Sept. 22, 1970 A. TRASK 3,529,659

DEFROSTING SYSTEM FOR HEAT PUMPS

Filed April 17, 1968 2 Sheets-Sheet 1

FIG. 1

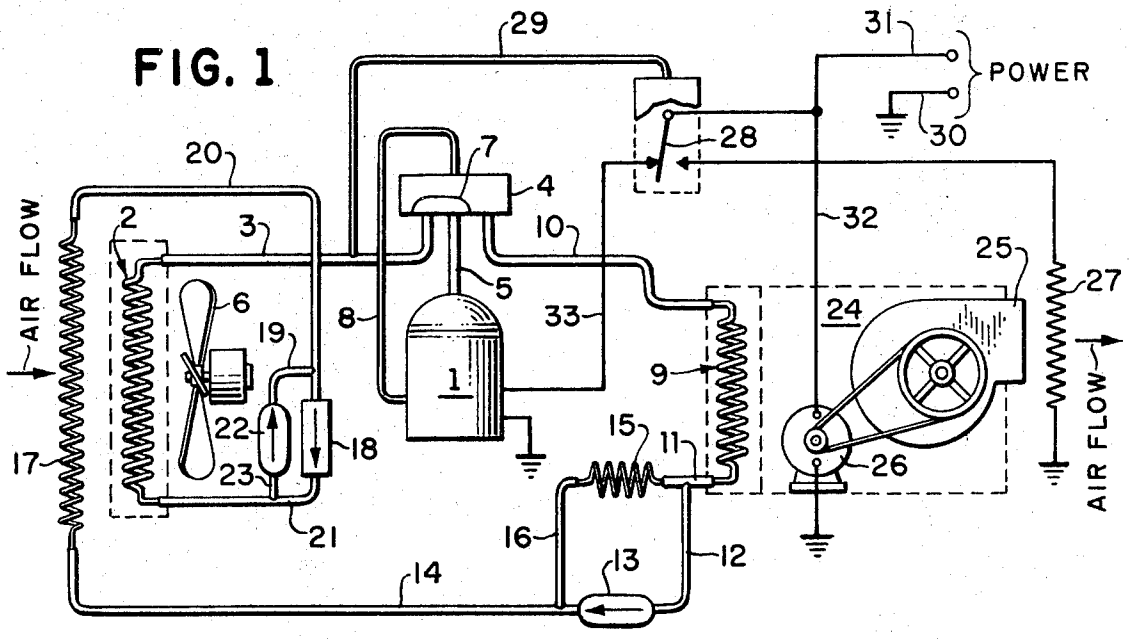
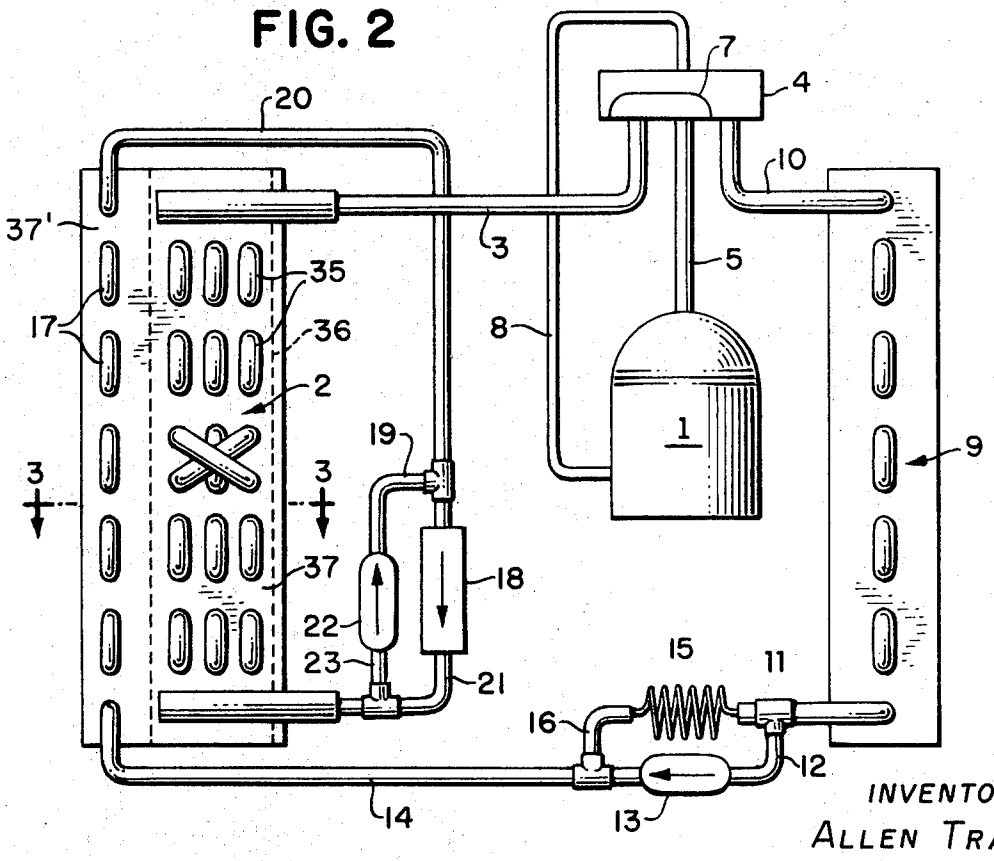


FIG. 2



INVENTOR:
ALLEN TRASK
BY M.R. Marsh
ATTORNEY.

Sept. 22, 1970 A. TRASK 3,529,659

DEFROSTING SYSTEM FOR HEAT PUMPS

Filed April 17, 1968 2 Sheets-Sheet 2

FIG. 3

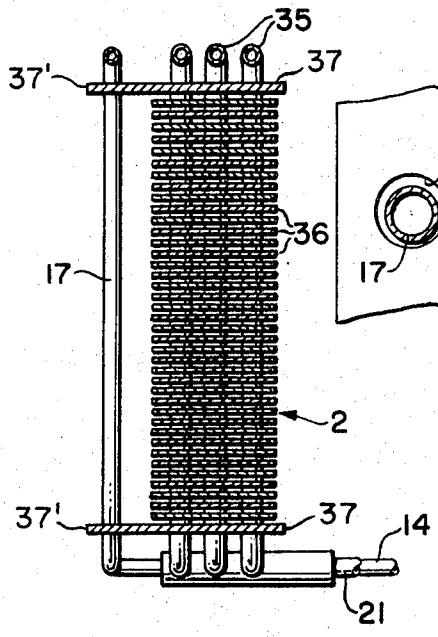


FIG. 4

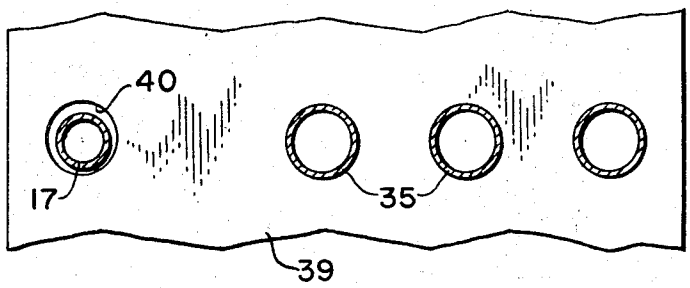
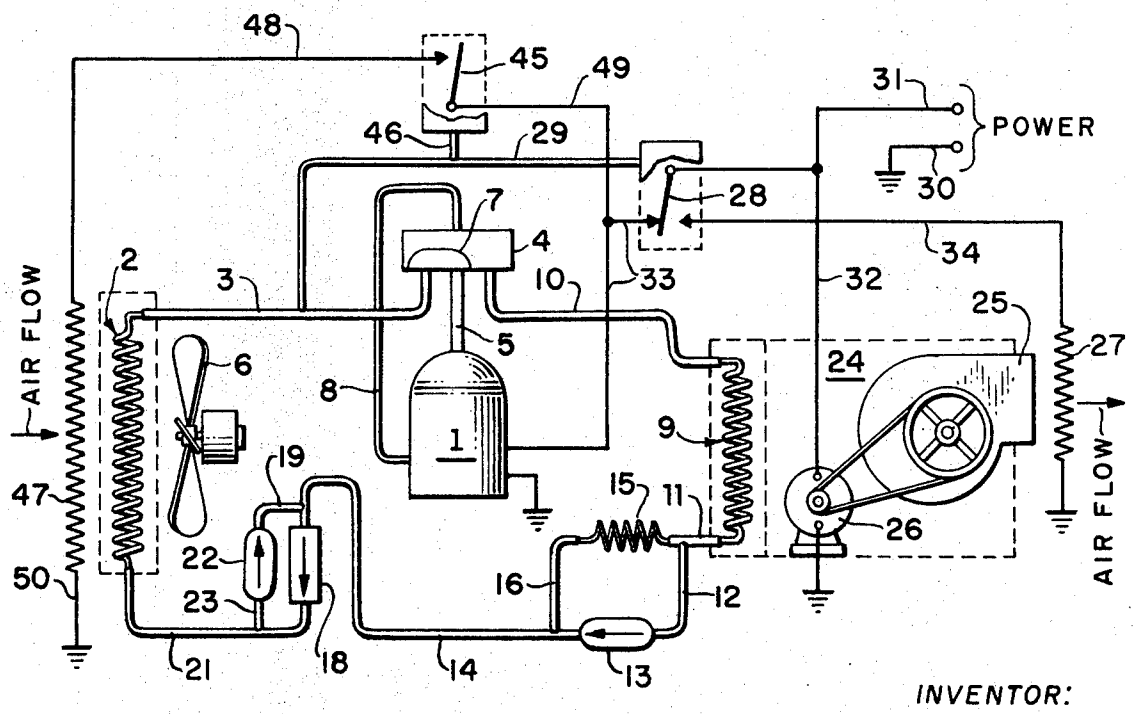


FIG. 5



INVENTOR:
ALLEN TRASK
BY M.R. Marsh
ATTORNEY.

United States Patent Office 3,529,659 Patented Sept. 22, 1970

3,529,659

DEFROSTING SYSTEM FOR HEAT PUMPS

Allen Trask, 288 Genesee St., Utica, N.Y. 13502

Filed Apr. 17, 1968, Ser. No. 722,093
Int. Cl. F25b 29/00
U.S. Cl. 165—29 5 Claims

ABSTRACT OF THE DISCLOSURE

An air-to-air heat pump having air moving means downstream of its outdoor heat exchanger coil, and radiant heating means upstream of the outdoor coil to inhibit the accumulation of frost thereon by maintaining water vapor in the outdoor air as a supercooled vapor as it passes through the outdoor coil at temperatures below 32 degrees, during heating cycles.

The invention relates to defrosting systems for heat pumps and particularly to a defrosting system wherein radiant heat is used to inhibit the accumulation of frost on the outdoor heat exchanger coil of an air-to-air heat pump.

In general this invention inhibits frost accumulation by the use of radiant heat from hot liquid refrigerant returning from the indoor heat exchanger coil to the outdoor coil while it is functioning as an evaporator coil during heating cycles. The radiant heat is introduced into the upstream air flow at the air intake of the outdoor heat exchanger coil to cause water vapor in the air passing therethrough to remain in a supercooled vapor state during heating cycles down to low outdoor temperatures.

The outdoor heat exchanger coil of this invention includes novel construction wherein the hot liquid refrigerant from the indoor coil flows through a row of radiant heat coil tubes at the front or the upstream side of, and spaced from the outdoor coil finned tubes. The radiant heat coil is held in position by extensions of the fin tube end plates, and its outlet is connected to the refrigerant expansion device for the outdoor coil.

In a modification of the invention, the radiant heat tubes pass through holes in the fins of the outdoor coil and are positioned on the upstream side of the outdoor coil. The tubes are loose in the fin holes with a minimum of contact therewith to reduce to a minimum heat transfer from the hot tubes to the fins by conduction. By this construction a maximum amount of heat from the hot tubes radiates therefrom into the air approaching the coil and into the air flowing through the coil, although some of the heat is unavoidably transferred to the passing air by convection.

Nature often demonstrates the miracle of supercooled water vapor in winter night air as cold as 10 to 15 degrees above zero when hoar frost is collected on the twigs and small branches of trees and bushes, and on the telephone and power wires. When this occurs at night we look upon outdoor decoration in the morning that appears to be designed for a northern Christmas.

In winter moisture is often held in the outdoor air as a vapor twenty or more degrees below the freezing point of water, until it encounters a small diameter object at night, in the absence of the sun's radiant heat, which will then trigger the moisture into freezing into crystals accumulating in surprisingly long strings, or hairs, that inspired the name "hoar frost." This phenomenon never occurs during the daytime on cloudy or on sunny days when radiant heat from the sun maintains the water vapor in a supercooled state. The radiation power of the sun on cloudy days to effect sun burned skin on sunbathers is well known, but its power to maintain water vapor in the outdoor air in a supercooled state is not so well known.

Another surprising phenomenon demonstrating the ability of radiant heat in preventing the accumulation of frost at low temperatures is the open-top frozen food chests, or cases, in supermarkets kept at temperatures of zero or colder. The laws of physics taught in schools indicate that we should expect water vapor in the ambient air to migrate rapidly into the low dewpoint air of the zero temperatures inside the cases to quickly freeze into frost and ice after first condensing into snow or water. But this does not happen. These frozen food cases commonly go for several weeks at a time without defrosting attention. Then after several weeks the frost accumulation is found to be limited to the inside top rim of the cases. It appears that radiant heat from the stores is adequate to retard, almost to prevention, the accumulation of ice and frost within the open-top frozen food cases.

The radiant heat defrosting system of this invention includes means for stopping compressor operation in cold weather, and substituting electric resistance heat therefor, when there is insufficient heat radiation from the radiant heat tubes to prevent the accumulation of frost on and within the outdoor coil. This may be done by sensing means to sense the refrigerant evaporating pressure or temperature within the outdoor coil during heating cycles. At a predetermined coil temperature, or pressure the sensing means is adapted to stop the compressor and activate the electric resistance heating means to add additional heat to the indoor air circulation of the heat pump system.

A temperature sensing means in the radiant heat coil can also be employed for stopping the compressor operation and substituting electric heat therefor, when there is insufficient heat radiation from the radiant heat coil to prevent the accumulation of frost on, and within the outdoor coil. This method would normally require auxiliary controls to permit starting of the compressor in heating cycles when the radiant heat coil has been cooled off during an off cycle period of the heat pump.

An air-to-air heat pump embodying this invention will inhibit accumulation of frost and/or ice on the outdoor coil to permit continuous operation in heating cycles, without the need for conventional defrosting cycles, to low winter temperatures above which the heat pump will be operative for heating during a very high percentage of the heating season in 87% of the area of the United States wherein the average winter temperatures are above 35 degrees. Conventional heat pumps have their seasonal coefficient of performance substantially reduced by their total time in defrosting cycles. The defrosting system of this invention does not have this handicap, and therefore can be constructed to surpass the coefficient of performance of conventional heat pumps. The elimination of automatic defrosting controls by the use of radiant heat also makes a significant reduction in the cost of manufacturing air-to-air heat pumps.

In view of the foregoing, a principal object of this invention is to eliminate the need for automatic defrosting controls in air-to-air heat pumps.

A further object of the present invention is to enable an air-to-air heat pump to operate with a higher coefficient of performance by eliminating heating time losses as are required by conventional heat pumps in defrosting cycles.

Another object of the invention is to provide an air-to-air heat pump of improved reliability of operation and a reduced requirement for service calls by the elimination of automatic defrosting controls.

Still another object of the invention is to provide an air-to-air heat pump of increased efficiency and of lower cost to manufacture.

The above and further objects of the present invention will be more apparent from the following detailed description of a preferred and modified embodiment thereof

wherein reference is made to the accompanying drawings in the latter of which:

FIG. 1 is an operational diagram of an air-to-air heat pump disclosing the preferred embodiment of the present invention;

FIG. 2 is an operational diagram of the refrigerant circuit and certain structural details of the outdoor heat exchanger coil and radiant heat coil;

FIG. 3 is a detailed cross section view taken on line 3—3 of FIG. 2;

FIG. 4 is a view showing a modified fin-tube construction for the outdoor coil and radiant heat coil of FIGS. 2 and 3.

FIG. 5 is an operational diagram showing a modification of the present invention wherein the radiant heat coil is electrically heated and controlled by a pressure switch.

Referring now to FIG. 1, compressor 1 is drawing refrigerant vapor from outdoor fin-tube heat exchanger coil 2, through conduit 3, reversing valve 4, and conduit 5. The D slide 7 in reversing valve 4 is shown in its position for heating cycles and with the D slide in this position the compressed refrigerant vapor is discharged from compressor 1, through conduit 8 to reversing valve 4, through which it flows to the indoor heat exchanger coil 9 via conduit 10. A fan-motor assembly 6 at the downstream side of outdoor coil 2 is arranged to draw outdoor air through the coil.

In a heating cycle the indoor coil 9 functions as a condenser coil. At such times the refrigerant vapor compressed into the indoor coil 9 gives up its heat to the indoor air and converts to a liquid which leaves indoor coil 9 under the refrigerant condensing pressure to flow through conduit 11, conduit 12, and check valve 13 into conduit 14. A small amount of liquid refrigerant flows from conduit 11, through capillary tube 15, and conduit 16 to join the refrigerant flow in conduit 14.

During cooling cycles the refrigerant flow is in the opposite direction through conduit 14 into conduit 16 and capillary tube 15 which reduces the refrigerant pressure and discharges the refrigerant into indoor coil 9 through conduit 11. In cooling cycles check valve 13 is closed to require the full refrigerant flow to pass through capillary tube 15 and thence into coil 9.

Returning to the heating cycle mode of operation, the liquid refrigerant in conduit 14, heated by compression into coil 9 to the temperature corresponding to its pressure, flows into radiant heat coil 17 located close to, but spaced from, the upstream side of outdoor coil 2. Water vapor in the outdoor air at temperatures below 32 degrees, when the fins and tubes of outdoor coil 2 are also at temperatures below 32 degrees, is maintained as a vapor in a supercooled state by the influence of radiant heat from the radiant heat coil 17 while the outdoor air and water vapor are drawn through coil 2 by fan-motor assembly 6. Thus outdoor coil 2 does not collect frost at sub-freezing temperatures.

Liquid refrigerant from radiant heat coil 17 flows through conduit 20 to expansion valve 18 and branching conduit 19. Expansion valve 18 releases refrigerant at a reduced pressure into outdoor coil 2 through conduit 21. Conduit 19 is connected to check valve 22 which remains closed in heating cycles. In cooling cycles the refrigerant flows in the opposite direction out of coil 2 into conduit 21, and through branch conduit 23 into and through check valve 22, conduits 19 and 20, and radiant heat coil 17 to conduit 14.

An air handling unit 24 which includes a blower 25, is associated with the indoor heat exchanger coil 9. The blower 25 is operated by blower motor 26, and an electric resistance heater element 27 is located downstream of coil 9 and blower 25. A pressure operated switch 28 is connected to sense the pressure in outdoor coil 2 through conduits 3 and 29, and is adapted to control the electrical circuit to compressor 1.

Electrical potential having grounded conductor 30 is supplied over conductor 31 to pressure switch 28, and over conductor 32 to blower motor 26 for maintaining constant operation of blower 25. During heating cycles the movable element of pressure switch 28 normally makes with its left hand contact to complete the circuit to compressor 1. This contact is maintained in heating cycles during the time radiant heat coil 17 is preventing the accumulation of frost or ice on the surfaces of outdoor coil 2. At an outdoor temperature below which the radiant heat coil 17 cannot prevent the accumulation of frost or ice on coil 2, as determined by the testing of specific heat pumps, the corresponding reduced pressure within coil 2, transferred to pressure switch 28 through conduits 3 and 29, causes the movable element of the switch to make with its right hand contact. Thus switch 28 interrupts the circuit to compressor 1 whereupon it creases operation and heating element 27 is energized through conductor 34 to introduce heat into the recirculated indoor air leaving blower 25.

In FIGS. 2 and 3 outdoor coil 2 is shown in the form of conventional construction wherein coil tubes 35 are arranged in three parallel rows with a number of fins 36 attached thereto. In residential heat pumps it is usual to have the fins spaced 10 or 12 to the inch. End plates 37 hold the assembly of tubes 35 and fins 36 in a unitary structure described as outdoor heat exchanger coil 2, and provide the structural means for mounting coil 2 in a heat pump system. Extension 37′ of coil end plates 37, extend toward the upstream side of coil 2, and support the tubes of radiant heat coil 17 in spaced relation to the fins 36 of coil 2 on their upstream side.

FIG. 4 shows an alternate construction for fin-tube coil 2 wherein fins 39 extend from the upstream side of the coil to encompass the tubes of radiant heat coil 17 with a minimum of contact. The tubes of coil 17 are held in parallel spaced relation by end plate extensions 37′ as in FIG. 3, and holes 40, in the extended fins 39 are of larger diameter than the outside diameter of the tubes in the radiant heat coil 17 so that contact between the fins and tubes is at an incidental minimum and insignificant for heat transfer from the tubes to the fins by conduction. It is desirable to have a maximum amount of heat available from the refrigerant within coil 17 released therefrom in the form of radiant heat radiating from the outside surfaces of coil 17.

In operation during a heating cycle the heated refrigerant liquid condensed within the indoor coil 9 flows through the tubes of radiant heat coil 17. Heat from the refrigerant passes through the tube walls by conduction and leaves the tubes by radiation into the air upstream of the coil 17 and into air passing through the coil 2. The effect of this radiation heat on the water vapor within the scope of the radiation is to cause the water vapor to remain in the vapor state at temperatures below 32 degrees so that it will pass through the coil 2 without being converted to ice or frost.

In the modification of the invention shown in FIG. 5 a pressure operated switch 45 is connected to conduit 29 through conduit 46 to sense the pressure within outdoor coil 2, and its movable element is arranged to make with its contact on pressure drop when the temperature of coil 2 is slightly above 32 degrees. An electric radiant heat coil 47 within a suitable tubular sheath is spaced upstream of, and parallel to, outdoor coil 2. Coil 47 is connected via conductor 48 to switch 45 which when closed continues the circuit via conductor 49, and a section of conductor 33 to the left hand contact of switch 28. With the movable element of switch 28 to the left the above circuit is continued to electrical potential via conductor 31. Conductor 50 connects electric heat coil 47 to ground. The electric radiant heat coil 47 in this modification may be constructed in a tubular metal sheath of the same outside diameter as radiant heat coil 17 hereinbefore described so that it will be similar to coil 17 in mechanical construction and assembly as well as

in its radiant heating function for the delay of frost accumulation on coil **2**.

In this modification of the invention conduit **14** delivers condensed liquid refrigerant directly to expansion device **18**, instead of first through radiant heat coil **17** and conduit **20** as shown in FIG. 1.

During operation in heat pump cycles wherein compressor **1** is energized through the left hand contact of pressure switch **28**, the electric radiant heat coil **47** is also energized by pressure switch **45** when the pressure within coil **2** drops to a pressure indicating a temperature of coil **2** to be approaching 32 degrees. The effect of the electric radiant heat on the water vapor within the scope of its radiation is to cause the water vapor to remain in the vapor state at temperature below 32 degrees so that it will pass through coil **2** without being converted into ice or frost. When the temperature of coil **2** falls to a temperature at which the radiant heat from coil **47** is inadequate to prevent frost accumulation on coil **2**, the movable element of pressure switch **28** moves from left to right to interrupt the circuits to the radiant heat coil **47** and compressor **1**, and complete the circuit to heating element **27**.

Thus in a heat pump embodying this invention frost accumulation on the outdoor coil during heating cycles in cold weather is prevented and delayed as ambient air temperatures, and the temperatures of the coil, descend to temperatures below 32 degrees.

While this invention has been shown and described in preferred and modified embodiments thereof, it will be obvious that various other modifications may be made therein without departing from the spirit or essential attributes thereof, and it is desired therefore that only such limitations be placed thereon as are specifically set forth in the appended claims.

What is claimed is:

1. In an air-to-air heat pump, a refrigerant circuit including a refrigerant, an outdoor heat exchanger, an indoor heat exchanger, a compressor ,a reversing valve for reversing refrigerant flow direction between heating and cooling cycles, and a radiant heat coil connected serially in said circuit, and means downstream of said outdoor heat exchanger for moving air therethrough, said radiant heat coil being positioned upstream of said outdoor heat exchanger and connected serially in said refrigerant circuit between said outdoor heat exchanger and said indoor heat exchanger, the heating of said radiant heat coil being initiated at the beginning of heating cycles by heated refrigerant from said indoor heat exchanger to continue therethrough to termination at the end thereof.

2. In an air-to-air heat pump as set forth in claim **1** wherein said outdoor heat exchanger coil is of the fin-tube type and said radiant heat means includes a bare tube radiant heat coil in spaced relation upstream of said fin-tube coil.

3. In an air-to-air heat pump as set forth in claim **2** wherein said outdoor fin-tube heat exchanger coil includes fin extensions on the upstream side thereof, and with said tubular radiant heating means disposed through holes in said fin extensions of said fin-tube coil, said fin holes being larger in diameter than the outside diameter of said tubular radiant heating means to minimize the heat transfer therebetween by conduction during heating cycles.

4. In an air-to-air heat pump system, an outdoor heat exchanger coil, means downstream of said outdoor coil for moving air therethrough, radiant heating means upstream of said outdoor coil, an indoor heat exchanger coil, a blower downstream of said indoor coil for moving air therethrough, an electric air heating element downstream of said blower, an electric motor operated compressor for circulating refrigerant around said refrigerant circuit, pressure responsive means operated by the evaporating pressures in said outdoor coil during heating cycles, and means including said last mentioned means for controlling the circuit to said compressor motor to complete the same when the pressures in said outdoor coil indicates that frost is not being collected thereon and to interrupt said circuit to said motor and complete the circuit to said electric air heating element when the pressure in said outdoor coil indicates the possible accumulation of frost or ice thereon.

5. In an air-to-air heat pump as set forth in claim **4** wherein said radiant heating means upstream of said outdoor coil is arranged for electrical energization and wherein the circuit to said radiant heating means is interrupted concomittantly with the interruption of the circuit to said compressor motor.

References Cited

UNITED STATES PATENTS

1,821,754	9/1931	Huyette	165—146 X
2,474,304	6/1949	Clancy	165—17 X
2,919,558	1/1960	Laver	165—29 X
2,970,816	2/1961	McCarty	165—17
3,189,085	6/1965	Eberhart	165—29 X
3,219,102	11/1965	Taylor	165—29 X
3,318,372	5/1967	Shell	165—29

EDWARD J. MICHAEL, Primary Examiner

U.S. Cl. X.R.

62—160, 324