CONTROL SYSTEM FOR AIR CONDITIONING UNITS

The present invention relates to air conditioning units for heating and cooling an enclosure and more particularly to a control system for air conditioning units of the air valve type. In this specification and the claims annexed hereto, the terms "air valve air conditioning unit" or "air valve unit" are meant to apply to those air conditioning units which, in some manner, direct air from within the enclosure over one heat exchanger during the cooling season and over the other heat exchanger during the heating season as distinguished from those types of air conditioners which reverse the flow of refrigerant through the system to change the function of the respective heat exchangers while passing the air from within the enclosure over the same heat exchanger during both the cooling and heating seasons.

In air conditioning units of the type used for supplying heat to an enclosure during the winter or heating season, outdoor air is passed over the evaporator of the unit which operates at temperatures ranging from 10 to 30 degrees below the temperature of the outdoor ambient. Thus, there are times when the evaporator operates below the freezing point of water and, during these times, a layer of frost is deposited on the evaporator coils. This frost layer acts as a barrier to heat transfer and as the thickness of the layer of frost increases, the efficiency of the air conditioning unit for supplying heat to the enclosure is greatly reduced. Air conditioners of the type which use a refrigerant reversing valve to interchange the functions of the heat exchangers, i.e., reverse refrigerant flow type of air conditioning units, have a "built-in" arrangement for accomplishing the defrosting of the evaporator. That is, the functions of the heat exchangers of these units may be reversed so that the heat exchanger exposed to the outdoor air is operated as a condenser and becomes warm enough to melt the frost. However, in these reverse refrigerant flow type of units, during the defrost cycle, when the refrigerant flow is reversed, the heat exchanger exposed to air from within the enclosure is operated as an evaporator and takes heat out of the air from within the enclosure to melt the frost layer. This is likely to cause some discomfort to the occupants of the enclosure since the air from within the enclosure is cooled during the defrosting periods. Since "air valve" type air conditioning units are not supplied with a means for reversing the refrigerant flow within the system, they have no "built-in" arrangement for utilizing hot gas for defrosting the evaporator.

It is, therefore, an object of the present invention to provide an arrangement wherein hot gas defrosting of the evaporator is provided in an air valve type air conditioner.

It is another object of the present invention to provide an air valve type air conditioner having a control arrangement employing hot gas defrost for the evaporator which operates quickly and efficiently without removing heat to any substantial degree from the enclosure and, therefore, causes no discomfort to the occupants of the conditioned enclosure.

It is a further object of the present invention to provide an improved control system for an air conditioning unit of the air valve type which is adapted to heat and cool an enclosure.

Further objects and advantages of the invention will become apparent as the following description proceeds, and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In accordance with the present invention, there is provided an air conditioning unit having the usual refrigeration system including an evaporator, a condenser, and a compressor connected in refrigerant flow relationship.

The system is provided with a refrigerant expansion means between the evaporator and the condenser for producing a pressure drop in the system between these two members. Also connected between the evaporator and the condenser is a normally closed bypass conduit for directing refrigerant around the expansion means if desired.

The unit is provided with fans or air moving means which, during the heating season, are adapted to circulate separate streams of air from the inside and from the outdoors over the condenser and the evaporator respectively. In order to automatically defrost the evaporator, there is provided a pressurestat which is responsive to the air pressure drop across the evaporator due to frost accumulation thereon. The pressurestat opens a valve closing the bypass refrigerant bypass passage whenever a predetermined air pressure drop occurs across the evaporator thereby shunting refrigerant from the condenser around the expansion means directly into the evaporator.

The pressurestat also energizes a holding relay which, in turn, interrupts the power to the fan motor and stops the operation in the fans. The holding relay also maintains the valve in the bypass conduit open when the air ceases to flow through the evaporator and a pressure drop is no longer present across the evaporator to energize the pressurestat.

A defrost terminating switch, responsive to the temperature of refrigerant flowing from the evaporator through the suction line, de-energizes the holding relay so that the valve in the bypass conduit is closed and power is again supplied to the fan motor to resume normal operation of the unit.

As a further aspect of the invention the control system includes a selector control means for conditioning the thermostat of the unit to operate the refrigeration system according to the temperatures above a predetermined temperature or according to decreases in the enclosure air temperature below a predetermined temperature. The selector control automatically adjusts the operation of the fan motor to a low speed whenever the thermostat is conditioned to operate the refrigeration system according to decreases in enclosure air temperature below a predetermined temperature.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

Fig. 1 is a schematic diagram of a self-contained air conditioning unit incorporating the present invention; and

Fig. 2 is a line diagram illustrating the components of the air conditioner and an electrical circuit for the control system of the present invention.

Referring now to Fig. 1, there is shown an air conditioner of the self-contained type including a casing adapted to be mounted in an aperture or window in the outer wall of an enclosure with one side of the casing facing the enclosure and the other side of the casing exposed to the outdoors. The casing is divided by a barrier into two separate compartments hereinafter designated the condenser compartment 7 and the evaporator compartment 8. Within the casing is a refrigeration sys-
3. The air conditioner of the present invention is of the air valve type. That is, during operation, the evaporator always removes heat from the air within the evaporator compartment 8 while the condenser 9 discharges heat or is cooled by the air within the condenser compartment. As may be seen in Fig. 1, the evaporator compartment may be divided into air inlet and outlet sections 13 and 14 respectively by the shroud 16 and a fan 17 which also circulates air through the evaporator compartment. A damper means or closure panel 18, which is movable to either the enclosure or outdoor facing sides as indicated by the dotted lines in Fig. 1) of the evaporator compartment, makes it possible to circulate either outdoor or enclosure air through the evaporator compartment where it is cooled by the evaporator. Similarly, the condenser compartment is divided by the shroud 19 and the fan 21 into condenser compartment inlet and outlet sections 22 and 23. A damper means or closure panel 24, similar to the panel 18 in the evaporator compartment, is arranged to direct air from the outdoors or from the enclosure into the inlet section 22 merely by moving the panel 24 from one side of the condenser compartment to the other. The fans 17 and 21 are both driven by a single fan motor 20 which, for reasons to be hereinafter explained, is preferably a two speed motor.

With the damper means or closure panels 18 and 24 positioned as shown in Fig. 1, the air conditioner is adapted to heat the enclosure 3. More specifically, air is circulated through the condenser compartment 7 from the enclosure where it is heated by the condenser and discharged back into the enclosure as indicated by the arrows in Fig. 1. Outdoor air is drawn from the outdoors into the evaporator compartment inlet section 13 where it encounters the evaporator 11 and gives up heat to the evaporator. The outdoor air, after giving up heat to the evaporator, is then discharged to the outdoors through the outlet section 14. The heat removed from the outdoor air by the evaporator 11 is carried through the system by the refrigerant and gives up this heat at the condenser to heat the air from the enclosure.

Movement of the damper means or closure panels 18 and 24 into their respective positions on opposite sides of the chamber may be accomplished automatically or manually. It is assumed in the following description that the occupants of the enclosure move the panels to their proper positions on the case whenever they desire to change the operation of the unit from cooling to heating or vice versa. In order to provide additional heat for the enclosure whenever the refrigeration system of the unit is not capable of maintaining the desired temperature within the enclosure there is provided an auxiliary or supplementary heater 25 in the form of a resistance heater. The heater 25 is positioned in the condenser compartment and heats the air circulated therethrough as it enters the enclosure.

The outdoor air, in passing over the evaporator 11, is cooled and, if of sufficient moisture content, it deposits a certain amount of moisture on the coils and evaporator surfaces. Under certain conditions which normally occur when the outdoor temperature is above a certain temperature, such as 42°F, the evaporator operates at a temperature above the freezing point of water. Under these conditions, the water deposited on the evaporator surface through air drops from the evaporator into a suitable collection tray or sump 26 and then from the sump to a compressor compartment. This water is removed from the unit through the drain 27 and suitable drain conduits (not shown) which lead to the outdoors or to any other suitable drain area. Whenever the outdoor temperature drops too low, such as below the temperature 42°F, the operating parameters of the refrigeration system cause the evaporator temperature to drop below 32°F or below the freezing point of water. Under these latter conditions of operation, there is a build-up of frost on the evaporator 11 if the outdoor air is cooled below dew point. This frost barrier acts as an insulator and prevents effective heat transfer between the evaporator coils and the air within the evaporator compartment, thus, greatly decreasing the amount of heat removed from this air which, in turn, decreases the heat output at the condenser. As will be hereinafter explained, the present invention deals with a control arrangement for controlling the operation of the air conditioning unit to provide either heating or cooling for the enclosure and for automatically defrosting the evaporator whenever the frost build-up thereon is such as to impair the efficiency of the unit.

Referring now to Fig. 2, there is shown a control arrangement for selectively operating the above-described air conditioner on the cooling or the heating cycle and for automatically defrosting the evaporator of the unit whenever there is an excessive frost build-up thereon. As may be seen in Fig. 2, power is supplied to the air conditioner through lines 31 and 32 and the main switch 33. A selector control means 34, which is manually operated by the occupants of the enclosure, is adapted to condition the unit for operation on the heating or cooling cycle. The selector control means includes a pair of switches 36 and 37 which are movable to selective positions for energizing, or partially energizing, various circuits leading to the components of the air conditioner. Thus, switch 36, which will hereinafter be referred to as the comfort control switch, is movable to complete the circuit between contacts 38 for contacts 39 while switch 37, which will hereinafter be referred to as the fan speed switch, is movable to separate positions to complete the circuit between contacts 41.

A thermostat 43 is provided which is conditioned by the selector control means 34. The thermostat is conditioned according to the refrigeration system of the air conditioner according to finite temperature increases or decreases above or below a predetermined temperature set on the thermostat by the occupants of the enclosure. Normally, the thermostat with its temperature sensing means is placed on the unit in a position where it can be exposed to the air from the enclosure during both the heating and cooling seasons. This is schematically illustrated in Figs. 1 and 2 by the thermal bulb 43a connecting with the thermostat 43. The thermal bulb 43a operates an expansion bellows 43b, or other responsive means, in the thermostat which, in turn, energizes mechanical linkages connected with electrical switches in the thermostat. When the contacts 38 of the comfort control switch 36 are closed, current is supplied to the thermostat through the heating cycle contact 44. With the current supplied to the heating cycle contact 44, the temperature sensitive member 43a, through bellows 43b of the thermostat, then energizes the circuits leading to the compressor and the other components of the system by closing the switch 46 whenever the temperature of the enclosure falls below a predetermined temperature.

Conversely, whenever the comfort control switch 36 is positioned across contacts 39 so that current is supplied to contact 47, or the cooling cycle contact of the
thermostat, then the circuits leading to the compressor and to the other components of the unit are energized by the switch 46 which is forced to move across contact 47 by the temperature sensing member 45a, through bellows 45b of the thermostat. The temperature of the enclosure rises above a predetermined temperature.

It will be noted that the thermostat 43 is also provided with a heater switch 48. The heater 25 is energized by the heater switch 48 which is automatically moved by the temperature responsive device of the thermostat 43. So, whenever the room temperature drops a certain number of degrees below that set by the occupant. That is, for example, if the thermostat were set at 75° F. and the actual room temperature fell to 70° F., it would be an indication that the heat load of the room was more than could be met by the refrigeration system alone, and the supplementary heater 25 would then be energized to supply additional heat. Thermostats having the above-described type of operation are well known in the art and a detailed description of their structure is not believed necessary in this specification.

Operation of the fan speed switch 37 is coordinated with the operation of the comfort control switch 36 so that the fan motor is operated on low speed only when the comfort control switch 36 is positioned to operate the refrigeration system in a manner to supply heat to the enclosure. That is, whenever the air conditioners is to be operated to supply heat to the enclosure or, more specifically, whenever the refrigeration system is operated upon the occurrence of temperature decreases within the enclosure, the fans are operated at low speed. The condenser fan 21 of air conditioning units is normally much larger than the evaporator fan 17 and its noise is accentuated by the high density of the room. Since the condenser fan 21 is exposed to the inside during heating, it is desirable, in order to reduce the noise level of the unit during this operation, to operate the fans at a lower speed. When the comfort control switch 36 is in the heating position across contacts 38, the fan speed switch 37 is moved across contacts 41. Thus, during the heating operation, current is supplied to the low speed terminal 51 of the fan motor 20 through the circuit including electrical conduits 52, 53, 54, 55 and 56. During the cooling operation when the comfort control switch 36 is bridged across contacts 39, the fan speed switch 37 is in its normal position and current is then supplied to the high speed terminal 57 of the fan motor through the electrical conduit 58.

As stated previously, the frost build-up on the evaporator 11 during the heating cycle reduces the efficiency of the system to supply heat at the condenser. This is because large amounts of frost on the evaporator reduce the efficiency of the condenser. A bypass passage 59 is connected between the condenser 9 and the evaporator 11 for shunting warm refrigerant or hot gas from the condenser directly into the evaporator. During normal operation of the system, the bypass conduit 59 is closed and means are provided in the form of a pressurestat control 61 and valve 62 for opening the conduit whenever a predetermined pressure drop occurs across the evaporator. In the illustrated embodiment of the invention the pressurestat 61 is provided with a first static tube 61a for sampling air pressure on the upstream side of the heat exchanger 11 and a second static tube 61b for sampling air pressure on the downstream side of the heat exchanger 11. Pressurestats of this type are well known in the art and a more detailed description thereof is not believed necessary for a full understanding of the invention except insofar as to state that the instrument measures the difference in pressures as sensed by the two static tubes and opens the switch for actuating a switch in accordance with a predetermined pressure differential across the heat exchanger. The pressurestat 61 is adapted to close the normally open switch 61a (see in Fig. 2) whenever the pressure drop across the evaporator is a predetermined amount. Thus, as the frost build-up on the evaporator increases and the space for the flow of air through the evaporator becomes more and more restricted, the pressure drop across the evaporator gives an indication of the frost build-up on the evaporator. As may be seen in Fig. 2, when the pressurestat switch 61a is closed to its dotted line position in Fig. 2 by the pressurestat, electrical current is supplied to the bypass valve solenoid coil 62a which then causes the valve 62 (of Fig. 1) to move to the open position. In this manner warm liquid refrigerant in the evaporator is passed or shuttled around the capillary 10 directly into the evaporator. Since the refrigerant flows generally in the same direction through the system, there is no need to shut off the compressor when the valve 62 is opened.

During the defrost cycle, circulation of cold outside air over the evaporator 11 is undesirable. In order to stop the fan motor 20 during the defrost cycle, a relay 63 is provided, which contains a coil 63a also in series with the pressurestat switch, that is energized when the pressurestat switch 61a is closed. The relay coil 63a operates a relay switch 63b which interrupts the current flowing to the fan motor. More specifically, relay switch 63b is normally closed across the contacts 66, is upon energization of the relay coil 63a, moved away from contact 66 into the dotted line position shown in Fig. 2 to open the circuit between electrical conduits 54 and 55 thereby interrupting the current flow to the fans 21 and 17. When the evaporator fan 17 ceases to rotate there is no longer a pressure drop across the evaporator, and the pressurestat 61 will open the pressurestat switch 61a. Since the opening of the pressurestat switch would ordinarily interrupt the power supplied to both the bypass valve solenoid 62a and the relay coil 63a, means must be provided for supplying electrical current to these members when the evaporator fan stops rotating so that the defrost operation will be continued. This is accomplished by causing the relay switch 63b to move across contact 67 (into the dotted line position shown in Fig. 2) thereby shunting current around the pressurestat switch 61a through the conduits 54 and 68. Thus, even though the pressurestat switch has moved to its normally open position, the relay switch 63b still interrupts the current to the fan motor and completes the holding circuit to the bypass valve solenoid 62a as well as to the bypass coil 63a. The hot gas from the condenser is, thereby, continuously delivered through the bypass conduit 59 to the evaporator 11 for melting the frost on the evaporator.

In order to terminate the defrost operation, means responsive to the temperature of the refrigerant leaving the evaporator are provided for interrupting the electrical current to the holding relay 63a. In Fig. 1 there is shown a temperature responsive bulb 69 which actsuates an expansion device 69a when the temperature of the refrigerant in the suction conduit 70 exceeds a predetermined value. The bulb and expansion device opens the defrost terminating switch 69b thereby de-energizing the holding relay coil 63a. The defrost terminating switch 69b is in the open or dotted line position of Fig. 2 whenever the temperature of the refrigerant is above a predetermined temperature such as 37° F. Thus, the circuit to the bypass valve solenoid 62a can never be energized unless the temperature of the refrigerant leaving the evaporator is sufficiently cold to close switch 69b.

The above-described invention provides a simple control arrangement for an air conditioner of the air valve type. It also proposes a defrost arrangement adapted to operate quickly and effectively to defrost the evaporator without utilizing the heat of the enclosure, to any substantial extent, to provide the heat necessary to melt the frost.

While, in accordance with the patent statutes, there has been shown and described what at present is considered to be the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without depart-
ing from the invention and it is, therefore, the aim of the appended claims to cover all such changes and 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. An air conditioner for both heating and cooling an enclosure comprising a casing adapted for mounting in an outer wall of said enclosure, a refrigeration system in said casing including a compressor, a condenser and an evaporator connected in refrigerant flow relationship, refrigerant expansion means connected between said condenser and said evaporator for expanding refrigerant from condenser pressure to evaporator pressure, a normally closed bypass conduit also connected between said condenser and said evaporator for bypassing refrigerant from said condenser around said expansion means directly into said evaporator, fans in said casing for circulating separate air streams over said condenser and said evaporator respectively, an electrical motor for driving said fans, openings in said casing communicating with said enclosure and the outside, damper means in said casing for directing air from inside and outside said enclosure over said condenser and evaporator respectively, means for defrosting said evaporator including a pressurestat responsive to the air pressure drop across said evaporator due to frost accumulation thereon, means actuated by said pressurestat for opening said bypass conduit to pass refrigerant around said expansion means from said condenser directly into said evaporator, a holding relay also energized by said pressurestat for interrupting the power to said fan motor and for maintaining said bypass conduit open when said pressurestat becomes inoperative as a result of the discontinued air flow through said evaporator, and means responsive to the temperature of refrigerant leaving said evaporator for de-freezing said holding relay so that said bypass conduit is again closed and power is again supplied to said fan motor for circulating air through said evaporator and said condenser respectively.

2. An air conditioner for both heating and cooling an enclosure comprising a casing adapted for mounting in an outer wall of said enclosure, a refrigeration system in said casing including a compressor, a condenser and an evaporator connected in refrigerant flow relationship, refrigerant expansion means connected between said condenser and said evaporator for expanding refrigerant from condenser pressure to evaporator pressure, a normally closed bypass conduit also connected between said condenser and said evaporator for bypassing refrigerant from said condenser around said expansion means directly into said evaporator, fans in said casing for circulating separate air streams over said condenser and said evaporator respectively, a high and low speed motor for driving said fans, openings in said casing communicating with said enclosure and the outside, damper means in said casing for directing air from inside and outside said enclosure over said condenser and evaporator respectively, a thermostat adapted to sense the temperature of the air within said enclosure, a selector control means for conditioning said thermostat to operate said refrigeration system according to one temperature within said enclosure or according to decreases in air temperature within said enclosure, said selector control means also switching said fan motor to operate on low speed only when said thermostat is conditioned to operate said refrigeration system according to decreases in the air temperature within said enclosure, means for defrosting said evaporator including a pressurestat responsive to the air pressure drop across said evaporator due to frost accumulation thereon, means actuated by said pressurestat for opening said bypass conduit to pass refrigerant around said expansion means from said condenser directly into said evaporator, a holding relay also energized by said pressurestat, a switch means energized by said holding relay for interrupting the power to said fan motor and for maintaining said bypass conduit open when said pressurestat becomes inoperative as a result of the discontinued air flow through said evaporator, and means responsive to the temperature of refrigerant leaving said evaporator for de-freezing said holding relay so that said bypass conduit is again closed and power is again supplied to said fan motor for circulating air through said evaporator and said condenser respectively.

3. An air conditioning unit for both heating and cooling an enclosure comprising a casing adapted for mounting in an outer wall of said enclosure, a refrigeration system in said casing including a compressor, a condenser, and an evaporator connected in refrigerant flow relationship, refrigerant expansion means connected between said condenser and said evaporator for expanding refrigerant from condenser pressure to evaporator pressure, a normally closed bypass conduit also connected between said condenser and said evaporator for bypassing refrigerant from said condenser around said expansion means directly into said evaporator, fans in said casing for circulating separate air streams over said condenser and said evaporator respectively, a high and low speed motor for driving said fans, openings in said casing communicating with said enclosure and the outside, damper means in said casing for directing air from inside and outside said enclosure over said condenser and evaporator respectively, means for defrosting said evaporator including a pressurestat responsive to the air pressure drop across said evaporator due to frost accumulation thereon, means responsive to decreases in air temperature within said enclosure, means for defrosting said evaporator including a pressurestat responsive to the air pressure drop across said evaporator due to frost accumulation thereon, means responsive to decreases in air temperature within said enclosure, means actuated by said pressurestat for opening said bypass conduit to pass refrigerant around said expansion means from said condenser directly into said evaporator, a holding relay also energized by said pressurestat, a switch means energized by said holding relay for interrupting the power to said fan motor and for maintaining said bypass conduit open when said pressurestat becomes inoperative as a result of the discontinued air flow through said evaporator, and means responsive to the temperature of refrigerant leaving said evaporator for de-freezing said holding relay so that said bypass conduit is again closed and power is again supplied to said fan motor for circulating air through said evaporator and said condenser respectively.

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