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R. E. BOSCH ET AL
ROTARY COMPRESSOR VALVE

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FIG. 1

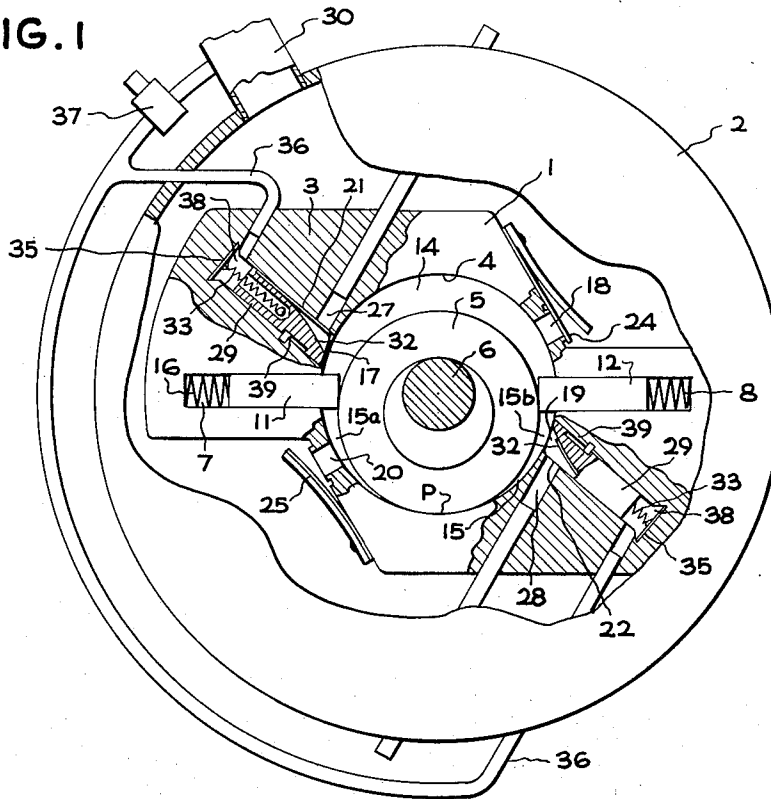
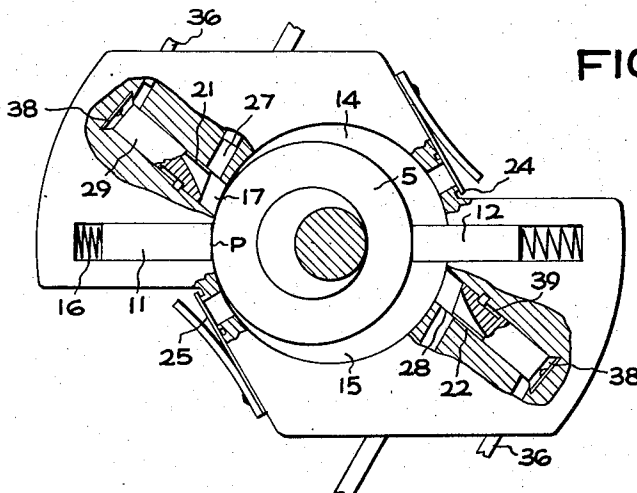


FIG. 2



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2,812,128

ROTARY COMPRESSOR VALVE

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5 Claims. (Cl. 230—138)

The present invention relates generally to rotary pumps and is more specifically concerned with a variable displacement rotary pump or compressor particularly adapted for use in refrigerating systems and the like.

For various reasons, it is desirable that the compressors employed for compressing gases, such as those used in refrigeration systems, be capable of operating at one displacement or output level under certain conditions and at higher or lower displacements under certain other conditions. For example, it is frequently desirable to unload or partially unload such compressors during the starting operation in order to reduce the load on the compressor driving means. Also in the operation of reversible refrigerating systems or heat pumps, the most efficient operation thereof is obtained when refrigerant flow rate through the system is higher under conditions of operation in which the ambient temperature at the evaporator is low than under other operating conditions in which the evaporator ambient temperature is relatively high. In other words, for optimum performance a relatively high refrigerant flow rate, which can be obtained by a compressor having a relatively high displacement, is desirable when the heat pump is operating on the heating cycle and the outdoor temperature is low and a somewhat lower refrigerant flow rate or compressor displacement is most efficient when the heat pump is operating either on the cooling cycle or on the heating cycle at relatively high outdoor temperatures.

In the copending application of Kenneth K. Cooper, Serial No. 548,810, filed concurrently herewith and assigned to the same assignee as the present invention, there is broadly described and claimed a multi-chamber rotary compressor including suction valve control means for varying the compressor displacement. The present invention, which is an improvement over the prior invention of the Cooper application, has as a primary object the provision of an improved suction valve arrangement for varying the displacement of a multi-chamber rotary compressor.

Further objects and advantages of the invention will become apparent as the following description proceeds and the features of novelty which characterize the invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of the present invention, there is provided a rotary compressor including a plurality of movable vanes engaging the periphery of the compressor rotor and dividing the compressor cylinder into a plurality of pumping chambers. Each of the chambers is provided with valve-controlled suction and discharge ports communicating with the respective chambers. In order to provide for variable displacement operation of the compressor, at least one of the suction ports is in the form of a slot communicating with the compressor cylinder and having a suction inlet in a side wall thereof. A valve support member having a valve member thereon is slidably disposed in the slot for movement between a

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position in which the valve member covers and controls the suction inlet and a position in which the inlet is open. Maximum displacement of the compressor or pump is obtained when the suction valve member overlies the inlet and operates between open and closed positions in response to pressure conditions within the chambers served by the valve while a lower output or displacement is obtained when the suction valve is rendered inoperable in an open position.

For a better understanding of the invention reference may be had to the accompanying drawings in which Fig. 1 is a schematic view illustrating an embodiment of the present invention; and

Fig. 2 is a view similar to Fig. 1 illustrating the position of the compressor components under different operating conditions.

Referring to Fig. 1 of the drawing, there is shown an embodiment of the present invention in the form of a rotary compressor 1 as part of a hermetically sealed compressor unit for a refrigerating system. The pump is therefore disposed within a sealed casing 2 which also contains a motor (not shown) for driving the compressor. The pump includes a housing 3 having therein a cylinder 4 in which is rotatably and eccentrically mounted a rotor 5. The rotor 5 is mounted on a drive shaft 6 concentrically disposed within the cylinder 4 and connected to the driving motor. The housing 3 is provided with diametrically opposed slots 7 and 8 which open into the cylinder 4 and receive a pair of movable vanes 11 and 12 engaging the rotor 5 and dividing the cylinder 4 into a plurality of pumping chambers 14 and 15. Springs 16 disposed within the slots 7 and 8 behind the respective vanes 11 and 12 serve to bias the vanes into continuous contact with the rotor 5 during its eccentric rotation within the cylinder 4.

Each of the chambers is also provided with spaced-apart inlet or suction ports and outlet or discharge ports, the relative positions of these ports in the chamber depending upon the direction of rotation of the rotor 5. When the rotor is driven or rotated in a clockwise direction as illustrated in the drawing, the suction port generally indicated by the numeral 17 for the chamber 14 is positioned immediately adjacent the vane 11 at the leading end of the chamber while the discharge port 18 for this chamber is positioned at the trailing end of the chamber immediately ahead of the vane 12. In the same manner, the chamber 15 is served by a communicating suction port 19 immediately following the vane 12 and a communicating discharge port 20 at the opposite end of the chamber immediately preceding the vane 11. Valve means are provided for controlling the inlets to each of the ports and in the illustrated embodiment of the invention these valve members are composed of spring material such as spring steel. The valve members for the suction ports 17 and 19 are respectively indicated by the numerals 21 and 22 while the valve members for the discharge ports 18 and 20 are respectively indicated by the numerals 24 and 25.

With particular reference to Fig. 1, the arrangement thus far described comprises a rotary compressor structure which, because of the presence of more than one vane and pumping chamber, has a higher displacement than the same size rotary compressor provided only with a single vane and hence having only a single chamber. As the plurality of vanes 11 and 12 are in continuous contact with the periphery of the rotor 5, the pumping chambers 14 and 15 operate independently of one another. The fluid to be compressed is drawn into the chamber 14 through the suction port 17 served by the suction inlet 27 and is discharged through the discharge port 18 into the interior of the casing 2 while fluid introduced into the

chamber 15 through the suction port 19 served by the suction inlet 28 is discharged from this chamber through the discharge port 20 which also communicates with the interior of the casing 2. It is to be understood that, in the illustrated application of the compressor, the lines to suction inlets 27 and 28 are connected to the evaporator of a refrigerating system when the compressor of the present invention is employed in such a system and that the compressed refrigerant introduced into the interior of the casing 2 from the discharge ports 18 and 20 flows from the casing through the discharge line 30 to the condenser of that refrigerating system.

The operation of the compressor may best be described with reference to the travel of the point P representing the point on the rotor which is in contact with, or closely adjacent, the wall of the cylinder 4.

In considering the operation of the compressor, it should be noted that both chambers go through the same operating cycle, the cycle for one chamber lagging the cycle for the other chamber by 180° when the compressor is provided with two vanes 11 and 12. With the point P in the position shown in Fig. 1 of the drawing, the upper chamber 14 has reached its maximum volume or displacement position following an expanding period during which gas has been drawn from the suction port 17 into this chamber and this volume represents one half of the total maximum displacement for a two chamber compressor. As the rotor moves past this point, the volume of chamber 14 will continue to decrease until the point P has reached a position opposite or closely adjacent the discharge port 18, at which point all of the fluid which has been drawn into the chamber 14 will have been discharged through the discharge port 18.

Again referring to Fig. 1, the position of the rotor relative to the lower chamber 15 illustrates another point in the operating cycle. In this position of the rotor, the chamber 15 may be said to be divided into two portions, one on each side of the point P. The portion 15a which is decreasing in size contains compressed fluid being discharged through the port 20 while the portion 15b which is expanding and will continue to expand until it reaches a volume comparable to that illustrated for chamber 14 is drawing suction gas through the suction port 19. Since the various valve members and particularly the valve members 21 and 22 open and close depending upon pressure conditions within the chambers served thereby or, more specifically, the pressure differences on opposite sides of these valve members, it will be seen that when a chamber reaches its maximum volume following the suction portion of the cycle and enters the compressor portion of the cycle, the suction valve members will close and remain closed until the particular chamber again enters a suction portion of the cycle. As a result, the displacement or maximum displacement of each of the chambers is represented by the volume or maximum volume of the chamber at the time that the suction valve feeding that chamber closes following a suction portion of the cycle. In other words, the chamber 14 as illustrated in Fig. 1 is full of suction fluid or gas and represents the total displacement of this chamber for one revolution of the rotor 5. As the rotor continues to rotate, the suction valve 21 closes and prevents the gas or fluid contained therein from re-entering the suction inlet 27 so that all of this gas will be discharged through the discharge port 18. Since the chamber 15 goes through the same cycle of operation as chamber 14 during each revolution of the rotor 5 and has the same displacement as the chamber 14, the total displacement of the compressor for each revolution of the rotor is equal to the combined total displacement of the plurality of chambers or, in the case of a two-chamber compressor, twice the volume of the chamber 14 as illustrated in Fig. 1.

In the illustrated modification of the invention, the suction ports 17 and 18 are in the form of slots in the peripheral wall of the housing 1 communicating at their

inner ends with the cylinder 4, or more specifically the respective chambers which they serve and the suction inlets 27 and 28 enter a side wall of the slots near their open ends. Slidably disposed within each of the slots is a valve supporting member 29 and the spring steel valve members 21, 22 are respectively fastened at one end thereof to the valve support members, each of which have sloping side portions 32 forming valve backing surfaces for the free or operating ends of the valve members 21, 22. The valve support members and therefore the flexible valve members attached thereto are free to move within the port slots 17 and 19 between a forward position in which the flexible end portions of the valve members 21, 22 overlie their respective inlets 27, 28 as shown in Fig. 1 and a withdrawn or recessed position in which the inlets 27, 28 are open in all positions of the rotor 5, or in other words, not controlled by the valve members.

Tension springs 33 suitably attached to the valve support members and the bottom walls 35 of the port slots 17, 18 bias the valve support members to the retracted or withdrawn position in which the valve members clear inlets 27, 28 and a pin and slot arrangement, generally indicated by numeral 39, limit the movement of the valve supporting members in either direction.

In order to overcome the biasing action of the springs 33 and to permit the suction valve members to operate in response to pressure conditions within the chambers and close their respective suction port inlets whenever the pressures within the chambers served by these ports are higher than the suction gas pressure within the suction supply lines 27 and 28, a control fluid is introduced through lines 36 into the cylinder 38 behind the valve support members 29. This control fluid is preferably at a pressure greater than the pressure within the suction lines 27 and 28 and serves to move the valve supports forwardly so that the suction valve members will overlie the inlets 27, 28 and move between open and port sealing positions in accordance with changing pressure conditions within the pump chambers.

The control fluid introduced into the cylinders 38 may be high pressure discharge gas from the discharge line 30 with the flow of the control fluid being regulated by means of a valve 37, although it is to be understood that the present invention is not restricted to any specific means for rendering the suction valves operable or inoperable or to a particular source of the control fluid or gas. For example in the hermetic compressor of the type shown in the drawing which normally contains a body of lubricating oil, this oil at compressor discharge pressure may be employed to effect movement of the valve support members 29. Alternatively the control may be by means completely separate or auxiliary to the system of which the pump forms a part. Likewise, it is to be understood that while a single means, such as valve 37, has been shown for controlling the operation of both of the support members for the suction valves 21 and 22, separate control means may be employed so that either one or both of the suction valves can be rendered operable or inoperable as to the respective inlets 27, 28 thereby providing a compressor having three different output levels.

The operation of the compressor at less than its maximum displacement, or more specifically at the displacement obtained when both the pressure is relieved in cylinders 38 and the suction valves are withdrawn to an inlet open position by springs 33, will best be understood by reference to Fig. 2 of the drawing. In this figure the rotor is shown in a position in which the point P is in contact with the vane 11 and is about to close off the suction port 17. With the suction valves in an open position, a portion of the suction gas drawn into each cylinder during part of the cycle is returned through the suction port before the pump enters the compression portion of the cycle. This return of part of the suction gas drawn into the chamber occurs as the rotor point P moves

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through an angle of ninety degrees from a position such as that illustrated in Fig. 1 to the position illustrated in Fig. 2. As a significant portion of the gas drawn into the chamber 14 up to the point where it attained its maximum volume as shown in Fig. 1 has been returned through the open suction port 17 and inlet 27, only the remaining volume of gas represented by the area of chamber 14 in Fig. 2 is discharged through the discharge port 18. Thus the chamber volume representing the maximum chamber displacement when the suction valve is inoperable is that represented by the volume of the cylinder 14 when the rotor point P is in a position close to that shown in Fig. 2 and in which is first sealed the suction port 17. In other words, the volume of the chamber 14 as shown in Fig. 2 represents the relative displacement of the pump during operation with the suction valves in retracted or inoperable position while the volume of the chamber 14 as illustrated in Fig. 1 represents the relative displacement of the pump when the suction valves operate in the usual manner, i. e., in response to pressure conditions within the chamber. Of course, since chamber 15 functions in the same manner as chamber 14, the actual total displacement of the pump is equal to the combined displacement of the chambers under either set of operating conditions. An intermediate displacement is, of course, obtained when only one of the two suction valves is inoperable and the remaining valve operates in the usual manner.

From the foregoing it will be seen that there has been provided in accordance with the present invention a rotary pump or compressor having at least three steps of displacement. While the advantages of such a pump for various applications may be obvious, it should perhaps be noted that it is particularly useful in connection with refrigeration systems. For example if valve 37 is of the normally open type, and is used as shown to control the flow of discharge gas from the discharge line 30 to the suction valve control cylinders, the invention makes provisions for starting the compressor in a partially loaded state since the discharge pressure in line 30 is then low and the valves 21 and 22 are therefore held in an open position by the respective springs 33 acting on support members 29. As the pressure in the discharge line 30 increases, the biasing action of the springs 35 will be overcome by the increasing pressure of the discharge gas until finally the supporting members move inwardly to a point where the suction valves overlie the inlets 27, 28 and the valves open and close to control the passage of gas through the inlets depending only upon the pressure conditions within the chambers served thereby. Alternatively, the valve 37 can be controlled by pressure or temperature conditions within or as a function of some other portion of a refrigerating system, for example by evaporator pressure or temperature or other suitable control means so that for example the rotary compressor will operate at a low displacement level with the suction valves open under certain operating conditions and under other conditions at a higher displacement with the control suction valves operable.

While there has been shown and described some specific embodiments of the invention, it is not desired that the invention be limited to the particular construction shown and described and it is intended by the appended claims to cover all modifications within the spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A rotary compressor comprising a housing having a cylinder therein, a rotor eccentrically mounted with said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, suction and discharge ports for each chamber, each of said suction ports comprising a slot in said housing communicating with one of said chambers, a suction inlet in a side wall of said slot, a valve support

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member slidably disposed in said slot, a flexible valve having one end secured to said supporting member in parallel relationship to said side wall, said support member being movable in said slot between a position in which the free end of said flexible valve is in an operative position relative to said suction inlet and a position in which said inlet is always open for all positions of the rotor, and means for effecting movement of said support member to each of said positions.

2. A rotary compressor comprising a housing having a cylinder therein, a rotor eccentrically mounted within said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, suction and discharge ports for each chamber, each of said suction ports comprising a slot in said housing communicating with one of said chambers, a suction inlet in a side wall of said slot, a valve support member slidably disposed in said slot, a flexible valve having one end secured to said support member, said support member being movable in said slot between a position in which the free end of said flexible valve overlies said suction inlet and a position in which said inlet is always open for all positions of said rotor, means biasing said support member to one of said positions and means operable to move said support member to the other of said positions.

3. A rotary compressor comprising a housing having a cylinder therein, a rotor eccentrically mounted within said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, suction and discharge ports for each chamber, each of said suction ports comprising a radially-extending slot in said housing communicating with one of said chambers, a suction inlet in a side wall of said slot, a valve support member slidably disposed in said slot and having a flexible valve mounted thereon, said support member being movable in said slot between a position in which said flexible valve overlies said suction inlet and a position in which said inlet is always open for all positions of the rotor, means biasing said support member to one of said positions and means for moving said support member to the other of said positions.

4. A rotary compressor comprising a housing having a cylinder therein, a rotor eccentrically mounted within said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, suction and discharge ports for each chamber, each of said suction ports comprising a radially-extending slot in said housing communicating with one of said chambers, a suction inlet in a side wall of said slot, a valve support member slidably disposed in said slot and having a flexible valve mounted thereon, said support member being movable in said slot between a position in which said flexible valve covers said suction inlet and a position in which said inlet is always open for all positions of said rotor, spring means biasing said support member rearwardly in said slot to an inlet open position and means operable to move said support member in a forward direction to a position in which said valve overlies said suction inlet.

5. A rotary compressor comprising a housing having a cylinder therein, a rotor eccentrically mounted within said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, suction and discharge ports for each chamber, each of said suction ports comprising a slot in said housing communicating with one of said chambers, a suction inlet in a side wall of said slot, a valve support member slidably disposed in said slot and having a thin flexible valve attached thereto at one end, said support member being movable in said slot between a position in which the free end of said flexible valve covers said suction inlet and a position in which said inlet is always open for all positions of said rotor, spring means biasing said support member to an inlet open position for operation

of said compressor at one displacement and means operable to move said support member to a position in which said valve overlies said suction inlet for operation of said compressor at a high displacement.

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