

[54] **AXIALLY BALANCED ROTARY PISTON MACHINE**

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[30] **Foreign Application Priority Data**

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[52] U.S. Cl.....**91/487, 91/492**

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

[58] Field of Search.....**91/492, 491, 497, 485**

[56] **References Cited**

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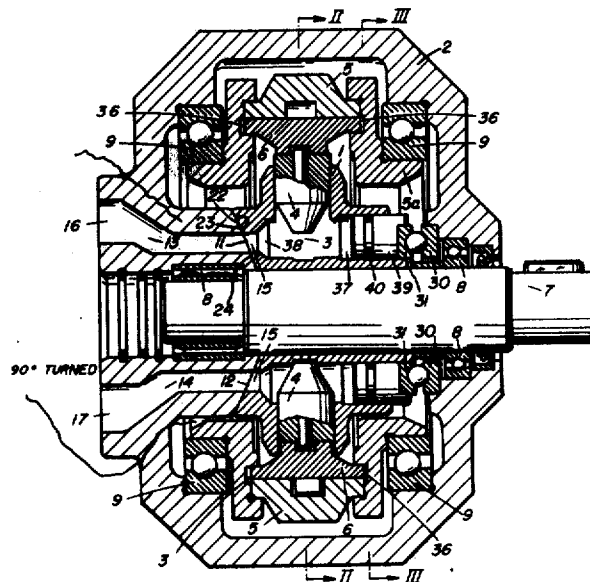
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[57] **ABSTRACT**

Axially movable balancing pistons are provided in axial cylinders of the rotor of a radial piston machine, pressing against the inner ring of a ball bearing whose outer ring is fixed to the housing so that the rotor, the balancing pistons, and the inner ring rotate together. The axial cylinders are the end portions of axial balancing passages extending between the ends of the rotor, and having on the end remote from the balancing pistons, ports on a rotary control face of the rotor cooperating with the inlet and outlet ports on a stationary control face of the housing. The pressure of the balancing pistons is transmitted by the ball bearing, or other thrust bearing, to the housing so that the rotor is axially displaced toward the stationary control face, and the rotary control face is pressed with the desired force against the stationary control face.

5 Claims, 4 Drawing Figures



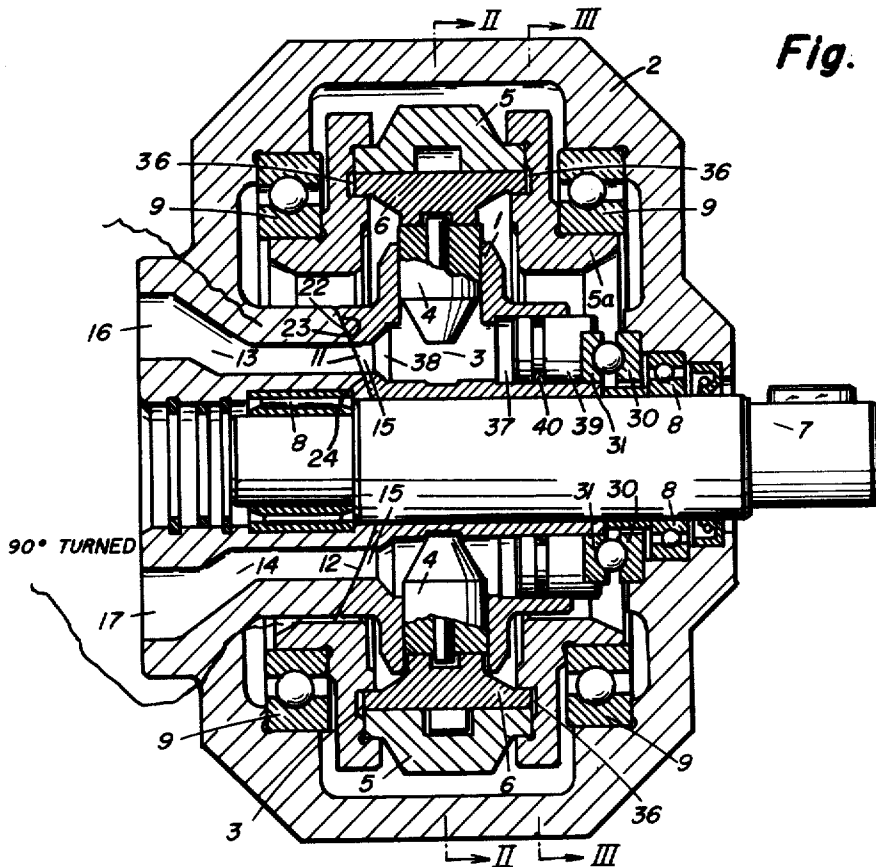


Fig. 1

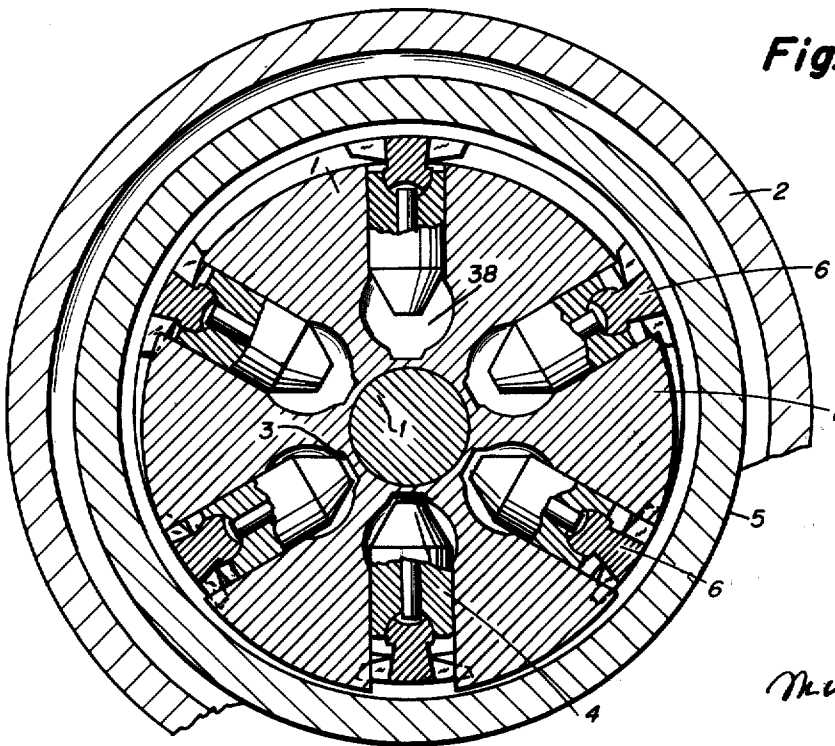


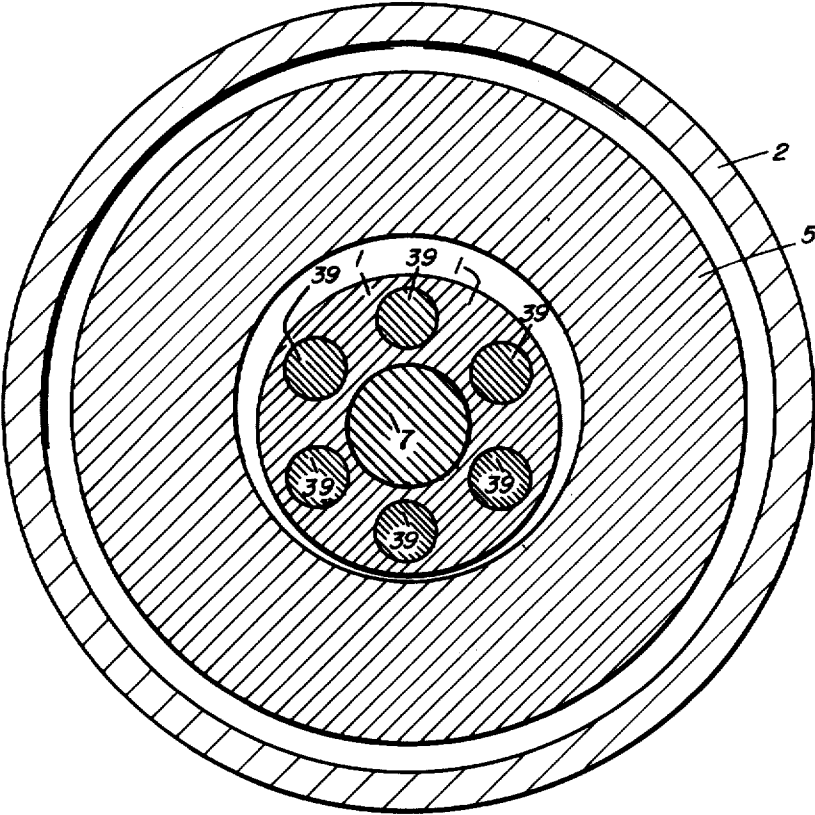
Fig. 2

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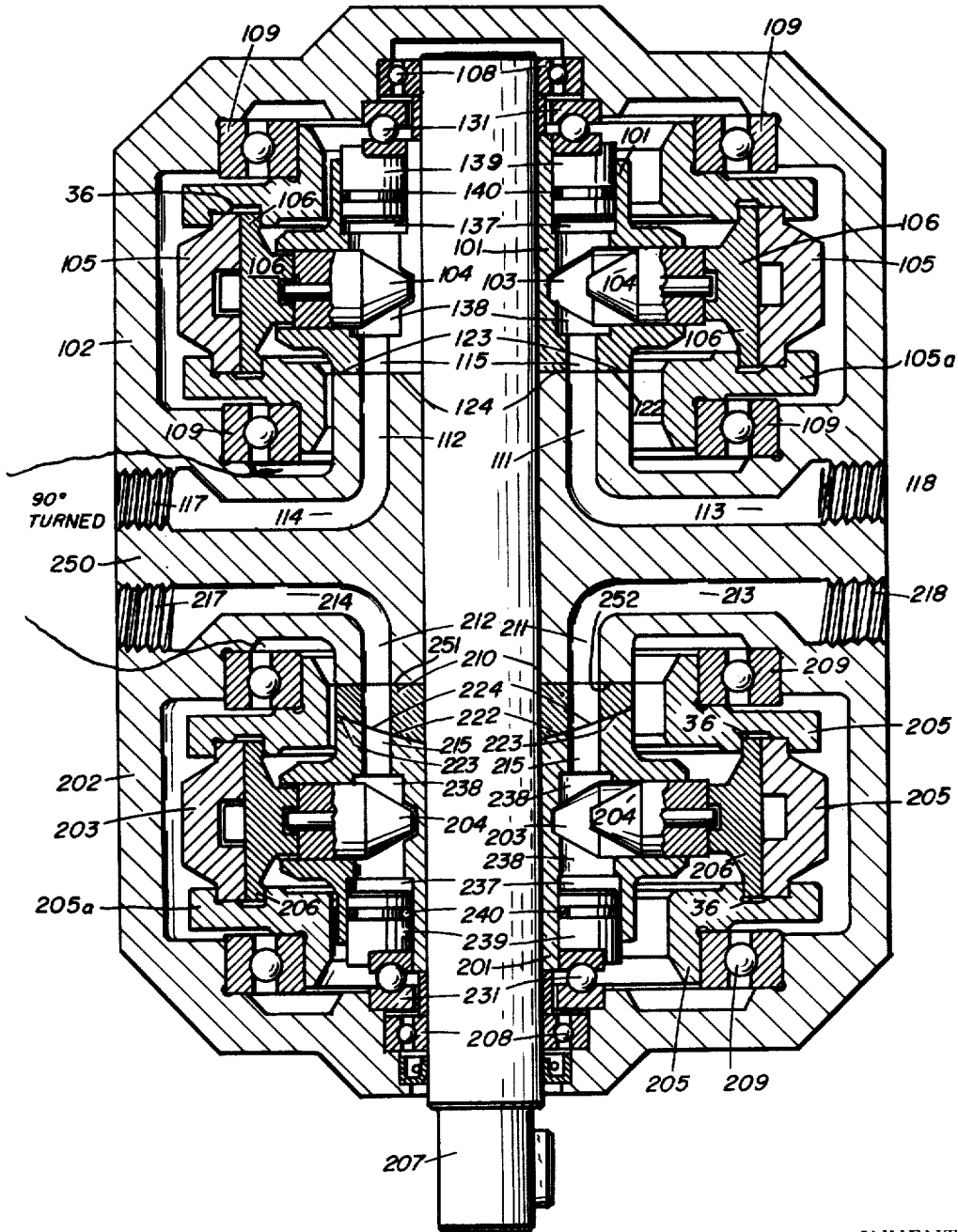
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Fig. 3



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Fig. 4



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AXIALLY BALANCED ROTARY PISTON MACHINE

RELATED PATENTS

The present application is a divisional application of my copending patent application Ser. No. 749,028 filed on July 31, 1968 as a continuation-in-part application of an application filed June 4, 1965 and issued as U. S. Pat. No. 3,398,698 on Aug. 27, 1968. The priority of a Swiss application filed July 10, 1964 in Switzerland is claimed for the present divisional application.

BACKGROUND OF THE INVENTION

The present invention is concerned with a rotary radial piston machine, pumps, hydraulic motors wherein pistons are reciprocated in radial cylinders of a rotor by an eccentric actuating or reaction ring for drawing and discharging fluid through passages having ports on a rotary control face of the rotor cooperating with inlet and outlet ports on a stationary control face of the housing.

In machines of this type, the rotary control face of the rotor must be pressed against the stationary control face of the stator with a sufficient force to reduce leakage, but the force should not exceed a certain value in order to prevent wearing, or tilting, of the engaging control faces due to high friction.

It is an object of the invention to provide a rotary piston machine which is axially balanced in such a manner that the rotary control face of the rotor is pressed with just the right force against the stationary control face of the stator. A related object is to prevent leakage from the control clearance between the rotary control face and the stationary control face, without causing substantial wear of the control faces.

SUMMARY OF THE INVENTION

With these objects in view the present invention provides an axially balanced rotary piston machine whose rotor has axially extending balancing passages between the ends thereof, the balancing passages having rotor ports in a rotary control face at one end of a rotor, and having axial cylinders at the other end of the rotor; balancing pistons in the axial cylinders; and an annular thrust bearing having an outer ring fixedly secured to the housing, and an inner rotary ring engaged by the projecting ends of the balancing piston and rotating with the rotor.

The effective cross-section of the balancing pistons and the location thereof is selected so that the rotary control face at the end of the rotor is pressed with a desired force against a stationary control face.

The invention is best understood with reference to the accompanying drawings illustrating embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view of an embodiment of the invention, the inlet and outlet passages being shown turned 90° for the sake of clarity;

FIG. 2 is a cross-sectional view taken on line II—II in FIG. 1;

FIG. 3 is a cross-sectional view taken on line II—II in FIG. 1; and

FIG. 4 is an axial sectional view illustrating another embodiment of the invention according to which two rotors are mounted in the same housing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment of FIGS. 1, 2 and 3, a radial piston machine is shown which has a housing 2 supporting a shaft 7 in annular ball bearings 8. A rotor 1 is mounted on shaft 7, and has a series of radial cylinder chambers 3 in which displacement pistons are mounted for reciprocating movement under the control of an eccentric actuator ring 5 which is engaged by piston shoes 6 at the outer ends of pistons 4. A pair of retaining means 5a is provided for retaining the actuator ring 5, and are supported on bearings 9 in housing 2. Rotor 1 has at one end, a rotary control face 24 in sliding engagement with a stationary control face 23 of the housing, the rotary and stationary control faces forming a control clearance 22. The end portions 15 of balancing passages form rotor ports 11 and 12 on the rotary control face 24, passing during rotation of rotor 2 over corresponding ports of inlet and outlet passages 13 and 14 leading to inlets and outlets 16, 17, the respective housing portion being shown turned 90° for the sake of clarity.

Each cylinder chamber 3 communicates with a corresponding axially extending balancing passage having an end portion 15 of small diameter, and another end portion 37 formed as an axial cylinder having a greater diameter than end portion 15. Between the end portions 15 and 37, an intermediate passage portion communicating with the radial cylinder chamber 3 is located, connected by an annular shoulder 38 with the passage end portion 15. The pressure in each axial cylinder 37 corresponds to the pressure in the respective cylinder chamber 3 which is high when one of the rotor ports 11 or 12 passes the high pressure inlet 16, and is low when the respective port passes the low pressure outlet 17, assuming that the machine operates as a hydraulic motor.

In each axial balancing cylinder 37, a balancing piston 39, provided with an annular sealing ring 40, is mounted, and the respective axial cylinders 37 and balancing pistons 39 are arranged in a circle, as best seen in FIG. 3. Each balancing piston 39 projects from the respective end of rotor 1, and bears on the inner ring 31 of an annular thrust ball bearing 30 due to the fact that the high pressure of inlet 16 is transmitted through the respective balancing passage to the axial cylinder 37. It is possible to use instead of an antifric-tion thrust bearing, a different thrust bearing having a strong film of a fluid. During rotation, the balancing pistons engage the inner ring 31, and rotate with the same and with the rotor 1.

The cross-sectional area of the axial balancing cylinders 37 is larger than that of the end portions 15 of the balancing passage. For manufacturing purposes, passage 15 has a small diameter, the intermediate portion 38 of the balancing passage is larger, and the diameter of the balancing cylinder 37 is the greatest.

The ends of pistons 39 can be provided with a stepped face conforming to the ring 31 so that balancing pistons 39 cannot rotate in the axial balancing cylinders 37.

The pressure in each axial balancing cylinder 37 corresponds to the pressure in the passage portion 15 of the respective balancing passage, and the pressure in the balancing cylinders is high, or low, respectively when the respective portion 15 communicates with the high pressure inlet and low pressure outlet, respectively. Therefore, rotor 1 is pressed with its rotary control face 24 against the stationary control face 23 with a pressure which is just suitable for overcoming the fluid pressure produced in the controlled clearance 22 by the ports 11, 12, 13, 14 and urging rotor 1 away from the stationary control face 23.

It will be appreciated that it is comparatively easy to drill the axially extending balancing passages 15, 38, 37 in the rotor 1. The intermediate passage portion 38 can be made a little larger than the diameter of the radial cylinder chambers 3 in order to simplify the manufacture, as best seen in FIG. 2.

If a rotary piston machine as described is operated at a small pressure, it is sufficient that the balancing pistons 39 slide on a non-rotatable surface of the housing. In accordance with the invention, however, the machine is to operate at high pressure. Therefore, when a passage 15 suddenly communicates with a high pressure port 16, for example, a very high sudden pressure peak acts on the fluid in the axial balancing cylinders 37 and thereby on the balancing pistons 39 which are pressed with a great force against the rotary inner ring. Such great peak forces could not be sustained by a non-rotatable supporting face, as provided in similar radial piston machines operated at low pressure. Fusing of the balancing piston to a stationary face would occur, and at the same time, the rotor 1 would receive additional forces which may force the rotor 1 to fuse to the stationary control face 23 on the housing.

It is therefore an important feature of the invention that the balancing pistons 39, which may be subjected to sudden peak pressure, bear on the ring 31 which is axially supported by the other ring of ball bearing 30 which is secured to the housing. It is possible to replace the balls of the ball bearing 30 by a fluid bearing member. The cross sections of the balancing passages must be dimensioned so that rotor 2 is not pressed with too great a force against the fluid film in the control clearance 22. The exact dimensioning, locating, and machining of the balancing passages and of the balancing pistons 39 must be very carefully carried out. The larger intermediate portion 38 between the passage end portion 15 and 37 makes such exact machining of the balancing passage portions possible.

For operation of the apparatus at very high pressures, it is necessary that the actuating ring 5 and slide shoes 6 of the pistons 4 engage, at a clear face contact in order to enable the transmission of a strong radial force to the pistons 4. Since the rotor 1 needs a some free axial mobility in order to adjust itself axially to the correct clearance distance 22 between the control face of the housing and the rotary control face of the rotor, a free clearance space 36 is provided in members 5a to permit axial movement of the piston shoes 6 to a limited extent.

If no free space would be provided to enable the rotor 1 and the piston shoes 6 to move freely to a limited extent in axial direction, the control faces of clearance 22 may wear during the power play between

the forces of the fluid in the control clearance 22 and in the axial balancing cylinders 37. Also, the piston shoes 6 may stick or fuse with the inner surface of the retaining actuating ring 5, if no free axial space were provided for movement of the piston shoes 6.

As best seen in FIG. 3, the eccentricity of the centers of the rotary actuator ring 5 and of rotor 1, causes the piston shoes 6 and the pistons 4 to move radially inward and outward during the rotation of rotor 1. FIG. 3 also shows the axial balancing cylinders 37 with the balancing pistons 39 arranged in a circle, one balancing piston 39 being provided for each cylinder chamber 3 and communicating with the same through the balancing passage portions 38 and 37.

FIG. 4 illustrates another embodiment of the invention in which a common housing 202 with a central partitioning wall 250 houses two rotors 101, 201 each of which corresponds to rotor 1 of the embodiment of FIG. 1. In FIG. 4, reference numerals are used which correspond to the reference numerals in FIG. 1 but provided with a prefix 1 for one of the rotors and with a prefix 2 for the other of the rotors. For purposes of illustration of possible modifications, rotor 201 has a planar control face 124 cooperating with the stationary control face 123 on a portion of the partitioning wall 250, while the other rotor has corresponding control faces 224 and 223 which, however, are shown to be curved. The control clearance 222 is formed on one side of a control body 210 which has a control face 251 cooperating with a stationary control face 252 on the partitioning housing portion 250. Control body 210 has at one end a planar control face 251, and on the other hand a curved control face 224 sliding on control face 223 of the rotor. If the control body 210 is stationary it may be considered a part of the housing 202, and if it rotates, it may be considered a part of rotor 201. A control body 210, interposed between the housing and the rotor simplifies maintenance and adjustment of the machine.

Otherwise, the embodiment of FIG. 4 has two rotors corresponding to the rotor of FIG. 1. A shaft 207 supports both rotors 101 and 201 in housing portions 102 and 202 by means of bearings 108 and 208. Cylinder chambers 103 and 203 in the rotors 101 and 201 guide radial pistons 104 and 204 having piston shoes 106 and 206 cooperating with actuating rings 105 and 205, having bearings 109 and 209. The clearances between the piston shoes 106, 206 and the retaining means 205a and 105a are designated 36, as in FIG. 1. Each housing part has inlet and outlet portions 114, 113 and 214, 213, respectively with connecting openings 117, 118 and 217, 218. The balancing passages have portions 115, 215 and connect with intermediate portions 138 and 238. The axial balancing cylinders 137 and 237 guide balancing pistons 139, 239 which have sealing rings 140, 240 and bear against the rotary rings 131, 231 which are revolving on stationary bearing rings 131, 231. The rotary control face 124 is planar, instead of spherical, as shown in FIG. 1. In the other rotor 201, the control body 210 is interposed between the housing 202 and rotor 201, and has on one side a planar control face 251 and on the other side a spherical control face 223. The spherical configuration of the control face 223 permits a shortening of the balancing passage portion 215, avoiding dead space and compression of fluid in the chambers of the rotor 201.

While the invention has been illustrated and described as embodied in a radial piston machine, 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.

I claim:

1. Axially balanced rotary piston machine, comprising housing means having a stationary control face, and inlet and outlet means forming inlet and outlet ports on said stationary control face; eccentric actuator ring means mounted in said housing means; rotor means mounted in said housing for rotation and including a rotor having radial cylinder chambers, and displacement pistons mounted in said cylinder chambers and being in contact with said actuator ring means so as to be reciprocated in said cylinder chambers, said rotor having at one end a rotary control face in sliding contact with said stationary control face, said rotor having axially extending balancing passages communicating with said cylinder chambers, respectively, and having rotor ports in said rotor control face communicating with said inlet and outlet ports during rotation, said balancing passages forming axial balancing cylinders at the other end of said rotor; balancing pistons in said axial balancing cylinder having ends projecting axially from said rotor; and an annular thrust bearing concentric with the axis of said rotor and having an outer ring fixedly secured to said housing means, and an inner rotary ring engaged by said projecting ends of said balancing pistons and rotating with said rotor, the effective cross section of said balancing pistons and the location thereof being selected so that said rotary control face of said rotor is pressed with a desired force

against said stationary control face while the fluid pressure in each axial cylinder exerted on the respective balancing piston and thereby on said thrust bearing, corresponds to the pressure in the respective balancing passage and in the respective chamber communicating therewith.

2. Rotary piston machine as claimed in claim 1 wherein each of said balancing passages has a first passage end portion ending in a rotor port on said rotary control surface, a second end portion forming one of said axial balancing cylinders, and a third intermediate portion communicating with one of said cylinder chambers, said second end portion having a diameter greater than the diameter of said first end portion.

3. Rotary piston machine as claimed in claim 1 wherein the end faces of said balancing pistons match the configuration of said inner rings so that said balancing pistons can not rotate in said axial balancing cylinder.

4. Rotary piston machine as claimed in claim 1 wherein said annular thrust bearing includes rolling elements between said outer and inner rings.

5. Rotary piston machine as claimed in claim 1 wherein said housing means includes a partitioning wall having two opposite stationary control faces; wherein said rotor means includes two rotors, each rotor having a rotary control face in sliding contact with one of said stationary control faces, respectively, said rotors having said balancing passages forming axial balancing cylinders; balancing pistons in said axial cylinders; and two annular thrust bearing means having inner rings engaged by said balancing pistons, respectively, and outer rings fixedly secured to said housing.

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