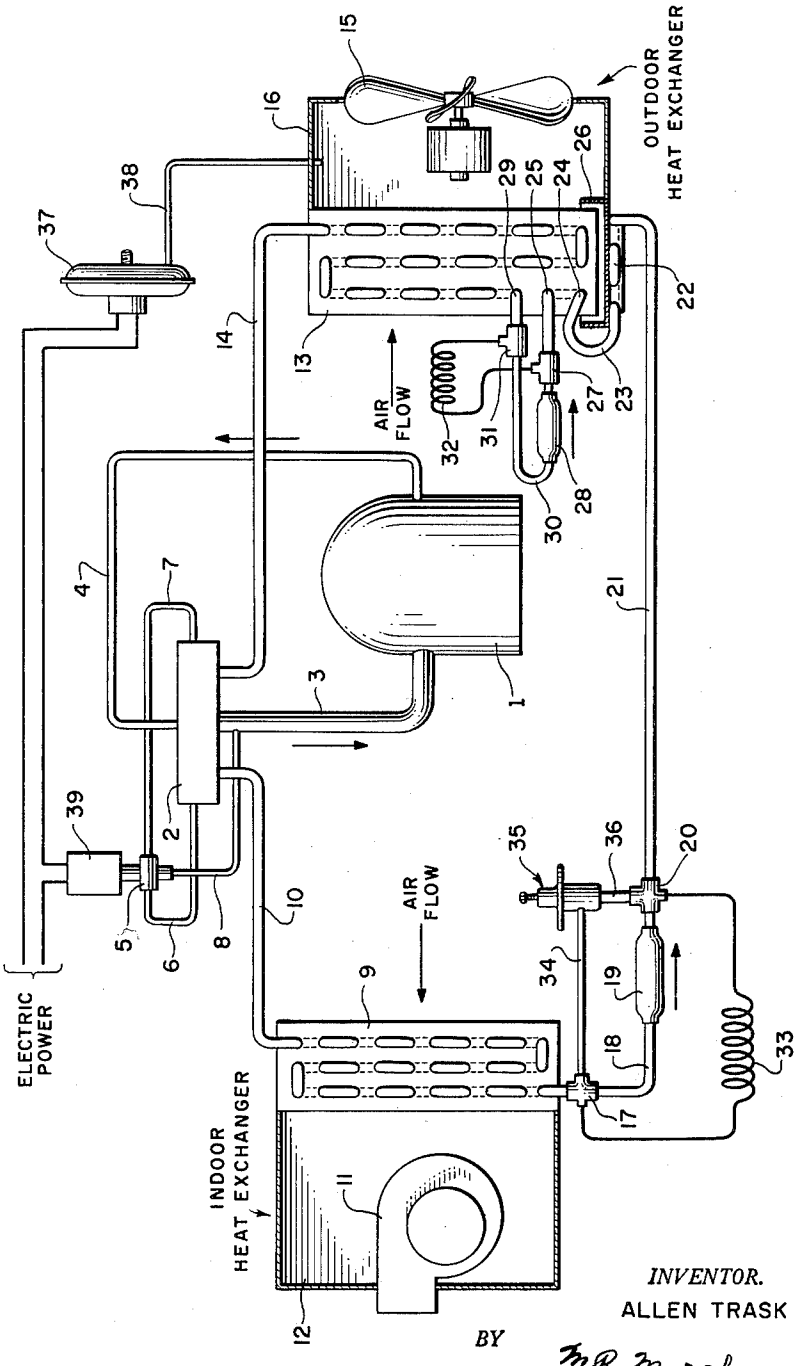
July 3, 1962 A. TRASK 3,041,845

DEFROSTING SYSTEM FOR HEAT PUMPS

Filed Feb. 25, 1960 2 Sheets-Sheet 1

FIG. 1



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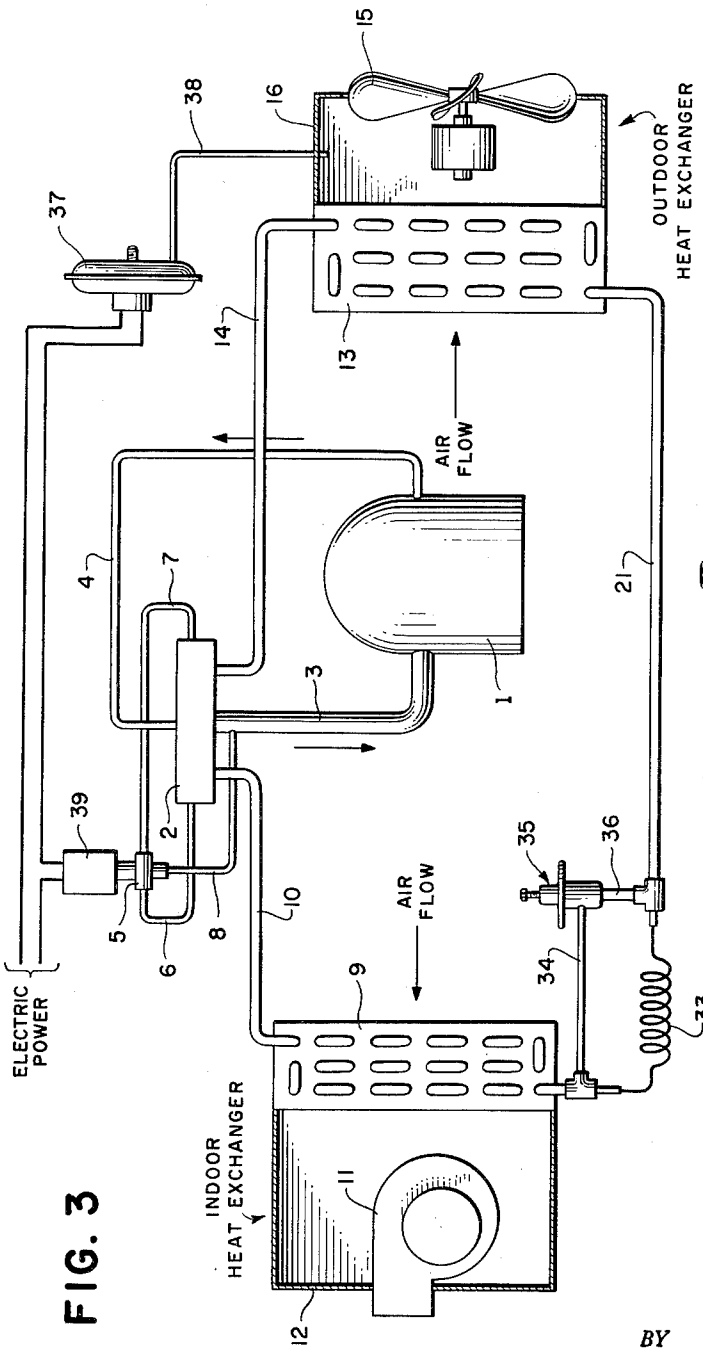


FIG. 3

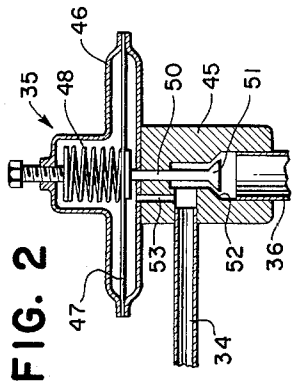


FIG. 2

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DEFROSTING SYSTEM FOR HEAT PUMPS

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5 Claims. (Cl. 62—140)

This invention relates to heat pumps, and more specifically to air-to-air heat pumps embodying components of a compression type refrigeration system wherein the refrigerant flow direction in its circuit between two heat exchangers is automatically reversible through a four way reversing valve.

In heat pumps of this type frost and ice commonly collect and freeze on the heat exchanger surface of the outdoor coil when, in the heating cycle, the temperature of that surface is cooled below 32 degrees. This heat exchanger surface is usually of the fin-tube type. When its temperature is reduced below freezing while absorbing heat from humid air flowing through it, frost will collect and build up between the coil fins to obstruct and reduce the normal flow of outdoor air through the coil. The heating capacity of the heat pump is thereby reduced.

To remove frost and/or ice from the outdoor heat exchanger operating in a heating cycle it is common practice to reverse the system temporarily causing it to operate in a cooling cycle automatically by means responsive to frost accumulation, or by an interval timer, thus transferring heat from the indoor heat exchanger and/or indoor air to the outdoor heat exchanger to melt the frost or ice collected on its surfaces. Means is provided to restore the heat pump to a heating cycle when the frost and/or ice is melted from the heat exchanger.

In conventional heat pump systems of this type the defrosting cycle usually requires several minutes and it is desirable to end this defrosting cycle as quickly as possible in order to reduce the time the system is extracting heat from the space to be heated. A major portion of the time of the defrosting cycle is caused by the slow build-up of refrigerant vapor pressure in the outdoor heat exchanger sufficient to force the condensed cold liquid refrigerant collected therein through the evaporative control device arranged to admit a normal cooling flow of refrigerant into the indoor heat exchanger when impelled by the relatively high compressor head pressure of a cooling cycle. Pressure in the outdoor heat exchanger must be substantially higher than the pressure in the indoor heat exchanger to induce a normal flow rate through the expansion device admitting refrigerant into it.

Sufficient pressure in the outdoor heat exchanger to accelerate refrigerant flow into the indoor coil cannot be built up to speed the defrosting cycle until sufficient refrigerant is circulated through the indoor heat exchanger to absorb heat therein and carry it to the outdoor exchanger to raise its temperature. Thus it is understood that the normal flow resistance of the refrigerant evaporative control device designed to admit the refrigerant flow of the full compressor capacity into the indoor heat exchanger under summer operating conditions of the cooling cycle, when the pressure difference between the two heat exchangers is comparatively high, will in a defrosting cycle, wherein the said pressure difference is comparatively low, permit only a greatly reduced rate of refrigerant flow and thus a proportionately long interval in defrosting cycle delivery of heat from the indoor exchanger to the outdoor exchanger for the purpose of melting frost and ice thereon.

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There is a further defrosting problem in heat pumps which have a drain pan under the outdoor heat exchanger for collecting and disposing of the water melted off the heat exchanger during defrosting cycles. When the outdoor temperatures remain below freezing ice will build up in the drain pan unless it is heated to a temperature above freezing. During snow storms, or when loose snow is blown into the outdoor heat exchanger, snow will lodge between the fins of the exchanger to restrict air flow therethrough and will fill the drain pan. In that event defrosting cycles will deposit water on the snow in the drain pan and the mixture of snow and ice will then often freeze into a mass bridging the drain pan and including the bottom rows of refrigerant tubes and fins of the outdoor heat exchanger. In an extended period of sub-freezing temperatures an ice accumulation will grow higher and higher into the heat exchanger to remove a substantial portion of its surface from effective service in extracting heat from the outdoor air. This result will occur even though the drain pan be heated. The heating capacity of a heat pump is thereby reduced.

One object of this invention is to provide an arrangement to enable the reduction of time intervals of the defrost cycles of heat pumps.

Another object of the invention is to provide a structure wherein the lower portion of an outdoor fin-tube heat exchanger and its drain pan will be kept free from an accumulation of ice by means of heat transferred from warm liquid refrigerant returned from the indoor heat exchanger during heating cycles in sub-freezing weather.

These and other objects are accomplished by my invention as will be apparent from the following description and claims considered with reference to the accompanying drawings forming a part of this application.

In the drawings FIG. 1 is a diagrammatic view of a heat pump system embodying this invention;

FIG. 2 is an enlarged sectional view of the pressure regulating valve of FIG. 1; and

FIG. 3 is a diagrammatic view of a heat pump embodying a modification of this invention.

In FIG. 1 a refrigerant compressor 1, is connected to a four-way reversing valve 2, by a suction conduit 3, and a discharge conduit 4. A three-way solenoid operated pilot valve 5, is connected by conduits 6 and 7, to the reversing valve 2, and by a conduit 8 to the compressor suction tube 3.

A three row single circuit fin tube type indoor heat exchanger coil 9, has its top end in communication with reversing valve 2, through a conduit 10. A blower 11, is arranged in shroud 12, to recirculate indoor air through the heat exchanger 9. A three row single circuit fin-tube type outdoor heat exchanger 13, has its top circuit end in communication with reversing valve 2, through a conduit 14. A fan motor assembly 15, is arranged in a shroud 16, to recirculate outdoor air through the heat exchanger 13.

The indoor heat exchanger 9, has the lower end of its circuit in communication with the lower end of the circuit of outdoor heat exchanger 13, through a series of elements including a cross fitting 17, a conduit 18, a check-valve 19 which permits one-way flow of refrigerant toward the outdoor heat exchanger 13, a cross-fitting 20, a conduit 21, a serpentine loop 22 in heat exchange relation with a drain pan 26, and a conduit 23 connecting the sepentine loop 22 with tube 24 in the heat exchanger 13. The heat exchanger 13 has its tube 25 connected to tube 24 in its single series circuit. The

next tube in the exchanger 13 circuit is tube 29. Between tubes 25 and 29 is a series branch circuit 30 including a T 27, a check-valve 28 which permits one-way flow of refrigerant through the branch circuit 30 to exchanger tube 25, and a T 31. A capillary tube 32 is connected as a parallel branch circuit to branch circuit 30 for evaporative control of refrigerant flow into the outdoor heat exchanger tube 29 and thence through its circuit during heating cycles.

A capillary tube 33 is connected between cross fittings 17 and 20 to form a parallel circuit to conduit 18 and check-valve 19 which are also connected in series between these fittings. Capillary tube 33 provides evaporative control of refrigerant flow into indoor heat exchanger 9 during cooling or defrosting cycles. A pressure regulating valve 35 is connected by conduits 34 and 36 to the cross-fittings 17 and 20 to form a third parallel circuit between them.

A diaphragm switch, 37, is in communication with the inside of fan shroud 16, through conduit 38. It is arranged to close an electric circuit to energize the solenoid 39 of valve 5 upon the reduction of air pressure in shroud 16 to a predetermined amount, and to open the circuit upon an increase in air pressure to a predetermined amount.

The pressure regulating valve 35 shown in cross-section diagram in FIG. 2 comprises a valve body 45, a diaphragm enclosure 46 suitably attached to the valve body, and a diaphragm 47. An adjusting spring 48, and an adjusting screw 49, are arranged in the diaphram enclosure 46 to exert a selected pressure against one side of diaphragm 47. The opposite side of diaphragm 47 engages a valve stem 50 having a valve 51 at its opposite end. The valve 51 engages the valve seat 52 in valve body 45. A pressure passage 53 in valve body 45 conducts the vapor pressure within the conduit 34 to the valve stem side of the diaphragm 47 where it tends to move the valve 51 onto its seat 52 against the opposing pressure of the spring 48.

When the heat pump system of FIGURE 1 is operating in a heating cycle, compressor 1 draws refrigerator vapor from the outdoor heat exchanger 13, through conduit 14, reversing valve 2, and conduit 3. It discharges the compressed and heated refrigerant vapor through conduit 4, reversing valve 2, and conduit 10, into the indoor heat exchanger 9, which transfers latent heat of the refrigerant vapor into a recirculated indoor air stream induced by the blower 11.

Liquid refrigerant condensed in the exchanger 9 flows therefrom through cross-fitting 17, conduit 18, check-valve 19, cross-fitting 20, and through conduit 21 to the serpentine tube loop 22 in heat exchange relation with the drain pan 26 under the outdoor heat exchanger 13. Here the warm liquid refrigerant maintains the drain pan temperature substantially higher than the outdoor air temperature so that in freezing weather the drain pan will be maintained at temperatures above freezing and ice will not accumulate therein.

From serpentine loop 22 a short conduit 23 leads warm liquid refrigerant into heat exchanger 13 through its tubes 24 and 25, which are the bottom two tubes in the first row on the down-stream side of the heat exchanger. These two tubes likewise are maintained at temperatures substantially higher than the outdoor air temperature. The heat exchange fins surrounding these tubes and adjacent to them are also heated with the warm refrigerant in the tubes so that in freezing weather frost or ice will not be collected on them.

From the exchanger tube 25 liquid refrigerant flows through the T fitting 27 into the capillary tube 32. The check valve 28 prevents flow into conduit 30. Capillary tube 32 restricts the flow of liquid refrigerant to reduce its pressure to the prevailing pressure in the outdoor heat exchanger 13 where the refrigerant is evaporated in its circuit by the heat of the outdoor air drawn through it by fan 15. This completes the circuit during a heating cycle.

In normal weather temperatures from 20° F. and 40° F., frost and ice accumulate on the fins and tubes of the outdoor heat exchanger 13 because the refrigerant temperature within the exchanger is below 32° F. During periods of rain or fog at temperatures around 35° F. this accumulation of frost and ice on the exchanger surface is rapid. At temperatures below 32° F. snow may be blown into or drawn into the fin-tube heat exchanger 13 to block the flow of air therethrough.

When the interstices between the fins of exchanger 13 are partially closed with ice, frost, and/or snow there is a corresponding air pressure reduction within the shroud 16 induced by the effort of the fan 15 to draw outdoor air through the restricted heat exchanger. When this pressure is reduced to a predetermined amount the diaphragm switch 37 closes to complete a circuit to the solenoid 39, which in turn actuates the solenoid valve 5 and the reversing valve 2. This directs the refrigerant flow in the direction required for a cooling cycle for the purpose of melting any frozen moisture accumulation from exchanger 13. Diaphragm switch 37 is arranged to open and return the system to a heating cycle when the defrosting cycle is completed and the pressure in the shroud 16 has returned to normal.

In the defrosting cycle compresor 1 draws hot refrigerant vapor from the indoor heat exchanger 9, through the conduit 10, the reversing valve 2, and the conduit 3. It discharges the hot refrigerant vapor into the relatively cold outdoor heat exchanger 13 where it warms the exchanger with its sensible heat, and its latent heat, imparted to the exchanger in the process of its condensing. It is common practice to provide means to stop the operation of the outdoor fan during defrosting cycles and this may be effected in the conventional manner.

At the beginning of the defrosting cycle the refrigerant pressure within the indoor exchanger 9 is higher than it is in the outdoor heat exchanger 13. Condensed liquid refrigerant then accumulates in the exchanger 13. When the refrigerant pressure in the exchanger 9 is reduced below the pressure in the exchanger 13, then the liquid refrigerant in exchanger 13 will flow from tube 29, through the T fitting 31, the conduit 30, the check-valve 28, the T fitting 27, tubes 25 and 24 of the heat exchanger, and from the exchanger 13 through conduit 23 into serpentine loop 22. The condensed liquid refrigerant then flows through conduit 21 to the T fitting 20 where it branches into two of three parallel circuits. It is prevented from flowing through the check-valve circuit by the closing of the check-valve 19 in the defrosting and/or cooling cycles. The refrigerant is free to flow from T fitting 20, through the capillary tube 33, and the T fitting 17 into the heat exchanger 9. Capillary tube 33 is sized for restricting refrigerant flow to cause a substantial pressure drop in the refrigerant pressure as it passes therethrough during a summer cooling cycle. When a refrigerant such as "Freon 22" is used the pressure drop in a cooling cycle would be in the range of 210–260 pounds per square inch.

During the first part of a defrosting cycle the refrigerant pressure difference available gradually increases from zero pounds per square inch. At low pressure difference the restriction of the capillary tube 33 permits only a very slow flow of refrigerant. A retarded and delayed flow of refrigerant through the full heat pump circuit during defrosting cycles increases the time length of the defrosting cycles. This is undesirable in a heat pump system of this type because the time available for heating is correspondingly reduced.

In this invention a second refrigerant circuit parallel to the capillary tube 33 is provided and arranged to permit substantially increased refrigerant flow into heat exchanger 9 during the first part of defrosting cycles. This second circuit connects the T fittings 20 and 17,

through the conduit **36**, the pressure regulating valve **35**, and the conduit **34**. Pressure regulating valve **35** is arranged to open during the first part of defrosting cycles to permit substantially increased volume of liquid refrigerant flow from the conduit **21** into the indoor heat exchanger **9**.

When the pressure regulating valve **35** is connected in the heat pump system as shown in FIG. 2 between conduit **36** and **34**, the pressure in the heat exchanger **9** is translated through the conduit **34**, and the pressure passage **53**, to the underside of the valve diaphragm **47**. Adjusting screw **49**, adjusting the regulating spring **48**, is set so that when the refrigerant pressure in the exchanger **9** falls below the normal range of the summer cooling cycle then spring **48** will open the valve **51**. A pressure reduction in the exchanger **9** will always be low enough to open the pressure regulating valve **35** during the first part of defrosting cycles. When this valve is opened the flow of liquid refrigerant into the indoor heat exchanger will be substantially increased and the time length of the defrosting cycle will be correspondingly reduced. In heat pump systems using a refrigerant, such as "Freon 22," a pressure regulating valve connected as shown in FIG. 2 may be set to open in the pressure range of 30–40 pounds per square inch.

An alternative method of connecting pressure regulating valves may be used. The refrigerant flow through the valve may be reversed in direction. The connections of conduits **34** and **36** may be exchanged so that the liquid refrigerant flow through the valve will be in opposite direction to that shown in FIGS. 1 and 2. When this exchange is made the valve control through the diaphragm **47** will be affected by the pressure of outdoor heat exchanger **13** translated through the series of conduits hereinbefore enumerated, and the pressure passage **53**. When this arrangement is used with a refrigerant, such as "Freon 22," the pressure regulating valve **35** may be adjusted to open in the pressure range of 100–150 pounds per square inch. At this setting the valve will always be closed during summer cooling cycles, and always open during the first part of defrosting cycles for reducing their time length.

A modification of a heat pump system is shown in FIG. 3 where similar parts and elements are identified by the same reference numerals as employed in FIG. 1. In this modified system the one refrigerant expansion device functioning alternately for both heat exchangers is employed. This type system is commonly used in small self-contained heat pumps.

In the system of FIG. 3, the indoor heat exchanger **9**, has the lower end of its circuit connected to the lower end of the circuit of the outdoor heat exchanger **13**, through the conduit **21**, and the capillary tube expansion device **33**. Capillary tube **33** provides evaporative control of the refrigerant to the heat exchanger on its downstream side of both directions of refrigerant flow.

Pressure regulating valve **35** is connected into the refrigerant circuit between the two heat exchangers as a bypass around capillary tube **33**, by means of connecting conduits **34**, and **36**. In this embodiment of the invention the pressure regulating valve **35** functions in the same manner as it does in the heat pump system of FIG. 2 described hereinbefore.

It will be obvious to those skilled in the art that the present invention is not limited to the arrangements shown and described but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereon as are specifically set forth in the appended claims.

What is claimed is:

1. In a heat pump including a reversible refrigerant circuit with an indoor heat exchanger and an outdoor heat exchanger, compressor and valve means in said circuit for effecting flow of refrigerant through said circuit in either direction to enable said indoor heat exchanger to function either as an evaporator or a condenser, said circuit between said two heat-exchangers including therein three parallel conduits, one of said conduits including means for evaporative control of refrigerant flow into said indoor heat exchanger during cooling cycles, a second parallel conduit including a check-valve arranged to prevent refrigerant flow therethrough into said indoor heat exchanger during cooling cycles, and a third parallel conduit including a pressure regulating valve responsive to the pressure in said indoor heat exchanger arranged to open at a pressure lower than the normal evaporating pressure in the indoor heat exchanger during cooling cycles, and means for automatically actuating said reversing valve means during heating cycles for operating the system temporarily in a cooling cycle for the purpose of melting frozen moisture from said outdoor heat exchanger.

2. A heat pump having a reversible cycle refrigeration circuit including an indoor heat exchanger and an outdoor multiple circuit heat exchanger disposed in an upright position, compressor and reversing valve means for effecting refrigerant flow through said circuit in either direction, a drain pan under said outdoor heat exchanger, a separate circuit within the bottom portion of said outdoor heat exchanger, said separate circuit having a first part in heat exchange relation with the other circuit of said heat exchanger and a second part in heat exchange relation with said drain pan and means for evaporative control of refrigerant flow into said outdoor heat exchanger during heating cycles, said control means being connected between said separate circuit and the other circuit in said outdoor heat exchanger.

3. A heat pump including an indoor heat exchanger, a refrigerant flow control means for said indoor heat exchanger, an outdoor heat exchanger, and a compressor and reversing valve means serially connected in a refrigerant circuit for effecting flow of refrigerant through said circuit in either direction whereby said heat exchangers function alternately as an evaporator and a condenser, a pressure control valve connected in said circuit parallel with the said flow control means for said indoor heat exchanger, said pressure control valve being responsive to pressure in said indoor heat exchanger and arranged to open at pressures lower than the normal evaporating pressures of said indoor heat exchanger during cooling cycles, and means for automatically activating said reversing valve means temporarily for purposes of defrosting said outdoor heat exchanger during heating cycles.

4. A heat pump having a reversible cycle refrigeration circuit including an indoor heat exchanger and an outdoor multiple circuit heat exchanger, a liquid refrigerant conduit for transferring refrigerant between said heat exchangers in its liquid phase, compressor and reversing valve means for effecting refrigerant flow through said circuit in either direction, a separate circuit within the bottom portion of said outdoor heat exchanger, means for evaporative control of refrigerant flow into said outdoor heat exchanger during heat cycles, said control means being connected between said separate circuit and the other circuits in said outdoor heat exchanger, a drain pan under said outdoor heat for collecting melted frost and ice removed from said outdoor heat exchanger during defrosting thereof, and means for warming said pan during heating cycles comprising said liquid refrigerant conduit in heat exchange relation with said pan.

5. A heat pump including an indoor heat exchanger, an outdoor heat exchanger, a refrigerant conduit including flow control means for controlling the flow of refrigerant from either of said heat exchangers to the other, and a compressor and a reversing valve means, serially connected in a refrigerant circuit for effecting flow of refrigerant through said circuit in either direction whereby said heat exchangers function alternately as an evaporator and a condenser, and a pressure control valve connected

in said circuit parallel with said flow control means, said pressure control valve being responsive to pressure in said indoor heat exchanger and arranged to open at pressures lower than the normal evaporating pressures of said indoor heat exchanger during cooling cycles, and means for automatically activating said reversing valve means temporarily for purposes of defrosting said outdoor heat exchanger during heating cycles.

References Cited in the file of this patent

UNITED STATES PATENTS

2,525,560	Pabst	Oct. 10, 1950
2,785,540	Biehm	Mar. 19, 1957
2,801,528	Parcaro	Aug. 6, 1957
2,955,439	Pinter	Oct. 11, 1960
2,976,696	Rhea	Mar. 28, 1961