

Jan. 17, 1961

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DEFROSTER CONTROL

2,968,167

Filed July 24, 1957

2 Sheets-Sheet 1

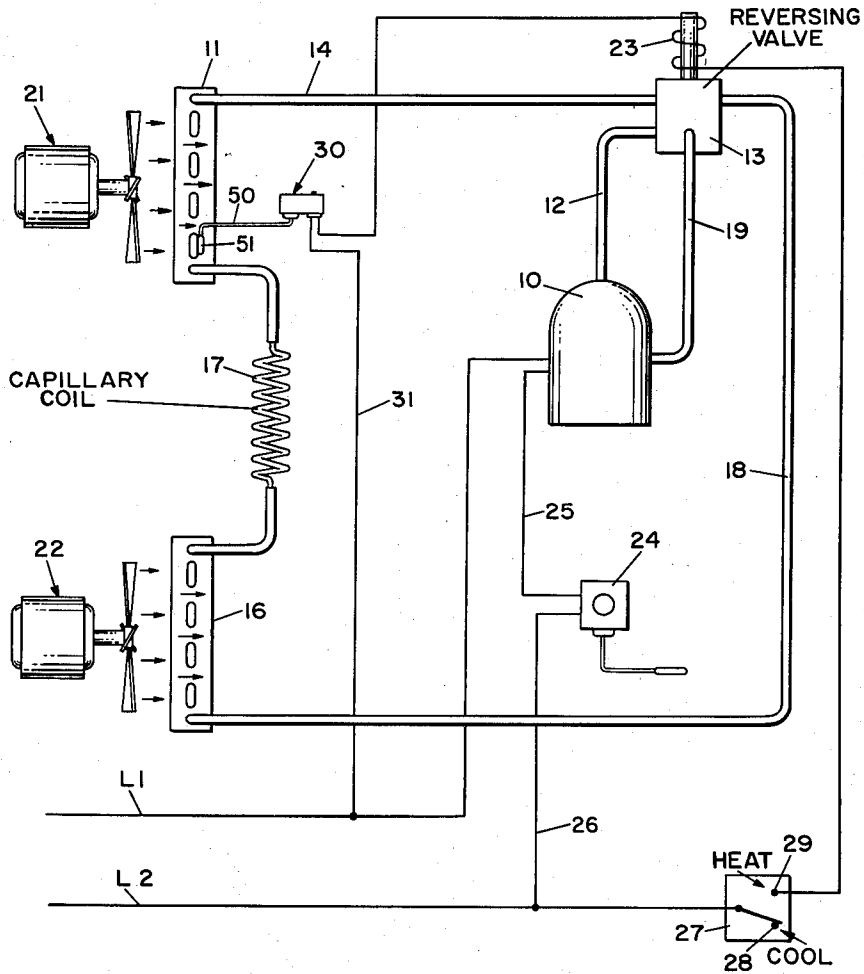


Fig - 1

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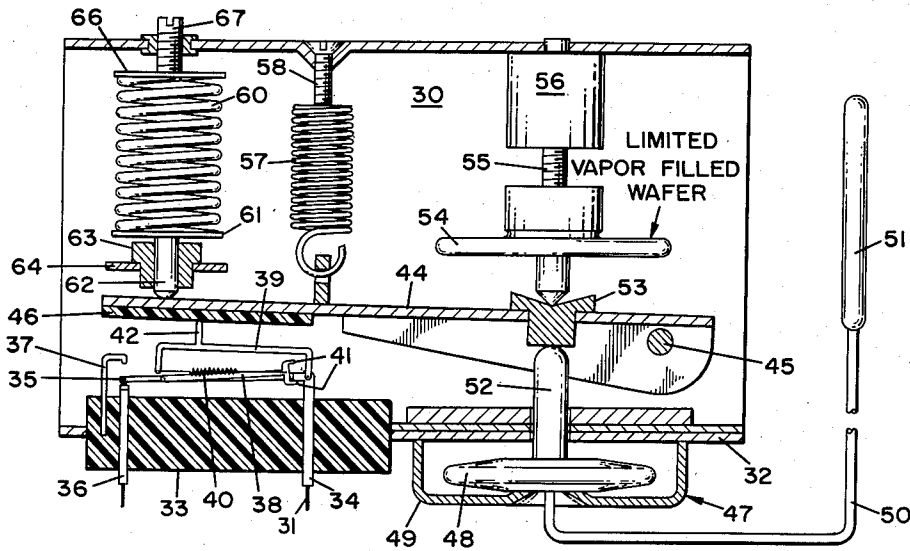
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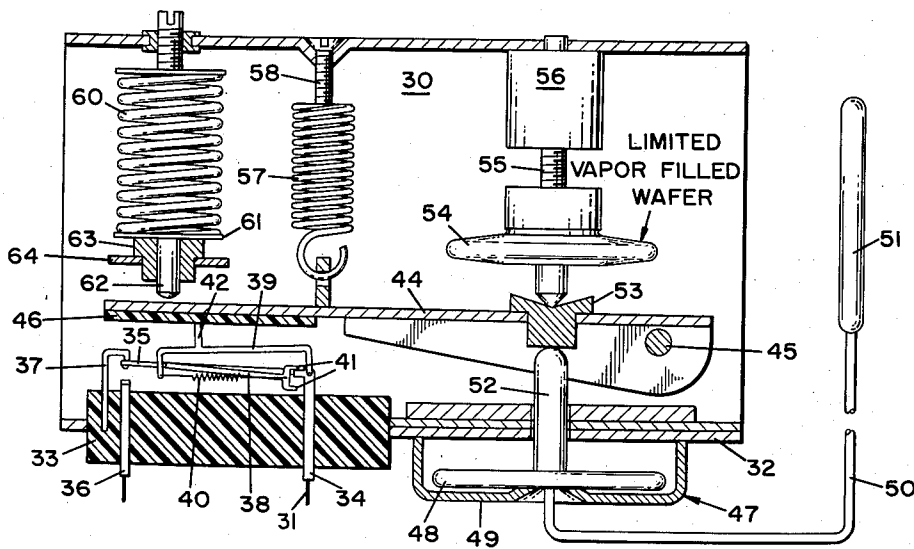
2,968,167

Filed July 24, 1957

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**Fig. 2**



**Fig. 3**

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Filed July 24, 1957, Ser. No. 673,958

4 Claims. (Cl. 62-156)

The present invention relates to improvements in control mechanism for initiating defrosting cycles in refrigerating systems in response to reduction of efficiency of heat exchange between the cooling unit and air passing thereover caused by collection of ice or frost on the cooling unit.

The invention is particularly useful in so-called heat pump systems comprising a refrigerant compressor connected with two heat exchangers each capable of functioning as a condenser or an evaporator depending on the order of flow of refrigerant therethrough, one exchanger, hereinafter referred to as the "inside" exchanger, affecting the temperature of air in an enclosure, such as a room, and the other heat exchanger, hereinafter referred to as the "outside" exchanger, being in heat exchange relation with outside air. The order of flow of refrigerant through the two heat exchangers is controlled by a reversing valve which in one setting effects a cooling cycle in which the outside exchanger functions as the condenser and gives up heat to the outside air while the inside exchanger functions as the evaporator and absorbs heat from the air passed thereover. By actuating the reversing valve to an opposite setting, the refrigerating cycle is reversed and the inside exchanger then acts as the condenser, giving up heat to the air of the room while the outside exchanger, functioning as the evaporator, absorbs heat from the outside air.

During the heating cycle in which the outside exchanger functions as the evaporator, ice is apt to form on the surfaces thereof when the air temperature falls to or below approximately 40° F. and this ice formation tends to insulate the surfaces of the exchanger from the air and materially reduces the rate of heat exchange thereby impairing the efficiency of the system. Unless such ice formations can be automatically detected and removed, heat pump systems of the type described are impractical for heating dwellings and other enclosures.

The present invention is directed to a control mechanism for heat pump systems of the type described and comprises a defrost cycle control device, which is preferably a switch in the circuit of an electrically operated reversing valve in the heat pump system, and two temperature responsive elements, one responsive to the temperature of the walls of the outside exchanger and the other, preferably responsive to temperature of air discharging from contact with the outside exchanger. The collection of frost or ice on the outside exchanger causes the temperature differential between the exchanger walls and the air passing in contact therewith to exceed a predetermined amount due to the insulating effect of the ice and the two temperature responsive elements co-act in response to this increased temperature differential to actuate the defrost control device or switch. To prevent operation of the defrost control device during operating conditions of the system which may result in the predetermined temperature differential mentioned but at a range above the freezing point of water, one of the temperature responsive elements is arranged to be ineffective at temperatures above 40° F. This feature is an improvement over the control mechanism shown in U.S. Patent Re. 20,087 which mechanism initiates a defrost cycle in response to an increase in differential between the evaporator and air temperatures in a refrigerator, but has

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no provision for automatically rendering the control inoperative above water freezing temperatures.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention, reference being had to the accompanying drawings wherein

Fig. 1 is a schematic view of a heat pump system embodying the invention; and

Figs. 2 and 3 are sectional, schematic views of a control mechanism embodying the invention showing certain parts in different operative positions.

Referring to Fig. 1, the heat pump system comprises an electric motor-driven compressor 10 having the discharge thereof connected to one end of an outside heat exchanger 11 through a tube 12, a reversing valve 13 and a tube 14. The other end of exchanger 11 is connected with one end of an inside heat exchanger 16 through suitable tubing including a capillary restrictor coil 17. The other end of inside exchanger 16 is connected to the suction side of compressor 10 through a tube 18, reversing valve 13 and tube 19. This system and the components thereof thus far described are well known in the art, and the exchangers 11 and 16 are of conventional construction comprising sinuously arranged copper tubing having closely spaced parallel fins attached thereto to form multiple air passages having extensive heat exchange surfaces so that air passed therethrough readily absorbs or gives up heat to the fluid in the exchangers.

Outside air is directed through outside exchanger 11 by an electric motor-driven blower 21, and air is directed through inside exchanger 16 by an electric motor-driven blower 22, which air may be re-circulated room air, fresh air from outside the room, or a mixture of both. The housing and air ducts for effecting the air passages described may be conventional and for sake of simplicity are not shown.

The reversing valve 13 may be of any suitable type operated by a solenoid 23 and when the solenoid is de-energized the valve functions to direct refrigerant from tube 12 to outside exchanger 11 through tube 14, and to direct refrigerant from inside exchanger 16 returning through tube 18 into tube 19, which is the intake side of the compressor. This cycle of operation, referred to as the "cooling cycle," causes outside exchanger 11 to function as a condenser which gives up heat to the outside air, and the condensed refrigerant is evaporated in inside exchanger 16 which absorbs heat from air passing there-through to provide cooling for the room.

When solenoid 23 is energized, the mechanism of valve 13 is shifted to direct refrigerant from the compressor discharge tube 12 through tube 18 to inside exchanger 16, and to direct refrigerant from the outside exchanger 11 returning through tube 14 to suction tube 19 so that the inside exchanger 16 then functions as a condenser and outside exchanger 11 functions as an evaporator. Thus, the inside exchanger 16 gives up heat to air passing therethrough for warming the room and exchanger 11 absorbs heat from the outside air passing thereover. During this cycle, which is referred to as the "heating cycle," should the outside air temperature fall below 40° F., the outside exchanger surfaces are likely to fall below 32° F. resulting in freezing of any water condensed thereon, as is well known in the art.

The motor for compressor 10 is controlled by a thermostat 24, which may be a suitable known type, comprising a thermal element responsive to room temperature for actuating switch means to open and close the compressor circuit, one side of which includes a power line L1 and the other side a wire 25 to one terminal of thermostat 24 and wire 26 connected with a second terminal of

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the thermostat to L2, the other side of the power circuit. The circuit described is closed by thermostat 24 when the room temperature reaches a predetermined degree, such as 80° F., and is opened when the temperature falls to 76° F., for example. This circuit is also closed by the thermostat to initiate a heating cycle when the room temperature falls to 72° F. and is opened when the temperature rises to 75° F., for example.

One side of the coil 23 is connected to power line L2 through a manually operated "on-off" switch 27 which includes a manually movable contact member 28 which may be moved to and from contact 29 to make and break the circuit to the solenoid as shown in Fig. 1 of the drawing. In the form of the invention shown, when contact 28 is removed from contact 29 the solenoid 23 is de-energized and the reversing valve is set to produce a cooling cycle, and when it is desired to provide heating cycles, the contact 28 is thrown to contact 29 which conditions the solenoid circuit for energization to thereby throw the heat pump system in condition for producing a heating cycle. It will be understood that the thermostat 24 controls the operation of the compressor 10 to maintain proper cooling and heating levels. The hand switch 27 could be replaced by a thermostatically operated switch responsive to room temperatures to automatically change the circuitry to provide for heating or cooling, depending upon the temperature prevailing in the room.

The other side of the solenoid 23 is connected to one terminal of a control mechanism 30 which comprises a normally closed switch mechanism which completes the circuit through wire 31 to line L1.

As mentioned previously, ice is likely to form on the outside exchanger during the heating cycles and to prevent an appreciable accumulation thereof, control mechanism 30 functions to open the solenoid circuit when ice collects on the outside exchanger to temporarily cause reversal of the function of the heat pump and quickly raise the temperature of the outside exchanger above 32° F. by passing hot gas from the compressor directly thereto, and after the ice has melted the solenoid circuit is reclosed to reinstate heating cycles according to the setting of switch 27.

Referring to Figs. 2 and 3, control mechanism 30 comprises an open ended frame 32 having a normally closed electric switch carried thereby on an insulating block 33 attached to the frame. The switch may be of any suitable design, and the form shown comprises a terminal member 34 embedded in the insulator and having one end of a contact carrying arm 35 pivotally attached thereto. The free end of contact arm 35 is moved with a snap action between a contact on a terminal member 36 embedded in the insulator block and a stop member 37 also embedded in the insulator block. A link 38 pivoted at its left end to arm 35, as shown, is connected to an actuating arm 39, pivoted on the terminal 34, by a tension spring 40 so that shifting of the actuating arm to one side or the other of the dead center position of the spring relative to the link 38 causes the link to snap from one side of arm 35 to the other and thereby snap move the arm between contact 36 and the stop 37 to make and break a circuit through terminals 34 and 36. The link 38 has spaced stop jaws 41 which engage a portion of the terminal member 34 to limit swinging movement thereof.

Actuating arm 39 is continually biased upwardly by the tension of spring 40 and a projection 42 thereon engages the bottom side of an actuating lever 44 which is pivoted to the frame 32 by a pin 45. In the form shown, an insulator 46 is carried on the bottom side of the lever 44 to electrically insulate the lever from the line switch members.

Movement of actuating lever 44 is affected by two thermal elements, one element 47 comprising a conventional, expansible metallic wafer 48 which is housed in

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a cup 49 attached to the underside of the frame. The wafer 48 has a tube and bulb 50, 51 attached thereto and the wafer, tube and bulb are partially filled with a suitable thermally responsive liquid to the extent that the bulb contains some liquid and vapor at all times and the bulb is attached to a portion of the tubing forming the outside exchanger 11 so that the temperature of the bulb closely follows temperature changes of the walls of the exchanger. Any suitable clamping arrangement (not shown) may be used to attach the bulb to the exchanger. By filling the bulb, tube and wafer so that liquid is present in all but a portion of the bulb, the pressure within the wafer corresponds at all times to the temperature of the bulb. The wafer 48 has a push rod 52 on the outer wall which engages a button 53 attached to lever 44.

The second thermal element comprises a vapor filled expansible metallic wafer 54 which engages button 53 on lever 44 on the opposite side from element 48 and opposes the latter with a force corresponding to the temperature of the air passing directly from the outside exchanger and through the open frame 32, the frame preferably being supported in a position with its ends aligned with the flow of air from the outside exchanger. Element 54 is adjustably supported from the top wall of the frame by a screw 55 threaded in a nut 56, as shown, so that the element 54 may be properly positioned relative to the operating lever 44. The wafer 54 contains a suitable vapor which commences to condense at approximately 40° F. so that above that temperature the increase in internal pressure is insignificant as compared to the increase in pressure corresponding to increases in temperatures below 40° F.

The lever 44 is urged clockwise by a tension spring 57 attached to a screw 58 rotatably supported in the top wall of the frame and which may be rotated to adjust the tension of spring 57 on lever 44.

Resistance to clockwise movement of lever 44 is provided by a compression spring 60 which bears against a plunger element comprising a disc 61 having a projection 62 extending through an opening in a bushing 63 attached to a bracket 64 supported between the side walls of frame 32. The upper end of the spring 60 is adjustably positioned by a washer 66 threaded on a screw 67 rotatably supported in the upper frame wall, as shown. Rotation of screw 67 moves washer 66 to increase or decrease the tension of the spring, as desired. The disc portion 61 limits the downward movement of projection 62, and the projection may extend beyond the lower end of bushing 63 so that it is engaged by lever 44 during the switch closing movement of the lever but not during the switch opening movement of the lever. Furthermore, bushing 63 forms a stop to limit clockwise movement of lever 44 when the temperature of bulb 51 is relatively high, as when the outside exchanger 11 functions as a condenser.

As mentioned previously, control device 30 is mounted relative to outside exchanger 11 so that air discharged therefrom passes through the frame 32 and surrounds thermal wafer 54 so that during heating cycles the wafer has an internal pressure which varies appreciably corresponding to changes in temperature of air leaving the outside exchanger, but only below 40° F. As noted previously, the wafer 48, tube 50 and only part of bulb 51 are filled with liquid so that the vapor pressure in the bulb determines the pressure in the wafer and the temperature of the liquid in the wafer has no effect on this pressure. The difference between the air temperature leaving outside exchanger 11 and the temperature of the walls of this exchanger will normally be relatively small, as in the order of 8 to 10° F. and the tension of spring 57 is adjusted so that when the pressures in the opposing wafers 48, 54 correspond to no more than 9° F. differential in temperature, for example, lever 44 will remain approximately in the position shown in Fig. 2, i.e., with

the switch contacts 35, 36 engaged. Should ice form on the exchanger, the insulating quality thereof reduces heat exchange between the exchanger and air, thereby causing the temperature of the exchanger walls to fall while the temperature of the air discharged therefrom tends to rise. The result is that thermal element 48 tends to collapse while the pressure within element 54 tends to increase. The tension of spring 57 is such that the changes in internal pressure of wafers 48, 54 just described result in counterclockwise movement of arm 44, which actuates switch arm 35 to move from contact 36 and thereby open the circuit through the reversing valve solenoid 23. This effects reversal of the heat pump cycle so that hot gas from the compressor is discharged into outside exchanger 11 and quickly raises the temperature thereof to melt the ice. The tension of spring 57 determines the differential in temperatures which must exist between bulb 51 and wafer 54 before the switch is opened, and this differential may be of different values for different equipment.

As the temperature of the exchanger 11 rises, the pressure in wafer 48 increases and moves the lever 44 against the pressure of wafer 54, which does not materially increase at temperatures above 40° F., and into engagement with projection 62 whereby further movement of the lever is opposed by spring 60 so that a higher pressure or temperature in the heat exchanger 11 is required to finally cause element 48 to move lever 44 and actuate contact arm 35 to engage terminal 36 and reclose the solenoid circuit to thereby restore the heating cycle of the system. It will be understood that the temperature at which the switch recloses depends on the tension of spring 60.

When the system is operating on the refrigerating or cooling cycle, the temperature of outside exchanger 11 may normally be in the order of 140 or 150° F. so that the pressure within element 48 will maintain arm 44 in the switch closing position and against the bushing 63 and, although the temperature of the air passing over wafer 54 may be substantially the same or within 10° thereof, the fact that wafer 54 has a limited fill or charge of thermal responsive fluid, it will not increase appreciably its force counteracting wafer 48 as the air temperature rises above 40° F. Thus, the control mechanism 30 is effective to operate its snap switch only during conditions in which ice is apt to form on the outside exchanger.

Although but one form of the invention is disclosed, other forms, modifications and adaptations could be made within the scope of the appended claims. It will be understood that the invention could be used to detect ice on heat exchangers of systems other than reverse cycle systems and could control other forms of defrost mechanisms than that shown.

What is claimed is:

1. In a reversible heat pump system having a heat exchanger operating during the cooling cycle of the pump at a relatively high temperature and operating during heating cycles of the pump below 32° F., and including means forcing air through said exchanger to effect heat exchange therewith, defrost means to temporarily raise the temperature of said exchanger and melt frost therefrom during the heating cycles, and control means for said defrost means comprising two thermally responsive elements, one subjected to the temperature of the walls of the exchanger and the second subjected to the temperature of air adjacent to said exchanger, said elements arranged to oppose one another so that upon substantially like changes in temperatures of the walls of said exchanger and said air said control means remains ineffective to cause a defrost cycle but upon a substantial reduction in temperature of the walls of said exchanger below the temperature of said air said control means is operative to activate said defrost means to produce defrosting of said exchanger, and means limiting the opposing effect of said second element at temperatures above

approximately 40° F. whereby during operation of said exchanger at temperatures in excess of 40° F. the first mentioned element is operative to maintain said defrost means ineffective to initiate a defrost cycle.

2. In a reversible heat pump system having a heat exchanger operating during the cooling cycle of the pump at a relatively high temperature and operating during heating cycles of the pump below 32° F., and including means forcing air through said exchanger to effect heat exchange therewith, defrost means to temporarily raise the temperature of said exchanger and melt frost therefrom during the heating cycles, and control means for said defrost means comprising two thermally responsive elements, one subjected to the temperature of the walls of said exchanger and the second subjected to the temperature of air directly discharged from said exchanger, said elements arranged to oppose one another so that upon substantially like changes in temperatures of the walls of said exchanger and said air said control means remains ineffective to cause a defrost cycle but upon a substantial reduction in temperature of the walls of said exchanger below the temperature of said air said control means is operative to activate said defrost means to produce defrosting of said exchanger, and means limiting the opposing effect of said second element at temperatures above approximately 40° F. whereby during operation of said exchanger at temperatures in excess of 40° F. the first mentioned element is operative to maintain said forest means ineffective to initiate a defrost cycle.

3. In a reversible heat pump system having a heat exchanger operating during the cooling cycle of the pump at a relatively high temperature and operating during heating cycles of the pump below 32° F., and including means forcing air through said exchanger to effect heat exchange therewith, defrost means to temporarily raise the temperature of the exchanger and melt frost therefrom during the heating cycles, and control means for said defrost means comprising two expansible thermally responsive elements, one subjected to the temperature of the walls of said exchanger and having an internal pressure proportional to the temperature of said exchanger throughout a range considerably above 40° F. and the second element having a limited fill of the thermally responsive fluid which is partly liquid at temperatures below about 40° F. and completely gas above 40° F. and said second element being subjected to the temperature of air adjacent to the exchanger, said elements arranged to oppose one another so that upon substantially like changes in temperatures of the walls of said exchanger and said air said control means remains ineffective to cause a defrost cycle but upon a substantial reduction in temperature of the walls of said exchanger below the temperature of said air said control means is operative to activate said defrost means to produce defrosting of said exchanger, said second thermally responsive element being ineffective due to its limited fill to effectively oppose said one element at temperatures above approximately 40° F. whereby during operation of said exchanger at temperatures in excess of 40° F. the first mentioned element is operative to maintain said defrost means ineffective to initiate a defrost cycle.

4. In a reversible heat pump system as set forth in claim 3 having control means for the defrost means in which said second thermally responsive element is subjected to the temperature of air directly discharging from the exchanger.

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