I. J. SNADER ET AL **2,177,008**

HYDRAULIC MOTOR

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Fig. 1

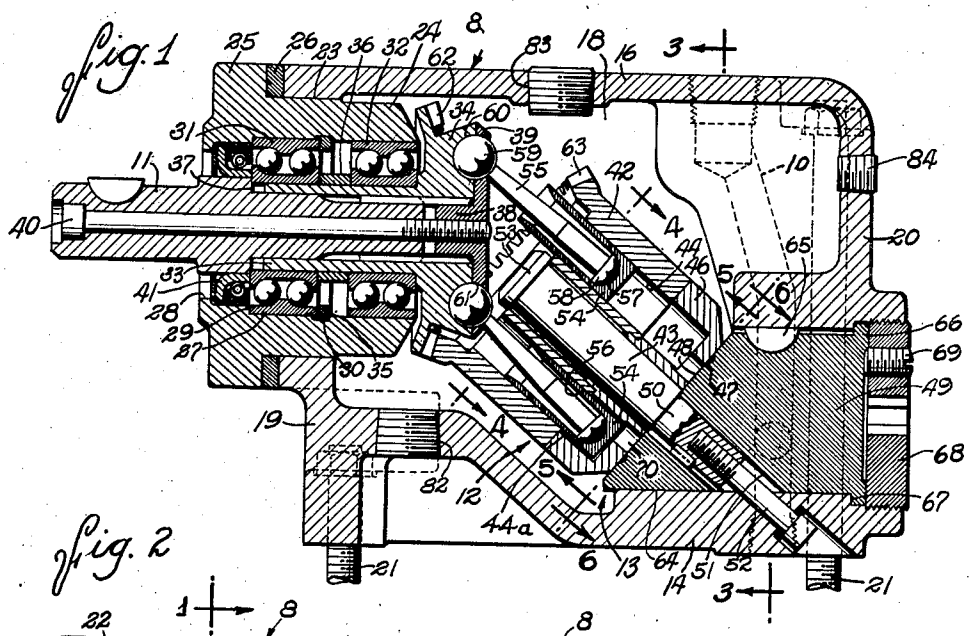
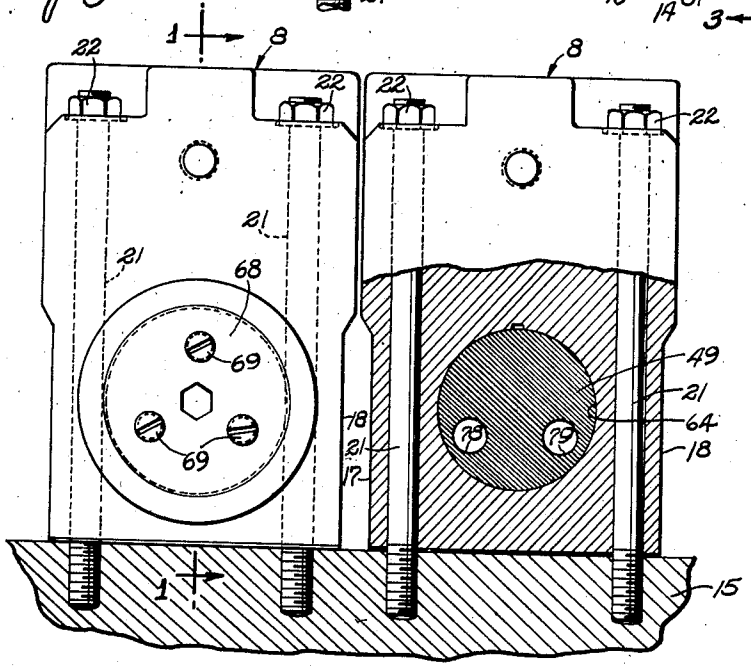


Fig. 2



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Fig. 3

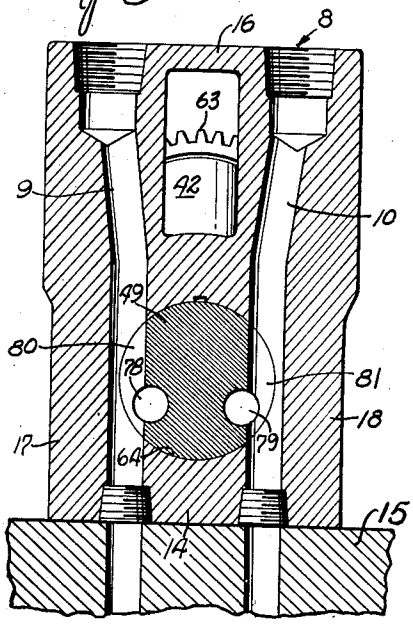


Fig. 4

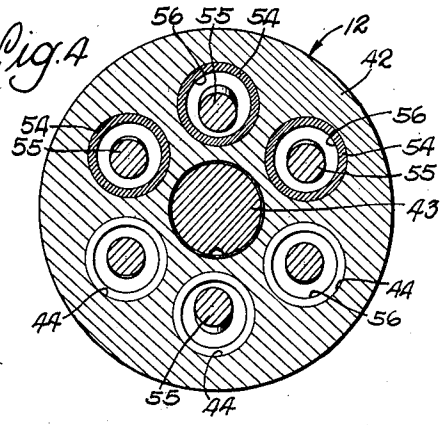


Fig. 5

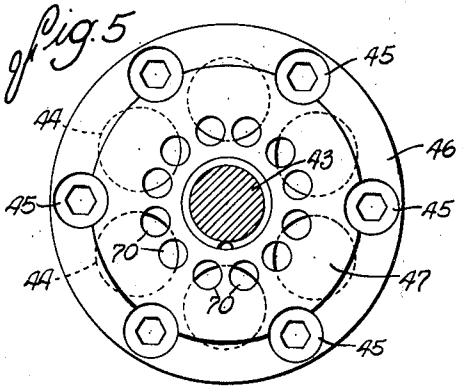


Fig. 6

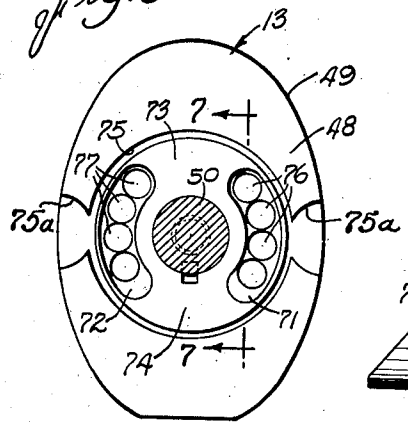
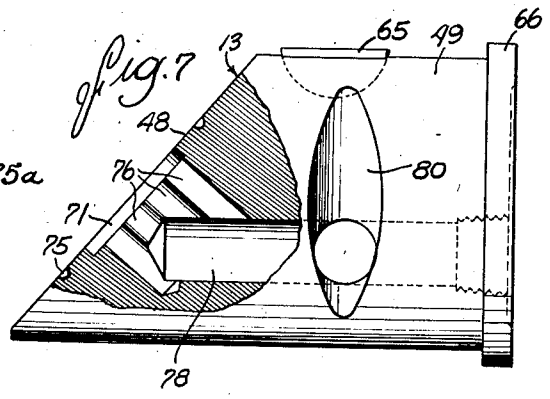


Fig. 7



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HYDRAULIC MOTOR

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13 Claims. (Cl. 121—62)

The present invention relates to improvements in rotary hydraulic motors.

One of the objects of the present invention is to provide a novel rotary hydraulic motor which is quiet, efficient and reliable in operation, and which is adapted for high pressure and high speed operation in either direction of rotation.

Another object is to provide a new and improved rotary hydraulic motor which is easily assembled and disassembled, and in which the wearing parts and particularly the valve members may be readily and conveniently replaced.

A further object is to provide a hydraulic motor with a novel operating valve having pressure-balanced self-seating flat valve faces to avoid objectionable wear, and with novel means for preventing leakage from the fluid passages leading to and from the valve.

Still another object is to provide a novel rotary hydraulic motor of a small compact construction capable of delivering a relatively large torque.

A further object is to provide a new and improved rotary hydraulic motor adapted for parallel mounting in multiple at close center distances as is desirable for independently operable multiple machine tool spindles.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings, Figure 1 is a vertical sectional view of a motor embodying the features of our invention.

Fig. 2 is an end elevational view of two motors, with the support therefor and one of the motors partially sectioned to illustrate the clamping means.

Fig. 3 is a transverse vertical sectional view taken substantially along line 3—3 of Fig. 1.

Fig. 4 is a sectional view taken along line 4—4 of Fig. 1.

Figs. 5 and 6 are views of the valve means taken respectively along lines 5—5 and 6—6 of Fig. 1.

Fig. 7 is a side elevational view of the stationary element of the valve means, partially in section along line 7—7 of Fig. 6.

While the invention is susceptible of various modifications and alternative constructions, we have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that we do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more particularly to the drawings, the hydraulic motor, constituting the exemplary embodiment of the invention, comprises a closed housing 8 having pressure fluid inlet and discharge passages 9 and 10, an outlet shaft 11 or power take-off journaled in and projecting from the housing, a rotor 12 in the form of a multiple cylinder and piston assembly mounted within the housing and adapted to exert a tangential component of thrust on the outlet shaft, and an end face valve 13 for controlling the connection of the passages 9 and 10 to the cylinders of the rotor.

The housing 8 may be of any suitable form, and preferably is substantially rectangular in shape. More particularly, the housing 8 has a bottom wall 14 adapted to be mounted on and secured to a suitable support, such as a mounting pad 15, a top wall 16, side walls 17 and 18, and opposite end walls 19 and 20 respectively supporting the outlet shaft 11 and the valve 13. Suitable clamp bolts 21 are fixed in the mounting pad 15, and project upwardly through corner portions of the housing 8 for the reception of nuts 22 to secure the motor in position.

The parts within the housing 8 are so constructed and arranged that the motor is relatively narrow. The side walls 17 and 18 are substantially flat and parallel, and the bolts 21 are spaced inwardly therefrom sufficiently to avoid the use of projecting ears or bosses. Hence, a number of the motors may be mounted in parallel relation with close center distances (see Fig. 2), as is frequently desirable for independently driven multiple machine tool spindles.

To provide a suitable mounting for the outlet shaft 11, the housing wall 19 is formed with a circular opening 23. A sleeve 24 extends through and is fixed in the opening 23, and is formed on the outer end with a peripheral flange 25. Interposed between the wall 19 and the flange 25 is a spacer ring 26 of a width to locate the sleeve 24 in proper axial position.

Opening through the sleeve 24 is a stepped bore 27 having an annular stop flange 28 at the outer end, an inwardly facing annular shoulder 29 adjacent the outer end, and a peripheral groove 30 spaced inwardly therefrom. Two suitable radial and axial thrust ball bearings 31 and 32 are secured in axially spaced relation in the bore 27, and support a tubular hub or sleeve

33 having a disk 34 on the inner end within the housing 8. The outer raceway of the bearing 31 is confined against the shoulder 29 by a snag-ring 35 positioned in the groove 30, and the inner raceway of the bearing 32 is positioned against the adjacent face of the disk 34. A spacer 36 on the sleeve 33 separates the inner raceways of the two bearings.

The outlet shaft 11 extends into and is axially splined to the sleeve 33 for joint rotation therewith, and has a peripheral shoulder 37 engaging the inner raceway of the bearing 31. A nut 38, integral with a retainer disk 39 positioned against the inner face of the disk 34, extends into the sleeve 33, and is threaded onto the inner end of a tie bolt 40 extending axially through and anchored at the outer end in the shaft 11. The nut 38 and bolt 40 serve to lock or clamp the shaft 11 and sleeve 33 together in axial position of assembly, with the inner raceways of the bearings 31 and 32 confined between the disk 34 and shoulder 37. An oil seal 41 confined in the bore 27 against the stop flange 28 prevents the outward leakage of oil along the shaft 11.

The rotor 12 comprises a cylinder body 42 which is mounted for rotation on a fixed shaft 43 inclined to the shaft 11 at a suitable angle in a common axial plane. A plurality of parallel bores 44 open through the body 42 in uniformly spaced relation about the shaft 43, and constitute the motor cylinders. Removably secured to the end of the body 42 remote from the disk 34, as by means of bolts 45, is a circular end plate 46 formed in its inner face with a plurality of bores 44^a providing slightly enlarged closed end extensions of the cylinders 44.

The plate 46 has an end face 47 which bears rotatably against an opposed face 48 on a stationary body 49 rigidly secured in the housing 8. The stationary pin or shaft 43 is mounted on the body 49 and projects axially from the face 48. In the present instance, the shaft 43 has a reduced extension 50 slidably keyed against rotation in a bore 51 in the body 49. A bolt 52 extends through the bottom wall 14 of the housing 8 into axial threaded engagement with the extension 50, and serves to clamp the shaft 43 rigidly against the face 48. A head 53 on the outer end of the shaft 43 confines the rotor 12 against the body 49. Preferably, the shaft 43 has a close rotary fit with the plate 46, and a relatively loose rotary fit with the body 42, as shown on an exaggerated scale in Figs. 1 and 3, to obtain good seating engagement between the faces 47 and 48.

Disposed respectively for reciprocation in the cylinders 44 are a plurality of plungers 54. The clearance space between the closed end extensions 44^a of the cylinders 44 and the plungers 54 at the inner end of the stroke is small to insure quietness in motor operation.

A plurality of connecting rods 55 are provided for transmitting the outward thrust of the plungers 54 with a tangential component against the disk 34 on the outlet shaft 11. Each of the plungers 54 is formed in the outer end with an axial bore 56 terminating in a spherical socket 57. The rods 55 extend freely into the bores 56, and have enlarged rounded ends 58 engaging the sockets 57 for limited universal rocking movement. The connecting rods 55 are also provided with outer ball ends 59 which are disposed respectively for universal rocking movement in a plurality of semi-spherical sockets 60 in the inner end face of the disk 34. It will be understood that the sockets 60 are annularly arranged in uniformly spaced relation about the axis of the shaft 11. The disk 39, which is clamped against the end face of the disk 34, is formed with a plurality of circular openings 61 in bearing engagement with the outer portions of the ball ends 59, and serves to anchor or retain the latter in the sockets 60. Consequently, the rods 55 are swiveled to the disk 34.

To maintain the rotor 12 and the drive assembly in correct relative angular position, the disk 34 and cylinder body 42 are suitably geared together. In the present instance, a bevel gear 62 is formed integral with the periphery of the disk 34, and meshes with a bevel gear 63 on the end of the body 42. The drive assembly is located axially, by the use of a spacer 26 of selected width, to obtain the proper tooth clearance between the gears 62 and 63. Only a small load is placed on the gear teeth since the effective tooth pressure is substantially balanced by the tangential component of thrust of the connecting rods 55 on the disk 34.

The body 49 constitutes the stationary element of the valve 13, and preferably is in the form of a cylindrical valve plug tightly pressed into a hole 64 opening through the end wall 20 of the housing 8. The valve plug 49 is located angularly by means of a longitudinal spline 65, and axially by means of an outer end flange 66 thereon seating against a shoulder 67 in the outer end portion of the hole or bore 64. A screw plug 68 is threaded into the outer end of the bore 64 against the end of the plug 49, and serves to clamp the flange 66 against the shoulder 67. A plurality of lock screws 69 are threaded in uniformly annularly spaced relation through the plug 68, as shown in Fig. 2, into engagement with the outer end face of the plug 49, and afford means for applying a uniform pressure thereto. The valve plug 49 extends parallel to the shaft 11, and hence the inner end face 48 is disposed at a suitable angle to the longitudinal axis.

The contacting end faces 47 and 48 of the replaceable plate 46 and the plug 49 constitute the faces of the valve 13. Opening respectively from the closed ends of the cylinders 44 to the face 47 are a plurality of cylinder ports 70. Preferably, the ports 70 open from the innermost sides of the cylinders 44 so that they scavenged continuously of air and gases. This also results in locating the ports 70 close to the axis of rotation, thereby permitting of a small valve face area and reducing the peripheral speed.

Formed in the valve block 49, and opening to the stationary valve face 48 in the path of the cylinder ports 70 at opposite sides of the common axial plane of the shafts 11 and 43, are two arcuate ports 71 and 72 separated by land areas 73 and 74. A concentric drain groove 75 is formed in the face 48 about the ports 71 and 72 and is relieved through passages 75^a opening to the interior of the housing 8. The groove 75 defines a pressure film area of such a size that the hydraulic pressure between the valve faces will substantially balance the reaction of the rotor 12 on the valve. The valve face area is larger than this pressure film area to provide an amply dimensioned wearing surface.

The valve plug or block 49 has substantial mass and is made of a single piece of steel. As a result, the valve face or surface 48 is not subject to deflection or distortion under heavy pressures. The block 49 is pressed into the housing 8 with

sufficient pressure to subject the walls of the bore 64 to a greater stress than would normally be caused by the hydraulic pressure.

The ports 71 and 72 are connected through the valve plug 49 respectively to the two passages 9 and 10 formed in the wall 8 and intersecting opposite sides of the bore 64. In the present instance, two sets of bores 76 and 77 open from the bottom surfaces of the ports 71 and 72, and are intersected respectively by two longitudinal bores 78 and 79. Two transverse notches 80 and 81 in opposite sides of the plug 49 respectively intersect the bores 78 and 79, and complete the connections to the passages 9 and 10. The close and accurately made fit between the wall 20 and the block 49, with the pressure engagement at the shoulder 67, provides a fluid-tight seal preventing leakage from the passages 9 and 10 along the bore 64.

Either one of the passages 9 and 10 may be connected to a suitable source (not shown) of motive fluid under pressure, the other opening to exhaust. Preferably, the passages 9 and 10 open vertically through the housing 8 (see Fig. 3) so that the pressure and exhaust connections may be made either at the top, the lower ends being sealed, or at the bottom through suitable passages (not shown) in the mounting pad 15, the upper ends being plugged.

Oil leaking into the housing 8 past the valve faces 47 and 48 or past the plungers 54 may be removed through any one of three normally closed holes 82, 83 and 84. The holes 82 and 83 also serve as assembly sight holes.

In operation, assume that motive fluid under pressure is supplied to the passage 9. The fluid will be directed through the port 71 to the cylinders 44 on one side of the rotor 12, while the cylinders on the opposite side will be connected through the port 72 and passage 10 to exhaust. The plungers 54 on the pressure side will be moved outwardly, and will impart a tangential component of thrust to the disk 34, thereby rotating the shaft 11 in a clockwise direction as viewed from the right in Fig. 1. Connection of the passage 10 with the pressure source will reverse the direction of rotation.

The motor is quiet in operation, readily assembled and repaired, not subject to excessive wear, and capable of delivering a heavy torque for its compact size.

We claim as our invention:

1. In a rotary hydraulic motor, in combination, a casing having an opening in one wall, and an outlet drive assembly adapted to be removably mounted as a unit in said opening, said assembly comprising a bearing sleeve removably inserted into said opening, two axially-spaced antifriction bearings mounted in said sleeve, an inner sleeve extending through and rotatably supported by said bearings and having an end disk formed in the inner end face with a plurality of sockets annularly arranged about the axis of rotation, an outlet shaft axially splined in said inner sleeve and having an inwardly facing annular shoulder, a plurality of pivotal connecting rods having rounded ends disposed in said sockets, a retainer disk having openings freely receiving said rods and disposed against said end face to confine said rounded ends in said sockets, and a draw bolt extending axially through said shaft into threaded engagement with said retainer disk to clamp said bearings between said first mentioned disk and said shoulder, whereby the rotary parts of said assembly are secured in assembled relation.

2. In a rotary hydraulic motor, in combination, a casing having an opening in one wall, and an outlet drive assembly adapted to be removably mounted as a unit in said opening, said assembly comprising a bearing sleeve removably inserted into said opening and having an outer end flange, a replaceable spacer clamped between said housing and said flange to define the axial location of said sleeve, said sleeve having an axial bore with an inwardly facing annular shoulder and with an annular groove spaced inwardly of said shoulder, two axially-spaced ball bearings with inner and outer raceways mounted in said bore, a snag ring in said groove for holding the outer raceway of the outermost bearing against said shoulder, an inner sleeve extending through and rotatably supported by the inner raceways of said bearings and having an end disk formed in the inner end face with a plurality of sockets annularly arranged about the axis of rotation, an outlet shaft axially splined in said inner sleeve and having an inwardly facing annular shoulder, a plurality of pivotal connecting rods having ball ends disposed in said sockets, a retainer disk having openings freely receiving said rods and disposed against said end face to confine said ball ends in said sockets, and a draw bolt extending axially through said shaft into threaded engagement with said retainer disk to clamp said inner raceways between said first mentioned disk and said last mentioned shoulder, whereby the rotary parts of said assembly are secured in assembled relation.

3. A rotary hydraulic motor comprising, in combination, a casing, an outlet shaft journaled in one wall of said casing, a valve plug removably inserted in an opposed wall of said casing and having an inclined valve face not subject to appreciable distortion under pressure, pressure inlet and exhaust passages opening to said face, a pin secured to said plug and extending perpendicularly from said face and at an angle to said shaft in a common axial plane, a rotor having a cylinder body loosely journaled on said pin and an end valve disk removably secured to said body and closely journaled on said pin for rotary bearing engagement with said valve plug, a plurality of cylinders in said body and annularly arranged about said pin, a plurality of pistons reciprocable in said cylinders, and means including a plurality of connecting rods operatively connecting said pistons to said outlet shaft for revolution therewith to impart to the latter a tangential component of thrust.

4. A rotary hydraulic motor comprising, in combination, a casing having an elongated opening in one wall with an outwardly facing stop shoulder, an outlet shaft journaled in said casing in an opposite wall, a valve plug tightly pressed into said opening and having an inner end valve face, a flange on said plug engaging said shoulder, means for clamping said flange against said shoulder, inlet and outlet passages opening through said valve plug to said face, a stationary pin mounted in said plug inclined to said shaft in a common axial plane, and a rotor mounted on said pin and having a plurality of annularly arranged piston and cylinder units operatively connected to said shaft and having a rotary end face valve member bearing against said first-mentioned face for connecting said passages to the cylinders of said rotor to effect reciprocation of the pistons of said rotor in timed sequence.

5. A rotary hydraulic motor comprising, in combination, a casing having a cylindrical open-

ing in one end wall with an outwardly facing sealing shoulder, an outlet shaft journaled in the other end wall of said casing, a cylindrical valve plug tightly pressed into said opening and having an inclined inner end valve face, a peripheral flange on the outer end of said plug engaging said shoulder, a screw plug threaded into the outer end of said opening against said valve plug, inlet and outlet passages opening through said valve plug to said face, a stationary pin removably mounted on said valve plug and inclined to said shaft in a common axial plane, and a rotor mounted on said pin and having a plurality of annularly arranged piston and cylinder units operatively connected to said shaft and having a rotary end face valve member bearing against said first-mentioned face for connecting said passages to the cylinders of said rotor to effect reciprocation of the pistons of said rotor in timed sequence.

6. A rotary hydraulic motor comprising, in combination, a casing having a cylindrical opening in one end wall with an outwardly facing sealing shoulder, an outlet shaft journaled in the other end wall of said casing, a cylindrical valve plug of steel tightly pressed into said opening and having an inclined inner end valve face not subject to appreciable distortion, a peripheral flange on the outer end of said plug engaging said shoulder, spline means for holding said plug against rotation, a screw plug threaded into the outer end of said opening against said valve plug, a plurality of screws threaded through said screw plug against the outer end of said valve plug, inlet and outlet passages opening through said valve plug to said face, a stationary pin removably mounted on said valve plug and inclined to said shaft in a common axial plane, and a rotor on said pin and having a plurality of annularly arranged piston and cylinder units operatively connected to said shaft and having a rotary end face valve member bearing against said first-mentioned face for connecting said passages to the cylinders of said rotor to effect reciprocation of the pistons of said rotor in timed sequence.

7. A rotary hydraulic motor comprising, in combination, a casing having an elongated opening of substantial wall thickness, a single piece solid steel valve plug tightly pressed into said opening under stress to provide a fluid-tight seal and to resist distortion under hydraulic pressure and having an inner end valve face with arcuate inlet and outlet ports, inlet and outlet passages opening respectively to said ports, a relief groove formed in said face concentrically about said ports to define a circumscribed pressure film area, a rotor having an end face valve member mounted for rotation against said valve face and having a plurality of parallel cylinders annularly arranged about the axis of rotation, a plurality of pistons reciprocable in said cylinders, said valve member having ports opening respectively from the innermost sides of said cylinders for movement successively across said inlet and outlet ports, an outlet shaft mounted in said casing, and means operatively connecting said pistons to said shaft.

8. A rotary hydraulic motor comprising, in combination, a casing having an elongated opening of substantial wall thickness, a valve plug tightly pressed into said opening under stress to provide a fluid-tight seal and to resist distortion under hydraulic pressure and having an inclined inner end valve face with diametrically spaced arcuate inlet and outlet ports, inlet and outlet passages opening respectively to said ports, a rotor having a valve member with an end face mounted for rotation against said inclined face and having a plurality of parallel cylinders annularly arranged about the axis of rotation, a plurality of pistons reciprocable in said cylinders, said valve member having ports opening respectively from said cylinders for movement successively across said inlet and outlet ports, a relief groove formed in one of said faces concentrically of said axis and about said ports to define a circumscribed pressure film area between said faces, an outlet shaft mounted in said casing, and means operatively connecting said pistons to said shaft.

9. A rotary hydraulic motor comprising, in combination, a casing, an outlet shaft journaled in said casing, a valve member mounted in said casing and having a valve face with diametrically opposed inlet and outlet arcuate ports, a pin secured to said member and extending perpendicular from said face at an angle to said shaft, a rotor having a multiple cylinder body loosely journaled on said pin and an end valve disk removably secured to said body and closely journaled on said pin for rotary self-seating engagement with said valve member, a plurality of pistons reciprocable in said cylinder body and annularly arranged about said pin, and means including a plurality of connecting rods operatively connecting said pistons to said outlet shaft for revolution therewith to impart to the latter a tangential component of thrust.

10. In a rotary hydraulic motor, a stationary valve member adapted to be removably mounted in a bore in a casing, and consisting of an elongated cylindrical single body of steel having an inclined valve face at one end, diametrically spaced arcuate inlet and outlet ports of equal radius formed in said face and separated by land areas, and two longitudinal passages in said body opening respectively to said ports, and two transverse notches intersecting said passages and opening to opposite sides of said body for registration with inlet and outlet passages intersecting said bore upon assembly of said member with said casing.

11. In a rotary hydraulic motor in combination with a casing having an elongated opening in one wall of substantial peripheral wall thickness, a plug tightly pressed into said opening under stress to provide a fluid tight seal and to resist distortion under hydraulic pressure and having an inner end valve face with diametrically spaced outlet and inlet ports, inlet and outlet passages opening through said plug respectively to said ports, and means for removably securing said plug in said opening.

12. In a rotary hydraulic motor in combination with a casing having an opening in one wall, a self-contained drive assembly adapted to be removably mounted as a unit in said opening and comprising an external bearing sleeve slidably interfitting with said opening, antifriction bearings in said sleeve, an inner sleeve extending through and rotatably supported by said bearings and having a disk on one end, a shaft axially splined in the other end of said inner sleeve and having an inwardly facing annular shoulder, and means coacting with said inner sleeve and said shaft to clamp said bearings between said disk and said shoulder, whereby the parts of said assembly are secured in assembled relation.

13. A rotary hydraulic motor comprising, in combination, a casing, an outlet shaft journaled in one wall of said casing, an elongated valve plug

removably inserted in an opposed wall of said casing and having a valve face and pressure inlet and exhaust passages opening to and from said face, a rotor having a plurality of annularly arranged piston and cylinder units and having a rotary valve member, means for confining said rotor for rotation against said plug with said rotary valve member in operative bearing engagement against said valve face, and means including a plurality of connecting rods operatively connecting the pistons of said units to said outlet shaft for revolution therewith to impart to the latter a tangential component of thrust in response to the reciprocation of said pistons.

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