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Thumm

[11] **3,708,250**

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[54] REGULATED RADIAL PISTON PUMP

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[52] **U.S. Cl.** **417/221**

[51] **Int. Cl.** **F04b 1/06**

[58] **Field of Search** ...91/497, 498; 92/12.1; 417/221

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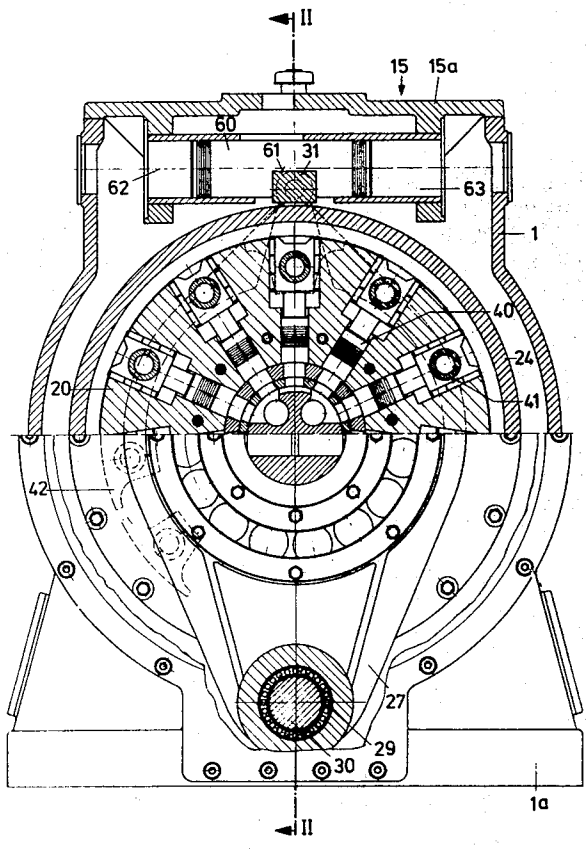
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Primary Examiner—William L. Freeh
Attorney—Michael S. Striker

[57] **ABSTRACT**

A radial piston pump has a rotor with working chambers and pistons or vanes in the same whose outer ends have shoes sliding on a circular guide ring mounted eccentrically to the rotor axis on a tiltable support whose angular position, and thereby the eccentricity of the guide ring, is varied by a setting device including a hydraulic motor angularly displacing the tiltable support under the control of a valve which is operated by a control circuit.

2 Claims, 8 Drawing Figures



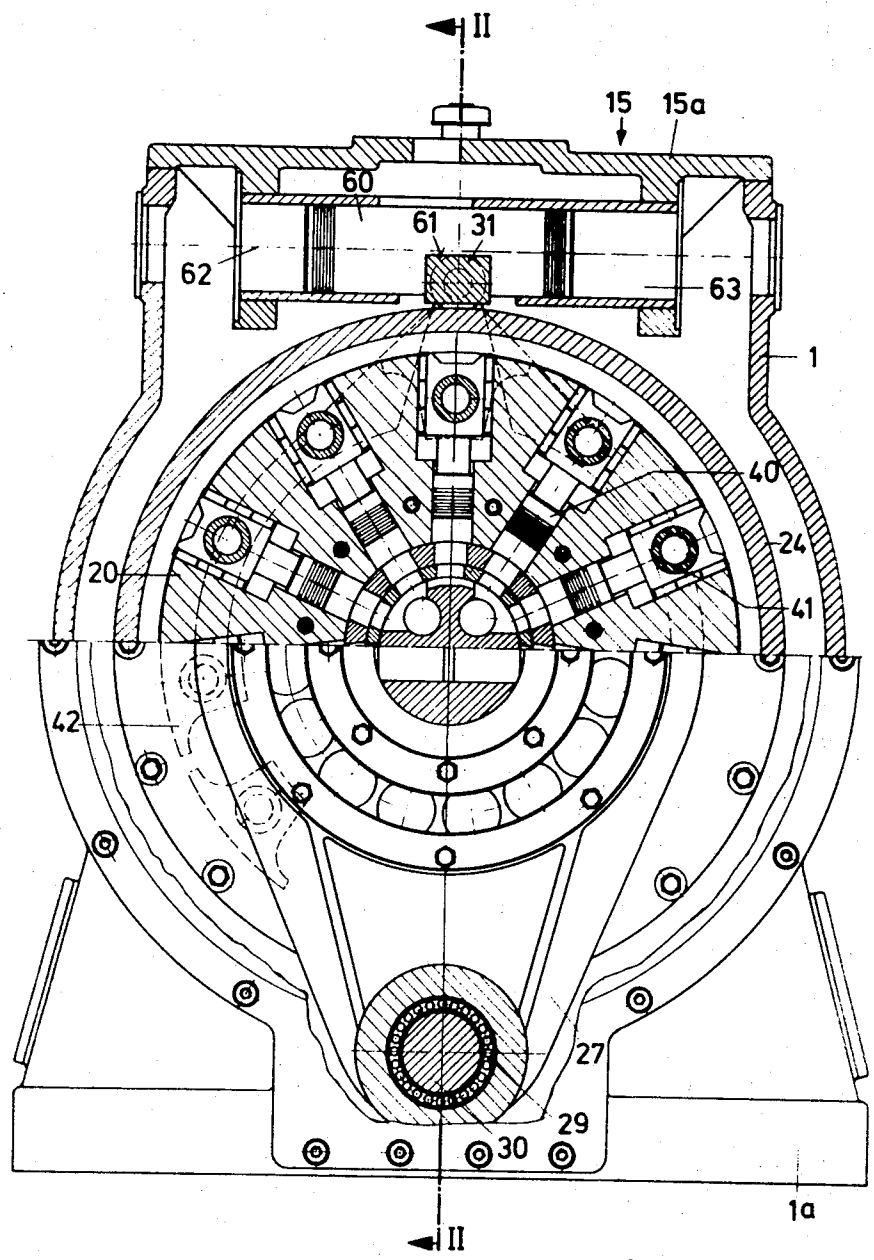


Fig. 1

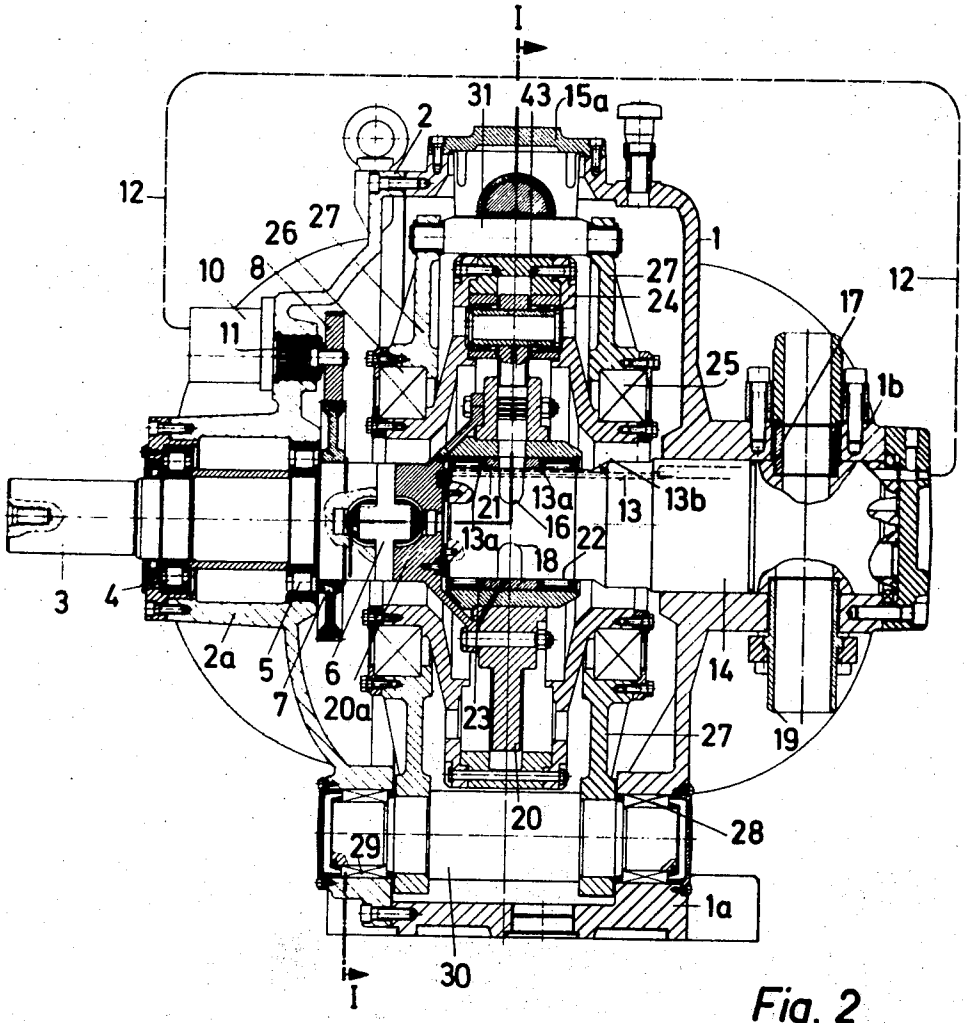

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Fig. 2

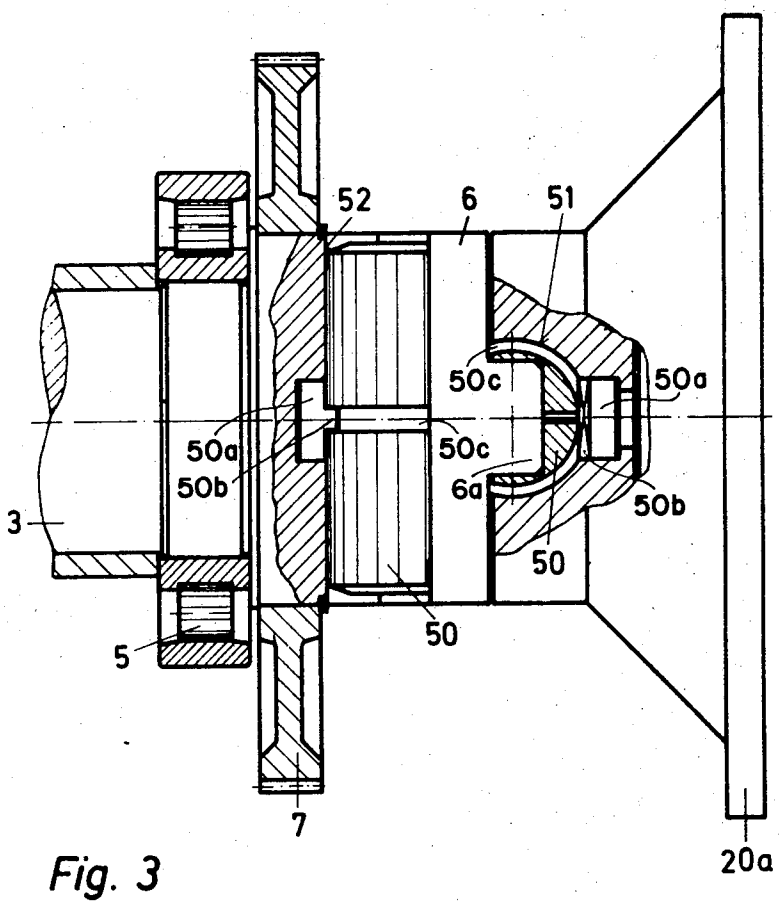


Fig. 3

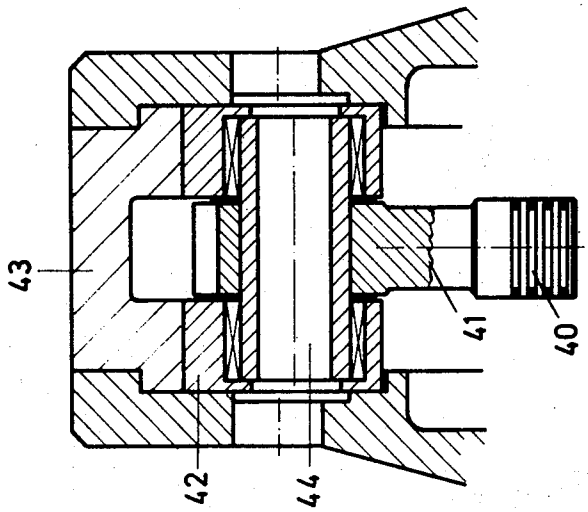


Fig. 4a

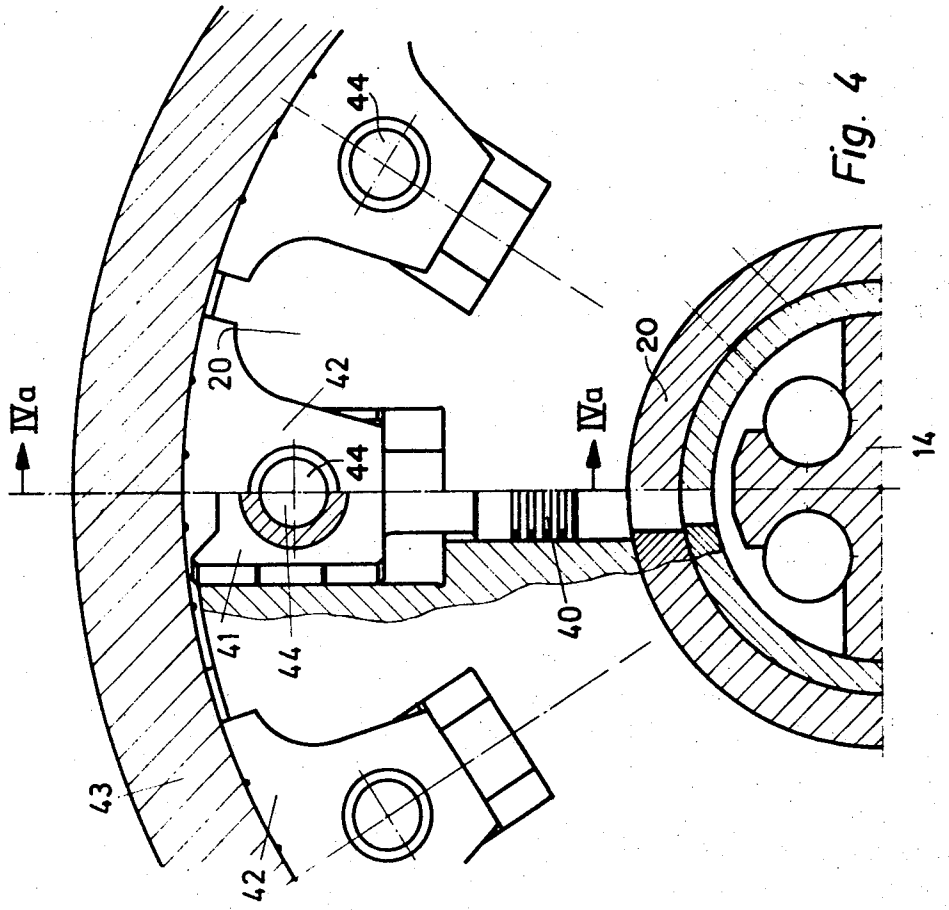


Fig. 4

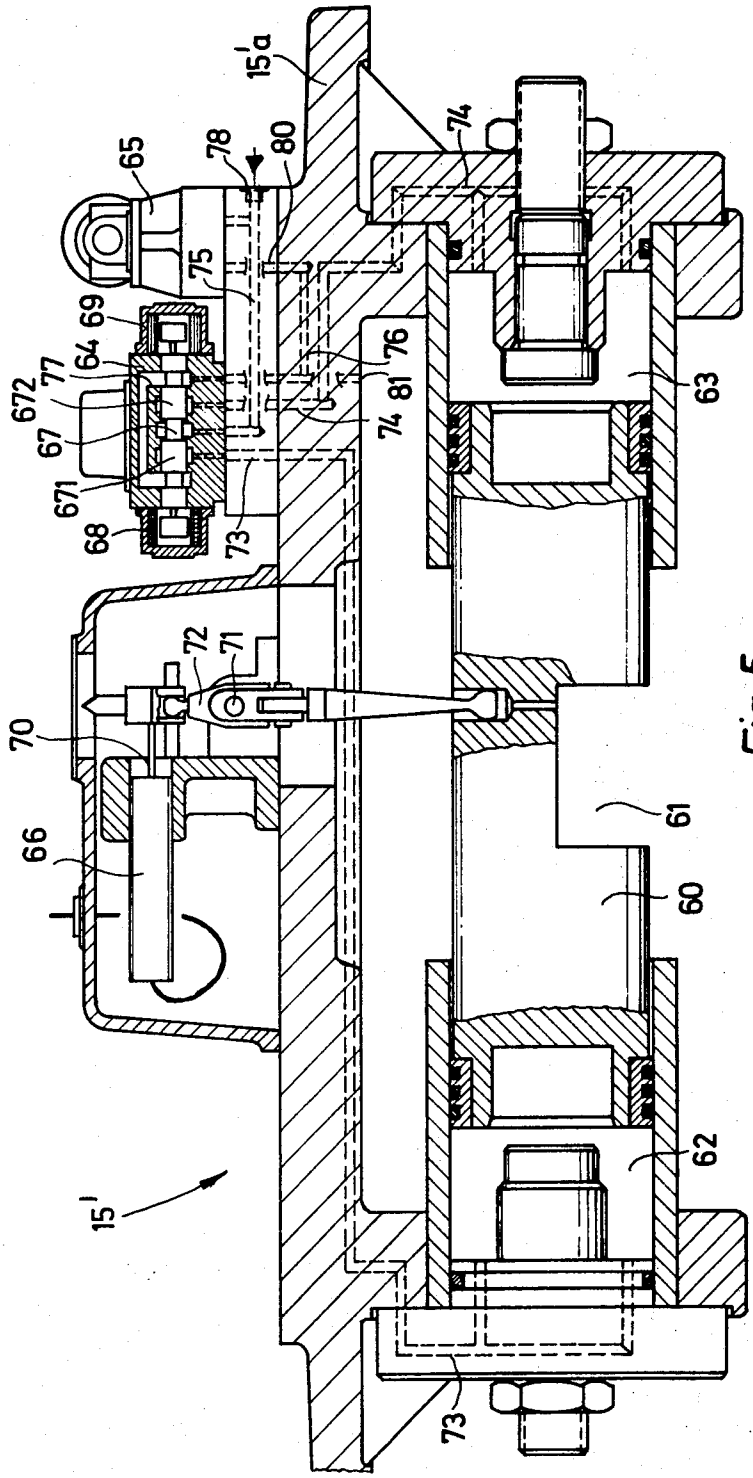

15'a
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Fig.5

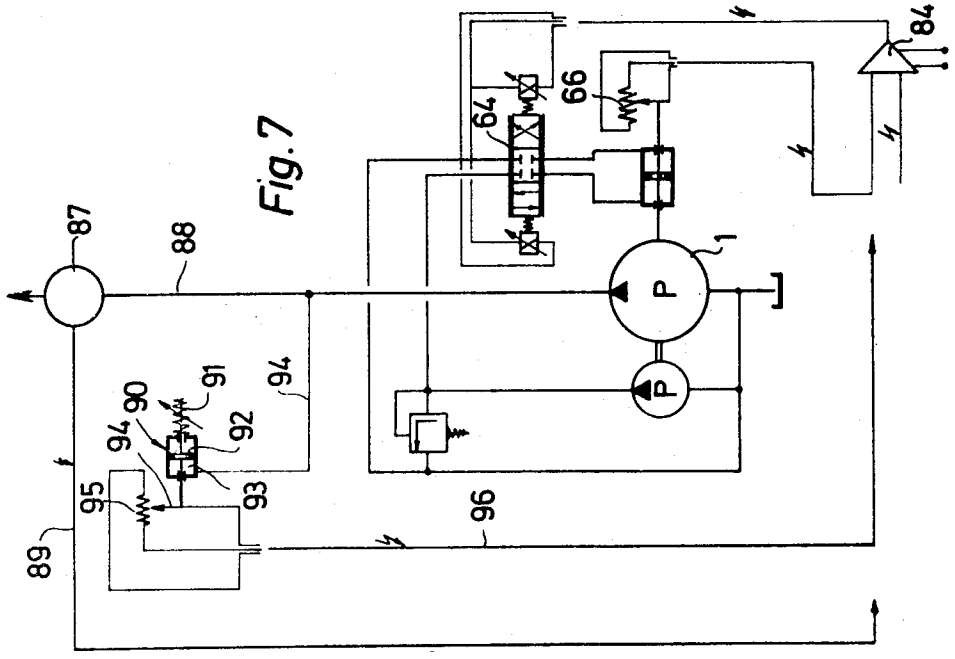

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Fig. 7

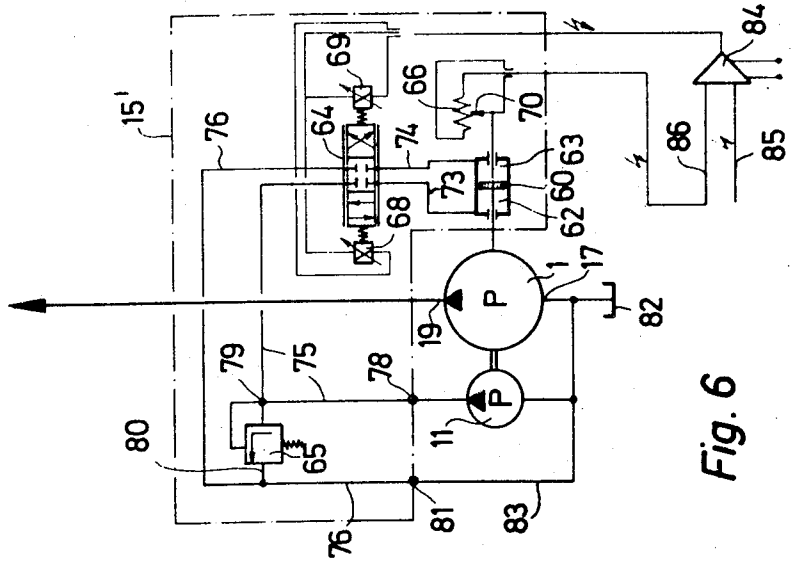

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Fig. 6

REGULATED RADIAL PISTON PUMP

BACKGROUND OF THE INVENTION

The present invention relates to a radial piston pump of the type in which the rotor is mounted on a journal and driven by a drive shaft. Inlet ducts and outlet ducts are provided in the journal for supplying a fluid such as oil to the chambers in the rotor. An eccentric guide ring is provided along which the pistons slide so that the same are moved into and out of the rotor chambers during rotation of the rotor.

Known pumps of this type have the disadvantage that the speed at which they can be adjusted, as well as the span of life of the entire pump, and also of individual parts of the same is comparatively short. Thereby, the purposes for which the pumps can be used are limited, and on the other hand pumps of this type cannot be used in arrangements in which a continuous operation of the pump is required.

SUMMARY OF THE INVENTION

It is the main object of the invention to provide a radial piston pump which has a very long span of useful life also at high pressures.

Another object of the invention is to provide a radial piston pump which can be regulated at very high speed by means of exchangeable control and setting devices.

With these objects in view, an embodiment of the invention comprises a casing, a journal mounted in the casing and having inlet and outlet ducts, driven rotor means mounted on the journal for rotation, and including a rotor having working chambers communicating with the ducts, and pistons movable in the working chambers, and having outwardly located slide shoes, tiltable support means mounted on the casing for angular movement about a pivot axis parallel to the rotor axis, a guide ring rotatably supported on the tiltable support means eccentrically surrounding the rotor and having an annular surface slidingly engaged by the slide shoes of the pistons so that the pistons are operated, and a setting device mounted on the casing and including movable control means engaging the tiltable support means for angularly shifting the same with the guide ring about the pivot axis between positions of different eccentricity in relation to the rotor axis.

The rotor means preferably include a driven shaft coaxial with the journal and disposed in end-to-end relation with the same, and a connecting coupling.

The casing means include a detachable part supporting the setting device, so that the same can be removed, exchanged or replaced, and then again mounted on the casing in an operative position.

The driven rotor shaft preferably drives auxiliary pumps, which include a lubricating pump pumping lubricating oil to several bearings of the pump.

The guide ring, along which the pistons slide, is mounted in the tiltable support by means of two symmetrically arranged roller bearings which are located laterally of the plane of the rotor, and support smaller diameter portions of the guide ring means whose diameter is selected to permit displacement of the guide ring with the tiltable support means without interference with the rotor shaft and with the rotor supporting journal which pass through the center of the guide ring means eccentrically to the same. Due to the fact that the portions of the guide ring means which are

mounted on bearings, have the smallest possible diameter, smaller than the diameter of the guide surface of the guide ring, the rotary speeds occurring at the bearings are small as compared with prior art constructions in which the guide ring is mounted on outer peripheral portions of the casing, so that the span of life of the respective bearings supporting the guide ring is comparatively long.

The pistons in the working chambers of the rotors are connected with a cross head on which a slide shoe is mounted for angular movement. The cross head has a portion which has a diameter greater than the piston diameter, so that forces transmitted from the slide shoe to the cross head are completely taken up by the cross head and transferred to the guide ring so that no lateral forces act on the pistons whose life span is thus increased.

The drive shaft which drives the rotor is connected with the same by a coupling of the Oldham type which permits relative movement, and has slide blocks preferably consisting of bronze so that the coupling can be serviced by exchanging only the slide blocks.

In accordance with the preferred embodiment of the invention, a control bushing surrounds the journal in the region of the ports of the inlet and outlet ducts and permits along the circumference and axial width thereof an equalizing of the pressure on the surface of the journal so that the control bushing floats on the journal. In axial direction, roller bearings are arranged on opposite sides of the control bushing which, due to the pressure equalization within the control bushing, only serve the purpose of guiding the rotor on the journal. This construction again assures a long span of life of the pump.

In the preferred embodiment of the invention, a drive gear is driven by the rotor shaft which meshes with one or several pinions mounted within the casing and having shafts projecting out of the same for driving the rotors of auxiliary pumps whose housings are secured to the casing of the main pump. The auxiliary pumps may include a lubricating pump for pumping lubricating oil to the bearings of the pump, and another auxiliary pump providing pressure fluid for the setting device which includes a hydraulic piston and cylinder motor and a valve for operating the same, and thereby the tiltable support means with the eccentric guide ring. Lubricating ducts in the journal supply the lubricating oil to the bearings on opposite sides of the control bushing, and also to the guide surface on which the shoes of the pistons slide. Due to the forced lubrications at the mentioned parts of the pump, a perfect lubrication is assured even if the pump operates for a long time without any load, when leakage oil lubrication is no longer assured.

The setting device may be controlled by hydraulic, pneumatic, electric or mechanical control mechanism which controls the control means by which the tiltable support means is angularly displaced with the guide ring so that the same has a desired eccentricity.

Due to the above explained constructive features of the movable parts of the pump, and of the bearings and coupling of the same, radial piston pumps in accordance with the invention, have a very long span of life even at high operational pressures. Due to the mounting of the tiltable support means, and of the set-

tling device for the same, the pump can be very rapidly adjusted so that a pump according to the invention can be used for large jarring machines in which a quick and continuous shifting of the pump has to be carried out. Pumps according to the present invention can be controlled at regulating speeds above 60 milliseconds, and operate at pressures up to 350 atmospheres, and peak pressures of 400 atmospheres.

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 be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an end view, and partially a section along line I—I in FIG. 2, and illustrating an embodiment of the invention;

FIG. 2 is an axial sectional view taken on line II—II in FIG. 1;

FIG. 3 is a sectional view illustrating a coupling means used in the embodiment of FIGS. 1 and 2;

FIG. 4 is a fragmentary cross-sectional view on a larger scale, illustrating a detail;

FIG. 4*a* is a fragmentary axial sectional view taken on line IV*a*—IV*a* in FIG. 4;

FIG. 5 is a fragmentary sectional view, illustrating the setting device of the pump on an enlarged scale;

FIG. 6 is a diagram illustrating the hydraulic and electric connections of the pump and the setting device thereof; and

FIG. 7 is a diagram illustrating the hydraulic and electric connection of the pump, and of a modified setting device thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The pump illustrated in the drawings, has a pump casing **1** which is integral with a base portion **1***a*. One side of the casing **1** is closed by a cover **2** which extends down to the base casing portion **1***a*. Cover **2** has a comparatively long hub portion **2***a* in which a shaft **3**, driven by a prime mover, not shown, is mounted on two roller bearings **4** and **5** which are arranged spaced a substantial distance in axial direction from each other. In this manner, shaft **3** is reliably supported, and the coupling, shown at **6** in FIG. **2** and better shown in FIG. **3** is relieved of transverse forces. In the region of the inner end of shaft **3**, a gear **7** is mounted which meshes with several gears which are mounted within the cover **2**, only one gear **8** being shown for the sake of simplicity.

The shafts of gears **8** project through openings in cover **2**, and are connected by plug and socket couplings **11** with the rotors of auxiliary pumps **10** whose housings are mounted on the outside of cover **2** in such a manner that the auxiliary pumps **10** can be replaced.

The auxiliary pump **10** shown in FIG. **2** functions as a lubricating pump and delivers through a lubricating duct **12**, shown as a chain line, lubricating oil through a duct **13** in the journal **14** of the pump. Another auxiliary pump, not shown in FIG. **2** supplies oil to the hydraulic motor of a setting device **15** which is exchangeably mounted on the casing, as will be described in greater detail with reference to FIGS. **5** to **7**.

Pump casing **1** has a tubular end portion **1***b* into which the stationary journal **14** of the pump is inserted. Inlet and outlet ducts are provided in journal **14**, and communicate with the inlet means **19** and outlet means **17**. The other ends of the inlet and outlet ducts terminate in circumferential ports **18** and **16** which cooperate with a circular control bushing **21** which surrounds the respective peripheral portion of the journal **14**. Control bushing **21** is formed with openings which control the flow of oil into the chambers of a rotor **20** which is mounted on journal **14** by means of control bushing **21**, and two roller bearings **22** and **23** on opposite sides of control bushing **21**. The control bushing **21** forms a small annular gap with the journal **14**, so that there is some leakage communication between the inlet and outlet ducts, for equalizing the pressure within the gap whereby the control bushing **21** floats on the journal **14**. The play between control bushing **21** and journal **14** is determined by the lateral precision bearings **22** and **23**, which serve only the purpose of guiding the rotor. Due to this bearing arrangement, a uniform very small leakage loss is assured during a long term of operations of the pump.

As best seen in FIGS. **4** and **4***a*, pistons **40**, which are guided in radially extending working chambers of rotor **20**, are connected by a cross head **41** with pairs of slide shoes **42** which slide on intermediate rings **43** of the guide ring means **24**. The cross heads **41** are mounted in rotor **20**, and have in the bearing region, a greater diameter than the pistons **40**. By this construction it is assured that non-radial forces acting on the unit formed by slide shoe **42**, cross head **41**, piston **40**, and piston pin **44**, are taken up by the cross head, and do not act on the respective piston **40**, which assures a long span of life for the pistons, even if the pump is operated at very high pressure.

The intermediate rings **43** of the guide ring means **24**, have inner cylindrical surfaces on which the shoes **42** slide, and since the center of the guide surfaces of rings **43** is eccentric to the axis of the journal **14** about which rotor **20** rotates, the pistons are moved into and out of the working chambers which are thus contracted or expanded for pumping the fluid, depending on the eccentricity of the guide surfaces of rings **43**. A pair of tiltable supports **27** is mounted on a pivot **30** which is rotatably supported by bearings **28** and **29** in the base portion **1***a* of the casing. Diametrically opposite the support portion of supports **27** and pivot **30**, a pin **31** connects the two supports **27**, and is engaged by a piston **60** which is movable in a cylinder **62** of a hydraulic motor, as best seen in FIG. **1**. Consequently, supports **27** can be together tilted about the axis of pivot **30**.

Supports **27** have large central openings in which roller bearings **26** and **27** are located whose inner races are secured to annular lateral portions of the guide ring means **24** which are located in opposite sides of the rotor. The lateral annular parts of the guide ring means **24** have equal inner diameters, and surround the shaft **3** and journal **19**, respectively. The diameters of the lateral annular portions of the guide ring means **24** are

selected so that the annular lateral portions do not engage or interfere with shaft 3 and journal 19 when the tiltable supports 27 are displaced together with the guide ring means 24 for adjusting the eccentricity of the same in relation to the axis of shaft 3 and journal 19, as required for the regulation of the pump. Due to the comparatively small diameter of the annular lateral portion as compared with the central guide portion of the guide ring means 24, the rotary speed of the roller bearings 26 and 25 is small, since the same have the smallest possible diameter.

A lubricating conduit 13 in journal 19 has outlet openings 13*a* in the region of the roller bearings 22, 23, and furthermore an outlet 13*b* radially projecting adjacent rotor 20, which supplies lubricating oil into the guide ring means 24, particularly for supplying lubricating oil to the slide shoes 42. The lubricating conduit 13 is connected with one of the auxiliary pumps 10 which are driven by rotor shaft 3.

FIG. 3 illustrates a coupling of the Oldham type which connects shaft 3 with a hub portion 20*a* of rotor 20, and compensates displacements of shaft 3 relative to journal 14. The coupling has part-cylindrical slide blocks 50 consisting of a bearing metal, for example bronze, and engaging corresponding part-cylindrical recesses 51 and 52 in the coupling portion 20*a* of rotor 20, and in a coupling portion of drive shaft 3. The coupling part 6 between the recesses 51 and 52 is a hardened metal, so that a long span of life of the coupling is assured. Coupling part 6 has projecting prismatic portions 6*a* located in corresponding inner recesses of slide blocks 50. The outer surfaces of slide blocks 50 have grooves 50*c* engaged by portions 50*b* of members 50*a* which are secured to shaft 3 and hub portion 20*a*, respectively, for preventing axial sliding of slide blocks 50. After a long time of use, only the slide blocks 50 are worn, and can be easily replaced.

In FIGS. 1 and 2, a setting device 15 is shown to be mounted on the detachable cover 15*a* of the casing 1, whose control piston 60 has a cutout 61 engaging the bolt 31 connecting the upper portions of the tiltable supports 27. The control piston 60 forms the chambers in cylinder 63 on opposite sides thereof, to which fluid is supplied, and from which fluid is exhausted in order to displace the tiltable supports 24. The unit can be removed together with cover 15*a*, and another unit can be substituted, depending on the manner of regulation of the pump which is intended.

FIGS. 5 to 7 show regulating devices 15'.

As shown in FIG. 5, the setting device 15' is controlled by the circuit shown in FIG. 6 for controlling the volume of fluid pumped by the pump. The setting device 15' is schematically indicated by a chain line in FIG. 6. The pump P, as shown in FIGS. 1 and 2, operates an auxiliary pump 11, see also FIG. 2, which supplies oil into the setting device 15', and is driven from gear 7 through gear 8. The casing cover 15'*a* of the setting device 15' also supports a hydraulic slide valve 64, an excess pressure valve 65, and an electrical distance indicator 66. Valve 64 is electromagnetically operated, and the control slide 67 has at opposite ends thereof, armature portions for electromagnets 68 and 69, see also FIG. 6 in which the valve 64 is schematically indicated in three control positions.

The distance measuring and indicating device 66 may include a potentiometer, as shown in FIG. 6, or an adjustable inductive resistance whose movable tap is connected by a pin 70 with a double-armed lever 72 turnable about a pivot 71. Consequently, the movements of control piston 60, which corresponds to the movements of the guide ring means 24, are transmitted to the turnable member of the potentiometer 66.

Control valve 64 has a central position in which conduit 74 is separated from conduit 76, and conduit 73 is separated from conduit 75. In the first control position of the slide valve, conduit 73 is connected with conduit 75, and conduit 74 is connected with conduit 76. In the third control position of slide valve 64, conduit 75 is connected with conduit 74, and conduit 73 is connected with conduit 76, as schematically shown in FIG. 6. Conduits 73 and 74 are connected with the chambers 62 formed in cylinder 63 on opposite sides of control piston 60. Conduit 75 has a connecting point 79 at which the excess pressure valve 65 is connected, and conduit 76 also has a connecting point 80, and is connected at the outlet 81 with a conduit 83 connected with the suction inlets of pump P and of auxiliary pump 11, which communicate with a container 82. When slide 67 is shifted by electromagnetic means 68 or 69 to the left, a connection between conduit 75 and conduit 73 is established so that pressure oil flows into chamber 62 and moves the control piston 60 to the right as viewed in FIG. 5, while the conduit 74 is connected with the other chamber and with the return conduit 76 so that the oil can flow out of the other chamber of cylinder and piston means 60. When slide 67 is moved to the right, the connections are reversed, and control piston 60 is moved to the left. The oil is pumped from auxiliary pump 11 through the connecting point 78 into the regulating device 15', where the pressure conduit 75 is connected at the point 79 with the excess pressure valve 65.

The regulating device is controlled by an electric control circuit which includes an operation amplifier 84 designed as a comparison device, which is known, and not an object of the invention. The desired amount of volume of fluid which is to be delivered by pump 1, is selected at an electrical device, not shown, which generates on line 85 a signal indicating the desired volume, and this signal is supplied to the comparison amplifier 84 while the actual position of control piston 60 is represented by a signal generated by the distance measuring means 66. Operation amplifier 84 produces a differential signal which causes energization of either electromagnet 68 or electromagnet 69 for displacing the valve slide 64 accordingly. In this manner, oil is directed into one of the two cylinder chambers 62 for shifting control piston 60 for angularly displacing the guide ring means 24 about the pivot axis 30 together with the supports 27 so that the volume delivered by the pump is varied. The displacement of control piston 60 is measured by the distance indicator 66 which causes a corresponding change of the signal thereof representing the actual position, until this signal corresponds fully to the signal representing the desired position and volume of fluid. At the moment when equality is reached, the slide 67 of valve 64 is returned to its position of rest in which the connecting conduit 73 to the two chambers 62 of cylinder 63 are closed.

A variation of the delivered volume makes many uses possible for the pump, particularly with apparatus which have a numerically controlled sequence of operations. A linear variation of the pumped amount in accordance with the value represented by an electric comparison signal representing a desired amount can be obtained, and small control voltages are sufficient to regulate the pump in a short period of time from idling to maximum delivered volume. The regulating time is only between **25** and **60** milliseconds, depending on the size of the pump.

The exchangeable and replaceable regulating devices **15**, **15'** cannot only effect a variation of the volume of the pumped fluid, but may also be constructed so that the volume can be varied depending on the pressure, or so that the volume is maintained constant, independently of the pressure.

As shown in FIg. **7** a measuring turbine **87** can be provided in the output conduit **88** of the pump P which produces a signal depending on the volume of oil flowing in outlet conduit **88**, and supplies this signal through an electric connector **89** to the only partly shown electrical part of the regulating device so that the pump is regulated in a manner which assures the maintaining of a constant pumped and delivered volume, independently of the pressure, which develops in the outlet line **88** dependent on the load determined by a consumer apparatus connected to the outlet conduit **88** of pump P.

The modified electrical control circuit shown in FIG. **7** additionally includes a pressure measuring valve **90** which is loaded by a spring **95** and has a spring biassed piston **92**. Piston **92** limits a cylinder chamber **93** which is connected by an oil conduit **94** to the outlet conduit **88** of the pump. The piston **92** is further connected with the movable member **94** of a variable resistor **95**, which is constructed similar to the distance measuring device **66** shown in FIG. **5**, and which supplies through an electric conductor **98** another signal to the operation amplifier **84**, this signal depending on the pressure in the outlet conduit **88**. The pressure responsive device **90** with the variable resistor **95** constitute a modulating control means whose regulating or control signal can be used for regulating a part of the load of the pump. The pressure responsive means **90** creates a pressure controlling signal, while the measuring turbine **87** creates a volume return signal for the regulating device, which is important for the compensation of leakage oil losses.

It will be seen that the pump of the invention can be adapted by means of an exchangeable regulating device to many complex uses, and can be regulated at a very high speed, even beyond the zero point of regulation between reversed conditions.

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 radial piston pumps differing from the types described above.

While the invention has been illustrated and described as embodied in a radial piston pump in which the eccentric guide ring is pivotally mounted for angular adjustment, and controlled by a regulating setting device responding to electrical signals, 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. Regulated readial piston pump, comprising, in combination, casing means; journal means mounted in said casing means and having inlet duct means and outlet duct means; driven rotor means mounted on said journal means for rotation about a rotor axis, and including a cylindrical control bushing surrounding said journal means in the region of said ports and forming a thin annular leakage gap with said journal means in which said duct means communicate so that said control bushing floats on said journal means, and a rotor having working chambers communicating with said duct means, and piston means radially movable in said working chambers and having outwardly located guide parts; two roller bearings located on said journal means on opposite sides of said control bushing and supporting said rotor for rotation; tiltable support means having a support part for mounting said support means on said casing means for angular movement about a pivot axis parallel to said rotor axis, and an operating part; guide ring means rotatably supported on said tiltable support means eccentrically surrounding said rotor and having an annular guide surface slidingly engaged by said guide parts of said piston means so that said piston means are operated during rotation of said rotor means; and a regulating setting device mounted on said casing means and including movable control means engaging said operating part for angularly shifting the same with said support means and said guide ring means about said pivot axis between positions of different eccentricity of said annular guide surface in relation to said rotor axis.

2. A pump as claimed in claim **1**, wherein said rotor means include a driven shaft coaxial with said journal and disposed in end-to-end relation with the same, comprising coupling means including two coupling members secured to said drive shaft and to said rotor, respectively, said coupling members having hardened part-cylindrical guideways crossing each other at an angle of 90°, part cylindrical slide block means slidingly mounted in said guideways and consisting of a soft material, and a coupling part having crossing prismatic portions projecting into corresponding crossing recesses in said slide blocks.

* * * * *