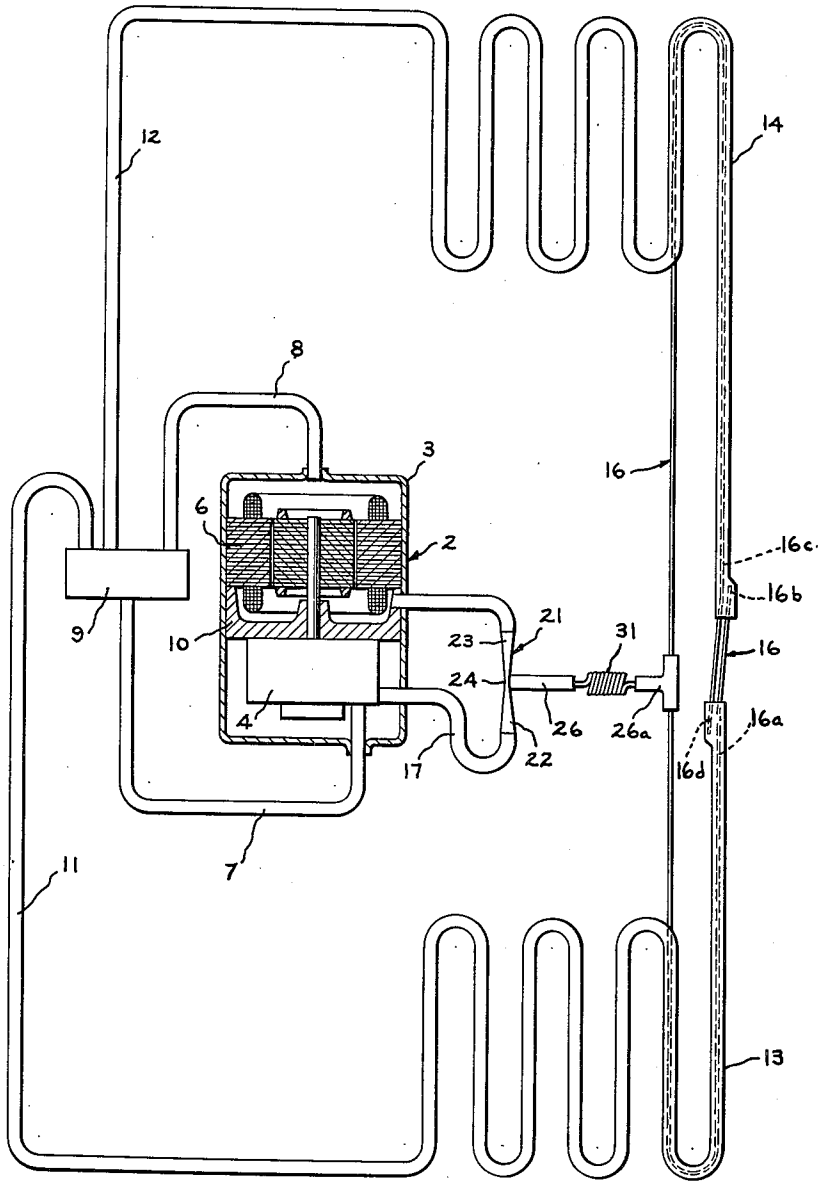
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COMPRESSOR MOTOR COOLING ARRANGEMENT FOR REVERSIBLE REFRIGERATION SYSTEM

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INVENTOR.
DON J. MASSA

BY

HIS ATTORNEY

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COMPRESSOR MOTOR COOLING ARRANGEMENT FOR REVERSIBLE REFRIGERATION SYSTEM

Don J. Massa, Louisville, Ky., assignor to General Electric Company, a corporation of New York

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The present invention relates to a reversible refrigeration system for an air conditioning unit adapted for heating or cooling an enclosure and more particularly to a reversible refrigeration system utilizing a compressor of the type commonly known as a "high side case" in which the high pressure discharge gas issuing from the compressor is passed into the compressor case for cooling the motor.

It is common practice in the field of refrigeration to mount both the refrigerant compressor and its drive motor within a hermetically sealed casing. In such an arrangement, it is necessary to devise some means for cooling the drive motor in order to maintain its temperature within safe operating limits. One means employed for this purpose is to pass the high pressure discharge gas from the compressor unit over the compressor motor after this high pressure gas has been cooled to a low enough temperature to remove heat from the motor thereby maintaining the motor at a safe operating temperature. The heat removed from the motor is carried by the gas into the condenser of the refrigeration system where it is dissipated into the air stream flowing over the condenser. This is an efficient method of maintaining the motor at a proper operating temperature but requires that the high pressure discharge gas be precooled before being passed into intimate contact with the motor.

One means devised for cooling the high pressure discharge gas incorporates the injection of condensed refrigerant from some portion of the refrigerating system, such as from the condenser, into the hermetic casing where it mixes with the high pressure discharge gas to cool this gas prior to passing it over the motor. However, in order to introduce liquid refrigerant from some other portion of the refrigeration system into the high pressure gas stream from the compressor, it is necessary to overcome the pressure drop which occurs in the system up to the point from which the refrigerant is to be taken. An arrangement for accomplishing this function in a non-reversible refrigeration system is disclosed in the invention of the application of James L. Schulze, Serial No. 860,848, filed December 21, 1959, now Patent No. 2,967,410, and assigned to the assignee of the present application. The present invention is an improvement over the Schulze invention, which invention was made by the said James L. Schulze prior to the present invention. The present application does not claim anything shown or described in said Schulze application, which is to be regarded as prior art with respect to this present application.

A difficulty encountered when applying an injection type cooling arrangement to a reversible type refrigeration system is that the condensed refrigerant is not always found in the same portion of the system. That is, during the summer when the unit is operating on the cooling cycle, the condensed liquid refrigerant is available at the outdoor heat exchanger, while in the winter when the unit is operating on the heating cycle to provide heat for an

enclosure, the source of condensed refrigerant is at the indoor heat exchanger. Thus, in order to supply condensed refrigerant for injection into the hermetic case, it is necessary to devise some means for always assuring that the condensed liquid refrigerant will be available regardless of the direction of operation of the system.

Accordingly, it is an object of the present invention to provide an improved arrangement in a reversible refrigeration system for injecting condensed liquid refrigerant into the hermetic casing for cooling the motor during operation of the system in either direction.

A more specific object of the present invention is to provide, in a reversible refrigeration system using a capillary to expand the refrigerant from condenser pressure to evaporator pressure, an improved injection cooling arrangement for a compressor motor in which liquid refrigerant utilized for injection purposes is tapped from the capillary of the refrigeration system.

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 accordance with the present invention, there is provided a reversible refrigeration system for an air conditioning unit adapted for heating and cooling an enclosure including a motor-compressor unit sealed within a hermetic casing and connected in reversible refrigerant flow relationship with an indoor heat exchanger and an outdoor heat exchanger. A capillary is connected between the heat exchangers for expanding refrigerant from condenser pressure to evaporator pressure as refrigerant flows through the system. A discharge passage leads from the compressor into the hermetic casing for conducting high pressure discharge gas from the compressor into the casing for cooling the motor of the unit. A portion of this discharge passage takes the form of an aspirating means, such as a venturi or jet pump, which means creates a region of lower pressure in the high pressure gas flowing through the passage. A liquid refrigerant conduit is connected between the aspirating means and the capillary for introducing liquid refrigerant from the capillary into the aspirating means where it mixes with the high pressure gas flowing through the aspirating means to cool the high pressure gas flowing through the aspirating means and thereby to cool the compressor motor. In order to reduce the pressure drop in that portion of the capillary prior to its connection with the liquid refrigerant conduit regardless of the direction of refrigerant flow through the system, the capillary is arranged so that the portion thereof adjacent its end communicating with the outdoor heat exchanger is in heat exchange relationship with the indoor heat exchanger and that portion thereof adjacent its end communicating with the indoor heat exchanger is in heat exchange relationship with the outdoor heat exchanger so that the heat exchanger operating as an evaporator during either direction of refrigerant flow through the system cools that portion of the capillary prior to its connecting point with the refrigerant supply conduit.

For a better understanding of the invention reference may be had to the accompanying drawing, the single FIGURE of which illustrates in somewhat schematic form a reversible refrigeration system incorporating the present invention.

Referring now to the drawing, there is shown a rever-

sible cycle refrigeration system for use in an air conditioner of the type adapted to both heat and cool the air from an enclosure. For compressing and pumping refrigerant through the system there is provided a motor-compressor unit, generally designated by the reference numeral 2. The motor-compressor unit 2 is mounted in a hermetically sealed casing 3 which houses the compressor 4 and its drive motor 6 and which is suitable for containing a high pressure refrigerant gas. A suction line 7 connects directly with the suction inlet (not shown) of the compressor and carries low pressure refrigerant gas to the compressor. A discharge line 8 is connected to the case for carrying the high pressure gas from within the case into the remaining portions of the system. The discharge line and suction line are both connected to a reversing valve 9. Also connected to the reversing valve 9 are a pair of conduits 11 and 12 which lead respectively to the indoor and outdoor heat exchangers or coils 13 and 14. Included in the system for the purpose of expanding refrigerant from condensing pressure to evaporator pressure is a first or main capillary expansion means 16. This capillary operates as an expansion means during both cooling and heating cycles and maintains a predetermined pressure differential between the evaporator and the condenser regardless of the direction of refrigerant flow.

In an air conditioning unit of this type, the indoor coil 13 is arranged for heating or cooling air from the enclosure, while the outdoor coil 14 is arranged for either rejecting heat to or extracting heat from the outside atmosphere. The reversing valve 9 is selectively reversible to direct discharge gas into either one of the lines 11 and 12 while receiving low pressure gas from the other line, thereby making the system reversible for either heating or cooling an enclosure. Thus, if it is desirable to set this system on the heating cycle, compressor discharge gas flowing through the discharge line 8 is connected by means of the reversing valve 9 to the line 11 which carries the hot discharge gas to the indoor coil 13. This coil then acts as a condenser to give up its heat to the enclosure. If it is desired to set the system for cooling the enclosure, the suction line 7 is connected to the indoor coil 13 through a line 11, which then acts as an evaporator, while the discharge gas is carried to the outdoor coil 14 by the line 12.

During operation of the compressor, low pressure refrigerant, entering the compressor unit 6 from the suction line 7, is compressed within the compressor unit to a relatively high pressure and temperature and is then discharged by the compressor through a suitable discharge passage 17, leading from the compressor discharge port (not shown) into the hermetic casing 3. For purposes of illustration, the discharge passage 17 is shown as a tube leading out of the hermetic casing and then back into the hermetic casing. However, this discharge passage could be a passage, such as that illustrated in the aforementioned Schulze application, which leads from the discharge port of the compressor unit directly through the main frame 10 of the unit into the hermetic casing 6 without leaving the hermetic casing. Included within the discharge passage is an aspirating means or a venturi section, generally designated by the reference numeral 21, through which hot discharge gas passes prior to entering the hermetic case. The passage 17 discharges the high pressure gas into the case below the motor 6 whereupon it flows upwardly over the motor to cool the motor. The high pressure gas is then conducted out of the casing 3 through the conduit 8 into the remaining portions of the system.

In order to cool the discharge gas flowing through the discharge passage 17 sufficiently to maintain the motor 6 at a safe operating temperature, cool liquid refrigerant is withdrawn from the capillary 16 through the liquid supply conduit 26 and introduced into the high pressure gas as it flows through the aspirating means. As may be seen in the drawing, the aspirating means contains a nozzle or gas accelerating section 22 and a diffuser or gas decelerating section 23 separated by a pinched or throat portion 24. As the high pressure discharge gas flows through the aspirating means, it drops in pressure in the nozzle section 22 where its velocity is increased. Then, in the diffuser section of the aspirating means, the gas pressure increases to approximately its original pressure as the velocity of the gas decreases. Thus, a pressure drop is created in the aspirating means and a region of somewhat lower pressure is created in the throat 24 of the aspirating means as compared to the pressure of the gas discharging from the aspirating means. This pressure drop in the throat 24 causes liquid or condensed refrigerant to be siphoned through the liquid supply conduit 26 which connects with the capillary. The condensed refrigerant is than mixed with the high pressure gas flowing through the discharge passage 17 and is carried by the high pressure gas into the hermetic casing 3.

Obviously, if the pressure of the refrigerant at the point the system is tapped by the conduit 26 is not greater than the pressure of the gas in the throat 24 of the venturi or aspirating means, there will be no flow of liquid refrigerant through the conduit 26. Normally the pressure in the throat 24 is less than the latter stages of the heat exchanger operating as a condenser. However, the restriction in the early stages of the capillary must be reduced as much as possible in order to prevent the pressure of the refrigerant at the conecting point 26*a* of the conduit 26 and the capillary from dropping below that in the throat 24 of the venturi.

In order to reduce the pressure drop in that portion of a capillary 16 prior to its connecting point 26*a* with the refrigerant supply conduit 26, the capillary is arranged so that the portion thereof ahead of the connecting point with the refrigerant supply conduit 26 is always cooled by the heat exchanger operating as an evaporator. Referring now to the drawing, it can be seen that the portion 16*a* of the capillary adjacent the end 16*b*, which communicates with the outdoor heat exchanger 14, is disposed within the indoor heat exchanger 13. That is, the portion 16*a* of the capillary is in heat exchange relationship with the heat exchanger 13 and is influenced by the temperature of that heat exchanger. Similarly, the portion 16*c* of the capillary adjacent the end 16*d*, which communicates with the indoor heat exchanger, is disposed within the outdoor heat exchanger 14. That is, that portion 16*c* of the capillary is in heat exchange relationship with the outdoor heat exchanger 14 and is influenced by the temperature of that heat exchanger. Thus, it will be seen that, regardless of the direction of flow of the refrigerant, the heat exchanger operating as an evaporator always cools that portion of the capillary ahead of the connecting point 26*a* between the capillary and the conduit 26. When the system is operating on the cooling cycle and the indoor heat exchanger 13 is the evaporator, refrigerant flow through the system is from the condenser 14 through the end 16*b* of the capillary 16 into that portion 16*a* of the capillary which is in heat exchange relationship with the heat exchanger 13 acting as an evaporator. On the cooling cycle refrigerant flows through portion 16*a* of the capillary prior to reaching the connecting point 26*a* of the conduit 26. On the heating cycle, the refrigerant flow through the system is from the heat exchanger 13, which is then operating as a condenser, through the end 16*d* of the capillary into that portion 16*c* of the capillary in heat exchange relationship with the heat exchanger 14, then operating as an evaporator. Thus, during the heating cycle, the portion 16*c* of the capillary is in heat exchange relationship with the evaporator of the system or heat exchanger 14, and that portion 16*c* of the capillary is cooled prior to the connecting point 26*a* of the refrigerant supply conduit 26. By cooling that portion of the capillary just

prior to the connection **26***a* between the capillary and the conduit **26** the refrigerant in that portion of the capillary is maintained in liquid form and flows rapidly through the capillary with very little pressure drop.

However, it will be noted that the portion of the capillary after the connecting point **26***a* with the refrigerant supply conduit **26** is always in heat exchange relationship with the condenser of the system. This portion of the capillary, therefore, is heated by the condenser and causes the refrigerant flowing therethrough to become vaporous thereby greatly increasing the restriction in that portion of the capillary. By this arrangement, therefore, most of pressure drop in the capillary is experienced in that portion of the capillary after the connecting point with the refrigerant supply conduit **26** regardless of the direction of refrigerant flow through the system and the pressure drop in that portion of the capillary prior to the connecting point **26***a* with the conduit **26** is slight. By keeping the pressure drop in the portion of the capillary prior to its connecting point with the conduit **26** as small as possible, the pressure of the refrigerant at the connecting point **26***a* is greater than the pressure in the throat **24** of the aspirating means and liquid refrigerant consequently flows through the conduit **26** into the aspirating means. The condensed refrigerant then mixes with the high pressure gas flowing through the discharge passage **17** and is carried by the high pressure gas into the hermetic casing **3** to cool the motor **6**. When liquid refrigerant is introduced into the throat or low pressure region of the aspirating means, it encounters the hot discharge gas and is vaporized or flashed into gaseous form. Heat removed from the discharge gas in vaporizing the liquid refrigerant reduces the temperature of the discharge gas and the violent reaction created by the flashing of the liquid into vaporized form completely mixes the gas so that the resultant gas mixture issuing from the passage is at a uniform temperature and much cooler than the temperature of the original high pressure gas discharge from the compressor.

It is sometimes desirable to include a restricting means or second capillary **31** in the conduit **26** as illustrated in the drawing. The design of the restricting means or second capillary **31** should permit enough condensed refrigerant to flow through the conduit **26** to sufficiently cool the discharge gas but still limit the flow sufficiently to eliminate short circuiting of the evaporator and eventual collection of the refrigerant in liquid form within the case. Obviously a capillary does not have to be used for this purpose. Other means such as a needle valve or other type of restriction could easily be substituted for a capillary.

In operation, the venturi section or aspirating means **21** acts as a modulating device for supplying greater or lesser amounts of condensed refrigerant to cool the high pressure discharge gas according to the flow of gas through the discharge passage in the condenser unit. Since the amount of liquid refrigerant flowing through the supply conduit **26** depends to a great extent upon the pressure recovery experienced in the diffuser section **23** from the throat **24** to the outlet of the diffuser and, since the amount of pressure recovery in the venturi or aspirating means is a function of the quantity of gas flowing therethrough, it is apparent that the amount of liquid refrigerant siphoned from the liquid refrigerant supply conduit **26** depends upon the quantity of discharge gas flowing through the discharge passage **17** leading from the compressor unit. Whenever the pressure of the suction gas is high, the temperature of the gas at the discharge outlet of the compressor **6** is, under normal conditions, relatively high and its cooling requirement is, therefore, substantial. It is well known, however, that when the suction pressure is high, a correspondingly greater quantity of gas is pumped and this results in a greater flow of liquid refrigerant through the passage **17** and through the throat **24** thereby increasing the flow of liquid refrigerant through the conduit **26** and supplying the necessary cooling of the high pressure discharge gas. Conversely, when the suction pressure is low and the compressed discharge gas is at a relatively low temperature, the amount of gas being pumped through the discharge passage **17** is correspondingly less. This, consequently, produces a correspondingly smaller pressure difference between the throat **24** and the outlet of the aspirating means thereby resulting in a diminished flow through the conduit **26** and a lesser amount of cooling of the discharge gas. Thus, under most conditions, of operation, the aspirating means automatically modulates the amount of cooling of the discharge gas from the compressor, and automatically increases or decreases the cooling effect on this gas to maintain the motor within safe operating limits.

It will be noted that the connecting point **26***a* between the conduit **26** and the capillary **16** is more toward the indoor heat exchanger side of the capillary than toward the outdoor portion of the capillary. It has been found desirable to provide as little of the capillary as possible between the connecting point **26***a* of the conduit **26** and the cooled portion **16***a* of the capillary during the cooling cycle so that the amount of pressure drop in that portion of the capillary is held to a minimum on the cooling cycle operation. On the heating cycle this factor is not as critical since the amount of liquid refrigerant required for motor cooling purposes is normally less. Also, in this arrangement, that portion of the capillary adjacent the outdoor heat exchanger is generally exposed to outdoor air which, during the heating cycle, is usually fairly cold and, thus, serves to cool that portion of the capillary between the outdoor heat exchanger **14** and the connecting point **26***a* and to reduce the pressure drop therein.

By the present invention there has been provided in a reversible refrigeration system a siphoning arrangement for injecting liquid refrigerant into the hermetic casing of a motor-compressor unit for motor cooling purposes regardless of the direction of refrigerant flow through the system. Moreover, this arrangement taps liquid refrigerant from the capillary of the system and provides an arrangement whereby the pressure drop in the capillary up to the tapping point is maintained relatively small regardless of the direction of refrigerant flow through the system thereby assuring flow of liquid refrigerant from the capillary into the siphoning means.

While in accordance with the patent statutes there has been described what at present is considered to be the preferred embodiment of the 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, 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 I claim as new and desire to secure by Letters Patent of the United States is:

1. A reversible refrigeration system for an air conditioning unit adapted for heating and cooling an enclosure comprising a motor-compressor unit, an indoor heat exchanger and an outdoor heat exchanger connected in reversible refrigerant flow relationship, means for reversing the flow of refrigerant through said system thereby to operate each of said heat exchangers interchangeably as a condenser or as an evaporator, a hermetic casing surrounding said motor-compressor unit for containing a high pressure refrigerant gas, a discharge passage leading from said compressor of said unit into said hermetic casing for conducting compressed refrigerant gas into said casing for cooling said motor, said discharge passage including an aspirating means for creating a low pressure region in said discharge gas as said gas passes through said aspirating means, a capillary having one end thereof communicating with said indoor heat exchanger and the other end thereof communicating with said outdoor heat exchanger for expanding refrigerant from condenser pres-

sure to evaporator pressure during either direction of refrigerant flow through said system, a portion of said capillary adjacent said other end of said capillary communicating with said outdoor heat exchanger being in heat exchange relationship with said indoor heat exchanger and a portion of said capillary adjacent said one end of said capillary communicating with said indoor heat exchanger being in heat exchange relationship with said outdoor heat exchanger, and a liquid refrigerant supply conduit having one end connecting with said capillary at a point between said portions thereof in heat exchange relationship with said heat exchangers, said conduit connecting at its other end with said aspirating means for conducting liquid refrigerant from said capillary into said low pressure region of said aspirating means where it mixes with and cools said discharge gas in said passage prior to entering said hermetic case, said heat exchanger operating as an evaporator during either direction of refrigerant flow through said system cooling that portion of said capillary prior to its connecting point with said refrigerant supply conduit so that there is little pressure drop in that portion of said capillary prior to said connecting point with said refrigerant supply conduit as compared to the pressure drop in that portion of said capillary after said connecting point with said refrigerant supply conduit.

2. A reversible refrigeration system for an air conditioning unit adapted for heating and cooling an enclosure comprising a motor-compressor unit, an indoor heat exchanger and an outdoor heat exchanger connected in reversible refrigerant flow relationship, means for reversing the flow of refrigerant through said system thereby to operate each of said heat exchangers interchangeably as a condenser or as an evaporator, a hermetic casing surrounding said motor-compressor unit for containing a high pressure refrigerant gas, a discharge passage leading from said compressor of said unit into said hermetic casing for conducting compressed refrigerant into said casing for cooling said motor, said discharge passage including a venturi for creating a low pressure region in said discharge gas as said gas passes through said venturi, a capillary having one end thereof communicating with said indoor heat exchanger and the other end thereof communicating with said outdoor heat exchanger for expanding refrigerant from condenser pressure to evaporator pressure during either direction of refrigerant flow through said system, a portion of said capillary adjacent said one end of said capillary communicating with said indoor heat exchanger being in heat exchange relationship with said outdoor heat exchanger and a portion of said capillary adjacent to said other end of said capillary communicating with said outdoor heat exchanger being in heat exchange relationship with said indoor heat exchanger, and a refrigerant supply conduit connected at one end to said venturi and connecting at the other end with said capillary at a point between said portions of said capillary in heat exchange relationship with said heat exchangers, said conduit adapted to conduct liquid refrigerant from said capillary into said venturi for mixing with and cooling said discharge gas flowing therethrough, said heat exchanger operating as an evaporator during either direction of flow through said system cooling that portion of said capillary prior to its connecting point with said refrigerant supply conduit so that there is little pressure drop in that portion of said capillary prior to said connecting point with said refrigerant supply conduit as compared to the pressure drop in that portion of the capillary after said connecting point with said refrigerant supply conduit.

3. A reversible refrigeration system for an air conditioning unit adapted for heating and cooling an enclosure comprising a motor-compressor unit, an indoor heat exchanger and an outdoor heat exchanger connected in reversible refrigerant flow relationship, means for reversing the flow of refrigerant through said system thereby

to operate each of said heat exchangers interchangeably as a condenser or as an evaporator, a hermetic casing surrounding said motor-compressor unit for containing a high pressure refrigerant gas, a discharge passage leading from said compressor of said unit into said hermetic casing for conducting compressed refrigerant gas into said casing for cooling said motor, said discharge passage including a venturi for creating a low pressure region in said discharge gas as said gas passes through said venturi, a capillary communicating at one end with said indoor heat exchanger and communicating at the other end with said outdoor heat exchanger for expanding refrigerant from condenser pressure to evaporator pressure, a portion of said capillary adjacent said one end thereof communicating with said indoor heat exchanger being in heat exchange relationship with said outdoor heat exchanger and a portion of said capillary adjacent said other end thereof communicating with said outdoor heat exchanger being in heat exchange relationship with the indoor heat exchanger, a refrigerant supply conduit connecting at one end to said venturi and connecting at the other end thereof with said capillary at a point between said portions of said capillary in heat exchange relationship with said heat exchangers for conducting liquid refrigerant from said capillary into said venturi, said conduit connecting with said capillary at a point closer to said indoor heat exchanger than to said outdoor heat exchanger, said heat exchanger operating as an evaporator during either direction of refrigerant flow through said system cooling that portion of said capillary prior to its connecting point with said refrigerant supply conduit so that there is little pressure drop in that portion of said capillary prior to said connection point with said refrigerant supply conduit as compared to the pressure drop in that portion of said capillary after connecting point with said refrigerant supply conduit.

4. A reversible refrigeration system for an air conditioning unit adapted for heating and cooling an enclosure comprising a motor-compressor unit, an indoor heat exchanger and an outdoor heat exchanger connected in reversible refrigerant flow relationship, means for reversing the flow of refrigerant through said system thereby to operate each of said heat exchangers interchangeably as a condenser or as an evaporator, a hermetic casing surrounding said motor-compressor unit for containing a high pressure refrigerant gas, a discharge passage leading from said compressor of said unit into said hermetic casing for conducting compressed refrigerant gas into said casing to cool said motor, said discharge passage including an aspirating means for creating a low pressure region in said discharge gas as said gas passes through said aspirating means, a first capillary having one end thereof communicating with said indoor heat exchanger and the other end thereof communicating with said outdoor heat exchanger for expanding refrigerant from condenser pressure to evaporator pressure during either direction of refrigerant flow through said system, a portion of said first capillary adjacent said other end of said capillary communicating with said outdoor heat exchanger being in heat exchange relationship with said indoor heat exchanger and a portion of said first capillary adjacent said one end of said capillary communicating with said indoor heat exchanger being in heat exchange relationship with said outdoor heat exchanger, a refrigerant supply conduit connecting at one end with said low pressure region in said aspirating means and having its other end connecting with said first capillary at a point between said portions thereof in heat exchange relationship with said heat exchangers, said refrigerant supply conduit adapted to conduct liquid refrigerant from said first capillary into said low pressure region of said aspirating means where it mixes with and cools said discharge gas in said passage prior to entering said hermetic casing, a second capillary in said refrigerant supply conduit for restricting flow through said refrigerant supply conduit and preventing

short circuiting of said refrigerant around said heat exchanger operating as an evaporator, said heat exchanger operating as an evaporator during either direction of refrigerant flow through said system cooling that portion of said first capillary prior to its connecting point with said refrigerant supply conduit so that there is little pressure drop in that portion of said first capillary prior to said connecting point with said refrigerant supply conduit as compared to the pressure drop in that portion of said

first capillary after said connection with said refrigerant supply conduit.

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