Sept. 20, 1971 B. W. ROMERHAUS 3,606,588

PRESSURE EQUALIZING MEANS FOR COMPRESSORS AND THE LIKE

Filed April 10, 1969 2 Sheets-Sheet 1

FIG. 1

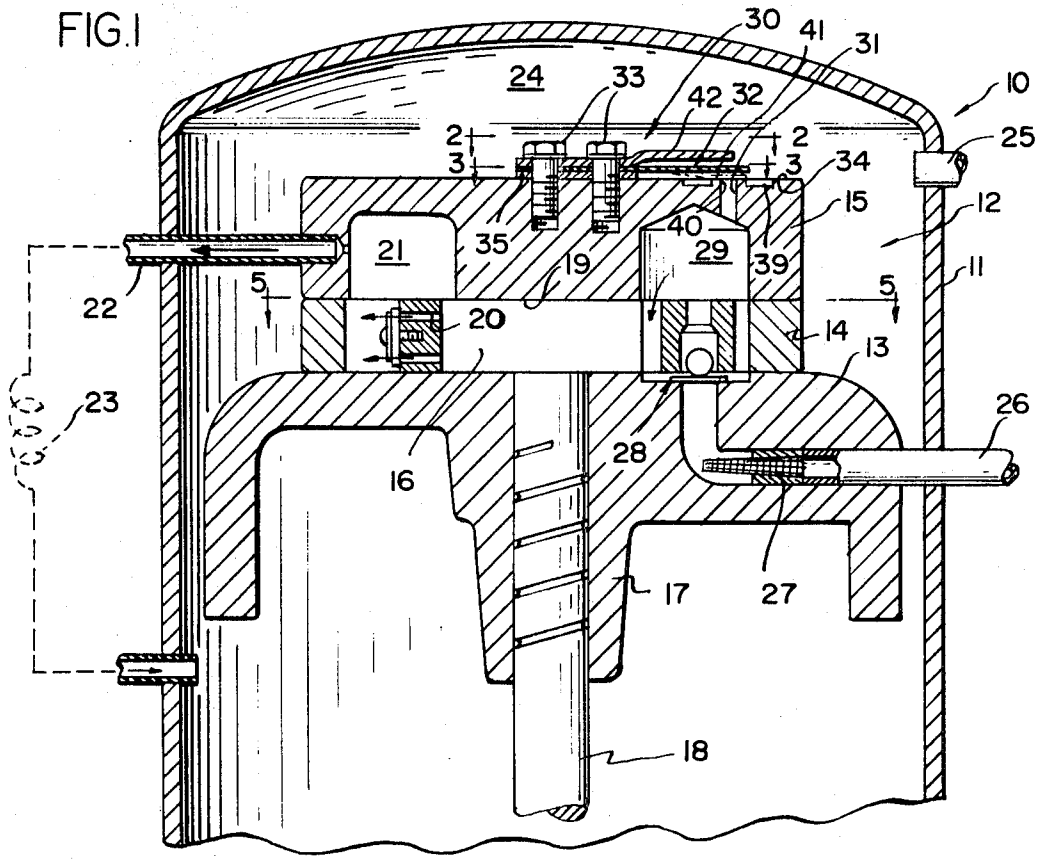


FIG. 2

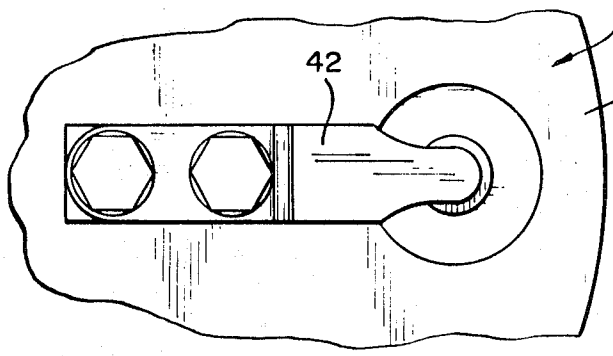


FIG. 4

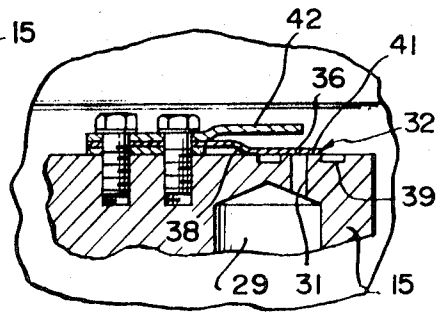
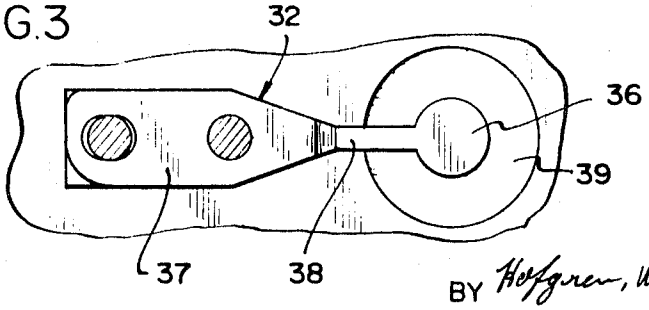


FIG. 3



INVENTOR.
BERT W. ROMERHAUS

BY Hofgren, Wegner, Allen, Stellman & McCord

ATTORNEYS.

PRESSURE EQUALIZING MEANS FOR COMPRESSORS AND THE LIKE

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FIG.5

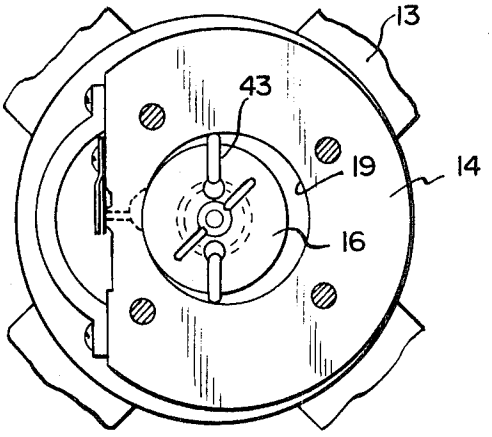


FIG.6

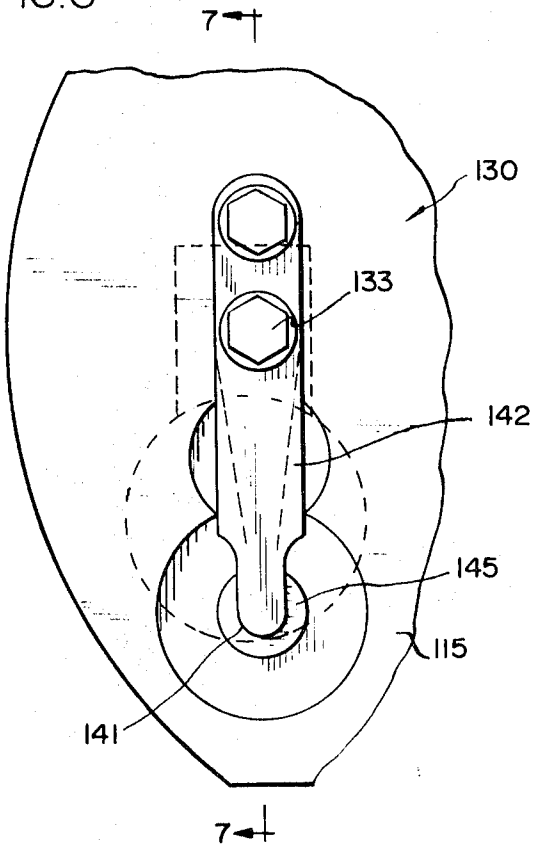
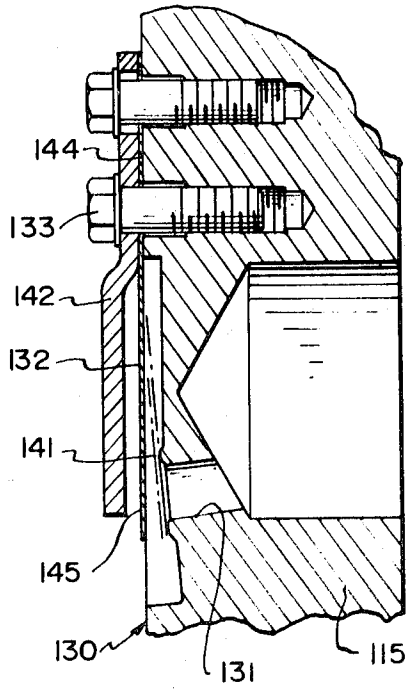


FIG.7



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PRESSURE EQUALIZING MEANS FOR COMPRESSORS AND THE LIKE

Bert W. Romerhaus, Haubstadt, Ind., assignor to Whirlpool Corporation

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Int. Cl. F04b 49/00
U.S. Cl. 417—292 5 Claims

ABSTRACT OF THE DISCLOSURE

A pressure equalizing device for a compressor wherein a valve controlled passage between a high pressure chamber and a suction chamber of the compressor is provided for equalizing the pressure in the suction chamber and the high pressure chamber during start-up of the compressor. The compressor comprises a rotary compressor having a rotor disposed in the compression chamber for compressing fluid such as refrigerant fluid which is precooled and then delivered to the high pressure chamber for delivery to associated apparatus such as refrigeration apparatus. The fluid is returned to the suction chamber of the compressor through a return inlet which is provided with a check valve for preventing reverse flow from the suction chamber.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to compressors and, in particular, to means for facilitating start-up of compressors such as rotary compressors.

Description of the prior art

A number of pressure equalizing devices have been developed for use in rotary compressors such as employed in refrigeration apparatus for compressing refrigeration fluid. In such apparatus, repeated cycling places a severe strain on the compressor motor, and more specifically, places a severe strain on the motor during start-up of the compressor, when relatively high pressure differentials occur between the suction and discharge sides of the compressor. Conventionally, split-phase motors are employed for use in such motor compressors and thus, while the load requirements are such that a high starting torque is desirable, such motors providing relatively low starting torque are severely strained by the high pressure differential loading.

To provide improved use of such relatively low starting torque motors, devices for equalizing the pressure during a start-up of the compressor have been developed. One example of such a pressure equalizing means is in my U.S. Pat. 3,348,764, owned by the assignee hereof. In that patent, a gravity biased valve member is provided for controlling communication between the compressor inlet and outlet to equalize pressure across the compressor during the start-up period. To provide a delayed action of the valve, a restriction is provided on the high pressure side thereof. In U.S. Letters Pat. No. 2,370,909, issued to Penn, an unloader device is provided including a passage connecting the compressor inlet and outlet, a pivoted member, and a valve which is normally open during idle periods and connected to the pivoted member for closing the unloading passage. The pivoted member is actuated by a magnetic means located adjacent the motor so as to be in the magnetic field of the motor when the motor is energized, thereby to close the valve substantially immediately upon energization of the motor and hold the valve closed throughout the continued energization of the motor.

SUMMARY OF THE INVENTION

The present invention comprehends an improved pressure equalizing means replacing the gravity biased valve member of my earlier patent, and the magnetic operating means of the Penn patent, and providing a simple and economical control of the pressure equalization wherein the compressor is unloaded for a preselected period at start-up. In the present invention, the pressure equalization period is terminated as an incident of the compressor providing a preselected rate of flow of the refrigerant fluid through a bypass which automatically closes the bypass. The bypass is caused to remain closed as an incident of the maintained pressure differential between the high pressure chamber and the suction chamber of the compressor.

More specifically, the invention comprehends a new and improved means for equalizing the pressure in the suction and high pressure chambers during start-up of a compressor having a compression chamber, a suction chamber, a high pressure chamber, and means for pumping fluid at high pressure from the pump chamber to the high pressure chamber. The pressure equalizing means comprises a bypass passage providing direct communication between the suction and high pressure chambers and flow control means responsive to the mass flow of fluids from said high pressure chamber through the passage to the suction chamber to close the passage as a result of the mass flow reaching a preselected value.

Further more specifically, the invention comprehends the provision of such a pressure equalizing means wherein the flow control means comprises a reed valve.

Still further, the invention comprehends the provision of such a pressure equalizing means wherein the flow control means includes means for maintaining the bypass passage closed as a result of the pressure differential between the high pressure chamber and the suction chamber of the compressor obtained after the start-up period.

Still further more specifically, the invention comprehends the provision of such a pressure equalizing means wherein substantially all of the fluid circulated by the compressor during the start-up period is delivered through the bypass passage to the suction chamber.

Still further more specifically, the invention comprehends the provision of an improved reed valve for use as a pressure equalizing means in such a compressor.

Further more specifically, the invention comprehends the provision of such an improved reed valve which is responsive to the mass flow of refrigerant flowing therepast through a bypass passage. The mass flow is proportional to the velocity as well as the density of the refrigerant. The compressor herein is driven by a motor having a preselected operating torque characteristic so that upon closing of the equalizing valve the motor will continue to accelerate to the desired operating speed.

The compressor motor generates sufficient torque to cause a sufficient mass flow to close the valve at a speed substantially less than the normal operating speed of the motor. Where the compressor is operated at low ambient temperatures, the motor generates sufficient heat to increase the vapor pressure of the refrigerant to effect the desired closing of the pressure equalizing valve.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages will be apparent from the specification and the drawings, in which:

FIG. 1 is a fragmentary vertical section of a compressor having pressure equalizing means embodying the invention;

FIG. 2 is a fragmentary enlarged horizontal section taken substantially along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary horizontal section taken substantially along the line 3—3 of FIG. 1;

FIG. 4 is a fragmentary vertical section illustrating the closed arrangement of the reed valve;

FIG. 5 is a reduced horizontal section of the compressor taken substantially along the line 5—5 of FIG. 1;

FIG. 6 is a fragmentary enlarged horizontal section of a compressor having a modified pressure equalizing means embodying the invention; and

FIG. 7 is a fragmentary vertical section taken substantially along the line 7—7 of FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in FIGS. 1 through 5 of the drawing, a motor compressor generally designated **10** is shown to comprise a housing **11**, a compressor **12** defined by a front head **13**, a cylinder **14**, a rear head **15**, and a rotor **16**. The front head **13** further defines a hub **17** carried on a motor shaft **18** which is rotatably driven by a conventional electric motor (not shown). The front head **13**, rear head **15** and cylinder **14** cooperatively define a compression chamber **19** in which the rotor **16** is rotatably disposed for compressing, in a conventional manner, a fluid such as refrigerant fluid through discharge ports **20** to a discharge chamber **21**. The high pressure fluid may be precooled as by delivery through a line **22** to a precooler **23** and thence back into the high pressure chamber **24** of the housing **11**. Such return to the housing permits the cooled fluid to cool the compressor and thereby permit greater efficiency in the operation thereof. The high pressure fluid is delivered through an outlet **25** to the associated refrigeration apparatus (not shown) and is returned to the compressor throuugh an inlet tube **26** which, as shown in FIG. 1, may be provided with a filter screen **27** and a check valve **28**. The inlet tube **26** opens to a suction chamber **29** which communicates with the pump chamber **19** to complete the normal circuit of the fluid.

As discussed briefly above, the invention comprehends providing means for equalizing the pressure between the high pressure chamber **24** and the suction chamber **29** during start-up of the compressor. As shown in FIG. 1, the pressure equalizing means generally designated **30** comprises a bypass passage **31** in the rear head **15** communicating with the high pressure chamber **24** and the suction chamber **29**. As illustrated, the passage **31** may comprise a right cylindrical passage providing direct communication between the chambers **24** and **29**. The passage **31** is controlled by a reed valve **32** which is carried on the rear head by means of a pair of bolts **33**. The reed valve **32** is spaced from the upper surface **34** of the rear head **15** by a spacer **35** to dispose a movable valve member portion **36** thereof slightly above the opening **40** of the passage **31**. As shown in FIG. 3, the valve member portion **36** is connected to a base portion **37** of the valve **32** by a narrowed connecting portion **38**. The upper surface **34** of rear head **15** is provided with an annular depression **39** coaxially about the opening **40** of passage **31** to define an annular valve seat **41** coaxially of opening **40** and coplanar with surface **34**. A rigid guard **42** is carried by bolts **33** outwardly of the valve **32** to protect the reed valve **32** during assembly of the compressor.

More specifically, as shown in FIG. 4, valve **32** flexes to have the valve member portion **36** seat coplanarly on the valve seat **41** by a flexing of the connecting portion **38** away from the guard **42**. The flexing of the valve is accomplished herein by the mass flow of the refrigerant fluid past the valve member portion **36** into the passage opening **40** of the bypass passage **31** during the start-up of the compressor. The diameter of the passage **31** is preselected to assure a flow of substantially all of the refrigerant fluid being pumped by the rotor **16** during the start-up period, with weighed check valve **28** maintaining the return inlet tube **26** closed at this time. Thus, during

the start-up portion of the compressor operation, the compressed refrigerant fluid is delivered from the compression chamber **19** through the line **22** to the high pressure chamber **24**. The fluid then flows past the valve member portion **36** and through bypass passage **31** directly back to the suction chamber **29** for recirculation by the compressor rotor **16**. However, when the rate of flow of the fluid past the valve member **36** reaches a preselected value, the dynamic forces generated by the fluid flow cause the valve member **36** to move downwardly across the valve seat **41** to close the passage **31**. The mass flow effecting the closing of the passage may be controlled by suitably varying the parameters of the pressure equalizing system such as the size of the valve member **36**, the flexibility of the connecting portion **38**, the resilient flex characteristic of the valve **32**, the size of the passage **31**, and the proximity of the valve member portion **36** to the valve seat **41** in the open position.

As the operation of the reed valve **32** is controlled by the mass flow of the refrigerant, a variation in either the velocity or density of the refrigerant affects the operation of the valve. The density of such a refrigerant is related to the ambient temperature at the compressor housing, and at low ambient temperature, such as approximately 0° F., the vapor pressure of the refrigerant may be relatively low, such as approximately 10 p.s.i.g. At such a low pressure the density of the refrigerant may be insufficient to provide a sufficient mass flow to cause a closing of the reed valve. However, sufficient heat is generated by the drive motor to raise the temperature and pressure of the refrigerant, and thus the density thereof is sufficient to provide a mass flow suitable for closing the valve.

The speed of the compressor at which the valve closes is preferably substantially less than the normal operating speed of the compressor. Thus, after the valve is closed, the compressor accelerates to the desired operating speed under increased load conditions, requiring substantially greater torque capabilities of the drive motor.

Illustratively, in one embodiment of the invention providing highly satisfactory operation of the conpressor, the compressor cylinder had a diameter of 1.850 inches and a depth of .575 inch, and the rotor had a diameter of 1.593 inches. The compressor was driven by a conventional two-pole, 3600 r.p.m. split-phase electric motor. The compressor displaced in that compression approximately 2200 cubic inches per minute of refrigerant fluid at the normal running speed of approximately 3600 r.p.m. The valve **32** was formed of Swedish spring steel having a thickness of approximately .005 inch. The valve member portion **36** had a diameter of approximately .312 inch, the connecting portion had a width of approximately .09 inch, and the length of the connecting portion was approximately .308 inch. The spacer **35** had a thickness of approximately .05 inch, and the diameter of the passage **31** was approximately $\frac{3}{16}$ inch. It was found in such a compressor structure that the valve means **30** effected a closing of the passage **31** at approximately 1500 r.p.m., or when the displacement of refrigerant by the compressor was approximately 930 cubic inches per minute, as compared to a normal operating speed of 3600 r.p.m., providing a displacement of approximately 2200 cubic inches per minute.

After the valve member **36** seats on the valve seat **41**, it is maintained seated thereagainst by the pressure differential existing between the low pressure fluid in suction chamber **29** and the high pressure fluid in chamber **24**. When operation of the compressor is terminated, the valve **32** returns to the normally open position of FIG. 1 in a short time (usually less than a minute), thereby opening the bypass passage **31** for equalized pressure restarting of the compressor. The delay in the return of the valve **32** to the open position is caused by the delayed reduction of the pressure differential across the valve to approximately 10 p.s.i.g. The reduction in the pressure differential re-

sults only through leakage of the housing pressure through the bearing clearances and oil grooves past the rotor into the low-pressure cavity portion of the housing.

During the start-up of the compressor, only a small pressure differential occurs between the suction chamber 29 and the high-pressure chamber 24 as a result of the substantially direct communication provided by the passage 31. Illustratively, in a fractional horsepower compressor the pressure differential may be of an order requiring approximately .8 ounce feet of motor starting torque. Thus, the motor is substantially completely unloaded during the start-up condition, whereby the motor need only overcome the normal friction of the compressor and provide the acceleration force to bring the compressor up to speed. A highly desirable feature of the present invention is the substantial elimination of underblade pressure during the start-up period, whereby the rotor blades 43 (FIG. 5) may ride over any excess oil accumulation in the pump chamber 19.

Thus, the structure of claims 1–5 provides an improved pressure equalizing means which is extremely simple and economical of construction while yet providing an effectively positive control of the pressure-equalized starting conditions of the motor compressor. The pressure equalizing control is effectively removed from the system by the pressure differential occurring during the normal operating conditions of the compressor while yet the pressure equalizing system becomes effective shortly after stopping the compressor.

Turning now to FIGS. 6 and 7, a modified form of pressure equalizing means generally designated 130 is shown to comprise a pressure equalizing means generally similar to pressure equalizing means 30 of motor compressor 10 but having a modified arrangement of the valve seat wherein the seat 141 is at an angle to the normal planar disposition of the reed valve 132. Thus, as shown in FIG. 7, the reed valve 132 merely flexes about the portion 144 secured by bolts 133 to have the distal portion 145 extend substantially parallel to the seat 141 at the time of closing. As further shown in FIG. 7, the bypass passage 131 extends perpendicularly to the valve seat 141. In all other respects, the pressure equalizing means 130 is similar to the pressure equalizing means 30 and functions in a similar manner. Elements of pressure equalizing means 130 similar to those of pressure equalizing means 30 are identified by similar reference numerals but 100 higher.

While I have shown and described one embodiment of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a compressor having means defining compression, suction and high-pressure chambers and means for pumping fluid at high pressure from said compression chamber to said high-pressure chamber including an electric drive motor, the improvement comprising: means for equalizing the pressure in said suction and high-pressure chambers during start-up of the compressor, including means defining a bypass passage providing direct communication between said suction and high-pressure chambers, and a reed valve disposed adjacent said bypass passage constructed to have its physical arrangement changed as a result of mass flow of fluid therepast from said high-pressure chamber into said bypass passage and thence to said suction chamber for closing said passage only when said mass flow reaches a preselected value thereby permitting said motor to start with substantially no pressure differential between said suction and high-pressure chambers, said mass flow being a function of both the temperature and volume rate of flow of said fluid.

2. The pressure equalizing means of claim 1 wherein said reed valve comprises means for closing said passage when said drive motor reaches at least approximately one-third normal running speed.

3. The pressure equalizing means of claim 1 wherein said reed valve further defines means for maintaining said bypass passage closed as a result of the pressure differential between said high-pressure chamber and said suction chamber being maintained above a preselected minimum subsequent to the closing thereby by said mass flow reaching said preselected value.

4. The pressure equalizing means of claim 1 wherein said flow control means comprises a reed valve having a base portion secured to said means defining said bypass passage and an end portion cantilevered from said base portion to be normally spaced adjacent the inlet opening of said bypass passage.

5. The pressure equalizing means of claim 1 wherein said bypass passage comprises a right cylindrical passage opening toward said compression chamber.

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WILLIAM L. FREECH, Primary Examiner

U.S. Cl. X.R.

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