Aug. 12, 1958 J. P. SLATTERY ET AL 2,847,190

AIR CONDITIONING APPARATUS HAVING AUTOMATIC DEFROST

Filed Nov. 16, 1955

FIG. 1

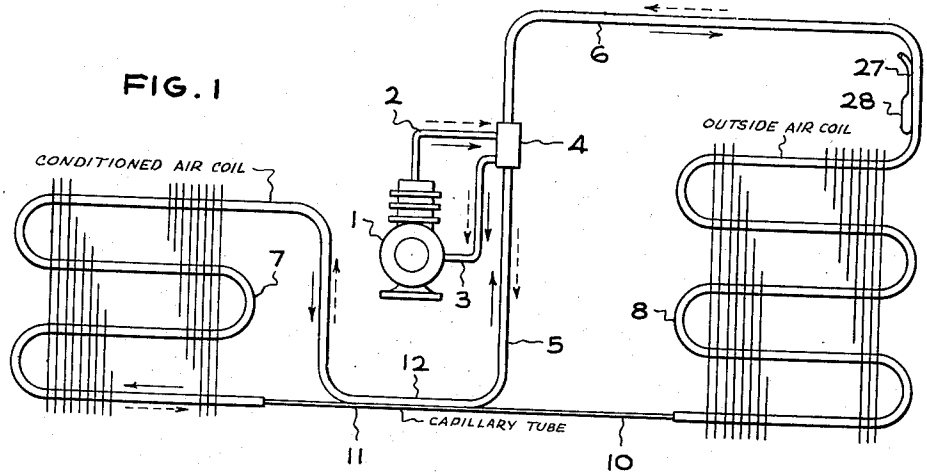


FIG. 2

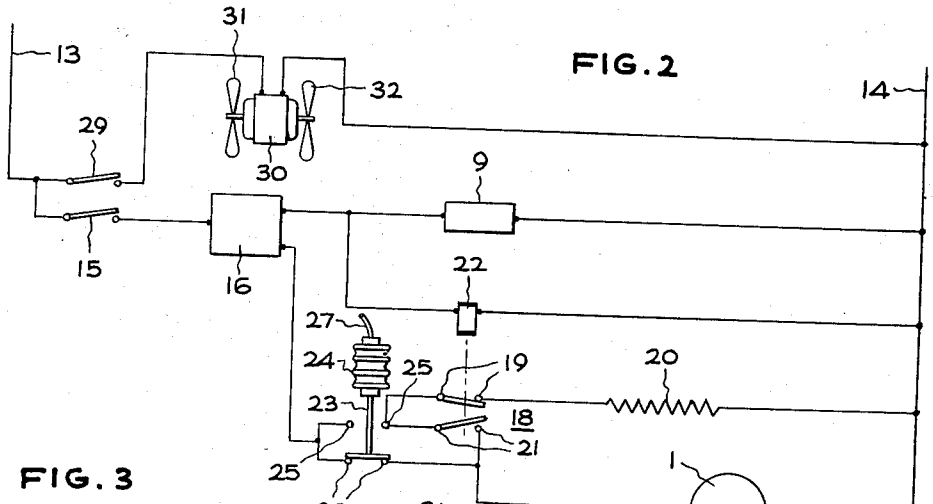
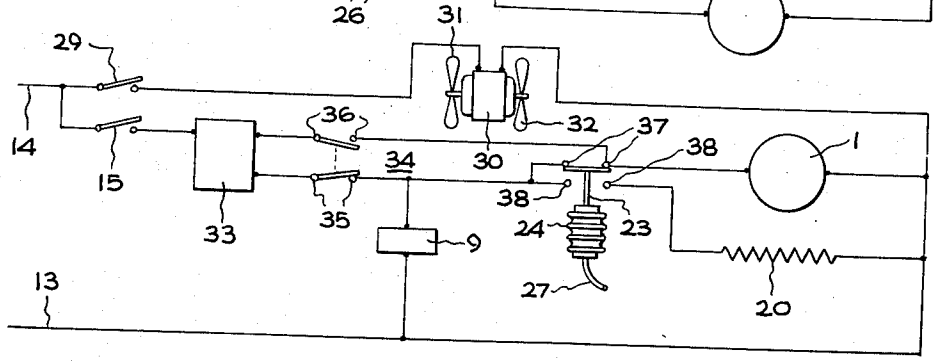


FIG. 3



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AIR CONDITIONING APPARATUS HAVING AUTOMATIC DEFROST

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Application November 16, 1955, Serial No. 547,069

12 Claims. (Cl. 257—3)

Our invention relates to self-contained, air conditioning apparatus and more particularly to reverse cycle, air conditioning apparatus capable of both heating and cooling.

Where it is desired to both heat and cool the air within an enclosure the reversible cycle, air conditioning unit has been used to advantage. The present invention is an improvement over the invention of the application of Gerald G. Coyne, Ser. No. 489,427, filed February 21, 1955, now abandoned, and assigned to the assignee of the present application which application discloses an automatic control arrangement for such a reversible air conditioner. We do not herein claim anything shown or described in said Coyne application, which is to be regarded as prior art with respect to the present application. During the heating operation of a reverse cycle air conditioner of the Coyne application, frost may collect on the outdoor heat exchanger and the above-mentioned application describes and claims control means responsive to a predetermined low temperature of the refrigerant flowing from the outdoor coil (preferably 30°) which are intended to discontinue the operation of the air conditioner and permit the outdoor coil to warm up to defrosting temperatures. When the unit is shutdown because the temperature responsive means senses a low outdoor coil temperature, an auxiliary heater arranged in the air path to the enclosure is energized so as not to interrupt the flow of heated air to the enclosure.

Self-contained reverse-cycle units of this type are frequently installed in rooms or enclosures served by ordinary heating systems and when so installed they are used to cool the enclosure during the summer season and also to provide the heating under milder or above-freezing weather conditions during the heating season. Thus they are actually available for year-around operation and in some cases, as where the operation of the main heating system is not under control of the room occupant and the room is too warm, the occupant may desire to buck the main heating system and operate the air conditioning unit on the cooling cycle regardless of outdoor temperatures. With the control circuit of the above-identified application, if the outside temperature has dropped below the above-mentioned predetermined temperature even though no frost has formed on the outdoor coil, the control means functions to stop the refrigerating unit and connect the auxiliary heater into the circuit. Therefore, if the operator tries to oppose the regular or central heating means by operating the unit on cooling when the outdoor temperatures are low, he will only get heat from the circuit auxiliary heater. Also if the unit is defrosting, the same action would result if the operator attempted to operate the unit on the cooling cycle.

Accordingly, it is an object of our invention to provide a new and improved control arrangement for a reverse cycle, air conditioning unit having automatic defrosting means responsive to the temperature of the outdoor coil which may be operated on the cooling cycle regardless of outdoor temperatures.

It is another object of our invention to provide an improved control system for a reverse cycle, air conditioning unit having combination automatic defrosting means and auxiliary heating means operable during the heating cycle, both of which means are disconnected from the circuit when the unit is connected for the cooling cycle.

It is a still further object of our invention to provide a new and improved control system for a reversible air conditioning unit provided with automatic defrosting means and which automatically both selects and controls the proper cycle of operation for the unit in response to the temperature of the enclosure to be conditioned and independent of the outside ambient temperature or whether the unit is defrosting.

In carrying out our invention, we provide a self-contained, air conditioning unit of the reversible type which is adapted to both heat and cool air for an enclosure. Our air conditioning unit includes a refrigeration system having a pair of heat exchangers, one inside and one outside the enclosure. We also include with our unit an auxiliary heater which can be used to heat air for the enclosure. When frost forms on the outdoor heat exchanger of our unit during the heating operation, automatic defrost control means responsive to a predetermined low temperature on the outdoor heat exchanger de-activate the refrigeration system to permit the outdoor coil to defrost. The auxiliary heater is simultaneously energized so that there is no interruption of the flow of heated air to the enclosure. We also provide within our novel circuit means which bypass the defrost control and condition the unit for operation on the cooling cycle at any time and independent of the outside ambient temperature or the temperature of the outdoor heat exchanger.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation may be best understood by reference to the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a diagrammatic view of a reversible cycle, refrigeration system suitable for use in our self-contained, air conditioning unit;

Fig. 2 is a schematic diagram of our novel electrical circuit adapted for use with the refrigeration system of Fig. 1; and

Fig. 3 is a schematic diagram of a modification of our electrical circuit adapted for use with the refrigeration system of Fig. 1.

Referring now to Fig. 1, we have shown therein a reversible cycle refrigerating system which is described at length and claimed in the co-pending application Ser. No. 445,250 (now Patent No. 2,750,762, dated June 19, 1956) of Gerald G. Coyne, filed July 23, 1954, and assigned to the same assignee as the present invention. The refrigeration system includes a motor driven compressor 1 having a discharge line 2 and a suction line 3. The discharge and suction lines are both connected to a reversing valve 4. Also connected to the reversing valve 4 are a pair of conduits 5 and 6 which lead respectively to indoor and outdoor heat exchangers or coils 7 and 8. The indoor coil 7 is arranged for cooling or heating air for the enclosure to be conditioned, and the outdoor coil 8 is arranged for either rejecting heat to or absorbing it from the outside atmosphere.

The reversing valve 4 is controlled by suitable electrical actuating means such as the solenoid 9 shown in Fig. 2. The valve 4 is normally biased to one position, but is movable against the biasing means to a second position by the solenoid 9 when it is energized. When the solenoid is again de-energized, the valve 4 returns automatically to its first position. We have not shown

any particular reversing valve structure since it will be understood that any suitable reversing valve having the above characteristics may be used.

In its first position, the reversing valve connects the suction and discharge of the compressor 1 to conduits 5 and 6 respectively and thus to the indoor and outdoor coils 7 and 8 respectively. In its second position, the valve reverses that connection and joins the discharge line 2 to the indoor coil 7 and the suction line 3 to the outdoor coil 8. Thus, as will be more fully explained hereinafter, if the solenoid 9 is de-energized so that the valve may assume its first or normal position, the system is adjusted so that the coil 7 absorbs heat from the indoor air and thereby cools it. Conversely, if the solenoid 9 is energized so as to hold the valve in its second position, the system is adjusted so that the coil 7 rejects heat to the indoor air and thereby warms it.

Included in the refrigeration system for the purpose of expanding the refrigerant from condensing pressure to evaporating pressure is a capillary tube 10. This tube operates as an expansion means during both the cooling and heating cycles, and it is so connected and arranged that an efficient flow rate is obtained in the system during both cycles. More specifically, the capillary tube is so connected and arranged that it offers more restriction to the flow of refrigerant during the heating cycle than during the cooling cycle whereby a lesser amount of refrigerant flows during the heating cycle. The reasons for and the advantages of such an arrangement of the capillary tube are described in the aforesaid co-pending application Serial No. 445,250. In this arrangement the capillary tube 10 is positioned in heat exchange relation with the conduit 5 connecting the reversing valve 4 to indoor coil 7. Specifically, the center portion 11 of the capillary tube is positioned in intimate heat exchange relationship with a portion 12 of the conduit 5 intermediate the ends thereof. The intimate heat exchange relation may be accomplished by any suitable means as, for example, by soldering the portion 11 of the capillary tube to the portion 12 of the conduit. By reason of this relationship between conduit 5 and the capillary tube 10, the tube is cooled during the cooling cycle and heated during the heating cycle, and as a result it is less effective to pass refrigerant during the heating cycle than during the cooling cycle.

If the reversing valve 4 is set for a cooling operation, the hot, gaseous refrigerant from compressor 1 first passes through the outside coil 8 wherein heat is rejected to the outside atmosphere. The condensed refrigerant then passes through the capillary tube 10 being expanded thereby. The cool, expanded refrigerant next absorbs heat from the room in the inside coil 7 and finally returns to the compressor 1 through the conduit 5 and the compressor suction line 3. Thus during the cooling cycle the coil 7 acts as an evaporator to absorb heat from the indoor air and the coil 8 acts as a condenser to reject the absorbed heat to the outdoor air. However if the reversing valve 4 is operated to its other position by means of the solenoid 9, the compressor discharge is then fed directly to the inside heat exchanger 7. The heat exchanger 7 thus rejects heat from the hot, gaseous refrigerant to warm air for the room. After being condensed in the coil 7 due to this heat loss, the refrigerant then passes through the capillary tube 10 being expanded thereby. The cool, expanded refrigerant next absorbs heat from the outside atmosphere and the heat exchanger 8. After so picking up heat the refrigerant returns to the compressor through the conduit 6 and the suction line 3. Thus during the heating cycle, the coil 8 acts as an evaporator to absorb heat from the outside air and the coil 7 acts as a condenser to reject this absorbed heat to the air of the enclosure. The path of the refrigerant flow through the system in the two cycles is indicated by the arrows in the diagram, the solid arrows indicating the flow during the cooling cycle and the dotted arrows indicating the flow during the heating cycle.

During the cooling cycle, frosting of the coil or heat exchanger acting as an evaporator is not likely to occur. The coil 7 then acting as the evaporator is exposed to the relatively warm room air and hence operates at such a high temperature and pressure that frosting does not occur. However, during the heating cycle when the outside coil 8 is acting as the evaporator, frosting may occur thereon. Rather than being exposed to a 75° to 85° F. room as is the coil 7 during the cooling cycle, the coil 8 is exposed to an ambient temperature of perhaps from 45° to 60° F. As a result, the outside coil 8 operates at a lower temperature and pressure. In fact as the outside temperature drops, the operating temperature and pressure of the coil also drops and if the outside temperature drops far enough, as for example to 40° F., the coil 8 then operates below freezing. As a result, frost formation may occur on the outside coil 8 during the heating cycle. Frost formation on the coil is of course disadvantageous in that it impairs the heat transfer between the coil and the outside air flowing over it. A layer of frost formed on the coil tends to act as an insulator so as to lower the heat transfer rate between the surface of the coil and the outside atmosphere. The more frost is formed, the lower is the heat transfer rate and the less heat can be absorbed by the refrigerant flowing through the coil. The less heat is absorbed by the coil 8, less heat will be available at the coil 7 for warming the room, and hence less work is done by the system. Thus for proper operation of the system, the coil 8 should be defrosted whenever any appreciable amount of frost forms thereon during the heating operation.

We have shown in Fig. 2 automatic means for controlling the operation of our air conditioning unit and for defrosting the outdoor coil 8 during the heating cycle. More specifically, we have shown therein an electrical circuit for use in a self-contained air conditioner, this circuit being particularly adapted for use with a reverse cycle refrigeration system. This circuit is an improvement over the invention of the application of Gerald G. Coyne, Serial No. 489,427, filed February 21, 1955, and assigned to the assignee of the present application. The circuit is energized from a household electrical circuit by means of a pair of supply conductors 13 and 14. The supply conductor 14 is connected directly to the one side of the motor of the compressor 1. The other line 13 is however connected to the other side of the compressor motor by means of a plurality of switch means.

One of these switch means comprises a manually-operated switch 15 connected directly to the supply line 13. This switch 15 provides a means whereby the refrigeration system may be shut on and off at the option of the user. Connected in series circuit relationship with the switch 15 is a thermostat 16. The thermostat 16 is of such construction that it performs a plurality of functions in our electrical control circuit. In one capacity, the thermostat responds to room temperature to either energize or de-energize the valve solenoid 9 to select the position of reversing valve 4 for operating the unit on the heating or cooling cycle respectively. The line 14 is connected to one side of the solenoid 9, and by means of switch 15 and the thermostat 16 a connection to line 13 can be made from the other side of the solenoid. In its second function, when the proper connections are made through the remaining intervening switch means in the circuit, the thermostat 16 cycles the compressor on and off during either the cooling cycle or the heating cycle. The thermostat may be any of the well known thermostats which are operative in response to room temperature to produce this desired control.

Within our circuit, we have also provided second switching means 18 for establishing the proper connections in our circuit to operate the unit on either the heating or cooling cycle. More specifically, the switch 18

is arranged to move between two positions. In the position shown in Fig. 2, the switch 18 bridges a pair of contacts 19 comprising one of two switches in a circuit including an auxiliary heater 20 and thermostat 16. With the switch 18 in the position of Fig. 2, the system is conditioned for the heating cycle using heater 20. In the second position of switch 18, the contacts 19 are opened and a second pair of contacts 21 are bridged by the switch closing one of two switching means in a second compressor control circuit between the thermostat 16 and the compressor 1. In this position the system is conditioned for the cooling cycle.

The operation of the switch 18 is automatic in the circuit and is effected by thermostat 16. As shown in Fig. 2, we have provided a second solenoid 22 electrically connected in parallel relationship with the valve solenoid 9. The plunger (not shown) of solenoid 22 is fixed to the switch 18 and moves therewith. Thus when the valve solenoid 9 is energized by the action of thermostat 16 to move valve 4 to the heating cycle position, the switch solenoid 22 is also energized moving its plunger upwardly carrying the switch 18 to the heating cycle position of Fig. 2 wherein the contacts 19 are closed. When the valve solenoid 9 is de-energized accompanied by a consequent deenergization of the solenoid 22 as determined by thermostat 16 when cooling is called for, the plunger falls dropping switch 18. The switch 18 therefore opens contacts 19, disconnecting the heater 20 from the circuit and closing contacts 21.

In order to provide for automatic defrosting of the unit, we locate another switch means 23 between the thermostat 16 and the selector switch 18. Through this switch 23, we are able to effect automatic defrosting of the outdoor coil 8 during the heating cycle. More specifically, defrosting switch 23 is arranged to move between two positions. Movement of the switch 23 is controlled by a suitable frost sensing actuating device, as for example the temperature responsive bellows 24. In one position, the switch 23 bridges a pair of contacts 25 and in its other position it bridges a pair of contacts 26. When the switch 23 bridges contacts 26, the compressor 1 is directly connected with the thermostat 16. When the switch 23 bridges the contacts 25, the heater 20 is connected through the contacts 19 bridged by the switch 18 to the thermostat 16.

The bellows 24 is connected by means of tubing 27 to a temperature responsive bulb 28 as shown in Fig. 1. The bellows 24, tubing 27, and bulb 28 together form a conventional fluid-type thermostat and define a closed chamber for an expansible liquid or vapor. As is well understood, the pressure within the bellows 24 is a function of the temperature of the bulb 28. It is well known that the temperature of the suction refrigerant leaving the outdoor coil is one good indicator of frost formation on the outdoor coil. As frost forms on the coil, the refrigerant is able to absorb less heat as it passes therethrough and consequently the temperature of the suction refrigerant drops. The more frost that is formed, the lower the temperature of the refrigerant. Thus, in our control arrangement, we initiate defrosting of the outdoor coil 8 in response to a predetermined low temperature of the refrigerant flowing in the suction conduit 6.

More specifically, we have so located the bulb 28 on the outdoor coil 8 that the bulb is in intimate heat transfer relationship with the refrigerant flowing from the coil at the point on the suction line 6 where the refrigerant leaves the coil. The bulb 28 thus senses the temperature of the suction refrigerant leaving the coil 8 during the heating cycle.

In the operation of our control circuit, the line switch 15 must, of course, be first closed to connect the circuit to supply conductor 13 as a connection has already been provided to conductor 14. When the thermostat 16 responds to a drop in room temperature to call for operation of the unit on the heating cycle, the valve solenoid 9 is energized along with the switch solenoid 22 which is arranged in parallel circuit relationship with the valve solenoid 9. When the valve solenoid 9 is energized, the proper connections are made by the valve 4 in the refrigerant system for operation on the heating cycle wherein the indoor coil acts as a condenser and the outdoor coil as an evaporator. When the switch solenoid 22 is energized, its plunger is drawn upwardly moving the switch 18 into the position of Fig. 2, wherein contacts 19 are bridged. This movement of the switch 18 brings the auxiliary heater 20 under control of the thermostat. Thus with the switch 18 in the position of Fig. 2, operation of the heater 20 or of the compressor 1 is selectively determined by the position of the bellows actuated defrost switch 23.

More specifically, when the switch 23 is in the position of Fig. 2 wherein contacts 26 are bridged, a direct connection is made between the thermostat 16 and the compressor 1. Thus the thermostat 16 cycles the unit on and off during the heating operation when heating is required within the enclosure to be conditioned.

As frost accumulates on the outdoor coil 8 resulting from a drop in the ambient temperature, the reduction in the amount of heat absorbed from the outside atmosphere by the coil 8 due to the insulating properties of the frost causes the suction refrigerant to drop in temperature. When the suction refrigerant falls to a predetermined temperature which is detected by the bulb 28, contraction of the fluid within the thermostat bellows 24 causes the bellows to actuate the switch 23 where it bridges the contacts 25. This is accompanied by an opening of contacts 26.

During the heating cycle, the opening of contacts 26, of course, initiates defrosting as the compressor is deactivated and the system is shut down. The temperature at which the bellows opens the contacts may of course be varied in accordance with how much frost is permissible before the coil should be defrosted. We have found that the best results are obtained if defrosting is initiated when the temperature of the suction refrigerant leaving the outdoor coil 8 falls to about 30° F. Once the frost has melted, the temperature of the outdoor coil will then be raised by the heat transferred to it by the outside atmosphere. This warms up the bulb 28 until it causes the bellows 24 to expand and close the contacts 26. In this manner, the compressor is automatically set back in operation after the defrosting has been completed. The closing of switch 23 as controlled by the bulb 28 is thereby effected to provide an automatic defrosting of the outdoor coil during the heating cycle whenever such defrosting may be necessary.

Since the refrigeration system is inactivated to effect the defrosting, this of course means that the coil 7 is rendered ineffective as a heating means during the defrosting period. However, since the defrosing of the coil may take some time, as for example 15 minutes, it may not be advantageous to cease the heating of the room completely during this period. A noticeable and undesirable fluctuation of temperature in the room might possibly occur as a result. In order to avoid such temperature fluctuation during defrosting, we have provided the auxiliary heating means comprising the electrical heater 20 in our new and improved apparatus, which is automatically activated whenever the refrigerating system is inactivated to defrost the outside coil 8.

More specificially, closing of contacts 19 when the switch solenoid 22 is energized connectes the auxiliary heater 20 into the circuit controlled by contacts 25. When the defrost control bellows 24 opens the contacts 26 to initiate defrosting, it simultaneously closes the contacts 25 automatically initiating the heater 20. When the defrosting is completed and the bellows 24 expands so as to again close the contacts 26, the contacts 25 are at the same time open so that the heater 20 is de-energized at the same time that the compressor 1 is again energized.

The heater 20 is thus normally de-energized during the heating operation of the apparatus, but whenever the unit is de-energized for defrosting, it is then automatically energized so that the flow of heated air to the room is not interrupted.

With a 30° F. cut-off temperature for the compressor 1, we avoid frequent cycling on and off by the compressor by setting the starting or cut-in temperature for the compressor at approximately 45° F. Operating the defrosting temperature sensing means within this temperature range avoids the initiation of defrosting when there is no frost formed on the outdoor coil commonly occurring when the outside humidity is low. Thus the 45° F. cut-in setting not only keeps the high wattage heater 20 on during lower ambient temperatures but also prevents the frequent cycling of the compressor at low humidity conditions.

The heater 20 is preferably mounted in the air conditioner so that the air that normally flows over the indoor coil 7 also flows over it. Thus no complicated damper arrangements are needed within the air conditioner. When the refrigeration system is shut off for defrosting, no change need be made in the flow of room air.

Often an additional source of heat is employed for an enclosure which is conditioned by the reversible air conditioner. Therefore, it is conceivable that the temperature in the enclosure might become high enough that the thermostat 16 will call for operating our unit on the cooling cycle opposing the heat from the additional heat sources. If the outdoor temperature has dropped to below the compressor cut off temperature used to initiate defrosing (30° F. in the setting described above), the defrosting switch 23, which is responsive to the temperature of the refrigerant leaving the outdoor coil 8 and also responsive to the outside ambient temperature, is actuated to open contacts 26 disconnecting the compressor 1 while closing contacts 25 connecting heater 20 into the circuit as in defrosting although there is no frost on the outdoor coil 8. In the control system of the above-mentioned Coyne application Ser. No. 489,427, heating by the heater 20 would result even though cooling is called for by the thermostat 16. However in our novel circuit, when the thermostat 16 calls for cooling, the unit is operated on the cooling cycle regardless of whether the unit has previously been defrosting or the outside ambient temperature is below the defrosting temperature.

More specifically, if the temperature conditions in the enclosure are such that the thermostat 16 calls for operating the unit on the cooling cycle, both the valve solenoid 9 and the switch solenoid 22 are de-energized by the action of the thermostat 16 permitting the valve 4 to return to its normal position for the cooling operation and allowing the plunger of solenoid 22 to release the switch 18 opening contacts 19 and closing contacts 21. Thus when the contacts 21 are closed the thermostat 16 can cycle the compressor on and off for the cooling cycle regardless of whether the defrost control switch 23 bridges contacts 25 or 26. In addition, heater 20 is no longer connected into the circuit.

The flow of indoor air over the coil 7 and the heater 20 may be accomplished by air moving means such as fan 31 driven by a motor 30. The air may be moved over the outside coil by fan 32 which is preferably driven from the same shaft of motor 30 as fan 31. The fan circuit is controlled by means of manually actuated switch 29 which may be opened and closed independently of the compressor control switch 15. The defrosting switch means are not included in the fan circuit so that fans 31 and 32 normally remain running when the refrigeration system is inactivated for defrosting. Thus during the defrosting period indoor air is passed over the heater 20 to be warmed and outdoor air is passed over the coil 8 to melt the accumulated frost.

Referring now to Fig. 3, we have shown a semi-automatic or manual control circuit for the air conditioning unit of Fig. 1, in which are provided means to manually condition the unit for operation on the heating or cooling cycle. We have indicated by the same numerals those parts in Fig. 3 which are identical to those in Fig. 2.

One side of the compressor 1 is connected to supply conductor 13 and the other side of the compressor is connected through a plurality of switch means to supply conductor 14. Switch 15 is a manually-actuated line switch to connect the unit to the supply conductor 14. A thermostat 33 is connected in series with the switch 15 and cycles the unit on and off during both the heating as well as the cooling operation. This thermostat 33 may be of any desired type generally used to accomplish this type of control. A manually-actuated selector switch 34 is arranged in series with the thermostat 33 and may be selectively moved between two positions by the operator for conditioning the unit for the heating or the cooling cycle. In the switch position shown in Fig. 3, the unit is conditioned for the heating cycle with contacts 35 being bridged by the switch 34. The upper pair of contacts 36 associated with the switch 34 are opened during the heating operation.

When the switch 34 is in the position of Fig. 3 and contacts 35 are closed, the solenoid valve 9 is energized moving the valve 4 to its second position for the heating cycle. The defrost control 23 operated by the bellows 24 bridges a pair of contacts 37 to permit the compressor to be cycled on and off by the thermostat 33 for the heating operation. When the outdoor coil 8 becomes so frosted that the bulb 28 (located as shown in Fig. 1 on the suction line 6) senses a predetermined low temperature of the suction refrigerant, the bellows contracts and the switch 23 opens contacts 37 disconnecting the compressor from the system. Simultaneously the lower set of contacts 38 are bridged by the switch 23 to connect the auxiliary heater 20 into the circuit so as not to interrupt the flow of heated air to the enclosure.

If at any time it is desired to operate the unit on the cooling operation, the switch 34 is moved upwardly manually to close the upper contacts 36 and open the contacts 35. This connects the compressor 1 directly into the circuit with the thermostat 33 which can cycle the compressor on and off during the cooling operation completely independent of the position of the defrost control 23. Thus our novel circuit arrangement provides for manually conditioning the unit for the cooling operation regardless of whether the unit has previously been defrosting or the outside ambient temperature is below the defrosting temperature.

In a manner similar to the embodiment of Fig. 2 a manually operated switch 29 operates the fan motor 30 to rotate fans 31 and 32, thus setting up an indoor air flow over the heater 20 and coil 7 through fan 31 and an outdoor air flow over coil 8 by means of fan 32.

From the foregoing it will be seen that we have provided a new and improved control arrangement for both heating and cooling air for an enclosure. Through the simple and efficient arrangement of our system, we have provided both a completely automatic and a semi-automatic or manually-operated system in which the unit is operated on either the heating or cooling cycle according to the temperature conditions within the enclosure to be conditioned. Our improved circuit automatically cycles on and off during either heating or cooling to maintain the proper temperature setting within the enclosure regardless of outside temperature. One of the outstanding features of our control arrangement is that the automatic control, which selectively operates either the compressor or auxiliary heater during the heating cycle, is bypassed when the system thermostat calls for

cooling from the unit. Our system lends itself readily to not only automatic operation but also manual operation wherein the unit is manually switched to either the heating or cooling cycle. In the manually-controlled circuit also, when the unit is selectively conditioned for the cooling operation, the automatic defrost control is bypassed completely and does not interfere with the operation of the compressor.

While in accordance with the patent statutes we have described what at present is considered to be the preferred embodiments of our invention, it will be understood by those skilled in the art that various changes and modifications may be made therein without departing from our invention, and we, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

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

1. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, an auxiliary heater for heating air for said enclosure, means to condition said system for operation on a cooling cycle with the inside heat exchanger as the evaporator, means to condition said system for operation on the heating cycle with the inside heat exchanger as the condenser, means responsive to the temperature of said outdoor heat exchanger during said heating cycle for de-activating at a predetermined low temperature said refrigeration system and activating said heater and means for bypassing said outdoor heat exchanger temperature responsive means to provide for operation of said system on the cooling cycle under outdoor temperature conditions wherein said outdoor temperature responsive means requires energization of said heater.

2. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, an auxiliary heater for heating air for said enclosure, means to condition said system for operation on a cooling cycle, means to condition said system for operation on a heating cycle, temperature responsive means associated with said outdoor heat exchanger, control means operable by said temperature responsive means at a predetermined low temperature of said outdoor heat exchanger during said heating cycle for de-activating said refrigeration system and activating said auxiliary heater, and means for bypassing said outdoor heat exchanger temperature responsive means to provide for operation of said system on the cooling cycle under conditions wherein said outdoor temperature responsive means requires energization of said heater.

3. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, an auxiliary heater for heating air for said enclosure, means to condition said system for cooling, means to condition said system for heating, a motor for driving said compressor, means responsive to a predetermined low temperature of said outdoor heat exchanger during said heating cycle for de-activating said compressor motor and activating said heater, and means for bypassing said outdoor heat exchanger temperature responsive means to provide for operation of said system on the cooling cycle under conditions wherein said outdoor temperature responsive means requires energization of said heater.

4. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, an auxiliary heater for heating air for said enclosure, means to condition said system for cooling, means to condition said system for heating, thermostatic means for sensing the temperature of the refrigerant during said heating cycle at a point in said system where the refrigerant low temperatures are indicative of excessive frost on said outdoor heat exchanger, control means operated by said thermostatic means at the occurrence of a predetermined temperature in said refrigerant for de-activating said refrigeration system and activating said heater, and means form bypassing said control means to provide for operation of said system on the cooling cycle under conditions wherein said thermostatic means requires energization of said heater.

5. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, switch means to selectively condition said system for heating or cooling, temperature responsive means associated with said system for controlling the temperature of said enclosure, an auxiliary heater for heating air for said enclosure, means responsive to the temperature of said outdoor heat exchanger during said heating cycle for de-activating at a predetermined low temperature said refrigeration system and activating said heater, said switch means bypassing said outdoor heat exchanger temperature responsive means to provide for operation of said system on the cooling cycle under conditions wherein said outdoor heat exchanger temperature responsive means requires energization of said heater.

6. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, an auxiliary heater for heating air for said enclosure, a motor for driving said compressor, manually operated switch means to selectively condition said system for heating or cooling, temperature responsive means associated with said system for controlling the temperature of said enclosure, thermostatic means for sensing the temperature of the refrigerant during said heating cycle at a point in said system where the refrigerant low temperatures are indicative of excessive frost on said outdoor heat exchanger and control means operable by said thermostatic means at the occurrence of a predetermined temperature in said refrigerant for de-energizing said compressor motor and activating said heater, said switch means bypassing said control means to provide for operation of said system on the cooling cycle under conditions wherein said thermostatic means requires activation of said heater.

7. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, electromagnetically operated valve means in said system for reversing the operation of said heat exchangers, an auxiliary heater for heating air for said enclosure, a motor for driving said compressor, a thermostat in said system for controlling the temperature of said enclosure, manually operated switch means for actuating said electromagnetic valve means to condition said system for heating or cooling, a temperature sensitive bulb arranged to sense the temperature of the refrigerant during said heating cycle

at a point where said refrigerant leaves said outside heat exchanger, bellows actuated switch means operated by said temperature sensitive bulb upon the occurrence of a predetermined temperature in said refrigerant for de-energizing said compressor motor and energizing said heater, said manually operated switch means arranged to permit bypassing of said bellows actuated switch means to provide for operation of said system on the cooling cycle under temperature conditions in said refrigerant wherein said temperature sensitive bulb causes said bellows actuated switch means to energize said heater.

8. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, a thermostat associated with said system for automatically controlling the temperature of said enclosure and for automatically conditioning said system for heating or cooling, an auxiliary heater for heating air for said enclosure, means responsive to a predetermined low temperature of said outdoor heat exchanger during said heating cycle for de-activating said refrigeration system and activating said heater, said thermostat bypassing said outdoor heat exchanger temperature responsive means to provide for operation of said system on the cooling cycle under conditions wherein said outdoor temperature responsive means is conditioned to energize said heater.

9. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, a motor for driving said compressor, a thermostat associated with said system for automatically controlling the temperature of said enclosure and for automatically conditioning said system for heating or cooling, an auxiliary heater for heating air for said enclosure, temperature responsive means for sensing the temperature of the refrigerant during said heating cycle at a point in said system where the refrigerant low temperatures are indicative of excessive frost on said outdoor heat exchanger and control means operable by said temperature responsive means at the occurrence of a predetermined temperature in said refrigerant for de-energizing said compressor motor and activating said heater, said thermostat arranged to bypass said control means to provide for operation of said system on the cooling cycle under temperature conditions wherein said temperature responsive means require energization of said heater.

10. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers operable interchangeably as a condenser or evaporator, electromagnetically operated valve means in said system for reversing the operation of said heat exchangers, an auxiliary heater for heating air for said enclosure, a motor for driving said compressor, a thermostat in said system for automatically controlling the temperature of said enclosure, said thermostat also automatically actuating said electromagnetic valve means to condition said system for heating or cooling, a temperature sensitive bulb for sensing the temperature of the refrigerant during said heating cycle at the point where said refrigerant leaves said outside heat exchanger, bellows actuated switch means responsive to a predetermined low temperature in said refrigerant sensed by said bulb for de-energizing said compressor motor and energizing said heater and electromagnetically operated switch means actuated by said thermostat for bypassing said bellows actuated switch means to provide for operation of said system on the cooling cycle under temperature conditions wherein said temperature responsive bulb causes said bellows actuated switch means to energize said heater.

11. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heat exchangers being operable interchangeably as a condenser or evaporator, valve means in said system for reversing the operation of said heat exchangers, an auxiliary heater for heating air from said enclosure, a thermostat for controlling the operation of said system responsive to the temperature of said enclosure, said thermostat automatically actuating said valve means to condition said system for heating or cooling, a heater control circuit, a first compressor control circuit, a second compressor control circuit, a temperature responsive switch means responsive to a predetermined low temperature in said outside heat exchanger, said temperature responsive switch means being movable at said predetermined low temperature from a first position wherein said first compressor control circuit is energized to a second position wherein said heater control circuit is conditioned for energization, a second switch movable between a first position wherein said heater control circuit is energized when said temperature responsive switch means is in said second position and a second position wherein said second compressor control circuit is energized when said temperature responsive switch means is in said second position, movement of said second switch being independent of said movement of said temperature responsive switch means thereby to permit energization of said compressor to cool said enclosure under temperature conditions in said outdoor heat exchanger which normally call for energization of said heater.

12. In a self-contained, air conditioning unit for heating and cooling an enclosure, a reversible cycle refrigeration system including a compressor and having a pair of interconnected heat exchangers one inside and one outside said enclosure, said heater exchangers being operable interchangeably as a condenser or evaporator, valve means in said system for reversing the operation of said heat exchangers, an auxiliary heater for heating air for said enclosure, a thermostat for controlling the operation of said system responsive to the temperature of said enclosure, said thermostat automatically actuating said valve means to condition said system for heating or cooling, a heater control circuit, a first compressor control circuit, a second compressor control circuit, a temperature responsive switch means responsive to a predetermined low temperature in said outside heat exchanger, said temperature responsive switch means being movable at said predetermined low temperature from a first position wherein said first compressor control circuit is energized to a second position wherein said heater control circuit is conditioned for energization, a second switch movable between a first position wherein said heater control circuit is energized when said temperature responsive means is in said second position and a second position wherein said second compressor control circuit is energized when said temperature responsive switch means is in said second position, said second switch being automatically actuated to its first position by said thermostat when said system is conditioned for heating, said second switch being automatically moved to said second position by said thermostat when said system is conditioned for cooling, thereby permitting said thermostat to automatically condition said system to cool said enclosure under temperature conditions in said outdoor heat exchanger which normally call for energization of said heater.

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