The present invention relates to heat pumps, otherwise known as reverse cycle refrigeration systems, and is more particularly concerned with a heat pump including a rotary compressor and means for supplying condensed liquid refrigerant to the compression chamber of the compressor for cooling purposes during operation of the heat pump on either the heating or the cooling cycle.

It is common practice in refrigeration systems to employ hermetically sealed motor compressor units in which the refrigerant compressor and its drive motor are both contained within a hermetically sealed casing and the motor is cooled by the circulating refrigerant. When the hermetic compressor unit is of the high side type, that is one in which the compressor withdraws low pressure refrigerant from the system and discharges high pressure refrigerant into the hermetic casing, it is desirable to provide some means for cooling the high pressure discharge gas from the compressor before it is passed over the motor. One means for cooling the discharge gas before passing it in heat exchange relationship with the motor comprises injecting a small amount of liquid refrigerant into the gas being compressed by the compressor. The injected liquid refrigerant flashes into vapor thereby cooling the discharge gas sufficiently to provide the desired cooling of the motor by the discharge gas. Compressors including means for injecting liquid refrigerant into the high pressure side of a rotary compressor for mixture with the gas being compressed therein are disclosed for example in Patents 3,109,297—Rinehart and 3,105,633—DeLario assigned to the same assignee as the present invention. In such compressors, liquid refrigerant from the condenser component of a refrigeration system including the compressor is introduced into the compression chamber through an injection port that is opened to the chamber during a period when the pressure of the gas in the chamber is lower than the pressure in the condenser and the pressure differential required for the injection is obtained by means of a fluid restriction between the condenser and evaporator components of the system.

The present invention is directed to heat pumps including rotary compressors including injection cooling arrangements and has as its principal object the provision of a heat pump or reverse cycle refrigeration system including means for assuring the required pressures at the injection port for introducing liquid refrigerant into the compression chamber during the operation of the heat pump on either the heating or the cooling cycle. Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification. In carrying out the objects of the present invention, there is provided a heat pump comprising an indoor heat exchanger and an outdoor heat exchanger connected in a closed refrigerant circuit and a hermetically sealed motor-driven rotary compressor and reversing valve means for effecting flow of refrigerant through the circuit in either direction whereby the heat pump can be operated either on the cooling cycle with the indoor heat exchanger functioning as an evaporator or on a heating cycle with the indoor heat exchanger functioning as a condenser. The hermetically sealed compressor includes a rotary compressor unit and a drive motor contained in a hermetic casing, the compressor unit being adapted to discharge high pressure refrigerant into the casing where it is passed in heat exchange relationship with the drive motor. For cooling the high pressure refrigerant discharged from the compressor into the casing, the compressor includes a port for injecting condensed liquid refrigerant into the high pressure side of the compression chamber during compression of the gas therein. In order to provide the required pressure differential to assure the liquid injection, the circuit includes two series-connected capillary tube sections for restricting the flow of refrigerant from either of the heat exchangers to the other and the liquid refrigerant supply means for supplying liquid refrigerant to the injection port is connected to the refrigeration circuit at a point between these two capillary tube sections whereby during operation of the heat pump on either cycle, the restriction provided by the one of the sections between the connection point and the heat exchanger operating as an evaporator will provide a pressure differential sufficient to introduce liquid refrigerant into the compression chamber.

For a better understanding of the invention reference may be had to the accompanying drawing in which:

FIGURE 1 is a somewhat schematic view of a heat pump including the present invention and

FIGURE 2 is a partial plan view of the compressor component of the system of FIGURE 1 taken generally along the line 2—2 of FIGURE 1.

Referring now to FIGURE 1 of the drawing, there is shown a heat pump or reversible refrigeration system comprising an indoor heat exchanger 1 and an outdoor heat exchanger 2, the indoor heat exchanger 1 being adapted to be employed for heating or cooling an enclosure. The two heat exchangers form part of a closed refrigerant circuit including means for withdrawing refrigerant from either one of the two exchangers and discharging compressed refrigerant into the other, such means comprising a compressor 3 and a reversing valve 4. The reversing valve 4 is designed to reversibly connect the discharge line 6 and the suction line 7 of the compressor to the remaining portion of the system so that the compressor will withdraw low pressure refrigerant from either the indoor or the outdoor heat exchanger and discharge compressed refrigerant into the other of the two heat exchangers. Thus the outdoor heat exchanger 2 functions as a condenser and the indoor heat exchanger 1 as an evaporator when the system is operated on the cooling cycle while the indoor heat exchanger 1 functions as a condenser and the outdoor heat exchanger 2 as an evaporator when the system is operated on the heating cycle.

For the purpose of controlling or restricting the flow of refrigerant from one heat exchanger to the other during normal operation of the system on either cycle, there is provided flow restricting means comprising series-connected capillary flow restrictors 8 and 9. A bypass line 10 including a check valve 11 is provided for bypassing the capillary 9. During operation of the heat pump on the heating cycle the check valve 11 is closed so that both the capillaries 8 and 9 provide flow restriction between the two heat exchangers. During operation of the system on the cooling cycle refrigerant flowing from the heat exchanger 2 bypasses the capillary 9 the only flow control is provided by the capillary 8, the purpose of this combination of flow restricting means being to provide a greater flow restriction during operation of the system on the heating cycle than on the cooling cycle.

The compressor 3 is of the type more fully described in the aforementioned Rinehart Patent 3,109,297 to which reference is made for a detailed description thereof. The compressor comprises a hemetic casing 12 in which there is contained a rotary compressor 14 including a housing...
3 defining an annular compression chamber 16. A rotor 17 is eccentrically rotated within the chamber 16 by means of an eccentric 18 forming part of a drive shaft 19 driven by a motor 20. The chamber 16 includes a suction or inlet port 22 connected to the suction line 7 through which low pressure refrigerant is drawn into the chamber 16 during rotation of the rotor 17. The gas 23 spaced from the inlet port 22 is provided for discharging high pressure or compressed refrigerant from the chamber 16 into a discharge chamber 24 from which it flows through a passage 25 into heat exchange relationship with the refrigerant within the chamber 16 and the discharge valve 27 controls the flow of refrigerant from the discharge port 23 and prevents the reverse flow of gas back into the chamber 16.

A movable blade 29 spring biased into engagement with the periphery of the rotor 17 and positioned between the suction port 22 and the discharge port 23 divides the chamber 16 into a low pressure side 30 and a high pressure side 31 whereby during eccentric rotation of the rotor 17 within the chamber 16, low pressure refrigerant is drawn into the chamber through the suction port 22 and is discharged through the discharge port 23 in accordance with the well known operation of a rotary compressor of this type.

For the purpose of introducing small amounts of liquid refrigerant into the high pressure gas discharged from the compressor through the passage 25 so that it may have a lower temperature gas stream for cooling the motor 20, there is provided an injection port 34 connected by a supply line 35 to a point in the refrigerant circuit containing high pressure condensed liquid refrigerant during operation of the system on either the heating or the cooling cycle. More specifically, the line 35 is connected to the point 36 in the circuit between the two capillary flow restrictors 8 and 9. Included in the supply passage 35 is a restriction schematically illustrated by the capillary 37 in order to limit the amount of refrigerant flow through the passage 35 and thereby prevent short circuiting of the evaporator component of the system during operation of the injection means.

As is more fully described in the aforementioned Ninehart patent, the injection port 34 is positioned in an end wall of the chamber 16 on the high pressure side of the blade 29, that is adjacent the discharge port 23, whereby the injected liquid refrigerant is mixed with the compressed refrigerant during compression and prior to discharge thereof with the valve 27. More specifically, the injection port 34 is positioned so that it is closed by the rotor 17 except for a short time during the latter portion of the compression cycle when it is opened to introduce liquid refrigerant into the chamber for mixture with the compressed refrigerant contained therein. Preferably the injection port 34 is opened at about the same time that the pressure of the gas being compressed within the high pressure side 31 of the chamber 16 is about 50% that in the case 12 and is closed before the pressure in the high pressure side 31 exceeds that of the case or exceeds the pressure at the point 36 between the two capillaries 8 and 9. The injected liquid refrigerant cools the gas flowing from the compressor into heat exchange with the motor 20 and thereby provides a lower temperature gas stream for removing motor heat.

By connecting the supply conduit or line 35 to a port in the refrigerant circuit between the two capillaries, the presence of one or the other of the two capillaries on the downstream side of the port 35 causes the heat pump on either of the heating or the cooling cycle to assure a pressure condition at the point 36 sufficient to effect injection of liquid refrigerant into the compressor chamber. More specifically, when the system is operating on the cooling cycle, the check valve 11 is open and the point 36 is at substantially the same pressure as the heat exchanger 2 operating as a condenser and the total flow restriction in the system and hence the pressure differential is provided by the capillary 8. As a result only high pressure liquid refrigerant at substantially the same pressure as that existing within the heat exchanger 2 flows through the conduit or passage 35 each time that the injection port 34 is open. During operation of the heat pump on the heating cycle, the check valve 11 is closed and the line of the capillaries 8 and 9 provide restriction to the flow of refrigerant from the indoor heat exchanger 1 operating as a condenser to the outdoor heat exchanger 2 operating as an evaporator. However, as the capillary 9 is downstream from the point 36 that is between the two heat exchangers the capillary 9 operating as an evaporator, the flow restriction provided by the capillary 9 produces a pressure differential sufficient to cause introduction of liquid refrigerant into the chamber 16.

While there has been shown and described what is presently considered to be a preferred embodiment of the present 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 intended by 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. A heat pump comprising an indoor heat exchanger and an outdoor heat exchanger, and a refrigerant circuit and a hermetically sealed motor-driven rotary compressor and reversing valve means in said circuit for effecting flow of refrigerant through said circuit in either direction whereby said pump may be operated on a cooling cycle with the indoor heat exchanger functioning as an evaporator or on a heating cycle with the indoor heat exchanger functioning as a condenser, flow restricting means comprising two series-connected capillary tube sections, said hermetically sealed compressor comprising a hermetic casing and a rotary compressor unit discharging high pressure refrigerant into said casing and a drive motor in said casing cooled by said high pressure refrigerant, said compressor unit including spaced inlet and discharge ports and a blade slidably extending into said chamber into contact with said rotor between said ports thereby to divide said chamber into high and low temperature portions and means for injecting liquid refrigerant into said casing through an injection port for injecting condensed liquid refrigerant into the high pressure side of said annular chamber during compression of refrigerant gas therein, and a liquid refrigerant supply means connecting said injection port with a point in said circuit between said capillary tube sections whereby during operation of said heat pump on either cycle, the restriction provided by the one of said sections between said point and the heat exchanger operating as an evaporator will provide a pressure differential sufficient to introduce liquid refrigerant into said chamber.

2. A heat pump comprising an indoor heat exchanger and an outdoor heat exchanger connected in a closed refrigerant circuit and a hermetically sealed motor-driven rotary compressor in said circuit for effecting flow of refrigerant through said circuit in either direction whereby said pump may be operated on a cooling cycle with the indoor heat exchanger functioning as an evaporator or on a heating cycle with the indoor heat exchanger functioning as a condenser, flow restricting means comprising two series-connected capillary tube sections, said hermetically sealed compressor comprising a hermetic casing and a rotary compressor unit discharging high pressure refrigerant into said casing and a drive motor in said casing cooled by said high pressure refrigerant, said compressor unit including spaced inlet and discharge ports and a blade slidably extending into said chamber into contact with said rotor between said ports thereby to divide said chamber into high and low temperature portions and means for injecting liquid refrigerant into said casing through an injection port for injecting condensed liquid refrigerant into the high pressure side of said annular chamber during compression of refrigerant gas therein, and a liquid refrigerant supply means connecting said injection port with a point in said circuit between said capillary tube sections whereby during operation of said heat pump on either cycle, the restriction provided by the one of said sections between said point and the heat exchanger operating as an evaporator will provide a pressure differential sufficient to introduce liquid refrigerant into said chamber.
means comprising two series-connected capillary tube sections and a check valve controlled conduit bypassing the one of said sections closest to said outdoor heat exchanger only during operation of said heat pump on the cooling cycle,
said hermetically sealed compressor comprising a hermetic casing and a rotary compressor unit discharging high pressure refrigerant into said casing and a drive motor in said casing cooled by said high pressure refrigerant,
said compressor unit including spaced inlet and discharge ports and a blade slidably extending into said chamber onto contact with said ports thereby to divide said chamber into high and low pressure sides,
means including an injection port for injecting condensed liquid refrigerant into the high pressure side of said annular chamber during compression of refrigerant gas therein,
and a liquid refrigerant supply means connecting said injection port with a point in said circuit between said capillary tube sections whereby during operation of said heat pump on either cycle the restriction provided by the one of said sections closest to said outdoor heat exchanger only during operation of said heat pump on the cooling cycle,
flow restricting means in said circuit between said heat exchangers for controlling the flow of refrigerant from either of said heat exchangers to the other heat exchanger, said flow restricting means comprising two series-connected capillary tube sections and a check valve controlled conduit bypassing the one of said sections closest to said outdoor heat exchanger only during operation of said heat pump on the cooling cycle,
said hermetically sealed compressor comprising a hermetic casing and a rotary compressor unit and a drive motor in said casing,
said compressor unit including a cylinder having an annular compression chamber therein and end walls enclosing the ends of said annular chamber and a rotor eccentrically rotatable within said chamber and having a peripheral surface adapted to move progressively into sealing relation with successive portions of said annular chamber,
said motor including a shaft for driving said rotor within said chamber,
said compressor unit including spaced inlet and discharge ports and a blade slidably extending into said chamber into contact with said rotor between said ports thereby to divide said chamber into high and low pressure sides,
said inlet port being connected to said valve means,
means for conducting hot compressed refrigerant gas from said discharge port into said hermetic casing, means for conducting high pressure refrigerant from said casing to said valve means,
means for injecting condensed liquid refrigerant into said annular chamber including a liquid refrigerant injection port on the discharge port side of said blade and adapted to be covered and uncovered by the end of said rotor during the rotation thereof to compress refrigerant in said chamber,
and a liquid refrigerant supply means connecting said injection port with a point in said circuit between said capillary tube sections whereby during operation of said heat pump on either cycle the restriction provided by the one of said sections between said point and the heat exchanger operating as an evaporator will provide a pressure differential sufficient to introduce liquid refrigerant into said chamber when said injection port is uncovered.

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WILLIAM J. WYE, Primary Examiner.