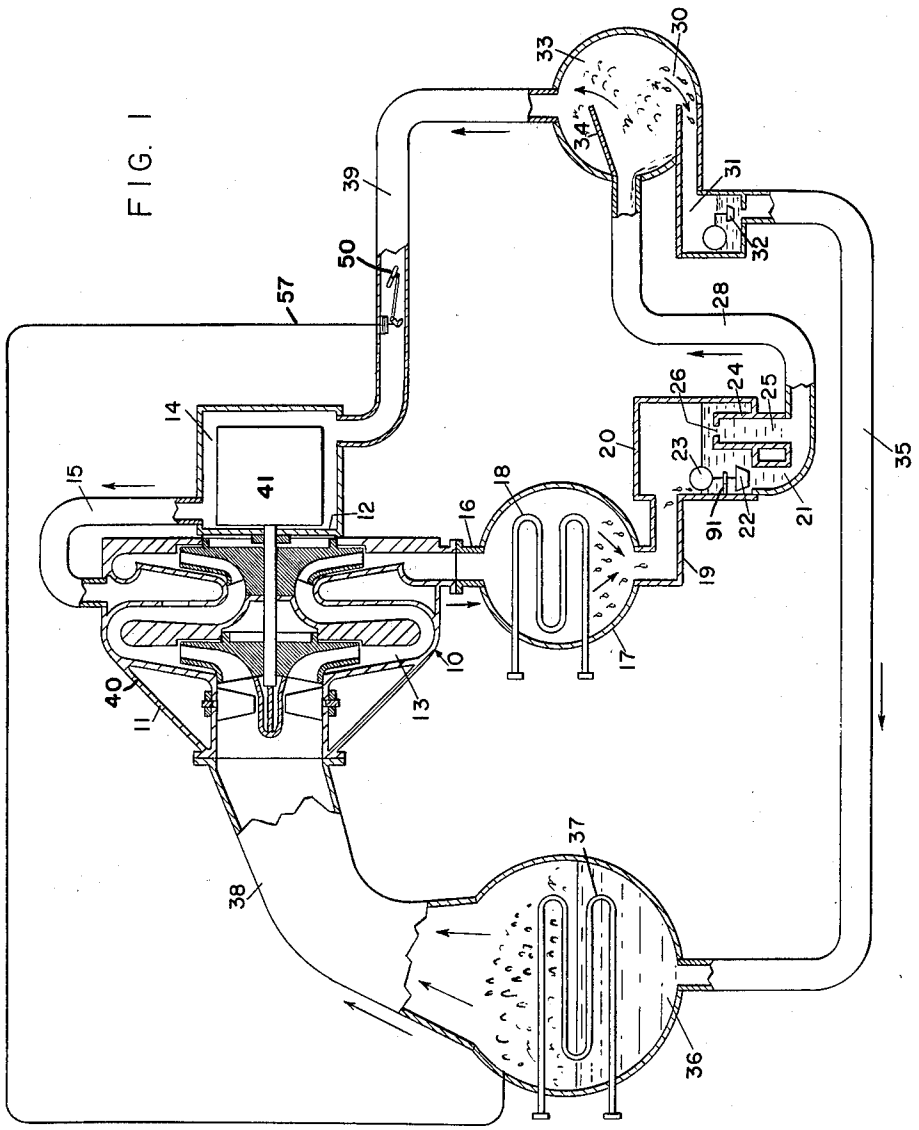
Jan. 19, 1960 C. M. ASHLEY ET AL 2,921,445

CENTRIFUGAL REFRIGERATION MACHINES

Filed Feb. 17, 1956 3 Sheets-Sheet 1

FIG. 1



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FIG. 3

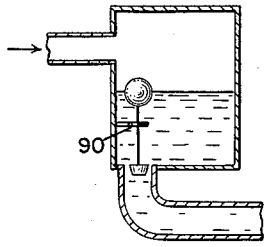
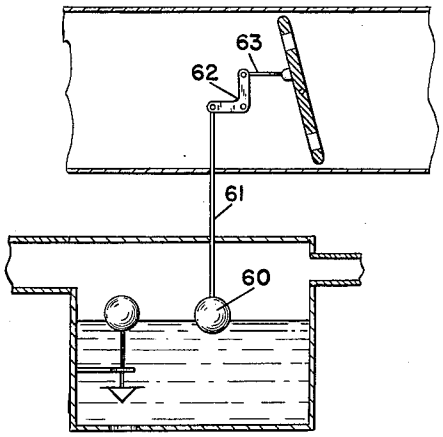


FIG. 5



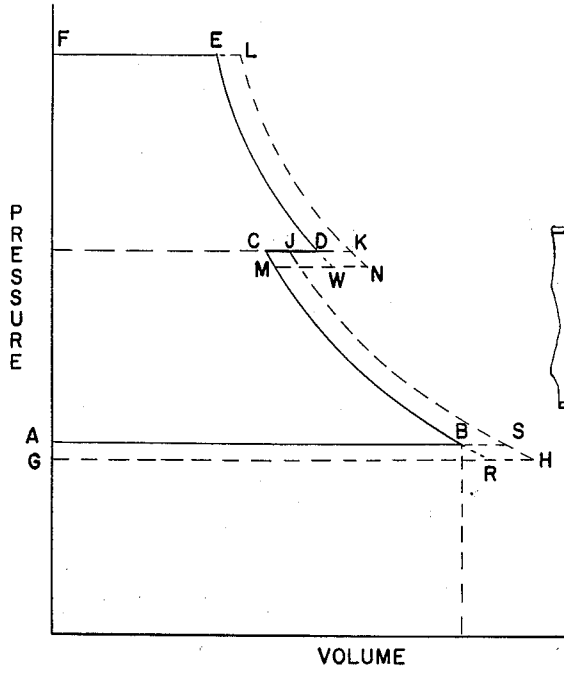


FIG. 2

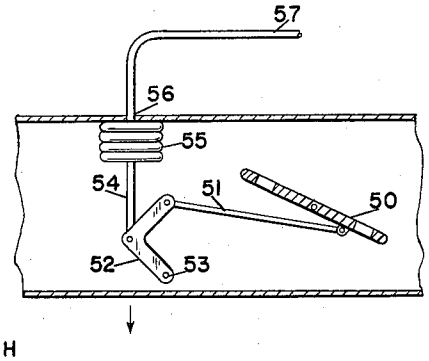


FIG. 4

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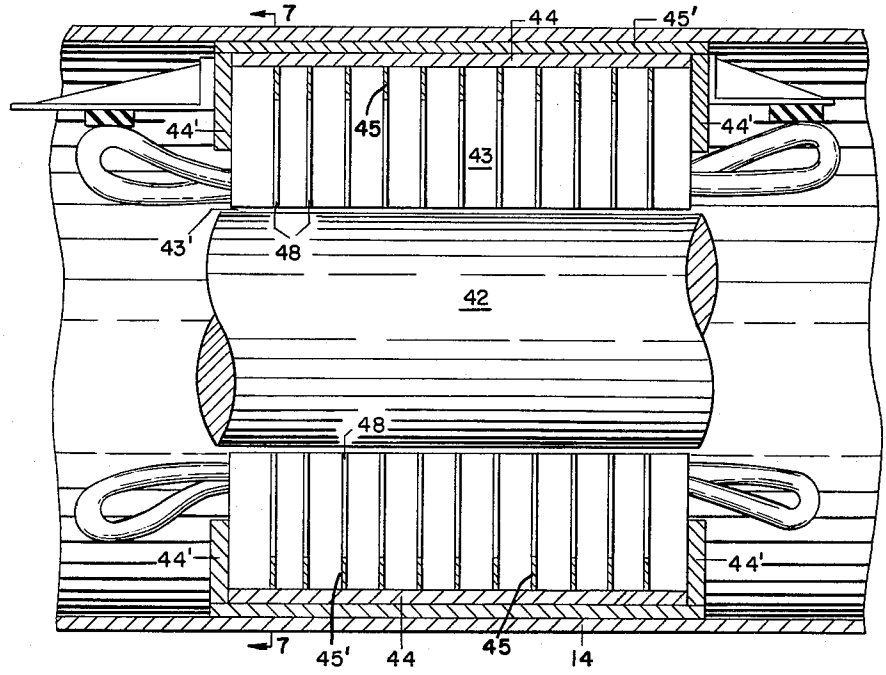


FIG. 6

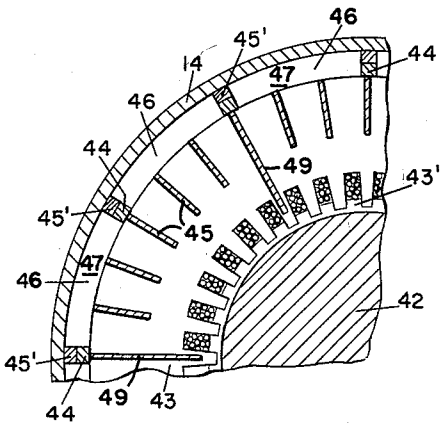


FIG. 7

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CENTRIFUGAL REFRIGERATION MACHINES

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Application February 17, 1956, Serial No. 566,190

12 Claims. (Cl. 62—117)

This invention relates generally to refrigeration systems. More specifically this invention pertains to refrigeration systems of the type utilizing a motor driven centrifugal compressing unit. Still more specifically this invention concerns a refrigeration system of the type under consideration wherein improved means are provided for cooling the motor which supplies rotational movement to the rotor of the compressor.

A refrigeration system of the type under consideration includes, in addition to the compressor mentioned above, an evaporator, a condenser, and an economizer, all interconnected in a manner so as to form a closed circuit for the flow of a refrigerant. Refrigerant in liquid form is passed into the evaporator and vaporized therein as heat is extracted from a medium such as water or the like passing in heat exchange relation with the refrigerant in the evaporator. The vaporous refrigerant is then withdrawn by the compressor from the evaporator and forwarded at a higher pressure to the condenser where the refrigerant is once again converted to the liquid state when it is passed in heat exchange relation with a cooling medium. When a centrifugal compressor is used it is common practice to insert in the circuit between the condenser and the evaporator an economizer designed to effect a pressure change in the system which in turn causes a portion of the liquid refrigerant to vaporize. The gaseous refrigerant so formed in the economizer then passes to the compressor and is introduced therein at an intermediate stage of compression in the interest of economical operation of the system.

It is the chief object of this invention to provide an arrangement for cooling the motor driving the compressor by passing substantially water-free gaseous refrigerant formed in the economizer in heat exchange relation with the motor. This, provides a cooling action for the motor as heat flows from the motor to the cooler economizer gas. Additional heat is added to the refrigerant cycle at a higher temperature level as the heated gas flows to an intermediate stage of compression and therefore takes less horsepower at the compressor. Heretofore it has been proposed to utilize a conventional cooling jacket employing water or some other cooling medium about the casing of the motor. Obvious disadvantages arise when a construction of this type is used such as leakage, scaling and inadequate cooling. Accordingly the arrangement proposed wherein gas from the economizer is used to cool the motor affords many advantages, chief among which is the elimination of the sealing problems involved in the jacket type cooling arrangement.

Another object of this invention is the provision of an arrangement for ensuring passage of refrigerant in heat exchange relation with the motor under substantially all machine loadings so that even when the refrigeration system is operating at a low load, refrigerant is available for cooling. This object may be achieved by means permitting passage of gaseous refrigerant from

the condenser to the motor during certain predetermined conditions of operation of the refrigeration system.

Another object of the invention is the provision of an arrangement for ensuring the flow of a supply of refrigerant to the motor compartment from a second source in the refrigeration system on those occasions when flow of refrigerant from the economizer to the motor compartment would be insufficient to obtain proper cooling of the motor.

A still further object of the invention is the provision of an arrangement for controlling the flow of refrigerant in the line connecting the economizer and the motor casing to prevent the introduction, during those periods when the evaporator pressure may exceed the pressure in the line, of an excessive quantity of liquid refrigerant into the motor casing from the economizer.

Other objects and features of the invention will be apparent from a consideration of ensuing specification and drawings wherein:

Figure 1 is a schematic drawing of a refrigeration system utilizing the invention;

Figure 2 is a graphical representation showing a comparison of the amount of work involved in the system when gaseous refrigerant is used to cool the motor driving the compressor in the system;

Figure 3 is a schematic view of one arrangement for ensuring passage of refrigerant from the condenser to the line connecting the economizer and the motor casing;

Figure 4 is a fragmentary view showing, diagrammatically, one arrangement for controlling a valve in the line connecting the economizer and the motor casing;

Figure 5 is a fragmentary view showing diagrammatically a modification of the control illustrated in Figure 4;

Figure 6 is a view partly in elevation and partly in section showing the path of flow of the refrigerant through the motor; and

Figure 7 is a partial view in section along lines 7—7 on Figure 6. This figure is reduced in size.

Referring more particularly to the drawings it will be noted that there is shown a motor-compresor unit 10 including a casing 11 provided with a partition 12, dividing the unit into a first compartment 13, housing the compressor 40 and a second compartment 14 housing the motor 41. While the unit shown illustrates a hermetic compressor, that is a compressor and motor sealed within the same casing, it will be obvious that the invention will apply in those circumstances where the motor is provided with a separate enclosure from the enclosure for the compressor.

For purposes of clarity these elements have not been illustrated in the drawings. Line 15 is shown extending outside the casing of the motor compressor unit and serves to permit communication between the motor compartment 14 and the compressor compartment 13. Discharge line 16 connects the compressor unit with the condenser 17 having a conventional purge, not shown. Gaseous refrigerant passes from the compressor to the condenser through line 16 and is converted to the liquid phase through the action of a cooling coil 18 in the usual manner. Line 19 connects the condenser with a receiver 20 having an outlet line 21 under the influence of a valve 22 responsive to the operation of the float 23. It will be understood that member 91 confines the path of movement of the float. In addition to the construction described the receiver 20 includes a standpipe 24 communicating with a line 25 disposed substantially parallel to the outlet line 21. The end of the standpipe projecting upwardly into the receiver is provided with an orifice 26, the purpose for which will be later described. Liquid refrigerant from the receiver passes to the economizer 30

through line 28, which is in communication with both outlet line 21 and standpipe line 25. The economizer is provided with a liquid chamber 31 equipped with a float valve 32, and a vapor compartment 33 equipped with an eliminator 34. The operation of the economizer is well-known to those versed in the art, it being understood that refrigerant vapor flashing in the economizer is forwarded to the compressor while the liquid refrigerant cooled by the flashing action passes through the valve and on into the evaporator or low pressure zone where it is passed in heat exchange relation with the medium to be cooled. Line 35 permits the passage of the liquid refrigerant from the economizer to evaporator 36. Coil 37 accommodates the medium to be cooled as heat is extracted therefrom by the cooler refrigerant. The refrigerant as it is passed in heat exchange relation with the medium in coil 37 is converted to the gaseous phase and flows in that phase to the compressor through suction line 38.

Line 39 is connected to the economizer and permits passage of gas or vaporous refrigerant generated therein to the motor compartment of the motor-compressor unit. The gas then flows around the motor and through line 15 into the compressor compartment of the motor-compressor unit. The motor operating at a temperature in excess of the gaseous refrigerant is cooled as the cooler refrigerant gas flows in contact therewith.

Referring more particularly to Figures 1, 6 and 7 for a description of one arrangement for ensuring flow of gaseous refrigerant over the motor it will be noted that the gaseous refrigerant formed in the economizer enters the motor compartment 14 at one side thereof. A small portion of the gaseous refrigerant flows through the space or clearance between the rotor 42 and the stator 43 and a portion of slots 43'.

The stator 43 is constructed by connecting individual packages of the usual laminated structure together in spaced relation with positioning bars 45 shown diagrammatically and maintaining them in this position by circumferentially spaced rods 44 cooperating with support blocks 44'. The bars 45 form ventilating passages 48 between the individual packages. The inside of the housing is also provided with longitudinally extending circumferentially spaced members 45' adapted to overlie the rods 44 and to form therewith longitudinally extending passages 46. To complete the passages 46, sheet metal blocking members 47 are placed at alternate entrances of passages 46 and at alternate exits, so that those passages having their entrance blocked have an unobstructed exit, and those passages having an unobstructed entrance have a blocked exit. Gaseous refrigerant flowing through the motor enters the unrestricted portion of the passages 46. Portions of the gas flowing through passage 46 flow radially inwardly toward the rotor through the longitudinally spaced vents or passages 48 provided by the spaced packages. Circumferentially spaced radial baffles 49 are positioned in radial alignment with rods 44. Baffles 49 terminate short of the rotor and serve to determine the circumferential limits of the gas flow. The inward flow of gaseous refrigerant through passage 48 is also circumferential to an extent determined by the baffles 49. The path of flow then continues outwardly from the rotor to that portion of passage 46 having an unobstructed outlet.

Thus the gaseous refrigerant from the economizer enters each of the unobstructed, circumferentially spaced passages 46. As the gas flows longitudinally of the rotor in the passage 46, portions thereof "peel off" and flow inwardly through the longitudinally spaced passages 48. Flow of gas through passages 48 is also in a transverse or circumferential direction so that the gas flow is in alignment with the passage 46 adjoining the original entrance passage. As pointed out this passage 46 has an unobstructed exit so that as the gas in passage 48 flows

outwardly or away from the rotor it enters a passage 46 having an exit communicating with line 15. Suitable baffles, not shown, permit the cooling gas to be distributed over the ends of the windings projecting beyond the stator.

Referring more particularly to receiver 20, it will be obvious that under conditions of reduced load, as represented, for example, by a reduction in the temperature of the medium flowing through coil 37, the quantity of liquid refrigerant in the receiver may drop below the upper end of the standpipe 24. The float valve 23 will act to close the opening between the receiver 20 and the line 21 as the system tends to reach equilibrium. With the construction shown gaseous refrigerant will flow through the opening 26, standpipe 24 to the economizer 30 and into the motor compartment 14 of the compressor unit. This arrangement provides cooling for the motor under reduced load conditions. While one arrangement for accomplishing the motor cooling at low loads has been shown, other constructions will suggest themselves to those skilled in the art. For example, a conventional two chamber economizer may be employed in place of the receiver and economizer construction shown. Under these circumstances one of the economizer chambers, the upper one normally, would serve the same purpose as the receiver 20. Thus when a change in a system operating condition, such as a low load or a high temperature of the condensing medium occurs, gaseous refrigerant would flow to the motor through the first economizer chamber.

Another arrangement for ensuring passage of condenser gas to the motor casing at low load conditions is shown in Figure 3 and involves forming the valve member in the receiver undersize in comparison to the size of the opening in the bottom of the receiver. Thus under light or low loads, when all the liquid drains through, an opening will be assured for the passage of gas. The liquid will then collect in the economizer where the valve member prohibits passage of refrigerant to the evaporator. Thus at low loads the undersized valve will still function to create a pressure drop and will at the same time permit passage of condenser gas to the motor casing while at higher loads only liquid will enter the valve. Guiding member 90 confines the movement of the valve to a substantially vertical path. An arrangement in the form of a stop member limiting the throttling action of the valve by limiting the operation of the float will also provide the desired clearance.

Another feature of this invention resides in the control of the flow of refrigerant in the line connecting the economizer and the motor casing. Under certain operating conditions the pressure within the evaporator may exceed the pressure in the line connecting the economizer and the motor casing. For example, the condenser pressure might drop causing a corresponding drop in the economizer or intermediate stage compressor pressure to a point below the evaporator pressure. Flow of liquid refrigerant upwardly through line connecting the economizer and the motor casing would then occur due to the reduction of the pressure in the line 39. In order to prevent this situation, a flow controlling member, shown in the form of a damper 50, is assembled in the line 39. Movement of the damper may be under the control of linkage responsive to a relationship between economizer and evaporator pressure. Pivotally connected to the damper below the pivoted connection between the damper and the sides of the conduit or line is an arm 51 having one end pivotally secured to one arm of bell crank lever 52. The lever 52 is keyed to cross shaft 53. Rod 54 is also connected to the lever 52. The end of rod 54 opposite to the end connected to the lever 52 is fixed to a bellows 55. The interior of the bellows is in communication with a tube 56 which in turn is in connection with evaporator pressure through

line 57. Movement of the bellows occurs in response to pressure differences between the economizer and the evaporator. An opening 80 in the damper 50 permits some communication between the economizer and the motor casing. In the illustrated embodiment the throttling action of the damper 50 causes the pressure to rise in the economizer up stream from the damper.

Figure 5 illustrates another arrangement for actuating the control damper in the line connecting the economizer and the motor compartment. An additional float valve 60 is provided in the economizer and is positioned so as to be unaffected by the normal operating level of liquid in the economizer. However, when an abnormal accumulation of liquid occurs in the economizer, a situation indicative of an evaporator pressure approaching or in excess of that in the economizer then the float valve 60 operates to close damper 50 through the connecting arm 61, bell crank 62 and rod 63.

Heretofore it has been proposed to use the gaseous refrigerant in the suction line as a cooling medium for the motor employed to drive the compressor. However, the gaseous refrigerant emanating from the economizer permits the attainment of certain benefits not realized when the suction gas is used. For example, when gaseous refrigerant is used to cool the motor, the gas sustains a pressure drop and is superheated as it flows in heat exchange relation with the motor. The amount of work performed in the compression phase of the process is directly related to the amount of pressure drop and superheat involved. The additional work necessary when the suction gas is used to cool the motor to offset these conditions is shown graphically in Figure 2. The area encompassed by lines AB, BC, CD, ED, EF and FA illustrates, normally, the work done as the gas is compressed. Line AB represents the volume of gas at the compressor inlet. Line CD represents an increase in volume caused by the introduction of the economizer gas at an intermediate stage of compression. The lines GH, HJ, JK, KL, LF and FG illustrate the work done when a volume of suction gas has been enlarged due to the pressure drop and superheating of the gas with area ABRG, the increase due to pressure drop and the remainder due to superheating. It will be obvious that when the economizer gas is used as a cooling agent for the motor the additional work to be performed is limited to the area depicted by the lines MN, NL, LE, ED, DC and CM. Here area CMWD represents additional work due to pressure drop of the gas through the motor and the remainder due to superheat. It will also be obvious that for the same amount of work involved a greater pressure drop may be sustained with the economizer gas (thus permitting more effective heat transfer).

A further advantage available through the use of economizer gas obtains by virtue of the density of the gas. The gas flowing from the economizer being denser than the suction gas provides a more efficient heat exchange action between the motor elements and the gas.

A still further feature involved in using economizer gas as a motor cooling medium resides in the fact that the economizer gas is relatively dry in the sense that it has a low relative humidity. Consequently the economizer gas has the inherent ability to absorb moisture. This feature becomes important when operation of the refrigeration machine resumes after a shutdown period. Very often during the shutdown period the windings of the motor may absorb moisture present in the system. The economizer gas, upon start up, will have the ability to absorb this moisture because of its low relative humidity.

While we have described certain preferred embodiments of the present invention, it will be understood the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

We claim:

1. In a refrigeration system including a compressor, a motor for operating the compressor, a condenser, an economizer, and an evaporator connected to form a closed circuit for the flow of a volatile refrigerant, means for controlling the flow of liquid refrigerant formed in the condenser to the economizer, means for delivering gaseous refrigerant formed in the economizer in heat exchange relation with the motor to cool the motor, said liquid refrigerant flow control means being operable in the absence of liquid refrigerant to assure communication between the condenser and the economizer and thus afford a passage for gaseous refrigerant to the economizer.

2. The invention set forth in claim 1 wherein said liquid refrigerant flow control means includes a receiver, interposed in the refrigeration circuit between the condenser and the economizer, adapted to collect liquid refrigerant for subsequent passage to the economizer.

3. The invention set forth in claim 2 wherein said receiver is provided with a first opening, a float valve controlling passage through said opening and means providing a second passage from the receiver when passage through the first opening is prevented by operation of the float valve.

4. A refrigeration system comprising a compressor, a condenser, an economizer, an evaporator, lines interconnecting the elements to form a closed circuit for the flow of a refrigerant, a motor including a casing for operating said compressor, means including a line connecting the economizer with the motor casing providing a path of flow for gaseous refrigerant formed in the economizer in heat exchange relation with the motor to cool the same, means responsive to an operating characteristics of the refrigeration system for controlling the flow of refrigerant in said line, and means providing a path of flow for the gaseous refrigerant from the motor casing to the compressor.

5. The invention set forth in claim 4 wherein said last mentioned means is operable in response to a predetermined relationship between the pressure in the evaporator and the pressure in the economizer.

6. The invention set forth in claim 4 wherein said last mentioned means includes a valve and a linkage for controlling said valve, said linkage being operable in response to an abnormal level of liquid refrigerant in the economizer.

7. The method of operating a refrigeration machine including a motor driven compressor, a condenser, an economizer and an evaporator interconnected to form a closed circuit for the flow of refrigerant which consists in the steps of withdrawing gaseous refrigerant from the evaporator, compressing the withdrawn refrigerant and forwarding it to the condenser, passing a cooling medium in heat exchange relation with the gaseous refrigerant in the condenser to liquefy the refrigerant, directing the liquid refrigerant to a zone of relatively lower pressure in the economizer whereby portions of the liquid refrigerant are vaporized, directing the vaporized portions of the refrigerant in the economizer into heat exchange relation with the motor driving the compressor, forwarding the liquid refrigerant in the economizer to the evaporator and controlling the flow of the refrigerant from the economizer to the motor in response to a predetermined pressure relationship between the evaporator and the economizer.

8. In a refrigeration system including a motor driven compressor, a condenser, an economizer, and an evaporator connected to form a closed circuit for the flow of refrigerant, the method of cooling the motor which consists in the steps of withdrawing gaseous refrigerant from the evaporator and forwarding it to the condenser at a higher pressure, converting the vaporous refrigerant in the condenser to the liquid phase, directing the liquid refrigerant from the condenser to a zone of lower pres-

sure in the economizer, forwarding the gaseous refrigerant formed in the economizer to the motor casing, directing the refrigerant introduced into the motor casing into heat exchange relation with the motor, supplying under predetermined operating conditions gaseous refrigerant from the condenser for flow in heat exchange relation with the motor and transmitting the liquid refrigerant in the economizer to the evaporator.

9. The invention set forth in claim 1 wherein said liquid refrigerant flow control means includes an opening providing for the passage of liquid refrigerant from the condenser to the economizer and a valve member undersized with respect to the opening so that communication between the condenser and economizer is always possible.

10. In a refrigeration system, including a compressor, a motor for operating the compressor, an enclosure housing said motor, a condenser, an economizer and an evaporator, means forming a path for the flow of gaseous refrigerant formed in the economizer in heat exchange relation with the motor, and means forming a path of flow for the gaseous refrigerant from the motor enclosure to a portion of the system having a pressure lower than the pressure in the motor enclosure.

11. The invention set forth in claim 10 wherein means

are provided for automatically preventing flow of liquid refrigerant from the economizer to the motor enclosure.

12. In a refrigeration system, a compressor, a motor for operating the compressor, a condenser, an economizer, an evaporator, lines connecting the system components to form a closed circuit for the flow of refrigerant, a line connecting the economizer and the motor, a receiver interposed in said system between the condenser and the economizer, and means including a valve controlled opening in said receiver and a valve undersized with respect to the opening so that communication between the receiver and the economizer is always possible so as to pass condenser gas to the economizer for transmittal to the motor.

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