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OIL SEPARATOR IN REFRIGERATION APPARATUS

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Fig. 2.

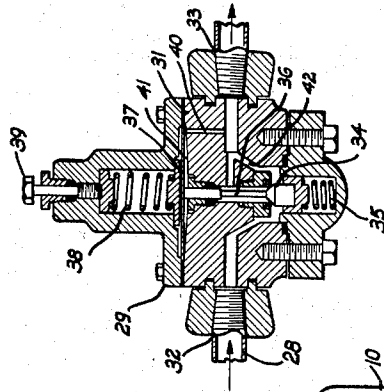
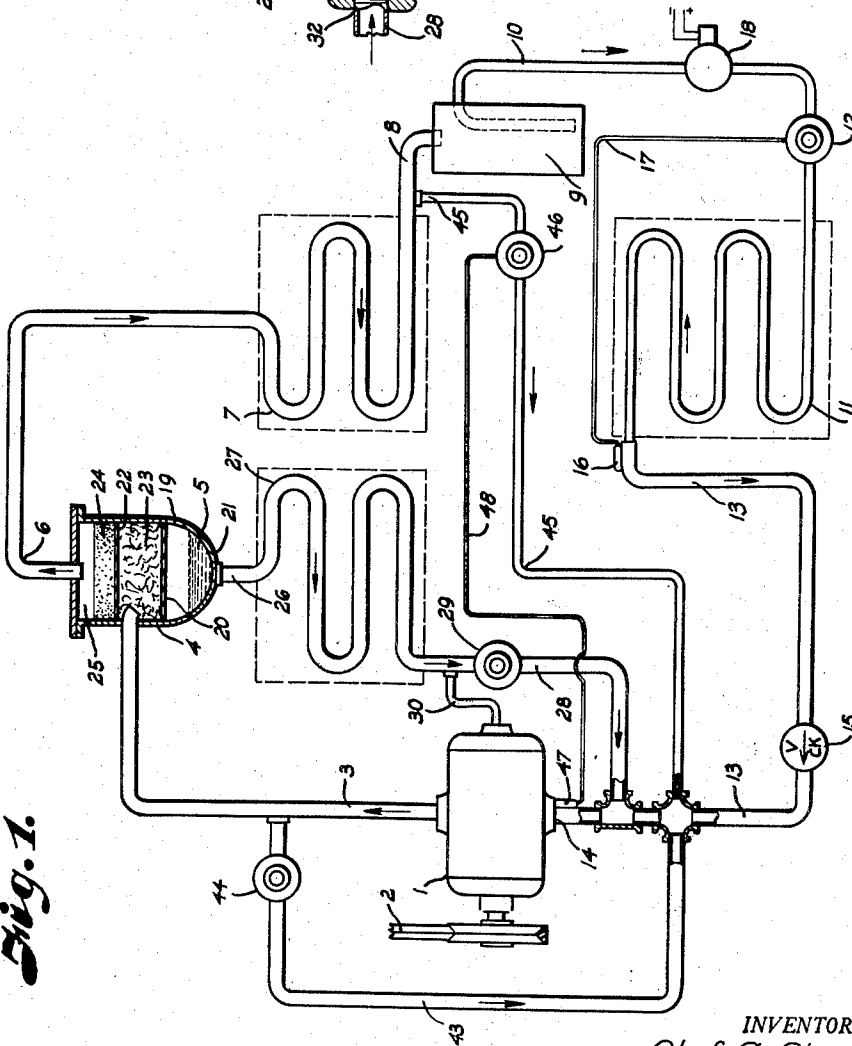


Fig. 1.



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OIL SEPARATOR IN REFRIGERATION APPARATUS

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6 Claims. (Cl. 62—192)

This invention relates to refrigerating apparatus and, more particularly, to such apparatus for use in an automobile air conditioning system, and has for its principal object to provide a refrigeration apparatus with an improved arrangement for control to maintain constant capacity for refrigeration under widely varying outdoor air temperatures and compressor or pump speeds.

In automobile air conditioning, it is desirable to have the refrigeration apparatus of such capacity that it will maintain comfortable temperatures in the passenger compartment at slow or idling speeds as, for example, approximately 500 R. P. M. of the engine; however, in the operation of automobiles, the range of speed of the engine is from a slow or idling speed of approximately 500 R. P. M. to full speed of approximately 4000 R. P. M. which, obviously, with a direct driven compressor provides a refrigerant output from the compressor of many times that required to maintain maximum comfort in the passenger compartment. In automotive air conditioning or refrigeration, or other installations wherein the compressor or fluid pump is directly driven by the vehicle propulsion engine or other prime mover having a wide variety of speeds, it has been the practice to provide a refrigerant bypass that is opened when the required amount of refrigeration lowers below a selected minimum and is closed when the refrigeration requirement is above said minimum. It has also been the common practice to provide expensive disconnect devices such as clutches, either manual or electrical, in the compressor or pump drive so as to stop the compressor when refrigeration is not needed. The expensive disconnect devices in the drives are commonly used in the systems having refrigerant gas bypasses as the bypassing of the hot gas from the discharge side to the suction side of the compressor causes excessive heating of the compressor at high speeds which may cause seizing of the mechanical parts of the compressor.

Further objects of the present invention are to provide a refrigeration apparatus capable of operating at the wide range of speeds as in automobile air conditioning that eliminates the above-named difficulties; to provide a refrigeration apparatus with a compressor or pump of the rotary type capable of pumping liquid and compressing gas with an improved arrangement in the apparatus whereby the capacity of the gas compressing of the compressor is varied by liquid such as oil delivered to the intake or suction side of the compressor; to provide a refrigeration apparatus with a supply of liquid lubricant carrier for the refrigerant which supply of carrier is under pressure for delivery to the compressor bearings and intake with suitable controls whereby the gas capacity of the compressor is varied by the liquid that is moved therethrough; to provide such a refrigerating apparatus with suitable gas and liquid refrigerant bypasses to maintain constant capacity for refrigeration at a variety of speeds of the compressor with a minimum of power for driving the compressor without excessive compressor temperatures; and to provide a refrigerating apparatus with suitable con-

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trols to maintain a suitable load on the compressor of the system whenever the load on the evaporator is reduced; and to provide a refrigerating apparatus that is relatively efficient in operation and adapted to be built in a relatively small size for use in an automotive vehicle and at a relatively low cost.

In accomplishing these and other objects of the present invention, I have provided improved details of structure, the preferred form of which is illustrated in the accompanying drawings, wherein:

Fig. 1 is a diagrammatical view of the refrigeration apparatus.

Fig. 2 is an enlarged diagrammatical view of a suitable modulating type valve in the oil line leading to the intake of the compressor.

Referring more in detail to the drawings:

1 designates a refrigerant compressor capable of pumping liquids and preferably of a rotary vane type which is drivingly connected to a suitable prime mover such as a vehicle engine (not shown) by a belt 2 whereby when the engine is operated the compressor is driven. The compressor 1 discharges compressed refrigerant such as Freon gas and a liquid such as castor oil or other suitable lubricant compatible with the refrigerant through a high pressure line 3 to a separator 4 of suitable construction to separate the liquid from the gas, the liquid being collected in a sump at the bottom of the separator as at 5 and the gas flowing through a high pressure line 6 connecting the upper portion of the separator with a suitable condenser 7 wherein the refrigerant gas is condensed to a liquid. The condensed refrigerant flows from the condenser 7 through a line 8 to a receiver 9. A liquid refrigerant line 10 connects the outlet of the receiver 9 with the inlet of an evaporator unit 11. A conventional thermostatic expansion valve 12 is located in the line 10 adjacent the inlet of the evaporator and controls the admission of refrigerant to the evaporator 11. The outlet of the evaporator is connected by a low pressure line 13 to the suction side or inlet 14 of the compressor, a check valve 15 being arranged in the line 13 to prevent backflow therein.

The thermostatic expansion valve 12 has a thermosensitive bulb 16 adjacent the outlet of the evaporator and acting through a control line 17 to the valve 12 whereby an increase in the load on the evaporator which results in an increase in the heat of the vapor leaving the evaporator causes the thermo-sensitive bulb to act through the control line 17 to open the valve 12 and permit an increased flow of liquid refrigerant to the evaporator to satisfy the load condition. A decrease in the load on the evaporator results in a decrease in the heat of the vapor leaving same causing the bulb to act through the control line to move the valve towards closed position and reduce the flow of liquid refrigerant to the evaporator. A suitable valve 18 of the solenoid type or manually operated is arranged in the line 10 between the receiver and the thermostatic expansion valve 12 for closing said line and stopping all flow of liquid refrigerant to the suction side or inlet 14 of the compressor, a check valve that no refrigeration is required.

The separator 4 may be of any conventional structure but preferably includes a shell 19 having a perforated partition 20 therein spaced from the bottom 21 to define an oil sump 5 of substantial capacity therebetween. A second perforated partition 22 is arranged in the shell in vertically spaced relation from the partition 20 and the line 3 discharges into the shell 19 between the partitions 20 and 22. It is preferred that a metal wool 23 be arranged in the shell between the partitions 20 and 22 to facilitate removing fine oil particles from the gas delivered to the separator. Above the perforated partition 22 is a filter 24 of felt or other suitable material

that will permit the gas to pass therethrough but prevent the liquid or oil from passing whereby only gas enters the chamber 25 adjacent the upper end of the separator which is in communication with the line 6. An oil line 26 is connected with the bottom of the separator and communicating with the oil sump therein for flow of oil to an oil cooler 27 which has its outlet connected by a flow line 28 with the low pressure line 13 between the check valve 15 and the inlet 14 of the compressor 1 and preferably adjacent the inlet of said compressor. The lines 26 and 28 and flow capacity of the oil cooler 27 are preferably substantially the same size as the high pressure line 3 whereby if only liquid is moved by the compressor the entire output thereof may return to the suction side of said compressor for continued circulation.

A modulating type valve 29 is arranged in the line 28 for control of the flow of oil or liquid to the suction side of the compressor, and an oil line 30 communicates with the line 28 between the oil cooler and valve 29 and is connected with the compressor 1 for flow of oil under pressure to the bearings in said compressor for lubrication of same, when the structure of the compressor is such that the bearings require separate lubrication from the oil being pumped thereby. A suitable type of modulating valve 29 is illustrated in Fig. 2 and includes a housing 31 having inlet 32 and outlet 33 with a valve 34 for controlling flow therebetween. A valve spring 35 is arranged in the housing to urge the valve into closed position. The valve has a stem 36 engaged with a diaphragm 37 loaded by a diaphragm spring 38, an adjusting screw 39 being provided to adjust the diaphragm spring pressure for the desired loading on the diaphragm. A small passage 40 provides communication between the outlet 33 and the diaphragm chamber 41 whereby the outlet pressure acts on the diaphragm and when said outlet pressure overbalances the spring loading the valve is closed. When the outlet pressure is such that the spring loading is greater than said pressure, the valve is opened for flow of liquid therethrough, the valve opening being greater for increased flow in response to decrease of pressure at the compressor inlet. A small passage or bypass 42 extends from the inlet to the outlet of the valve 29 for flow of liquid through the valve housing when the valve 34 is closed, the capacity of the bypass being such that there is always sufficient liquid or lubricant flowing through the valve 29 and line 28 to supply lubricant to the rotor of the compressor.

A bypass line 43 communicates with the high pressure line 3 and is connected with the line 13 adjacent the inlet 14 of the compressor between said inlet and the check valve 15. A valve 44 is arranged in the bypass line 43 to control the flow of gas and/or liquid from the compressor discharge to the compressor inlet. Any suitable conventional thermostatic or pressure controlled valve may be used as the valve 44. It is preferred, however, to use an automatic modulating type pressure actuated valve, for example, a valve having the structure of the modulating type valve 29 with the passage or bypass 42 thereof omitted. It is also preferable that the adjusting screw in the valve 44 be set to provide slightly less loading on the diaphragm whereby slightly less pressure on the suction side of the compressor is required before the valve 44 opens for bypass of the gas and/or liquid from the discharge to the suction side of the compressor. In other words, when the pressure at the inlet of the compressor is lowered to a predetermined amount, the valve 29 will start to open to supply more oil to the inlet of the compressor, and then on further reduction of the pressure at the inlet of the compressor, the valve 44 will open to supplement the oil for supplying the full capacity of the compressor. Also, the adjusting screws of both the valves 29 and 44 may be adjusted whereby the sequence of opening is reversed or only one or the other opened to supply the necessary fluid medium for the capacity of the compressor.

If the combined medium of refrigerant gas and oil

supplied to the inlet of the compressor during operation is heated above a desired temperature, liquid refrigerant is delivered to said compressor inlet to reduce the temperature thereof. The liquid refrigerant may be taken from any portion of the system between the condenser and evaporator. In the illustrated structure, a line 45 is connected with the liquid refrigerant line 8 adjacent the outlet of the condenser 7 with the other end of said line connected with the line 13 between the check valve 15 and compressor inlet 14 and preferably adjacent said inlet. A conventional thermostatic valve 46 is arranged in the line 45 to control the supply of liquid refrigerant delivered to the inlet of the compressor 1. It is preferred that the valve 46 be a thermostatic expansion valve with a thermo-sensitive bulb 47 arranged at the inlet 14 of the compressor to act through a control line 48 whereby increase of temperature at the inlet of the compressor will open the valve 46, and on decrease of the temperature the bulb 47 will react to move the valve 46 toward closed position to decrease the flow of liquid refrigerant through the line 45.

In using a refrigerating apparatus constructed and assembled as described, a quantity of lubricant is placed in the separator so as to fill the coils of the oil cooler and provide a supply in the sump of the separator whereby said quantity is sufficient for full capacity operation of the compressor in movement of the oil through the line 3, separator 4, cooler 27, and line 28 to the suction side of the compressor. A suitable quantity of refrigerant is placed in the receiver 9 and lines of the refrigerating system to provide an adequate supply for operation of the apparatus. With the refrigerating apparatus in an automotive vehicle and the compressor 1 drivingly connected by the belt 2 to the engine of the vehicle, operation of said engine drives the compressor 1. Assuming that cooling of the passenger compartment is desired, the valve 18 is opened and the compressor 1 draws expanded refrigerant from the evaporator through the line 13 and check valve 15 into the intake of the compressor. Simultaneously, oil is drawn through the passage 42 in the valve 29 and the line 28 to the intake of the compressor to supply needed lubricant for the rotor and vanes thereof.

The compressor drives the refrigerant gas and oil at high pressure through the line 3 to the separator 4 where the filter 24 permits the refrigerant gas to pass into the line 6 but retains the oil whereby it is delivered to the sump 5 of the separator. The high pressure refrigerant gas flows through the line 6 to the condenser 7 where said refrigerant is liquefied and the liquid flows through the line 8 to the receiver 9 and through the line 10 to the evaporator 11 under control of the thermostatic expansion valve 12. When the load on the evaporator decreases, the thermo-sensitive bulb 16 reacts to partially close the valve 12 to reduce the flow of liquid refrigerant to the evaporator, with the result that the compressor 1 has a capacity greater than the refrigerant required to handle the load on the evaporator. Also, the vehicle may be operated at higher speeds with no material increase in the load on the evaporator and in any of such instances there is a substantial reduction of the pressure at the inlet of the compressor. This reduction in pressure acts on the diaphragm of the valve 29 whereby said valve is opened for flow of oil from the cooler 27 through the line 28 to the inlet of the compressor.

In order to obtain a minimum artificial load on the compressor, it is preferred that the valve 29 opens relative to the reduced pressure at the inlet of the compressor whereby the oil flowing through the line 28 does not supply the full requirements of the compressor at the speed operated resulting in further decrease of pressure at the inlet of the compressor whereby the valve 44 opens for flow of gas and/or liquid from the discharge line 3 of the compressor through the line 43 to the inlet side of the compressor. If this recirculation of the gas and

liquid discharged by the compressor in excess of the requirements of the load on the evaporator raises the temperature of the medium at the inlet of the compressor to a value higher than desired, the bulb 47 reacts to start opening the thermostatic valve 46 for flow of liquid refrigerant to the inlet of the compressor, said liquid refrigerant being evaporated as it moves in the compressor to cool same and reducing the temperature of the gas and liquid discharged by the compressor. The valves 12, 29, 44 and 46 are all preferably of the modulating type to regulate the flow of medium therethrough in accordance with the change of the control medium. If the compressor 1 is stopped, or the speed thereof suddenly reduced, whereby the pressure in the line between the check valve 15 and the compressor inlet 14 becomes more than the pressure in the line 13 upstream from the check valve 15, said check valve closes to prevent oil or liquid from backing up into the evaporator.

It is to be understood that while I have illustrated and described one form of my invention, it is not to be limited to the specific form or arrangement of parts herein described and shown except insofar as such limitations are included in the claims.

What I claim and desire to secure by Letters Patent is:

1. In a refrigeration system, the combination of a condenser, a refrigerant receiver containing a supply of refrigerant, a discharge line connecting the receiver and condenser, an expansion valve, a line connecting the expansion valve and the receiver, an evaporator connected to the expansion valve, a separator containing a supply of liquid lubricant carrier and having an inlet and a gas outlet and a liquid outlet, a flow line connecting the gas outlet of the separator to the condenser, a rotary refrigerant compressor adapted to pump a liquid lubricant carrier and combinations of said liquid lubricant carrier and refrigerant gas, said compressor having an inlet and a discharge outlet, said compressor discharge outlet being connected to the separator inlet for delivering the compressor output of liquid and gas to the separator under pressure which acts on the liquid lubricant carrier in said separator, a suction line connecting the evaporator and the compressor inlet, means for governing the operation of the expansion valve in response to temperature in said suction line adjacent the evaporator, a check valve in the suction line to prevent backflow from the compressor inlet to the evaporator, a flow connection between the liquid outlet of the separator to the suction line downstream from said check valve for flow of liquid to the compressor inlet, and means in said flow connection partially restricting flow of liquid lubricant carrier to the compressor inlet whereby pressure in the separator maintains flow of said carrier to the compressor inlet.

2. In a refrigerating apparatus including a condenser, an evaporator, a refrigerant compressor adapted to pump liquid and combinations of liquid and refrigerant gas and discharge same under pressure, said compressor having an inlet and outlet, and refrigerant circulating lines between said elements including a suction line connecting the evaporator to the compressor inlet, said elements and circulating lines containing a supply of refrigerating agent, a liquid and gas separator between the compressor outlet and the condenser containing a supply of liquid lubricant carrier for the refrigerating agent and having outlets for the separated gas and liquid with the gas outlet connected to the refrigerant circulating line to the condenser, means controlling flow of refrigerant through the evaporator in response to variations in the heat load on said evaporator, a flow line between the liquid outlet of the separator and the suction line to the compressor inlet for flow of liquid to the compressor inlet, means in the suction line between the evaporator and the connection of said flow line to prevent flow of liquid to the evaporator, and means in said flow line normally restricting flow of liquid therethrough to the compressor inlet and operative to open for increased flow of liquid to the compressor inlet in response

to a predetermined reduced pressure at the inlet side of the compressor whereby an increased quantity of liquid will be pumped through the compressor to the separator and reduce the refrigerant gas output of said compressor.

3. In a refrigerating apparatus including a condenser, refrigerant receiver, an evaporator, a refrigerant compressor adapted to pump liquid and combinations of liquid and refrigerant gas and discharge same under pressure, said compressor having an intake and discharge outlet, and refrigerant circulating lines between said elements including a suction line connecting the evaporator to the compressor inlet, said refrigerant receiver containing a supply of refrigerating agent, a liquid and gas separator between the compressor discharge outlet and the condenser containing a supply of liquid lubricant carrier for the refrigerating agent and having outlets for the separated gas and liquid with the gas outlet connected to the refrigerant circulating line to the condenser, means controlling flow of refrigerant through the evaporator in response to variations in the heat load on said evaporator, a flow line between the liquid outlet of the separator and said suction line for flow of liquid to the compressor inlet, means in said suction line between the evaporator and the connection of said flow line to said suction line to prevent flow of liquid to the evaporator, means in said flow line normally restricting flow of liquid therethrough to the compressor inlet and operative to open for increased flow of liquid to the compressor inlet in response to existence of a predetermined low pressure at the inlet of the compressor whereby an increased quantity of liquid will be pumped through the compressor to the separator and reduce the refrigerant gas output of said compressor, and means bypassing the flow restricting means in said flow line for maintaining a flow of liquid lubricant to the compressor for lubricating same.

4. In a refrigerating apparatus including a refrigerant compressor having an intake and a discharge outlet, said compressor being adapted to pump both liquid and a combination of liquid and refrigerant gas and discharge same under pressure, a liquid and gas separator containing a supply of liquid lubricant carrier for a refrigerating agent and having outlets for separated gas and liquid, means delivering compressed gas and liquid from said compressor to said separator, a condenser, connections between said gas outlet of the separator and the condenser, an evaporator unit, connections between said condenser and high pressure side of said evaporator unit including a thermostatically-actuated expansion valve having a temperature sensitive bulb adjacent the low pressure side of said evaporator unit whereby flow through said expansion valve is increased in response to increased temperature at the low pressure side of said expansion unit, a suction line between said compressor intake and the low pressure side of said evaporator unit including means spaced upstream from said compressor intake to prevent backflow toward said evaporator unit, and means responsive to variation in pressure in the suction line adjacent the compressor intake to vary the compressed gas output of the compressor while maintaining the total output of said compressor, said means including a flow line between the liquid outlet of the separator and the suction line between the backflow prevention means therein and the intake of the compressor and a valve in said flow line operable to increase flow of liquid therethrough to the compressor intake in response to reduced pressure at the intake of the compressor whereby lowering of said pressure at the compressor intake increases the flow of liquid through said flow line to said compressor intake and increases the proportion of liquid to gas in the compressor output and reduces the refrigerant gas delivery therefrom.

5. In a refrigerating apparatus including a condenser, refrigerant receiver, an evaporator and refrigerant circulating lines between said elements, said refrigerant receiver containing a supply of refrigerating agent, means controlling flow of refrigerant through the evaporator in

response to variation in the heat load on said evaporator, a separator containing a supply of liquid lubricant carrier for the refrigerating agent and having an inlet and a gas outlet and a liquid outlet, a refrigerant compressor having an inlet and a discharge outlet with said discharge outlet 5 connected to the separator inlet, said compressor being adapted to pump liquid and combinations of liquid and refrigerant gas and discharge same under pressure to the separator, a flow line between the gas outlet of the separator and condenser, a suction line between the evaporator 10 and the compressor inlet, a second flow line between the liquid outlet of the separator and the compressor inlet, a check valve in said suction line upstream from said second flow line to prevent flow of liquid from said second flow line to the evaporator, valve means in said second flow 15 line normally restricting flow of liquid therethrough to the compressor inlet and operative to open for increased flow of liquid to the compressor inlet in response to a predetermined low pressure at the inlet of the compressor whereby an increased quantity of liquid will be supplied 20 to said compressor and increase the proportion of liquid and decrease the proportion of refrigerant gas in the compressor output, a flow connection between the discharge outlet and the inlet of the compressor, and valve means in said flow connection and normally closing same and operative to open for flow of gas and liquid through said flow connection to the inlet of the compressor in response to a predetermined pressure at the inlet of the compressor which is lower than the predetermined pressure to which the valve means in the second flow line is responsive.

6. In a refrigerating apparatus including a condenser, refrigerant receiver, an evaporator, and refrigerant circulating lines between said elements, said refrigerant receiver containing a supply of refrigerating agent, means controlling flow of refrigerant through the evaporator in response to variation in the heat load on said evaporator, a separator containing a supply of liquid lubricant carrier for the refrigerating agent and having an inlet and a gas outlet and a liquid outlet, a refrigerant compressor having an inlet and a discharge outlet with said discharge out- 40

let connected to the separator inlet, said compressor being adapted to pump liquid and combinations of liquid and refrigerant gas and discharge same under pressure to the separator, a flow line between the gas outlet of the separator and the condenser, a suction line between the evaporator and the compressor inlet, a second flow line between the liquid outlet of the separator and the compressor inlet, a check valve in said suction line upstream from said second flow line to prevent flow of liquid from the second flow line to the evaporator, valve means in said second flow line normally restricting flow of liquid therethrough to the compressor inlet and operative to open for increased flow of liquid to the compressor inlet in response to existence of a predetermined low pressure at the inlet of the compressor whereby an increased quantity of liquid will be supplied to said compressor and increase the proportion of liquid and decrease the proportion of refrigerant gas in the compressor output, a flow connection between the circulating lines upstream from the evaporator and the compressor inlet, and valve means in said flow connection normally in closed position and operable to open for flow of refrigerant to the compressor inlet in response to existence of a predetermined high temperature at said compressor inlet.

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