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Aldinger

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[54] **PUMP PRESSURE AND FLOW VOLUME REGULATING APPARATUS**

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[51] **Int. Cl.** **F04b 49/08**

[58] **Field of Search** 418/26, 31; 417/220, 417/310; 91/475, 497

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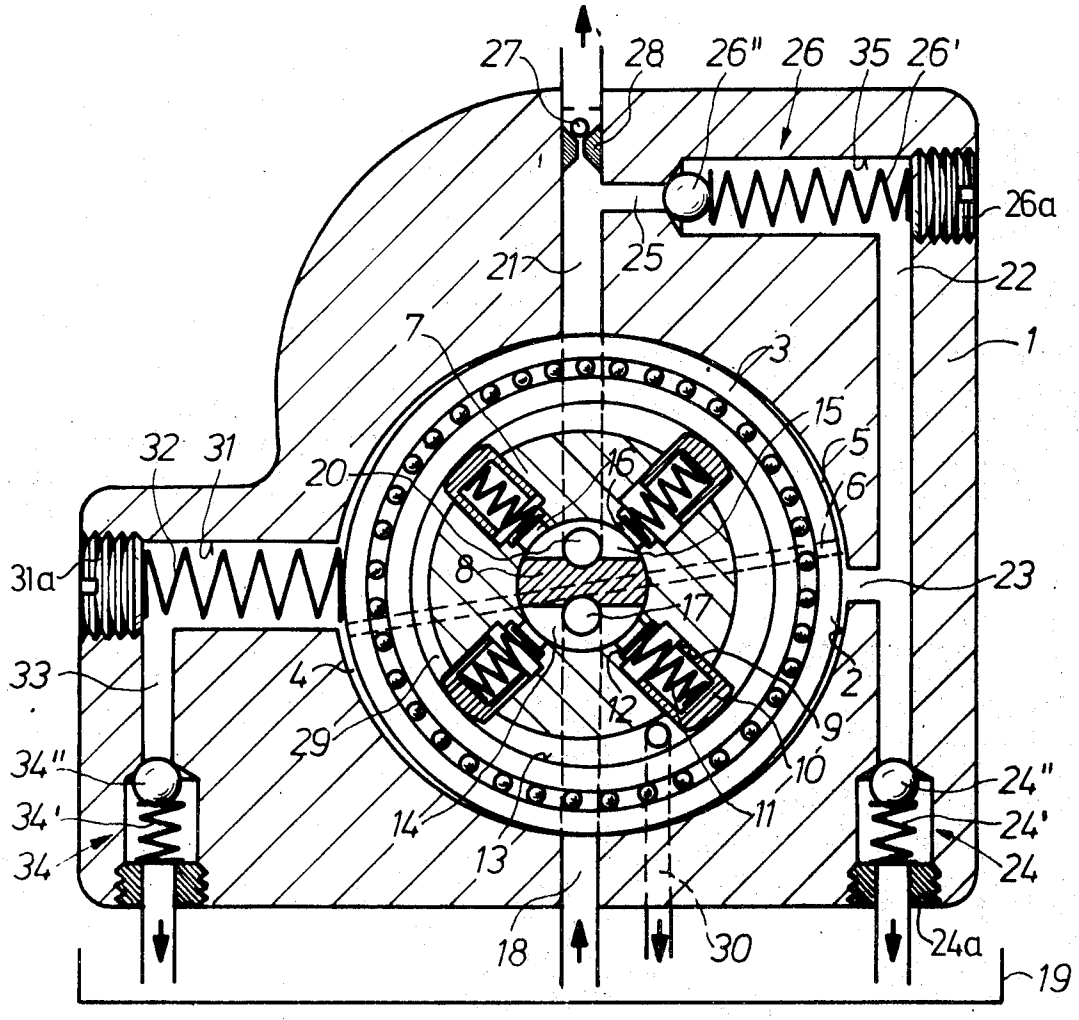
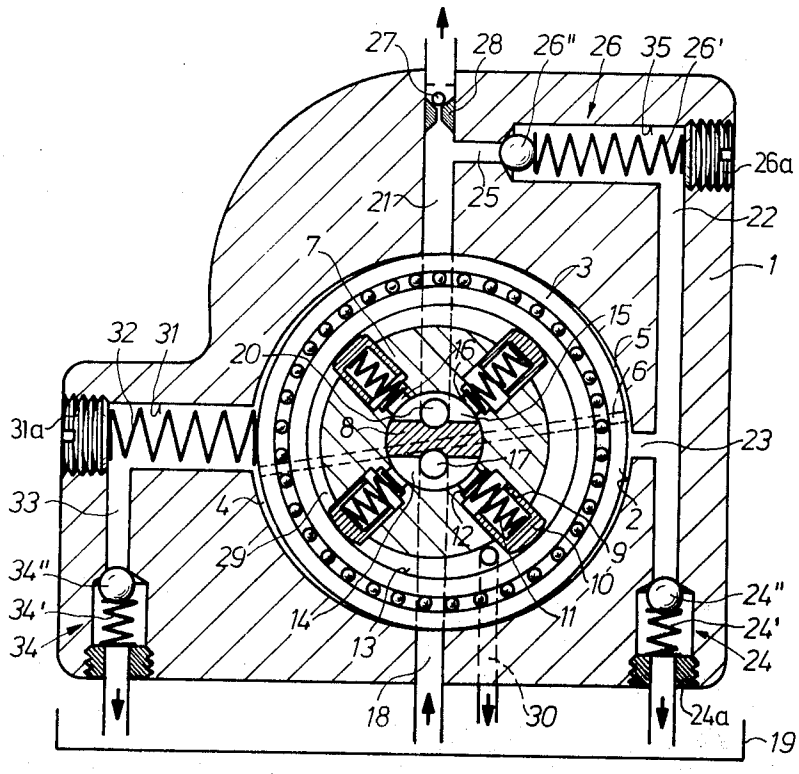
[57] **ABSTRACT**

The outlet pressure and pumped volume of a radial piston pump are automatically regulated by adjusting the eccentricity of the actuating ring which reciprocates the pistons during rotation of the cylinder block of the pump. A spring urges the actuating ring in one direction to a position in which the maximum volume is pumped, and a control valve, responsive to the pressure in the outlet conduit, opens at an excess pressure and supplies fluid to a regulating chamber between the actuator ring and a stator cavity, overcoming the spring force and reducing the eccentricity of the actuating ring and thereby the pressure and flow volume in the outlet conduit.

9 Claims, 1 Drawing Figure

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PUMP PRESSURE AND FLOW VOLUME REGULATING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a positive displacement pump, preferably a radial piston pump in which pistons or vanes are mounted in cylinder chambers of a rotary cylinder block and are reciprocated due to engagement with an eccentric actuating ring mounted on the stator for adjustment so that by a variation of the eccentricity of the actuating ring, the flow volume and pressure of the pump can be adjusted.

The U. S. Pat. No. 2,878,756 discloses a pump of this type in which the actuating ring is disposed between two pressure chambers which are connected by a throttling passage. A spring urges the actuating ring in one direction, and fluid pressure from the outlet means of the pump acts in one of the pressure chambers to urge the actuating ring against the action of the spring to correspondingly adjust the position of the actuating ring when the pressure in the outlet conduit of the pump becomes too high.

In accordance with the prior art, a shiftable valve controls the supply of pressure fluid to the pressure chamber for the displacement of the actuating ring. The valve has a neutral position in which a first pressure chamber, containing the spring, is connected with the high-pressure outlet of the pump so that spring force and fluid pressure act together on the actuating ring to move the vanes in one direction to a position in which the maximum volume is pumped. The other pressure chamber communicates with the low-pressure inlet of the pump. When a predetermined pressure is exceeded, the shifting valve reverses so that the second pressure chamber is connected with the high-pressure outlet, and the first pressure chamber is connected with the low-pressure inlet, the pressure fluid now acting in the second pressure chamber, displacing the actuating ring against the action of the spring so that the pumped volume of fluid is reduced. When the pressure has dropped below a predetermined minimum pressure, the valve is again reversed, and the actuating ring is returned to a position of which the eccentricity in which a greater amount of fluid is pumped.

The construction of the shifting and reversing valve is complicated, and the costs of manufacture high. Furthermore, the apparatus is capable only of regulating the pressure of the pump.

SUMMARY OF THE INVENTION

It is one object of the invention to improve the prior art and to provide simple, efficient and inexpensive regulating apparatus for a pump.

Another object of the invention is to provide an apparatus which regulates the pressure and flow volume of a rotary pump.

With these objects in view, the present invention provides a pressure-responsive control valve between the high-pressure outlet conduit of the pump and a regulating chamber so that at high pressure, the control valve opens and pressure fluid is supplied to the regulating chamber to move the actuating ring to a less eccentric position against the action of the spring. In accordance with the invention, a bypass valve connects the respective control conduit and regulating chamber with a low-pressure discharge region, in response to a far lower pressure than the pressure to which the control valve responds. Furthermore, a throttling duct is provided in the high-pressure outlet conduits of the pump, downstream of the control conduits and control valve, so that the volume pumped by the pump is limited. This has the advantage that commercially available, inexpensive valves of simple construction can be used for the combined pressure regulating and flow volume regulation of the pump.

One embodiment of the invention comprises a stator having an oblong inner cavity; a cylinder block located in the cavity and having cylinder chambers and pistons reciprocable in the cylinder chamber; actuating ring means, preferably a ball bearing, located in the inner cavity and having an endless eccentric inner surface for reciprocation of the piston, and an endless outer surface forming in the cavity two diametrical regulating chambers symmetrical to an axial plane; spring means biasing the actuator ring means to move in one direction so that the volume of one of the regulating chambers is normally greater than the volume of the other regulating chamber, whereby greater eccentricity of the endless inner surface at a great pump volume is obtained; inlet conduit means for supplying fluid to the expanding cylinder chambers, and outlet conduit means for discharging fluid from the contracting cylinder chambers; control conduit means connecting the outlet conduit means with the other regulating chamber; and pressure-responsive control valve means normally closing the control conduit means.

The pressure-responsive control valve means preferably includes a spring-biased pressure limiting valve responsive to high selected pressure to open so that high pressure fluid from the outlet conduit means is supplied to the other regulating chamber for moving the actuating ring means against the action of the spring means until the pumped volume and the pressure in the outlet conduit means are reduced. Thereupon, the pressure-limiting valve closes and the spring means moves the actuating ring means again to a position for increasing the pumped volume and the pressure.

In a preferred embodiment of the invention, a spring-biased bypass valve is provided in the control conduit means downstream of the regulating chamber, and is responsive to a lower pressure than the pressure-limiting valve so as to connect the control conduit means with a low-pressure region.

Preferably, a throttle means, which is advantageously combined with a check valve, is provided in the outlet conduit means.

The regulating chamber with which the control conduit is not connected, is preferably provided with a pressure-responsive discharge valve which opens in response to a pressure lower than the pressure of the bypass valve. A throttling passage connects the two regulating chambers so that pressure fluid flows from the regulating chamber having higher pressure to the respective other regulating chamber.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the drawing is a partially schematic cross-sectional view illustrating a radial piston pump provided with a regulating apparatus according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A radial piston pump has a stator and housing **1** with an oblong cavity **2** in which a circular ball bearing, constituting an actuating ring **3**, is arranged, so that two regulating chambers **4** and **5** are formed between the actuating ring means **3** and the ends of the cavity **2**. A throttling passage **6** connects the two regulating chambers **5** and **4**.

A cylinder block **7** is mounted on a journal **8** for rotation, and has substantially radial cylinder bores **9** in which pistons or vanes **10** are mounted for reciprocation. Pressure springs **11**, abutting annular shoulders of the cylinder chambers **9**, press the piston **10** against the circular inner surface **13** of the actuating ring means **3** so that the pistons are reciprocated in the usual manner when the center of the circular inner surface **13** is located eccentric to the axis of rotation of cylinder block **7**.

The journal **8** also serves for supplying and discharging liquid or fluid to and from the cylinder chambers **9**, respectively, and has for this purpose two diametrically opposite pressure chambers **14** and **15** of which pressure chamber **15** is a high-pressure chamber communicating through conduits **20** and **21** with the outlet of the pump, and pressure chamber **14** is a low-pressure chamber connecting the conduits **17** and **18** with the inlet of the pump. The cylinder chambers **9** have inner cylinder ports **12** on a circular bearing surface of cylinder block **7**, and successively sweep the high- and low-pressure chambers **15** and **14** during rotation of the cylinder block **7** so that fluid is discharged from contracting cylinder chambers **9**, and sucked into expanding cylinder chambers **9**. The pumped volume of fluid depends on the amount of eccentricity of the actuating ring **3**.

The inlet conduit **18** sucks liquid from the open container **19**, and the outlet conduit **21** supplies high-pressure fluid to consumer apparatus, such as a hydraulic motor.

A stepped bore **25** in stator **1**, has a frusto-conical valve seat on which a spherical ball **26''** abuts against the action of a spring **26'** which is adjusted by a screw **26*a***. The device constitutes a pressure-limiting valve which is located in the control conduit **22** which communicates through a branch conduit **23** with the regulating chamber **5**. Control conduit **22** opens into a low-pressure region, schematically indicated by the open container D , but the discharge is controlled by a bypass valve **24** including a spherical ball **24''**, a spring **24'**, and an annular screw **24*a***. The pressure-limiting valve **26** and the bypass valve **24** together constitute control valve means connecting the outlet conduit **21** with the regulating chamber **5** so that fluid at a predetermined pressure enters regulating chamber **5**.

In the normal closed position of the pressure-limiting valve **26**, the pressure fluid cannot flow from outlet conduit **22** through control conduit **22** into regulating chamber **5**. The selected pressure at which the pressure-limiting valve **26** opens may be, for example, 190 kg/cm². The bypass valve **24** which is located directly adjacent the low-pressure region of container **19**, maintains a predetermined pressure, for example 15 kg/cm² in control conduit **22** and in regulating chamber **5**.

Downstream of the stepped bore **25** of the pressure-limiting valve **26**, a throttle **28** is provided which forms a throttling duct, and a seat for a spherical ball **27** so that the pressure-limiting valve **26** is subjected to a pressure higher than the pressure of the consumer apparatus. If the pressure produced by the consumer apparatus, not shown, becomes too great, check valve ball **27** closes.

A space formed between the inner surface **13** of the actuating ring means **3**, and the outer surface of the cylinder block **7**. Space **29** communicates with the discharge conduit **30** opening into a low-pressure region.

A discharge conduit **33** forms a space **31** in which spring **32** is located. One end of the spring **32** abuts a screw **31a**, and the other end projects into regulating chamber **4**, abutting the outer surface of the actuator ring means **3** to urge the same towards the right as viewed in the drawing to a position in which the actuating ring means **3** has maximum eccentricity in a horizontal axial plane.

Discharge conduit **33** opens into a low-pressure region, but is normally closed by discharge valve **34** which has a spring **34'** urging a spherical ball **34''** against a seat formed in discharge conduit **33**. Discharge valve **34** maintains a predetermined low pressure, for example 8 kp/cm², in space **31** and regulating chamber **4**. The pressure maintained by the discharge valve **34** is less than the pressure at which the bypass valve **24** responds.

During rotation of the cylinder block **7** in counterclockwise direction by means of a prime mover engine, not shown, the pistons **10**, which are urged by springs **11** into sliding engagement with the inner surface **13** of the actuator ring means **3**, are reciprocated in the cylinder chambers **9**, if the actuator ring means in an eccentric position with relation to the axis of the rotary cylinder block **7** and the stationary journal **8**.

Due to the expansion and contraction of the cylinder chambers **9**, fluid is sucked through inlet conduits **18** and **17**, and discharged through outlet conduits **20** and **21**. High pressure is built up upstream of the throttle **28** which is added to the pressure required by the consumer apparatus, not shown. When a predetermined maximum pressure, adjusted by screw **26*a***, is reached, the pressure-limiting valve **26** opens, and fluid flows through control conduit **22** and out of the bypass valve **24** which opens at a substantially lower pressure than required for opening the pressure-limiting valve **26**, but this lower pressure is still above the pressure required for opening the counterpressure discharge valve **34**.

The fluid in control conduit **22** flows through branch conduit **23** into the regulating chamber **5**, and exerts pressure on the actuating ring means **3** to move the same against the action of spring **32**, and the force of the pressure fluid in regulating chamber **4**, towards the left as viewed in the drawing, so that the eccentricity of the actuator ring means is reduced, and the pumped amount is decreased.

The fluid displaced out of regulating chamber **4** flows through the counterpressure discharge valve **34** into the open container **19**. The counterpressure discharge valve **34** delays the discharge of the pressure fluid from regulating chamber **4**, and consequently has a damping

effect on the movement of the actuating ring means **3**.

When, due to the reduced amount of pumped fluid, and to the discharge of pressure fluid, the pressure drops to a predetermined minimum pressure, the valve **26** closes so that no pressure fluid is supplied to the regulating chamber **5**, and shortly thereafter, the bypass valve **24** also closes when the pressure in control conduit **22** is sufficiently low.

The regulating chamber **5** still contains fluid under higher pressure than the fluid in regulating chamber **4**, so that pressure fluid flows through the throttling passage **6** from regulating chamber **5** into regulating chamber **4** until the pressure in regulating chamber **5**, acting on the actuating ring means **3**, is insufficient to maintain the actuating ring means **3** against the combined force of spring **30** and the pressure in regulating chamber **4**. Consequently, the actuating ring means **3** is again moved to the right as viewed in the drawing for increasing the eccentricity of the actuating ring means **3**. During this movement, the volume of regulating chamber **5** is reduced, and pressure fluid flows out of regulating chamber **5** through the throttle passage **6** into regulating chamber **4**. Due to the slow flow through the throttle passage **6**, the return movement of the actuating means is damped.

When pressure fluid leaks into the space **29** within the actuating ring means **3, 13**, it flows through the discharge conduit **30** into the open low-pressure container **19**.

The throttle means **28** has a pressure loss increasing in accordance with the square function of the volume flowing therethrough. This pressure loss is added to the pressure consumed by the pressure required by the consumer apparatus, not shown, and to a lesser extent is also added to the working pressure which depends on the flow volume. Consequently, a predetermined pressure upstream of throttle **28** can be correlated with the flow volume depending substantially on a square function. If the pressure-limiting valve **26** is suitably selected and adjusted, also the flow of volume can be limited. In this manner, pressure regulation is combined in the present invention with a substantially exact regulation of the pumped flow volume.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of pump regulating apparatus different from the types described above.

While the invention has been illustrated and described as embodied in a pump pressure and flow volume regulating apparatus including pressure-responsive control valve means connecting the outlet conduit of a pump with the regulating chamber by which the eccentricity of actuating ring means is adjusted, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that from the standpoint of prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. Pump pressure and low volume regulating apparatus, comprising, in combination, a stator having an oblong inner cavity; a cylinder block located in said cavity and mounted on said stator for rotation about an axis, said cylinder block having cylinder chambers and pistons reciprocable in said cylinder chambers; actuating ring means located in said oblong inner cavity surrounding said cylinder block and having an endless eccentric inner surface for reciprocation of said pistons whereby said cylinder chambers expand and contract, and an endless outer surface forming in said oblong cavity two diametrically opposed regulating chambers symmetrical to an axial plane, said actuating ring means being mounted in said stator for adjusting movement in said plane for varying the eccentricity of said endless inner surface, and thereby the stroke of said pistons and the volume of the pumped fluid; spring means biasing said actuator ring means to move in one direction in said plane so that the volume of one of said regulating chambers is normally greater than the volume of the other regulating chamber so as to obtain a great eccentricity of said endless inner surface and a great pumped volume of fluid; inlet conduit means for supplying fluid to expanding cylinder chambers, and outlet conduit means for discharging fluid from contracting cylinder chambers; control conduit means connecting said outlet conduit means with said other regulating chamber; pressure-responsive control valve means between said outlet conduit means and said control conduit means normally closing said control conduit means, and responding to a selected maximum pressure in said outlet conduit means to open so that high pressure fluid from said outlet conduit means is supplied to said other regulating chamber for moving said actuating ring means opposite to said one direction against the action of said spring means until the pumped volume, and the pressure in said outlet conduit means, control conduit means, and other regulating chamber are reduced so that said control valve means closes, and said spring means moves said actuating ring means again in said one direction for increasing the pumped volume and the pressure in said outlet conduit means, said control valve means including a spring biased pressure limiting valve responsive to a high selected pressure and located in said control conduit means between said outlet conduit means and said other regulating chamber, and a spring biased bypass valve in said control conduit means downstream of said other regulating chamber, and being responsive to a substantially lower predetermined pressure than said pressure limiting valve so as to connect said control conduit means with a low pressure region.

2. Regulating apparatus as claimed in claim **1** comprising a throttle means in said outlet conduit means downstream of said pressure limiting valve so that the pressure acting on said pressure limiting valve is greater than the pressure of fluid supplied by said outlet conduit means to consumer apparatus.

3. Regulating apparatus as claimed in claim **1** comprising a discharge conduit means connecting said one regulating chamber with a low pressure region, and including a pressure responsive biased counter-pressure discharge valve which opens in response to a pressure lower than the pressure of said bypass valve; and a

throttling passage means connecting said two regulating chambers so that pressure fluid in said other regulating chamber flows through said throttling passage means, said one regulating chamber, said discharge conduit means and said counterpressure discharge valve to said low pressure region when the pressure in said one regulating chamber is less than the pressure in said other regulating chamber.

4. Regulating apparatus as claimed in claim **1** comprising a downstream opening check valve in said outlet conduit means downstream of said pressure limiting valve.

5. Regulating apparatus as claimed in claim **4** wherein said check valve includes a throttling duct and a movable ball for opening and closing said throttling duct.

6. Regulating apparatus as claimed in claim **1** comprising a throttling passage means connecting said two regulating chambers; and a discharge conduit means connecting said one regulating chamber with a low pressure region, and including a spring biassed discharge valve which opens at a predetermined discharge pressure.

7. Regulating apparatus as claimed in claim **6** wherein said discharge conduit means forms a space in said stator communicating with said one regulating chamber; and wherein said spring means is located in said space abutting said actuating ring means in said one chamber.

8. Regulating apparatus as claimed in claim **1** wherein a space is formed between the endless inner surface of said actuating ring means and said cylinder block; wherein said pistons have end portions slidingly engaging said inner surface and located in said space; and comprising discharge conduit means connecting said space with a low pressure region.

9. Pump pressure and flow volume regulating apparatus, comprising, in combination, a stator having an oblong inner cavity; a cylinder block located in said cavity and mounted on said stator for rotation about an axis, said cylinder block having cylinder chambers and pistons reciprocable in said cylinder chambers; actuating ring means located in said oblong inner cavity surrounding said cylinder block and having an endless eccentric inner surface for reciprocation of said pistons whereby said cylinder chambers expand and contract, and an endless outer surface forming in said oblong cavity two diametrically opposed regulating chambers symmetrical to an axial plane, said actuating ring means being mounted in said stator for adjusting movement in said plane for varying the eccentricity of said endless inner surface, and thereby the stroke of said pistons and the volume of the pumped fluid; spring means biasing said actuator ring means to move in one direction in said plane so that the volume of one of said regulating chambers is normally greater than the volume of the other regulating chamber so as to obtain a great eccentricity of said endless inner surface and a great pumped volume of fluid; inlet conduit means for supplying fluid to expanding cylinder chambers, and outlet conduit means for discharging fluid from contracting cylinder chambers; control conduit means connecting said outlet conduit means with said other regulating chamber; pressure-responsive control valve means between said outlet conduit means to open so that high pressure fluid from said outlet conduit means is supplied to said other regulating chamber for moving said actuating ring means opposite to said one direction against the action of said spring means until the pumped volume, and the pressure in said outlet conduit means, control conduit means, and other regulating chamber are reduced so that said control valve means closes, and said spring means moves said actuating ring means again in said one direction for increasing the pumped volume and the pressure in said outlet conduit means; a discharge conduit means connecting said one regulating chamber with a low pressure region, and including a pressure-responsive biased counter pressure discharge valve opening at a predetermined discharge pressure; and a throttling passage means connecting said two regulating chambers so that pressure fluid in said other regulating chamber flows through said throttling passage means, said one regulating chamber, said discharge conduit means, and said counter pressure discharge valve to the low pressure region when the pressure in said one regulating chamber is less than the pressure in said other regulating chamber.

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