United States Patent [19]

Aldinger

[11] **3,747,477**

[45] **July 24, 1973**

[54] **VARIABLE VOLUME HYDRAULIC APPARATUS**

[75] Inventor: **Ulrich Aldinger,** Stuttgart, Germany

[73] Assignee: **Robert Bosch GmbH,** Stuttgart, Germany

[22] Filed: **May 21, 1970**

[21] Appl. No.: **39,225**

[30] **Foreign Application Priority Data**

May 28, 1969 Germany .... P 19 27 074.7

[52] **U.S. Cl.** **91/497**

[51] **Int. Cl.** **F01b 13/06**

[58] **Field of Search** 91/497, 484, 485, 91/487; 418/25, 26

[56] **References Cited**

UNITED STATES PATENTS

2,009,851	7/1935	Link	417/217
2,509,256	5/1950	Sorensen	417/219
3,028,814	4/1962	Rumsey	417/219
2,433,484	12/1947	Roth	418/26
3,155,047	11/1964	Reel	91/485
2,630,681	3/1953	Ferris	418/26
2,164,888	6/1939	Sassen et al.	91/487
3,087,437	4/1963	Henrichsen	91/484
2,716,945	9/1955	Presnell	91/485

FOREIGN PATENTS OR APPLICATIONS

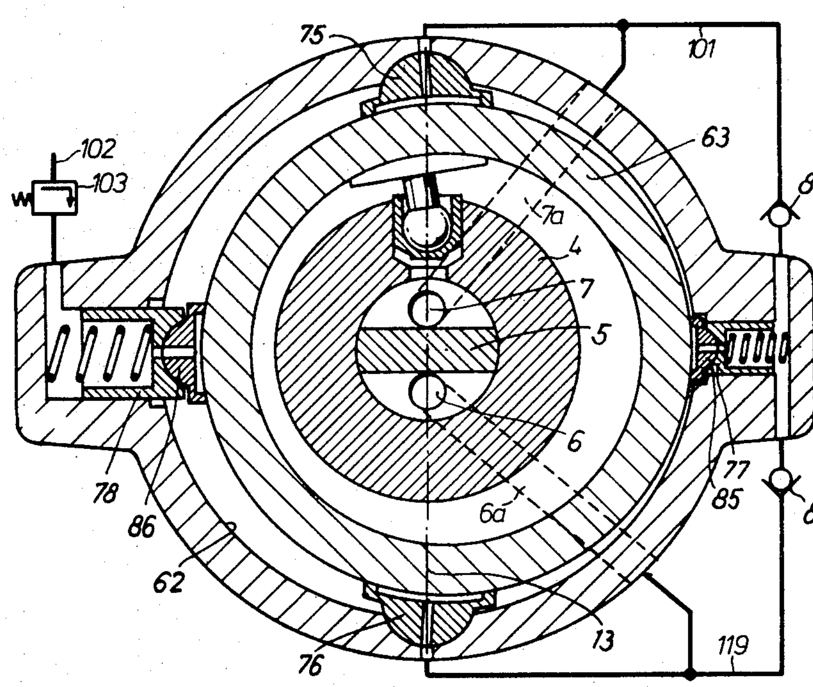
109,849	10/1917	Great Britain	91/497

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

[57] **ABSTRACT**

A hydraulic pump or motor of the radial piston type has a control ring for the pistons whose eccentricity to the axis of the rotor determines the transported volume of fluid. Two pistons are diametrically disposed in an axial plane and abut the control ring. The pistons are respectively connected with a source of fluid whose pressure is variable, and with the high pressure side of the hydraulic apparatus so as to vary the eccentricity of the control ring while the same is guided by two supporting means which are diametrically disposed in an axial plane perpendicular to the first-mentioned axial plane.

5 Claims, 4 Drawing Figures



PATENTED JUL 24 1973 3,747,477

SHEET 1 OF 2

Fig. 1

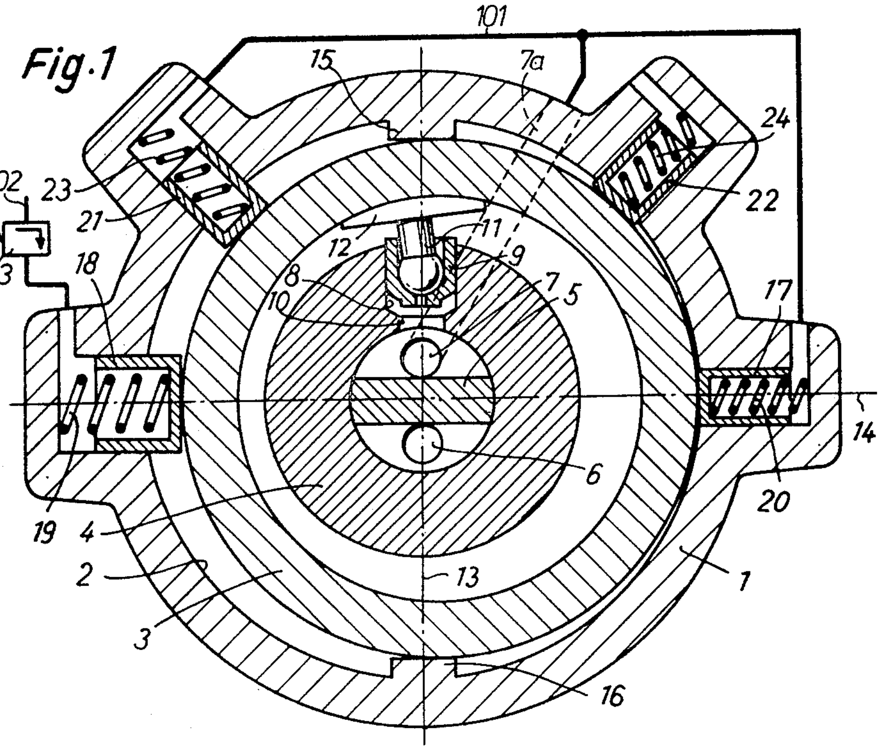
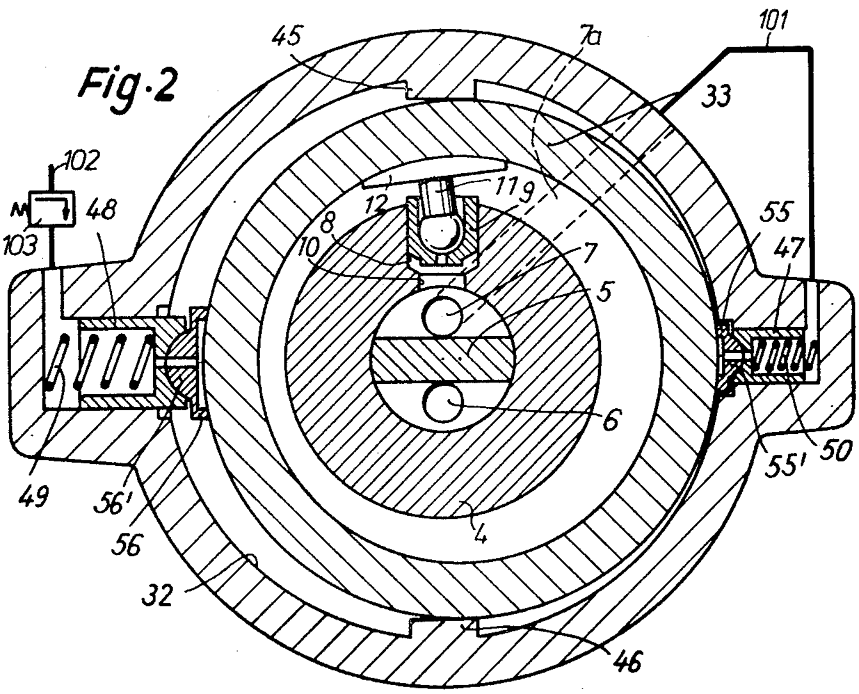


Fig. 2



INVENTOR.
Ulrich ALDINGER

BY Michael S. Striker
Attorney

PATENTED JUL 24 1973

3,747,477

SHEET 2 OF 2

Fig. 3

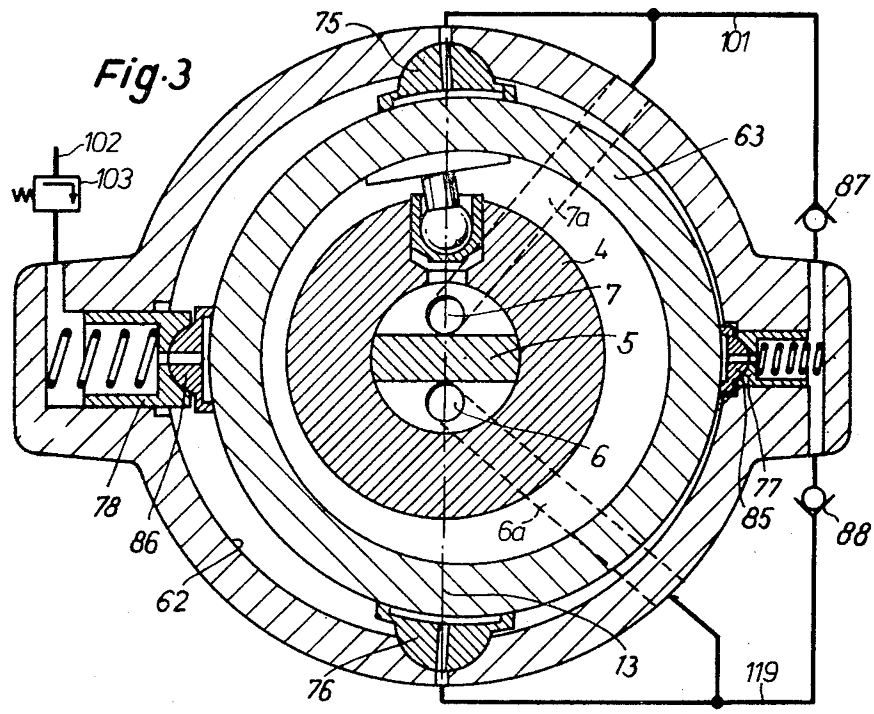
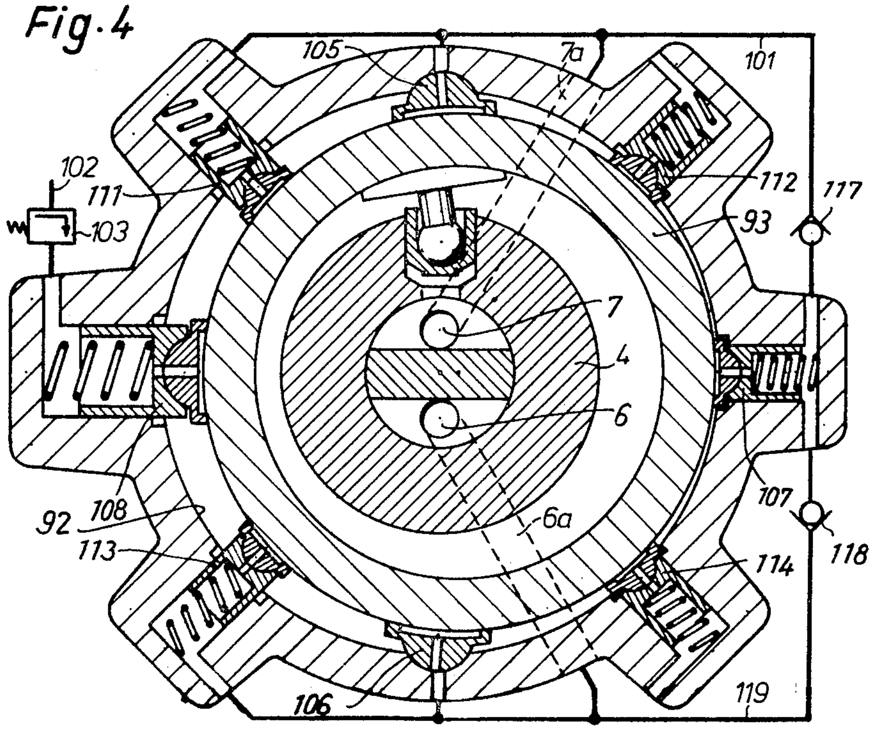


Fig. 4



INVENTOR.
Ulrich ALDINGER

BY Michael S. Striker
Attorney

VARIABLE VOLUME HYDRAULIC APPARATUS

BACKGROUND OF THE INVENTION

Radial piston pumps and vane pumps and hydraulic motors are known whose piston chambers are alternately connected with the high pressure side and low pressure side during each revolution of the pump or motor, and which are provided with a control ring on which the outer ends of the pistons or vanes abut. The control ring is freely movable in a cavity of the housing, and assumes a neutral position in which its center coincides with the axis of the rotor, or operative eccentric positions in which the pump or motor operates.

In accordance with the prior art, rather complicated mechanical apparatus is provided for displacing the control ring relative to the axis of the rotor.

It is one object of the invention to provide a hydraulic apparatus, either a pump or a motor, with simple and reliable means for mounting and displacing the control ring.

Another object of the invention is to provide operating means for displacing the control ring while compensating deformations of the same caused by the action of the operating means and by the supporting means of the ring.

Another object of the invention is to provide hydraulic operating means for displacing the control ring for varying the volume of fluid transported by the apparatus.

Another object of the invention is to provide operating means including at least one operating piston abutting the control ring and controlled by pressure fluid whose pressure is selectable and adjustable.

SUMMARY OF THE INVENTION

In accordance with the invention, the control ring means is supported on a plurality of supporting means which inwardly project from the housing, and at least some of which are movable radially with respect to the control ring.

A preferred embodiment of the invention comprises a rotor having an axis, peripheral chambers, and piston elements mounted in the chambers for substantially radial movement; a control ring surrounding the rotor and having an inner control surface engaged by the piston elements so that the latter move in the respective chambers when the center of the control ring is located eccentric to the axis of the rotor; housing means having an inner surface forming an inner cavity in which the control ring and rotor are located, and including fluid supply means and fluid delivery means communicating with the chambers; a pair of supporting means mounted in the housing diametrically disposed in an axial control plane inwardly projecting from the inner surface of the housing means, and having free inner ends abutting the outer surface of the control ring for guiding the same in a controlled direction with the center of the control ring moving in an other axial plane perpendicular to the axial control plane between a neutral position in which the center of the control ring coincides with the axis and a plurality of operative positions in which the center is eccentric to the axis; and operating means including at least one pair of cylinders diametrically disposed in the other axial plane and mounted on the housing means, a pair of operating pistons movable in the cylinders, respectively, and abutting the outer surface of the control ring, first conduit means for supplying to one of

the cylinders pressure fluid at selected pressures, and second conduit means for supplying to the respective other cylinder high pressure fluid.

In this manner, the movement of the control ring by the operating pistons and the volume displaced by the piston elements, depends on the selected pressure of the fluid in the first conduit means, and on the pressure in the second conduit means.

It is advantageous to provide additional cylinders and pistons angularly spaced 45° from the operating pistons and supporting means. Preferably, slide shoes are used to which pressure fluid is supplied so that a hydrostatic pressure area forms on the inner face of the shoe which is in contact with the outer surface of the control ring.

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 drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic cross-sectional view illustrating a first embodiment of a pump according to the invention;

FIG. 2 is a cross-sectional view illustrating a second embodiment of the invention;

FIG. 3 is a cross-sectional view illustrating a third embodiment of the invention; and

FIG. 4 is a cross-sectional view illustrating a fourth embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It will be assumed that the hydraulic apparatus shown in FIGS. 1 to 4 operate as pumps, but the apparatus can also be used as a hydraulic motor. The general constructions of the embodiment of FIGS. 1 – 4 is the same, and corresponding parts will be designated by like reference numerals.

In all illustrated embodiments, a rotor **4** is driven from a prime mover to rotate about an axis at which the axial planes **13** and **14** intersect at right angles. A valve means **5** is stationarily mounted in a cylindrical bore of rotor **4**, and is located in the axial plane **14** to separate the high pressure conduit **7** and the low pressure conduit **6** from each other. Conduits **6** and **7** communicate with supply means and delivery means for a fluid, depending on whether the apparatus is operated as a pump or motor.

The cylindrical rotor body has peripheral radially extending bores **8**, forming cylinder chambers in which pistons **9** are mounted for radial movement. FIGS. **1** to **4** show only one cylinder **8** and piston **9**, but it will be understood that a plurality of angularly spaced cylinder chambers and pistons therein is provided angularly spaced about the periphery of the cylindrical rotor **4**, only one piston being shown for the sake of simplicity in view of the conventional nature of this arrangement.

The cylinder chambers **8** on one side of the axial plane **14** are connected by openings **10** either with the low pressure supply conduit **6** or with the high pressure delivery conduit **7** during each revolution of rotor **4**.

Each piston **9** has a spherical seat engaged by a spherical head on a piston rod **11** to which a slide shoe

12 is secured. The outer surface of slide shoe 12 is part-circular, so that its contour matches the circular inner surface of a control ring 3, located in a cavity 2 of a housing means 1 which is large enough to permit translatory movement of control ring 3 in the direction of the axial plane 14.

A pair of diametrically arranged supporting means 15 and 16 is located in the axial control plane 13 which extends at right angles to axial plane 14. The inner end faces of abutment means 15 and 16 engage diametrically located portions of control ring 3, guiding the same for translatory movement with the center of control ring 3 moving in the direction of axial plane 14 between a position coinciding with the axis of rotor 4, and a plurality of eccentric positions, one eccentric end position being shown in the drawing.

Due to the fact that supporting means 15 and 16 project from the inner surface of housing 1, they cause only little wear of the control ring. The length of the inner end faces of supporting means 15 and 16 is preferably three to four times the maximum eccentricity of the center of control ring 3 in relation to the axis of rotor 4. Supporting means 15, 16 may be inserts consisting of a wear resistant material, or be integral parts of the housing 1 and cast with the same.

Two diametrically disposed operating pistons 17 and 18, which also constitute supporting means for control ring 3, are located in the axial plane 14. Operating pistons 17 and 18 are mounted for radial movement in corresponding cylinders formed on housing 1, and are urged by springs 20 and 19, respectively, into engagement with control ring 3, even if no pressure fluid is supplied to the cylinders of pistons 17 and 18. Piston 18 has a greater effective surface and a larger spring 19 than piston 17 and spring 20 so that control ring 3 is biased toward the illustrated eccentric end position.

In the embodiment of FIG. 1, other pistons 21 and 22 are provided in corresponding cylinders of housing 1, and are biassed by springs 23 and 24 toward engagement with control ring 3. Pistons 21 and 22 are located in the two quadrants on the high pressure side of the pump, and of axial plane 14, and spaced angles of 45° from planes 13 and 14.

The cylinders of pistons 17, 22 and 21 are connected by high pressure conduit means 101 with a radial high pressure conduit 7*a* communicating with the high pressure delivery conduit 7.

Another conduit means 102 communicates with the cylinder of operating piston 18, and contains valve means 103 for selectively varying and adjusting the pressure of the pressure fluid supplied to piston 18. When pressure fluid is supplied through conduit 102, piston 18 advances inward, and control ring 3 is pressed against the end face of piston 17, and braked in this eccentric end position. The amount of eccentricity of the center of control ring 3 in relation to the rotor axis, depends on the height of the pressure supplied through conduit means 102 to piston 18.

Control ring 3 is not pressed against the inner surface of casing 1, but against the end face of piston 17. The pressure between pistons 18 and 17 tends to deform control ring 3, which is prevented by the pressure of pistons 21 and 22 on control ring 3. Consequently, control ring 3 can have a smaller cross-section as compared with the construction, such as shown in FIG. 2, in which no additional pistons 21 and 22 are provided. Another advantage of pistons 21 and 22 is that the pressure of control ring 3 is distributed to a greater number of supported points.

When the control pressure applied to piston 18 is relieved, piston 17 moves control ring 3 against the action of spring 19 to a neutral position in which the center of control ring 3 coincides with the rotor axis, and the pump idles and delivers no fluid.

The embodiment of FIG. 2 corresponds to the embodiment of FIG. 1, the pistons 21 and 22 being omitted, while pistons 47 and 48 are provided with slide shoes 55 and 56, respectively. It will be understood that pistons 21 and 22 could also be provided in the embodiment of FIG. 2.

The control ring 33 is supported and guided by supporting means 45 and 46, and is operated by pistons 48, 56 and 47, 55 to move between positions of different eccentricity, as explained with reference to FIG. 1. A selectively variable control pressure is supplied to the cylinder of piston 48, and high pressure fluid is supplied by conduit 101 to the cylinder of piston 47. Springs 49 and 50 urge the pistons 48 and 47, respectively, toward control ring 33. Piston 48 has a cylindrical or spherical seat engaged by a corresponding cylindrical spherical head 56′ of slide shoe 56, and piston 47 has a spherical or cylindrical seat engaged by a spherical or cylindrical head 55′ of slide shoe 55. A duct connects each cylinder with a pressure area at the end face of each slide shoe so that the pressure of conduit 102 prevails under slide shoe 56, and the pressure of conduit 101 prevails on the slide face of slide shoe 55. Due to the produced hydrostatic pressure, the friction during the displacement of control ring 33 is reduced, and a lesser adjusting force required. During the pumping operation, control ring 33 cannot rotate since it is braked by piston 47, 55.

The axis or center of the cylindrical or spherical head 55′, 56′ is located on the outer circular surface of control ring 33. Due to this fact, the slide shoes cannot be tilted by control ring 33 which rotates during adjustment of the apparatus.

FIG. 3 shows an embodiment of the invention in which the operating pistons 77 and 78 are provided with slide shoes 85 and 86, as explained with reference to FIG. 2. Instead of rigid supporting means 15, 16 or 45, 46, slide shoes 75, 76 are provided in the axial plane 13 in diametrical position in relation to control ring 63. Slide shoes 75 and 76 have spherical or cylindrical heads mounted in corresponding seats in the inner surface 67 of the housing. The duct in slide shoe 75 on the high pressure side of the pump is connected with high pressure conduit 101 which communicates with the delivery conduit 7 of the pump through radial conduit 7*a*. The duct in slide shoe 76 is connected by a conduit 119 with a radial conduit 6*a* which communicates with the low pressure supply conduit 6 of the pump. Conduits 101 and 119 are connected over check valves 87 and 88 with the cylinder in which piston 77 is mounted. When the apparatus is operated as a pump, high pressure fluid from conduit 101 enters the cylinder of piston 77 through the opening check valve 87, but cannot enter the low pressure conduit 119 due to the provision of check valve 88.

When the direction of rotation of rotor 4 is reversed, conduit 119 becomes the high pressure conduit, and conduit 101 becomes the low pressure conduit, and piston 77 is operated by the high pressure produced by the pump since check valve **88** opens and check valve **87** closes.

In the embodiment of FIG. **3**, the control ring **63** is completely hydrostatically supported, so that very small friction forces occur, permitting rotation of control ring **63** even during operation of the pump. Control ring **63** rotates at an intermediate speed, lower than the rotary speed of rotor **4**, so that slide shoe **12** slides at a comparatively low speed on the inner annular surface of control ring **63**.

If the supporting slide shoe **56** is connected with the low pressure side of the pump, pressure fluid can be discharged from the pressure area in the curved face of slide shoe **76** abutting the outer surface of control ring **63**, so that the same is lubricated and cooled along its periphery.

As in the embodiments of FIGS. **1** and **2**, pressure fluid at a selectable control pressure is supplied to the cylinder in which piston **78** is mounted.

The embodiment of FIG. **4** combines features of the embodiments of FIGS. **1**, **2** and **3**. Supporting slide shoes **105** and **106** are arranged and constructed as the slide shoes **75** and **76** in FIG. **3**. Operating pistons **107** and **108** correspond to operating pistons **77** and **78** of the embodiment in FIG. **3**, and have corresponding slide shoes. Pistons **111** and **112** are also provided with slide shoes, and correspond to piston **21** and **22** in the embodiment of FIG. **1**, preventing deformation of control ring **93** which is located in the cavity of the housing having the inner surface **92**. Pressure conduit means **101** connects the delivery conduit **7** with the cylinders of pistons **111** and **112**, and over a check valve **117** with the cylinder of piston **107**. A low pressure conduit **119** connects the cylinders of pistons **113** and **114** with the low pressure supply conduit **6**, and over a check valve **118** with a cylinder of operating piston **107**.

High pressure conduit **101** is also connected with a duct of supporting slide shoe **105**, and low pressure conduit **119** is also connected with the duct of supporting slide shoe **106**. The cylinder of piston **108** is connected with a source of pressure fluid at a selectable control pressure. Pistons **111**, **112**, **113** and **114** prevent a deformation of control ring **93** by the pressure between pistons **107** and **108**. The slide shoes around the periphery of control ring **93** support control ring **93** for translatory movement from the eccentric end position shown in FIG. **4** to a position in which the center of control ring **93** coincides with the axis of rotor **5**. When the direction of rotation is reversed, high pressure fluid is supplied to pistons **113**, **114**, and **107**, and also to the supporting slide shoe **106**, while low pressure fluid is supplied to pistons **111**, **112** and supporting slide shoe **105**.

The effective surface of pistons **111**, **112**, **113** and **114** is selected in accordance with the occurring deformation of control ring **93** so that the same remains exactly circular.

The embodiments of FIGS. **3** and **4**, which permit rotation of control rings **63** and **93**, respectively, are particularly suited for high pressure and high rotary speed. The illustrated apparatus has been described for operation as a pump, but it is evident that the apparatus can also serve as a hydraulic motor.

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 variable volume hydraulic apparatus having a control ring slidably engaged by piston elements differing from the types described above.

While the invention has been illustrated and described as embodied in a pump or hydraulic motor in which a control ring for piston elements is operated by fluid pressure to vary the transported volume of fluid, 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. Variable volume hydraulic apparatus, comprising a rotor having an axis, chambers, and piston elements mounted in said chambers for substantially radial movement; a control ring surrounding said rotor and having an inner control surface engaged by said piston elements so that the latter move in said chambers when the center of said control ring is located eccentric to said axis; housing means having an inner surface forming an inner cavity in which said control ring and said rotor are located, and including a fluid supply conduit and a fluid delivery conduit communicating with said chambers; at least two supporting means mounted in said housing means disposed symmetrically to an axial control plane inwardly projecting from the inner surface of said housing means, and having free inner ends abutting the other surface of said control ring for guiding the same in one direction with the center of said control ring moving in an other axial plane perpendicular to said axial control plane between a neutral position, in which the center of said control ring coincides with said axis, and a plurality of operative positions in which said center is eccentric to said axis; and operating means including at least one pair of cylinders diametrically disposed in said other axial plane and mounted in said housing means, a pair of operating pistons movable in said cylinders, respectively, and abutting the outer surface of said control ring, first conduit means including a pressure adjusting valve means connected with a source of pressure fluid and being operable for supplying to one of said cylinders pressure fluid at selected control pressures, and second conduit means connected with said supply and delivery conduits in said housing for supplying to the respective other cylinder high pressure fluid from the one of said supply and delivery conduits at which high pressure prevails so that the displacement of said control ring by said operating pistons in said other axial plane, and the volume displaced by said piston elements depends on the adjusting of said pressure adjust-ing valve and on the selected control pressure of the fluid in said first conduit means overcoming the pressure in said second conduit means; each supporting means and each operating piston including a movable slide shoe having a curved face on said inner end matching the curvature of said outer surface of said control ring and slidingly

engaging the same, each slide shoe being formed with a duct for receiving pressure fluid, said duct ending at said curved face forming on the same a hydrostatic pressure area.

2. Hydraylic apparatus as claimed in claim **1** wherein each slide shoe has a cylindrical or spherical mounting portion having the center of curvature thereof located on said outer surface of said control ring.

3. Hydraulic apparatus as claimed in claim **1** comprising two diametrically disposed supporting means in said axial control plane; wherein ducts in said slide shoes of said two supporting means respectively communicate with said supply and delivery conduits so that the ducts in slide shoes on the high pressure side of said other axial plane receive high pressure fluid and the ducts on the low pressure side of said other axial plane receive low pressure fluid.

4. Hydraulic apparatus as claimed in claim **1** wherein said second conduit means include two conduits connecting said supply and delivery conduits, respectively, with said ducts, and two check valves in said conduits, respectively, so that high pressure fluid is supplied to said ducts irrespective of which of said conduits contains high pressure fluid during operation of the apparatus as pump or motor.

5. Variable volume hydraulic apparatus, comprising a rotor having an axis, chambers, and piston elements mounted in said chambers for substantially radial movement; an integral control ring surrounding said rotor and having an inner control surface engaged by said piston elements so that the latter move in said chambers when the center of said control ring is located eccentric to said axis; housing means having an inner surface forming an inner cavity in which said control ring and said rotor are located, and includ-ing a fluid supply conduit and a fluid delivery conduit communicating with said chambers; at least two supporting means mounted in said housing means disposed symmetrically to an axial control plane inwardly projecting from the inner surface of said housing means, and having free inner ends abutting the outer surface of said control ring for guiding the same in one direction with the center of said control ring moving in an other axial plane perpendicular to said axial control plane between a neutral position, in which the center of said control ring coincides with said axis, and a plurality of operative positions in which said center is eccentric to said axis; said operating means including at least one pair of cylinders diametrically disposed in said other axial plane and mounted in said housing means, a pair of operating pistons movable in said cylinders, respectively, and slidingly abutting the outer surface of said control ring, each supporting means and each operating piston including a movable slide shoe having a curved face on said inner end matching the curvature of said outer surface of said control ring and slidingly engaging the same, each slide shoe being formed with a duct for receiving pressure fluid, said duct ending at said curved face forming on the same a hydrostatic pressure area, first conduit means including a pressure adjusting valve means connected with a source of pressure fluid and being operable for supplying to one of said cylinders pressure fluid at selected control pressures, and second conduit means connected with said supply and delivery conduits in said housing for supplying to the respective other cylinder high pressure fluid from the one of said supply and delivery conduits at which high pressure prevails so that the displacement of said control ring by said operating pistons in said other axial plane, and the volume displaced by said piston elements depend on the adjusting of said pressure adjusting valve and on the selected control pressure of the fluid in said first conduit means overcoming the pressure in said second conduit means, said second conduit means including two conduits connecting said supply and delivery conduits, respectively, with said other cylinder, and two check valves in said two conduits, respectively, operable in opposite flow directions so that high pressure fluid is supplied to said other cylinder irrespective of which of said two conduits contains high pressure fluid during the operation of the apparatus as a pump or motor, so that the high pressure applied by said other piston on said control ring is overcome by the adjusted greater pressure acting in said one of said cylinders on the respective operating piston.

* * * * *