies the action of the timer in those circumstances where the temperature of the coil would indicate an absence of an accumulation of frost. Further the operation of the thermostat is such that once the defrosting action is commenced, in accordance with the existence of a condition sensed by the thermostat, the termination thereof occurs when the frost has been removed.

It is the chief object of this invention to provide a defrost control arrangement operable to periodically eliminate the frost during the operation of the air conditioning unit on the heating cycle. This is achieved by causing a portion of the main control circuit of the machine, when it is operating on the heating cycle, to be periodically interrupted by the momentary opening of a switch in the control circuit. The switch in the control circuit is part of a secondary circuit having a normally closed switch adapted to be momentarily opened periodically by a cam element or an equivalent element on the power shaft of a timer member. A by-pass circuit is provided broadly responsive to the temperature of the refrigerant in the outside coil for rendering ineffective the influence of the timer switch under circumstances where the defrosting action is not required.

Another object of the invention is the provision of a defrosting arrangement for a heat transfer coil in a refrigeration system including a valve for reversing flow of refrigerant within the system, wherein a timer member operates to periodically initiate a defrosting cycle and a by-pass circuit under the control of a thermal responsive member cooperates with a relay to regulate the action of the timer so that defrosting action is limited to those instances where absolutely necessary and for a duration sufficient to adequately remove frost from the coil and in any event no longer.

A further object of the invention involves the provision of a method of defrosting a heat transfer coil which is under the control of a timer, modified by a thermostat.

Other objects and features of the invention will be apparent upon the consideration of the ensuing description and drawings, in which

Figure 1 illustrates schematically a refrigeration system of the type to which the invention applies; and

Figure 2 is a schematic diagram of the wiring circuit used with the invention.

Figure 3 is a schematic wiring diagram of a modification of the invention.

One embodiment of the invention will be described as it pertains to an air conditioning unit of the room cooler type. As is well known to those skilled in the art, a housing or casing supports the components of the room cooler within a window having the lower sash in the raised or upper position. The casing is usually positioned within a cradle secured to the window sill. Figure 1

3

illustrates a refrigeration system of the kind employed in conventional room coolers. A compressor 10 forwards high pressure vaporous refrigerant to the condenser 11 through line 12 and reversing valve 19 in the path indicated by the solid arrows. The vaporous refrigerant is converted to the liquid phase in the condenser as air at ambient temperatures is circulated over the condenser by the fan 13. From the condenser, the liquid refrigerant flows through liquid line 14 to a restriction 15 shown in the form of a capillary tube. It will be obvious that other constructions such as a constant pressure valve or a thermostatic expansion valve may be used in place of the capillary tube. The liquid refrigerant flows from the capillary into the low pressure side of the system. Here a change in phase occurs as air at room temperature is circulated over the evaporator 16. Heat, in this instance, sufficient to vaporize the refrigerant, flows from the warm air to the cool refrigerant. The cooled air is directed through grilles formed in the casing into the room. The vaporous refrigerant formed in the evaporator flows, through the reversing valve 19 and suction line 18, to the compressor 10 to complete the refrigerant flow circuit.

A partition in the casing divides the refrigeration system in such a manner that the high pressure side (compressor and condenser), is located in that part of the casing positioned outside the window and the low pressure side (evaporator) in that part of the casing inside the window. Thus it is common to refer to the condenser coil 11 as the outside coil and the evaporator coil 16 as the inside coil.

In order to supply the room with warm or heated air when temperature of the air within the room or enclosure being supplied by the room cooler falls below that necessary for comfort, refrigerant flow is reversed within the circuit described above through the action of the reversing valve 19 located in the discharge line of the system. When the valve is operated to permit flow of refrigerant in the path indicated by the dashed arrows, the normal functions of the condenser and evaporator are exchanged so that the air being circulated by fan 17 extracts heat from the refrigerant being condensed in the inside coil 16. Moisture present in the air stream flowing under the influence of fan 13 condenses on the surface of the outside coil 11 as an exchange of heat sufficient to lower the temperature of the air below its dew point occurs. As pointed out above, under certain circumstances this moisture freezes on the surface of the coil so that a layer of frost may progressively build up on the outside coil. This accumulation of frost serves to impair the efficiency of the heat transfer action of the unit by acting as a layer of insulation and by restricting air flow. Accordingly it is contemplated by this invention to provide an arrangement for removing this accumulation of frost in response to a condition indicating the necessity for such removal.

This is accomplished by providing a secondary electrical circuit adapted to influence the operation of the main electrical control circuit of the unit. Included in the main control circuit of the unit is a pair of contacts adapted to be closed by a relay operable under the influence of a secondary circuit. The secondary circuit includes a mechanism for periodically opening the secondary circuit to deenergize the relay and open a portion of the main control circuit, and means including a by-pass circuit responsive to a condition indicating the presence or absence of frost on the outside coil for controlling the operation of the secondary circuit.

Referring more particularly to Figure 2 wherein the main control, secondary and by-pass circuits are diagrammatically represented, main power lines 20 and 21 furnish the primary source of power for the unit. Connected across the main power lines is a rotatable switch 22 having an arcuate arm 23 arranged to engage contacts 24 and 25. When the switch 22 is moved to engage contact 24 a circuit is completed through the motor controlling the fan 17 associated with the indoor heat exchange unit.

4

Thus, if desired, the air conditioning unit may be operated to circulate the air in the enclosure only. Upon movement of the switch arm 23 to a position in engagement with contact 25 the refrigeration system is activated as a circuit is completed through the compressor as current flows through line 26. Circuits are also completed through the motor controlling fan 13 and a timer mechanism 27. In series with the motor controlling fan 13 are contacts 28 to be later described. With the control circuit above described, the air conditioning unit may be operated to supply cool air to the enclosure.

When the switch 22 is moved to the position engaging contact 25, a circuit through a heating-cooling switch 29 is made. Connected in series with the switch 29 is a solenoid controlling operation of the reversing valve 19 and the contacts 28. When it is desired to operate the unit on a cooling cycle, the main operating switch 22 is moved so the arm 23 engages both contacts 24 and 25, and the circuit through the solenoid controlling the reversing valve 19 is opened by maintaining the switch 29 in the position illustrated. When it is desired to operate the unit on the heating cycle, manually operated switch 29 is closed, completing a circuit for energizing the solenoid on the reversing valve to permit the reversed path of refrigerant flow described above.

As described above, during the operation of the unit on the heating cycle, a formation of frost on the outside or normal condenser coil (functioning now, however, as the evaporator coil), may build up under certain circumstances. Accordingly a defrost control in the form of a secondary circuit arranged to periodically shift the operation of the unit from the heating to a modified cooling cycle when a condition, representing the possibility of a frost accumulation, occurs is provided. To accomplish this it is intended that a secondary circuit be provided to control the operation of a coil 30 regulating a two pole single throw normally open relay 31 having a set of upper contacts for normally maintaining a flow of current through the heating cycle main control circuit by engaging the contacts 28. The function of the secondary circuit is to influence the main control circuit through control of the relay 31. The secondary circuit includes in series, line 39, coil 30, line 32, normally closed contacts 33, contacts 34 adapted to be engaged by a second set of contacts 35 of the relay 31 and line 36. The timer 27 is arranged so that a cam on the power shaft of the timer momentarily opens the contacts 33 periodically against the action of a spring 50, thereby opening the secondary circuit, deenergizing coil 30. This has the same effect on the main control circuit for the unit as if the heating-cooling switch 29 were opened. In other words the unit operates on the cooling cycle except that the fan 13 is inactive. When the coil 30 is deenergized, the relay 31 moves under the influence of a spring 51 in a manner to open the main control circuit at contact 28 and the secondary circuit at contact 34. Thus when the contacts 33 are re-made as the timer continues its movement the secondary circuit is still open and the unit continues to operate on the cooling cycle with hot gas from the compressor passing directly to the outside or condenser coil. The frost accumulation is thus melted as the hot gas warms the coil. Normal heating action is restored as the warmed condenser coil causes thermostatic switch 44 to close its contact 38 thereby completing the by-pass circuit thus energizing relay coil 30 causing contacts 28 and 35 to remake. It will be appreciated that very often the defrosting action will be unnecessary. Consequently it will be advantageous to nullify the influence of the timer switch under circumstances where an accumulation of frost would be unlikely. Accordingly a by-pass circuit mentioned above is provided to maintain the relay coil energized when the defrosting action is unnecessary. The by-pass circuit includes line 37 connected to line 36 between contacts 34 and main supply line 20, contacts 38 of a thermostatic switch 39, and line 40 connected to line 41 which in turn connects contacts 33 to

5

the relay coil 30. Thus the by-pass circuit permits a flow of current through relay coil 30, if the thermal requirements of switch 45 are satisfied, despite the intermittent action of timer 27. This circuit also permits normal uninterrupted summer cooling operation to take place.

Considering the thermally responsive switch or thermostat 44, it is contemplated that this switch be responsive to the temperature of the liquid refrigerant in the outside or condenser coil. It will be obvious that the switch may be responsive to the temperature of the coil surface if desired. This temperature indicates the presence or absence of frost on the coil because it substantially reflects the temperature of the coil surface. The switch assembly includes a thermal responsive fill in bulb 42 which in turn is connected by capillary tube 43 with a bellows 60 having a contact carrying arm 45 mechanically connected thereto. The switch is constructed so that the circuit closes in response to a temperature of about 45° F. and opens at 30° F., remaining open until a temperature of 45° F. is again reached.

Considering the operation of the defrosting arrangement, when the unit is operating on the heating cycle with switch 29 closed, circuits are completed through the compressor, indoor coil fan, outdoor coil fan and the solenoid controlling the reversing valve 19. The relay 31 is in the position shown in Figure 2 due to the energization of coil 30 as the secondary circuit is activated. The by-pass circuit is closed as long as the temperature of either the refrigerant or the outdoor coil stays above 30° F. When the timer opens the secondary circuit the relay falls out if the thermostat opens the by-pass circuit and opens the portion of the main control under influence of the relay. The action of spring 50 causes contacts 33 to be re-engaged after the cam on the timer moves out of engagement with the arm supporting contact 33. The secondary circuit is not re-activated because contacts 34 and 35 are separated, so the unit is on defrost cycle which is the modified cooling cycle described above. Hot gas from the compressor flows directly into the outside coil 11, raising the temperature of the coil to a value sufficient to melt the frost from the surface of the coil. In a matter of minutes the bulb 42 will sense a temperature sufficient to indicate complete defrosting, as for illustration 45° F. The action of the bulb bellows and arm 45 in response to this cut-in temperature results in the by-pass circuit being energized. Coil 30 is once again energized causing the unit to revert to the heating cycle. Operation on the heating cycle continues until the bulb 42 senses a temperature of about 30° F. The thermostat is so constructed that the arm 45 is separated from contacts 38 at the cut-out temperature of 30° F. resulting in the opening of the by-pass circuit. The secondary circuit remains energized, however, until the timer subsequently opens it.

When the unit is operating on the cooling cycle in response to the opening of the switch 29, the by-pass circuit is energized because the temperature of the hot gas in the outside coil 11, now operating as the condenser is above the point (45° F.) necessary to keep the contacts 38 closed.

It will be appreciated that a defrosting arrangement for a refrigeration system operative in response to the action of a timer mechanism regulated in accordance with the temperature of the refrigerant in the coil to be defrosted, is provided. As shown in Figure 2 the fan 17 is in operation during the defrosting cycle. If the action of this fan proves uncomfortable during the defrost period then it will be inactive if connected in the manner shown in Figure 3.

Other constructions embodying the invention will suggest themselves to those skilled in the art. For example, the invention may be utilized under any circumstances requiring an application of a refrigeration system of the kind under consideration. Therefore, it is not the intention to limit the invention to the embodiment described but rather to consider it in terms of the appended claims.

6

It will be further obvious that the operation of the various control elements may be varied without departing from the invention.

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 air conditioning apparatus utilizing a refrigeration system including a compressor; a first heat exchange coil normally adapted to release heat to a cooling medium; an expansion member; a second heat exchange coil normally adapted to extract heat from air to be supplied to an enclosure, connected to form a closed path of flow for a volatile refrigerant and means for reversing the flow of refrigerant within the circuit to reverse the functions of the heat exchange coils so as to heat the air being supplied to the enclosure, means for defrosting the heat absorbing coil when the apparatus is operating on the heating cycle, said last mentioned means including a primary control circuit, a secondary control circuit in association with the primary circuit, a relay having a first set of contacts forming part of the primary circuit and a second set of contacts forming a part of the secondary circuit, a coil in the secondary circuit controlling the operation of the relay, means for periodically opening the secondary circuit to deenergize the coil and open the primary circuit and means including a by-pass circuit for maintaining the coil energized despite the action of the secondary circuit opening means.

2. The invention as described in claim 1 wherein said last mentioned means includes a switch, responsive to the temperature of the first heat exchange coil, in the by-pass circuit.

3. Air conditioning apparatus of the type including a refrigeration system operable to heat or cool air, said system comprising a compressor; a first heat exchange unit; an expansion member and a second heat exchange unit, means including a first control circuit for operating the system in a manner to cause air flowing over the second heat exchange unit to be cooled; means including a second control circuit for operating the system in a manner to cause air flowing over the second heat exchange unit to be heated, and means including a secondary circuit for defrosting the first heat exchange unit when the apparatus is operating under the influence of the second control circuit, said secondary circuit including a normally closed switch adapted to be opened intermittently; a relay normally operable under control of the secondary circuit and having a first pair of contacts in the second control circuit, said relay being normally deenergized when the switch is opened so as to open the second control circuit, and a by-pass circuit having a switch therein for energizing said relay despite opening of the switch to maintain the second control circuit energized.

4. A defrost control for a refrigeration system of the compressor-condenser coil-evaporator coil type having means for reversing the path of refrigerant flow through a portion of the circuit to interchange the normal functions of the coils, comprising means controlling the refrigerant flow reversal means to temporarily interchange the normal functions of the coils to supply refrigerant from the compressor to the coil functioning as the evaporator and to automatically reinstate the original refrigerant flow path in the absence of a condition indicating need for defrosting, said last mentioned means including a primary control circuit including a portion controlling the refrigerant flow reversal means, a relay in said circuit, a secondary circuit controlling said relay, a timer mechanism for periodically opening said secondary circuit to deenergize said relay and open the portion of the primary circuit including the refrigerant flow means and a by-pass circuit arranged to maintain said relay energized despite the action of the timer mechanism in re-

7

sponse to a predetermined condition indicating a need for defrost in the system.

5. A defrost control for a refrigeration system including a condenser, an evaporator and means for reversing the path of refrigerant flow through the coils to interchange their normally intended functions, comprising a primary circuit including the said means and a relay, a secondary circuit for controlling said relay, means for periodically opening said secondary circuit to deenergize said relay and open the portion of said primary circuit through the refrigerant flow reversal means, and means responsive to predetermined thermal conditions within the system for maintaining the relay energized despite the operation of the secondary circuit opening means.

8

6. A defrost control of the kind set forth in claim 5 wherein said last mentioned means includes a by-pass circuit having a thermally responsive switch.

References Cited in the file of this patent

UNITED STATES PATENTS

2,143,687	Crago	Jan. 10, 1939
2,276,814	Zwickl	Mar. 17, 1942
2,513,373	Sporn et al.	July 4, 1950
2,666,298	Jones	Jan. 19, 1954
2,666,299	Sutton	Jan. 19, 1954