Feb. 7, 1961 W. J. McCARTY 2,970,816

DEFROST ARRANGEMENT FOR AIR CONDITIONING APPARATUS

Filed Aug. 31, 1959

FIG. 1

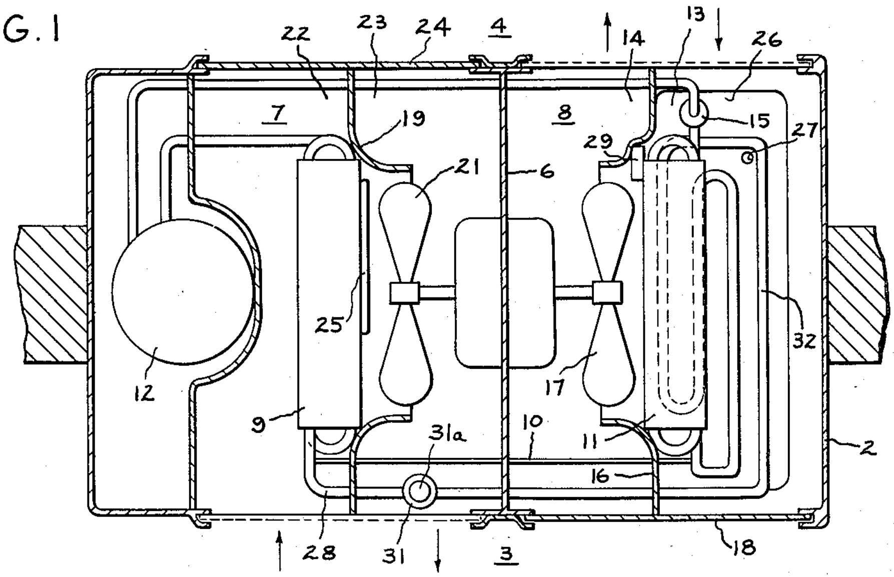
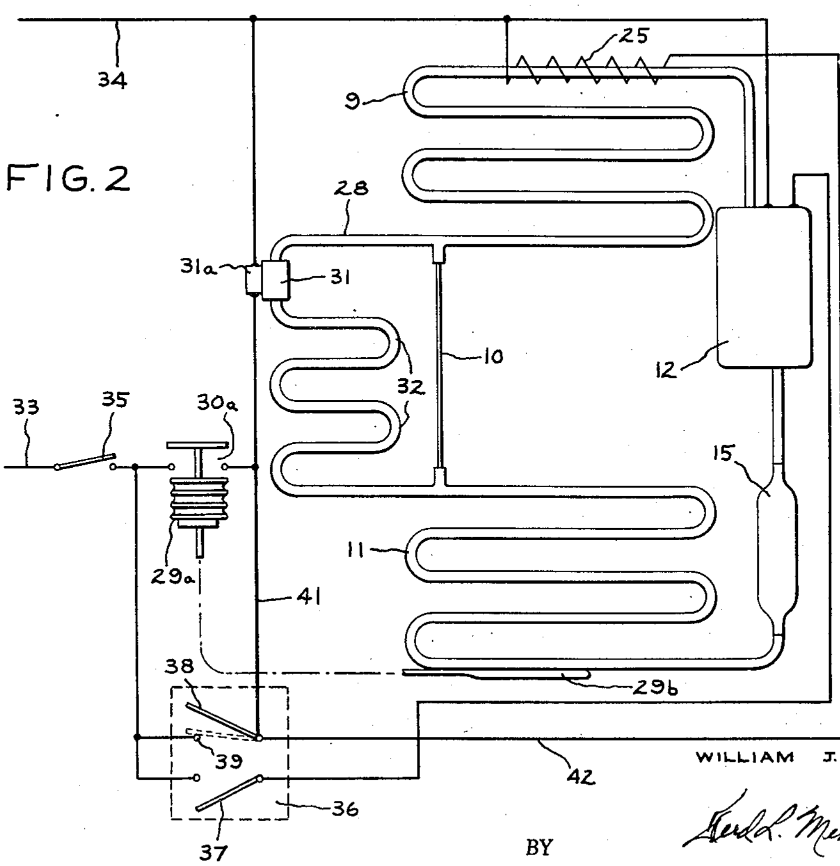


FIG. 2



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HIS ATTORNEY

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1

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DEFROST ARRANGEMENT FOR AIR CONDITIONING APPARATUS

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3 Claims. (Cl. 257—278)

The present invention relates to air conditioning apparatus of the type used during cold weather to supply heat to an enclosure and more particularly to an arrangement for quickly defrosting the evaporator of such apparatus.

In air conditioning units of the type which are used for supplying heat to an enclosure during the winter months, the evaporator of the unit is exposed to the outdoor air and, if the outdoor temperature becomes too cold, the evaporator rapidly accumulates a coating or layer of frost. The frost layer operates 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 markedly reduced. The frost layer on the evaporator usually builds up at an accelerated rate as the outdoor temperature becomes lower and lower. This has the effect of reducing the heat output of the unit when it is most needed.

Most units now on the market provide supplementary heating in the form of resistance heaters to augment the output of the air conditioning unit during these low outdoor temperatures. In addition, some units provide defrosting means for melting the layer of frost on the evaporator whenever it begins to affect the efficiency of the unit so that heat can be supplied by the refrigeration system even during the lower outdoor temperatures. Defrosting has been carried out in the past by use of resistance heaters disposed adjacent the evaporator or by passing hot gas from the refrigeration system directly through the evaporator for melting the frost layer. The latter type of arrangement is normally considered to be the most desirable since it does not require the additional resistance heating means or the additional electrical wiring and connections in the wet atmosphere of the evaporator. However, hot gas defrost arrangements are usually slower in operation and, in those systems which reverse the refrigerant flow therethrough for purposes of defrost, there is the added disadvantage that the heat exchanger being used to supply heat to the enclosure becomes cold and reduces the heat supply to the enclosure. The present invention is an improvement over both of the above-mentioned types of defrost arrangements and eliminates the disadvantages of these arrangements.

It is an object of the present invention to provide, in an air conditioner of the type adapted to heat an enclosure, an improved defrost arrangement which uses hot gas to melt the frost on the evaporator and which is so arranged as to take advantage of the resistance heat already provided in the air conditioner to enhance the defrosting operation.

It is another object of the present invention to provide an improved defrost arrangement which utilizes heat as well as hot gas to melt the frost while requiring no electrical connections in the moist atmosphere of the evaporator compartment.

A more specific object of the present invention is to provide an improved defrost arrangement utilizing the flow of warm refrigerant through the evaporator coils to

2

melt the frost and to provide the arrangement with additional heat input from the auxiliary heater to assure an adequate supply of vaporous refrigerant flow through the sytsem during the defrost period.

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 particularly 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 with a refrigerant expansion means between the evaporator and the condenser for producing a pressure drop in the system between these two members. 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. The unit is also provided with a resistance heater for supplying additional heat to the enclosure whenever the refrigeration system is unable to supply sufficient heat to maintain the enclosure at the desired temperature. To quickly defrost the evaporator of the unit during the heating season after an excessive build-up of frost thereon, there is provided a refrigerant bypass passage which is opened by a frost sensing means to shunt the refrigerant from the condenser around the expansion means directly into the evaporator. In order to maintain a sufficietly high suction pressure during the defrost operation so that an adequate supply of vaporous refrigerant is pumped through the system and to add heat to the vaporous gas to enhance the defrosting operation, the above-mentioned supplementary heater is positioned so that it heats the condenser and, thereby, also heats the refrigerant flowing through the condenser. The frost sensing means for initiating the defrosting operation also energizes the supplmenetary heater to supply heat to the condenser even though the temperature conditions of the enclosure may be such as not to require the additional resistance heat.

For a better understanding of the invention references may be had to the accompanying drawings in which:

Fig. 1 is a plan view of an air conditioner unit incorporating the present invention; and

Fig. 2 is a line diagram illustrating the components of the air conditioner with an arrangement for initiating the defrost operation and for simultaneously energizing the supplementary heater.

Referring now to the drawing, in 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 **6** into two separate compartments hereinafter designated the condenser compartment **7** and the evaporator compartment **8**. Within the casing is a refrigeration system including a condenser **9**, an evaporator **11**, and a compressor **12** connected 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 the required pressure drop in the refrigerant system between these two members. An accumulator **15** is provided in the system between the evaporator **11** and the compressor **12** for collecting liquid refrigerant which, under certain conditions of operation, overflows from the evaporator. The accumulator **15** stores liquid refrigerant and prevents it from flowing directly into the compressor. During operation of the illustrated air conditioner, 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.

The evaporator compartment is divided into air inlet and outlet sections 13 and 14 respectively by a fan shroud 16 and a fan 17 which also circulates air through the evaporator compartment. A closure panel 18, which may be moved 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 to be cooled by the evaporator. Similarly, the condenser compartment is divided by the shroud 19 and a fan 21 into condenser compartment inlet and outlet sections 22 and 23. A closure panel 24, similar to panel 18 in the evaporator compartment, is arranged to direct air into the inlet section 22 either from the outdoors or from the enclosure merely by moving the panel from one side of the condenser compartment to the other.

With the 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 into the evaporator compartment inlet section 13 where it encounters the evaporator 11 and gives up heat to the evaporator and is then discharged to the outdoors again through the outlet section 14. The refrigerant flowing through the system delivers to the condenser 9 the heat removed from the outdoor air by the evaporator 11. 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. Normally, the operation of the heater 25 is made automatic according to the temperature of air within the enclosure. The heater 25 is usually energized by a thermostat (seen only in Fig. 2) whenever the room temperature drops a certain number of degrees below that set by the occupant. That is, if the thermostat was 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 add additional heat.

The outdoor air in passing over the evaporator 11 is cooled and 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 or lower portions 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. However, whenever the outdoor temperature drops too low, such as below the temperature of 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. 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 now be explained, the present invention deals with an arrangement for defrosting the evaporator whenever the frost build up thereon reaches a predetermined amount. Referring to Fig. 1, there is shown a refrigerant bypass passage 28 which is connected between the condenser 9 and the evaporator 11 which is designed to shunt refrigerant from the condenser around the capillary 10 directly to the evaporator. During normal operation of the system the bypass passage 10 is closed, but means are provided in the form of a defrost control 29 and a valve 31 for opening the passage whenever the frost build up on the evaporator becomes too great. In the air conditioner of Fig. 1, the defrost control 29 is meant to schematically illustrate a pressure actuated switch which is energized 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. The control 29 initiates the defrost cycle whenever the pressure drop across the evaporator is such as to indicate an undesirable amount of frost build up on the evaporator.

It will be understood that the defrost sensing control device 29 is not limited, merely, to a pressure drop sensing device or switch and may comprise any of the well known frost sensing devices readily available on the market, such as the temperature sensing bulb 29*b* and bellows actuator 29*a* shown in Fig. 2. These are well known in the art and a detailed explanation of the various types available or the operation thereof is not believed necessary except to say that the device must be capable of sensing conditions resulting from a predetermined frost build up on the evaporator and must be capable of actuating a valve either directly or indirectly, such as shown in Figs. 1 and 2, through the energization of an electrical switch which, in turn, initiates movement of a valve.

In Fig. 1, whenever there is a predetermined pressure drop across the evaporator, resulting from the restriction caused by the frost build-up on the evaporator, the defrost control 29 energizes the solenoid 31*a* of the valve 31 which then moves to the open position. In this manner warm liquid refrigerant or vaporous refrigerant is passed or shunted directly into the evaporator for heating and, thereby, defrosting the evaporator. In the process of warming the evaporator, much of the refrigerant in the evaporator is condensed and collects in the accumulator 15 which is made large enough to store all of the liquid refrigerant in the system to prevent "slugging" of the compressor with liquid during the defrost period. Because the compressor is no longer working against a head pressure, except for the small pressure drop present in the tubing of the system, the vaporous refrigerant is no longer compressed to any great extent as it passes through the compressor and its temperature is greatly reduced. In fact, if the outdoor temperature is very low most of the refrigerant within the system condenses out and collects in the accumulator 15 thereby reducing the pressure of the system. This leaves very little gaseous refrigerant to be pumped by the compressor as well as greatly reducing the temperature of vaporous refrigerant that is pumped. This condition, which will hereinafter be referred to as "running out of gas," greatly increases the length of time required to defrost the evaporator.

In order to prevent the system from "running out of gas" during the defrost cycle and to provide additional heat for quickly defrosting the evaporator, the auxiliary or supplementary heater 25 is so positioned within the condenser compartment 7 that it also supplies heat to the condenser 9. Thus, as may be seen in Fig. 1, the heater 25 is disposed closely adjacent the condenser and during defrosting of the evaporator, the supplementary heater **25** is energized to heat the refrigerant flowing through the condenser **9**. During the defrost cycle, operation of the fans **17** and **21** is normally discontinued so that a great amount of the heat from the heater **25** is carried by radiation through all portions of the condenser. This, of course, raises the temperature of the vaporous refrigerant immediately supplied to the evaporator and, of course, hastens the melting of the frost layer. The addition of heat at the condenser **9** also warms the gas flowing through the system and maintains a sufficient quantity of refrigerant at a high enough temperature to prevent it from condensing out and causing the system to "run out of gas." Thus, an adequate quantity of vaporous refrigerant is continuously pumped through the system for carrying the heat added at the compressor to the evaporator.

The use of a means, such as described above, for quickly defrosting the evaporator **11** makes it possible to operate the refrigeration system of the air conditioner to supply heat to the enclosure at times when the outdoor temperature is well below 32° F., or below the freezing point of water. This means that the condensate sump **26** in the evaporator compartment **8** will be exposed to temperatures cold enough to freeze water. In order to prevent the drain **27** of the sump **26** from becoming frozen shut and to assure drainage of water from the sump during defrosting of the evaporator, the bypass conduit **28** is provided with a plurality of turns **32** which circulate in contact with the sump **26** and which heat the sump during the defrosting operation. The turns **32** utilize the heat added by the auxiliary heater **25** to raise the temperature of the sump **26** and drain **27** above the freezing point of water making it possible to drain the water melting from the evaporator.

During operation of the unit on the heat cycle, there are times when the evaporator requires defrosting under operating circumstances when the supplementary heater is not normally energized because the temperature within the enclosure is being adequately maintained by the refrigeration system. That is, at times, the refrigeration system is capable of supplying all of the heat necessary to maintain comfort conditions within the room so that there is no need for additional resistance heat, but the frost build-up on the evaporator is such as to necessitate defrosting thereof in order to permit a continued efficient operation of the system and a continuous supply of heat. When this occurs, it is desirable to energize the auxiliary heater just for the purpose of obtaining quick defrost. An arrangement for accomplishing this purpose is shown in Fig. 2 which illustrates the components of the air conditioner in schematic form. Power is connected to the unit through the power lines **33** and **34** and the main switch **35**. A thermostat **36**, of any well known type now on the market, is provided for controlling the operation of the compressor or the refrigeration system through the switch **37**. The thermostat also controls the energization of the resistance heater **25** through the switch **37** according to the needs of the enclosure. The heater **25** is shown wrapped around a portion of the condenser **9** to indicate that it is positioned closely adjacent the condenser for supplying heat thereto during the defrost operation. As was previously pointed out, frost conditions on the evaporator **11** are sensed by a control device which, in the modification illustrated in Fig. 2, is shown as a temperature sensing bulb **29*b*** and expansion bellows **29*a***.

The temperature sensing bulb of the control device is shown schematically in position adjacent the last portion of the evaporator connected to the accumulator **15**. It is this portion of the evaporator which normally operates at the coldest temperature and, it is here where the frost build up is generally the greatest. The bulb **29*b*** is so positioned with respect to the evaporator coils as to sense lower and lower temperatures as the frost build up on the evaporator increases.

Thermostat **36** energizes the heater whenever switch **38** is moved to engage contact **39**. This is normally accomplished by making the switch **38** movable to the dotted line position whenever the thermostat senses a temperature within the enclosure that is a predetermined number of degrees, such as 4°, below the temperature set for the enclosure. For example, if the occupants of the enclosure desire a temperature of 72° F. in the enclosure and set the thermostat to maintain this temperature, the switch **38** will move to its dotted line position across the contact **39** whenever the thermostat senses a temperature of 4° below 72° F., or 68° F. At all other times the switch **38** opens or breaks the circuit through contact **39**.

When frost conditions occur, the bulb **29*b*** and bellows **29*a*** operate switch **30*a*** to connect the electrical current to the solenoid **31*a*** which in turn moves the valve **31** into the open position. Closing of the switch **31*a*** also places the heater **25** into the circuit by energizing the heater circuit **42** through the line **41**. In this way the heater is always energized during the defrost cycle even though the thermostat **36** may not actually be conditioned to energize the heater **25** through the contact **39**. As may be seen in Fig. 2, the solenoid and heater circuit energized by the switch **30*a*** are connected in parallel. Furthermore, the energization of the heater **25**, during frost conditions when switch **30*a*** is actuated to supply power to the solenoid **31*a***, does not depend upon the temperature conditions sensed by the thermostat **36**. Thus, the energization of the heater **25** is controlled by either the thermostat **36** or by the frost sensing control device so that the heater always supplies heat to the condenser during defrost operation regardless of the temperature of the air within the enclosure.

By the present invention there is provided, for an air conditioner adapted to heat an enclosure, a defrost arrangement for the refrigeration system thereof which utilizes resistance heat for melting the frost on the evaporator but which does not require that the heater be positioned closely adjacent the evaporator or within the moist atmosphere of the evaporator compartment. Furthermore, the air conditioner of the present invention utilizes a single resistance heater not only for supplying heat to the enclosure but also for the additional purposes of defrosting the evaporator and for melting ice within the condensate sump.

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 departing 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. In an air conditioning unit of the type adapted for heating air from an enclosure comprising a refrigeration system including a compressor, a condenser and an evaporator connected in refrigerant flow relationship, an accumulator connected in said refrigeration system between said compressor and said evaporator for temporarily storing liquid refrigerant overflowing from said evaporator, a supplementary heater arranged in close proximity to said condenser for supplying additional heat to said enclosure under certain ambient conditions and for heating said condenser, refrigerant expansion means connected in said system between said evaporator and said condenser, a normally closed refrigerant bypass conduit connected between said evaporator and said condenser for bypassing refrigerant pumped by said compressor through said condenser around said expansion means to said evaporator, means responsive to frost conditions

on said evaporator for opening said bypass to permit flow of unexpanded refrigerant liquid or hot gas from said condenser for defrosting said evaporator, said means also energizing said supplementary heater to heat said condenser during defrost periods so that refrigerant gas flowing through said condenser is heated and an adequate quantity of vaporous refrigerant is pumped by said compressor through said system at a sufficiently high temperature to assure quick defrost of said evaporator.

2. In an air conditioning unit of the type adapted for heating air from an enclosure comprising a refrigeration system including a compressor, a condenser and an evaporator connected in refrigerant flow relationship, refrigerant expansion means connected in said system between said evaporator and said condenser, a condensate sump for collecting condensate water from said evaporator, means for directing separate streams of air from inside and outside said enclosure over said condenser and said evaporator respectively, a supplementary heating means arranged in close proximity to said condenser for supplying additional heat to said air flowing over said condenser and for supplying heat to said condenser, a condensate sump for collecting condensate water from said evaporator, a normally closed refrigerant bypass conduit connected between said evaporator and said condenser for bypassing refrigerant pumped by said compressor through said condenser around said expansion means to said evaporator, said by pass conduit including several turns thereof positioned in close proximity to said condensate sump for heating said condensate sump during the flow of refrigerant through said bypass conduit, and means responsive to the frost condition on said evaporator for opening said bypass conduit to permit flow of unexpanded refrigerant liquid or hot gas from said condenser for defrosting said evaporator and said condensate sump, said means also energizing said supplementary heater to supply heat to said condenser during defrost periods so that refrigerant gas flowing through said condenser is heated and an adequate quantity of vaporous refrigerant is pumped by said compressor through said system at a sufficiently high temperature to assure quick defrost of said evaporator and said condensate sump.

3. In an air conditioning unit of the type adapted for heating air from an enclosure comprising a refrigeration system including a compressor, a condenser and an evaporator connected in refrigerant flow relationship, an accumulator connected in said refrigeration system between said compressor and said evaporator for temporarily storing liquid refrigerant overflowing from said evaporator, a supplementary heater for supplying additional heat to said enclosure under certain ambient conditions, said supplementary heater being arranged in close proximity to said condenser for heating said condenser, refrigerant expansion means connected in said system between said evaporator and said condenser, a condensate sump for collecting condensate water from said evaporator, a normally closed refrigerant bypass conduit connected between said evaporator and said condenser for bypassing refrigerant pumped by said compressor through said condenser around said expansion means to said evaporator, said bypass conduit including several turns thereof positioned in close proximity to said condensate sump for heating said condensate sump during the flow of refrigerant through said bypass conduit, means responsive to frost conditions on said evaporator for opening said bypass conduit to permit flow of unexpanded refrigerant liquid or hot gas from said condenser for defrosting said evaporator and said condensate sump, said means also energizing said supplementary heater to heat said condenser during defrost periods so that refrigerant gas flowing through said condenser is heated and an adequate quantity of vaporous refrigerant is pumped by said compressor through said system at a sufficiently high temperature to assure quick defrost of said evaporator and said condensate sump.

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