Jan. 3, 1967 R. C. GRIFFITH 3,295,459

HYDRAULIC PUMPS

Original Filed April 4, 1963 3 Sheets-Sheet 1

FIG. 2.

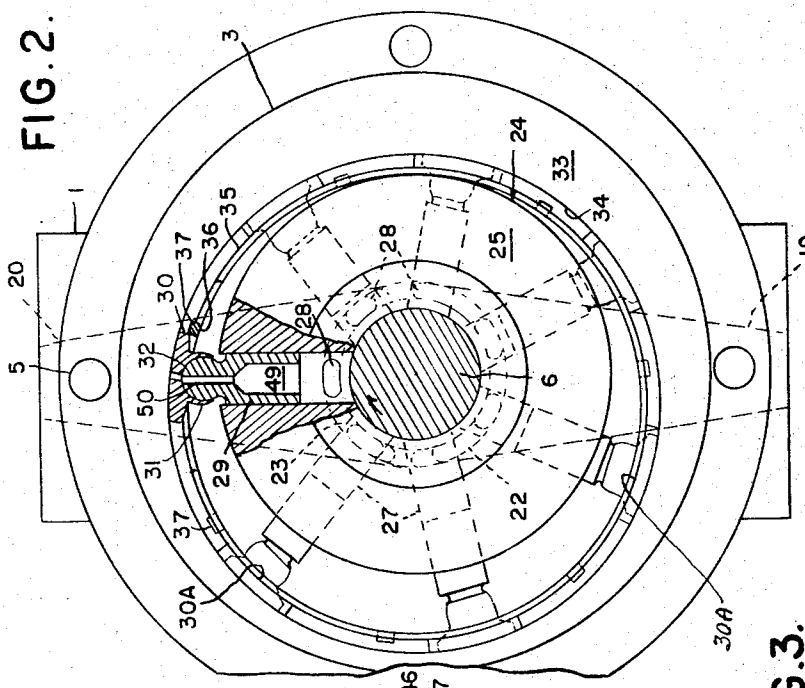


FIG. 3.

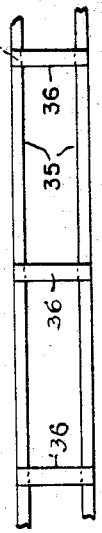
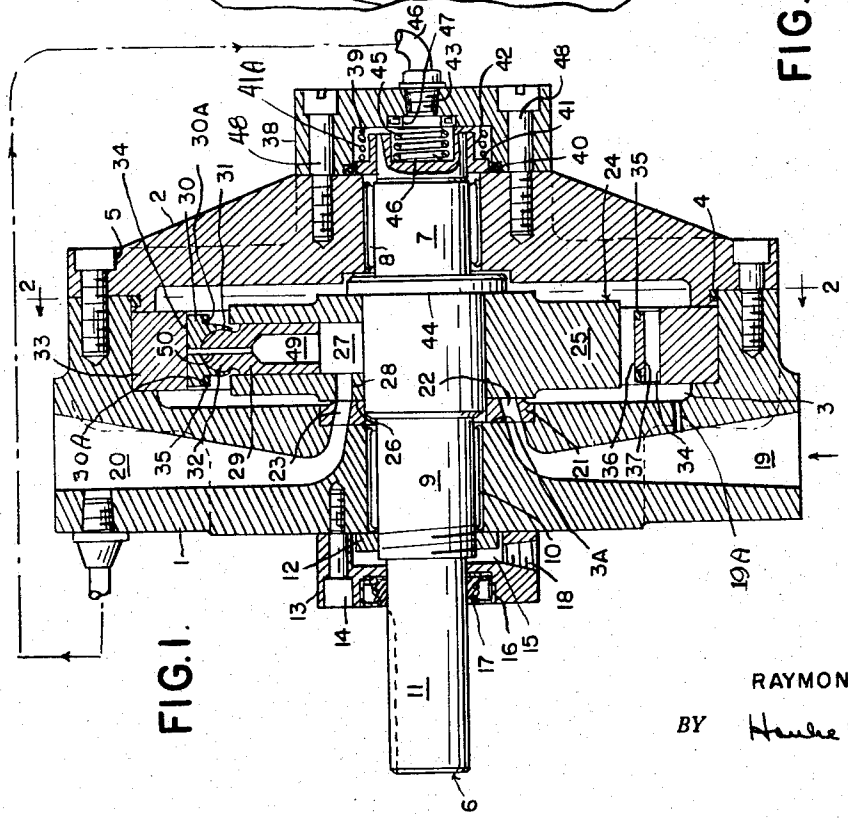


FIG. 1.



INVENTOR.
RAYMOND C. GRIFFITH

BY Hauke & Hauke

ATTORNEYS

Jan. 3, 1967 R. C. GRIFFITH 3,295,459

HYDRAULIC PUMPS

Original Filed April 4, 1963 3 Sheets-Sheet 2

FIG. 5.

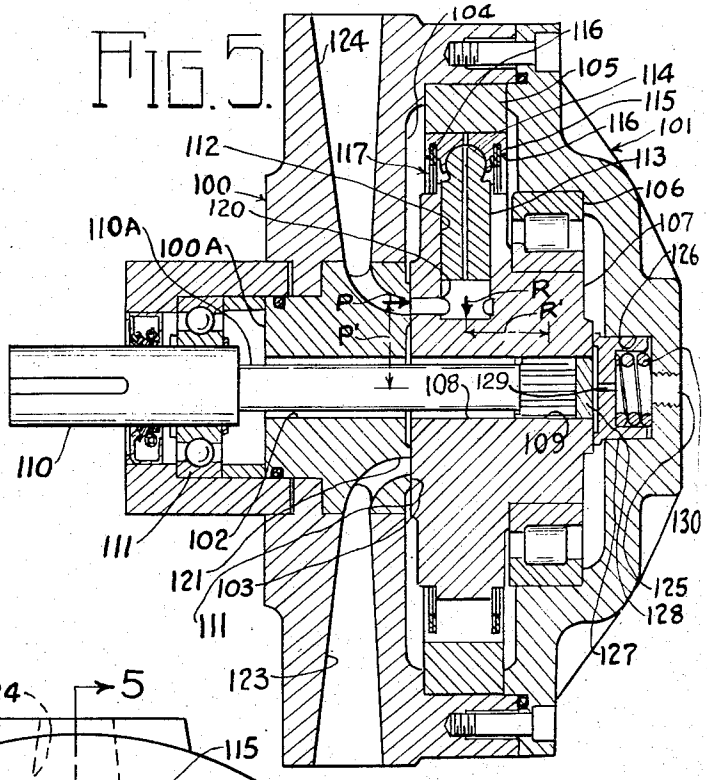


FIG. 6

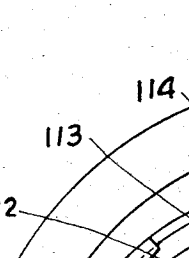


FIG. 4.

INVENTOR.
Raymond C. Griffith
BY
Hauke & Hauke
ATTORNEYS

Jan. 3, 1967 R. C. GRIFFITH 3,295,459

HYDRAULIC PUMPS

Original Filed April 4, 1963 3 Sheets-Sheet 3

FIG. 7.

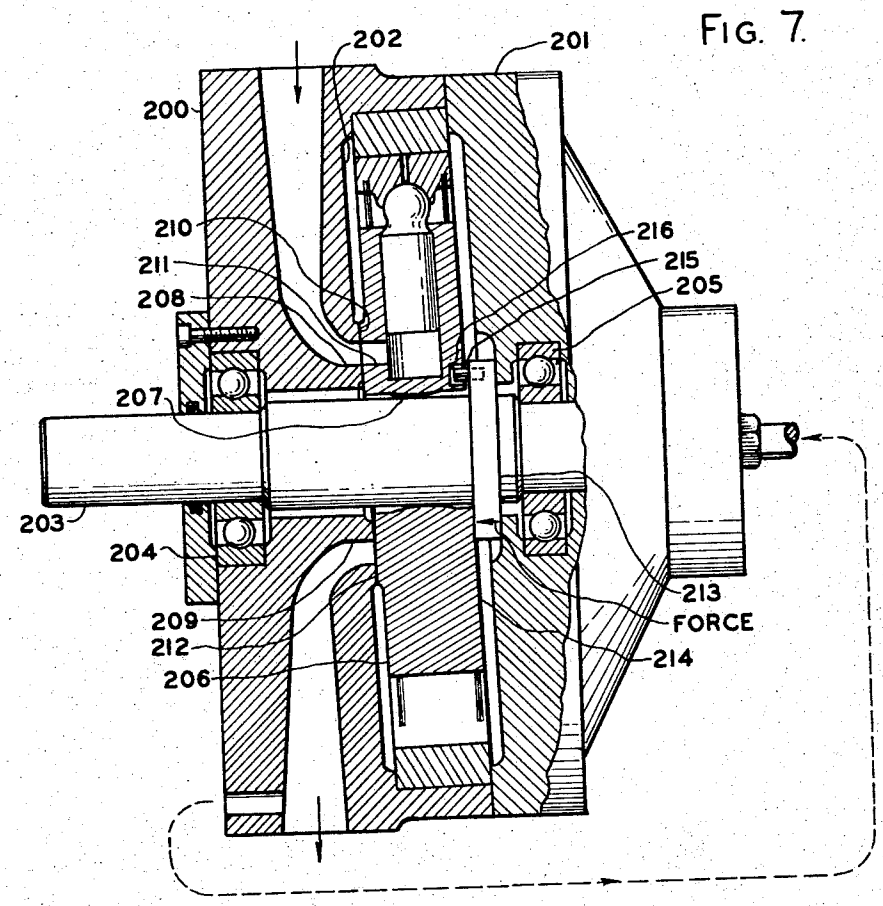
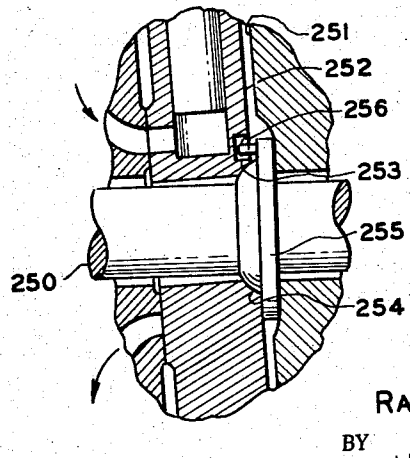


FIG. 8.



INVENTOR.
RAYMOND C. GRIFFITH

BY Hauke & Hauke

ATTORNEYS

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HYDRAULIC PUMPS

Raymond C. Griffith, 12683 Arnold St., Detroit, Mich. 48223

Original application Apr. 4, 1963, Ser. No. 271,050. Divided and this application Aug. 23, 1965, Ser. No. 493,299

6 Claims. (Cl. 103—161)

This application is a division of Ser. No. 271,050 filed April 4, 1963 now U.S. Patent No. 3,225,701, which in turn was a continuation-in-part of patent application Ser. No. 45,470, now abandoned.

This invention relates to fluid pumps, and more particularly to pumps of the radial piston type.

The present embodiment of the pump employs a chambered casing having a fixed valve face on a wall or side of the chamber, and formed with inlet and outlet ducts opening in said valve face. A rotatably driven shaft extends through the chamber and is concentrically connected to the shaft of a rotor operable in the chamber, the rotor carrying reciprocable pistons in radially extending cylinders.

Shoes carried at the outer ends of the pistons engage the annular peripheral surface of said chamber which has a cam ring disposed in eccentric relation to the shaft, whereby upon rotation of the rotor, the sliding travel of the shoes effects reciprocation of the pistons.

A valve face is formed on one side of the rotor and contacts face-to-face on the aforesaid fixed valve face. Ports extending from the piston cylinders open on the valve face of the rotor and alternately communicate with said intake and discharge ports of said casing. Such arrangement, as hereinafter explained, affords induction of fluid pressure through the discharge duct. The rotor in reaction to said pressure tends to shift axially and cause separation between the rotor valve face and the fixed valve plate.

The above pump arrangement or assembly generally is to be found in prior art such as the T. R. Almond Patents Nos. 580,838 and 622,318, the Egersdorfer Patent No. 1,506,893, the J. C. Naylor et al. Patent No. 2,525,498, and the F. A. Serman Patents Nos. 2,797,643 and 2,833,225.

The value in this type of pump is that it can be made inexpensively, is very durable, and theoretically should be able to produce high fluid flow and pressure.

However, the problem presented by the aforesaid separation between rotor face and valve plate has not been solved satisfactorily heretofore. Springs and other devices tending to hold the faces in contact either produce ununiform forces under varying discharge pressures or cause excessive wearing of the faces.

A further problem, which I have recently uncovered is that no rotor shaft can satisfactorily be made to withstand forces of deflection caused (1) by unbalanced piston reaction and (2) by unbalanced separating forces at the valve. The slightest, even immeasurable deflections, produced on the most accurately centered and completely supported rotor and shaft cause uneven wear on the valve faces, particularly at high pressures and speeds, and leakage results due to non-intimate contact of the valve faces, lowering pump efficiency. With two bearings, one at each side of the rotor, the bearings defect unevenly, with the same result.

Another problem encountered heretofore in radial piston pumps is the difficulty of maintaining the piston shoes in contact with the peripheral wall of the chamber under variable pressure conditions.

Retainer rings, such as those shown in the Ferris Patent No. 2,074,068, have been found unsatisfactory for various

reasons. For example, wearing of parts occurs, and retaining forces are difficult to balance.

An object of this invention then is to provide for transmission of pressure from the discharge duct to an end face of the shaft to oppose axial shift of the rotor and maintain contact with uniform frictional contact throughout said engaged faces.

Another object of the invention is to provide within the chamber annular means, substantially concentric with the drum and engaging with said shoes to maintain said shoes in sliding engagement upon the annular drum.

A further object of the invention is to eliminate the problems of the aforementioned valve face separation by providing a new supporting means for the rotor so arranged that various innate forces operate to cancel each other's deflection causing tendencies.

These and various other objects are attained by the construction hereinafter explained and illustrated in the accompanying drawings wherein

FIG. 1 is a sectional elevation of a preferred pump taken on the rotational axis of the shaft.

FIG. 2 is a view in partial section on the line 2—2 of FIG. 1.

FIG. 3 is a fragmentary plan view of a part in the pump, namely, a preferred means for maintaining the shoes in contact with the peripheral wall of the chamber.

FIG. 4 is an end view, partially in section and with one end removed for clarity, of another preferred embodiment of the pump.

FIG. 5 is a cross section taken substantially on the line 5—5 of FIG. 4.

FIG. 6 is a perspecive view of a retaining ring utilized with the pump of FIGS. 4–5.

FIG. 7 is a longitudinal cross-sectional view of another embodiment of the invention, and

FIG. 8 is a fragmentary cross-sectional view of still another modification of the invention.

Referring to FIGS. 1–3, the reference character 1 designates a stator casing preferably having a cover plate 2 with which it jointly forms an annular chamber or stator recess 3 and retains a fluid seal 4. Screws 5, or the like, secure said cover plate to the casing.

A rotatably driven shaft 6 extends axially through the chamber, and has an end portion 7 journaling in needle bearings 8 provided in the cover plate. The opposite end portion 9 of the shaft 6 extends through the casing and journals in needle bearings 10 provided therein. The end portion 9 is provided with an extension 11 projecting from the casing to receive a drive connection (not shown). A nut 12 threads upon the end portion 9 to restrain the shaft to limited axial motion.

The extension 11 passes through a cap 13 secured to the casing by any means such as screws 14. A recess 15 in said cap accommodates the nut 12, while an oppositely formed recess 16 retains a fluid seal 17 which embraces said extension 11. In order to drain fluid which may reach the recess 15, the cap 13 is provided with a pipe tapped hole 18 to receive an appropriately threaded drain connection (not shown).

The stator casing is formed with an intake duct 19 leading from the exterior of the casing to the end wall 3A of the chamber or recess 3. A discharge duct 20 opens into said wall 3A of the chamber 3 in similar form and leads to the exterior of the casing. A valve plate 21 is non-rotatably recessed into said wall of the chamber. Said plate overlies the wall 3A and has elongated arcuate apertures 22 and 23 as indicated in FIG. 2, and which connect respectively with inlet and outlet passages 19 and 20.

The chamber 3 houses a fluid pumping mechanism, including a cylindrical rotor element 25 rigidly mounted

upon the shaft 6 for rotation by said shaft. Said rotor element 25 is formed with a valve face 26 rotatably contacting the fixed valve plate 21. Said rotor 25 is further formed with a plurality of angularly spaced radially elongated cylinder bores 27, from which lateral passages 28 open upon said valve face 26.

Pistons 29 are reciprocably operable in the bores 27, and at their outer ends carry shoes 30. Such shoes are swivelly attached to the pistons and in the particular construction herein illustrated are formed with spherically socketed shanks 31 affording a ball-joint connection 32 with said pistons. An annular insert or ring 33 is concentrically fixed in the chamber 3, and its inner annular surface provides a cam surface 34 on which the shoes 30 ride. The rotor 25 is eccentric with respect to said cam surface 34 of the stator casing 1, and the shoes 30 ride on the guide as the cylinder block 25 rotates.

To ensure constant contact of the shoes 30 against the cam surface 34, a pair of axially spaced annular rings 35 straddle the shoes, engaging with shoulders 30A provided on the underside of said shoes as shown in FIGS. 1 and 2, to locate the shoes 30 with respect to the cam surface 34. To prevent dislodgment of the rings, elongated bars 36 extend between and rigidly interconnect the rings. Said ring and bar assembly loosely floats in the stator recess 3 and is supported solely by said shoes 30, practically eliminating frictional wear and effectively balancing and distributing the retaining forces among the pistons. At least one of such bars 36 is constantly engaged by the leading edge of a shoe, so that the rings are rotated with the rotor. The bars are preferably provided with outwardly protruding abutments 37, to assure contact with the leading edge of the shoe as shown in FIG. 2.

The end 7 of the shaft 6, which journals in the cover plate or closure 2, projects slightly through said closure and is enclosed by a cap 38 recessed as at 39 for such purpose. Such cap retains a fluid seal 40 which tightly encircles the flange 41 of a sleeve 42 inserted over the end of the shaft. The flange 41 has a close fit against the outer end face of the cover plate 2, and the cylindrical sleeve portion 42 is preferably made relatively thin. A compression spring 41A bears against flange 41.

The end of this drive shaft is preferably recessed as at 46A and a spring 45 seats therein and bears against the cap 38, thus urging the shaft and rotor carried thereby axially so as to urge the end face of said rotor against the valve face of the insert valve plate 21.

It will be understood that pressure in the exhaust line 20 will vary depending on varying conditions in the system downstream of the pump. The spring tension of the spring 45 is substantially constant, and if constructed strong enough to urge the rotor into tight engagement with the valve face of plate 21 when pressure in the exhaust 20 is at a maximum, the pressure exerted thereby when the pressure in exhaust 20 is at a minimum is too much, thereby resulting in high frictional losses and undue wear of engaging faces of said rotor and valve plate. I therefore have a spring strong enough to operate satisfactorily under low or minimum pressures and arrange for connecting the recess in said cap 28 with the exhaust 20 so as to transfer exhaust pressure to recess 39. Any suitable means for connecting recess 39 to exhaust passage 20 may be utilized and one such means is herein illustrated, comprising a conduit or pipe 46 leading from said exhaust to the fitting 47. It may be further noted that the fluid pressure in recess 39 exerts a radial force against the sleeve 42 tending to close this relatively thin sleeve portion about the shaft and also a force axially against the flange 41.

Rotation of the rotor 25 results in reciprocation of the pistons 29 due to the travel of the shoes 30 on the eccentrically disposed cam surface 34 of the annular insert 33. The ports 28 in the rotor are alternatively communicable with the apertures 22 and 23 in the valve plate 21 and that reciprocation of said pistons is timed to induct fluid through the intake duct 19 and to expel it under pressure through the discharge duct 20.

The rotor, in reaction to such pressure tends to shift axially within the stator recess or chamber 3 against the pressure of spring 45, tending to separate the contacting faces of the rotor and end face of valve plate 21, thus reducing the effective operation and output of the pump.

The arrangement whereby the conducting means transmits discharge pressure to the end of the shaft, thus maintains the engagement of the rotor valve face upon the valve plate face 26. The transmission and application of said pressure in the manner described affords the advantage that it is uniformly effective over the full contacting areas of the rotor valve face and the face of the valve plate. The pressure is thus uniform through the operative range of the pump irrespective of variations of pressure in discharge passage 20.

Although the rotor 25 is preferably secured to the shaft by a shrink fit or otherwise fixed thereon, it is preferred to form a flange 44 on said shaft to guard against eventual slipping of the cylinder block axially of the shaft under the pressures discussed above.

The pressure transmitted to and directed upon the end of the shaft is generally adequate or sufficient to maintain the desired engagement of the faces of said rotor and valve plate 21. The spring 45 is preferably employed to react between said cap and the end of said shaft and to thereby act along with fluid pressure transmitted to said shaft and to maintain said valve faces in contact. When utilizing the spring 45, it is desirable to recess into the cap a needle bearing 47 upon which the spring may rotate. Screws 48 or other suitable means removably secure the cap 38 to said rotor cover plate 2.

Where the described pump is to be used in pumping a liquid which can serve as a lubricant, the pistons 29 may be formed with pockets 49. A lubricating passage 50 formed jointly in the ball connection 32 and the shoes 30 may then conduct such liquid to the cam surface to lubricate same.

A drain hole 19A is preferably provided to drain excess fluid from chamber 3 to the intake passage 19.

In FIGS. 4–6, a more improved pump construction is illustrated, in which a two-part casing 100, 101 is shown. In FIG. 4, the part 101 and elements carried thereby are removed for clarity. Part 100 has a central insert 100A provided with a bore 102 and an annular valve face 103. Part 100 is also recessed as at 104 to provide a pumping chamber, supporting on its periphery an eccentric cam ring 105.

Part 101 closes the recess 104 and carries a bearing 106 for rotatably supporting a rotor 107 having a central bore 108 splined as at 109 in the same radial plane as the bearing 106.

A drive shaft 110 is supported by a bearing 111 mounted on the part 100 as shown and has a reduced portion 110A extending through and radially spaced from the insert bore 102 and the rotor bore 108. The end of the portion 110A is splined to drivingly engage the rotor spline 109.

The side of the rotor 107 opposite the bearing 106 has a valve face 111 slideably contacting the insert valve face 103. The rotor has radial pumping chambers 112 in which reciprocate pistons 113 having spherical end portions 114 supporting shoes 115.

The shoes 115 slide on the eccentric cam ring 105 as the rotor 107 rotates, causing the pistons to reciprocate. The shoes 115 each have radial side slots 116 in which are engaged annular retainer rings 117, one of which is illustrated in FIG. 6 as comprising a flat spring coil. The rings 117 are radially compressible to enable them to be assembled to the shoes 115 and when so assembled they urge and hold the shoes 115 radially outwardly against the cam ring 105.

Ports 120 communicate the inner ends of the chambers 112 with the valve face 111, where they alternately register, as the rotor rotates, with arcuate inlet and outlet ports 121, 122 respectively, assuming the rotor to be moving clockwise as viewed in FIG. 4. The part 100 has intake and discharge passages 123, 124 as shown connecting with the ports 121, 122.

The rotor 107, being supported only by one bearing 106 on one side, is in effect a free floating rotor, subjected to the action of two forces. One force, designated by the arrow P, tends to separate the valve faces in the vicinity of the outlet ports 120 since fluid pressure produced by the piston is being discharged therethrough. This force P tends to deflect the rotor from its axis.

The other force, designated by the arrow R, is produced by the radial fluid pressure reaction of the pistons 113 on their pumping strokes, and since the bearing is on only one side, the force R tends to deflect the rotor in the opposite direction to force P.

The area of the rotor face subject to pressure can be analyzed to determine a center locus having an average force P^{ave}, which will be offset from the axis of the rotor a distance P^{d}. The forces produced by the pistons also have an average force R^{ave}, and the radial axes of the pistons lie on a common plane offset from the center plane of the bearing 106 by a distance R^{d}. The products $P^{ave} \times P^{d}$ and $R^{ave} \times R^{d}$ represent the moments of the two forces, and by proper choice of the axial offset of the bearing 106 these moments can be made equal so that the rotor will maintain a constant axis precisely normal to the valve face 103, even though the forces mentioned are individually unbalanced.

Of course, the rotor will have a tendency to move away from the valve face 103, the same as in the pump of FIG. 1, so pressure is admitted to the end of the casing part 101 through a port 125 as in the pump of FIG. 1, so pressure is admitted to the end of the casing part 101 through a port 125 as in the pump of FIG. 1.

The part 101 has a recess 126 carrying a thrust element 127 bearing on the side of the rotor 107 and the fluid pressure is admitted to the side of the rotor, the bore 108 being closed by a plug 128, by a port 129.

The area between element 127 and the rotor subjected to fluid pressure preferably is about 5% less than the outer end area of the element 127, which in turn is about 5% more than the total effective area of the rotor valve face 111 subjected to fluid pressure.

A spring 130 acts to urge the valve faces together on starting, when fluid pressure is low.

FIG. 7 illustrates another method of counterbalancing the valve separating forces, in which a two-part casing 200, 201 has a chamber 202 which is slightly inclined with respect to a shaft 203 supported at both ends by bearings 204, 205. A rotor 206 rotatable in the chamber 202 has a central bore wiht an annular boss 207 spheroidal in cross-section as shown so that the rotor is in effect free-floating. Casing valve ports 208, 209 open to an inclined side wall 210 of the chamber 202 for alternate registry with rotor ports 211 opening to one side face 212 of the rotor 206. In this modification, the lower port 209 is the pressure port.

The shaft 203 has a flange 213 which engages the side face 214 of the rotor opposite the valve face 212. Fluid pressure is directed to the right-hand end of the shaft, but this pressure will be transmitted to the rotor as an unbalanced force, due to the inclination of the casing valve side wall 210 against which the rotor is urged, the unbalanced force having a moment with respect to its axis equal and opposite to the moment of the valve face separating pressure with respect to its axis. The rotor 206 is driven from the flange 213 by a means such as a pin 215 engaged in a slot 216 in the rotor 206.

In FIG. 8, a further modification is shown in a fragmentary view in which the shaft 250 is inclined with respect to the chamber 251 as in FIG. 7, but the rotor 252 has a spheroidal annular seat 253 engaged on a spheroidal annular shoulder 254 of the flange 255 from which the rotor 252 is driven by a pin 256. Function and unbalanced forces will be the same here as in the modification of FIG. 7.

Although I have described but several embodiments of the invention, it will be apparent to those skilled in the art to which my invention pertains that various changes and modifications may be made therein without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. A fluid pump comprising a stator casing structure, a power shaft supported by said stator casing structure, a rotor secured on said shaft, said stator casing structure provided with a chamber having an annular peripheral cam surface eccentric to the shaft axis, said rotor having a plurality of angularly spaced radially extending fluid pumping instrumentalities, each comprising a pump chamber and a pump plunger reciprocatingly supported by said rotor in said pump chamber, and a shoe movably carried on the outer end of the pump plunger and constructed to slidably contact the eccentric cam surface of said stator casing structure, fluid intake and exhaust means for said pumping instrumentalities, and a free floating annular shoe retaining ring assembly disposed concentric with respect to the annular peripheral cam surface of the stator casing chamber and engaged with said shoes to retain same in position for operable contact with said cam surface and to restrain said shoes from rotary displacement about the pump plunger axis, said ring assembly being rotatable with respect to said rotor and to said stator casing structure, said free floating annular shoe retaining ring assembly comprising a pair of axially spaced annular rings engaging the radially inner sides of said shoes, and means fixing said rings in said spaced relation with respect to each other, said means fixing said rings in spaced relation comprising cross members secured to both rings and which extend intermediate adjacent shoes, one or more of said cross members being engaged by a shoe to effect rotation of said retaining ring asembly with said rotor.

2. A fluid pump comprising a stator casing structure, a power shaft supported by said stator casing structure, a rotor secured on said shaft, said stator casing structure provided with a chamber having an annular peripheral cam surface eccentric to the shaft axis, said rotor having a plurality of angularly spaced radially extending fluid pumping instrumentalities, each comprising a pump chamber and a pump plunger reciprocatingly supported by said rotor in said pump chamber, and a shoe movably carried on the outer end of the pump plunger and constructed to slidably contact the eccentric cam surface of said stator casing structure, fluid intake and exhaust means for said pumping instrumentalities, and a free floating annular shoe retaining ring assembly disposed concentric with respect to the annular peripheral cam surface of the stator casing chamber and engaged with said shoes to retain same in position for operable contact with said cam surface and to restrain said shoes from rotary displacement about the pump plunger axis, said ring assembly being rotatable with respect to said rotor and to said stator casing structure, said annular retaining ring assembly comprising a pair of concentric rings disposed concentric with and radially spaced inwardly of the cam surface of said stator casing structure, and axially spaced to straddle said shoes, and angularly spaced cross member abutments secured to said rings and extending intermediate said adjacent shoes.

3. A fluid pump as set forth and described in claim 2 wherein said cross member abutments are provided with portions projected radially outwardly of the external circumferential surface of said rings whereby to provide for positive engagement with the leading edge of said shoes.

4. In a fluid pump of the type having a rotor peripherally encircled by an annular cam surface eccentric with re-

spect to the rotor axis and radially actuable pistons carried by the rotor, a retainer structure comprising

(a) shoe elements carried by said pistons and slidably engaging said cam surface,

(b) an annular shoe retaining ring assembly disposed concentric with and inwardly spaced from said cam surface and slidably engaged with said shoes, said shoes being disposed between the ring assembly and the cam surface,

(c) said shoes and retaining ring assembly having means coacting to support said ring assembly solely by said shoes against radial and axial disengagement therefrom,

(d) said means comprising grooves disposed in said shoes in a common plane disposed normal to the rotor axis, and said ring assembly comprising a pair of flat spring coils each having a pair of circumferentially spaced end portions and an intermediate portion which axially spaces said end portions whereby said ring assembly is radially compressible and engages in said grooves at a radially expanded position.

5. In a fluid pump of the type having a rotor peripherally encircled by an annular cam surface eccentric with respect to the rotor axis and radially actuable pistons carried by the rotor, a retainer structure comprising

(a) shoe elements carried by said pistons and slidably engaging said cam surface,

(b) an annular shoe retaining ring assembly disposed concentric with and inwardly spaced from said cam surface and slidably engaged with said shoes, said shoes being disposed between the ring assembly and the cam surface,

(c) said shoes and retaining ring assembly having means coacting to support said ring assembly solely by said shoes against radial and axial disengagement therefrom,

(d) said ring assembly comprising a pair of concentric rings disposed concentric with and radially spaced inwardly of said cam surface and axially spaced to straddle said shoe elements, and angularly spaced cross members extending between said rings.

6. The fluid pump as defined in claim **5** and in which said cross members extend intermediate adjacent shoe elements with one or more of said cross members being engaged by a shoe element to effect rotation of said ring assembly.

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MARK NEWMAN, *Primary Examiner.*

R. M. VARGO, *Assistant Examiner.*