Oct. 18, 1966 CHUJI SUZUKI 3,279,385

VANE PUMP

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FIG. 1

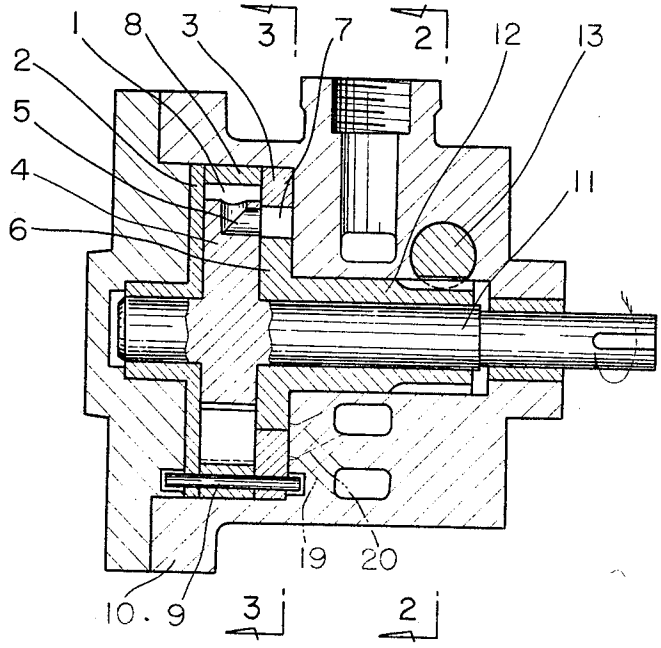
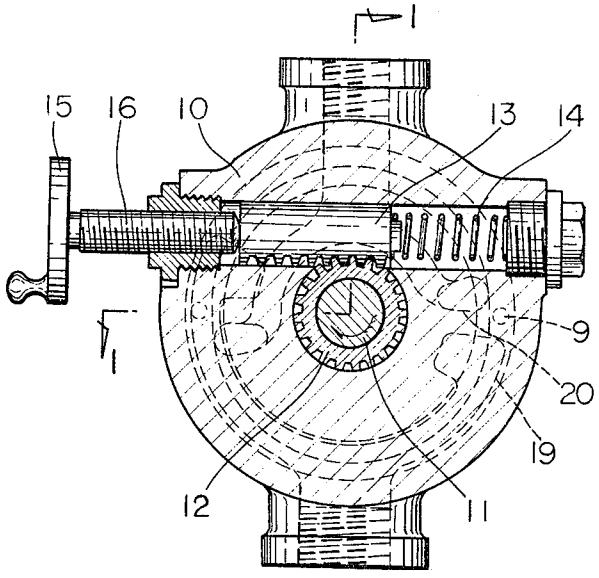


FIG. 2



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FIG. 3

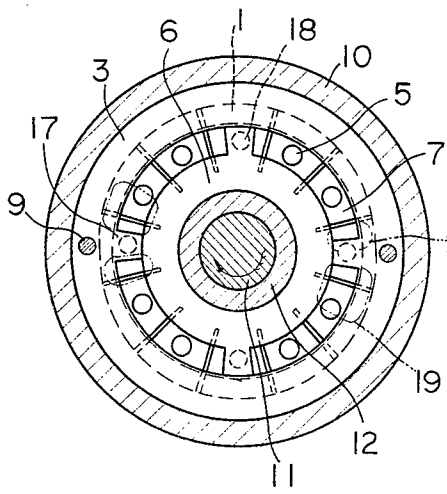


FIG. 4

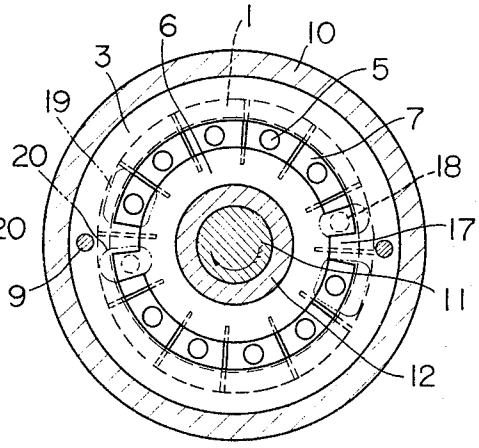
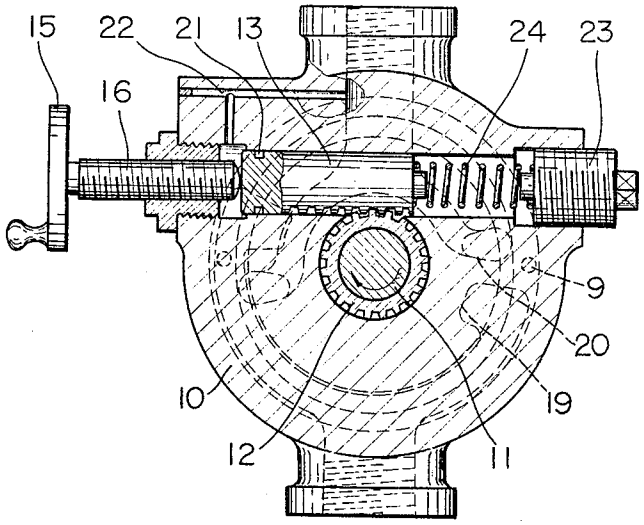


FIG. 5



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VANE PUMP

Chuji Suzuki, Yokohama-shi, Japan, assignor to Tadashi Kobayashi, Shizuoka-ken, Japan

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The present invention relates to vane pumps and more particularly to a vane pump with a variable discharge rate.

Unlike conventional balanced vane pumps currently used most popularly as oil pumps, in which the pump chamber is equally divided by a fixed bushing with four arc-shaped passages equal in area serving as suction and discharge channels, and which consequently cannot vary its discharge rate when turning at a fixed speed, the present invention permits a pump of this type to vary its discharge rate while operated at a fixed speed. Specifically, one side of the pump chamber is closed with a bushing having no oil passage whereas the other side is fitted with two bushings, outer and inner, the former having on its inner circumference trapezoidal projections to divide the pump chamber into crescents and fixed with a cam ring to the casing of the pump, and the latter having on its outer circumference sector projections that can divide each crescent pump chamber equally into a suction and a discharge chamber. By displacing these sector projections around the rotor shaft, a part or all of the discharge chamber may be opened to the suction chamber to vary the discharge rate.

Thus, it is an object of this invention to provide a vane pump which can vary its discharge rate while turning at a fixed speed.

Another object of the invention is to make the discharge rate continuously variable from maximum to zero.

The invention as well as other objects and advantages will be more apparent from the following description when taken in conjunction with the accompanying drawing in which:

FIGURE 1 is a sectional view of the pump cut along the line 1—1 of FIGURE 2;

FIGURE 2 is a sectional view of the pump shown in FIGURE 1, cut along the line 2—2;

FIGURE 3 is a sectional view cut along the lines 3—3 of FIGURE 1;

FIGURE 4 is a sectional view similar to FIGURE 3 illustrating the inner bushing in a different operating position;

FIGURE 5 is a sectional elevation of an embodiment of the present invention with a pressure compensating device.

Generally speaking, in the vane pump of the present invention, there is a cylindrical pump chamber closed at one side with rotating vanes therein and with a duct leading into the pump chamber. The vanes rotate on a central shaft axially passing through the pump chamber. According to the present invention, there is provided an outer bushing mounted on the inner periphery of the other side of the pump chamber and an inner bushing mounted over the central shaft, the central shaft rotating freely in the inner bushing. Inner projections on the outer bushing define at least one arc-shaped chamber between the inner and outer bushings alongside the pump chamber. There is at least one connecting first passage from said pump chamber opening in to said arc-shaped chamber; at least one second discharge passage with its opening in said arc-shaped chamber, and at least one outer section on said inner bushing extending into said defined arc-shaped chamber of a size sufficient to cover one of said passage openings. Coupled to said inner bushing is a pinion gear mounted over the central shaft, the central shaft being freely rotatable therein. Rack means act on the pinion gear so that by turning the pinion gear with the rack means, the outer section on the inner bushing will turn so as to at least partially cover one of the passage openings thus regulating the amount of discharge from the vane pump.

In a typical embodiment of the invention as illustrated in these drawings, the sides of a pump chamber **1**, as FIGURE 1 shows, are fitted with a bushing **2** having no oil passage and an outer bushing **3**. In each vane, half way from the periphery of the rotor, is an L-shaped connecting hole **5**, which permits fluid to be sucked in or discharged through an arc-shaped passage **7**, serving as suction and discharge channel, that is formed by the inner circumference of the outer bushing **3** and the outer circumference of the inner bushing **6**. The bushing **2** and the outer bushing **3**, together with the cam ring **8**, are fixed by pins **9** to the casing **10**. The inner bushing **6** has a cylindrical part **12**, in whose bore is fitted a freely rotating rotor shaft **11**, and one end of cylindrical part **12** is shaped to serve as a pinion gear, which is engaged by a rack **13**. Fitted in the casing **10** so as to be able to slide freely, as FIGURE 2 illustrates, the rack **13** is loaded by a compression spring **14** and controlled by an adjustment screw **16** with a handwheel **15**, which may be turned to slide the rack right or left and thus to turn the inner bushing **6**. The arc-shaped passage **7** connected with the pump chamber **1**, as FIGURE 3 indicates, is wider than the connecting hole **5**; it is divided by trapezoidal projections **17** of the outer bushing **3** into two equal crescents, each of which is further divided by sector projections **18** of the inner bushing **6** into two equal parts, serving as suction and discharge channels leading to the suction and discharge chambers of the pump chamber **1**. The side of each of the trapezoidal projections **17** and the sector projections **18** extend radially towards the center of the rotor shaft. The width of sector projection **18** is large enough at least to close the connecting holes, and its top slides oil-tight over the inner or the outer wall, as the case may be. The arc-shaped passage **7** sucks in and discharges oil through a suction hole **19** and a discharge hole **20** in the casing **10** that open with the trapezoidal projection **17** between them.

Now, if the rotor shaft **11** turns in the direction of the arrow mark, the suction and the discharge are equal since the pump chamber **1** is evenly divided by the sector projections. But if, as illustrated in FIGURE 4, the inner bushing **6** is rotated in the same direction as the rotor shaft **11** so that the sector projection **18** touches the trapezoidal projection **17**, the arc-shaped passage **7** connects the suction side and the discharge side of the pump chamber **1** to each other while the sector projection **18** closes the discharge hole **20** in the casing **10**, with the result that the oil discharge is suspended. This is an important part of the present invention, for, while the pump is turning, one can vary the rate of discharge continuously from maximum to zero by turning the handwheel **15**, causing the adjustment screw **16** to shift the rack **13**, which in turn displaces the inner bushing **6** properly.

Heretofore, sliding vane pumps have been popularly used as oil pumps in various equipment including machine tools, ships and construction machinery; but where there is a need for discharge control, they have often had to be rejected in favor of other types of pumps providing this feature though they are poorer in performance and efficiency. The present invention completely solves this problem.

Another feature of this invention is that it can easily incorporate a means of discharge pressure compensation. Namely, as shown in FIGURE 5, an "O" ring **21** may be fitted on the outer perimeter of the rack **13** to make it an oil-tight sliding plug, with an oil passage **22** providing connection with the discharge channel. The rack is given such a sectional area that it can turn the inner bushing in the discharge-reducing direction as the discharge pressure

rises. The rack is loaded by a spring **24** whose force is controlled by the pressure adjustment screw **23**. If the force of the spring **24** is equalized with the force of the rack under a specific pressure, any undue rise in the discharge pressure will shift the position of the rack, thus turning the inner bushing and reducing the discharge rate until the pressure returns to normal.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. In a vane pump including a cylindrical pump chamber closed at one side with rotating vanes therein having a duct leading into said pump chamber, said vanes rotating on a central shaft axially passing through said pump chamber, in combination, an outer bushing mounted on the inner periphery of the other side of said pump chamber and an inner bushing mounted over said central shaft, said central shaft rotating freely therein, inner projections on said outer bushing defining at least one arc-shaped chamber between said inner and outer bushings alongside said pump chamber, at least one connecting first passage from said pump chamber opening into said defined arc-shaped chamber, at least one second discharge passage with its opening in said arc-shaped chamber; at least one outer section on said inner bushing extending into said defined arc-shaped chamber of a size sufficient to cover one of said passage openings; a pinion gear coupled to said inner bushing mounted over said central shaft, said central shaft being freely rotatable therein; and, rack means acting on said pinion gear, whereby by turning said pinion gear with said rack means, said outer section will turn so as to cover one of said passage openings regulating the amount of discharge from said vane pump.

2. A vane pump as claimed in claim **1**, said outer section being so constructed and adapted as to cover said second discharge passage.

3. A vane pump as claimed in claim **1**, said inner projections defining a plurality of arc-shaped chambers there being a first and second passage associated with each of said arc-shaped chambers as well as a plurality of outer sections on said inner bushing, one outer section being in each of said defined arc-shaped chambers.

4. A vane pump as claimed in claim **1** said rack means including spring biased means and a handwheel for moving said rack means.

5. A vane pump as claimed in claim **4** including pressure responsive means responsive to the discharge from said pump, excess discharge acting on said pressure responsive means against said spring biased means and handwheel which act as a restoring force.

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MARK NEWMAN, *Primary Examiner.*

H. F. RADUAZO, *Assistant Examiner.*