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HEAT PUMP DEFROST CONTROL

Filed Aug. 26, 1963 2 Sheets-Sheet 1

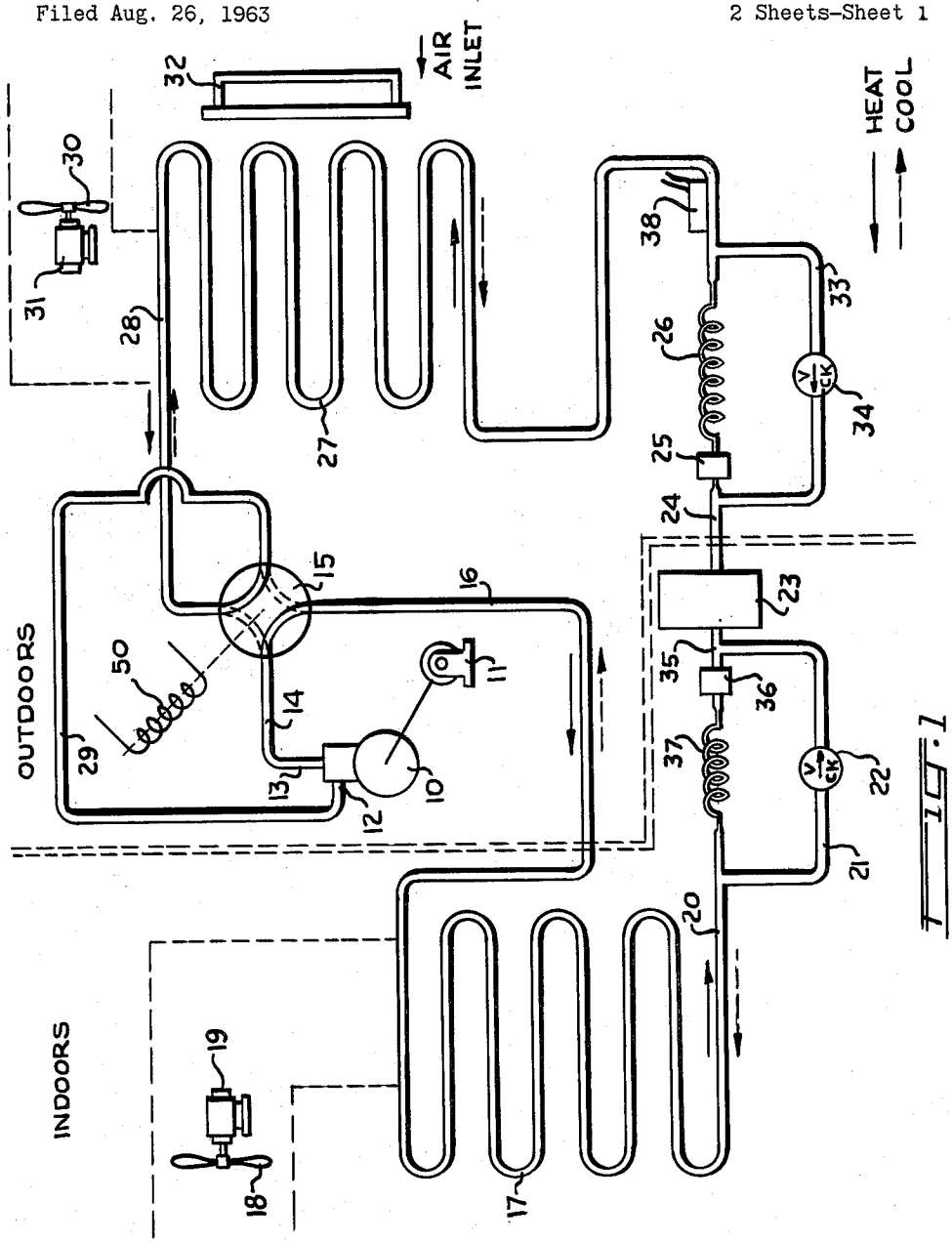


FIG. 1

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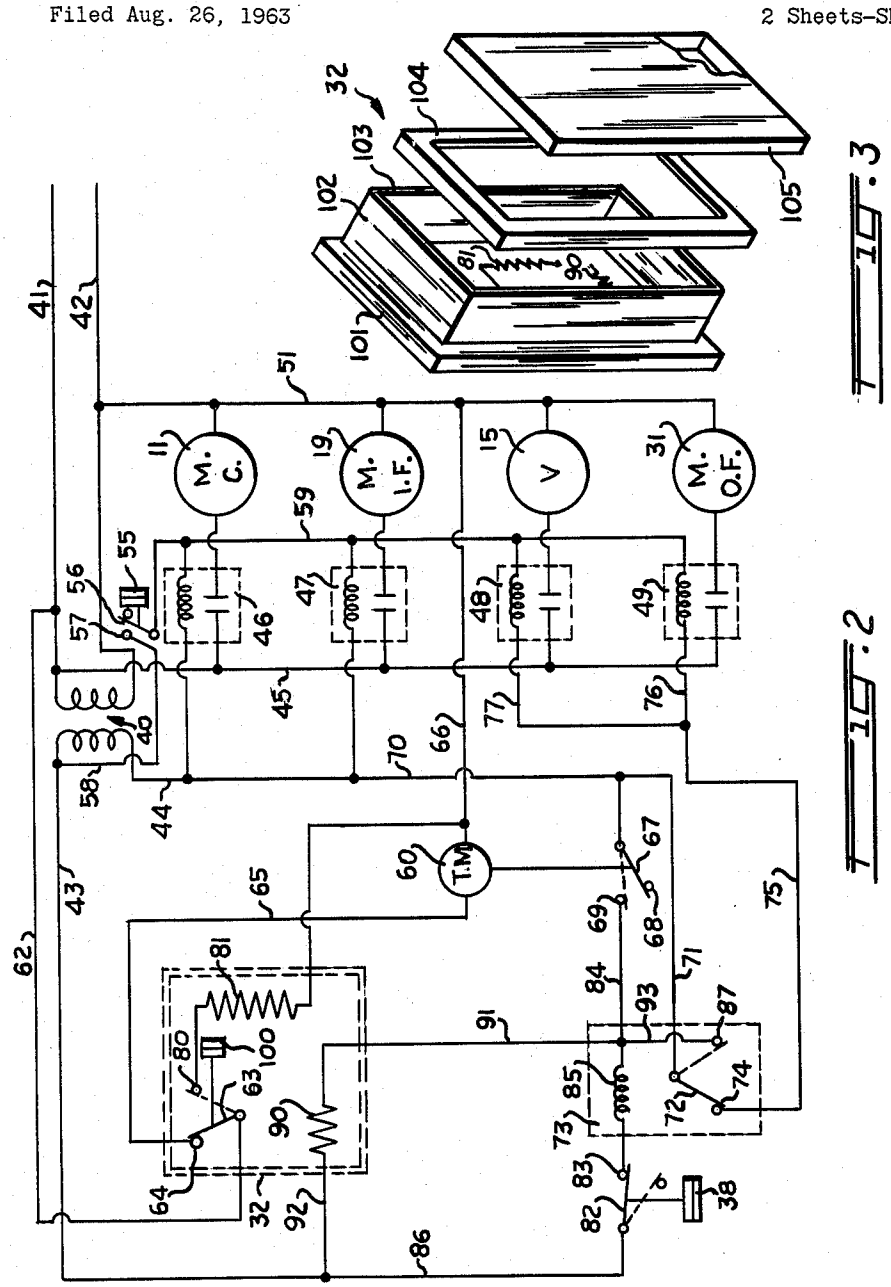


FIG. 2

FIG. 3

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HEAT PUMP DEFROST CONTROL

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This invention relates to a means for defrosting an air-conditioning apparatus which uses a refrigeration system operable on the reverse cycle principle to produce heat, and more particularly to an improved defrost mechanism for such apparatus in which a variable cycle timer is employed.

Conventional timers used in the defrost control of such apparatus have the advantages of being reliable in operation, inexpensive, and of offering to the user a wide range of timing cycles depending upon the particular timer which is chosen for a given apparatus. However, when the timer is once chosen and installed it usually is intended to cause the defrosting to occur at a fixed or built-in time interval and if in a particular installation a different time interval is later found to be desirable, a modification or replacement of the selected timer becomes necessary. Moreover, the atmospheric conditions surrounding the coil to be defrosted remain a variable and if the timer is so chosen as to cause a defrosting at a fixed frequency, such a defrosting will often occur when it is not needed. Under these conditions an unnecessary waste of power and of heat will take place. In similar manner, when the defrosting is effected by a control based entirely upon thermostats responsive to the temperature of the evaporator coil, a waste of power also may occur. In addition, the use of alternate timers with different cycles and with thermostatic means to actuate the proper timer in order to modify the frequency of defrosting affords only an approximate solution to the problem and is relatively expensive. It is these and other disadvantges found in the defrost control systems of conventional heat pumps which it is a purpose of my invention to overcome.

An object of the invention is to provide a heat pump defrost control employing a single timer whose normal timing cycle is lengthened when the atmospheric conditions surrounding the coil to be defrosted become less contributory to a frosting action.

Another object is to provide a defrost control for a heat pump which prevents the apparatus from prematurely initiating a defrosting operation.

A further object is to provide an improved defrost control for a heat pump which provides a maximum of heat output and which utilizes relatively few and inexpensive components.

Other objects and advantages of the invention will become more apparent as the description proceeds and when considered in conjunction with the accompanying drawings in which

FIG. 1 is a schematic view of a heat pump system employing the invention and including certain descriptive symbols.

FIG. 2 is a wiring diagram indicating the controls exerted upon the several portions of the apparatus by the variable cycle timer during a normal heating and subsequently defrosting cycle, and

FIG. 3 is a perspective and exploded view of one form of heat-exchange enclosure for the thermostatic switch controlling the timer motor.

In accordance with the invention, a heat pump defrost control having a single timer with its inherent reliability of operation is employed, and which timer, after a predetermined cumulative period of running time of its

motor, triggers the defrosting operation. The running of the timer motor, however, is made dependent upon atmospheric conditions surrounding the evaporator coil and when such conditions, as for example, an outside air temperature in the order of 0° F., are not contributory to a defrosting requirement, the running of the timer motor is temporarily suspended. Accordingly, a lengthening of the timer cycle, or a less frequent defrosting cycle, is effected and the single timer becomes in effect, a variable cycle timer even though its construction is simple and inexpensive.

Referring now to FIG. 1, a reverse cycle refrigeration system for selectively cooling or heating air within the space indicated as "indoors" includes a compressor 10 driven by an electric motor 11 and having an inlet at 12 and an outlet at 13. During the heating cycle, the compressor compresses a suitable refrigerant and delivers it through line 14, valve 15 and line 16 to a condensing or second coil 17, which is adapted to heat air drawn thereover by fan 18 driven by electric motor 19. The valve 15 is of a conventional solenoid operated type, which by way of illustration and not of limitation may comprise the well-known Alco, 4-way, sliding type of reversing valve.

Upon leaving coil 17 the refrigerant passes through line 20, by-pass line 21 having a conventional check valve 22 therein, and thence into receiver 23. From the receiver the refrigerant passes into line 24 through drier 25, expansion means 26, and thence to the evaporator or first coil 27 which is in contact with the atmosphere outdoors. In coil 27 the refrigerant is evaporated and absorbs heat from the atmopshere after which the refrigerant passes through line 28, valve 15, and line 29 to the compressor inlet 12. A fan 30 driven by a constant speed electric motor 31 pulls air across evaporator coil 27 and against a heat-exchange control enclosure 32 later to be described and which forms a significant feature of the invention.

Conversely, during a cooling cycle, as well as during the short duration of the defrosting cycle, valve 15 will occupy the position indicated by its dotted lines and compressor 10 thereupon will deliver the compressed hot refrigerant through line 28, coil 27, by-pass line 33 having a conventional check valve 34 therein and thence into receiver 23. From the receiver the refrigerant then passes into line 35, through drier 36, expansion means 31, and thence to coil 17 which now is serving as an evaporator coil. From coil 17 the refrigerant then passes through line 16, valve 15, and line 29 to the compressor inlet 12. During the described passage of the refrigerant to effect defrosting of coil 27, the frost or ice thereon is melted. A period of about three minutes for accomplishing this action is usually sufficient and after which period the defrost termination thermostat located adjacent the refrigerant distributor exerts its control in the manner later to be explained. After the conclusion of the defrosting action the valve 15 also is shifted to its first position whereupon the heating cycle is resumed.

The expansion means 26 and 37 may comprise any suitable conventional type of device serving to interpose resistance to the flow of refrigerant therethrough, such as expansion valves or capillary tubing. The expansion means 26 normally will provide a greater resistance than its companion expansion means 37. The conventional defrost termination thermostat 38 is responsive to the temperature of the refrigerant between coil 27 and expansion means 26 and normally opens its contacts when the refrigerant temperature rises to about 57° F. and recloses its contacts when the refrigerant temperature drops to about 32° F.

Considering now FIG. 2, in a preferred arrangement a conventional transformer 40 having a primary con-

nected to lines 41 and 42 with a voltage thereacross of, for example, 230 volts, will have its secondary connected to lines 43 and 44 with a voltage thereacross of, for example, 24 volts. In its broader aspects, however, the invention is adapted for use with a single voltage adequate to serve the motors of the several elements of the apparatus. A common conductor 45 extends from line 41 to one contact of each of the relays 46, 47, 48 and 49, each of which relays contains a coil adapted to be energized in the manner later to be explained. From the other contact of these relays connection is made to the respective compressor motor 11 indicated by M.C., the inside fan motor 19 indicated by M.I.F., the solenoid 50 (FIG. 1) of the reversing valve 15, and the outside fan motor 31 indicated by M.O.F., and thence to the common conductor 51 leading to return line 42.

A conventional wall thermostat 55 located within the space to be heated is adapted to actuate switch 56 which, when closed upon terminal 57 establishes a circuit from the line 43 through conductor 58, terminal 57, switch 56, common conductor 59, the respective coils of relays 46 and 47 and thence to return conductor 44 on the secondary of the transformer. Controlled by the same thermostat 55, and not shown herein since it forms no part of the present invention, are circuits for operating the heat pump apparatus on its cooling cycle as during a summertime operation when defrosting of the evaporator coil will not be required. When the coils of relays 46 and 47 are energized, both of the compressor motor 11 and the inside fan motor 19 are actuated and the heat pump system is brought into operation. At this same time a timing motor 60 for the single timer employed by the invention normally is energized by means of a circuit from line 41, conductor 62, the switch 63 of thermostat 100, terminal 64, conductor 65, motor 60, conductor 66, conductor 51, and thence to return line 42. The timer and its motor may be of any conventional type having a construction which, after a predetermined cumulative period of timer motor operation, causes its switch 67 to shift from the dead abutment 68 to terminal 69 and to hold its position on terminal 69 for a prescribed length of time, for example, about 20 seconds, and thereafter to return to its position on abutment 68. By way of illustration and not of limitation, the commercially available Haydon synchronous timer with a one-hour cumulative running time per cycle is suitable for the purposes of the invention.

When, therefore, the timer motor 60 is accumulating the necessary running time preparatory to triggering the defrosting action, a circuit is made from line 44, conductor 70, conductor 71, switch 72 of a de-energized relay 73, terminal 74, conductor 75, parallel conductors 77 and 76, the respective coils of relays 48 and 49, common conductor 59, switch 56, terminal 57, and conductor 58 to the return line 43. Energization of relays 48 and 49 causes the solenoid of the reversing valve 15 and the motor for the outside fan 31 to be energized. During the heating cycle with valve 15 occupying the position shown in FIG. 1 and with the outside fan operating, a steady stream of air is drawn into contact with enclosure 32 in which the thermostat 100 is located.

This thermostat may be of any suitable type, such as the well-known Klixon thermostat having a single-pole, double-throw switch 63 movable between terminals 64 and 80. As will be understood, a thermal lag of a few degrees of temperature is inherent in the thermostat action and as an example, when the temperature of the air within enclosure 32 reaches, for example, 28° F., the switch 63 is moved into contact with terminal 80 and when the temperature of the air within enclosure 32 reaches, for example, 38° F. the switch 63 is moved into contact with terminal 64. Thus while the air within enclosure 32 is undergoing a gain in heat content the switch 63 is in its second position in contact with terminal 80 and the circuit to timer motor 60 is interrupted,

and when that air is undergoing a loss in heat content the switch 63 is in its first position in contact with terminal 64 and the timer motor is operating.

The functioning of the thermostat 100 thus is related to the construction and location of enclosure 32 which is at all times in heat-exchange relation with the outside air surrounding the evaporator or first coil 27 of the heat pump. In order to establish this heat-exchange relationship in a reliable manner, enclosure 32, as best seen in FIG. 3, is hermetically sealed and is constructed in large part of a metal having a high coefficient of heat conductivity. Contained within the enclosure 32 is a small heating element 81, for example, a 2½-watt heater, which becomes energized whenever switch 63 moves to its second position. If the ambient air is appreciably cooler than 28° F. at this time, it will take a relatively long time for the air within enclosure 32 to reach 38° F. and concomitantly the operation of timer motor 60 will be interrupted for a relatively long time. Moreover, after switch 63 again is moved to its first position following generation of sufficient heat by the small heater 81 to raise the confined air temperature to the necessary 38° F. value, if the temperature of the outside air still is appreciably lower than 28° F. the air within enclosure 32 will quickly drop to 28° F. and the running time of timer motor 60 during that temperature drop will be short.

Since the temperature of the outside air is a prime factor in determining how frequently a defrost of coil 27 is required, it thus is seen that the colder the outside air the less frequent will the timer trigger a defrosting cycle. In the example given, if the outside air at all times was above 38° F. the thermostat 100 would of course hold switch 63 constantly in its first position and the timer motor would run continuously and cause a defrosting at the end of each hour, or at the end of whatever other period the timer is calibrated for. Therefore, after the timer motor has accumulated the necessary running time, and usually after numerous startings and interruptions and during which time the coil 27 will have become covered with frost, the following actions occur. The timer moves its switch 67 into contact with terminal 69 and holds it in the latter position for the time necessary to energize the coil 85 of relay 73. As this occurs, and assuming that the termination thermostat 38 at this time is still holding its switch 82 in contact with terminal 83, a circuit will be made from the line 44, conductor 70, switch 67, terminal 69, conductor 84, the coil 85 of relay 73, switch 82 and conductor 86 to return line 43. Energization of coil 85 thereupon shifts the switch 72 from its contact with terminal 74 to contact with terminal 87 and interrupts the circuits to the outside fan motor 31 and de-energizes the solenoid 50 of the reversing valve 15, thus causing that valve to shift to the cooling position as previously described with respect to FIG. 2.

As will be understood, the overriding control exerted upon timer motor 60 by the thermostatic switch 63 continues during the brief period during which the timer motor is initiating the defrost circuit, and if the timer motor should come to rest at ths time an unduly long defrosting might occur. To avoid this contingency, the invention provides an optional safeguard in the form of a booster heater 90 mounted within the enclosure 32 and having a sufficient heating capacity to keep the switch 63 closed on terminal 64 until the timer motor has again moved its switch 67 out of contact with terminal 69. A conventional heating element, for example, a 5-watt heater, is found to be satisfactory for this purpose.

When the relay coil 85 is energized, a circuit extending from conductor 84, conductor 91, heater 90 and conductor 92 to line 43 is made temporarily. Then, as the energized coil 85 moves switch 72 into contact with terminal 87, an alternate circuit for holding the coil 85 and the heater 90 both energized will be established from line 44, conductor 70, conductor 71, switch 72, conductor 93, and

thence in parallel through coil **85** and heater **90** to return line **43**. This latter circuit will be maintained until the defrost termination thermostat **38** opens its switch **82** at the conclusion of the defrosting of heat pump coil **27**. When this switch **82** opens, the circuit to relay coil **85** is broken, booster heater **90** is de-energized, and switch **72** returns into contact with terminal **74**. As this occurs, the earlier described circuits to the coil of relays **48** and **49** are re-established and reversing valve **15** returns to its heating cycle position and the motor for outside fan **30** is re-energized. Under average conditions the defrosting period requires about 3–5 minutes.

Considering now FIG. 3, the enclosure **32** which is mounted in heat-exchange relation with the ambient air surrounding heat pump coil **27** is suitably calibrated in advance of its installation with respect to its ability to dissipate heat generated therein by either or both of the heaters **81** and **90**. Various materials of construction and sizes of the enclosure **32** may be employed within the scope of the invention. Preferably, a base mounting plate **101** serving as a heat insulator and comprising wood or plastic is employed and through this plate apertures are provided for receiving the electrical conductors leading to the heaters and to the thermostatic switch within the enclosure, the conductors being sealed in the apertures as by resilient grommets or the like in order to assist in rendering the enclosure air tight. Affixed in sealed relation to the base plate is a continuous wall structure **102** having an outer edge **103** and this wall structure comprises a metal such as galvanized steel having a high coefficient of heat conductivity. A separate continuous sealing member **104** is provided for engagement with the wall edge **103** and for engagement with the interior of the imperforate outside cover **105**. This cover likewise is of steel or the like and is securely affixed in air tight relation to the wall **102** by any suitable fastening means (not shown). As will thus be apparent, a volume of dead air is confined within the sealed enclosure and heat introduced into that air by heaters **81** and **90** will result in a heating of the metallic portions of the enclosure. The thermostat **100** located within the enclosure and responsive to the temperature of that body of confined air will have the usual thermal lag associated with the rise and fall of the temperature of the confined air.

Accordingly, with the outside fan **30** pulling ambient air into contact with the exterior of the enclosure, the temperature of that ambient air will directly affect the rate of dissipation of the heat generated by the heaters and concomitantly the temperature acquired at any time by the air confined in the enclosure. Since it is the variable denoted primarily by the outside air surrounding the heat pump coil **27** which requires compensation in order to avoid having too frequent defrosting, it thus will be seen that the above-described defrost control mechanism affords the necessary compensation and meanwhile permits the use of a single timer with its desirable inherent reliability of operation.

If desired, various forms of heat insulation may be employed in connection with the structure of the heat-exchange enclosure **32** for the purpose of calibrating the same with respect to the heaters and the thermostat **100** located therein.

The amount of power consumed by the 2½- and 5-watt heaters comprises only a minor fraction of the power which otherwise would be consumed in a too frequent defrosting cycle since during the defrosting operation a certain amount of heating loss is sustained and the power for the compressor and inside fan motors must still be supplied while defrosting is taking place.

Having thus described the invention with respect to a preferred embodiment, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made; and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an air-conditioning apparatus of the type including a refrigeration system operable selectively to heat or cool air and having a compressor with an inlet and an outlet, first and second heat-exchange coils normally connected to said inlet and outlet, respectively, when said apparatus is used for heating, expansion means coupling said coils to each other, valve means coupled between said coils and said compressor for selectively causing said first and second coils to be coupled to said compressor outlet and inlet respectively in order to effect defrost of said first coil; the improvement comprising a defrost control mechanism effective to prevent premature initiation of defrost and including a timer-operated switch, a timer having a motor and adapted to operate said switch upon expiration of a cumulative period of timer operation thereby to initiate defrost of said first coil, and means for controlling said period of timer operation including a hermetically-sealed, air-filled enclosure in heat-exchange relation with ambient air surrounding said first coil, a thermostatically operated switch within said enclosure movable between a first position establishing a running circuit to said timer motor and a second position opening said running circuit, and a heating means within said enclosure adapted to generate heat therein when said thermostatically controlled switch occupies its second position, said thermostatically controlled switch moving automatically to said second position when the temperature of the confined air within said enclosure drops to a predetermined first value as a result of cooler ambient air passing against said enclosure, and moving automatically to said first position when the temperature of the confined air within said enclosure rises to a predetermined and higher second value.

2. Apparatus as defined in claim 1 wherein said heat-exchange enclosure includes at least one metallic wall separating the air confined within said enclosure from said ambient air and forming a path for heat transfer therebetween.

3. Apparatus as defined in claim 2 wherein said enclosure is mounted adjacent said first coil of said heat pump and in the path of ambient air drawn toward said first coil.

4. In an air-conditioning apparatus of the type including a refrigeration system operable selectively to heat or cool air and having a compressor with an inlet and an outlet, first and second heat exchange coils normally connected to said inlet and outlet, respectively, when said apparatus is used for heating, expansion means coupling said coils to each other, valve means coupled between said coils and said compressor for selectively causing said first and second coils to be coupled to said compressor outlet and inlet respectively, in order to effect defrost of said first coil; the improvement comprising a defrost control mechanism effective to prevent premature initiation of defrost and including a timer-operated switch, a timer having a motor and adapted to operate said switch upon expiration of a cumulative period of timer operation thereby to initiate defrost of said first coil, and means for controlling said period of timer operation including a hermetically-sealed, air-filled enclosure in heat-exchange relation with ambient air surrounding said first coil, a thermostatically operated switch within said enclosure movable between a first position establishing a running circuit to said timer motor and a second position opening said running circuit, a first electrical heating element within said enclosure adapted to generate heat therein when said thermostatically controlled switch occupies its second position, said thermostatically controlled switch moving automatically to said second position when the temperature of the confined air within said enclosure drops to a predetermined value as a result of cooler ambient air passing against said enclosure and moving

automatically to said first position when the temperature of the confined air within said enclosure rises to a predetermined and higher second value, and a second electrical heating element within said enclosure adapted to generate heat therein during the defrosting of said first coil thereby to insure retention of said thermostatically controlled switch in its first position during defrosting and in order to maintain said timer motor in operation during said defrosting.

5. Apparatus as defined in claim 4, wherein said second heating element has a greater heating output than said first heating element.

6. Apparatus as defined in claim 4 wherein said first and second heating elements are operated at different voltages.

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