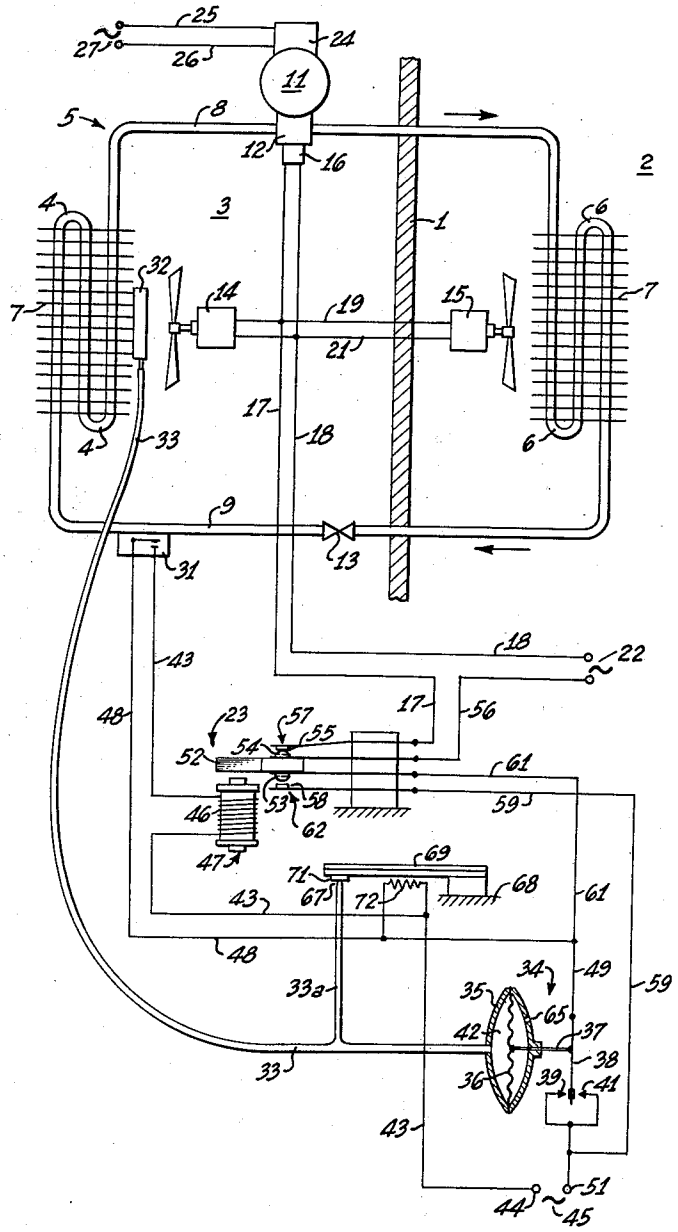
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TEMPERATURE-RESPONSIVE HEAT PUMP DEFROSTING UNIT

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TEMPERATURE-RESPONSIVE HEAT PUMP DEFROSTING UNIT

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This invention relates to and in general has for its object the provision of a system or circuit for controlling the cycle of operation of a heat pump or the like, and more specifically for controlling the defrosting cycle of a heat pump.

As is generally known, a heat pump includes a pair of coils or heat exchangers in reversible closed fluid circuit through a compressor and an expansion valve. When such a pump is used for the purpose of heating a room or building the compressed and therefore heated working medium passes through and heats the so-called internal coil. From the internal coil the working medium passes through a restricted orifice or expansion valve and in so doing the temperature of the fluid medium is depressed and then passes through the external coil of the pump and back to the compressor. This results in an exchange between the external coil and the working medium, and as a consequence the coil is cooled and the temperature of the working medium is elevated. Located in the room being heated is a thermostat in circuit with a control switch for controlling the compressor and fans of the heat pump.

Eventually the continued circulation of working medium through the heat pump will depress the temperature of the cold or external coil to the freezing point (32° F.) and at this or some lower temperature frost or ice will start to form on the external coil. In time the build-up of frost and/or ice on the coil effectively insulates it from the stream of warmer ambient air being forced over it by the external fan. This then precludes the further and effective heat exchange from the warmer ambient air to the external coil and the working medium flowing therethrough. When this occurs, it becomes necessary to defrost the unit.

However, it should here be noted that although frost may condense on the external coil at 32° F. it does not necessarily do so at this temperature. Frost may not condense until the external coil has reached a substantially lower temperature. Regardless of the specific temperature of the coil at which frost starts to form, the defrosting cycle should not be initiated until frost and/or ice has formed on the external coil, for so long as the coil is not covered by a substantial layer of frost or ice and so long as the ambient temperature is higher than the coil temperature, the heat pump remains effective to take heat from the ambient air.

More specifically, one of the objects of this invention is the provision of a heat pump defrosting control circuit wherein such circuit is dry-made at or about 32° F. but completed only in response to the formation of ice or frost on the external coil regardless of whether such frost forms at 32° F. or at some lower temperature.

Another object of this invention is the provision in a circuit of the character above described of means for inactivating the defrosting cycle only after the temperature of the external coil has been elevated to a temperature substantially above the freezing point, say a temperature in the order of 60° F.

Still another object of this invention is the provision of a circuit of the character above described including a relay circuit and a holding circuit, means for conditioning or dry-making the relay circuit in response to a first predetermined temperature of the external coil; a diaphragm switch for completing the relay circuit and the holding

circuit; fluid pressure means responsive to the formation of frost on the external coil for actuating the diaphragm switch and means under the control of the relay switch for inactivating said pressure-responsive means and thus reversing said diaphragm switch.

The invention possesses other advantageous features, some of which, with the foregoing, will be set forth at length in the following description where that form of the invention which has been selected for illustration in the drawings accompanying and forming a part of the present specification is outlined in full. In said drawings, one form of the invention is shown, but it is to be understood that it is not limited to such form, since the invention as set forth in the claims may be embodied in other forms.

Referring to the drawings:

The single FIGURE illustrated in these drawings schematically illustrates a heat pump defrosting control circuit embodying the objects of my invention.

More specifically the system shown therein includes a wall 1 separating a room 2 to be heated from the outdoors 3. Located externally of the wall 1 is the external coil 4 of a conventional heat pump generally designated by the reference numeral 5. Located internally of the wall 1 is the internal coil 6 of the heat pump 5, both of the coils 4 and 6 being provided as usual with radiating fins 7. Connected in closed fluid circuit with the coils 4 and 6 through conduits 8 and 9 is a compressor 11 provided with a conventional solenoid-operated, spring-biased reversing valve 12, and also an expansion valve 13. Disposed adjacent the external coil 4 is a fan or blower 14 and similarly disposed adjacent the internal coil 6 is a fan or blower 15. Both fans 14 and 15 and also the solenoid 16 of the reversing valve 12 are connected in parallel by lines 17, 18, 19 and 21 with a source of power 22 through a solenoid switch generally referred to by the reference numeral 23. The compressor motor 24 can be connected by lines 25 and 26 with a source of power 27, conventionally this being done through a thermostatic switch not shown.

As so far described, the heat pump 5, with the exception of the switch 23, is of standard construction and of conventional operation. The compressor 11 compresses and heats the working medium flowing through the system. The internal coil 16, warmed by the working medium, gives up a portion of its heat to the room 2. The working medium, in passing through the expansion valve 13, is cooled and passes into the external coil at a temperature lower than the ambient temperature. A heat transfer here occurs from the ambient air to the external coil and the working medium flowing therethrough. The resulting warmed working medium is returned to the compressor and the cycle is repeated so long as the room thermostat demands heat. Eventually, however, the temperature of the external coil 4 will be depressed to the freezing point or to a lower temperature and then a layer of ice or frost will start to condense on the surfaces of the external coil. At this point it becomes incumbent to initiate the defrosting cycle.

To this end a bimetal snap-disc type of switch 31 is mounted on the line 9 outboard of the expansion valve 13 and sufficiently near the coil 4 to sense the temperature thereof and consequently the temperature of the working medium at this point. Switches of this kind are procurable under the trade name "KLIXON" and, as is well known, are arranged to close at one predetermined temperature and to remain closed throughout a given range of temperature and then open at another and higher predetermined temperature. For the present application and for purposes of illustration the switch 31 is designed to close when the external coil temperature is depressed to

32° F. and then open only when its temperature has been elevated to 60° F.

Mounted on the radiating fins 7 of the coil 4 between this coil and its associated fan 14 is a pneumatic temperature-sensing element 32. More particularly, the element 32 consists of a rigid cylindrical air chamber communicating through a conduit 33 with a diaphragm switch generally designated by the reference numeral 34. The air pressure within the element 32, of course, varies directly with its temperature and due to the location of the element 32 on the fins 7 and with relation to the fan 14, it will normally sense the ambient air temperature. However, as soon as there is a frost or ice build-up on the coil 4 and such build-up comes in contact with the element 32, this element will then sense the temperature of the ice or frost with maybe 32° F. or some lower temperature. As the temperature of the air contained is depressed, the pressure thereof will drop and serve to actuate the diaphragm switch 34.

The switch 34 is of conventional construction, including a casing 35, a central diaphragm 36 and a diaphragm-actuated switch actuating stem 37. Connected to the stem 37 is a contactor 38 movable between a pair of switch contact points 39 and 41. The contraction of the air within the element 32, conduit 33 and the internal expansible chamber 42 of the switch 34 then serves to move the contactor 38 to the left and to close on the point 39. The expansion of such air produces the reverse effect of closing the contactor 38 on the point 41 provided that the air pressure is sufficiently great to do this. Normally the switch 34 operates merely to make and break the connection between the contactor 38 and the point 39.

It should here be noted that the element 32 should be made of metal or other good thermal conductor and that it should be thermally insulated from the conduit 33. From a practical standpoint this result can be attained by making the conduit 33 of thin metal tubing, by using plastic or rubber tubing, or by using metal tubing of standard gauge connected to the element by an intervening thermal insulating material, all this being well known in the industry.

One terminal of the switch 31 is connected by a line 43 to one terminal 44 of a source of power 45, through the coil 46 of a solenoid generally designated by the reference numeral 47. The other terminal of the switch 31 communicates through lines 48 and 49 and through the diaphragm switch 34 with the other terminal 51 of the source of power 45.

Included in the solenoid switch 23 is an armature 52 and provided thereon and movable therewith are opposed contact points 53 and 54. Also included in the switch 23 is a fixed contact point 55 on which the contact point is normally closed. The contact point 55 is connected to the line 17 and the movable contact point 54 communicates through a line 56 with the source of power 22. The contacts 54 and 55 therefore serve as a switch generally designated by the reference numeral 57 and which functions to control the power supply to the fans 14 and 15 and the solenoid 16 of the compressor reversing valve 12. With the contacts 54 and 55 closed as illustrated, the fans 14 and 15 are in their operative condition and the direction of flow of working medium through the heat pump is as indicated by the arrows. The heat pump is therefore in its working cycle.

Included in the switch 23 is a fixed contact point 58 on which the movable contact point 53 is arranged to close when the solenoid coil 46 is energized, and here it should be noted that when this happens the switch 57 simultaneously opens. Connected to the contact point 58 is a line 59 communicating with the terminal 51 of the source of power 45. To the movable contact point 53 is connected a line 61 communicating with the line 49 and also with the line 48. The contacts 53 and 58 therefore constitute a switch generally designated by the reference numeral 62 and which serves to open and close a holding circuit including on one side the line 59 and the power terminal 51 and on the other side the line 61, line 48, switch 31, solenoid coil 46, line 43, and the power terminal 44. If then the switch 31 is closed and the switch 62 closes, the solenoid 47 will remain energized and so long as this condition obtains, the armature 52 will be held down and the switch 62 will remain closed. This holding circuit can then be broken only when the switch 31 opens in response in this instance to an external coil temperature of 60° F.

However, the switch 62, although a part of the holding circuit, is normally open and will close only if the solenoid coil 46 is first energized. This can occur only when the switch 31 closes in response to a temperature of 32° F. followed by a closing of the diaphragm switch 34 in response to a pressure corresponding to the frost temperature as sensed by the element 32. When both of these events obtain, the solenoid coil 46 is closed on the power source 45 and the switches 57 and 62 are reversed and the defrosting cycle is initiated. It will therefore be seen that the solenoid coil circuit is conditioned or dry-made upon the closing of the external coil sensing switch 31 and is completed only when the switch 34 closes. When this occurs the armature 52 is drawn downwardly, thus reversing the switches 57 and 58. Opening of the switch 57 breaks the power circuit to the fans 14 and 15 and the solenoid 16, and the flow of working medium through the heat pump is reversed. The simultaneous closing of the switch 62 completes the holding circuit and the switches 57 and 62 are held in their reversed or defrosting cycle condition until the holding circuit is broken by the switch 31 in response to a temperature of 60° F. in the external coil 4. By this time the coil 4 has not only been defrosted but should also be free of all adhering water or moisture. This is important, for if the working cycle of the pump were to be initiated while water was still adhering to the external coil, it would immediately refreeze at 32° and promptly reinitiate the defrosting cycle. In short, the heat pump would keep hunting from its working cycle to its defrosting cycle.

The casing of diaphragm switch 34 is provided on its right-hand side with an air vent 65 for maintaining the right-hand side of the diaphragm under atmospheric pressure. Upon the initiation of each working cycle of the heat pump, the left-hand side of the diaphragm, the conduit 33, and the sensing element 32 should also be at atmospheric pressure. When such conditions obtain, the diaphragm switch 34 can be set to open in response to a predetermined differential pressure on the two sides of the diaphragm 36 and which results from a drop in the temperature of the element 32 from the ambient temperature to the temperature at which the frost builds up on the coil 4. Although not shown, the diaphragm switch 34 is provided with adjustable means for pre-loading its diaphragm 36 so that it will move to the right only in response to a predetermined minimum pressure.

To insure that at the start of each working cycle of the heat pump the interior of the element 32 is at atmospheric pressure, the conduit 33 is provided with a branch 33*a* terminating at its free end in a valve-opening and seat 67. Mounted on the casing 68 of the defrosting cycle control unit is a bimetal element 69 provided at its free end with a valve closure member 71 in registration with the valve-opening and seat 67 and arranged to normally close said opening. Connected across the lines 43 and 48 is a heating element 72 located in heat transfer relationship to the bimetal element 69. When the element 69 is heated, its valve closure member 71 moves away from the valve-opening and seat 67, thus venting the branch 33*a*, conduit 36, element 32 and expansible diaphragm switch chamber 42, thus subjecting the chamber 42 to atmospheric pressure. The circuit containing the heating element 72 includes the switches 31 and 34 and is closed on the power source 45 when these two switches are closed. Also the heating element 72 shunts the holding circuit

above described and consequently remains energized until the switch 31 breaks the circuit at 60° F., thus terminating the defrosting cycle. At this point the valve opening 67 is slowly closed, requiring a predetermined time delay to accomplish complete closure, thus allowing element 32 to obtain atmospheric pressure for whatever ambient temperature prevails at that time. The element 32 is again in condition to sense and respond to the lower temperature of frost when it forms around the fins 7 of the external coil 4.

I claim:

1. In combination, a heat pump including a pair of heat exchange units in closed fluid circuit with a compressor; a control unit for controlling the cycle of operation of said heat pump comprising: first and second switches; a solenoid including an armature for actuating said first and second switches and a solenoid coil communicating with a source of power through said first switch, through a pressure-responsive switch, and through a temperature-responsive switch, said temperature-responsive switch being arranged to close at a first predetermined temperature and to open at a second and higher predetermined temperature; and temperature-sensing means for actuating said pressure-responsive switch at a temperature lower than said second and higher predetermined temperature.

2. A combination of the character set forth in claim 1 including means under the control of said pressure-responsive switch inactivating said temperature-sensing means.

3. A control system: first and second switches, said second switch being arranged to control a controlled circuit; a solenoid including an armature arranged to actuate said first and second switches, and a solenoid coil communicating with a source of power through said first switch, through a pressure- responsive switch, and through a temperature-responsive switch, said latter switch being arranged to close in response to a first predetermined temperature and to open in response to a second and higher predetermined temperature; and temperature-sensing means for actuating said pressure-responsive switch in response to a temperature lower than said second and higher predetermined temperature.

4. A system of the character set forth in claim 3 including additional means under the control of said pressure-responsive switch for inactivating said temperature-sensing means.

5. A system of the character set forth in claim 3 wherein said first switch, said temperature-responsive switch, and said pressure-responsive switch are all normally open.

6. A system of the character set forth in claim 3 wherein said pressure-responsive switch is under the control of an expansible fluid chamber and wherein said temperature-sensing means is in the form of a rigid fluid chamber communicating with said expansible fluid chamber through a conduit.

7. A system of the character set forth in claim 6 including means for closing said pressure-responsive switch in response to either of two positions of said expansible fluid chamber.

8. A system of the character set forth in claim 6 wherein means is provided for venting said conduit to atmosphere and wherein said latter means is under the control of said pressure-responsive switch.

9. A system of the character set forth in claim 6 wherein said conduit is provided with a bimetal-actuated, normally closed valve for venting said conduit to atmosphere, wherein said valve is under the control of a heating element and wherein said heating element is under the control of said pressure-responsive switch.

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