Oct. 10, 1950 J. C. NAYLOR ET AL 2,525,498

RADIAL PUMP OR HYDRAULIC MOTOR

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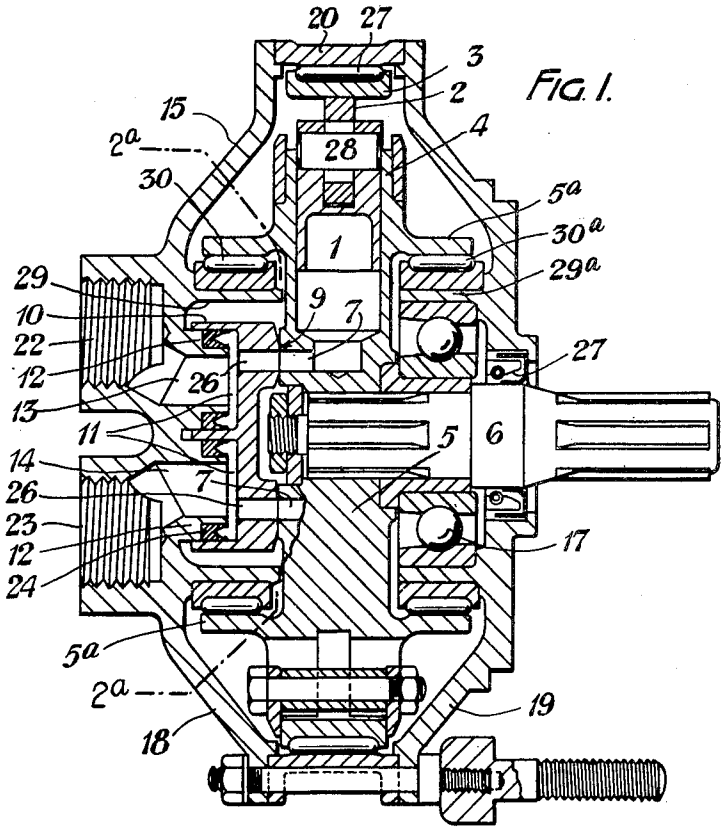


FIG. 1.

FIG. 3.

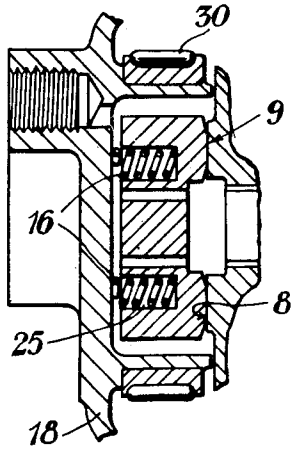
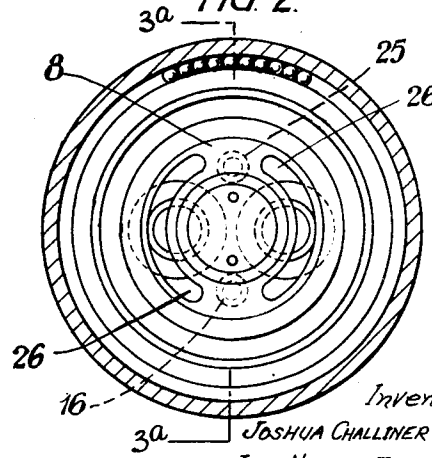


FIG. 2.



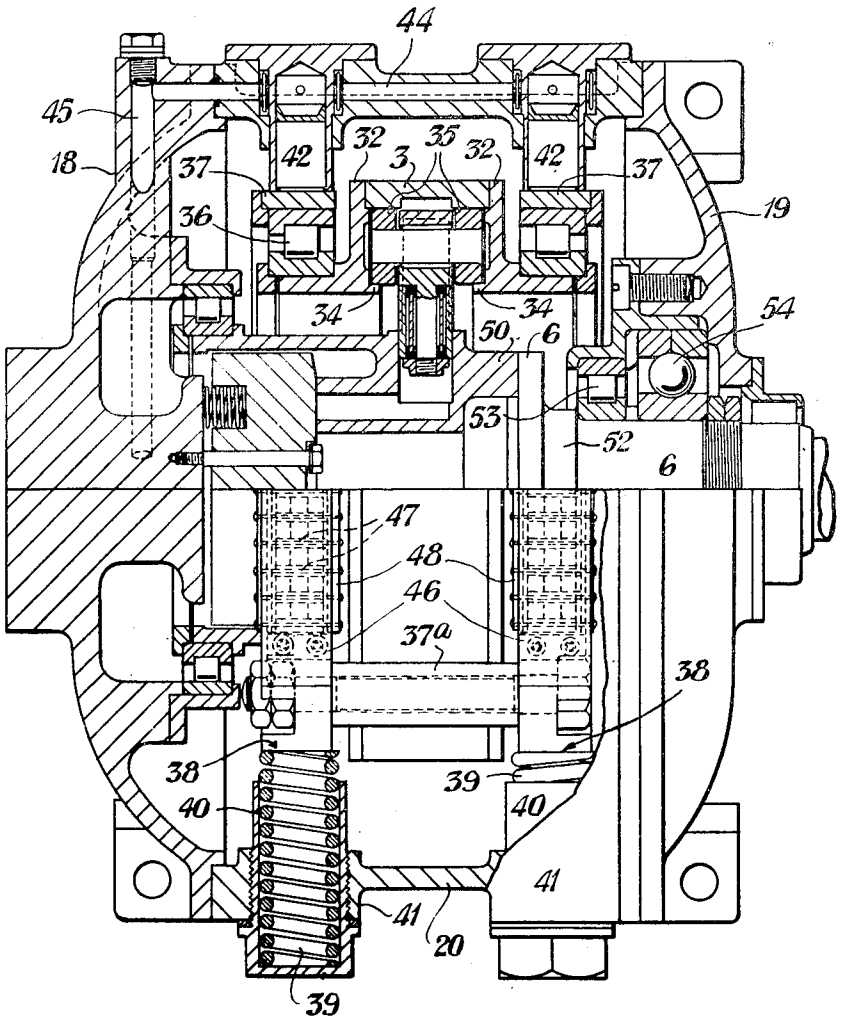
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RADIAL PUMP OR HYDRAULIC MOTOR

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FIG. 4.



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RADIAL PUMP OR HYDRAULIC MOTOR

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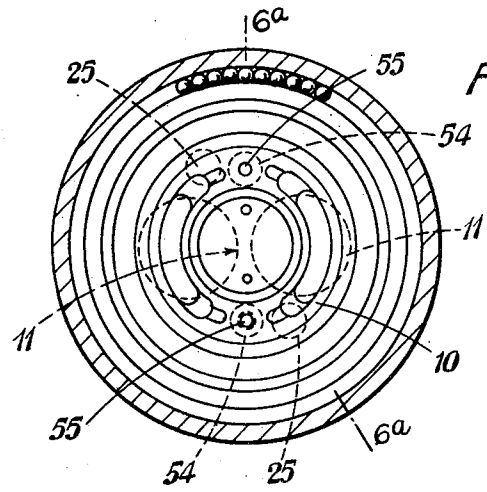


FIG. 5.

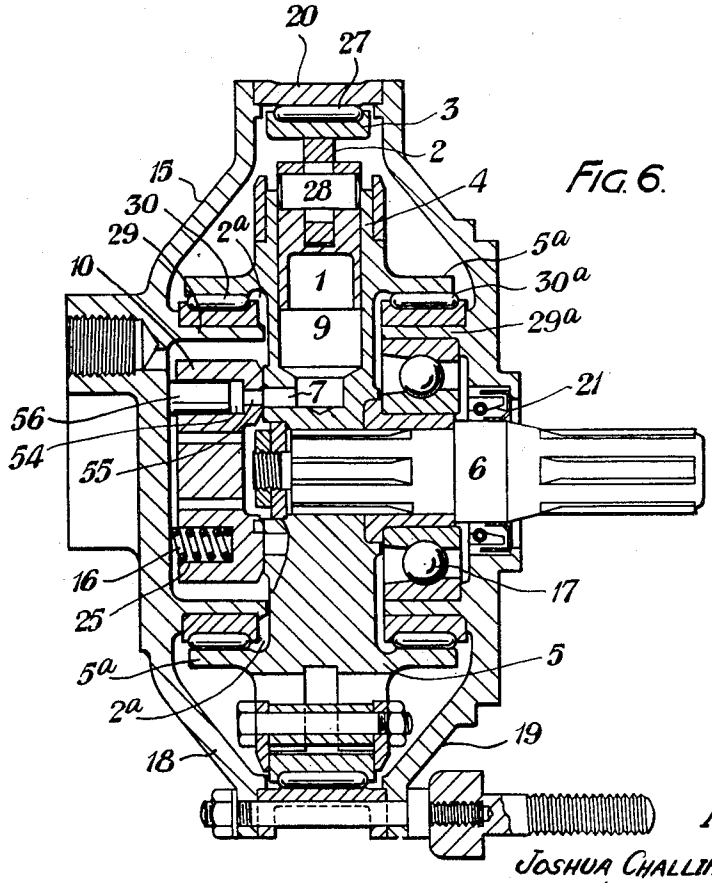


FIG. 6.

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RADIAL PUMP OR HYDRAULIC MOTOR

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FIG. 7.

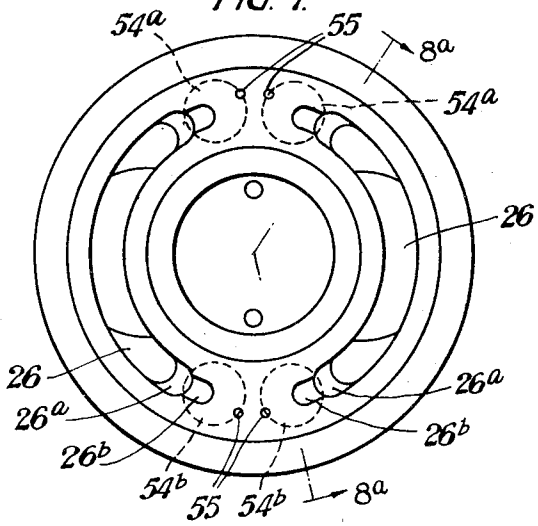


FIG. 8.

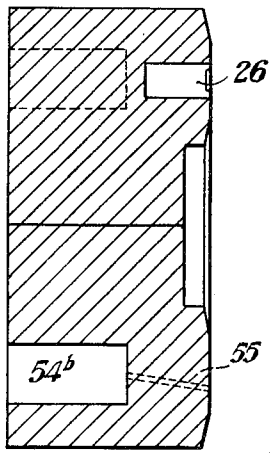


FIG. 9.

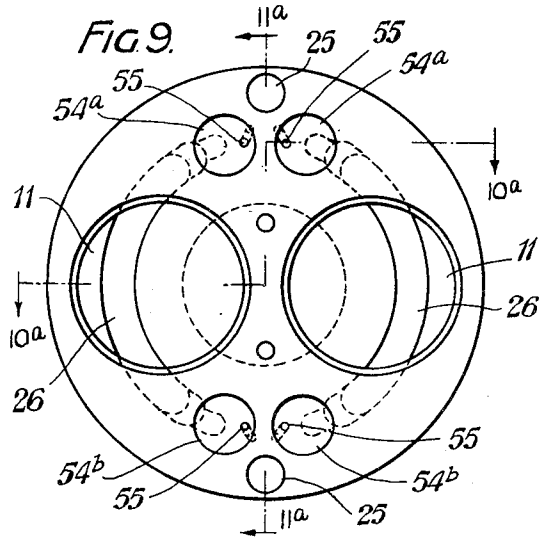


FIG. 11.

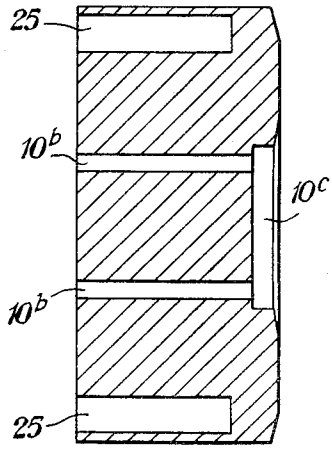
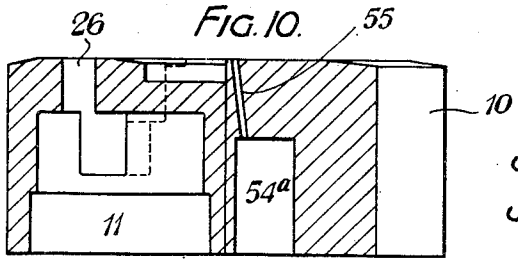


FIG. 10.



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RADIAL PUMP OR HYDRAULIC MOTOR

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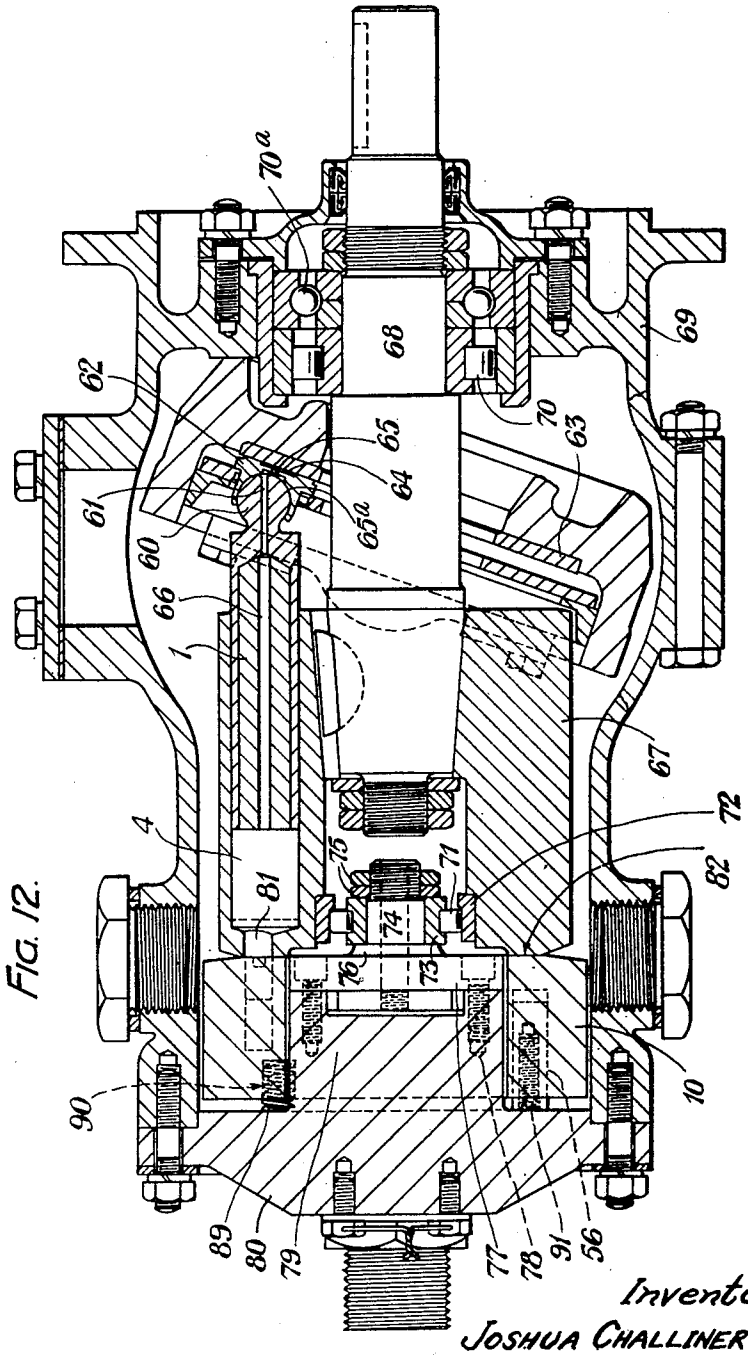


FIG. 12.

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RADIAL PUMP OR HYDRAULIC MOTOR

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FIG. 14.

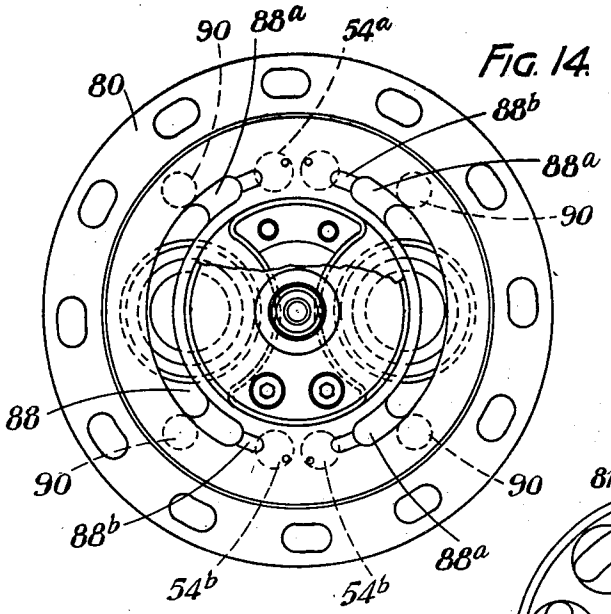


FIG. 15.

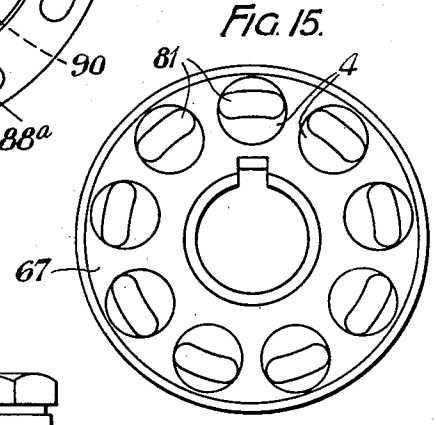
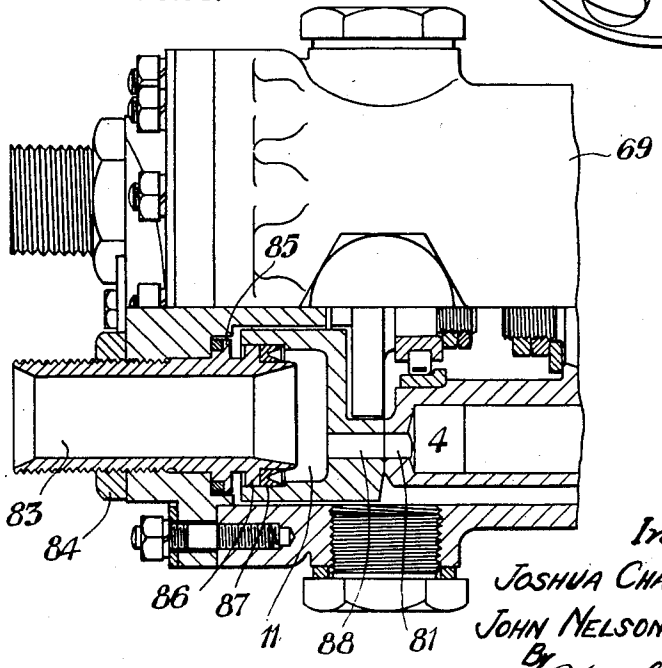


FIG. 13.



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Patented Oct. 10, 1950 2,525,498

UNITED STATES PATENT OFFICE

2,525,498

RADIAL PUMP OR HYDRAULIC MOTOR

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Application February 26, 1946, Serial No. 650,322
In Great Britain August 15, 1944

Section 1, Public Law 690, August 8, 1946
Patent expires August 15, 1964

6 Claims. (Cl. 103—161)

1

This invention relates to reciprocating pumps or hydraulic motors of the type in which the set of cylinders is carried by the driven or driving shaft, e. g. according to whether the appliance is a pump or motor, the pistons being reciprocated in the case of a radial type by reason of their engagement with a ring permanently displaced or adjustably displaceable eccentrically in relation to the said cylinders, or, in the case of an axial type of pump or motor, by reason of their connection with the inclined or tiltable plate, so that the invention is applicable to constant or variable stroke pumps or motors of the radial or axial type.

The chief object of this invention is to obtain a hydraulically balanced self-sealing and self-adjusting distributing valve for controlling the inlet and outlet and which automatically takes up for mechanical adjustments, wear and changes in oil viscosity.

Another object of the present invention is to provide improved means for preventing leakage due to running clearances, oil viscosity and temperature expansion changes such as, e. g. which takes place with diametrical or pintle type valves. The present invention also contemplates achieving a simplified and light construction of pump or motor capable of high speed and yet of minimum dimensions.

The present invention is broadly characterised in that ports in the cylinder assembly are brought successively into registration with ports formed in a valve member concentric with the axis of rotation of the shaft, such valve member having sealed sliding contact, with supporting means embodying the inlet and outlet ports of the pump or motor, means resiliently urging the said valve member in sealing engagement with the appropriate ported parts of the assembly of cylinders.

In order that the invention may be clearly understood and readily carried into effect, drawings are appended hereto illustrating embodiments thereof, and wherein

Figure 1 is a sectional side elevation view showing one form of the invention applied to a radial pump.

Figure 2 is a section on the line 2*a*—2*a* of Figure 1.

Figure 3 is a section on the line 3*a*—3*a* of Figure 2.

Figure 4 is a part sectional side elevation view showing one form of the invention applied to an automatic variable delivery pump.

Figure 5 is an inner face elevation view of the valve member showing the incorporation therewith of supplementary loading means to take care of the asymmetrical arrangement of the number of cylinders under pressure at once.

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Figure 6 is a section on the line 6*a*—6*a* of Figure 5.

Figure 7 is an inner face view of the valve showing a modification of the said supplementary loading means.

Figure 8 is a section on the line 8*a*—8*a* of Figure 7.

Figure 9 is a rear elevation of Figure 7.

Figure 10 is a section on the line 10*a*—10*a* of Figure 9.

Figure 11 is a section on the line 11*a*—11*a* of Figure 9.

Figure 12 is a sectional side elevation view showing the invention applied to an axial type of pump.

Figure 13 is a broken half-sectional plan view of the valve end of the pump shown in Figure 12.

Figure 14 is an end elevation view taken from Figure 12 of the inner or seating face of the valve with the housing removed from its end plate adjacent the valve end.

Figure 15 is an end elevation view looking along the cylinders of the cylinder block of the pump shown in Figure 12.

In carrying the present invention into practice, the pistons 1 can carry rollers 2, or if desired, slippers for engaging with the concentrically displaced or displaceable track ring 3, and various means for adjusting the eccentricity of the said ring may be provided or it may be fixed as with a constant stroke pump or motor. Various forms of the pump or motor will be described hereinafter but features in common with various modifications hereinafter described with reference to Figures 1 to 11 inclusive are the provision of the cylinders 4 in a common block 5 fixed to the driving or driven shaft 6, ports 7 at the inner ends of the cylinders passing axially through the block and having termini in a common flat annular face 9, formed on the said block concentric with the shaft, such annular face having engaged in close running contact therewith an annular valve member bar 10 having two or more parallel axis cylindrical recesses 11 in the face remote from the cylinder block, such recesses 11 being slidable upon hollow bosses 12 constituting the inner termini of the inlet and outlet ports 13 and 14 respectively of the pump housing 15 and being so proportioned to the flat annular face to produce a hydraulically balanced pressure lubricated seal. Alternating with these bosses are coiled compression springs 16 which are accommodated

in recesses 25 in the valve body as hereinafter explained, and urge the valve member axially against the cylinder block 5 to maintain contact when hydraulic pressure is not available. In this latter connection a convenient disposition of the main bearing 17 for the shaft 6 is as shown in Figure 1, between the cylinder block 5 and the end wall of the housing remote from the wall containing the inlet and outlet ports 13 and 14, and such main bearings may also take the thrust of the said springs 16 and the hydraulic thrust of the valve member 10, the cylinder block 5 being splined upon or integral with the shaft 6.

In the embodiment shown in Figure 1 the invention is applied to a constant stroke pump or motor, the housing 15 comprising two dished or shallow truncated conical end plates 18 and 19, separated by a ring 20, and is disposed eccentrically with the axis of the shaft 6, such shaft has associated therewith suitable gland or sealing means 21 housed in the end plate 19. The opposite end plate 18 is formed externally with a pair of symmetrical hollow bosses 22 and 23 with their axes diametrically opposed in relation to the axis of the housing, the boss 22 being co-extensive with the inlet port 13 and the boss 23 being co-extensive with the outlet port 14, and both bosses being threaded inside to receive suitable coupling members. Integral with this said latter end plate and projecting axially and inwardly therefrom are the said pairs of hollow bosses 12 one communicating with the inlet 13 and the other with the outlet 14 aforesaid but with their axes closer together than the axes of said threaded bosses 22 and 23. As already indicated these inner bosses serve to support the floating valve member 10 which, as shown more clearly in Figures 1, 2 and 3 is in the form of a disc in one face of which the cylindrical recesses 11 are formed to slide over the said latter hollow bosses 12. The inner ends of these bosses 12 are reduced in diameter to support circumferentially disposed packings or U leathers 24 making sealing contact with the cylindrical recesses in the valve member. Fluid pressure acting in these recesses maintains the inner annular face 8 (i. e. the face shown in Figure 2) of the floating valve member in sealed contact with the annular face 9 of the cylinder block.

The coiled compression springs 16 are accommodated in cylindrical recesses 25 in the disc and abut at their outer ends against the inner face of the said bossed cover plate 18 whereby the valve disc is pressed initially axially against the annular surface 9 formed on the substantially cylindrical block 5. The opposed annular faces 8 and 9 of the said disc and the cylinder block are of polished surface finish to obtain good sealing contact.

Communication of the inlet 13 and outlet 14 of the housing with the cylinders is effected through the said hollow bosses 12 and through part annular or arcuate shaped ports 26 (see Figure 2) formed in the said disc, and each extending for about 120°, and through the ports 7 which are also of part annular form, one of which is formed at the inner end of each cylinder. By this arrangement, upon rotation of the cylinder block, each cylinder will communicate once every revolution with the inlet and outlet of the pump.

In the present described embodiment, it is preferred to support the track ring 3 in the housing by needle roller bearings 27 interposed between the track ring and the intermediate ring 20 of the housing, each roller 2 is supported upon a pin 28 passed diametrically through the outer end of the appropriate piston and has an axial dimension not greater than the bore of the appropriate cylinder. The rollers may be fitted with needle bearings and be of larger diameter than the piston bore to engage slots in the cylinder walls, thus keeping the rollers in correct relation to the track ring. By supporting the track ring in this manner, it is free to rotate with the piston and the rotation speed of the rollers carried by the pistons is reduced. The end plate 18 of the housing formed with the said hollow bosses is also formed with a concentric inwardly directed integral ring 29 which surrounds the valve and also serves to support a set of needle roller bearings 30 which, in common with another set of needle roller bearings 30*a* supported upon a like inwardly directed ring 29*a* integral with the other cover plate 19, afford support for the cylinder block and shaft, by reason of these two sets of needle roller bearings being engaged by outwardly directed integral symmetrical cylindrical parts 5*a* of the cylinder block 5.

When the invention is applied to an automatic variable delivery pump the track ring can be spring loaded in one direction against the influence of one or more hydraulic rams operating in the opposite direction. An example of such an arrangement is shown in Figure 4, in which the track ring 3 is supported between two angle section rings 32 which can have inwardly directed cylindrical steps 34 at their inner corners to engage the pairs of rollers 35 carried by pistons 1. The cylindrical parts of these angle section rings are supported by two sets of rollers or ball bearings 36 supported in two ring members 37 disposed at opposite sides of the track ring and formed at one part of their periphery with flats 38 against which engage two or more parallel axis coiled compression springs 39 housed in sleeves 40 screwed into bosses 41 formed in the centre ring 20 of the housing. Engaged at diametrically opposite points to said springs with flats on these two collars 37 are two or more parallel rams 42, slidable in cylinders 43 also fitted in the centre ring 20 of the housing. Pressure fluid is admitted to these latter cylinders by a passage 44 passing through the centre ring 20 of the housing parallel with its axis and communicating at one end with a passage 45 passing through the end plate 18 in a substantially radial direction and connecting with the pressure port of the housing.

The pair of ring members 37 which receive the pressure of the said coiled compression springs 39 and rams 42 are connected together by bolts 37*a* to form a unit and they are formed with parallel edges on their perimeters carrying machined plates 46 which slide upon rollers or needle roller bearings 47 engaging plates 48 fixed to webs formed on the centre ring 20 of the housing. By this means there is the minimum of friction opposing the sliding movement of the track ring, consequently there will be a very sensitive response to the track ring to variations in output pressure of the pump.

The cylinder block 5 can be driven by an axially directed annular protuberance 50 in positive engagement with a flange 51 formed on the inner end of the driving shaft 6, this flange being formed with a concentric reduced diameter portion 52 engaging the inner ring of a roller bearing

53 axially opposed to a ball bearing 54 adapted to take the thrust due to the loading on the said valve disc 10.

In the aforesaid form of valve the number of cylinders and their sequence of communication with inlet and outlet is such that the number of cylinders 4 under pressure alternates to produce an asymmetrical arrangement of cylnders in relation to a given diametrical plane through the cylinder block so that e. g. there is an alternation of the number of cylinders 4 under pressure e. g. four and three, or five and four, under pressure and suction respectively followed by a reversal of such relationship and so on, according to the total number of cylinders in the pump or motor. This produces variations in the pressure loading of the valve. Accordingly, as shown in Figures 5 to 11 inclusive, to overcome this variation of loading, means is provided within the valve to impose thereon a seating sealing load supplementary to the load due to the fluid pressure in the main cylinders under pressure and to change the point of application of such supplementary load automatically in a manner complementary to the aforesaid alteration and variation of position of the number of cylinders under pressure.

As already indicated the fluid pressure acting in the said cylindrical recesses 11 contributes towards the sealing pressure of the valve 10, against the cylinder block, but owing to the incidence of the alternating number of cylinders under pressure also their changing angular relation to the valve there is a widely varying loading condition of the film face 8 of the valve against the film face 9 of the cylinder block and in the present described embodiment of this invention this variation is overcome by providing in the valve 10, additional cylindrical recesses 54 subject to internal fluid pressure, these additional cylindrical recesses 54 in the valve being disposed at opposed points in the valve so that the appropriate one or more thereof only come into operation when the number of pump or motor cylinders under pressure increases and decreases.

These additional valve cylinders may be fitted with rams for convenience of construction and in one embodiment (see Figures 5 and 6) may comprise a diametrically opposed pair of cylinders 54, with their axes parallel with the valve axes. Feed holes 55 are drilled through the film face of the valve 10, into the supplementary cylindrical recesses 54 to convey the requisite proportion of pressure fluid from the appropriate cylinder ports into the additional cylindrical recesses of the valve, it being understood that the additional cylindrical recesses are, as with the main cylindrical recesses, 11, located in the side of the valve remote from the cylinder block engaging face and if desired they may receive bosses in the opposed part of the pump housing in the same manner as for the main cylindrical recesses but for convenienece of construction plungers 56 can be located in the addition recesses to obtain the necessary effective pressure therein.

The diameter of the additional cylinders is appreciably less than the diameter of the aforesaid cylindrical recesses, and the said feed holes 55 need be no larger than bleed holes. Such feed holes must be positioned accurately to coincide with the change over position from the lesser to the greater number of cylinders under pressure.

Greater efficiency is obtained if, as shown in Figures 7 to 11 inclusive, these cylindrical recesses are arranged as two diametrically opposed pairs

54*a* and 54*b*. With only two additional cylindrical recesses the change of load occurs at each half piston position i. e. loading conditions change at a frequency of twice the number of pistons per revolution, whilst with four additional cylindrical recesses loading conditions are also more regularly distributed over the faces of the valve and cylinder block, this latter arrangement affording more uniform conditions in the maintenance of axial pressure upon the valve.

These additional cylindrical recesses are interposed between and symmetrically related to the main cylindrical recesses 11, and the spring receiving recesses 25 are interposed between the additional recesses.

In Figures 12 to 15 inclusive my invention as shown applied to an axial type of pump in which the ends of the pistons 1 remote from the cylinders 4 are formed with ball heads 60 which seat snugly in part-spherical seating 61 in cylindrical or other suitably shaped slippers 62 having annular bases formed with film surfaces making sliding contact with the opposed surface of an annular track member 63 in an inclined plate in well-known manner. Each said film surface of the slippers is formed with a shallow concentric recess 64 in the centre of which is a small aperture 65 communicating with an axial bore 66 in the appropriate piston, this bore extending through the piston so as to be exposed to the working pressure of the hydraulic fluid in the appropriate cylinders 4.

The area of the concentric recess 64 is smaller than the piston area so as to maintain a balance of between the piston and the inclined plate. The area of the annular portion of each slipper 62 in contact with the annular member 63 of the inclined plate is so proportional in relation to the cross section of the piston as to give hydraulic balance and to be self sealing.

To maintain continuity of communication between the said recess in each slipper and the bore in the appropriate piston, the said aperture 65 of the slipper which communicates with the bore is enlarged in diameter as at 65*a* where it enters the part spherical seating in the slipper so that relative angular movement between the slipper and piston is taken care of whilst maintaining a constant communication between the running face of the slipper and the inclined plate.

The cylinders 4 are formed in an annular barrel 67 mounted on a shaft 68 supported at one end in a casing 69 by roller bearings 70, additional support being afforded by roller bearings 71, which are afforded a slight axial displacement relatively to their outer ring 72 and are carried by a centre ring 73 fixed on a spigot 74 between nuts 75 threaded on such spigot, and a boss 76 carrying the spigot 74 and integral with a disc 77 fixed by screws 78 to a concentric boss 79 of an end cover plate 80. Endwise positioning and thrust are taken care of by ball bearings 70*a*.

The ports 81 at the appropriate ends of the cylinders 4 extend axially through the barrel and terminate in a common flat annular face 82 formed on the barrel for engaging with the valve 10. As in the aforesaid described embodiments, the annular valve member 10 has two or more parallel axis cylindrical recesses 11 in the face remote from the cylindrical barrel, such recesses being slidable upon the inner flanged ends 86 of a pair of inlet and outlet tubes 83 secured in the pump housing by nuts 84 co-operating with abutments 85, so that the recesses 11 and their

associated bosses etc. serve as hydraulic rams which when under pressure actuate in opposition to the loading on the valve face produced by the pistons.

The said hollow tubes **83** have disposed circumferentially about their inner ends packings or U leathers **87** making sealing contact with cylindrical recesses in the valve member, constituting hydraulic rams and being so proportioned to the flat annular face of the valve which opposes the annular face **82** of the cylinder barrel as to produce a hydraulically balanced pressure lubricated seal.

Alternating with the inlet and outlet tubes **83** are two pairs of coiled compression springs **89** accommodated in recesses **90** in the valve body **10** and abut against the adjacent end plate **80** of the housing **69** whereby the valve is pressed initially axially against the annular film surface formed on the annular barrel containing the cylinders.

As in the embodiment described with reference to Figures 7 to 11 two diametrically opposed pairs of additional cylindrical recesses **54***a* and **54***b* are provided in the rear part of the valve **10** to obtain a supplementary sealing load, these recesses receiving plungers **56** to abut against the end plate **80**. Holes **91** are threaded axially into the plungers to facilitate removal of the plungers. Bleed holes **55** communicate with the recesses **54***a* and **54***b* to receive pressure fluid from the cylinders **4**.

Communication of the inlet and outlet ports with the cylinders is effected through the said hollow bosses and through part annular or arcuately shaped ports formed in the valve, the ports in the cylinder barrel being likewise shaped. By this arrangement, upon rotation of the cylinder block, each cylinder will communicate once every revolution with the inlet and outlet of the pump.

It will also be appreciated that the invention may also be applied to pumps or motors having an elliptical track for reciprocating the pistons giving two strokes per revolution. Pressure relief holes **10***b* are formed axially along the valve and communicating at one end with a concentric recess **10***c* in the inner face of the valve, the other ends thereof communicating freely with the space inside the pump housing.

In order to obtain a lead and also a gradual cut-off in the supply of pressure fluid to the ports **26** or **88**, the ends of such part annular ports are merged by tapers **26***a* and **88***a* respectively into relatively narrow and much shorter shallow-channelled extensions **26***b* and **88***b* respectively comprising the termini of such ports.

We claim:

1. In a pump or hydraulic motor of the multiple cylinder type, a ported member, the ports of which communicate with the cylinders of the pump or motor, a valve member opposed to and having sliding contact with said ported member, such valve member and said ported member having opposed contacting smooth flat surfaces which permanently contact to produce a sealed sliding contact between the valve member and said ported member, inlet and outlet ports in said valve member which are brought successively into alignment or registration with the ports in the said ported member during operation of the pump or motor, sealed sliding joints with inlet and outlet passages in the pump housing and with which the ports in the valve member communicate means to utilize the reaction of the pressure fluid passing through the ports of said ported member to apply a load to the valve member to effect the aforesaid sealing contact of the valve member with the said ported member, means loading the valve against the said ported member to effect an initial sealing contact of the valve member with the ports leading to the working chambers or the ported member during starting up or idling stages of the pump or motor, and means to counteract the variation of loading of the valve due to asymmetrical arrangement of the cylinders and comprising recesses in the valve member adapted to be brought into communication with the ports connected to the working chambers or in the said ported member in such manner that any bias or pressure upon the valve member due to the asymmetrical arrangement of the cylinders under load is counter-balanced by the admission of supplementary fluid pressure to such recesses, said recesses including means for converting the fluid pressure received therein into substantially axial pressure between the valve and the said ports connected to the working chamber or between the valve and the said ported member.

2. A pump or motor according to claim 1 wherein the said recesses are supplementary cylinders in the valve and contain plungers displaceable axially relatively to the valve by reason of the said fluid pressure and cooperating with a non-displaceable abutment in the pump or motor housing.

3. A pump according to claim 1 wherein said supplementary cylinders alternate with the ports in the valve member.

4. A pump or motor according to claim 1 wherein said supplementary cylinders alternate singly with the said port in the valve.

5. A pump or motor according to claim 1 wherein said supplementary cylinders are arranged as a plurality between successive ports in the valve member.

6. A pump or motor according to claim 1 wherein the said supplementary cylinders are disposed as two diametrically opposed pairs and each pair is interposed between the ports in the valve.

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