

[54] **TWO-STAGE REFRIGERATION SYSTEM HAVING CRANKCASE PRESSURE REGULATION IN HIGH STAGE COMPRESSOR**

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[22] Filed: **Oct. 8, 1971**

[21] Appl. No.: **187,800**

[52] U.S. Cl. **62/193, 62/470, 62/510**
[51] Int. Cl. **F25b 31/00**
[58] Field of Search **184/6.16; 62/192, 193, 468, 62/420, 471, 472, 510**

[56] **References Cited**

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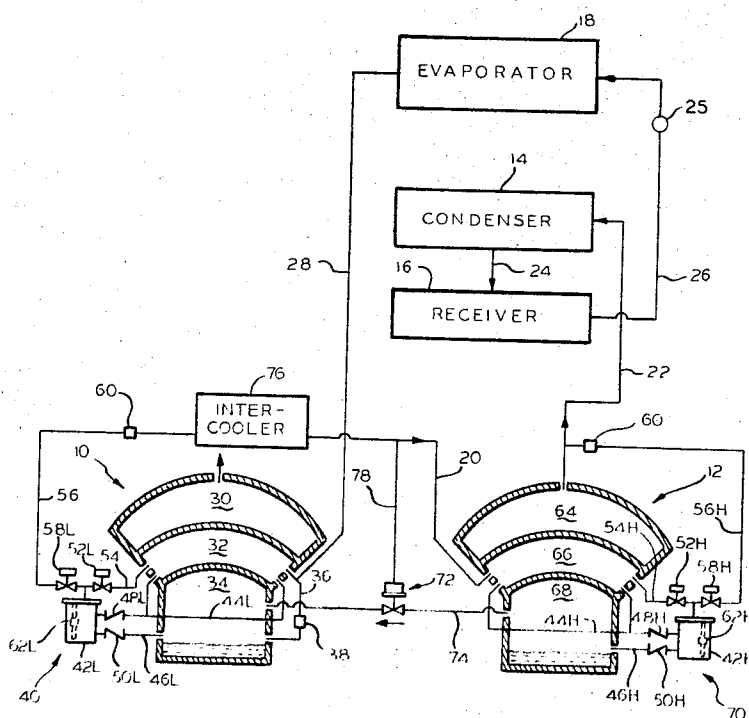
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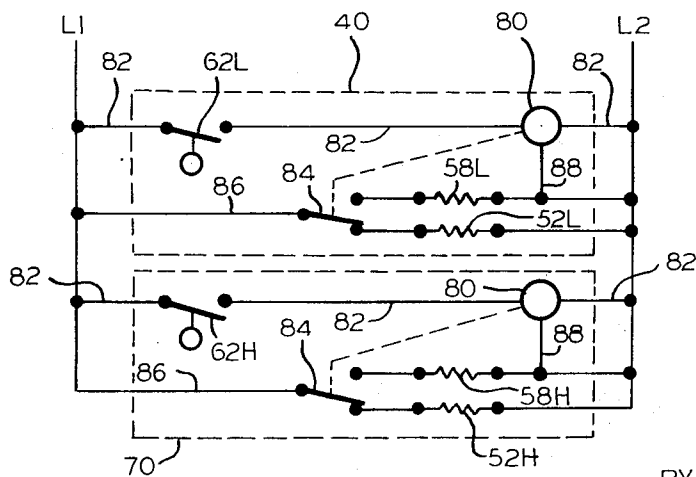
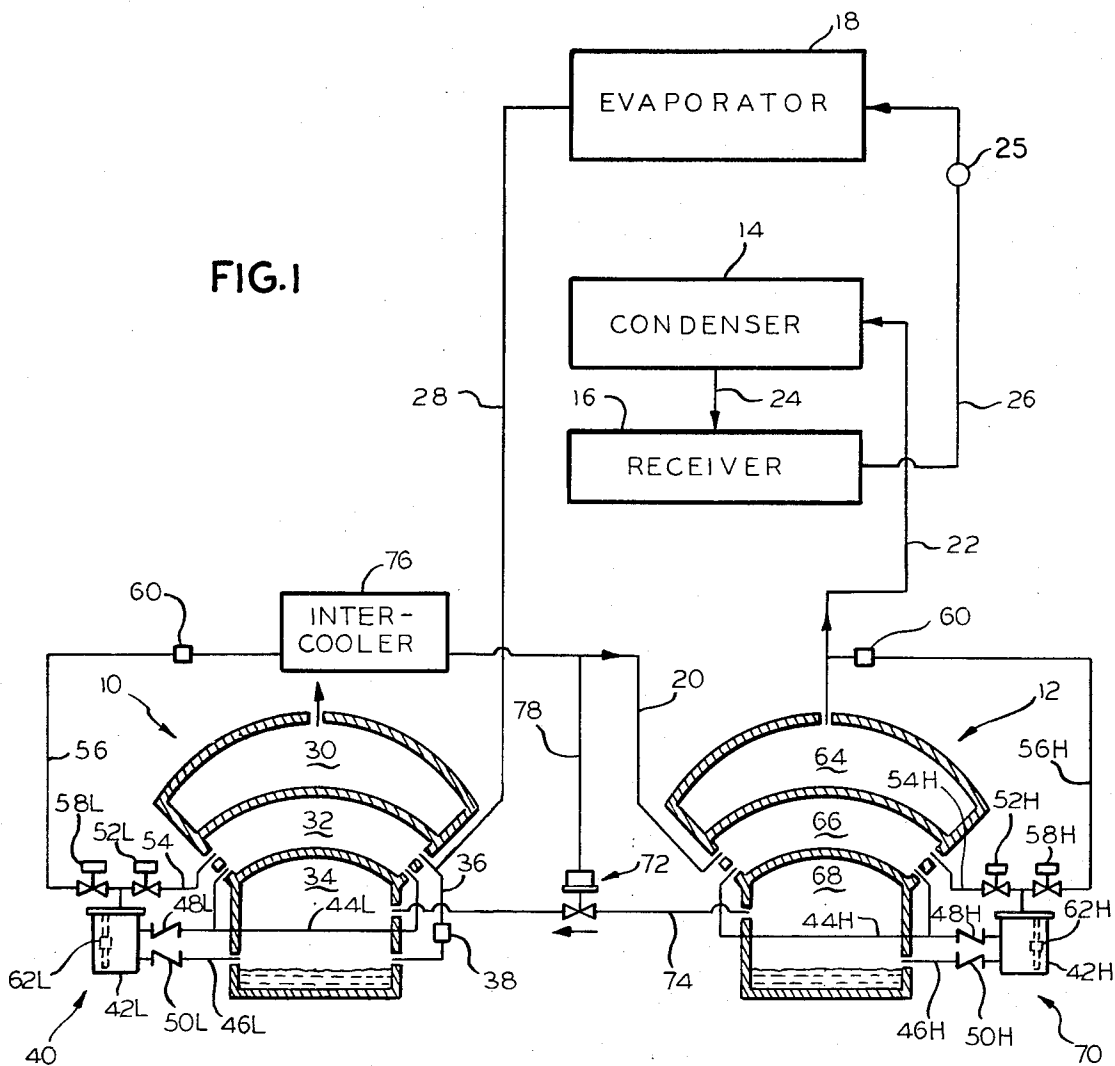
Primary Examiner—Meyer Perlin
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[57] **ABSTRACT**

A two-stage refrigeration system including a condenser, a receiver, an evaporator, a low-stage dry-wall compressor and a high-stage dry-wall compressor, the low-stage compressor including an oil-draining assembly for automatically draining oil from the suction chamber to the crankcase chamber, and a pressure-equalizing connection between the suction chamber and the crankcase chamber, the high-stage compressor having an oil-draining assembly for automatically draining oil from the high-stage suction chamber to the high-stage crankcase chamber, and a pressure connection between the high-stage crankcase chamber and the low-stage crankcase chamber; and a pressure-responsive regulating valve interposed in the connection between the high-stage crankcase chamber and the low-stage crankcase chamber, the pressure-responsive valve being connected to respond to the high-stage suction chamber pressure to maintain a predetermined pressure differential of one pound per square inch between the high-stage suction chamber and the high-stage crankcase chamber.

9 Claims, 2 Drawing Figures





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TWO-STAGE REFRIGERATION SYSTEM HAVING CRANKCASE PRESSURE REGULATION IN HIGH STAGE COMPRESSOR

BACKGROUND OF THE INVENTION

In most two-stage refrigeration systems, the presence of oil vapor in the suction chambers is not considered detrimental to the operation of the system. Where high accumulations are anticipated, automatic draining systems have been provided such as shown in U.S. Pat. No. 3,543,800. In this type of a system, the pressure in the crankcase chamber has been maintained equal to the pressure in the second stage suction chamber to reduce operating forces on the compressor bearings and rod seals so that they do not become overloaded. However, it has now been determined that the oil which is miscible in halocarbon refrigerants is often carried along through the refrigeration system with the gaseous refrigerant and collects in the various parts of the system. Oil-separating devices are often provided in the discharge line from the high-pressure discharge chamber in order to remove any oil which may have been carried into the discharge chamber from the suction chamber.

SUMMARY OF THE INVENTION

The two-stage refrigeration system of the present invention contemplates the use of drywall compressors and reduces the possibility of oil vapors being carried into the compressor suction and discharge chambers to a minimum. In my copending application, Ser. No. 187,801, entitled "Single Stage Dry Cylinder Compressor Having Automatic Oil Drain from Suction Chamber to Crankcase", an automatic oil draining assembly has been disclosed for a single-stage drywall compressor. However, in a two-stage drywall compressor system, the use of such an assembly on each stage has not been adequate to provide the necessary reduction of oil vapor in the system. In the present system, the pressure in the high-stage suction chamber and high-stage crankcase chamber is maintained at a predetermined pressure differential to eliminate overloading of the compressor bearings and piston rod and to assure that gas pressure leakage is from the high-stage suction chamber into the high-stage crankcase chamber.

Other advantages of the present invention become apparent from the following detailed description when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of the two-stage drywall compressor refrigeration system of the present invention; and

FIG. 2 is an electrical diagram of the circuit arrangement for the oil return assemblies.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A refrigeration system as contemplated herein is shown in FIG. 1 of the drawings and as seen therein, the refrigeration system includes a low-stage compressor 10, a high-stage compressor 12, a condenser 14, a receiver 16, and an evaporator 18. As is generally understood in the art, the low-stage compressor 10 is connected to the high-stage compressor 12 by means of a

discharge conduit 20. The high-stage compressor 12 is serially connected to the low-stage compressor 10 through the condenser 14, receiver 16 and evaporator 18 by means of high-pressure discharge conduit 22, liquid refrigerant conduit 24, high-pressure refrigerant conduit 26 and suction pressure conduit 28. A refrigerator control valve 25 is provided in conduit 28 to reduce pressure at the entrance of the evaporator.

Low-Stage Compressor

The low-stage compressor 10 includes a low-stage discharge chamber 30, a low-stage suction chamber 32, and a low-stage crankcase chamber 34. Means are provided to equalize the pressure between the suction chamber 32 and crankcase chamber 34 in the form of an equalizing line 36. Oil vapor is prevented from entering the suction chamber through the equalizing line 36 by means of an oil filtering device 38.

Means are provided to automatically drain oil from the suction chamber 32 back to the crankcase chamber 34, as more fully discussed in my copending application Ser. 187,801. Such means is in the form of an automatic oil return assembly 40 which includes a reservoir 42L operatively connected to allow oil to flow from the suction chamber 32 to the reservoir 42L by oil conduits 44 and operatively connected to allow oil to flow from the reservoir 42L to the crankcase chamber 34 by oil conduit 46. One-way check valves 48L and 50L are provided, respectively, in the oil conduits 44L and 46L to prevent reverse flow of oil through either of the conduits 44 or 46.

The flow of oil from the suction chamber to the reservoir 42 is controlled by means of a solenoid valve 52L interposed in a pressure line 54 provided between the suction chamber and the reservoir 42. The solenoid valve is normally open to equalize pressure between the suction chamber 32 and the reservoir 42L to allow any oil which accumulates in the suction chamber 32 to flow freely through the oil conduits 44 to the reservoir 42L.

Oil is forced from the reservoir 42L through the conduit 46L and into the crankcase chamber 34 by connecting the reservoir 42 to the discharge conduit 20 by conduit 56 to allow the high-pressure discharge refrigerant to enter the reservoir 42L. The flow of high-pressure refrigerant is controlled by means of a second solenoid valve 58L interposed in the conduit 56, which is normally closed when solenoid valve 52L is open. When solenoid valve 58L is opened, solenoid valve 52L is closed and the pressure in conduit 56 and reservoir 42 rises to force the oil through the oil conduit 46 into the crankcase chamber. The rate of pressure rise in the reservoir 42 can be restricted by means of a restricted orifice 60 provided in conduit 56.

Means are provided to selectively control the solenoids 52L and 58L in response to the level of oil in the reservoir 42L. Such means is in the form of a float valve 62L provided in the reservoir and operatively connected through a circuit as shown in FIG. 2 to the solenoids 52 and 58 to close the solenoid 52 and open the solenoid 58 whenever the oil in the reservoir reaches a predetermined height. The operation of the electrical circuit in FIG. 2 is described below.

High-Stage Compressor

The high-stage compressor 12 includes a high-stage discharge chamber 64, a high-stage suction chamber 66

and a crankcase chamber 68. Means are provided to allow for the flow of oil from the suction chamber 66 to the high-stage crankcase chamber 68 in the form of an oil-return assembly 70. The assembly 70 operates in substantially the same manner as oil-return assembly 40.

The flow of oil from the suction chamber 66 to the reservoir 42H is controlled by means of a solenoid valve 52H interposed in a pressure line 54H provided between the suction chamber 66 and the reservoir 42H. The solenoid valve 52H is normally open to equalize pressure between suction chamber 66 and the reservoir 42H to allow any oil which accumulates in the suction chamber 66 to flow freely through the oil conduits 44H to the reservoir 42H.

Oil is forced from the reservoir 42H through the conduit 46H into the crankcase chamber 68 by connecting the reservoir 42H to the discharge conduit 20 by a gas pressure conduit 56H to allow the high-pressure discharge refrigerant to enter the reservoir 42H. The flow of high-pressure refrigerant is controlled by means of a second solenoid valve 58H interposed in the conduit 56H which is normally closed when solenoid valve 52H is open. When solenoid valve 58H is opened, solenoid valve 52H is closed and the pressure of the gaseous refrigerant in the conduit 56H is applied to the reservoir 42H to force the oil into the crankcase chamber 68. The rate of pressure rise in the reservoir 42H is restricted by means of an orifice 60 provided in conduit 56H.

Means are provided to selectively control the solenoids 52H and 58H in response to the level of oil in the reservoir 42H. Such means is in the form of a float valve 62H provided in the reservoir 42H and operatively connected through the circuit shown in FIG. 2 to the solenoids 52H and 58H. Whenever the oil in the reservoir 42H reaches a predetermined level, the float valve will deenergize solenoid 52H to close conduit 54H and will open solenoid 58H and connect the reservoir 42H to the high-pressure discharge chamber 64.

Control Circuit

The control circuit for the two oil drain assemblies 40 and 70 are identical as seen in FIG. 2. The description of the circuit for controlling solenoids 52L and 58L is therefore described below. However, it should be understood that the description for the circuit for solenoids 52H and 58H is the same. As seen in FIG. 2, the float control valve 62L is connected across lines L₁-L₂ in series with timer 80 by lines 82. The solenoids 52L and 58L are alternately connected across the lines L₁-L₂ by timer switch 84 connected to line 86. A holding circuit is set up between the timer 80 and the solenoid 58L by a bypass line 88.

In operation, the solenoid valve 52L is normally energized by closed switch 84. When the float valve 62L closes to energize timer 80, switch 84 will open the circuit through solenoid 52L and close the circuit through solenoid 58L. The timer 80 will run for a preset time interval to allow for the complete discharge of oil from the reservoir 42L since the float valve 62L will open as soon as oil starts to drain from reservoir 42L. When the timer 80 opens the timer switch 84, the solenoids 58L and timer 80 will be deenergized and solenoid 52L will be energized.

Pressure-Regulating Valve Assembly

In accordance with the invention, the pressure differential between the high-pressure suction chamber 66 and the high-pressure crankcase chamber 68 is controlled by means of a pilot-operated pressure-regulating valve 72. In this regard, the crankcase chamber 68 is connected to the low-pressure crankcase chamber 34 by means of a gas pressure conduit 74. The low-pressure discharge chamber 30 is connected to the high-pressure suction chamber 66 by means of the gas pressure conduit 20. An intercooler 76 may be provided in the discharge pressure conduit 20, if desired.

The pilot-operated pressure-regulating valve is interposed in the gas pressure conduit 74 and is operatively connected to the discharge pressure conduit 20 by means of a bypass conduit 78. The pilot-operated pressure-regulating valve 72 is set to maintain the pressure in the high-pressure crankcase chamber 68 approximately 1 pound per square inch below the pressure of the high-pressure suction chamber 66. By maintaining this pressure differential at 1 pound per square inch, any oil vapor present in the high-pressure crankcase chamber 68 will be prevented from flowing into the high-pressure suction chamber 66. Since a one-pound pressure differential always exists between the high-stage suction chamber 66 and the high-stage crankcase chamber 68, a continual internal leakage of gas will occur between the suction chamber 66 and crankcase chamber 68.

In operation and under stable operating conditions, the pressure-regulating valve 72 will constantly bleed crankcase chamber pressure from crankcase chamber 68 to crankcase chamber 34 at the same rate as the internal leakage between the suction chamber 66 and the crankcase chamber 68. On a rise in high-stage suction pressure in chamber 66, the internal leakage will increase and the pressure-regulating valve will close until the pressure in the crankcase chamber 68 builds up to within one pound of the pressure in the suction chamber 66 at which point the pressure-regulating valve 72 will again open. On a drop in high-stage suction pressure, the pressure-regulating valve will open wide to immediately reduce the pressure in crankcase chamber 68 to one pound below the pressure in suction chamber 66.

By maintaining the pressure in the crankcase chamber 68 one pound below the pressure in suction chamber 66, the possibility of any oil vapor accumulating in the suction chamber 66 from the crankcase chamber 68 is substantially prevented. In the event any oil vapor in the discharge refrigerant from the low-stage discharge chamber 30 accumulates in the high-stage suction chamber 66, the accumulated oil will be allowed to return to the crankcase chamber 68 by the automatic oil drain assembly 70. The high-stage compressor 12, therefore, acts as a final filter in the event of any oil vapor passing from the low-stage compressor 10 to the high-stage compressor 12.

The high-stage crankcase chamber 64 is connected to the low-stage crankcase chamber 34 to prevent any loss of oil from the system. In this regard, the oil vapor within the crankcase chamber 68 will pass to the crankcase chamber 34. It should be apparent that with this arrangement oil will accumulate in chamber 34 and the oil level in chamber 68 will creep below normal. This can be compensated for by connecting an oil pump to

respond to the oil level in chamber 34 and to pump oil from chamber 34 to chamber 68.

RESUME

The present invention provides for an oil-free operation of a two-stage drywall compressor for a refrigeration system. This is accomplished by holding the pressure in the high-stage suction chamber higher than the pressure in the high-stage crankcase chamber. This pressure differential is controlled by a pressure-regulating valve which is connected to respond to the suction chamber pressure and the crankcase chamber pressure. Internal gas pressure leakage in the high-stage compressor will always be from the suction chamber to the crankcase chamber.

I claim:

1. A refrigeration system comprising,
 - a condenser,
 - a receiver,
 - and an evaporator,
 - a low-stage drywall compressor and a high-stage drywall compressor operatively connected to said condenser, receiver, evaporator and to each other, each compressor including a discharge chamber, a suction chamber and a crankcase chamber,
 - first means for draining oil from said low-stage suction chamber to said low-stage crankcase chamber,
 - second means for automatically draining oil from said high-stage suction chamber to said high-stage crankcase chamber,
 - and means for maintaining a predetermined pressure differential between said high-stage suction chamber and said high-stage crankcase chamber.
2. The system according to claim 1 wherein said maintaining means includes a pressure-responsive valve connected to vent said high-stage crankcase chamber and connected to respond to the discharge pressure of said low-stage discharge chamber.
3. The system according to claim 2 wherein said valve is set to maintain a one-pound pressure differential between the high-stage suction chamber and the high-stage crankcase chamber.
4. The system according to claim 1 wherein each of said oil-draining means includes a reservoir operatively connected to allow oil to drain from the corresponding suction chamber to the reservoir and from the reservoir to the corresponding crankcase chamber and including means responsive to the level of oil in the reservoir for

selectively connecting said reservoir in gas-pressure equalizing relation to one of the corresponding suction chambers or discharge chambers.

5. The system according to claim 1 including a first gas pressure conduit connected between said high-stage crankcase chamber and said low-stage crankcase chamber, and a second gas pressure conduit connected between said low-stage discharge chamber and said high-stage suction chamber, said maintaining means including a pressure-responsive regulating valve interposed in said first gas pressure conduit and connected to said second gas pressure conduit.

6. The system according to claim 5 wherein said valve is set to maintain the pressure in said high-stage suction chamber higher than the pressure in said high-stage crankcase chamber.

7. A refrigeration system having a condenser, a receiver, and an evaporator operatively connected to a first stage drywall compressor including a first stage suction chamber, a first stage discharge chamber and a first stage crankcase chamber, and a second stage drywall compressor including a second stage suction chamber, a second stage discharge chamber, and a second stage crankcase chamber, a gas refrigerant conduit connecting said first stage discharge chamber in gas pressure relation to said second stage suction chamber, a gas pressure conduit connecting said second stage crankcase chamber in gas pressure relation to said low-stage crankcase chamber, and means interposed in said gas pressure conduit for controlling the pressure in said second stage crankcase chamber.

8. The system according to claim 7 wherein said controlling means in connected to said gas refrigerant conduit to maintain a predetermined pressure differential between said second-stage suction chamber and said second-stage crankcase chamber.

9. The system according to claim 7 including means for equalizing pressure between said first-stage suction chamber and said first-stage crankcase chamber, first means operatively connected to said first-stage suction chamber and said first-stage discharge chamber for draining oil from said first-stage suction chamber and discharging oil under pressure into said first-stage crankcase chamber, and second means operatively connected to said second-stage discharge chamber and said second stage suction chamber for automatically draining oil from said second-stage suction chamber and discharging oil into said second stage crankcase chamber.

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