A rotary refrigerant compressor comprising a compression cylinder, a rotor eccentrically rotatable in the cylinder, suction and discharge ports communicating with the cylinder and a vane slidably mounted in a slot in the cylinder wall between the ports dividing the cylinder into high and low pressure sides includes means for modulating the compressor capacity. The modulation means comprises a bore communicating with the cylinder at a point intermediate the suction and discharge ports and having a modulating port on a side wall of the bore connected to the suction port. The modulating port is opened or closed by means of a plunger slidably mounted in the bore to modulate the compressor capacity.

4 Claims, 3 Drawing Figures
ROTARY COMPRESSOR WITH CAPACITY MODULATION

BACKGROUND OF THE INVENTION

In many uses of refrigerant compressors, it is desirable to be able to reduce the capacity or volume of displacement of the compressor under certain operating conditions in order to provide a cooling rate more closely matching the heat load. A means intended to provide the modulation or partial unloading of a rotary compressor is described in U.S. Pat. No. 2,904,973. Kosfeld as comprising an unloading or bypass passage having an unloading port communicating with the compressor cylinder in spaced relationship with the suction port and valve means in the port. In the compressor disclosed in the Kosfeld patent, the port contains a check valve. The compressor is intended to operate at full capacity by introducing high pressure refrigerant into the bypass passage behind the check valve to hold the valve closed. When suction pressure is substituted, the valve opens and gas compression in the cylinder is delayed until the passage is sealed by the rotor.

A check valve of the type disclosed in the Kosfeld patent has certain disadvantages. Under the changing pressure conditions within the compressor cylinder, it may not remain completely seated or completely open under varying operating conditions. In other words, a check valve operating only on pressure differences does not have a positive flow control for assuring continued operation of the compressor at either full or reduced capacity. Specifically, the Kosfeld unloading means have the control port and valve in the cylinder wall does not provide a high-low pressure seal when the rotor is tangent to the port. When the rotor reaches the center of the modulating port, the vertical seal is lost and high pressure gas leaks into and out of the port past the rotor cylinder wall seal and into the low pressure side causing a reduced compressor performance. Also, all gas compressed into the volume between the cylinder wall and the check valve, along with above-described volume of leakage, is re-expanded to occupy suction volume when the rotor tangent point is passing the unloader port. This reduces effective displacement and causes decrease in efficiency as well.

SUMMARY OF THE INVENTION

It is a general object of the present invention to provide a rotary compressor of the stationary vane type with improved valving means for controlling the full and partial capacity operation of the compressor.

In accordance with the preferred embodiment of the invention, there is provided a hermetic rotary refrigerant compressor comprising a hermetic casing containing a rotary compressor including a cylinder block having a cylindrical wall defining a compression cylinder, a rotor eccentrically rotatable in the cylinder, spaced suction and discharge ports in the wall communicating with the cylinder and a vane slidable mounted between the ports for engagement with the rotor to divide the cylinder into high and low pressure sides or chambers. In order to modulate the capacity of the compressor, there is provided a radially extending bore in the cylinder wall spaced from the suction port and communicating with the cylinder. A modulating port in a wall portion of the bore is connected by a passage to the suction port and is opened or closed by means of a plunger slidably mounted in the bore for movement between a restricted position in which the modulating port is open and an extended position in which the plunger engages the rotor and closes the port. For the purpose of positioning the rotor in one or the other of these two positions, means are provided for introducing either high pressure or suction pressure refrigerant into the bore reaewardly of the plunger. Preferably, also, there is provided a spring means for assisting retraction of the plunger.

BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing:

FIG. 1 is an elevational view, partly in section, of a hermetic compressor incorporating the present invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1; and

FIG. 3 is a schematic view of a refrigeration system disclosing one means for controlling the operation of the unloading valve.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIGS. 1 and 2 of the drawing, there is shown a hermetic compressor comprising a casing 1 in which there is disposed a rotary compressor unit 2 connected by means of a drive shaft 3 to an electric motor 4. The compressor includes a cylinder block 5 having an inner cylindrical wall or surface 6 which, in combination with upper and lower end plates 8 and 9, defines an annular compression cylinder 10. A rotor or roller 11 driven by and rotatable on an eccentric 12 on the shaft 3 is contained within the cylinder 10. A vane 14 is slidable disposed within a radial slot 15 in the cylinder wall 6 and is adapted to engage the periphery of the rotor 11 to divide the cylinder into a high pressure side 16 and a low pressure side 17.

A low pressure or suction port 18 communicates with the cylinder on the low pressure side 17 of the vane 14 and an outlet or discharge port 19 communicates with the high pressure side 16 of the cylinder on the opposite side of the vane. The discharge port 19 includes a discharge valve 20 for assuring proper compression of the gases issuing through the discharge port and for preventing reverse flow of discharge gases back into the compression cylinder. The discharge gas entering the valve chamber 21 passes through a passage 22 in the upper plate 8 into the upper portion of the case 1. A compressor of this type is adapted to be connected into a refrigeration system as shown, for example, in the schematic of FIG. 3.

Such a system, in addition to the compressor, includes a condenser 26, a capillary flow restrictor 27 and an evaporator 28. Low pressure refrigerant is withdrawn from the evaporator 28 through a suction line 29 connected to the suction port 18 and high pressure refrigerant is discharged from the compressor case through a discharge line 20 to the condenser. As the compressor rotor 12 rotates, in a clockwise direction as viewed in FIG. 2 of the drawing, low pressure refrigerant is drawn into the cylinder through the suction port 18, is compressed by rotation of the rotor and the compressed refrigerant is discharged through the discharge passage 19.

It will be seen that the maximum volume displacement of this type of compressor occurs at a time during
the cycle of rotation of the rotor when the periphery of the rotor engaging the cylinder wall progresses just beyond the suction port 18. At this point the maximum volume of gas has been drawn into the cylinder and the suction port sealed by the rotor for compression of the gas during the remaining portion of the rotor cycle.

For the purpose of decreasing the volume of gas compressed by the rotor during each cycle, or, in other words, to decrease the capacity of the compressor, means are provided for delaying the closing of the suction port connection to the compression cylinder or, in other words, decreasing the volumetric capacity of the effective compressor cylinder.

The present invention is directed to an improved valve means for controlling the modulating means. The modulating and valve means comprises a cylindrical bore 32 in the cylinder wall member spaced from the vane 14 and opening into the cylinder and a modulating port 33 (FIG. 2) opening into the wall of the bore at a point spaced from the cylinder end 34 thereof. Means within the casing for connecting this port to suction port 18 comprises, in series, a passage 35 in the cylinder block, a tubular conduit 36 and a second block passage 37. The valve of port 33 is accomplished by means of a plunger 38 slidably positioned in the bore 32 and adapted to move between an extended position, as illustrated in FIG. 1 of the drawing, in which the plunger engages rotor 11 and closes the port 33 in all positions of the rotor 11 and a retracted position in which the plunger is retracted in the bore a distance sufficient to open the port 33. Thus, when the plunger is in its extended position, the modulating port 33 is closed and while it is in its retracted position the modulating port 33 is open to the compression volume through cylinder bore 32.

For full displacement operating conditions, the plunger is positioned in its fully extended position where it is in constant contact with the rotor completely filling the cylinder end on the bore. The end of the plunger is provided with a flat face so that the cylindrical wall vertical seal of the rotor will be maintained when the rotor passes the point of the plunger location in the cylindrical wall.

To maintain the plunger in contact with the rotor and thereby close the modulating port 33, high or discharge pressure can be introduced into the bore 32 behind the plunger 38. When reduced capacity is desired, suction pressure is valved to the volume behind the plunger. This low pressure reduces the gas force on the plunger so that the plunger can move to its retracted position. Preferably, there is also provided a tension spring 41 threaded into the outer end of the plunger and having tension force biasing the plunger to its retracted position. In the retracted position of the plunger, the modulating port 33 is open so that the cylinder is connected to suction pressure until such time as the rotor closes the outlet or cylinder end of the bore. For example, by positioning of the bore as illustrated about 180° from the suction port, there is reduction in compressor capacity of approximately 42 percent when the modulating port is open, since the compression of the gas within the cylinder does not start until the rotor has passed the point of sealing the bore at which time part of the suction gas drawn into the cylinder through port 18 has been expelled through the modulating port 33 and the passage to the suction port.

Any suitable means may be provided for selectively connecting the volume of the bore behind the plunger to either discharge or suction pressures. The means schematically illustrated in FIG. 3 of the drawing comprises a three-way valve 45 having an outlet 46 connected to the bore 32. In one position of the three-way valve 45, the line 46 is connected by line 47 to the system discharge line 30 so that high pressure refrigerant is introduced into the bore. In the other position of the valve, the line 48 connects the suction line 29 to the bore so that the volume of the bore behind the plunger is at suction pressure. Thus, the positioning of the three-way valve 45 controls the positioning of the plunger 38 and hence the capacity modulation of the compressor by using system pressures.

During startup of the compressor, when the pressures are substantially equal throughout the system, the plunger 38 will normally be retracted with the aid of the tension spring 41 and the compressor will start in a partially unloaded condition of operation. If the three-way valve 45 is set to operate the compressor at full capacity, the discharge pressure built up in line 30 will thereafter force the plunger to its extended position to close the modulating port 33.

An alternative means for controlling the modulation of the compressor comprises the substitution of a solenoid for the three-way valve 45 and its connections to the system and bore and connecting the solenoid armature directly to the plunger 38. An armature spring forming part of the solenoid is employed to hold the plunger into contact with the rotor when the solenoid coil is not energized, the spring flexing to permit plunger movement during rotation of the rotor. When compressor capacity is to be reduced, energization of the coil and compression of the spring removes the plunger back past the port 33.

From the foregoing description, it will be seen that the valving arrangement of the present invention provides a positive control of the flow of gas through the modulating port. The spring aids in retaining the plunger in its retracted position and also assures full opening of the port 33 under conditions in which the pressure behind the plunger may be somewhat higher than cylinder pressure due to a pressure drop between the connection point of tube 48 and the cylinder pressure. When the plunger is extended in engagement with the rotor, its mass and the minimal effect of cylinder gas pressure thereon assures continuous closing of the port 33.

While there has been shown and described specific embodiments of the invention, it will be understood that it is not limited thereto and it is intended by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. A hermetic rotary refrigerant compressor comprising:
   a hermetic casing;
   a rotary compressor positioned in said casing and comprising means including a cylindrical wall member defining a compression cylinder;
   a rotor eccentrically rotatable in said cylinder;
   spaced suction and discharge ports in said wall member communicating with said cylinder;
   a vane slidable mounted in said cylindrical wall member between said ports for engagement with said
rotor to divide said cylinder into high and low pressure sides; and
means for modulating the capacity of said compressor comprising:
a radially extending bore in said cylindrical wall
member spaced from said suction port and communicating with said cylinder;
means including a passage in said wall member having a modulating port in a wall portion of said bore connecting said suction port to said bore; and
a plunger slidably mounted in said bore for movement between a retracted position opening said modulating port and an extended position closing said modulating port and contacting said rotor.
2. A compressor according to claim 1 including
means connecting the volume of said bore behind said plunger to discharge pressure for normally holding said plunger to its extended position; and
means connecting said volume to suction pressure to move said plunger to its retracted position for opening said modulating port and thereby reducing the capacity of said compressor.
3. A compressor according to claim 1 including tension spring means biasing said plunger to its retracted position.
4. A compressor according to claim 1 in which the connection to said suction port is within the hermetic casing.

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