March 21, 1961 J. A. PIETSCH 2,975,611

CONTROL SYSTEM FOR AIR CONDITIONING UNITS

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FIG. 1

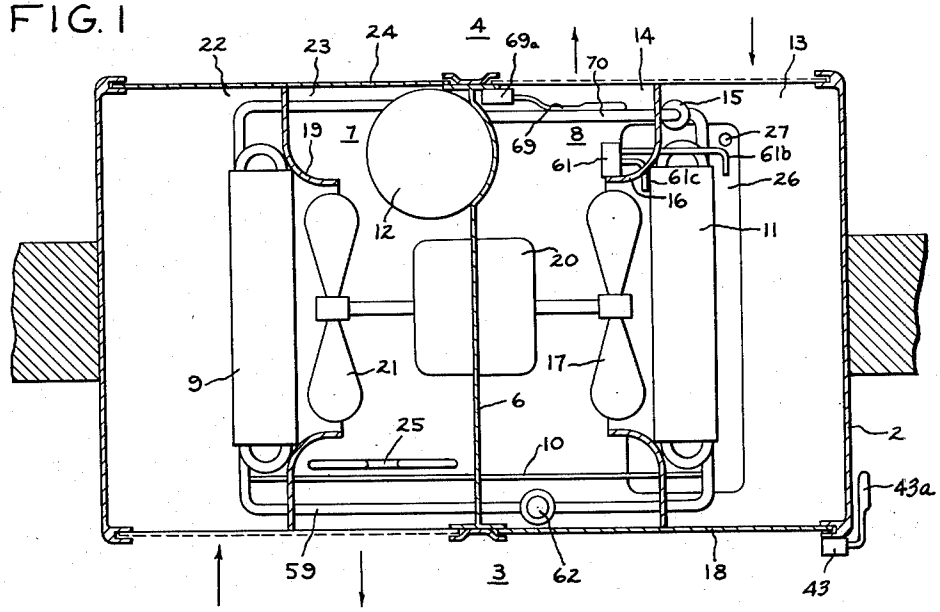
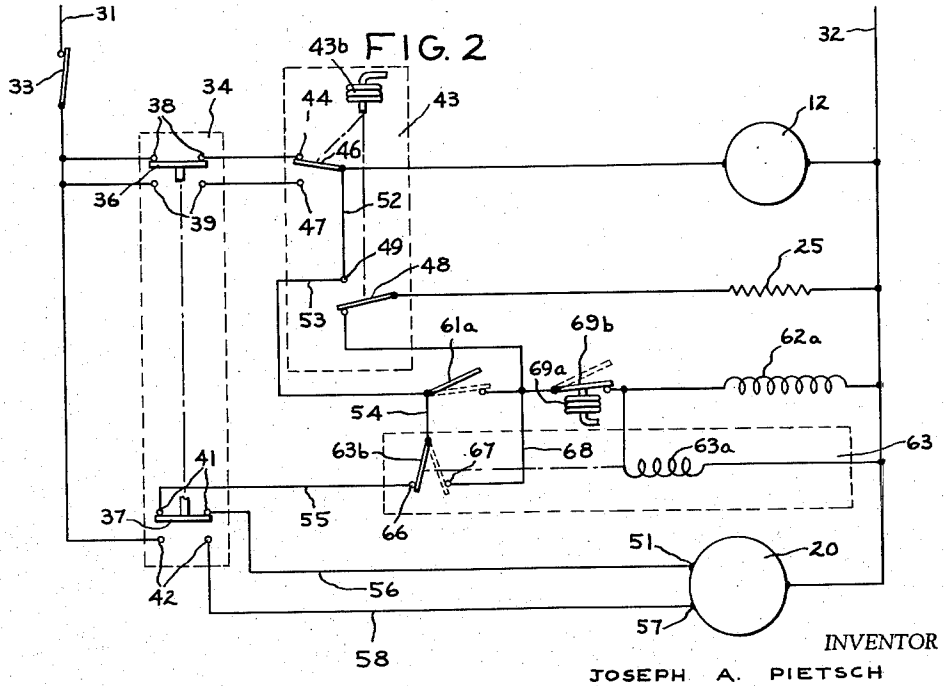



FIG. 2




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2,975,611

# CONTROL SYSTEM FOR AIR CONDITIONING UNITS

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3 Claims. (Cl. 62—151)

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 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 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 directly into the evaporator from the condenser. 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 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 increases in the enclosure air temperature above a predetermined temperature or according to decreases in the enclosure air temperature below a predetermined air temperature. The selector control also 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 2 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 3 and the other side of the casing exposed to the outdoors 4. 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-

tem including a condenser **9**, an evaporator **11** and a compressor **12** connected by suitable refrigerant conducting tubing in refrigerant flow relationship. The evaporator **11** is positioned in the evaporator compartment **8** while the condenser **9** and the compressor **12** are both mounted in the condenser compartment **7**. Suitable expansion means such as the capillary **10** or an expansion valve are provided between the condenser **9** and the evaporator **11** for producing a pressure drop in the refrigeration system between these two members. An accumulator **15** is provided in the suction conduit between the evaporator **11** and the compressor **12** for collecting liquid refrigerant which, under certain conditions of operation, overflows the evaporator. The accumulator **15** stores liquid refrigerant and prevents it from flowing directly into a compressor.

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 **7**. As may be seen in Fig. 1, the evaporator compartment is divided into air inlet and outlet sections **13** and **14** respectively by the fan 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 case 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 by the outdoor air drops from the evaporator into a suitable collection tray or sump **26** in the bottom of the evaporator 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 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 the dew point. This frost barrier acts as an insulation 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 hereinafter be 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** or 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 to operate 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 **43** 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 **43***a* connecting with the thermostat **43**. The thermal bulb **43***a* operates an expansion bellows **43***b*, or other responsive means, in the thermostat which, in turn, energizes mechanical linkage connecting 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 sensing member **43***a*, through bellows **43***b* 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 **43***a*, through bellows **43***b* of the thermostat whenever 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 across contact **49** 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 conditioner 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 correspondingly greater. 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 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 closes contacts **42** 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. In order to melt the frost on the evaporator whenever the build-up thereon creates too great a pressure drop across the evaporator, 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 but 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 **61***b* for sampling air pressure on the upstream side of the heat exchanger **11** and a second static tube **61***c* 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 is provided with means 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 **61***a* (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 **61***a* is closed to its dotted line position in Fig. 2 by the pressurestat, electrical current is supplied to the bypass valve solenoid coil **62***a* which then causes the valve **62** (of Fig. 1) to move to the open position. In this manner warm liquid refrigerant or vaporous refrigerant is passed or shunted 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 **63***a* also in series with the pressurestat switch, that is energized when the pressurestat switch **61***a* is closed. The relay coil **63***a* operates a relay switch **63***b* which interrupts the current flowing to the fan motor. More specifically, relay switch **63***b* which is normally positioned across the contact **66**, is upon energization of the relay coil **63***a*, 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 fan motor **20**. 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 **61***a*. Since the opening of the pressurestat switch would ordinarily interrupt the power supplied to both the bypass valve solenoid **62***a* and the relay coil **63***a*, 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 **63***b* to move across contact **67** (into the dotted line position shown in Fig. 2) thereby shunting current around the pressurestat switch **61***a* through the conduits **54** and **68**. Thus, even though the pressurestat switch has moved to its normally open position, the relay switch **63***b* still interrupts the current to the fan motor and completes the holding circuit to the bypass valve solenoid **62***a* as well as to the holding relay coil **63***a*. 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 **63***a*. In Fig. 1 there is shown a temperature responsive bulb **69** which actuates an expansion device **69***a* when the temperature of the refrigerant in the suction conduct **70** exceeds a predetermined value. The bulb and expansion device opens the defrost terminating switch **69***b* thereby de-energizing the holding relay coil **63***a*. The defrost terminating switch **69***b* 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 **62***a* can never be energized unless the temperature of the refrigerant leaving the evaporator is sufficiently cold to close switch **69***b*.

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 refrigerant 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-energizing 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 said 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 increases in air 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 refrigerant 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-energizing 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, a solenoid operated valve for opening said bypass conduit to bypass 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, control means for said air conditioning unit comprising a thermostat exposed to air from said enclosure, a selector control having first and second switches, said first switch adapted to condition said thermostat to operate said refrigeration system according to increases in air temperature within said enclosure or according to decreases in air temperature within said enclosure, said second switch adapted to condition said fan motor for operation on either high or low speeds, said second switch automatically connecting said fan motor to low speed operation only when said first switch conditions said thermostat to operate said refrigeration system according to decreases in air temperature within said enclosure, means for defrosting said evaporator including a pressurestat switch responsive to the air pressure drop across the evaporator due to frost accumulation thereon, said pressurestat switch being connected in series with said solenoid of said bypass valve for opening said bypass valve to pass refrigerant around said expansion means directly from said condenser into said evaporator to warm said evaporator, a holding relay also connected in series with said pressurestat switch, a fan interrupting switch energized by said holding relay for stopping said fan motor, a holding circuit completed by said fan interrupting switch for supplying power to said holding relay and said solenoid of said bypass valve for operating said bypass valve when said pressurestat becomes inoperative as a result of the discontinued air flow through said evaporator, and a defrost terminating thermostat responsive to temperature or refrigerant leaving said evaporator, said defrost terminating thermostat including switching means in said holding circuit for de-energizing 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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