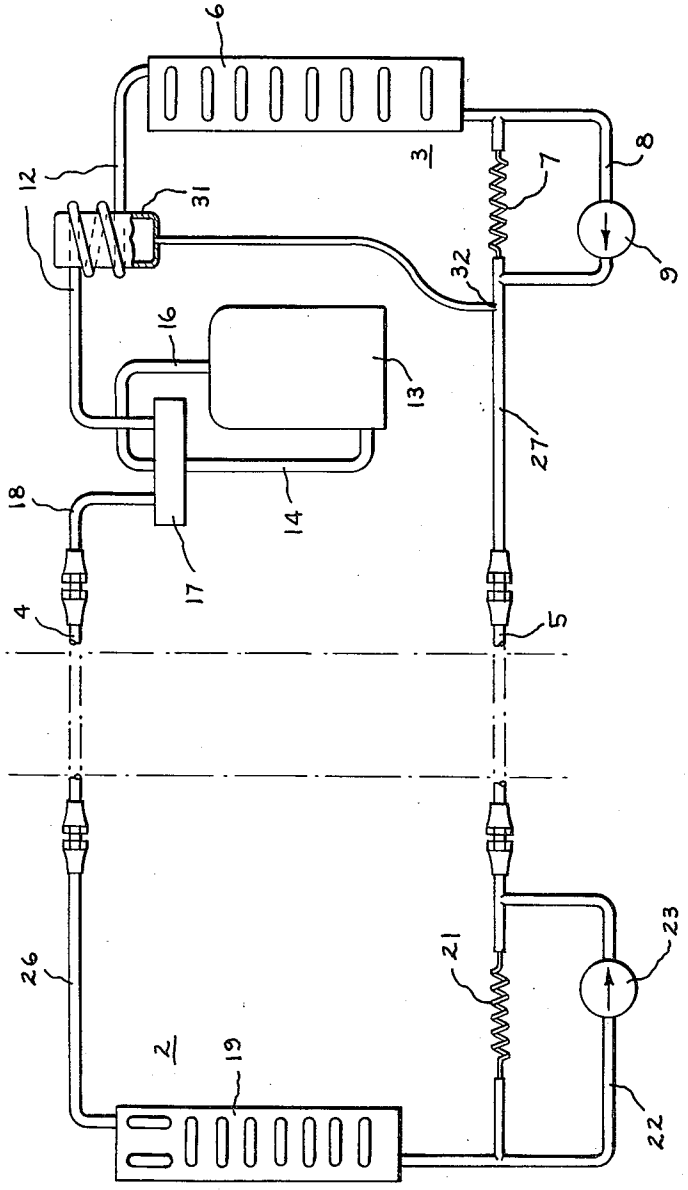
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HEAT PUMP INCLUDING CHARGE MODIFYING MEANS

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INVENTORS
HAROLD G. VANDERLEE
& HERBERT M. BRODY
BY
THEIR ATTORNEY

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HEAT PUMP INCLUDING CHARGE MODIFYING MEANS

Harold G. Vanderlee and Herbert M. Brody, Tyler, Tex., assignors to General Electric Company, a corporation of New York

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The present invention relates to heat pumps of the split system type having an outdoor unit and an indoor unit connected by lengths of refrigerant tubing and more particularly to a heat pump system of this type having an arrangement for varying the effective quantity of refrigerant flowing through the system during heating operation as compared to the quantity flowing through the system during cooling operation.

The length of tubing required to connect the separated units of a split-unit type heat pump system varies a great deal for the many different types of installation requirements. Thus the total volume of these systems cannot be known until they are installed, making it necessary to finalize the refrigerant charge of the particular system after it has been installed. Rather than attempt to compute the total volume of each installed system and then insert the required quantity of refrigerant, it is easier to charge the system according to methods generally used in the industry, such as charging it up to a particular pressure which pressure is the same optimum operating pressure for all such systems, under the temperature conditions prevailing when the system is to be charged, regardless of the amount of tubing required to connect the separate units of the system.

As is well understood in the art, a heat pump is normally provided with a reversing means for directing the flow of high pressure refrigerant gas from a compressor into either of two series connected heat exchangers and for returning the low pressure refrigerant from the other heat exchanger to the compressor. The conditions prevailing during operation of the system in one direction as compared to those prevailing while operating in the other direction are usually such as to require, for most optimum performance of the heat pump, that the refrigerant charge flowing through the system be less in one direction than when operating in the other direction. In most heat pumps, it is desirable to decrease the effective refrigerant charge flowing in the circuit during the winter or heating cycle operation over the charge designed to give optimum performance during the summer or cooling operation.

A well-known arrangement for automatically taking care of the different refrigerant flow requirements of the system is to utilize a receiver which permits a certain quantity of refrigerant to condense out of the system when the system is reversed from the cooling to the heating cycle. The use of a receiver for effecting charge modulation between the heating and cooling cycles in a split-unit type of system presents a problem with respect to field charging of the system to a predetermined pressure. That is, when the system is charged while on the cooling cycle and, if the receiver is exposed to the outdoor air stream, the refrigerant sometimes condenses in the receiver, completely filling it before the predetermined pressure for the system is attained. When the system is then changed to the heating cycle, there is no volume left in the receiver for removing or storing the excess refrigerant in the system and the heat pump must necessarily operate with more refrigerant flowing therethrough than is desired for optimum performance of the system on the heating cycle. This, of course, defeats the purpose of the receiver which must have unfilled volume available for storage of refrigerant when changed from the cooling cycle to the heating cycle. Therefore, split-type heat pump systems, which are to be charged in the field to a particular pressure, should be provided with other means for modulating the effective charge flowing through the system during the respective operating cycles.

It is desirable therefore, in split-unit type heat pump systems, to provide an arrangement whereby the effective refrigerant charge in the system may be changed to provide optimum performance on both the heating and cooling cycle operations which arrangement will not be affected during the charging operation by the temperature conditions under which the system is charged.

Accordingly, it is an object of the present invention to provide a refrigeration system of the split unit type having an improved arrangement for varying the effective refrigerant charge in the system during heating and cooling operations, yet permitting the system to be charged up to a particular pressure in the field under all temperature conditions rather than being charged with a particular quantity of refrigerant.

In carrying out the objects of the present invention there is provided a heat pump of the split unit type embodying the indoor heat exchange unit and an outdoor heat exchange unit connected by suitable refrigerant tubing to providing a closed refrigerant circuit. The indoor unit includes a heat exchanger, a refrigerant flow control means and means for bypassing refrigerant around the flow control means when flow of refrigerant is from the heat exchanger toward the indoor flow control means. The outdoor unit includes an outdoor heat exchanger, an outdoor flow control means, and means for bypassing the outdoor flow control means when flow of refrigerant is from the outdoor heat exchanger toward the outdoor flow control means. The outdoor unit also includes a compressor and a reversing valve for reversibly directing the flow of refrigerant through the circuit so that high pressure gas may be first directed either into the outdoor heat exchanger or into the indoor heat exchanger while withdrawing low pressure refrigerant from the opposite heat exchanger thereby operating each of these heat exchangers interchangeably as a condenser or as an evaporator. A dead-end charge modifying receptacle is connected by a two-way flow connection to the refrigerant circuit between the indoor and outdoor flow control means so that the modulator is always exposed to high pressure refrigerant during either cycle of operation. In order to control the modifying effect of the receptacle it is placed in heat exchange relationship with the conduit leading from the reversing valve to the outdoor heat exchanger so that the receptacle is heated or cooled by the refrigerant gas flowing through the conduit between the reversing valve and the outdoor heat exchanger. Thus, the receptacle is filled with condensed refrigerant from the system when suction gas is flowing through the conduit and the receptacle discharges this volume of refrigerant into the circuit when hot discharge gas from the compressor is flowing through the conduit.

For a better understanding of the invention, reference may be had to the accompanying drawing, the single figure of which is a diagrammatic illustration of a reverse cycle refrigeration circuit of the split-unit type embodying the present invention.

Referring now to the drawing, the heat pump of the present invention comprises an indoor heat exchange unit, designated generally by the reference number 2, and an outdoor heat exchange unit, designated by the reference numeral 3. The indoor and outdoor units are connected by suitable refrigerant tubing 4 and 5 connecting opposite sides of each of the units and forming a closed refrigerant circuit. The length tubing 4 and 5 is, of course, different for the various types of installations of heat

pump and, therefore, the total volume of the system cannot be determined until after installation is made.

The outdoor heat exchange unit 3 comprises an outdoor heat exchanger 6, an outdoor capillary 7, or other flow control means such as a well known thermally controlled expansion valve, and means for bypassing refrigerant around the outdoor capillary 7 when the heat pump is operated as a cooling unit and the outdoor heat exchanger is being utilized as a condenser. In order to bypass refrigerant around the capillary 7, there is provided a bypass line 8 and a check valve 9 which permits flow of refrigerant through the bypass line 8 when refrigerant is flowing from the heat exchanger 6 toward the flow control means or capillary 7, or when the heat exchanger 6 is operated as a condenser. When the refrigerant is flowing from the indoor unit 2 in the direction toward the heat exchanger 6, the check valve 9 closes and all refrigerant must flow through the capillary 7. The capillary 7 then changes the pressure of the refrigerant from condenser to evaporator pressure and the heat exchanger 6 is then operated as an evaporator.

The outdoor heat exchanger unit 3 also includes a compressor 13 having suction line 16 and discharge line 14 connecting respectively with a reversing valve 17. The reversing valve 17 connects the suction line 16 and the discharge line 14 with the remaining portions of the circuit so that the compressor withdraws refrigerant from either the outdoor heat exchanger 6 or from an indoor heat exchanger 19 and discharges refrigerant into the other of the two heat exchangers. More specifically, the reversing valve 17 connects with the outdoor heat exchanger 6 by means of the conduit 12 and also connects with the refrigerant tube 4 leading to the indoor heat exchange unit.

The indoor unit 2 comprises an indoor heat exchanger 19 and an indoor capillary or flow control means 21 connected in series, and a bypass means around the capillary 21 for bypassing refrigerant around the capillary when the heat pump is operating on the heating cycle or, more specifically, when the refrigerant flow is from the heat exchanger 19 toward the expansion valve 21. In the illustrated embodiment of the invention, the bypass means comprises a bypass tube 22 and a check valve 23 which prevents the flow of refrigerant through the tube 22 when refrigerant is flowing in the direction from the connecting tubing 5 leading from the outdoor unit toward the heat exchanger 19. It should be mentioned that capillary 21 is similar in operation to capillary 7 and that both capillaries 7 and 21 are sized to give optimum performance for the respective heating and cooling operations. That is capillary 21 provides the restriction for optimum performance of the refrigeration system under those conditions normally encountered during the cooling season and capillary 7 provides the restriction to give optimum performance of the refrigerating system under those conditions normally encountered during the heating season.

When the system is operated on the cooling cycle, compressed refrigerant from the compressor 13 is directed by the reversing valve 17 to the outdoor heat exchanger 6 in which the refrigerant is condensed. Liquid refrigerant flows from the outdoor heat exchanger 6 through the bypass line 8 and into conduit 27, which connects with the indoor unit through the refrigerant tube 5. Condensed refrigerant then flows through the indoor capillary 21 into the indoor heat exchanger 19, which functions as an evaporator. In heat exchanger 19 the refrigerant is evaporated by absorbing the heat from an air stream circulated through heat exchanger 19 from the dwelling or other structure being conditioned. When the circuit is operated on the heating cycle, the compressed refrigerant from the compressor 13 is directed by the reversing valve 17 through the line 18, connecting with the refrigerant tube 4, into the heat exchanger 19 where the heat liberated during condensation heats the space being conditioned. The condensed refrigerant from the indoor heat exchanger 19 then flows through the bypass conduit 22 into the refrigerant line 5 leading to the outdoor unit 3. The refrigerant then passes through the thermal expansion valve 7 and is expanded to evaporator pressures whereupon it enters the heat exchanger 6 which, on the heating cycle, functions as an evaporator. It should be mentioned that the conduit 12 contains hot discharge gas during operation of the system on the cooling cycle and contains cold suction gas during operation of the system on the heating cycle.

Because of the great difference in the temperature of the air being circulated over the evaporator during operation of the heat pump in the opposite directions and because the heat exchangers are usually made of different sizes, the reversal of the refrigerant flow through the heat pump circuit also changes the thermodynamic characteristics of the circuit, and the refrigerant charge in the system which is correct for one direction of flow is usually wrong for the other. In most cases it has been found desirable to provide a greater refrigerant charge when the heat pump is operating on the cooling cycle than when it is operated on heating cycle. As was pointed out previously, many types of refrigeration systems handle this disparity in the amount of charge required within the system for the different directions of operation by providing an accumulator or receiver in the system into which the excess refrigerant condenses out and is stored during operation of the system on the heating cycle and which evaporates and enters the system on the cooling cycle to supply the necessary refrigerant charge for optimum performance of the system. However, as stated before with respect to a refrigeration system of the split unit type, the use of a receiver is not always practical where it is desirable to charge the system up to a particular pressure in the field, because, under certain temperature conditions, the receiver becomes entirely filled with condensed refrigerant when it should remain substantially empty.

In order to control or modify the effective refrigerant charge circulating in the split-unit type of heat pump circuit for the purpose of obtaining maximum possible operating efficiency during both the heating and cooling operations and in order to permit charging of the system up to a predetermined pressure during either cycle of operation, the present invention provides a charge modifying receptacle 31 which controls the effective charge in the circuit during heating and cooling operation. The charge modifying receptacle is connected into the circuit between the indoor and outdoor capillaries 7 and 21, or between the indoor and outdoor flow control means, by a two-way flow connection 32 so that the receptacle is connected to a portion of the circuit which is always at a high pressure. In the illustrated embodiment, the receptacle 31 connects with the line 27 through which condensed high pressure refrigerant flows during both directions of operation. The charge modifying receptacle has no other outlet and is therefore a "dead-end" type of receptacle. The charge modifying receptacle 31 is of a volume equal to the difference in the charge required for optimum operating efficiency of the system between the cooling and heating cycles so that it will remove from the system or discharge into the system precisely that amount of refrigerant required for optimum operation of the heat pump on the heating or the cooling cycles.

As may be seen in the drawing, the receptacle 31 is in heat exchange relationship with the conduit 12 leading between the reversing valve 17 and the heat exchanger 6. Thus, it will be seen that, when the unit is operating on the cooling cycle and the heat exchanger 6 is functioning as a condenser, hot high pressure discharge gas, which flows from the compressor through the conduit 12, heats the charge modulating receptacle 31 and boils off all liquid refrigerant within the receptacle. This, of course, drives the refrigerant out of the receptacle 31 into the circuit. When the heat pump is operating on the heating cycle and the heat exchanger 6 is functioning as an

evaporator, the conduit **12** carries cold suction gas from the heat exchanger **6** to the reversing valve and this cools the receptacle **31** so that refrigerant, which is forced into the receptacle by the high pressure line **27**, is caused to condense therein and become effectively removed from the system.

It may be seen that the arrangement of the present invention permits charging of the refrigeration system up to a predetermined pressure while still permitting the system to regulate itself to provide optimum flow of refrigerant through the system during both the heating and cooling cycles. If this system is charged while on the cooling cycle, the conduit **12**, which is running hot, forces refrigerant out of the receptacle **31** into the system so that, when the system is fully charged up to a predetermined pressure, there is no condensed refrigerant in the charge modulating receptacle. Because the hot discharge conduit **12** is in heat exchange relationship with the receptacle **31**, there is never any condensation of refrigerant out of the system in the receptacle even though the temperature of the outdoor air stream may, on the cooling cycle, be such as to ordinarily condense the refrigerant within a receptacle exposed to this air stream. However, when the system is charged in the winter while operating on the heat cycle, the conduit **12** which is then carrying cold suction gas causes refrigerant to condense out of the system and fill the receptacle **31** before the system is completely charged up to the pressure desired for winter or heating operation. Therefore, when the heat pump is changed over for cooling operation this volume of refrigerant is discharged from the receptacle into the system to provide optimum performance of the system on the cooling cycle.

By the present invention there has been provided a simple arrangement for providing a heat pump adapted to modify the effective charge of the refrigerant in the circuit to provide optimum performance of the heat pump during both the heating and cooling cycles. Moreover, this arrangement permits the circuit or heat pump system of the split-unit type to be charged in the field up to a predetermined pressure without overcharging the system.

While there has been described what at present is considered to be the preferred embodiment of the invention it will be apparent to one skilled in the art that some 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 we claim as new and desire to secure by Letters Patent of the United States is:

1. A heat pump comprising an indoor heat exchange unit and an outdoor heat exchange unit adapted for field connection to a pair of refrigerant lines leading through the wall of an enclosure to provide a closed refrigerant circuit; said indoor heat exchange unit including an indoor heat exchanger, an indoor refrigerant flow control means, and means for bypassing refrigerant around said indoor flow control means when refrigerant flow is in a direction from said indoor heat exchanger toward said indoor flow control means, said outdoor heat exchanger unit including an outdoor heat exchanger, an outdoor refrigerant flow control means, means for bypassing refrigerant around said outdoor flow control means when said refrigerant flow is in a direction from said outdoor heat exchanger toward said outdoor flow control means, said outdoor and indoor flow control means being connected in series flow relation by one of said pair of refrigerant lines, a reversing valve having a conduit connecting with said outdoor heat exchanger, said reversing valve connecting with said indoor heat exchanger through one of said pair of refrigerant lines, a compressor having its suction and discharge lines connecting with said

reversing valve for selectively directing the flow of high pressure refrigerant gas into either of said heat exchangers while withdrawing low pressure suction gas from the opposite heat exchanger, and a charge modifying receptacle having a two-way flow connection to said refrigerant line between said indoor and outdoor flow control means, said charge modifying receptacle being in heat exchange relationship with said conduit connecting said reversing valve to said outdoor heat exchanger so that refrigerant equal to the volume of said modifying receptacle is withdrawn and discharged into said circuit in response to the temperature of refrigerant gas flowing through said conduit between said outdoor heat exchanger and said reversing valve.

2. A heat pump comprising an indoor heat exchange unit and an outdoor heat exchange unit adapted for field connection to a pair of refrigerant lines leading through the wall of an enclosure to provide a closed refrigerant circuit; said indoor heat exchange unit including an indoor heat exchanger, an indoor capillary expansion means, and means for bypassing refrigerant around said indoor capillary expansion means when refrigerant flow is in a direction from said indoor heat exchanger toward said indoor capillary expansion means; said outdoor heat exchange unit including an outdoor heat exchanger, an outdoor capillary expansion means, means for bypassing refrigerant around said outdoor capillary expansion means when refrigerant flow is in a direction from said outdoor heat exchanger toward said outdoor capillary expansion means, said outdoor and said indoor capillary expansion means being connected in series flow relationship by one of said pair of refrigerant lines leading through the wall of said enclosure so that said one refrigerant line conducts high pressure refrigerant during either cycle of operation; a reversing valve having a conduit connecting with said outdoor heat exchanger, said reversing valve connecting with said indoor heat exchanger through said other refrigerant line leading through the wall of said enclosure, a compressor having suction and discharge lines connecting with said reversing valve for selectively directing the flow of high pressure refrigerant gas into either of said heat exchangers while withdrawing low pressure suction gas from the opposite heat exchanger, and a charge modifying receptacle having a two-way flow connection to said refrigerant line between said indoor and outdoor capillary expansion means so that the connection to said charge modifying receptacle is always connected to a high pressure part of said circuit during either cycle of operation, said charge modifying receptacle being in heat exchange relationship with said conduit connecting said reversing valve to said outdoor heat exchanger so that liquid refrigerant equal to the volume of said receptacle is withdrawn and discharged into said circuit in response to the temperature of said refrigerant gas flowing through said conduit between said outdoor heat exchanger and said reversing valve.

3. A heat pump comprising an indoor heat exchange unit and an outdoor heat exchange unit adapted for field connection to a pair of refrigerant lines leading through the wall of an enclosure to provide a closed refrigerant circuit; said indoor heat exchange unit including an indoor heat exchanger, an indoor capillary expansion means, and means for bypassing refrigerant around said indoor capillary expansion means when refrigerant flow is in the direction from said indoor heat exchanger toward said indoor capillary expansion means; said outdoor heat exchange unit including an outdoor heat exchanger, an outdoor capillary expansion means, means for bypassing refrigerant around said outdoor capillary expansion means when refrigerant flow is in a direction from said outdoor heat exchanger toward said outdoor capillary expansion means, said outdoor and indoor capillary expansion means being connected in series flow relationship by one of said pair of refrigerant lines leading

through the wall of said enclosure, a reversing valve having a conduit connecting with said outdoor heat exchanger, said reversing valve connecting with said indoor heat exchanger through one of said pair of refrigerant lines extending through said wall of the enclosure, a compressor having its suction and discharge lines connecting with said reversing valve for selectively directing flow of refrigerant through said circuit in either direction so that said heat pump may be operated on a cooling cycle with said outdoor heat exchanger receiving high pressure refrigerant from said compressor and functioning as a condenser or operated on a heating cycle with said indoor heat exchanger receiving high pressure refrigerant from said compressor and functioning as a condenser, said circuit requiring a larger charge of refrigerant for efficient operation on said cooling cycle than on said heating cycle, a charge of refrigerant in said circuit substantially equal to that necessary for efficient operation of the circuit on said cooling cycle, and a charge modifying means including a dead-end receptacle having a two-

way flow connection with said refrigerant line between said indoor and outdoor capillary expansion means, said receptacle having a volume equal to the difference in liquid volume between the charge required for optimum performance during the cooling operation as compared to that required for optimum heating operation, said receptacle being in heat exchange relationship with said conduit connecting said reversing valve to said outdoor heat exchanger so that refrigerant condenses in said receptacle when low pressure refrigerant gas flows through said conduit from said outdoor heat exchanger and is expelled from said receptacle when high pressure refrigerant gas is directed into said conduit toward said outdoor heat exchanger.

References Cited in the file of this patent

UNITED STATES PATENTS

2,589,384	Hopkins	Mar. 18, 1952
2,934,323	Burke	Apr. 26, 1960