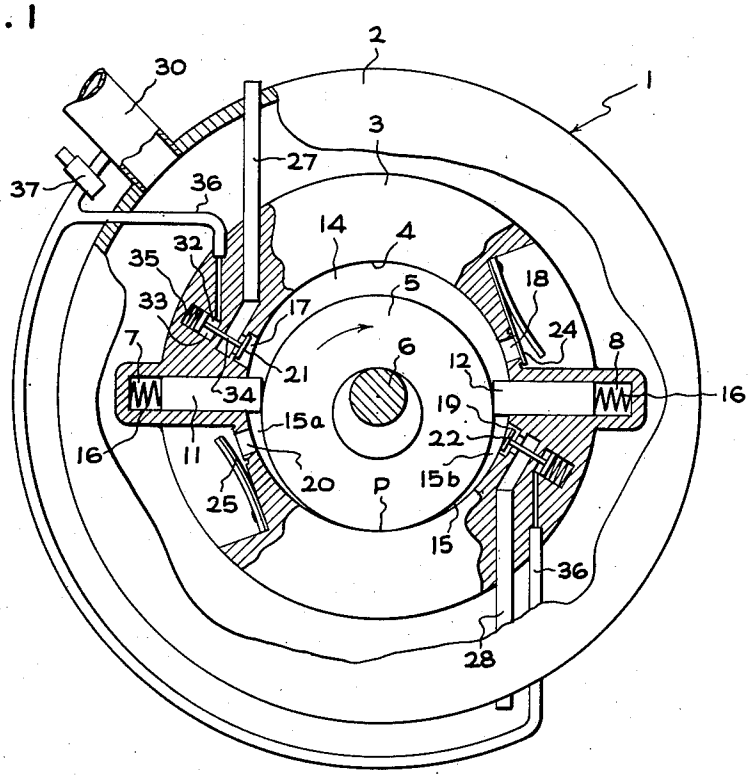
April 15, 1958 K. K. COOPER 2,830,756

VARIABLE DISPLACEMENT ROTARY PUMP

Filed Nov. 25, 1955

FIG. 1



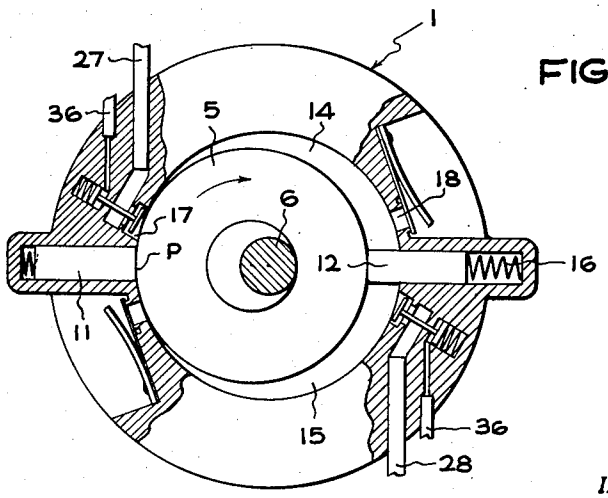


FIG. 2

INVENTOR.
KENNETH K. COOPER

BY Walter E. Rule

HIS ATTORNEY

United States Patent Office 2,830,756 Patented Apr. 15, 1958

2,830,756

VARIABLE DISPLACEMENT ROTARY PUMP

Kenneth K. Cooper, North Caldwell, N. J., assignor to General Electric Company, a corporation of New York

Application November 25, 1955, Serial No. 548,810

3 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 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 particularly 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 the refrigerant flow rate through the system is higher under conditions of operation in which the ambient temperature at the evaporator is lower 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.

It is a primary object of the present invention to provide an improved rotary compressor including means for varying the displacement and hence the output thereof.

It is another object of the present invention to provide a rotary compressor including inmproved valve control means for changing the displacement or pumping capacity of a compressor so that the compressor can be efficiently operated at two or more difficult output levels.

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 are provided with valve-controlled suction and discharge ports communicating with the respective chambers. For the purpose of varying the displacement of the compressor, means are provided for rendering one or more of the valves controlling suction ports inoperable in an open position. By means of the present invention, maximum displacement of the compressor or pump is obtained when the suction valves operate between open and closed positions in response to the pressure conditions within the chambers served by these valves while a lower output or displacement is obtained when one or more of the

suction valves are 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 are 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 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 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 hence more than one 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 independent of one another. The fluid to be compressed is drawn into the chamber 14 through the suction port 17 served by the suction line 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 line 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 the suction lines 27 and 28 are connected to the evaporator of a refrigeration 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 refrigeration 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 cycles, the cycle for one chamber lagging the cycle for the other chamber by 180° when the compresor 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 fluid 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 at or closely adjacent to 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 15*a* which is decreasing in size contains compressed fluid being discharged through the port 20 while the portion 15*b* which is expanding until it reaches a volume comparable to that illustrated for chamber 14 is drawing suction fluid through the suction port 19. Since the various valve members and particularly the valve members 21 and 22 open and close depending upon presure 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 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 port 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 displacement of the plurality of chambers or, in the illustrated modification, twice the volume of the champer 14 as illustrated in Fig. 1.

For the purpose of obtaining a variable displacement, specifically a decreased displacement, from the same compressor there is provided in accordance with this invention means for rendering at least one of the suction valve members inoperable in an open position so that a portion of the suction fluid or gas drawn into the chamber is again discharged through its suction port until such time as the point P on the rotor 5 seals the suction port.

In the illustrated embodiment of the invention, the suction valve control means comprises a control cylinder 32 in which is disposed a piston 33 having connected thereto a pin or rod 34 extending into the suction port behind the valve members 21 and 22. A spring 35 in the control cylinder continuously biases the pin into engagement with the suction valve member so that the valve member can be held in an open position as is shown for example in Fig. 2 of the drawing. In order to overcome this biasing action of the springs 35 and to permit the suction valve members to operate in response to pressure conditions within the chambers and therefor close their respective suction ports whenever the pressures within the chambers served by these ports are higher than the suction gas presure within the suction supply lines 27 and 28, a control fluid is introduced through lines 36 ahead of the piston 32. This control fluid is preferably at a pressure greater than the pressure within the suction lines 27 and 28 and serves to move the pin 34 away from the suction valves and permit these valve members to move between port open and port sealing positions in accordance with changing pressure conditions within the pump chambers.

The control fluid introduced into the cylinders 32 may be high pressure discharged 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 particular means for operating the suction valves or to a specific source of the control means. 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 operation of the pistons 33. 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 control cylinders for the suction valves 21 and 22, separate control means may be employed so that either one or both of the suction valves may be rendered inoperable in an open position 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 of the suction valves are rendered inoperable in an open position, will best be understood by references 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 gas drawn into each cylinder during part of the cycle is returned through the suction port before the pump enters the compresion portion of the cycle. This return of part of the suction gas occurs as the rotor point P moves 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 suction port 17, only the remaining volume of gas which will be discharged through the discharge port 18. Thus the chamber volume representing the maximum chamber displacement when the suction valve is inoperable is 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 it first seals 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 held in an open 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 value is of course obtained by rendering only one of the two suction valves inoperative and allowing the remaining valve or valves to operate 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 provision for starting the compresor in a partially loaded state since the discharge pressure in line **30** would be low and the valves **21** and **22** therefor held in an open position by their respective springs **35**. As the pressure in the discharge line **30** increases the biasing action of the springs **35** will be overcome by the higher pressure gas until finally the pins **34** are withdrawn to a point where the suction valve operation depends only upon the pressure conditions within the chambers served thereby. Alternatively, the valve **37** can be controlled by pressure or temperature conditions within 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 with the control suction valves operable for a higher displacement.

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 I 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 within said cylinder, a plurality of movable vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, spaced suction and discharge ports for each chamber, valve means controlling said ports normally operative between open and closed positions in response to changing pressure conditions within said chambers effected by rotation of said rotor, and means for holding at least one of said valve means controlling said suction ports in an open position for all positions of said rotor to lower the displacement of said compressor.

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, spaced suction and discharge ports adjacent opposite ends of each chamber, valve means controlling said ports normally operative between open and closed positions in response to changing pressure conditions within said chamber effected by rotation of said rotor, spring means holding at least one of said suction port valve means to an open position for all positions of said rotor during operation of said compressor to lower the displacement of said compressor, and means for rendering said spring means inoperable to effect normal operation of said suction valve means in accordance with changing pressure conditions within the chamber served by said suction valve means.

3. A rotary compressor comprising a housing having a cylinder therein, a rotor operating eccentrically in said cylinder, a pair of diametrically opposed vanes engaging the periphery of said rotor and dividing said cylinder into a plurality of chambers, spaced suction and discharge ports at opposite ends of each chamber, valve members for each of said ports operable between open and closed positions in response to changing pressure conditions within said chamber effected by rotation of said rotor, spring means normally biasing said suction valve members to an open position for all positions of said rotor for operation of said compressor at a low displacement and means for rendering at least one of said spring means inoperable to operate said compressor at a higher displacement.

References Cited in the file of this patent

UNITED STATES PATENTS

711,092	Bates	Oct. 14, 1902
1,424,977	Bidwell	Aug. 8, 1922
1,427,053	Bidwell	Aug. 22, 1922
1,575,860	Monk	Mar. 9, 1926
1,616,992	Ruckstuhl	Feb. 8, 1927
2,732,126	Smith	Jan. 24, 1956