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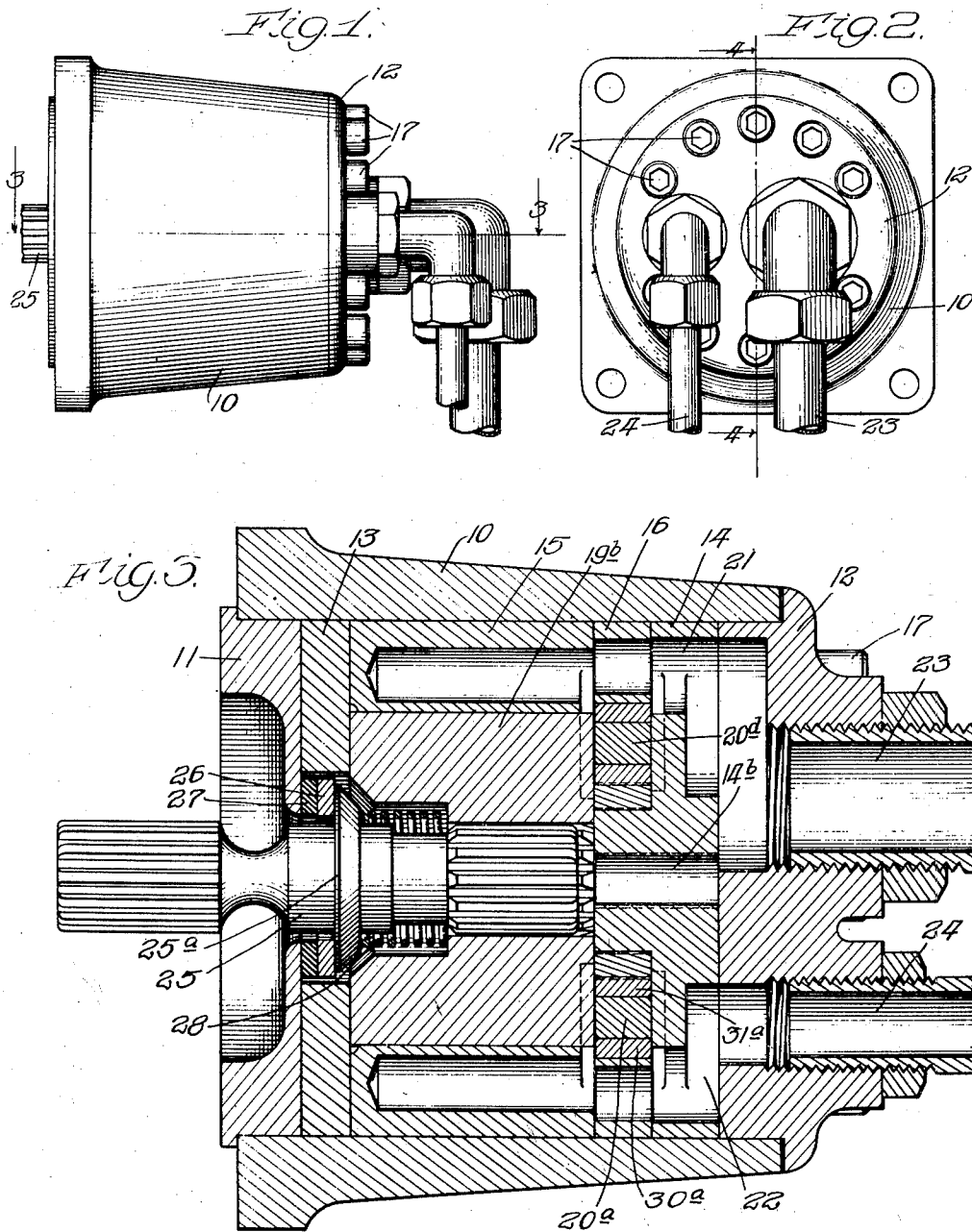
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2,491,670

ROTARY PUMP

Filed June 5, 1943

3 Sheets-Sheet 1



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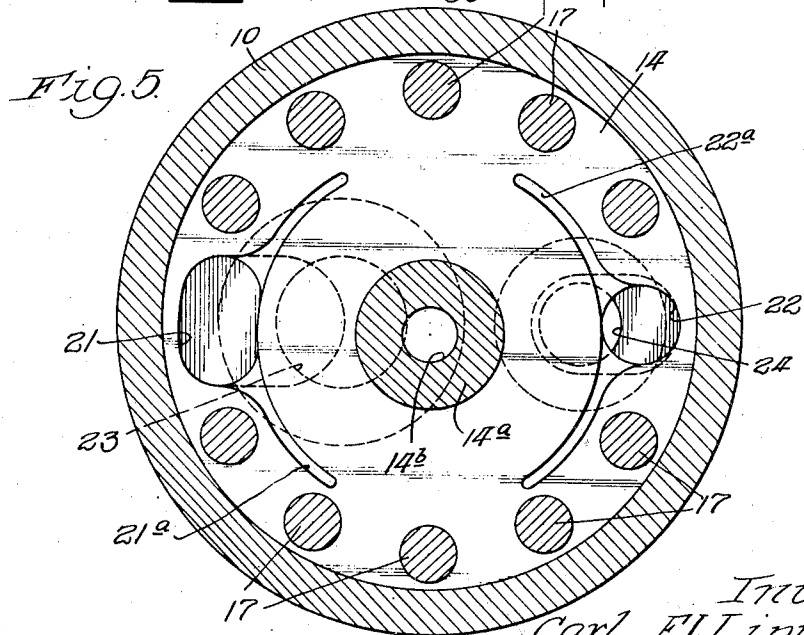
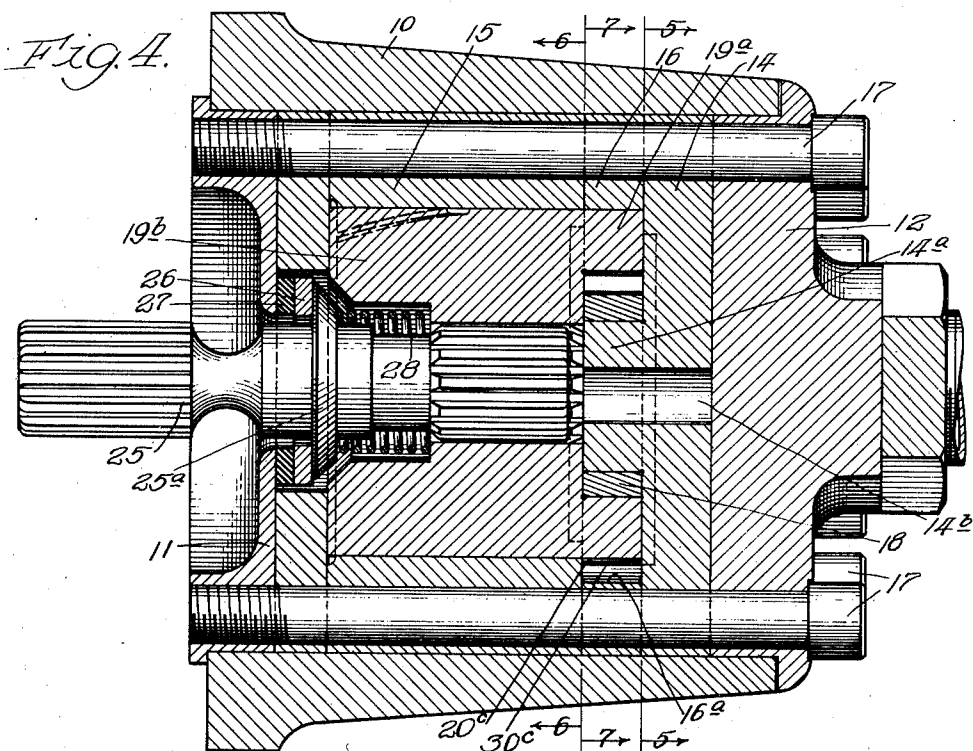
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ROTARY PUMP

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3 Sheets-Sheet 2



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Fig. 6.

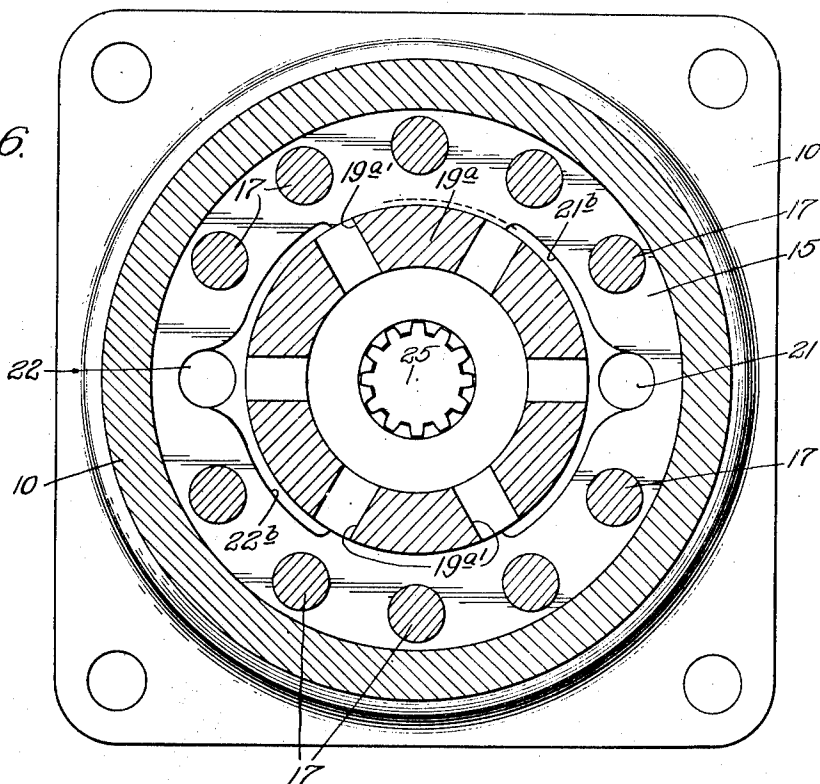


Fig. 7.

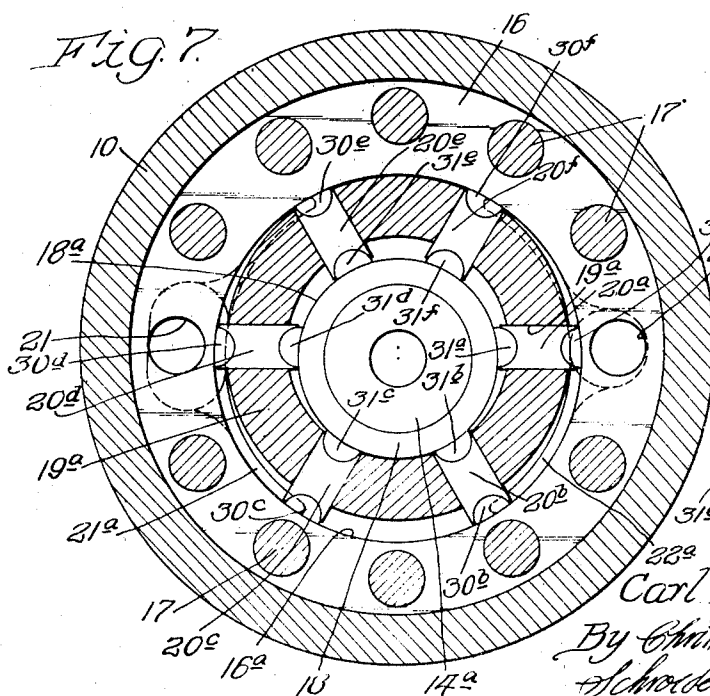
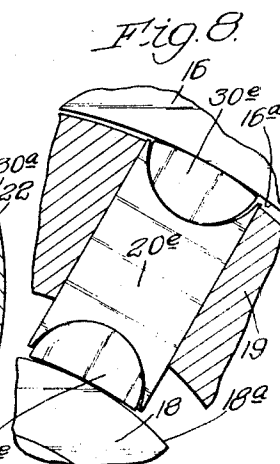


Fig. 8.



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UNITED STATES PATENT OFFICE

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ROTARY PUMP

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9 Claims. (Cl. 103—136)

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This invention relates to a rotary pump, and more particularly to a device of such character designed to develop exceptionally high outlet pressures.

One feature of this invention is that it provides a rotary pump capable of developing outlet pressure several times those of present commercial rotary pumps; another feature of this invention is that the pump will develop such pressures at widely varying rates of rotation; still another feature is that the various cooperating surfaces are so designed as to stand up, at high rates of rotation and high outlet pressures, without scoring or other damage; yet another feature is the provision of differential curvatures on cooperating surfaces to ensure the maintenance of a lubricating film between such surfaces; a further feature of this invention is the provision of a central floating ring operative to distribute bearing pressures over a larger area and to divide up viscous drag and relative lineal speeds; and still a further feature of this invention is the provision of a main bearing surface of the same diameter as the external diameter of the rotor, and concentric therewith. Other features and advantages of this invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a side elevational view of a pump particularly designed for aircraft use, and embodying my invention; Figure 2 is an end elevational view of such pump; Figure 3 is a longitudinal sectional view along the line 3—3 of Figure 1; Figure 4 is a longitudinal sectional view at right angles to that of Figure 3 along the line 4—4 of Figure 2; Figure 5 is a transverse view along the line 5—5 of Figure 4; Figure 6 is a transverse view along the line 6—6 of Figure 4; Figure 7 is a transverse view along the same plane as that of Figure 6 but looking in the opposite direction, along the line 7—7 of Figure 4; and Figure 8 is an enlarged fragmentary detail view illustrating a vane, its rockers, and portions of the associated members.

Rotary pumps have heretofore been considered to be restricted to the field of intermediate and low outlet pressures. Certain fields of use of rotary pumps, however, require high pressures, as for example in the hydraulic systems of aircraft. Such systems have heretofore usually operated at pressures in the neighborhood of a maximum of 600 pounds per square inch because of limitations imposed by the rotary pumps.

I have developed and am here disclosing and claiming an improved high pressure rotary pump, particularly designed for aircraft hydraulic sys-

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tems but capable of a number of other uses, wherein the pump is designed to operate at speeds ranging between 500 and 4,500 revolutions per minute at outlet pressures of 3,000 pounds per square inch. The particular pump here illustrated and described has been tested at 3,200 pounds per square inch, and is capable of developing even higher pressure.

While the device here illustrated is particularly designed as a pump, and the words "rotary pump" are used in the specification, it will be understood that such a device is inherently reversible. That is, when the shaft is supplied with mechanical power it operates as a fluid pump and delivers liquid under pressure; while if liquid under pressure is delivered to it, it operates as a motor and mechanical power may be taken off of its shaft. The identical device shown here, for example, may be used both as a pump to develop pressure and circulate liquid in the hydraulic system, and as a motor to use the fluid pressures thus developed to rotate a turret. As used in the claims, therefore, the word "fluid pressure device" is to be construed broadly enough to cover the device claimed whether as a pump delivering liquid under pressure or as a motor actuated by liquid under pressure.

In the particular embodiment of the invention illustrated herewith, a housing 10 is provided with caps 11 and 12 at each end thereof, with end plates 13 and 14 within and adjacent these caps. Between the end plates lie a cylindrical bearing sleeve 15 and an outer pumping chamber shell member 16. This whole assembly is locked together immovably by studs 17.

The end plate 14 has a projecting central stud portion 14a having a circular outer surface on which an annular ring 18 is freely rotatable. The pumping chamber shell member 16 has a circular inner surface 16a concentric with the circular outer surface 18a of the annular or ring member. Intermediate these concentric surfaces lies a rotor, here the rotor portion 19a of a rotor member also having a bearing portion 19b cooperating with the inner surface of the bearing sleeve 15.

In accordance with conventional practice, the axis of rotation of the rotor 19a is eccentric with respect to the center of the circular surfaces 16a and 18a, as may be best seen in Figure 7; and the rotor is radially slotted to receive radially reciprocable vanes 20. The pumping chamber used in this case is the crescent shaped chamber lying between the outer surface of the rotor 19a and the inner surface 16a of the shell 16. Cres-

cent shaped slots 21a and 21b lie adjacent the surface 16a and each side of the pumping chamber, each of these communicating with the inlet 21; and similar slots 22a and 22b communicate with the outlet 22. The inlet and outlet openings 21 and 22 in the end plate 14 communicate with inlet and outlet passageways 23 and 24 in the cap 12, to which appropriate pipe connections may be made. The inlet has an effective area always greater than the outlet so that the pump may deliver its full capacity at high pressure without drawing undesirable vacuum in the inlet. It will be understood, however, that the liquid available at the inlet is below atmospheric pressure in certain hydraulic systems.

Referring now more particularly to Figure 4, it will be seen that the rotor member is generally cylindrical, and that its two portions have coinciding outer surfaces. This is of considerable importance, in that it avoids the necessity of grinding right-angle corners between the rotor proper and the bearing portion. Such right-angle corners cannot be ground with the ultimate in precision, and accordingly provide a source of difficulty from leakage and seizure. In my pump the rotor member 19 is formed generally cylindrically and then the outer surface is precision machined, generally ground, to a very precise cylindrical surface, the radial slots 19a' thereafter being ground in the rotor portion. The result is that there is no right-angle corner adjacent the outer or pumping crescent; and any leakage from the pumping chamber is directly along the bearing surface between the bearing portion 19b and the inner surface of the bearing sleeve 15. In order to get the required eccentricity, the inner surface 16a is eccentric with the cooperating bearing surface between the rotor member and the sleeve 15. The right-angle corner machined or ground at the inner edge of the rotor is immaterial since the inner crescent is not used for pumping in the particular pump here being disclosed. In addition to having the bearing portion of the same external diameter as the rotor, it is desirable to have it of a length at least twice that of the rotor portion, preferably three or four times such length. The side thrust developed in the rotor at pumping pressures of 3,000 pounds per square inch or more are extremely high; and the additional length of the bearing portion prevents unduly high unit area bearing pressures.

The interior of the rotor member 19 is slotted to make splined connection with a drive shaft 25 which is also externally splined to make connection with a pulley, coupling, gear or other means for delivering the driving power to the pump. The shaft is provided with a shoulder portion 25a having a face rotatably bearing against the washer 26 in turn bearing against the gasket 27 held in place by the cap 11, the required co-operation between these parts being maintained at all times by the spring 28. In order to prevent leakage at this shaft seal, the chamber to the interior thereof communicates through the opening 14b in the center of the stud with the inlet of the pump, as may be best seen in Figure 3. This maintains the interior chamber of the rotor at inlet pressure, and causes any oil which works through the bearing surface to flow back to the inlet side of the pump. The particular pump here being disclosed is designed to pump oil and the liquid being pumped can, therefore, be utilized for lubrication.

The vanes 20 should be fairly wide as compared

with their length to withstand the stresses and shocks encountered during pumping, at least one-third and preferably about one-half as wide as they are long. Each vane has at each end thereof a depression or socket, in the form of a portion of a cylinder, the bottom of the socket being arcuate in one plane and straight in a plane at right angles thereto. Each such socket is designed to substantially entirely receive a rocker, these rockers having a shape somewhat similar to half a cylinder. The outer rockers are here identified as 30a—f, and the inner rockers as 31a—f. The inner arc or radius of curvature of each rocker very closely approaches, but is not quite the same as, that of the cooperating arcuate bottom surface of the socket in which it is received; and the outer faces of the rockers cooperating with the circular surfaces 16a and 18a have radii of curvature also very closely approaching, but not quite the same as, that of these surfaces. The radii must be close enough to each other that there is a broad area of contact, as distinguished from substantially a line contact which would tear up the cooperating surfaces under pressures of the kind handled by this pump. I have found, however, that a very slight divergence, causing a slight spacing between the cooperating surfaces at the edges of the rockers, enables them to pick up oil, particularly at a certain portion of the revolution as will be later described, and maintain a proper lubricating oil film. The differences in curvature should, of course, be such as to cause the rockers to contact the cooperating surfaces throughout a substantial area near their centers but to be slightly spaced near their edges.

I have found that the best results are obtained if the radii of curvature of cooperating surfaces differ by less than three per cent, preferably less than one per cent and more than one-tenth of a per cent. In a successful embodiment of my pump which has been built, the outer surface of the ring 18 has a radius of .580 inch, with the cooperating rocker surface having a radius of .584; the surface 16a has a radius of 1.060 inches, and the cooperating outer rocker surface a radius of 1.055; and the arcuate bottoms of the sockets at both ends of the vane have a radius of .1157 inch, with the cooperating inner curvature of the rockers being .1145 inch. These dimensions are representative, of course, and are plus or minus the allowed manufacturing tolerances, preferably less than one-thousandth of an inch.

Referring now more particularly to Figure 7, it will be seen that there are ten oil films across the diameter of the pump, at the outer and inner surfaces of each of the four rockers lying along a diameter, and between the ring 18 and the stud 14a. The most important requirement, of course, is to maintain a proper film on both sides of the rockers to permit good vane action and sealing. When the vane is at the position occupied by 20d, on the inlet side, any oil which has leaked into the inner space is being put under pressure and thus being forced between the rocker 31d, the ring, and the bottom of the inner vane socket, the vane being capable of ready outward movement to permit ingress of the oil at the inner end because of the very low pressure existing outside it at this time. This builds up a good oil film on both sides of the inner rocker to stand the terrific inward pressure shortly developed on the vane. A vane in the position occupied by vane 20b, for example, has 3,000 pounds per square inch driving oil between the surface 16a and the rocker

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30b and between the rocker and the outer socket and thus forcing the vane in with a very high force. It is during the movement of the vane from the position occupied by 20c to the position occupied by 20f that the greatest inward pressure is developed; and it is just ahead of this portion of the revolution that the inner rockers are supplied with a fresh film of oil of good thickness. The high pressures on the outside of the vanes during this portion of the revolution renew and increase the oil film in advance of the time when the centrifugal force creates the greatest outward pressures on the vanes on the intake side of the revolution. Picking up oil film when the vanes are in the positions occupied by 20a and 20d, moreover, is facilitated by the fact that there is one and one-half or two-thousandths of an inch greater clearance at this time than when the vanes are vertical (speaking with respect to the position of the parts as illustrated in Figure 7). This is occasioned by the fact that the vanes are directly lineal with respect to their cooperating circular surfaces when the vanes are vertical; but are offset somewhat, and therefore have greater clearance, when they are horizontal, since the center about which the vanes revolve is the center of the rotor eccentric to a slight extent with respect to that of the circular surfaces 16a and 18a.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. A rotary fluid pressure device of the character described, including: an outer member having a circular inner surface; an inner member having a circular outer surface concentric with said inner surface; a rotor intermediate said surfaces and eccentric with respect thereto, said rotor having radial slots therein; radially reciprocable vanes mounted in said slots; and rockers at each end of each vane, each rocker having one side bearing directly against one of said circular surfaces and the other side bearing directly against an end of the associated vane, the sides bearing against the circular surfaces being arcuate and having a radius of curvature very nearly but not quite the same as that of the associated surface each of said inner rockers having a radius of curvature slightly greater than that of the surface of the inner member against which they bear and each of said outer rockers having a radius of curvature slightly less than that of the surface of the outer member against which they bear so that the central portions only of said sides normally bear against said circular surfaces; said device being provided with inlet and outlet passages communicating with the space between said rotor and one of said surfaces.

2. A rotary fluid pressure device of the character described for developing high outlet pressures, including: an outer member having a circular inner surface; an inner member having a circular outer surface concentric with said inner surface; a rotor intermediate said surfaces and eccentric with respect thereto, said rotor having radial slots therein; radially reciprocable vanes mounted in said slots, each vane having an arcuate socket in each end thereof; and rockers at each end of each vane and at least partially received in said sockets, each rocker having an

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arcuate portion bearing directly against one of said circular surfaces and an arcuate portion bearing against the arcuate bottom surface of a socket, the radii of curvature of said portions being very nearly but not quite the same as that of the associated surface, each of said inner rockers having a radius of curvature slightly greater than that of the surface of the inner member against which they bear and each of said outer rockers having a radius of curvature slightly less than that of the surface of the outer member against which they bear so that the central part of each portion only normally bears against the associated surface; said device being provided with inlet and outlet passages communicating with the space between said rotor and one of said surfaces.

3. Apparatus of the character claimed in claim 2, wherein said radii differ by less than three per cent.

4. Apparatus of the character claimed in claim 2, wherein said radii differ by less than one per cent but more than one tenth of a per cent.

5. A rotary fluid pressure device of the character described for developing high outlet pressures, including: an outer member having a circular inner surface; an inner stud member; an annular member rotatable on said stud and having a circular outer surface concentric with said inner surface; a rotor intermediate said surfaces and eccentric with respect thereto, said rotor having radial slots therein; radially reciprocable vanes mounted in said slots, each vane having an arcuate socket in each end thereof; and a rocker at each end of each vane and each at least partially received in one of said sockets, each rocker having an arcuate portion bearing directly against one of said circular surfaces and an arcuate portion bearing against the arcuate bottom surface of a socket, the radii of curvature of said portions being very nearly but not quite the same as that of the associated surface, the innermost surface of each of said inner rockers having a radius of curvature slightly greater than that of the surface of the inner member against which they bear and the other surface of each of said inner rockers, and both the inner and outer surface of each of said outer rockers, all having a radius of curvature slightly less than that of the surfaces against which they bear so that the central part of each portion only normally bears against the associated surface; said device being provided with inlet and outlet passages communicating with the space between said rotor and one of said surfaces.

6. A rotary fluid pressure device of the character described for developing high outlet pressures, including: an outer member having a circular inner surface; an inner stud member; an annular member rotatable on said stud and having a circular outer surface concentric with said inner surface; a cylindrical rotor of substantial length, said rotor having a radially slotted end portion intermediate said surfaces and eccentric with respect thereto, the remainder comprising a bearing portion of the same external diameter as the slotted portion; bearing means receiving said bearing portion; radially reciprocable vanes mounted in the slots, each vane having an arcuate socket in each end thereof; and a rocker at each end of each vane and each at least partially received in one of said sockets, each rocker having an arcuate portion bearing directly against one of said circular surfaces and an arcuate portion bearing against the arcuate bot-

tom surface of a socket, the radii of curvature of said portions being very nearly but not quite the same as that of the associated surface, the innermost surface of each of said inner rockers having a radius of curvature slightly greater than that of the surface of the inner member against which they bear and the other surface of each of said inner rockers, and both the inner and outer surface of each of said outer rockers, all having a radius of curvature slightly less than that of the surfaces against which they bear so that the central part of each portion only normally bears against the associated surface; said device being provided with inlet and outlet passages communicating with the space between said rotor and one of said surfaces.

7. Apparatus of the character claimed in claim 6, wherein the bearing portion of the rotor has a length at least twice that of the slotted portion and said radii of curvature differ by less than one per cent but more than one tenth of a per cent.

8. Apparatus of the character claimed in claim 6, including a driving shaft operatively connected to the rotor and sealing means associated with the shaft in a chamber therearound, and wherein a passageway connects the interior of the chamber to the inlet of the fluid pressure device.

9. A rotary fluid pressure device of the character described for developing high outlet pressures, including: an outer member having a circular inner surface; an inner member having a circular outer surface concentric with said inner surface; a rotor intermediate said surfaces and eccentric with respect thereto, said rotor having radial slots therein; radially reciprocal vanes mounted in said slots, each vane having an arcuate socket in each end thereof; a rocker at the inner socket of each vane and at least partially received therein, each of said inner rockers having an arcuate portion bearing on the outer surface of said inner member and having a radius of curvature slightly greater than that of said

outer surface, and each of said inner rockers having an arcuate portion bearing against the said inner socket and having a radius of curvature slightly less than that of said socket; and a rocker at the outer socket of each vane and at least partially received therein, each of said outer rockers having an arcuate portion bearing on the inner surface of said outer member and having a radius of curvature slightly less than that of said inner surface, and each of said outer rockers having an arcuate portion bearing against the said outer socket and having a radius of curvature slightly less than that of said outer socket, said device being provided with inlet and outlet passages communicating with the space between said rotor and one of said surfaces.

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