United States Patent

Kusakabe et al.

[15] **3,656,870**

[45] **Apr. 18, 1972**

[54] PUMP

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[73] Assignee: **Toyoda Roki Kabushiki Kaisha**

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[21] Appl. No.: **5,461**

[30] **Foreign Application Priority Data**

Jan. 29, 1969 Japan.....44/6568

[52] **U.S. Cl.**.....**417/300,** 417/310, 417/311

[51] **Int. Cl.**.....**F04b 49/00**

[58] **Field of Search**.....417/300, 304, 310, 311, 308; 137/117, 497

[56] **References Cited**

UNITED STATES PATENTS

2,340,196	1/1944	Magrum et al.	417/304
2,748,711	6/1956	Drude	417/300
2,982,217	5/1961	Thrap	417/304
3,002,461	10/1961	Eames	417/300
3,059,580	10/1962	Farrell et al.	417/300
3,495,539	2/1970	Tomita et al.	417/310

Primary Examiner—Carlton R. Croyle
Assistant Examiner—John J. Vrablik
Attorney—Blum, Moscovitz, Friedman & Kaplan

[57] **ABSTRACT**

A pump is provided for supplying fluid under pressure to power steering apparatus of a vehicle, the pump equipped with a control device for regulating the flow rate and the pressure of delivery fluid, such the control device comprising the combination of flow and pressure control valves which sets the flow rate and the maximum pressure of delivery fluid at most preferable values for the power steering apparatus. A drive shaft is rotatably mounted in a casing member and is provided with a concentric suction channel and a discharge channel in the outer peripheral surface thereof; the shaft carrying an eccentric rotor thereon forms a crescent-shaped clearance between the rotor and the casing member, and a plurality of abutments are loosely received in radial grooves circumferentially disposed with uniform spacing in the inner peripheral surface of the casing member.

4 Claims, 9 Drawing Figures

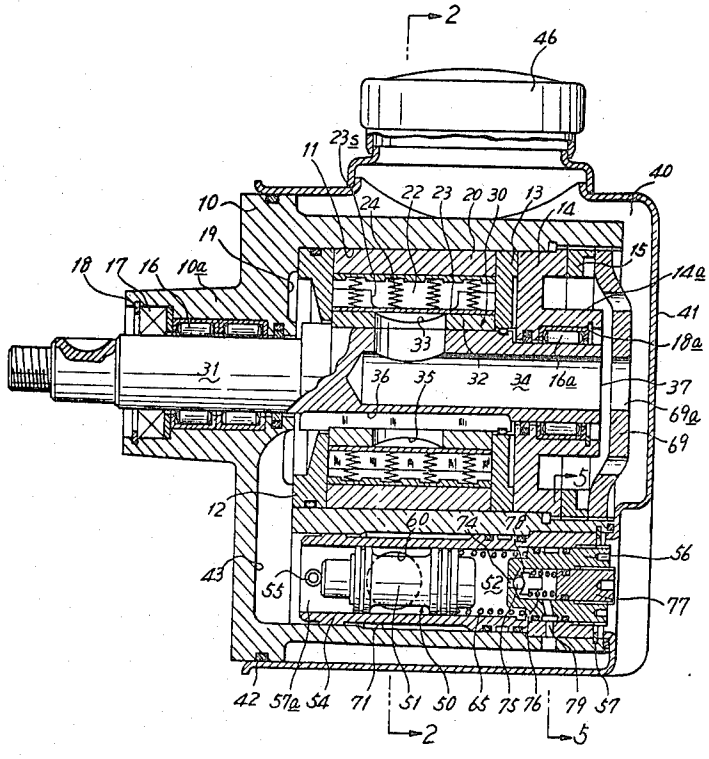


FIG. 1

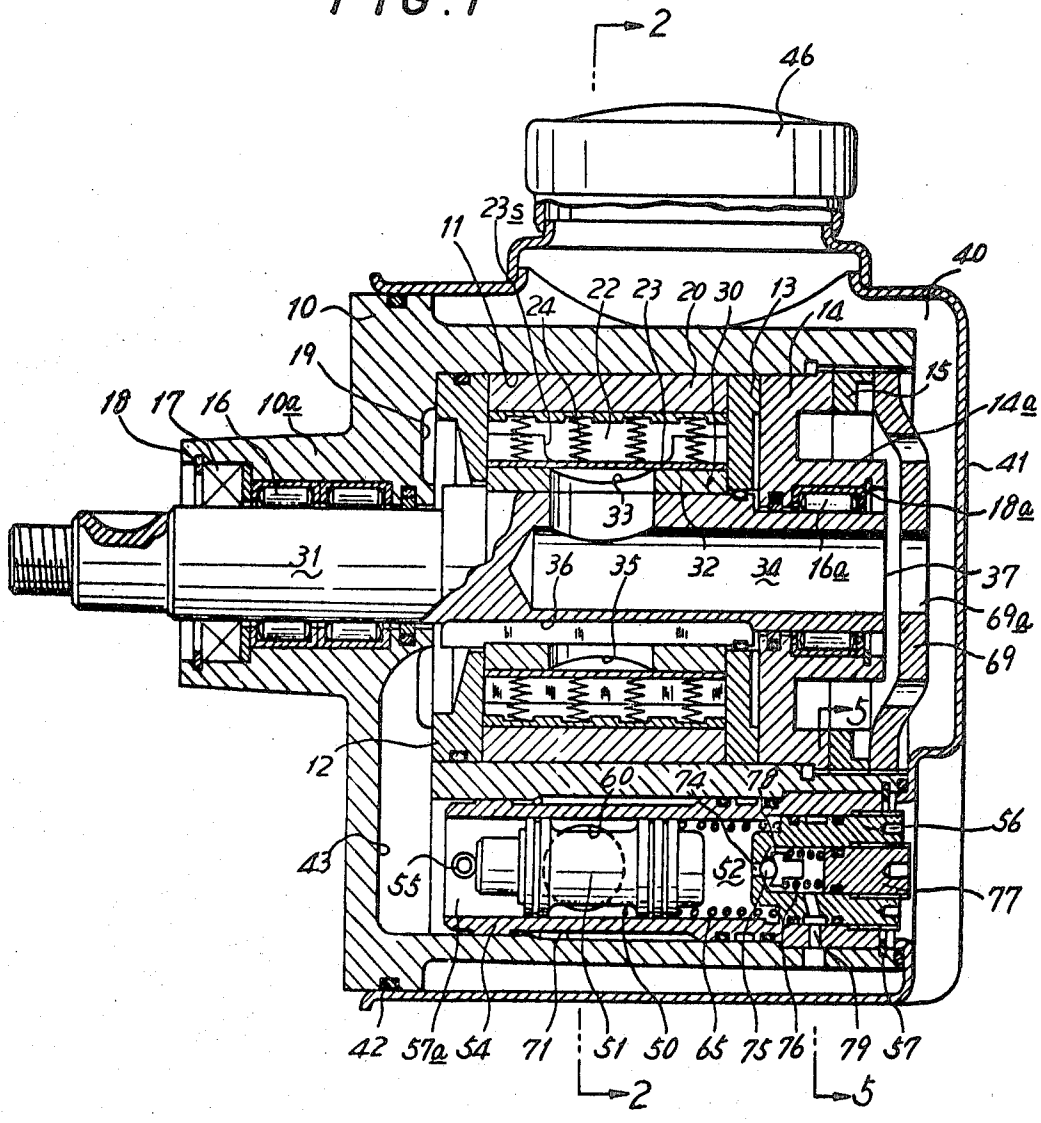

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FIG. 2

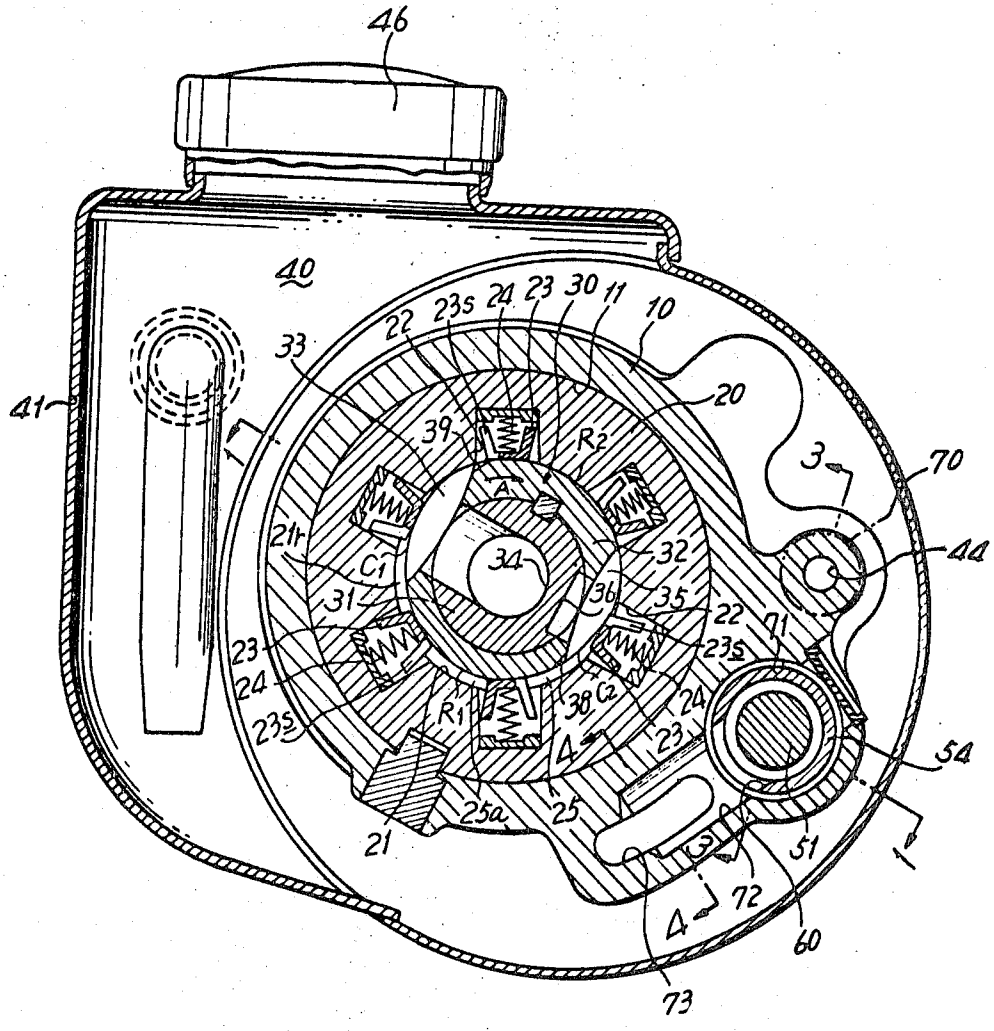

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FIG. 3

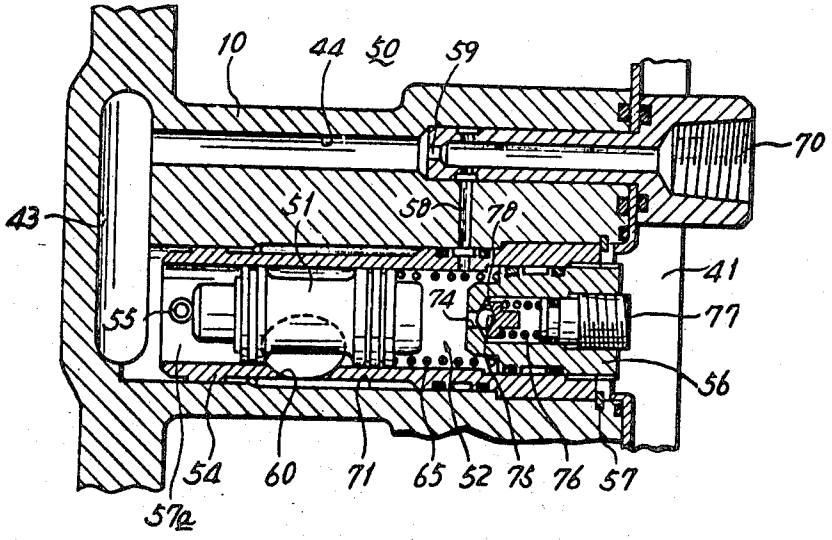

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FIG. 4

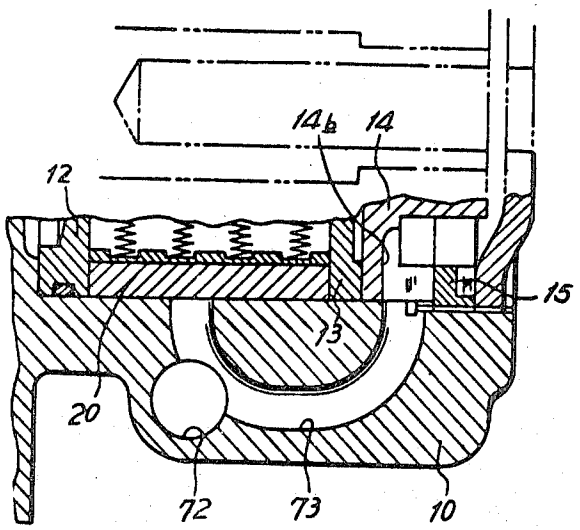

14b
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FIG. 5

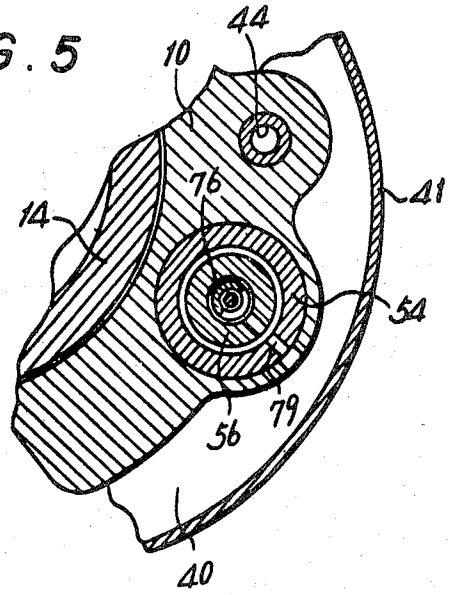


FIG. 6

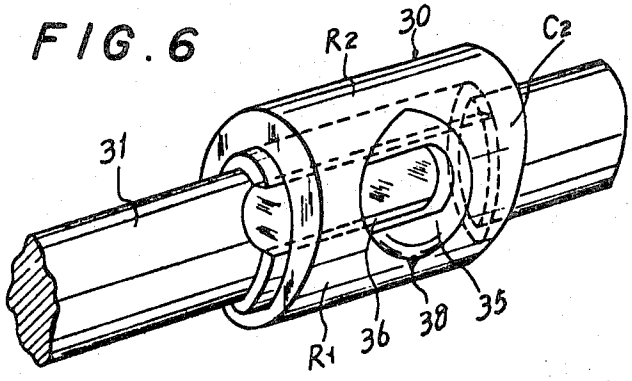


FIG. 7

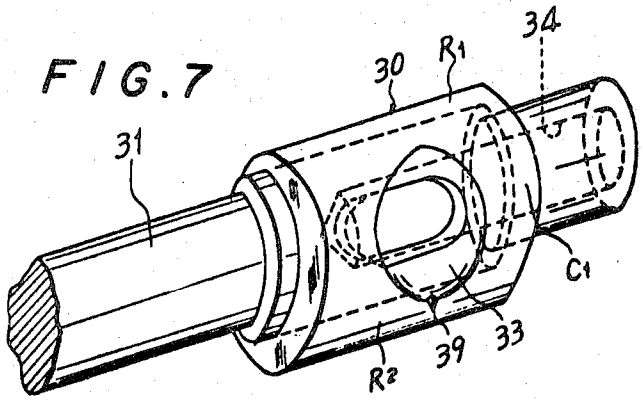


FIG. 8

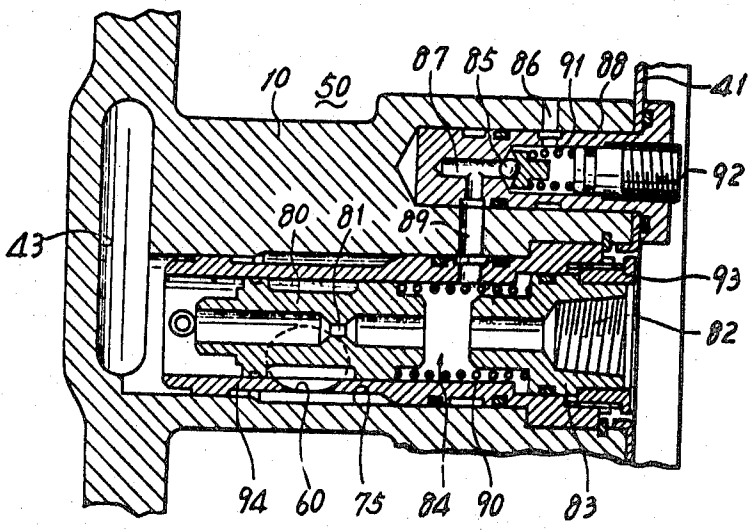
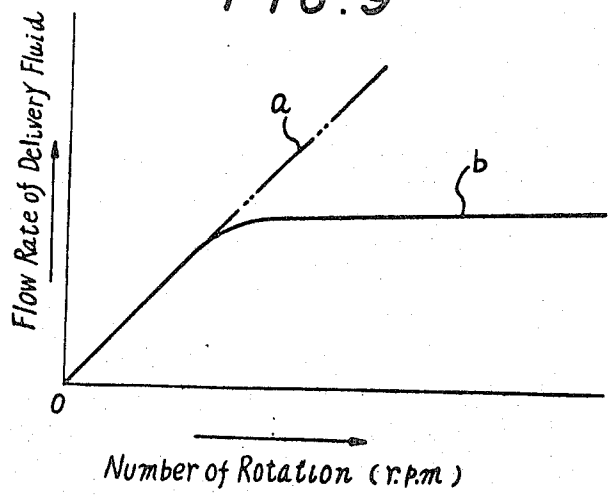

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90
83

FIG. 9


Flow Rate of Delivery Fluid
a
b
0
Number of Rotation (r.p.m)

PUMP

BACKGROUND OF THE INVENTION

The invention relates to a pump for converting the rotary energy of a vehicle engine to the pressure energy of fluid, and more particularly to a pump which is suitable for supplying the power steering apparatus of the vehicle with fluid under pressure.

Since, in general, the pump used in the power steering system of an automotive vehicle is directly coupled to the engine, the pump increases its delivery flow in accordance with the increase of the number of rotation of the engine. In other words, the pump delivers fluid under pressure in proportion to the speed of rotation of the engine and irrespective of the fluid consumption in the power steering apparatus. Thus, when the vehicle is driven at high speed or the power steering apparatus is not operated, a large quantity of excess fluid is required to be discharged to a reservoir without effect as to the operation of the power steering apparatus. To save the power of the engine and to achieve the most favorable pressure and flow rate of delivery fluid, a pump having control devices which may readily change the pressure and the flow rate of delivery fluid is required.

SUMMARY OF THE INVENTION

It is, therefore, a general object of the invention to provide a pump which delivers fluid under a required pressure and of a required quantity irrespective of the speed of rotation of an engine, thereby to reduce substantially the power loss consumed in the engine.

Another object of the invention is to provide a pump wherein fluid in a reservoir is sucked into the pump by centrifugal force due to rotor rotation.

Still another object of the invention is to provide a pump having a plurality of abutments which are loosely mounted in a casing member and are adapted to snugly follow the radial changes of a rotor surface to produce high pressure of delivery fluid.

Another object of the invention is to provide a pump with a control device which is adapted to adjust the flow rate of delivery fluid externally of the pump.

A further object of the invention is to provide a pump with a control device wherein the quantity of delivery fluid may be adjusted and the maximum pressure thereof may be set at most preferable value externally of the pump.

The foregoing and other objects of the invention will become fully apparent from the following description of some preferred embodiments of the invention with reference to the accompanying drawings, in which:

FIG. 1 is a sectional view of a pump according to the invention on line 1—1 of FIG. 2;

FIG. 2 is a sectional view on line 2—2 of FIG. 1;

FIG. 3 is a fractional section on line 3—3 of FIG. 2;

FIG. 4 is a fractional section on line 4—4 of FIG. 2;

FIG. 5 is a fractional section on line 5—5 of FIG. 1;

FIGS. 6 and 7 are perspective views of the pump rotor viewed from different directions respectively;

FIG. 8 shows a modified form of the invention corresponding to FIG. 3; and

FIG. 9 is a diagram showing the characteristic of delivery flow.

Referring now to FIGS. 1 to 7 inclusive, there is provided a cylindrical casing member 20 in the bore 11 perforated in a housing 10. A rotatable rotor 30 is accommodated in the cylindrical casing member 20. A pair of discs 12 and 13 liquid-tightly engage the opposite ends of the casing member 20 and the rotor 30. The open end of the housing 10 (right end in FIG. 1) is covered by a blocking member 14 urged toward left by a nut 15 which is threadly engaged with the housing 10, whereby discs 12 and 13, casing member 20 and rotor 30 are maintained in their proper positions. A locking member 69 is further threadly engaged with the housing 10 and effects to lock the nut 15 in the housing 10. The housing 10 and the blocking member 14 co-axial provided with coaxial outwardly—projected portions 10*a* and 14*a* wherein there are provided bearings 16 and 16*a* respectively. The bearing 16*a* is maintained at its proper position within the projected portion 14*a* by a snap action ring 18*a*. A seal member 17 for preventing the leakage of operating fluid, is provided and within the projected portion 10*a* by a snap action ring 18. A drive shaft 31 carrying the rotor 30 thereon is supported by the bearings 16 and 16*a*, one end of which is coupled to an output shaft of an engine of a vehicle (not shown) by usual means. A cam ring 32 which constitutes the non-circular rotor 30 is fixed on intermediate portion of the drive shaft 31. The shape of the rotor will be described in detail hereinafter.

There is provided a crescent-shaped clearance between the inner cylindrical bore 21 of the casing member 20 and the rotor 30. Moreover, a plurality of radial slots 22 are distributed circumferentially at equal distances around the inner bore 21 of the casing 20, and within each slot 22, an abutment 23 is positioned and urged toward the periphery of the rotor by a compression spring 24 which is interposed between the abutment and the slot 22. By the provision of a slidable engagement of the rotor 30 and the abutments 23, the crescent-shaped clearance 21 defines a plurality of separate individual pumps—operating chambers 25. While six abutments 23 are shown in FIG. 2, it will be appreciated that the number of the abutments are not limited in six in number.

It is desirable that the abutments 23 are formed by bending a sheet metal in U-shape having small mass in order to obtain their excellent following performance in the high speed region. A cut out portion 23 S is provided on each side of the U-shaped abutments, whereby the fluid pressure is led into the back of the abutments in order to urge the abutments toward the periphery of the rotor 30 more positively.

On the periphery of the cam ring 32 constituting the pump rotor 30, there are formed concentric portions R_1 and R_2 diametrically opposite each other. The first concentric portion R_1 is of arc of a circle having the center of the drive shaft 31 as its center with a radius which is smaller than that of the inner bore 21 of the casing member 20. The second concentric portion R_2 is also of the arc of a circle having the same center, but with a radius which is almost the same as that of the inner bore of the casing member 20 so as to assure a sliding engagement therewith. The two intermediate portions are connected with opposite smooth surfaces C_1 and C_2, whereby the crescent-shaped clearance 21*r* is formed between the rotor 30 and the inner bore 21 as above mentioned. The opposite surfaces C_1 and C_2 will be hereinafter referred to as eccentric portions C_1 and C_2 respectively. Connecting points between the concentric portions R_1 and R_2 and eccentric portions C_1 and C_2 are interconnected in substantially smooth configuration to avoid the abrupt changes of the curvature. The concentric portions R_1 and R_2 may serve to achieve better sealing engagement between the rotor 30 and the abutments 23, since the abutments 23 may follow the radial changes of the periphery of the rotor 30 snugly so that the abutments 23 begin their radial displacement after resting on the concentric portions where there are not any radial interconnections.

A recess 33 connected with a suction channel 34 which is co-axially provided in the drive shaft 31 is formed on the central portion of the first eccentric portion C_1 at intermediate end of the rotor 30 as shown in FIG. 7. A recess 35 formed on the second eccentric portion C_2 is connected with a delivery channel 36 provided in the outer periphery of the drive shaft 31, the channel 36 being opened to a fluid collecting groove 19 formed on the side wall of the housing 10 and a small clearance between the disc 13 and the blocking member 14. As fluid discharged from the delivery channel 36 is led to the outsides of the discs 12 and 13 and urge the discs 12 and 13 toward the opposite ends of the rotor 30, fluid leakage from the operating chambers 25 through and between the discs and the opposite ends of the rotor is prevented.

The chambers in suction cycle (shown at the left side in FIG. 2) are separated by the abutments 23, but they are con-

nected with the single suction channel 34 to effect the suction operation of fluid into the pump so that the angular degree of the recess 33 is almost the same as the first eccentric portion C_1. On the opening edge of the recess 33, there is provided a small convergent groove 39 extending into the concentric portion R_2 from the recess 33 in order to avoid abrupt pressure change of fluid within the slot 22 which is about to go into suction cycle after delivery cycle. As the recess 35 connected with the channel 36 extends almost over the second eccentric portion, the delivery operating chambers (shown at the rightside in FIG. 2) are connected with the delivery channel 36. To give a gradual compression on the fluid in the operating chamber 25*a* which is about to go into delivery cycle, the recess 35 is formed to begin at the point somewhat behind the starting point of the second eccentric portion C_2 or delivery cycle. Moreover, on the edge of the recess 35, there is provided a small convergent groove 38 extending toward the concentric portion R_1 from the recess 35. The groove 38 serves to prevent the pulsating change of the delivery pressure by gradually applying the fluid in the chamber in delivery cycle into the operating chamber 25*a* which is about to go into delivery cycle.

In the pump above mentioned, since the sealing actions are effected positively on the two diametrically opposed concentric portions R_1 and R_2, the crescent-shaped clearance 21*r* between the rotor 30 and the inner bore 21 of the casing member is substantially divided into a pair of spaces i.e., an operating space for suction cycle and an operating space for delivery cycle.

The operating space for suction cycle corresponding to the first eccentric portion C_1 is separated into two or three chambers in a preferred embodiment shown in FIG. 2 by the abutments 23, but the separated chambers are connected with the suction channel 34 by means of the recess 33.

The operating space for delivery cycle (right side space in FIG. 2) corresponding to the second eccentric portion C_2 is connected with the delivery channel 36 by means of the recess 35. When the rotor 30 is rotated in a clockwise direction as shown by the arrow A in FIG. 2, the volume of the operating space for suction cycle is increased resulting in sucking the fluid from the suction channel 34, and the volume of the operating space for delivery cycle is decreased thereby to deliver the fluid into the delivery channel 36.

An outer cover 41 encloses the housing 10 and constitutes a fluid reservoir 40, the open end of which is sealed by a rubber ring 42, shown in FIG. 1 inserted between said cover 41 and the housing 10 in order to prevent the leakage of fluid therefrom. A removable cap 46 for pouring operating fluid therefrom is provided on the top of the reservoir 40.

In the arrangement according to the invention, the efficiency of suction cycle is excellent so that the suction of fluid in the suction channel 34 into the operating space for suction cycle is promoted by centrifugal force produced by rotation of the drive shaft 31.

Fluid is sucked from a suction port 37, opened to the reservoir 40, through an opening 69*a* provided in the locking member into the suction channel 34 and discharged into the delivery channel 36 and thence, led into a channel 44 in a control device 50 (FIG. 3) through the fluid collecting groove 19 and a depressed channel 43.

The control device 50 is described referring to FIGS. 1 and 3. A hole 71 is perforated in parallel with the axis of the shaft 31 in the housing 10. One end of the bore 71 is connected with the depressed channel 43 and the other end thereof is opened to the outside thereof. A sleeve 54 is mounted in the bore 71 and retained against axial movements by a snap action ring 57. A spool valve 51 is slidably accommodated in the sleeve 54, whereby the spool valve 51 is not affected by the deflection of surrounding parts due to the thermal changes. Provided in the sleeve is a by-pass port 60 led to the reservoir 40 through by-passes 72 and 73 and a cut out portion 14*b* on the rim of the blocking member 14. The by-pass port may be controlled by the displacement of the spool valve 51. A plug member 56 threadly engages the sleeve 54 at the open end thereof. Between the member 56 and the spool valve 51, there is interposed a compression spring 65 which always urges the spool valve 51 in a direction to close or shut off the by-pass 60. A stop 55 provided in the vicinity of the left end of the sleeve 54 serves to regulate the displacement range of the spool valve 51. The delivery channel 44 is led to a delivery port 70, in the middle of which there is provided an orifice restrictor 59 (FIG. 3), whereby the pressure of delivery fluid from the delivery channel 36 is led to a left chamber 57*a* for pushing the spool valve 51 right and the pressure reduced at the orifice 59 is applied to a right chamber or control chamber 52 between the spool valve 51 and the plug member 56 through a throttle 58. The compression spring 65 serves to determine the pressure drop across the orifice 59 by controlling the quantity of fluid by-pass to the reservoir 40 through the by-pass port 60, whereby the flow rate through the orifice 59 is maintained almost constant by the agency of the spool valve 51. The delivery fluid from the delivery port 70 is led to the power steering apparatus of the vehicle (not shown) to reinforce manual steering torque.

A poppet valve 75 is contained in the member 56 and urged toward a valve seat 78 in a passage 74 by a compression spring 76 which is interposed between the poppet valve 75 and an adjusting member 77 threadly engaged with the plug member 56. Since fluid pressure in the control chamber 52 is applied to the poppet valve 75, when the pressure becomes higher than the predetermined value determined by the spring 76, the poppet valve 75 is disengaged with the valve seat 78 or moved rightwardly against the force of the spring 76, whereby fluid in the control chamber 52 is vented to the reservoir 40 through the passage 74 and a vent hole 79 perforated through plug 56, sleeve 54 and housing 10 as shown in FIGS. 1 and 5. When the chamber 52 is vented to the reservoir 40, the spool valve 51 is shifted toward right for increasing the flow through the by-pass port 60 into the reservoir 40, so that the pressure in the control chamber 52 is not compensated by the throttling agency of the throttle 58. Accordingly, while the maximum pressure of delivery fluid does not exceed the predetermined value, the flow rate thereof is maintained almost constant at the value required by the power steering apparatus without anything to do with number of the rotor rotation i.e. the engine rotation as shown by the solid line *b* of FIG. 9. However, the flow rate and the maximum pressure of the delivery fluid are manually changed from the outside of the rotary pump by changing the force of the compression springs 65 and 76 through the members 56 and 77 respectively so that both of them are exposed to the outside of the rotary pump as shown in FIGS. 1 and 3. As the result of changing the flow rate and the maximum pressure of the delivery fluid, the rotary pump may have great versatility to apply every kind of power steering apparatus such as for large, middle and small-sized vehicles.

A modified form of the invention heretofore described is illustrated in FIG. 8. The modified device of the invention is particularly related to control means comprising the combination of a modified flow control valve having a spool valve 80 provided with a delivery channel having an orifice and a modified pressure relief valve. Since the same rotary pump described heretofore is also used, the description about the modified form is made about the control device.

Referring now to FIG. 8, fluid discharged from the delivery channel 36 is led to a hole 75 via a depressed channel 43 and thence to a control chamber 84 through an orifice 81 in the spool valve 80 and then delivered from a delivery port 82 provided in the plug member 83. The flow rate of delivery fluid is always kept nearly constant according to the same principle as above-mentioned embodiment, since the spool valve 80 may change axial position in relation to the by-pass port 60, led to the reservoir 40 by response to the pressure difference across the orifice 81. When the pressure in a control chamber 84 between the spool valve 80 and the member 83 i.e. the pressure of the delivery fluid becomes higher than the predeter-

mined value, a poppet valve 85 is pushed leftwardly, whereby fluid in the control chamber 84 is vented to the reservoir 40 through a passage 86 so that the control chamber 84 is connected to a passage 87 in a sleeve 88 via a channel 89. Upon this occurrence, the spool valve 80 is shifted right to increase the flow through the by-pass port 60 into the reservoir 40. As understood from the above-description, the flow rate of delivery fluid is kept nearly constant and the maximum pressure never excess the predetermined value. The forces of a compression spring 91 for determining the pressure and the compression spring 90 for determining flow rate may be manually changed by operating an adjusting member 92 threadly engaged with the sleeve 88 and an adjusting nut 93 respectively. The adjusting nut 93 is threadly engaged with a sleeve 94 and may change the axial position of the plug member 83 through engagement therewith. The member 92 and the nut 93 are exposed to the outside of the rotary pump. Thus, the pressure and the flow rate of the delivery fluid which are to be predetermined may be manually changed from the outside of the rotary pump by operating the member 92 and the nut 93.

While the foregoing description is concerned with the preferred embodiments of the invention, it will be evident to those skilled in the art that various changes and modifications may be made therein without thereby departing from the basic principle of the invention, and the appended claims are intended to cover all such changes and modifications as fall within the spirit and scope of the invention.

What is claimed is:

1. A pump for supplying fluid under pressure to power steering apparatus of a vehicle comprising:

a body having an inlet and outlet zones and by-pass passage connecting the outlet zone to a reservoir,

a pump casing member mounted in the body, said pump casing member being formed as a cylindrical bore therein,

a pump rotor rotatably accommodated in said cylindrical bore and adapted to form a crescent-shaped clearance therebetween,

a plurality of abutments for dividing said clearance into a plurality of operating chambers, each of abutments being slidably received in a respective slot formed in said casing member so as to follow the radial changes of said pump rotor,

an orifice provided in a delivery channel connecting said outlet zone to an outlet port,

spool means slidably mounted in the body and responsive to the pressure difference across said orifice for controlling the by-pass passage in a manner to maintain the constant flow rate of delivery fluid through the delivery port,

first spring means operable to urge said spool means in a direction to close the by-pass passage thereby,

a first plug member threadably engaged with said body and abutting against one end of said first spring means, one end of said first plug member being exposed to the outside of said pump and adapted to change the force of said first spring means,

a control chamber between said spool means and said first plug member and subjected to the pressure behind said orifice through a throttle,

a valve seat formed in a passage opening to said control chamber,

a poppet valve provided in a chamber led to said reservoir and a second spring means normally urging said poppet valve toward said valve seat being provided in said first plug member,

a second plug member threadably engaged with said first plug member and abutting against one end of said second spring means, one end of said second plug member being exposed to the outside of said pump and adapted to change the force of said second spring means.

2. A pump for supplying fluid under pressure to power steering apparatus as claimed in claim 1, wherein said poppet valve comprises a ball.

3. A pump for supplying fluid under pressure to power steering apparatus as claimed in claim 1, wherein said body is provided with a sleeve, said sleeve being retained against axial movements by a snap action ring, said spool means being slidably mounted in said sleeve.

4. A pump for supplying fluid under pressure to power steering apparatus as claimed in claim 3, wherein said first plug member is threadably engaged with said sleeve.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,656,870 Dated April 18, 1972

Inventor(s) Takeshi Kusakabe; Akira Suzuki

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Assignee: Toyoda Koki Kabushiki Kaisha

Signed and sealed this 3rd day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334