

March 26, 1946.

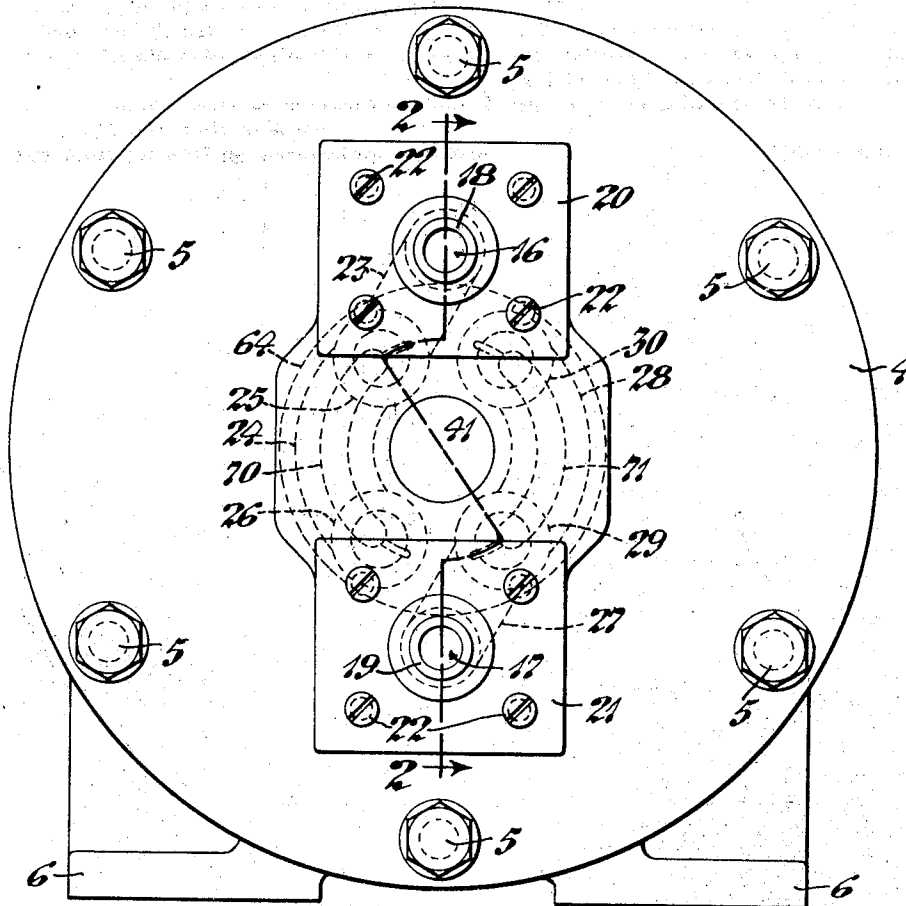
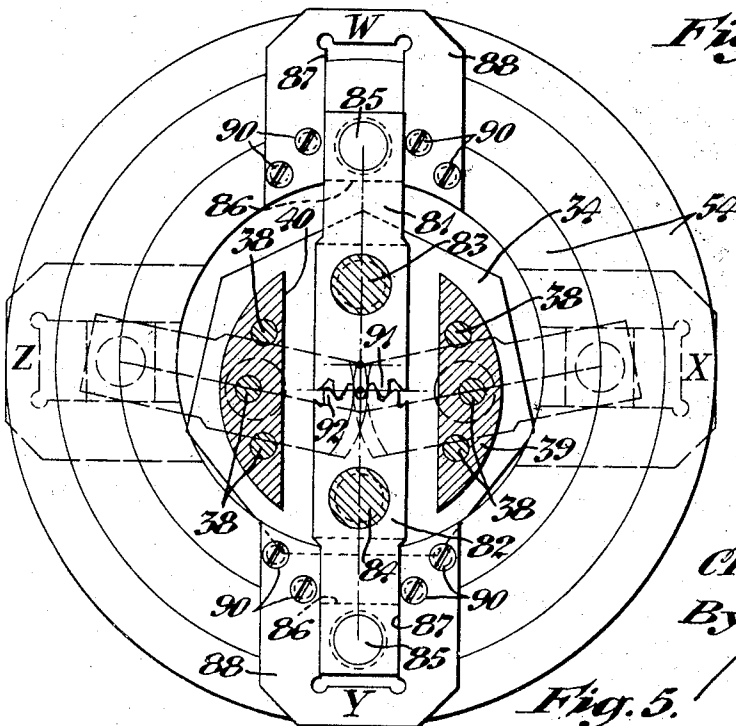
C. E. GROSSER

2,397,314

PUMP OR MOTOR UNIT

Filed Aug. 26, 1943

3 Sheets-Sheet 1



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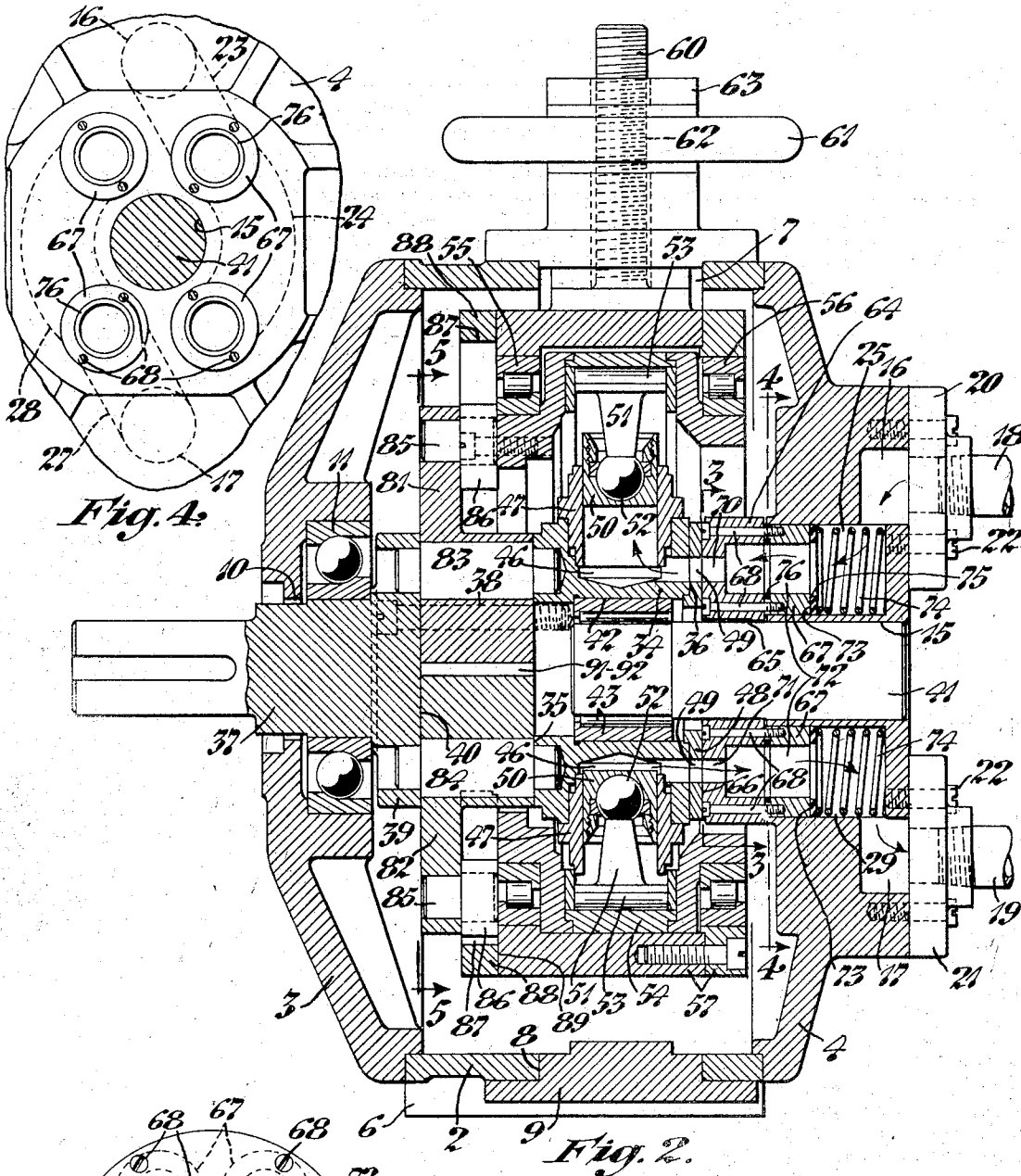
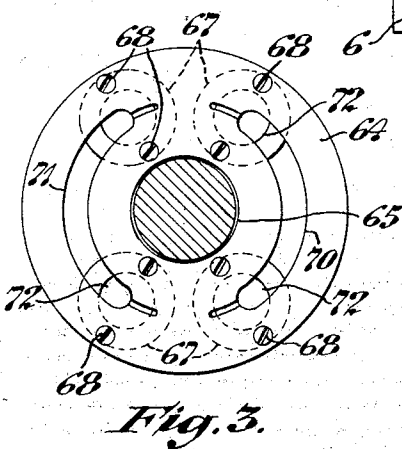
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PUMP OR MOTOR UNIT

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3 Sheets-Sheet 2



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PUMP OR MOTOR UNIT

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3 Sheets-Sheet 3

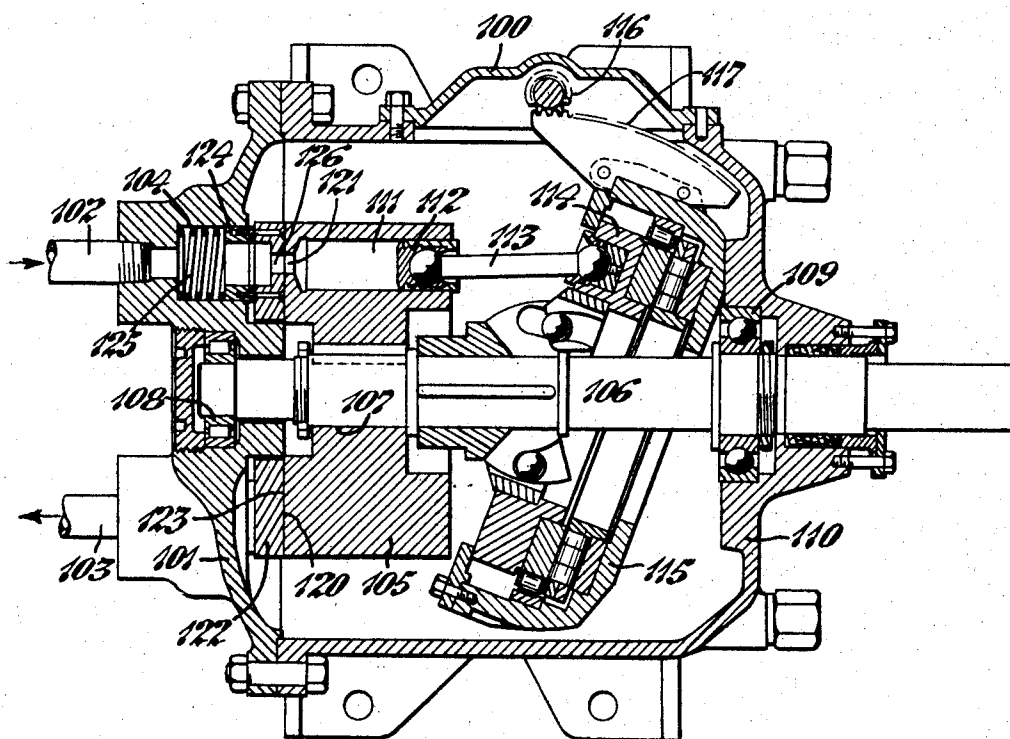


Fig. 6.

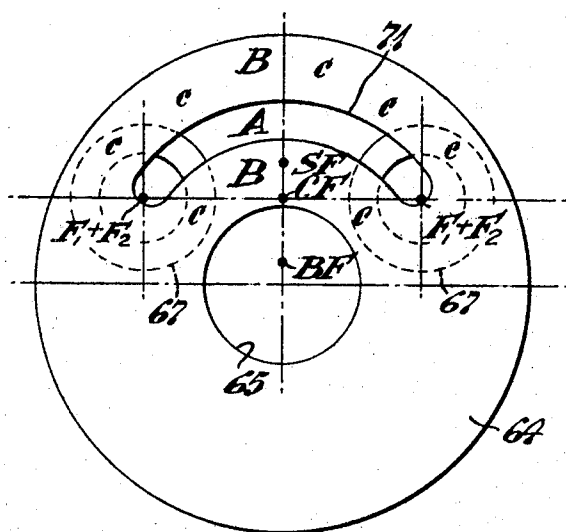


Fig. 7.

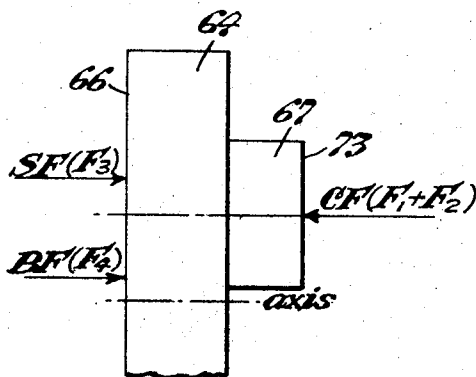


Fig. 8.

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UNITED STATES PATENT OFFICE

2,397,314

PUMP OR MOTOR UNIT

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Application August 26, 1943, Serial No. 500,046

6 Claims. (Cl. 103—161)

The present invention relates to improvements in hydraulic pump or motor units of the type illustrated and described in my copending application for United States Letters Patent entitled Pump or motor unit, Serial No. 462,939, filed October 22, 1942, now Patent No. 2,381,741 dated August 7, 1945.

One of the objects of the present invention is to provide a pump or motor unit of the type indicated with improved valve-means for controlling the inlet and exhaust of motive fluid to and from the cylinders.

Another object is to provide a pump or motor unit of the type indicated in which the rotor is supported at each end for rotation in its casing and the flow of the motive fluid is controlled by a floating valve-plate yieldingly engaging a valve-face at one end of the rotor.

Another object is to provide a pump or motor unit of the type indicated in which the valve-plate yieldingly engages the valve-face at the end of the rotor with a contact pressure proportional to the pressure of the motive fluid and slightly in excess of the force tending to separate the plate from the face.

Another object is to provide a pump or motor unit of the type indicated having an annular valve-plate surrounding a supporting spindle for the rotor and provided with a face on one side engageable with the valve-face on the rotor and a plurality of piston-plugs on its opposite side extending into the inlet and outlet ports in the casing.

Another object is to provide a coupling for connecting the rotor and reaction-ring of a radial type pump or motor unit for rotation about eccentric axes.

Another object is to provide a coupling of the type indicated comprising a pair of arms connecting the rotor and ring and adapted to rock to compensate for the relative movement of the rotor and ring during their rotation about eccentric axes.

Another object is to provide a pump or motor unit of the type indicated which is of simple and compact construction, efficient in performing its intended functions and adapted for use over long periods of time without requiring repair or replacement of its parts.

Further objects of the improvement are set forth in the following specification which describes the invention as applied to several forms of pump or motor units, by way of example, as illustrated by the accompanying drawings.

In the drawings:

Fig. 1 is an end view of a radial type pump or motor unit incorporating the novel features of the present invention;

Fig. 2 is a sectional view on line 2—2 of Fig. 1 showing the rotor supported at each end for rotation in the casing and the valve-means surrounding the supporting spindle at one end of the rotor and cooperating with the valve-face thereon;

Fig. 3 is a transverse part-sectional detail view on line 3—3 of Fig. 2 showing the annular valve-plate having ports therein which cooperate with the ports in the valve-face at the end of the rotor;

Fig. 4 is a transverse part-sectional detail view on line 4—4 of Fig. 2 showing the hollow piston-plugs on the valve-plate which extend into the inlet and outlet ports in the end wall of the casing;

Fig. 5 is a transverse part-sectional view taken on line 5—5 of Fig. 2 showing the coupling for connecting the rotor and reaction-ring for rotation about eccentric axes;

Fig. 6 is a longitudinal sectional view of an axial type pump or motor unit incorporating the novel valve-means of the present invention;

Fig. 7 is an enlarged elevational view of the face of the annular valve-plate turned 90° from the position shown in Fig. 1 and indicating the application and distribution of forces applied thereto; and

Fig. 8 is a fragmentary edge view of the valve-plate further indicating the application and distribution of the forces.

In the hydraulic pump or motor unit illustrated and described in my prior copending application, referred to above, the rotor has a valve-face at one end which cooperates with a valve-face on the casing. The rotor is mounted for longitudinal movement and piston-plugs at one end thereof cooperate with the casing to yieldingly maintain the valve-face at its opposite end in contact with the valve-face on the interior of the casing. Pump or motor units having this type of construction operate quite satisfactorily, but the rotor must be loosely mounted on its supporting shaft which consequently permits undesirable movement and vibrations in certain operating conditions.

The present invention relates generally to a pump or motor unit of either the radial or axial type embodying a valve-face at one end thereof. The rotor is supported at its opposite ends for rotation about a fixed axis and is positively held against axial movement. The support at the

valve-face end of the rotor may comprise a continuation of the rotor-shaft or it may be in the form of an axial stud mounted in the casing and extending into a bearing at the axis of the valve-face. With either a rotating shaft or stationary stud, hereinafter referred to as a spindle, the rotor will be supported at both ends for rotation about a fixed axis. An annular valve-plate surrounds the spindle and has a planar face at one side for cooperation with the corresponding valve-face at the end of the rotor, being also provided with hollow piston-plugs at its opposite side which extend into the inlet and outlet ports in the casing. The valve-plate has ports in its face communicating with the hollow piston-plugs for controlling the inlet and exhaust of the motive fluid to and from the cylinders. The pressure of the motive fluid acts on the ends of the plugs to maintain the valve-plate engaged against the valve-face at the end of the rotor with a force proportional to and slightly in excess of the force tending to separate the plate from the face of the rotor. Another feature of the present improvement in the pump or motor unit resides in the construction of the coupling for connecting the rotor and reaction ring in a radial type unit while permitting displacement of corresponding points on the two elements during their rotation about eccentric axes.

Referring to Figs. 1 to 5 of the drawings, the present invention is shown as applied to a radial type hydraulic pump or motor unit comprising a casing having an annular enclosing section 2 with disk-like end walls 3 and 4. The annular section 2 and end walls 3 and 4 are held in assembled relationship by horizontal bolts 5, see Fig. 1, extending through the section and end walls. The casing section 2 may have feet 6 for supporting the unit and openings 7 and 8 at its top and bottom, the opening 8 being closed by a drain-plug 9. An axial bore 10 provided in the end wall 3 is counterbored to support an anti-friction bearing 11 for the axial shaft of the rotor, to be later described, see Fig. 2.

The end wall 4 is provided with an axial bore 15 and inlet and outlet ports 16 and 17. Conduit pipes 18 and 19 communicating with the inlet and outlet ports 16 and 17, respectively, are connected to apertured plates 20 and 21. The plates 20 and 21 are attached to the outer face of the end wall 4 by means of screws 22 with the ends of the conduit pipes 18 and 19 screwed thereinto in alignment with the ports 16 and 17 to admit and exhaust motive fluid to and from the ports. As shown in Fig. 1, the port 16 has branches 23 and 24 which communicate with longitudinal bores 25 and 26 extending to the inside face of the end wall 4, see also Fig. 2. The port 17 is similar to the port 16 having branches 27 and 28 which communicate with bores 29 and 30. For purposes of illustration the ports 16 and 17 are shown in the drawings as in the plane of the section on line 2-2 of Fig. 1, but it will be understood that in the units as manufactured the port 16 will be positioned between the bores 25 and 26 while the port 17 will be positioned between the bores 29 and 30.

The rotor or cylinder-block 34 is in the form of a polygonal prism, see Fig. 5, with generally flat, parallel faces 35 and 36 at its opposite ends. An axial shaft 37 projects from the end face 35 of the rotor 34, being fastened thereto by screws 38 extending through a radial flange 39 on the shaft. The shaft 37 is journaled for rotation in the anti-friction bearing 11 in the end wall

3 of the casing with its end projecting there-through. As shown in Fig. 5, the flange 39 on the shaft 37 is provided with a transverse slot 40 for a purpose explained hereinafter. The end of the rotor 34 opposite from the shaft 37 is also supported at its axis either by a shaft rotatable therewith and journaled in the end wall 4 of the casing or by a stud fixed to the casing and extending into a bearing in the end of the rotor. Such support for the end 36 of the rotor 34, whether in the form of a rotatable shaft or a fixed stud, is hereinafter referred to as the spindle 41. In the embodiment of the invention illustrated in Figs. 1 to 5, the spindle 41 is in the form of a stud fixedly mounted at one end in the axial bore 15, previously referred to, in the end wall 4 of the casing and extending into an axial bore 42 in the end 36 of the rotor 34. The rotor 34 is supported for rotation on the reduced end of the spindle 41 by means of an anti-friction roller-bearing 43 positioned in the bore 42 of the rotor, see Fig. 2. Thus, the rotor 34 is supported at each end for rotation in the casing and due to the form of the bearings 11 and 43 it is held against axial movement in either direction.

The rotor 34 has a series of radial bores 46 intersecting its flat polygonal faces, see Fig. 2, with lining sleeves 47 welded or otherwise secured therein, the plurality of sleeves constituting the radial cylinders of the unit. An annular face-plate 48 of bronze or other suitable metal is fixedly attached to the end 36 of the rotor by brazing or welding, the face-plate being provided with a series of ports 49, one for each cylinder, arranged in equally spaced relationship. Each port 49 extends through the face-plate 48 and the end of the rotor 34 to communicate with its respective cylinder 47. Reciprocably mounted in the cylinders 47 is a series of pistons 50 connected to piston-rods 51 of the type illustrated and described in my prior application referred to above. Each piston-rod 51 has a ball and socket connection 52 with its piston 50 and a rocker bearing plate 53 at its opposite or outer end for engagement with the interior face of a reaction-ring 54 surrounding the rotor 34.

The reaction-ring 54 is mounted to rotate with-in roller-bearings 55 and 56 supported in a slidable carriage 57, the ring and carriage being of channel shape in cross-section and arranged in nested relationship as shown in Fig. 2. The carriage 57 is mounted to slide vertically in the casing section 2 to adjust the eccentricity of the axis of the ring 54 with respect to the axis of the rotor 34. For this purpose the carriage 57 has flat sides which slide in suitable guideways, not herein shown, in the casing-section 2 and the carriage is provided with a threaded stem 60 projecting through the opening 7 at the top of the casing-section. A handwheel 61 has a threaded bore 62 in engagement with the threaded stem 60 whereby it will cooperate with a bracket 63 on the casing section 2 to adapt the carriage for vertical adjustment with respect to the rotor 34.

In accordance with the present invention a valve-plate 64 is provided for cooperation with the face-plate 48 at the end 36 of the rotor 34. As shown most clearly in Fig. 3, the valve-plate 64 is of annular form having an axial bore 65 through which the spindle 41 extends. Preferably, the bore 65 in the valve-plate 64 is of a diameter slightly larger than that of the spindle 41, providing a clearance therebetween to permit a slight freedom of the valve-plate on the spindle. The valve-plate 64 has a face 66 at one side for

cooperation with the face-plate 48 of the rotor 34 and a plurality of hollow or tubular piston-plugs 67 on its opposite side which project into the bores 25, 26, 29 and 30 in the end wall 4 of the casing. The piston-plugs 67 may be attached to the valve-plate 64 in any suitable manner and, as herein illustrated, they are fastened in place by means of screws 68 extending through the plate with their ends screwed into the plugs, the heads of the screws being seated in countersunk holes. The piston-plugs 67 are located on the valve-plate 64 in alignment with the bores 25, 26, 29 and 30 in the end wall 4 of the casing 2 and are of such dimensions as to provide a close fit therein. The valve-plate 64 also is provided with arcuate ports 70 and 71, see Fig. 3, for cooperation with the ports 49 in the face-plate 48 at the end of the rotor. The port 70 communicates with the openings 72 in the hollow piston-plugs 67 projecting into the bores 25 and 26 in the end wall 4 of the casing while the port 71 communicates with the openings 72 in the hollow piston-plugs projecting into the bores 29 and 30 in the end wall of the casing. Thus, each piston-plug 67 has an annular end face 73 subjected to the pressure of the motive fluid supplied to or discharged from the ports 16 and 17. Helical springs 74 pocketed in the bores 25, 26, 29 and 30 act against the annular end faces of the piston-plugs 67 to normally maintain the face 66 of the valve-plate 64 in contact with the face-plate 48 at the end of the rotor 34. Preferably, resilient washers 75 of "neoprene" or similar material are provided between the ends of the springs 74 and the piston-plugs 67 and similar washers 76 are positioned between the piston-plugs 67 and the valve-plate 64 to seal the joints.

Another feature of the present invention consists in the provision of an improved coupling for connecting the rotor 34 and reaction-ring 54 for rotation about eccentric axes. The coupling comprises a pair of arms 81 and 82 positioned in the transverse slot 40 in the flange 39 of the shaft 37, see Figs. 2 and 5. The arms 81 and 82 are pivoted intermediate their ends on pins 83 and 84 arranged parallel to the axis of the shaft and mounted in aligned bores in the flange 39 and end face 35 of the rotor 34. The outer ends of the arms 81 and 82 are pivotally connected to pins 85 carried by and projecting outwardly from crosshead-blocks 86. The crosshead-blocks 86 are mounted to slide in rectangular slots or guideways 87 formed in guide-members 88 fastened to the end face 39 of the ring 54 by means of screws 90. The inner ends of the arms 81 and 82 are provided with intermeshing gear-teeth 91 and 92 which permit simultaneous rocking motion of the arms from the position shown in full lines to that indicated by dash lines in Fig. 5, and vice versa. The intermeshing engagement of the gear-teeth 91 and 92, however, has a reactive effect on forces at the outer ends of the arms tending to rock them on their pivot-pins 83 and 84 whereby to provide a rigid driving connection between the rotor 34 and ring 54. That is to say, the arrangement is such as to permit relative rocking motion of the arms to compensate for the displacement of corresponding points on the rotor 34 and ring 54 during their rotation about eccentric axes while maintaining a rigid driving connection between the rotor and ring. One form of the invention having been described in detail, the mode of operation of the unit is explained as follows:

For purposes of description let it be assumed that the unit is to be operated as a pump with the rotor 34 driven in clockwise direction, as viewed

in Fig. 1, by means of a suitable prime-mover connected with the shaft 37. The reaction-ring 54 first is adjusted with respect to the rotor 34 by turning the handwheel 61 on the threaded stem 60 connected to the carriage 57 to slide the latter vertically. Such movement of the carriage 57 and ring 54 will adjust the eccentricity of the latter with respect to the rotor 34 and thereby regulate the displacement of the pistons 50 in the cylinder 47 to control the capacity of the unit. The motive fluid is supplied through the conduit 18, port 16 and bores 25 and 26 in the end wall 4 of the casing, thence through the hollow piston-plugs 67 and the ports 70 in the valve-plate 64 to successive ports 49 in the face-plate 48 of the rotor 34 which communicate with the cylinders 47 at one side of the rotor. Similarly, the motive fluid will be discharged from the cylinders 47 at the opposite side of the rotor 34 through the ports 49 in the face-plate 48, the arcuate port 71 in the valve-plate 64, the hollow piston-plugs 67, and thence through the bores 29 and 30 and the port 17 in the end wall 4 of the casing to the conduit 19. At the beginning of a pumping operation the springs 74, acting on the ends of the piston-plugs 67, will yieldingly maintain the face 66 of the annular valve-plate 64 in contact with the face-plate 48 at the end of the rotor 34.

The arms 81 and 82 of the coupling connect the flange 39 on the rotor 34 with the reaction-ring 54 for rotation of the rotor and ring as a unit. Due to the rotation of the rotor 34 and ring 54 about eccentric axes, any point on the ring, such for example as the axial center of the pin 85, will follow or lag behind a corresponding point on the rotor 34, such as the axis of the pivot-pin 83 as they move from the position indicated at W to the position indicated at X in Fig. 5. During the rotation of the rotor 34 and reaction-ring 54 from W to X the arm 81 will rock on the pivot-pins 83 and 85 to compensate for the displacement of corresponding points on the rotor and ring. To permit such rocking movement of the arm 81 the crosshead-block 86 will slide radially outward in the guideway 87 in the guide-member 88 from the position shown in full lines at W to the position indicated by dash lines at X. Simultaneously with the movement of the arm 81 from W to X the arm 82 will have moved from the position indicated at Y to that indicated at Z. During such movement of the arm 82 any point on the reaction ring 54, such as the axial center of the pin 85 on the crosshead block 86, will advance with respect to a corresponding point on the rotor 34, such as the axial center of the pivot-pin 84. At any particular time during such rotation of the rotor 34 and ring 54 the axial center of the pivot-pin 85 for the arm 81 will lag behind the axial center of the pivot-pin 83 a distance equal to the advance of the axial center of the pin 85 ahead of the axial center of the pivot-pin 84 for the arm 82. Thus, the two arms 81 and 82 will rock concurrently relatively of each other to compensate for the displacement of corresponding points on the rotor 34 and ring 54 during their rotation about eccentric axes. The intermeshing gear-teeth 91 and 92 at the inner ends of the arms 81 and 82 permit such concurrent or simultaneous rocking motion of the arms during rotation of the parts but prevent any other movement of the arms to provide a rigid driving connection between the rotor 34 and ring 54. During the movement of the arm 81 from X to Y and the movement of the arm 82 from Z to W, the relative displacement of corresponding points on the

rotor 34 and ring 54 will be reversed from that previously described, but the rate of their relative movement will be the same in opposite directions so that the arms will rock back to their straight line relationship. It will be apparent, therefore, that the ring 54 will be driven from the rotor 34 through the arms 81 and 82 of the coupling and the arms will rock simultaneously to compensate for the displacement of the rotor and ring while providing a rigid driving connection therebetween.

Due to the eccentric relationship of the axes of the rotor 34 and ring 54 the distance between the ring and rotor gradually decreases in clockwise direction during their advance from the position indicated at W to that indicated at Y and gradually increases during the advance from Y to W. During rotation of the rotor 34 and ring 54 from W to Y the piston-rods 51, acting against the ring 54, will force the pistons 50 radially inward to slide them in the cylinders 47. The motive fluid thus will be discharged from the cylinders 47 through the ports 49 in the rotor 34 and the port 71 in the annular valve-plate 64 and thence through the hollow pistons 67. The pressure of the motive fluid discharged from the cylinders 47 will act on the annular faces 73 at the ends of certain two of the piston-plugs 67 to urge the face 66 of the valve-plate 64 against the face-plate 48 at the end of the rotor. The force applied to the piston-plugs 67 by the motive fluid will be proportional to the pressure of the fluid and slightly in excess of the force tending to separate the valve-plate 64 from the face-plate 48 of the rotor. Consequently, the annular valve-plate 64 will be pressed against the face-plate 48 at the end of the rotor with a force only slightly in excess of that necessary to maintain the proper contact so that a minimum amount of energy will be dissipated by friction between the contacting faces. However, the force necessary to maintain the valve-plate 64 pressed against the face-plate 48 on the rotor is automatically increased as the pressure of the motive fluid increases. Furthermore, due to the relatively small mass of the annular valve-plate 64 it is adapted to tilt somewhat to adjust itself to the contour of the face-plate 48 at the end of the rotor 34 whereof to compensate for any slight variations or inequalities resulting from machining operations. It has been found in actual tests that the present construction, including the support of the rotor at its opposite ends and the arrangement of the annular valve-plate surrounding the spindle, improves the volumetric efficiency and other operating characteristics of the unit over units of usual valve construction.

During the operation of the unit successive pistons 50 will be moved radially inward during the first 180° of rotation of the rotor 34 and ring 54 to discharge the motive fluid from the cylinders 47 through the conduit 19, while the pistons will be moved radially outward during the second 180° of rotation to draw motive fluid into the cylinders through the conduit 18. During the rotation of the rotor 34 and ring 54 the arms 81 and 82 of the coupling will rock concurrently to compensate for the angularity resulting from the rotation of the parts about eccentric axes, but will act to positively connect the rotor and ring for rotation one from the other. During the operation of the unit the rotor 34 is supported at both ends for rotation about its axis. It is to be understood that the unit may be operated as a motor by merely supplying the motive fluid under pressure through

the conduit 19 and exhausting the motive fluid through the conduit 18.

An important feature of the present construction and arrangement of the valve-plate 64 resides in the relationship of the ports 70 and 71 and piston-plugs 67 to properly distribute the forces acting on the valve-plate to maintain its bearing pressure uniform as indicated diagrammatically in Figs. 7 and 8. It will be apparent that the force applied to the valve-plate 64 by the springs 74 and the pressure of the motive fluid, acting on the ends of the piston-plugs 67, to hold the valve-plate engaged against the face-plate 48 at the end of the rotor 34 (hereinafter referred to as the contacting force CF) and the oil-leakage force tending to separate the valve-plate from the face-plate at the end of the rotor (hereinafter referred to as the separating force SF) are applied only on the high-pressure side of the unit. The contacting force CF and separating force SF on the lower pressure side of the unit are negligible and may be disregarded in computation so that the forces may be considered as operating only on one-half or on the high-pressure side of the annular valve-plate 64. The contacting force CF is the resultant of the forces F_1 of the high-pressure motive fluid acting on the two piston-plugs 67 and the forces F_2 of the springs 74 acting on the piston-plugs and is applied at a point midway between the piston-plugs as indicated diagrammatically in Figs. 7 and 8. The separating force SF is the resultant of the oil-leakage pressure along the arcuate surface of the high-pressure half of the annular valve-plate 64 and is the sum of A (full fluid pressure in the port 71) and B (half fluid pressure) applied at a point on the same radial line as the force CF. The reaction-bearing force BF is the resultant of the bearing forces c applied around the arcuate surface of the contacting side of the valve-plate 64 and its point of application is dependent upon the point of application of the contacting force CF and separating force SF.

The contacting force CF is applied at a position radially inward from the separating force SF so that the bearing reaction-force BF will also be positioned inwardly of the separating force. By proper design of the valve-plate 64 and proper positioning of the piston-plugs 67 thereon, the bearing reaction-force BF will be applied so as to give a uniformly distributed bearing pressure c over the entire area of the contacting side of the valve-plate. However, the spindle 41 for supporting the end 36 of the rotor 34 imposes certain limitations as to the inward position of the piston-plugs 67. With the present form of construction the bores 29 and 30 in the end wall 4 of the casing are positioned as closely as possible to the axial bore 15 to cause the contacting force CF, see Fig. 8, to be applied radially inward from the separating force SF and so position the point of application of the bearing reaction-force BF as to produce a bearing pressure on the valve-plate which is substantially uniform at every point c over the entire high-pressure area of the valve-plate. To accomplish that result, the wall between the bores 29 and 30 and the axial bore 15 is made quite thin, but the end of the spindle 41 which has a close fit in the bore will reinforce and support the thin wall therebetween. As a result, a substantially uniform bearing pressure is secured on the contacting side of the valve-plate 64 to hold it engaged with the

face-plate 48 at the end of the rotor 34 and maintain it in equilibrium.

As indicated in Figs. 7 and 8, the distribution of the forces is illustrated diagrammatically as follows:

A=full fluid pressure applied on area of port 71
B=half fluid pressure applied on contacting areas at sides of port
c=bearing pressure at any point on the valve-plate

F_1 =oil pressure times area of piston-plugs

F_2 =force of springs

F_3 =resultant of separating force= $A+B$

F_4 =resultant of reaction bearing forces= C

CF =total contacting force= F_1+F_2

SF =separating force= F_3

BF =bearing reaction force= F_4

$F_1+F_2>F_3$ to maintain valve-plate engaged

$F_4=(F_1+F_2)-F_3$

For condition of equilibrium:

$$F_1+F_2=F_3+F_4$$

therefore:

F_1+F_2 will be applied at a position radially inward toward the axis from F_3 to cause F_4 to apply an equal bearing pressure uniformly distributed over the valve-plate. As CF equals F_1+F_2 , SF equals F_3 and BF equals F_4 the contacting force is applied radially inward from the separating force to so apply a bearing reaction force as to produce a substantially uniformly distributed bearing pressure over the entire arcuate surface at the contacting face of the bearing plate 64.

In Fig. 6 of the drawings the valve-plate construction is shown as applied to an axial type hydraulic pump or motor unit comprising a casing 100 having end walls 101 and 110. The end wall 101 is similar to the end wall 4 of the construction previously described, being provided with conduits 102 and 103 communicating with a plurality of bores 104, only one of which is shown in the drawings. The rotor 105 is mounted fast on a shaft or spindle 106 extending through an axial bore 107 in the rotor and journaled at its opposite ends in antifriction bearings 108 and 109 in the end walls 101 and 110 of the casing. The rotor 105 has a plurality of equidistantly-spaced cylinder-bores 111 extending parallel to its axis of rotation. Pistons 112 are provided in the cylinders 111 and connected by means of piston-rods 113 to a swash-plate 114 rotatable in a tilting box 115 of usual construction. The tilting box 115 may be adjusted manually by means including a gear 116 and rack 117 to vary the stroke of the pistons and thereby the capacity of the unit when used as a pump or the speed of rotation of the unit when used as a motor. The end of the rotor 105 opposite from the swash-plate 114 is provided with a valve-face 120 having ports 121 which communicate with the cylinders 111. An annular valve-plate 122 for cooperation with the valve-face 120 is substantially identical with the valve-plate 64 previously described. The annular valve-plate 122 surrounds the shaft 106 and has a face 123 at one side which bears against the face 120 at the end of the rotor 105. At the opposite side of the valve-plate 122 from the face 123 are a plurality of hollow piston-plugs 124 which extend into the bores 104 in the end wall 101 of the casing. Springs 125 pocketed in the bores 104 normally maintain the face 123 of the annular valve-plate 122 in contact with the end face 120 of the rotor 105. The annular valve-plate 122 is provided with arcuate

ports 126 which communicate with the ports 121 in the rotor 105 and the bores of the hollow piston-plugs 124.

The pump or motor unit shown in Fig. 6 operates in a manner substantially identical with that previously described with respect to the embodiment illustrated in Figs. 1 to 5. During rotation of the rotor 105 the swash-plate 114 rotating in the box 115 will operate through the piston-rods 113 to reciprocate the pistons 112 in the cylinders 111. It is to be understood that the form of construction illustrated in Fig. 6 could be modified with the rotor 105 supported for rotation at its opposite ends by a shaft similar to the shaft 37 and a spindle corresponding to the spindle 41 shown in Figs. 1 to 5. Upon rotation of the rotor 105 the cylinders 111 at one side of the rotor will be successively supplied with motive fluid through one or the other of the conduits 102, 103 while the cylinders at the opposite side of the rotor will successively discharge the motive fluid through the other conduit. The motive fluid under pressure in a pair of the bores 104 will act against the annular ends of the hollow piston-plugs 124 to urge the valve-plate 122 against the face 120 at the end of the rotor 105 with a force proportional to and slightly in excess of the force tending to separate the valve-plate from the face.

It will be observed from the foregoing specification that the present invention provides a pump or motor unit in which the rotor is supported at each end for rotation in the casing, in combination with an annular valve-plate surrounding the supporting spindle and cooperating with a valve-face at the end of the rotor. It also will be observed that the present invention provides for maintaining the valve-plate against a valve-face at the end of the rotor with a force proportional to and slightly in excess of the force tending to separate the plate from the rotor. It further will be observed that the present invention provides a novel form of coupling for connecting the rotor and reaction-ring for rotation as a unit about eccentric axes.

While several forms of the improvement in pump or motor units are illustrated and described herein, it is to be understood that further modifications may be made in the structure and arrangement of the parts of the mechanism without departing from the spirit or scope of the invention.

Therefore, without limiting myself in this respect, I claim:

1. In a hydraulic pump or motor unit of the type in which two cylindrical members are arranged for rotation one within the other about eccentric axes, a coupling for connecting the members for rotation as a unit comprising a pair of radial arms pivotally connected to the inner member intermediate their ends and having articulated sliding connection with the outer member adjacent their outer ends, and intermeshing means at the inner ends of the arms for preventing relative sliding movement therebetween while permitting concurrent rocking motion of the arms on the inner member.

2. In a hydraulic pump or motor unit of the type in which two cylindrical members are arranged for rotation one within the other about eccentric axes, a coupling for connecting the members for rotation as a unit comprising a pair of arms pivotally mounted intermediate their ends on the inner member to rock about axes extending parallel to the axis of said member, said

arms being pivotally connected to crossheads mounted to slide radially on the outer member, and intermeshing segmental gear-teeth at the inner ends of the arms adapted to permit concurrent rocking motion of the arms on their pivots.

3. In an apparatus in which two members are arranged for rotation one within the other about eccentric axes, a coupling for connecting the members for rotation as a unit comprising a pair of arms pivotally connected intermediate their ends to the inner member and having articulated sliding connection with the outer member, and intermeshing means connecting the inner ends of the arms to prevent relative sliding movement therebetween while permitting concurrent rocking motion of the arms on their pivotal connections with the inner member.

4. A hydraulic pump or motor unit comprising a casing having a bearing at one end and inlet and outlet ports at its opposite end, a rotor having a shaft at one end journaled in the bearing in the casing and a radial valve-face at its opposite end, said rotor embodying a series of cylinders with ports opening through the valve-face, pistons in the cylinders, a valve-plate adapted to seat against the valve-face on the end of the rotor and provided with ports for registering with the ports therein, and a plurality of hollow piston-plugs projecting from the side of the valve-plate opposite to that seated against the valve-face on the rotor with their bores communicating with the ports in the valve-plate, said piston-plugs projecting into the inlet and outlet ports in the casing to adapt the motive fluid acting against their annular ends to maintain the valve-plate pressed against the valve-face on the rotor with a uniformly-distributed force, and said piston-plugs being located with their axes radially outward from the axis of the valve-plate at such a distance that the resultant force representing the combination of the thrust on the piston-plugs and the leakage separation force shall lie within one-half of the outside radius of the valve-plate bearing area on the rotor.

5. A hydraulic pump or motor unit comprising a casing having inlet and outlet ports for the motive fluid, a rotor embodying a plurality of cylinders rotatable within the casing and having a valve-face at one end, ports in the valve-face communicating with the cylinders, pistons in the cylinders, a valve-plate having one side engaging the valve-face at the end of the rotor and formed with ports communicating with the ports therein, and a plurality of hollow piston-plugs on the opposite side of the valve-plate projecting therefrom into the ports in the end of the casing, said piston-plugs adapted to receive the pressure of the motive fluid against their annular ends and being so arranged and located at a distance radially outward from the axis of the valve-plate that the resultant force representing the combination of the plug thrust and the leakage separation force shall lie within one-half of the outside radius of the valve-plate bearing area on the rotor.

6. A hydraulic pump or motor unit comprising a casing having inlet and outlet ports for the motive fluid, a rotor embodying a plurality of cylinders rotatable within the casing and having a valve-face at one end, ports in the valve-face communicating with the cylinders, pistons in the cylinders, a valve-plate having one side engaging the valve-face at the end of the rotor and provided with ports communicating with the ports therein, a plurality of hollow piston-plugs projecting from the opposite side of the valve-plate into the ports at the end of the casing to adapt them to slide therein, and springs acting on the ends of the piston-plugs to force the valve-plate against the valve-face on the rotor when the pump or motor unit is at rest, said piston-plugs adapted to receive the pressure of the motive fluid against their annular ends to apply a thrust to seal the valve-plate against the end of the rotor when the pump or motor unit is operated hydraulically.

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