Dec. 8, 1964 B. HUSKEY 3,159,981

HEAT PUMP INCLUDING FROST CONTROL MEANS

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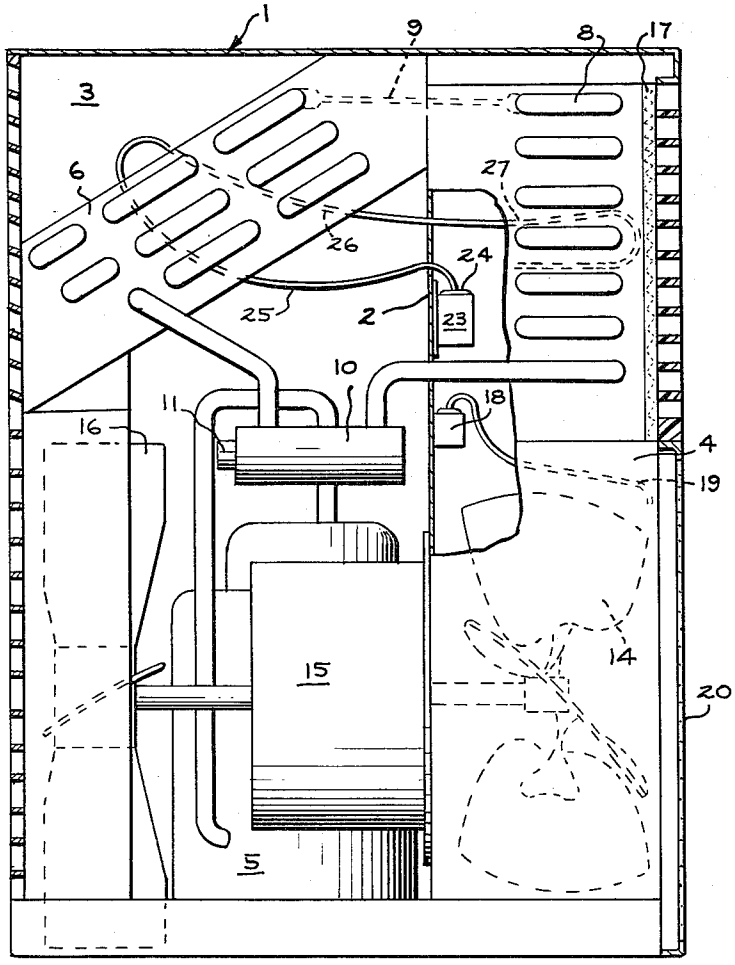
FIG. 1



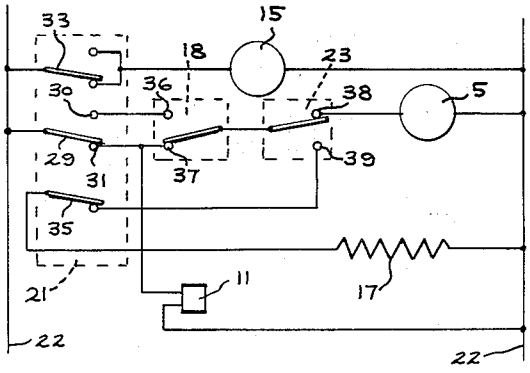


FIG. 2

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HEAT PUMP INCLUDING FROST CONTROL MEANS

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The present invention relates to heat pumps and is more particularly concerned with a self-contained air conditioning unit including a reversible refrigerating system including improved means for stopping operation of the system whenever either heat exchanger component thereof is subjected to frosting conditions.

Self-contained air conditioning units of the reversible type which are adapted to be mounted in the outer wall of an enclosure and utilized for heating the air from the enclosure during the winter and cooling the air from the enclosure during the summer comprise a housing divided into an indoor section and an outdoor section. An indoor heat exchanger is disposed in the indoor section while an outdoor heat exchanger and usually the compressor are located in the outdoor section. The compressor is reversibly connected to the heat exchangers so that the indoor heat exchanger functions as an evaporator when the unit is operating on the cooling cycle and the outdoor heat exchanger functions as the evaporator on the heating cycle. Suitable fan means are provided for circulating indoor air over the indoor heat exchanger and outdoor air over the outdoor heat exchanger during operation of the system on either the heating or cooling cycle. Under certain operating conditions, whichever heat exchanger is functioning as the evaporator may operate at such a low temperature as to cause the accumulation of a coating or layer of frost thereon. Since such a frost layer operates as a barrier to heat transfer between the evaporator and the air being circulated over the evaporator, the efficiency of the unit is markedly reduced. Also, unless means are provided for interrupting this accumulation of frost, the evaporator can become completely filled with a layer of frost which may eventually cause water or other damage to the unit.

It is a primary object of the present invention to provide a self-contained heat pump including control circuitry comprising a single frost control switch arranged to interrupt the operation of the reversible air conditioning unit or system whenever either heat exchanger attains a frosting temperature.

Another object of the invention is to provide a self-contained air conditioning unit including a reversible refrigerating system and control circuitry designed to interrupt the operation of the refrigerating system whenever either heat exchanger attains a frosting temperature and to supply auxiliary heat to the enclosure whenever the operation of the refrigerating system is thus interrupted during a heating cycle.

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 carrying out the objects of the present invention, there is provided a self-contained air conditioning unit adapted to be mounted as a unit in an outer wall of an enclosure and comprising a reversible refrigerating system so that it can be employed for either heating or cooling the air from the enclosure. The reversible refrigeration system comprises an indoor heat exchanger, an outdoor heat exchanger, a compressor and flow control means for directing the flow of high pressure refrigerant from the compressor either directly into the indoor

heat exchanger or directly into the outdoor heat exchanger for operation of the heat exchangers interchangeably as a condenser or as an evaporator. Control circuitry for controlling the operation of the heat pump on both the heating and the cooling cycles includes, in addition the usual thermostat responsive to indoor air temperatures for cycling the compressor on and off during either the heating or the cooling cycle, a frost control switch for interrupting the operation of the compressor whenever either heat exchanger attains a frosting temperature. The frost control switch includes a vapor-filled bellows and capillary tube sensing element connected to the bellows. The tube is arranged with a first portion thereof in contact with one of the heat exchangers and a second portion in contact with the other heat exchanger whereby the switch means operated by the bellows will stop the compressor when either heat exchanger attains a frosting temperature. Preferably, the heat pump unit also includes an auxiliary heater in the path of the air from the enclosure flowing through the indoor section and the frost control switch means is designed to energize this heater whenever the operation of the compressor is interrupted during a heating cycle.

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

FIGURE 1 is a view, partially in cross section, of the self-contained air conditioning unit incorporating the present invention; and

FIGURE 2 is a schematic diagram of electrical control circuitry adapted to control the unit in accordance with the present invention.

Referring to FIGURE 1 of the drawing, there is shown an air conditioning unit of the reversible or heat pump type including a housing 1 divided by means of a partition 2 into an outdoor section 3 and an indoor section 4. A reverse cycle refrigerating system contained within the housing comprises a compressor 5 and an outdoor heat exchanger 6 mounted within the outdoor section 3 of the housing and an indoor heat exchanger 8 mounted within the indoor section 4. The outdoor heat exchanger 6 and the indoor heat exchanger 8 are connected by means of a suitable flow restricting means such as a capillary tube 9 while the compressor is connected to the heat exchangers through a reversing valve 10 operated by a solenoid 11 so that the indoor heat exchanger 8 can be connected to the compressor either as the evaporator or as the condenser component of a refrigerating system. A fan 14 driven by a motor 15 is provided in the indoor section for circulating indoor air over the indoor heat exchanger 8 while a fan 16 driven by the same motor 15 is provided in the outdoor section for circulating outdoor air over the outdoor heat exchanger 6. An auxiliary heater in the form of an electric resistance heater 17 is preferably provided in the indoor section in the path of the air flowing through the indoor heat exchanger 8 for the purpose of supplying heat to that air stream under certain operating conditions.

Positioned within the unit at some point in the air stream upstream from the heat exchanger 8 is a thermostat 18 which controls the operation of the compressor 5 during operation of the unit on either the heating or the cooling cycle. This thermostat is of the type well-known in the art and includes sensing means 19 responsive to the temperature of the indoor air for actuating a switch in the compressor circuit. In the illustrated embodiment of the invention, this temperature responsive means 19 is arranged in the air stream flowing from the enclosure and into the indoor section 4 through the inlet grille 20. The unit is also provided with a main or selector switch 21 (FIGURE 2) through which electrical power from supply lines 22 is connected to the

unit and by means of which the operator of the unit may select operation thereof on either the heating or the cooling cycle.

In accordance with the present invention, the unit also includes a frost control switch 23 which is mounted in the indoor section 4 and which is actuated by a vapor-filled bellows 24 and a capillary tube sensing element 25 connected to the bellows 24. The sensing element 25 of this switch 23 is arranged to interrupt the operation of the compressor whenever either heat exchanger 6 or 8 attains a frosting condition or temperature during operation of the unit on either the heating or cooling cycle. To this end, the capillary sensing element 25 is threaded through both the outdoor heat exchanger 6 and the indoor heat exchanger 8 so that it includes a first portion 26 which continuously senses the temperature of the outdoor heat exchanger 6 and a second portion 27 which continually senses the temperature of the indoor heat exchanger 8. As is well known, a vapor-filled capillary-bellows type of thermostat has the characteristic of controlling from the coldest point of the bellows-capillary system due to the fact that a vapor-liquid boundary is formed at the coldest point and this boundary establishes the vapor pressure of the capillary-bellows system. Hence, the operation of the frost control switch 23 will be controlled either by the portion 26 or the portion 27 of the capillary sensing element 25, depending upon which of these portions is the colder.

For a more complete understanding of the control circuitry and the manner in which the frost control switch 23 operates, reference is made to the wiring diagram shown in FIGURE 2 of the drawing. The manually operated main or selector switch 21 by means of which the operator energizes the unit and selects the operation thereof on either the heating or cooling cycle includes a first switch means 29 including a cooling contact 30 and a heating contact 31 by means of which the operation of the unit on either the cooling cycle or the heating cycle can be selected. The main switch 21 also includes a fan energizing switch 33 adapted to energize the fan motor 15 so that the fans will run continuously during operation of the unit on either the heating or the cooling cycle. An additional switch means included in the main control switch means is a switch 35 included in the energizing circuit for the heater 17 and adapted to be closed when the main switch is positioned for operation of the unit on the heating cycle.

In addition to the switch means 29, the compressor circuit also includes the thermostat 18 and the frost control switch 23. The thermostat switch 18 includes a cooling contact 36 and a heating contact 37 which are respectively series connected to the cooling and heating contacts 30 and 31 of the switch 29 so that the thermostat 18 cycles the compressor on and off to maintain the desired temperatures during either a heating or a cooling cycle. The other terminal of the thermostat switch is connected to the common terminal of the frost control switch 23 which includes a first normally closed contact 38 and a second or back contact 39. Normally, the switch 23 completes the compressor circuit through the contact 38 since, during normal operation of the heat pump on either the cooling or the heating cycle, the heat exchangers 6 and 8 are operating at above frosting temperatures. Under such conditions, when the switch means 29 is positioned, for example, in its cooling position, a circuit is completed through the contact 30 of the switch 29 and the contact 38 of the switch 23, and the compressor is cycled on and off by the thermostat switch 18 through the cold contact 36 thereof. Similarly, the heating control circuit is traced through contact 31 of the switch 29, contact 37 of the thermostat 18 and contact 38 of the defrost control switch 23. It will also be noted that when the main switch component 29 is in the heating position, a circuit energizing the solenoid valve 11 is completed through the switch 29. Energization of the solenoid 11 moves the valve 10 to its heating position so that the refrigerant flow is from the compressor to the indoor coil or heat exchanger 8 and then to the outdoor heat exchanger 6.

Under abnormal operating conditions, that is, under any condition in which either the outdoor heat exchanger 6 or the indoor heat exchanger 8 attains a frosting temperature sensed by either portion 26 or 27 of the element 25, the frost control switch means 23 is designed to break contact with the compressor contact 38 and to make contact with the heater contact 39. If this occurs when the main switch is set for cooling, the compressor is de-energized until the frost control sensing element 25 again senses above-frosting temperatures in both heat exchangers. However, the heater 17 is not energized since the switch 35 is open. On the other hand, when the main switch 21 is set for operation of the unit on the heating cycle, a frosting condition of the heat exchanger 6, operating as an evaporator, not only de-energizes the compressor circuit, but also completes the heater circuit through the contact 39 so that auxiliary heat is supplied to the enclosure by the heater 17 during the period that the refrigerating system is de-energized due to the frosting condition.

From the above description, it will be seen that in accordance with the present invention only a single frost sensing means is required to de-energize the compressor when either of the two heat exchangers reaches a frosting temperature and this de-energization of the compressor takes place regardless of whether the system is operating on the heating cycle or on the cooling cycle. Since heat is not required or desired within the enclosure when the unit is operating on the cooling cycle, the auxiliary heater 17 is energized only when a frosting condition exists on the heating cycle.

While there has been shown and described what at present is considered to be a 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 departing from the invention and it is therefore intended by 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. In a self-contained air conditioning unit for heating and cooling an enclosure, an outdoor heat exchanger and indoor heat exchanger, a compressor, means for selectively connecting said compressor to said heat exchangers whereby said outdoor heat exchanger functions as an evaporator during operation of said unit on the heating cycle and said indoor heat exchanger functions as an evaporator during operation of said unit on the cooling cycle, and compressor control means comprising a thermostat including a vapor filled bellows and a capillary tube sensing element connected to said bellows, said element including a first portion in contact with said indoor heat exchanger and a second portion in contact with said outdoor heat exchanger whereby the compressor is stopped when either of said heat exchangers attains a frosting temperature.

2. In a self-contained air conditioning unit for heating and cooling an enclosure, a reversible refrigerating system including an outdoor heat exchanger and indoor heat exchanger, a compressor and refrigerant flow control means for selectively connecting said compressor to said heat exchangers whereby said outdoor heat exchanger functions as an evaporator during operation of said unit on the heating cycle and said indoor heat exchanger functions as an evaporator during operation of said unit on the cooling cycle, control means for controlling the operation of said compressor comprising a thermostat including a vapor filled bellows and a single capillary tube sensing element connected to said bellows, said thermostat being adapted to de-energize said compressor when said sensing element senses a frosting temperature, said element in-

cluding a first portion in contact with said indoor heat exchanger and a second portion in contact with said outdoor heat exchanger whereby said compressor is stopped when either of said heat exchangers attains a frosting temperature.

3. In a self-contained air conditioning unit for heating and cooling an enclosure, an outdoor heat exchanger and indoor heat exchanger, a compressor, refrigerant flow control means for selectively connecting said compressor to said exchangers whereby said outdoor heat exchanger functions as an evaporator during operation of said unit on the heating cycle and said indoor heat exchanger functions as an evaporator during operation of said unit on the cooling cycle, means for circulating outdoor air over said outdoor heat exchanger and air from the enclosure over said indoor heat exchanger, an auxiliary heater in the path of the air circulated over said indoor heat exchanger, control means for controlling the operation of said unit including a selector switch for operating said

unit on either a heating cycle or a cooling cycle and a frost control switch including a vapor filled bellows for operating said frost control switch and a capillary tube sensing element connected to said bellows, said element including a first portion in contact with said indoor heat exchanger and a second portion in contact with said outdoor heat exchanger and operable to stop said compressor on either cycle when either heat exchanger attains a frosting temperature, said frost control switch including means for energizing said auxiliary heater when said frost control switch operates to stop said compressor on a heating cycle.

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