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HEAT PUMP BOOSTER

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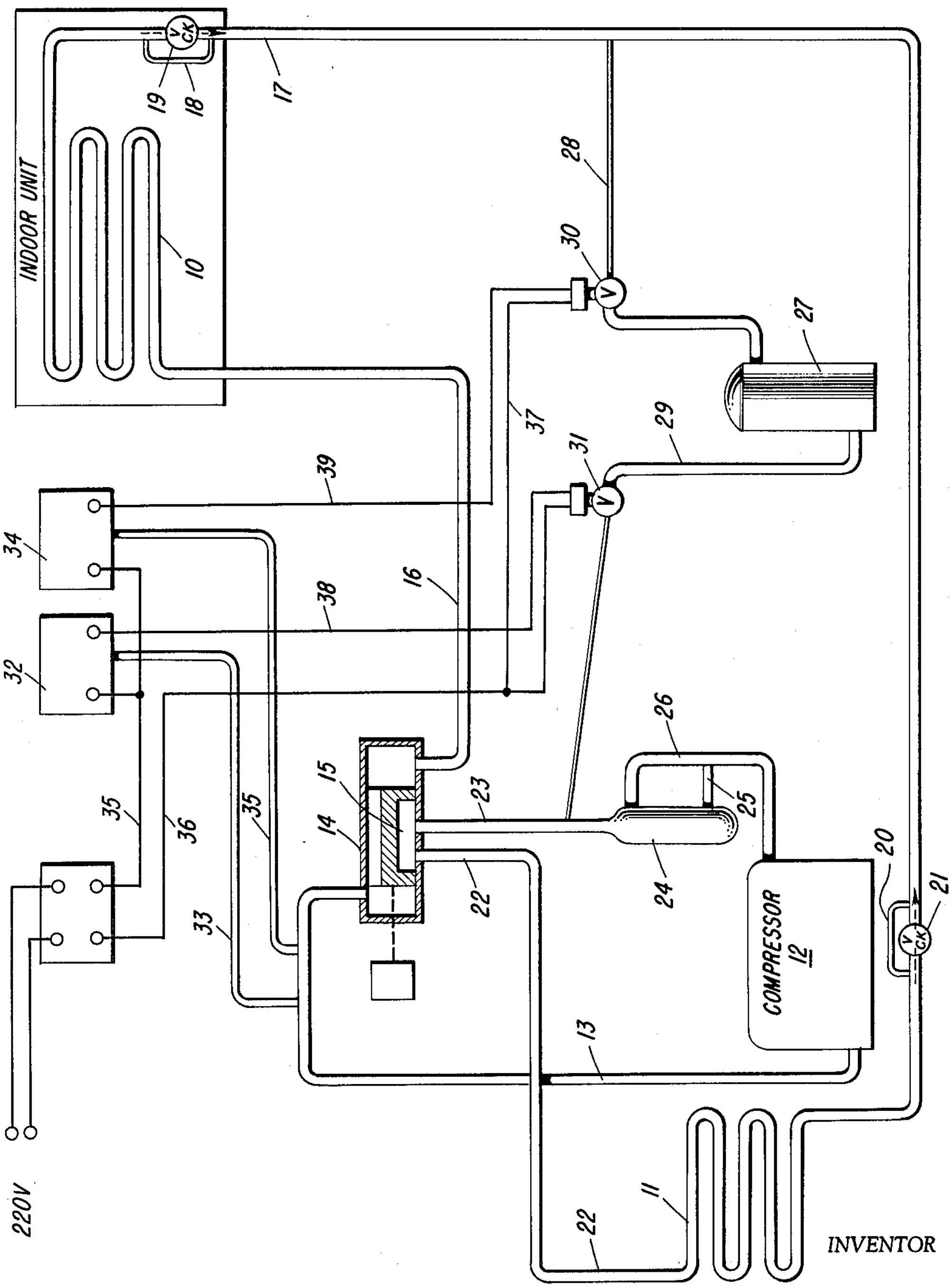

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HEAT PUMP BOOSTER

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The present invention relates to heat pumps and more particularly to a heat pump including fluid flow modulating means for regulating or compensating and increasing the effective circulating pressures or supply of refrigerant to achieve maximum operating efficiency under varying operating conditions within the system primarily during the heating cycle upon large pressure fluctuations.

The utilization of a reversible refrigerant circuit, commonly referred to as a heat pump, includes an indoor heat exchanger and an outdoor heat exchanger with a reversing valve mechanism within a closed refrigerant circuit to regulate the direction of refrigerant flow through the closed circuit under suitable pressure maintained with a fixed refrigerant supply in the desired direction under a positive head pressure generated from a motor-operated compressor, with control means governing the refrigerant flow between heat exchangers under maintained pressure differentials between the heat exchangers within the system.

Conventional heat pumps of the type disclosed in U.S. Patent No. 2,977,773 may be utilized to incorporate basically the improvements of this invention whereby increased operating efficiencies may be achieved by the utilization of a capacity booster receiver to augment the refrigerant supply in order to compensate for differences during pressure fluctuations that normally produce pressure drops within the system particularly when on the heating cycle at below normal temperatures when additional capacity is required.

The present invention has for one of its main objectives the provision of an improved heat pump system in which capillary tube flow restricting means and refrigerant control means are incorporated in conjunction with a capacity booster for maintaining the desired operating pressure of a heat pump under below normal operating conditions particularly during the heating cycle.

Still another objective of this invention is to provide a heat pump in which there is an auxiliary capacity booster containing a receiver for refrigerant that will supplement the normal charge within a closed circuit upon increased pressure fluctuations in the system for maintaining a more uniform or constant pressure, within limits, in the system particularly when operation is on the heating cycle.

The preferred embodiment of executing the present invention will be described as it relates to the heating cycle since it is during this cycle that increased refrigerant demand or capacity is required. The system includes a heat pump in which there is an indoor heat exchanger and an outdoor heat exchanger operatively connected within a primary closed refrigerant circuit in which circuit a motor-operated compressor will discharge refrigerant at a pressure range of from 250 pounds per square inch to 310 pounds per square inch through a discharge line and into a reversible valve mechanism for reversibly connecting the discharge line either to the indoor heat exchanger or to the outdoor heat exchanger and returnable to the compressor by way of a suction line and in which suction line a refrigerant receiver or accumulator is provided. Depending upon the positioning of the valve mechanism, refrigerant may flow either in the direction of a heating cycle or cooling cycle depending upon the utilization to be made of the heat exchangers. Suitable fixed flow heating and cooling capillaries for restricting refrigerant flow are supported within the primary closed system substantially adjacent to each of the heat exchangers; the two capillaries are series-connected in the circuit. The heating capillary will be by-passed during operation of the heat pump on the cooling cycle so that the cooling capillary provides the desired flow restriction in the line, while on the heating cycle the cooling capillary is similarly by-passed. Through this closed circuit, the heating and cooling cycles will produce a high pressure liquid refrigerant flow between heat exchangers and, depending upon the ambient temperatures within the zone of the heat exchangers, there will result certain pressure differentials. The primary receiver or accumulator within the closed circuit with the various components including the valve mechanism and the compressor will contain a predetermined refrigerant charge dependent upon the normal range of operating conditions to permit more effective control and regulation thereby reducing large pressure differentials to obtain maximum operating efficiencies over the normal range of operating conditions. During abnormally cold weather conditions additional heating load capacity is required, however, the pressure in the closed circuit will drop appreciably. An auxiliary receiver or capacity booster installed in the system through a supplementary circuit will supplement the refrigerant supply in the closed circuit to increase or augment the primary supply to meet the new demand conditions enabling the system to function within wider ranges of pressure fluctuations and variations. Fluctuations that produce marked pressure differentials will be depressed through avoidance of excessive starving of refrigerant that will occur in the high pressure discharge line during periods of severe weather by introducing additional refrigerant into the primary circuit from the supplementary circuit at these periods of high pressure demand.

Other advantages will become more readily apparent from the accompanying drawing in which the diagrammatic presentation of a heat pump circuit embodying the present invention will illustrate the flow of refrigerant in the various circuits and apparatuses that are shown schematically.

In the drawing, the system is illustrated as operating in the heating cycle only as it is this phase to which the invention is particularly directed. The heat pump circuit illustrated includes an indoor heat exchanger or unit **10** utilized in the heating cycle and an outdoor heat exchanger or unit **11** for the cooling cycle in which the outdoor unit generally is provided with a larger coil surface area than the indoor heat exchanger coil surface area. Refrigerant, usually Freon 22, under pressure is supplied throughout the primary closed circuit by the motor-operated compressor **12** through the main discharge line **13** from the compressor which discharge pressure, without limiting this invention for the purpose of one specific illustration, may be within the range of from 250 to 310 pounds per square inch, and refrigerant will flow into the four-way reversing valve mechanism **14**. The reversing valve mechanism **14**, which may be of conventional construction permitting discharge either to the outdoor or indoor heat exchangers, is provided with a suitable slide gate to direct the flow of refrigerant to the indoor heat exchanger **10** through the line **16** as is illustrated during the heating cycle position.

During normal heating cycle operation, the liquid refrigerant will flow under pressure through the indoor unit coil and into the high pressure liquid refrigerant line **17**. A cooling cycle capillary tube **18** is installed in the high pressure line **17** with inlet and discharge positions spaced from each other so as to straddle the check valve **19**. During the heating cycle, liquid refrigerant will flow through the check valve **19** in its path of flow to the heating cycle capillary tube **20** with inlet and discharge openings spaced apart so as to starddle the check valve **21** in the pressure line **17**. Liquid refrigerant flowing through the line **17** in the direction of the outdoor heat exchanger **11** will not pass through the check valve **21** but will pass through the capillary tube **20** which will be in close proximity to the outdoor unit that will be used as the evaporator. The refrigerant will return from the outlet of the outside heat exchanger through line **22** to the valve mechanism **14** and pass through the valve gate **15** into the suction line **23**, the lower end of which is provided with an accumulator **24** at the bottom of which is an oil reservoir and an overflow oil return line **25** that communicates with the suction return line **26** leading to the compressor **12**.

The closed circuit containing the desired supply of refrigerant including an additional quantity contained within the accumulator **24** is generally adequate during heating and cooling cycles for a given system under normal operating conditions with reasonable temperature fluctuations to maintain the desired supply of refrigerant within the system. However, the heating cycle requires additional refrigerant during extended or abnormally low temperature conditions at which time the pressure of the refrigerant within the closed system decreases appreciably. It will be readily apparent that during the cooling cycle, the valve gate **15** may be shifted to the right changing the course of flow of the refrigerant whereby the refrigerant under pressure will pass from the line **13** through the valve **14** into the line **22** leading to the outside heat exchanger. The liquid refrigerant will pass through the check valve **21** in the pressure line **17** bypassing the capillary tube **20** and will pass through the cooling capillary tube **18** leading to the indoor heat exchanger **10** with the refrigerant ultimately returning through line **16** to the suction line **23** on its return to the compressor **12**.

A supplementary or auxiliary circuit for refrigerant is interconnected with the primary closed circuit to supply or remove refrigerant in accordance with predetermined pressure conditions in the refrigerant. An auxiliary receiver or capacitor booster **27** containing a supply of refrigerant is connected to the high pressure refrigerant line **17** by means of line **28** which may be suitable tubing. The receiver or capacity booster **27** is also connected to the suction line **23** by the line **29** which may be made of tubing.

A solenoid valve **30** is installed in the line **28** and a solenoid valve **31** is installed in the line **29**. A pressure-operated switch **32** is electrically connected to solenoid valve **31** and a refrigerant pressure tube **33** is connected at one end to the discharge line **13** and at the other end to switch **32** for conveying refrigerant pressure in the discharge line to the switch **32** which will operate between predetermined pressure limits. In one preferred installation, the switch **32**, which may be a high pressure switch available commercially as a Penn 27AP20, may have a cut-out pressure of 260 pounds per square inch and a cut-in pressure of 240 pounds per square inch. The switch **34** for actuating solenoid **30** is of the same type as switch **32** but is provided with a cut-in setting of 310 pounds per square inch and a cut-out setting of 280 pounds per square inch with the line or tubing **35** connected at one end to the switch and at the other end to the high pressure discharge line **13**. The individual solenoid valves **30** and **31** suitable for installation are available as Alco solenoid valves S102–2.

Line current of 220 volts may be supplied to the switches **32** and **34** and to the solenoid valves **30** and **31** through the conductors **35** and **36**. The wiring diagram included in the drawing presents the common conductor **35** to both switches **32** and **34** with the line **36** being connected to the solenoid valves directly or through a jumper line **37**. The switch-valve return lines **38** connect the valve **31** with the switch **32** and line **39** connects valve **30** to switch **34**.

The utilization of the capacity booster or receiver **27** within the auxiliary or supplementary circuit will permit the head pressure to be varied, modulated or compensated for by the switch and valve setting controls so that when pressure builds up to 310 pounds per square inch, the solenoid valve **30** will open while solenoid valve **31** will remain closed permitting liquid refrigerant in line **17** to flow into the capacity booster **27** through the line **28**. When the overall pressure in the system drops to approximately 280 pounds per square inch in the line **13**, the solenoid valve **30** will close and solenoid valve **31**, which is normally closed, will remain closed thereby storing the liquid refrigerant in the capacity booster **27**. The head pressure will then remain between the selected range of from approximately 280 pounds to 310 pounds per square inch. Depending upon the high pressure cut-out, the switch will not trip out on high pressure as it is set sufficiently high to avoid being tripped out except a safety switch may be employed in the line which will kick out in the event the head pressure builds up rapidly such as when there is a malfunction in the system or when a fan belt breaks.

In extremely severe cold weather, additional refrigerant supply is required in order to maintain the elevated head pressure in the system so as to deliver an adequate quantity or supply of energy to the space being heated by the indoor heat exchanger **10**. When the head pressure in the discharge line drops to 240 pounds per square inch, switch **32** will actuate the solenoid valve **31** to open it while the solenoid valve **30** remains in the closed position. Refrigerant in the capacity booster **27** will be introduced and supplied into the system through the line **29** that leads to the suction line **23** that passes to the compressor **12**. Sufficient refrigerant will be supplied through the line **29** from the capacity booster **27** until the head pressure builds up from 240 to 260 or 280 pounds per square inch. With the additional refrigerant supplied into the primary system from the auxiliary closed circuit, additional refrigerant contained within the primary circuit will result in additional heat pick-up in the coil **11** which will ultimately be discharged into the area to be heated through the indoor heat exchanger **10**.

The utilization of the capacity booster in the system will permit the head pressure during the heating cycle to be maintained in operating condition at maximum pressure levels. When frost is generated on the outside heat exchanger coil, the valve mechanism **14** will usually go into the cooling cycle at which time the outside fan (not shown) utilized with the outside heat exchanger will cut-out by means of another control (not shown) from another source which when actuated defrosting is initiated as more refrigerant is fed through the system. Additional refrigerant supplied from the auxiliary to the primary system will permit increased internal heat pick-up with the valve **31** being open to supply the additional refrigerant charge to the system thereby accelerating the defrost cycle from the usual period of ten minutes down to a period of from three to five minutes.

It will be readily apparent that modifications and variations may be made in the types of valves and electrical controls for the valves to permit the introduction of the additional refrigerant into the system from the capacity booster by incorporating spring-loaded pressure valves pre-set within the desired pressure range to open and close, however, the system described above is preferred as it requires a minimum of maintenance. It may also be desirable to incorporate check valves in the lines **28** and **29** without deviating from the purpose and spirit of this invention and such modifications are contemplated within the scope of the appended claims.

What is claimed is:

1. A heat pump comprising a reversible closed refrigerant circuit including an indoor heat exchanger, an outdoor heat exchanger, means in said circuit including a compressor having a discharge line and a suction line and reversing valve means for reversibly connecting said discharge and suction lines to said heat exchangers for effecting flow of refrigerant through said circuit in either direction whereby said pump may be operated on a cooling cycle with the outdoor heat exchanger functioning as a condenser and receiving high pressure refrigerant from said compressor or on a heating cycle with the indoor heat exchanger functioning as a condenser and receiving high pressure refrigerant from said compressor, flow restricting means in said circuit for controlling the flow of refrigerant from either of said heat exchangers to the other and for maintaining a pressure difference between said heat exchangers, said flow restricting means comprising a cooling capillary connected in series to said indoor heat exchanger and a heating capillary connected in series to said outdoor heat exchanger, a conduit connecting said capillaries in series, and means for by-passing one or the other of said capillaries whereby the pressure difference between said heat exchangers is provided by said cooling capillary during operation of said pump on the cooling cycle and by said heating capillary during operation of said pump on the heating cycle so that said conduit conducts high pressure refrigerant during either cycle of operation, and a refrigerant capacity booster means for augmenting refrigerant supply and refrigerant pressure circulating in said circuit, said booster means comprising a receiver having a supply of refrigerant therein, a supplementary circuit connecting said receiver to said capillary-connecting conduit and to the compressor suction line pressure responsive valve means in said supplementary circuit selectively operable between limits to supply refrigerant to said closed refrigerant circuit upon reduction of refrigerant pressure in said closed circuit or to remove refrigerant from said closed circuit upon increase of refrigerant pressure.

2. A heat pump as claimed in claim **1** and wherein said pressure responsive valve means comprises solenoid valves in the supplementary circuit, each of said solenoid valves having refrigerant pressure actuating means for energizing said valves at predetermined pressure limits to open or close said valves.

3. A heat pump as claimed in claim **2** and wherein said refrigerant pressure actuating means has a line connected to said discharge line to transmit refrigerant pressure.

4. A heat pump as claimed in claim **1** and wherein said pressure responsive valve means comprises a first solenoid valve operative to open between a first set of pressure conditions to admit refrigerant into said booster from said closed circuit and a second solenoid valve operative to open between a second set of pressure conditions to supply refrigerant to the closed circuit.

5. A heat pump comprising a reversible closed refrigerant circuit including an indoor heat exchanger, an outdoor heat exchanger, means in said circuit including a compressor having a discharge line and a suction line and reversing valve means for reversibly connecting said discharge and suction lines to said heat exchangers for effecting a flow of refrigerant through said circuit in either direction whereby said pump may be operated on a cooling cycle with the outdoor heat exchanger functioning as a condenser and receiving high pressure refrigerant from said compressor or on a heating cycle with the indoor heat exchanger functioning as a condenser and receiving high pressure refrigerant from said compressor, flow restricting means in said circuit for controlling the flow of refrigerant from either of said heat exchangers to the other and for maintaining a pressure difference between said heat exchangers, said flow restricting means comprising a cooling capillary connected in series to said indoor heat exchanger and a heating capillary connected in series to said outdoor heat exchanger, a conduit connecting said capillaries in series, and means for by-passing one or the other of said capillaries whereby the pressure difference between said heat exchangers is provided by said cooling capillary during operation of said pump on the cooling cycle and by said heating capillary during operation of said pump on the heating cycle so that said conduit conducts high pressure refrigerant during either cycle of operation, and a refrigerant capacity booster means for augmenting the refrigerant supply and pressure circulating in said circuit, said booster means comprising a receiver having a supply of refrigerant therein, an auxiliary circuit connecting said receiver to said capillary-connecting conduit and to the compressor suction line, electrically operated pressure responsive valve means in said supplementary circuit selectively operable automatically between limits to supply refrigerant to said closed refrigerant circuit upon reduction of rerfrigerant pressure in said closed circuit or to remove refrigerant from said closed circuit upon increase of regfrigerant pressure.

6. A heat pump as claimed in claim **5** in which said pressure responsive valve means comprises a first pressure actuated electrically energized solenoid valve operative to open only between a first set of pressure conditions to admit refrigerant into said capacity booster and a second pressure actuated electrically energized solenoid valve operative to open only between a second set of pressure conditions to remove refrigerant into said closed circuit suction line, said first valve being closed when said second valve is open and vice-versa.

7 A heat pump as claimed in claim **5** and wherein said pressure responsive valve means includes a pair of solenoid operated pressure operated valves, one of said valves being operative to admit refrigerant to said booster from said conduit and another of said valves being operative to admit refrigerant from the booster to the suction line of the closed circuit.

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