W. FERRIS AND W. E. MAGIE.

HYDRAULIC TRANSMISSION DEVICE.

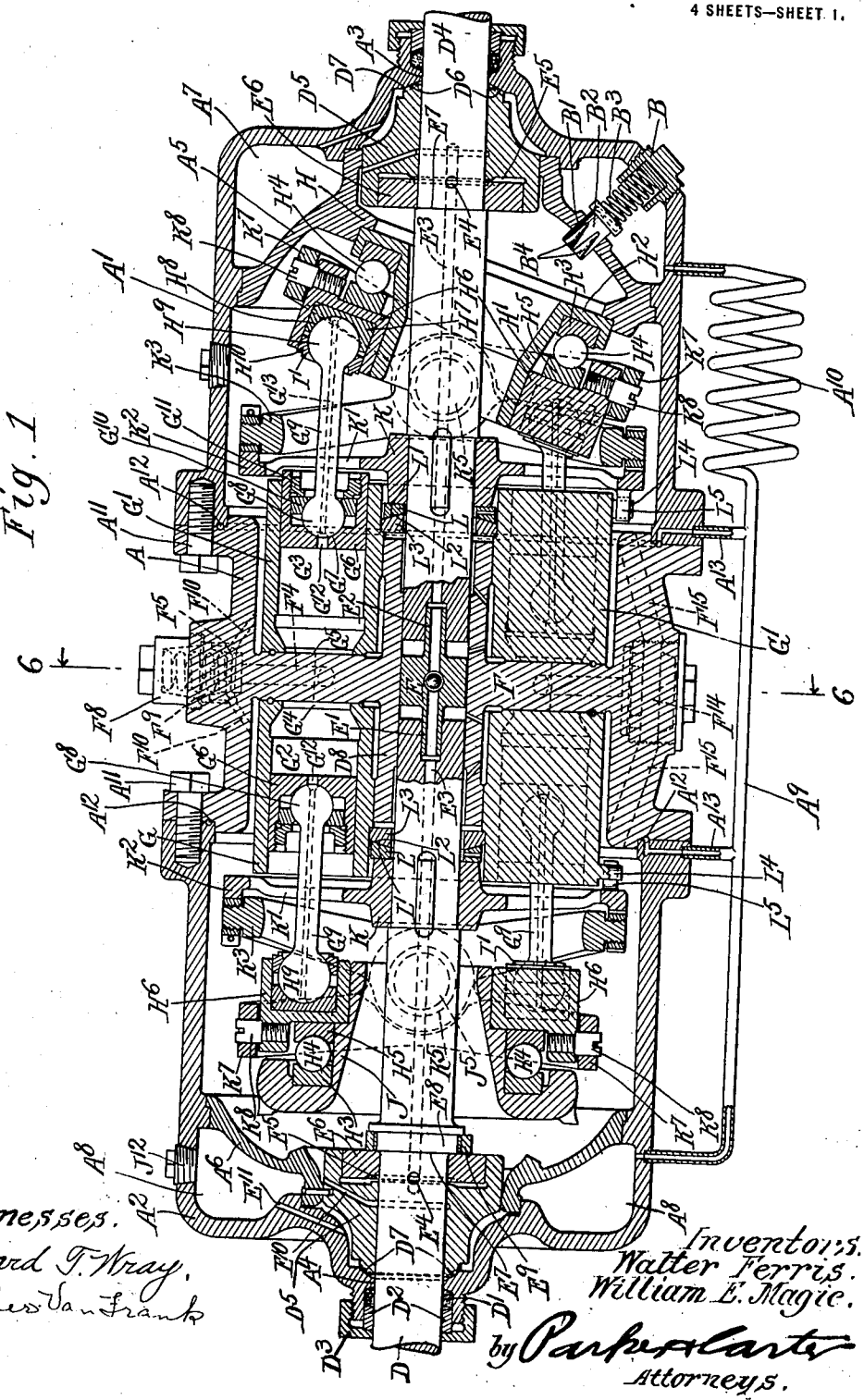
APPLICATION FILED FEB. 26, 1916.

1,308,844.

Patented July 8, 1919.

4 SHEETS—SHEET 1.

Fig. 1



Witnesses.
Edward T. Wray.
Esther Van Frank

Inventors.
Walter Ferris.
William E. Magie.
by Parker & Carter
Attorneys.

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4 SHEETS—SHEET 2.

Fig. 2.

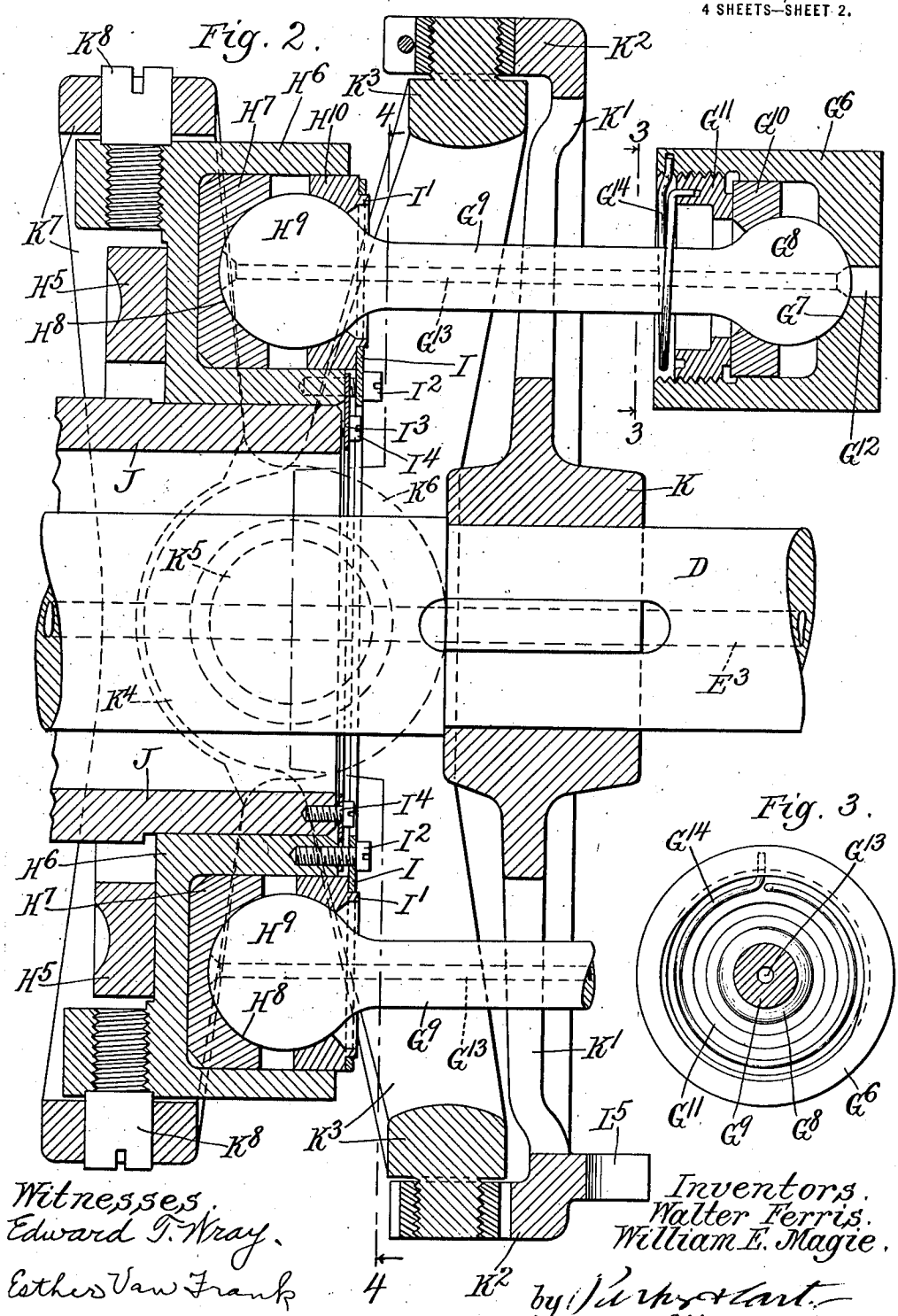


Fig. 3.

Witnesses.
Edward T. Wray.
Esther Vaw Frank

Inventors.
Walter Ferris.
William E. Magie.
by Church & Church
Attorneys.

W. FERRIS AND W. E. MAGIE.

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4 SHEETS—SHEET 3.

Fig. 4.

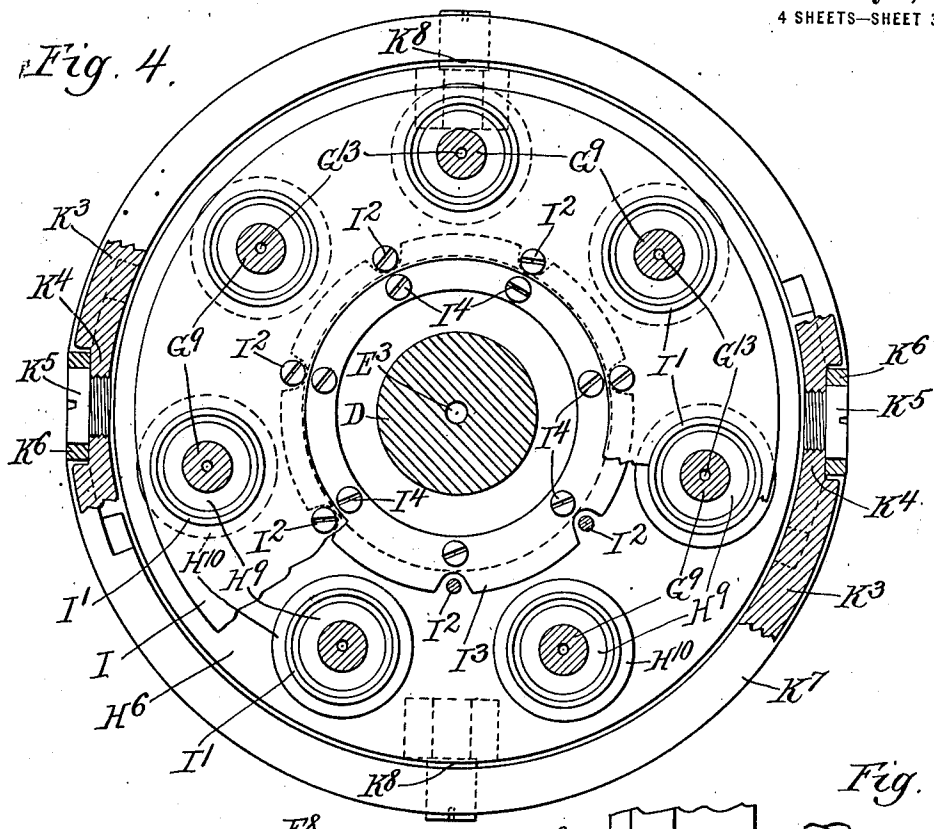


Fig. 5.

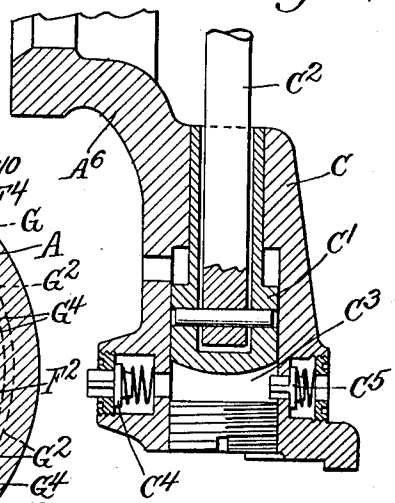
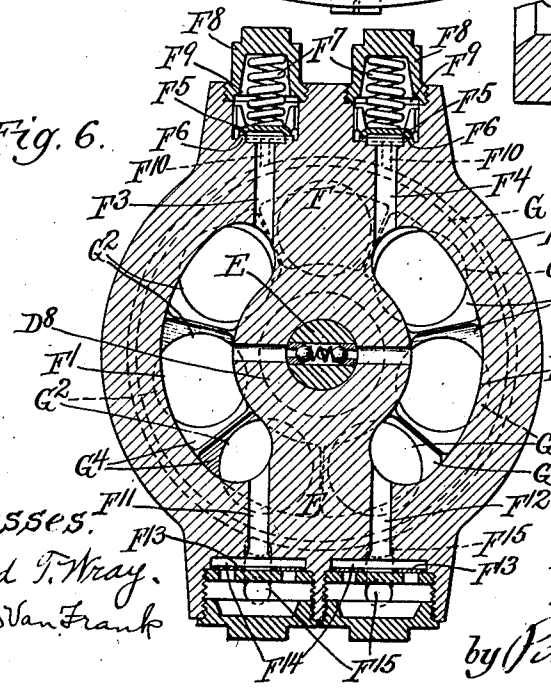


Fig. 6.



Witnesses.
Edward T. Wray.
Esther Van Frank

Inventors.
Walter Ferris.
William E. Magie.
by Parker & Co
Attorneys.

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4 SHEETS—SHEET 4.

Fig. 7.

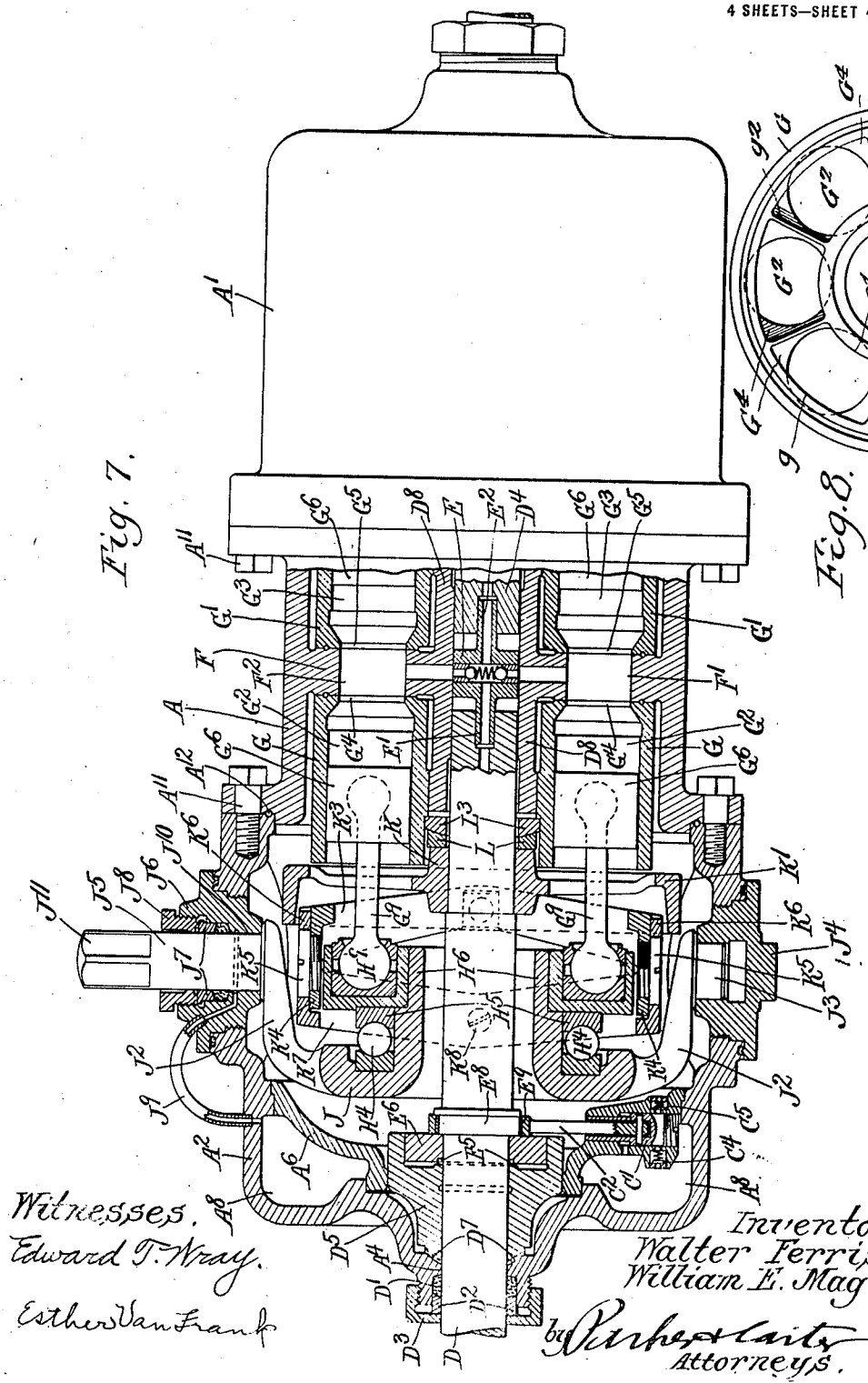


Fig. 8.

Witnesses.
Edward T. Wray.
Esther VanFrank

Inventors.
Walter Ferris.
William E. Magie.
by Parker & Carter
Attorneys.

UNITED STATES PATENT OFFICE.

WALTER FERRIS, OF MILWAUKEE, WISCONSIN, AND WILLIAM E. MAGIE, OF EVANSVILLE, INDIANA.

HYDRAULIC TRANSMISSION DEVICE.

1,308,844. Specification of Letters Patent. Patented July 8, 1919.

Application filed February 26, 1916. Serial No. 80,580.

To all whom it may concern:

Be it known that we, WALTER FERRIS and WILLIAM E. MAGIE, citizens of the United States, residing, respectively, at Milwaukee, Wisconsin, and Evansville, Indiana, have invented certain new and useful Improvements in Hydraulic Transmission Devices, of which the following is a specification.

Our invention relates, generally speaking, to improvements in hydraulic transmissions of the so-called axial type wherein the motor and pump cylinders and pistons are all arranged in groups axially about a central shaft.

In our preferred form of device the motor and pump together with the operating mechanism are all contained within a single housing. This housing forms what we prefer to call an operating chamber. Within it is a pressure chamber comprising the area occupied by the oil or liquid under pressure within the pump and motor cylinders, valve plates, ports and passages. A portion of the housing is given over to a reservoir or make-up chamber. This chamber is adapted to contain a certain amount of motive fluid in a condition of rest and means are provided for forcing this fluid from the make-up chamber back into the operating chamber either by the pump or hydrostatic pressure or otherwise. A pressure relief is provided for the operating chamber and the operating chamber is intended to be at all times completely filled with the motive fluid at a certain predetermined pressure. Any introduction of more fluid will only result in increased pressure and a controlled discharge from the operating chamber to the reservoir. Since the operating chamber is all the time full of the motive fluid, oil leakage from the main pump into the operating chamber immediately forces an equal quantity of oil back into the exhaust port, filling the cylinders communicating therewith. In our preferred form we provide a circulating pump which will constantly force a small supply of motive fluid from the reservoir into the working chamber and this supply will keep up the pressure to the desired point and keep the working chamber always filled. To permit this pump always to operate there must be a relief valve and this relief valve is set to keep a certain predetermined pressure in the valve chamber.

Our invention is illustrated more or less diagrammatically in the accompanying drawings, wherein

Figure 1 is a longitudinal section through the housing and parts contained therein with parts omitted;

Fig. 2 is a detail section on an enlarged scale showing part of the driving and swash plate connections;

Fig. 3 is a section on the line 3—3 of Fig. 2;

Fig. 4 is a section on the line 4—4 of Fig. 2;

Fig. 5 is an enlarged detailed section of the circulating pump;

Fig. 6 is a section on the line 6—6 of Fig. 1;

Fig. 7 is a part elevation and part section along a plane perpendicular to the plane of the section of Fig. 1; and

Fig. 8 is a section of the cylinder ports where they engage the valve plate.

Like parts are indicated by like letters throughout the several figures.

Housing.

The cylinder housing in which all the working parts are contained is made up of three separate sections rigidly fastened together to form a cylindrical working chamber. A is a central sleeve-like member which may be described as the valve housing. On one side of it is the motor housing A^1, on the other side the pump housing A^2. These two housings are, of course, wide open at the end abutting upon the valve housing but closed at the other end except for central axial apertures A^3, A^4. Curved annular walls A^5, A^6 in the ends of the housings A^1, A^2 form reservoirs or make-up chambers A^7, A^8. These reservoirs or make-up chambers may be regarded as one because they are connected by a pipe A^9, a portion of which is coiled as at A^{10} to provide a cooling or radiating surface whereby the temperature of the oil may be kept down below a certain predetermined danger point.

In the wall of the housing A^1 is a screw threaded adjustable plug B. This plug is in line with an aperture B^1 in the wall A^5 and slidably mounted within this aperture is a pressure relief valve B^2. This pressure relief valve is adapted to be yieldingly seated against the wall A^5 by the spring B^3, the

tension in which may be adjusted by a rotation of the plug B. The valve itself is made up of a plug in which are cut a series of slots B^4 increasing in width inwardly so that as the pressure in the main working chamber increases pressing back the valve against the spring any fluid in the housing will be free to pass out through these slots. The greater the pressure and the further the plug is moved the greater the effective opening through which such fluid or liquid may pass.

Formed in the wall A^6 is a circulating pump housing C. This pump is a single acting pump having a piston C^1 driven by a connecting rod C^2 reciprocating in a cylinder C^3 located in the housing C. C^4 is a spring seated intake valve, C^5 a spring seated exhaust valve so that as the pump reciprocates the oil is drawn from the reservoir A^8 through the intake valve C^4 into the cylinder C^3 and thence expelled through the exhaust valve C^5 to the interior of the working housing.

The housings A^1, A^2 are bolted to the housing A by means of the cap screws A^{11} as indicated. The flanges between these two housings are protected against leakage by the annular rings A^{12} and bleeder tubes leading therefrom through pipes A^{13} communicating with the pipe A^9, thus relieving the outer portion of the packing surface between these flanges from the direct pressure of the oil in the working chamber.

Operating shafts and supports.

D is a pump shaft projecting out through the aperture A^4 in the housing A^2 and suitably connected for driving with any desired prime mover not here shown. D^1 is a packing; D^2 a packing ring and D^3 a holding cap. D^4 is a motor shaft leading from the motor out through the aperture A^3 and adapted to deliver its power in any suitable manner. It also is packed as indicated at the other end of the machine. The shafts D and D^4 are each guided and supported adjacent the ends of the housing by the floating bearings D^5. These bearings have spherical ends as at D^6 engaging the spherical surface D^7 on the housing so that they will be free to move and adjust themselves for any bending or change in position of the shafts and prevent distortion of the parts and any binding or frictional losses. D^8 is a centrally disposed hub furnishing separate bearing surfaces for each of the shafts D, D^4. Contained within the center of this hub is a plug E. This plug E is longitudinally apertured and has at either end the pipes E^1, E^2 projecting into the ends of the shafts D, D^4 respectively. These shafts contain oil passages E^3 leading longitudinally from the ends of the pipes E^1, E^2 to transverse pipes E^4. These transverse pipes E^4 communicate each with annular chambers E^5 surrounding the shafts within the bearing blocks D^5. This annular chamber is formed within the blocks D^5 behind the slidable collar or plunger E^6. The slidable collar E^6 is in engagement with a shoulder E^7 on the shaft so that any oil forced in through the pipes E^3 and E^4 to the annular chamber will tend to force the shoulder on the shaft in one direction toward the hub and the bearing block in the other direction toward the spherical bearing surface. An eccentric E^8 is provided on the shaft D to drive by means of an eccentric collar E^9 the connecting rod C^2 to operate the circulating pump. The bearing on the shaft in the bearing block is lubricated by the off flow from this same tube and annular chamber and a bleeder pipe E^{10} leads from the bearing to permit run-off of excess oil and to prevent the full oil pressure from coming upon the packing sleeve at the end of the shaft. There is also a bleeder pipe E^{11} as indicated to permit out flow of oil from the space between the bearing block and the housing to the reservoir.

Valve plate and cylinder barrel assembly.

F is a valve disk or plate. It is as shown centrally located in and integral with the member A and carries the hub D^8. This valve plate has through it two crescent shaped ports F^1, F^2. These ports may each of them be either an intake or an exhaust port depending on the direction in which the machine is running. When one is an intake the other is always an exhaust port. F^3, F^4 are relief passages leading from the ports F^1, F^2 respectively. These passages are controlled each by a safety valve F^5 pressed upon a seat F^6 by the spring F^7 the tension in which may be adjusted by manipulation of the screw-threaded cap F^8. When the pressure is sufficiently great to raise this valve the liquid escapes into the valve chamber F^9 thence through the bleeder pipes F^{10} to the interior of the housing. F^{11}, F^{12} are oil return ducts communicating respectively with the ports F^1, F^2 and controlled each by the check valve F^{13}. This check valve works in a return chamber F^{14} fed by means of the ducts F^{15} from the interior of the housing so that when the pressure in one port rises above the safety point and the relief valve is unseated the oil thus forced into the housing will raise the pressure there and cause oil to be forced from the housing through the return valve into the opposed port, thus keeping the pressure chamber always completely filled.

G is a pump barrel, G^1 a motor barrel. These barrels are, generally speaking, similar one to the other. They are mounted for rotation each upon one arm of the hub D^8 and guided and supported thereon. Each

barrel contains seven cylinders. These cylinders G^2, G^3 are provided with ports G^4, G^5. These cylinder ports are made as large as is practicable and are preferably of equal or greater cross sectional area than the cylinder. They are as indicated somewhat longer measured in the line of movement than they are in a radial direction because this best utilizes the available space and because the area of contact between the barrel and valve plate is thus reduced to a minimum. They discharge each against the valve plate F and are of substantially the same width measured along a radial line as the ports F^1, F^2. These ports are controlled by, and discharged through, the valve plate F. In each cylinder is a piston G^6 free to move back and forth therein. These pistons contain each a spherical bearing G^7 in which sets a ball G^8 on the end of a connecting rod G^9. The ball is held against the bearing by a disk G^{10} having a spherical bearing thereupon. This disk is held in position by a follower nut G^{11} so as to hold the connecting rod firmly in position in proper relation to the piston. The center of the piston is apertured as at G^{12} in register with an oil duct G^{13} through the connecting rod. G^{14} is a coil spring anchored at one end in the piston G^6 and at the other end in the follower nut G^{11} so that as wear takes place on the spherical bearing the spring tends to rotate the follower nut to tighten it on the ball.

H is an annular ring formed on the wall A^5 inclined to the axis of rotation of the shaft, its center being so located as to bring its axis to an intersection with the shaft axis in the plane of the connecting rod sockets. On it rests a flanged guide sleeve H^1, the flange H^2 thereof containing the ball race H^3. H^4 are balls traveling along the ball race and supporting a movable ball race H^5. This ball race H^5 carries an annular channeled driving block ring H^6 guided on sleeve H^1 and containing spaced thereabout seven driving blocks H^7. These driving blocks form spherical bearing surfaces H^8 to engage the balls H^9 on the ends of the connecting rods G^9. These balls are held firmly seated on the spherical bearings by the follower rings H^{10} which are slidable toward and from the bottom of the block.

I is an annular spring plate having seven apertures therethrough which apertures are in engagement with the projecting flanges I^1 on the follower rings. This spring plate holds each and every one of the follower rings bound in position to clamp the ball ends of the connecting rods close in their sockets. This plate is held in position by a plurality of cap screws I^2 which pass through it and engage the ring H^6 at points removed from the follower rings so that the spring ring is not supported at those points and presses down thus transmitting yieldingly this pressure to the follower rings to hold them in position and thus by the yielding pressure of this plate each follower ring is caused to automatically follow up and compensate for any wear in the ball end. I^3 is a spring ring mounted on each of the sleeves H^1 and J and held rigidly thereon by the cap screws I^4. This spring ring overlies the channel ring H^6 and presses yieldingly against it and holds that ring yieldingly but firmly against the ball bearing.

The above description applies to both the pump and the motor ends of the apparatus, but the pump end is exactly the same except that the swash plate assembly consisting of the ball bearing, the annular ring and the blocks which drive the connecting rods, are mounted for rotation about an axis at right angles to the shaft, so as to permit adjustment of the stroke of the pump. No such adjustment of the motor is usually needed, and so the motor parts are shown fixed in position.

In the pump assembly then the bearing sleeve or quill J is substituted for the bearing sleeve H^1. This quill J is mounted on the yoke J^2, which yoke is provided with a pin J^3 pivoted in a bearing plug J^4 at one side of the housing A^2, and provided with a control shaft J^5 pivoted at a plug J^6 at the other side of the housing. J^7 is a packing ring, and J^8 a packing sleeve to prevent leakage of the oil along the shaft, the bleeder pipe J^9 discharging from a point inside the packing ring into the reservoir A^8, so that the pressure on the packing sleeve is only the pressure in the reservoir, the bearing J^{10} being thus lubricated by the oil escaping from the working chamber. The shaft J^5 is square as at J^{11} so that it may be manipulated by any suitable wrench, handle or the like to adjust the inclination of the swash plate and thus the stroke of the pump. J^{12} is a filler plug discharging into the reservoir A^8, whereby the supply of oil may be replenished. It will be noted that the axis of the shaft J^5 and pin J^3 intersects the pump shaft at the same point that the plane located by the centers of the outer end balls of the connecting rods, when the swash plate occupies a neutral position, intersect this shaft, so that no matter what the inclination of the yoke, the movement of the swash plate, whose plane is the plane above referred to, is symmetrical with respect to the pump shaft.

The parts interposed between the bearing sleeve J and the pistons G^6 are, of course, exactly the same as the parts interposed between the bearing sleeve H^1 and the piston G^6.

Universal joint.

In the operation of our machine, it is necessary that the swash plates rotate in unison

with the cylinder barrels, and since these barrels are mounted on the shafts as shown, a connection between the shafts and the swash plates is necessary. In the case of the pump, the angle of the swash plate is variable, and this connection must, therefore, be by means of some type of universal joint and this universal joint connection takes care of this inclination and permits a continuous drive. It is also important that the angular rotative position of the swash plate with respect to the shafts be fixed or constant, and since the ordinary or universal joint does not get this desired result, it is necessary to employ a special type of universal joint which will drive the driven part so that its angular position will always be the same with respect to the angular position of the driving part, that is to say, a universal joint which has what is called a constant velocity ratio.

K is a hub keyed to the shaft. It carries a spider K^1 having a flange K^2. On this flange is pivoted a warped ring K^3. This ring is trunnioned at k k' on two diametrically opposed sides on the flange K^2, and has on either side midway the trunnion points, a pivoted bearing K^4, to which is joined by means of the screw K^5 a pivoted bearing K^6 on a somewhat similar ring K^7. This ring is slightly smaller in diameter than the ring K^3, and is pivoted on opposed sides halfway between the pivoted bearing K^6 on pins K^8, which project from the ring H^6. Thus the two rings K^3 and K^7 are pivoted one on the swash plate, the other on the spider on the shaft, along two lines in the same plane. These two rings are also pivoted together along a line approximately perpendicular to this plane. There is also a slight axial movement of the parts and so to accommodate this the pivot block k' in which one side of the ring K^3 is pivoted, is mounted free to slide slightly in the flange K^2, thus insuring proper freedom of action.

The hub K, which carries the driver or spider K^1, is located partially within the cylinder barrel. This hub is, of course, keyed to the shaft, and has resting against it an annular washer L surrounding the shaft. This washer has a spherical surface L^1 in engagement with a spherical surface L^2 on a compensating washer L^3, which is supported by the cylinder barrel. Thus the thrust of the shaft operates to hold the cylinder barrel firmly and snugly against the valve plate, independent of any distortion or displacement of the shafts. The barrels themselves are driven in unison with the driver by pins L^4 projecting therefrom in engagement with the yokes L^5 on the driver.

Resumé.

The pressure chamber, as above pointed out, comprises the spaces between the pistons and the valve faces on the pressure side in pump cylinders and motor cylinders; the volume of the main ports in the valve plate, the auxiliary ports to the double check valves, the passages E^3 in shafts, and the pressure chambers back of the plungers E^6 on said shafts. All of the leakage from this pressure system goes either directly into the operating chamber past the pistons and valve faces or is returned thereto after leaking from the pressure chamber, along the ducts or between the bearings or past the collars or plungers E^6, as the case may be.

The operating chamber or inner casing is the space containing the cylinders, valve plate, universal joints and thrust bearings, and is characterized by the fact that it is filled solidly full of oil during operation and when circulating pump is used is supplied either with an expansion diaphragm or other expansion member or a relief valve to accommodate expansion of oil by temperature; and has a make-up opening communicating with make-up reservoir, and submerged beneath the oil level in that reservoir. The operating chamber also includes return ducts which receive the leakage around the shaft from pressure chambers back of plungers E^6 and return it to the main operating chamber, thus relieving the circulating pump from the work of returning this leakage from the reservoir system. The piston and cylinders are of uniform size and stroke, and the ports of the valve plate of equal size, and opposite each other. They are so placed as to insure the division of the operating chamber into zones of high and low pressure of equal size. This is the case since the valve ports are disposed at equal distances on either side of a line through the center of the valve plate, and at right angles to the axis of rotation of the piston controlling ring. The reservoir or make-up chamber is in this case divided into two sections A^7 A^8, one at each end of the machine, and connected by an exterior pipe. The reservoir is characterized by the fact that it is normally partly full of oil, the remainder being filled with gaseous material, capable of accommodating oil expansion, the pressure being lower than in the operating chamber. The pressure in the reservoir may be substantially the same as that in the operating chamber if the machine is built without a circulating pump; or the operating chamber pressure may be considerably higher than the reservoir pressure, this increase being incidental to the operation of the circulating pump. The reservoir system also comprises the leakage return ducts near the ends of the main shafts, the end of the operating shaft, from the flanged joints, and the return pipe from the auxiliary or relief valve reservoir to main or pump reservoir. Ducts receive the leakage from the

operating chamber system along the main shaft and operating shaft, and return it directly to the main reservoir, thus relieving the shaft packings from the work of holding back the pressure of the operating chamber. The shaft packings are therefore only subjected to reservoir pressure, which in most cases will approximate atmosphere pressure, or may be lower.

From the above it appears that the entire casing is divided into three zones of pressure. The leakage from each higher zone passing automatically into the next lower zone. The packings around the external shaft openings only have to hold the pressure of the lowest or reservoir zone. The leakage is automatically returned from the lowest pressure zone into the next pressure zone or operating chamber by the expansive pressure of the gas or air which occupies part of the reservoir system or by the circulating pump when the circulating pump is used. This circulating pump will also serve to augment the pressure in the operating chamber when so desired. Certain advantages in the operation of the machine can be attained by a gradual circulation of the oil from the reservoir into the operating chamber and back again. These advantages lie principally in giving each fraction of the oil in turn an opportunity to leave the operating chamber, where it is violently agitated, and spend some time in the reservoir, where it is practically at rest and has a chance to deposit any solid matter held in suspension, and to free itself from entrained air. This circulation is maintained by means of the plunger pump of small capacity and in this case operated by the eccentric formed on the main pump shaft. At each stroke this pump transfers a small quantity of oil from reservoir to operating chamber through the check valves and an equal quantity is forced out of the operating chamber through the relief valve, returning to the main reservoir through the connecting pipe. An additional advantage of this circulating system is the cooling effect of the exterior pipe, which, if desired, may be expanded into coils or a radiator A^{10}, thereby radiating any necessary amount of heat from the oil. Certain other advantages may be gained by carrying a comparatively high pressure in the operating chamber. This merely requires additional spring pressure on the relief valve B^2. It is also advisable to design the relief valve in this case as a plunger having ports of graduated area. By adjusting the spring the desired pressure is automatically maintained in the operating chamber and the plunger moves inward during each period when pump plunger is not delivering oil to the operating chamber, the plunger thereby maintaining the pressure practically uniform, notwithstanding intermittent delivery of pump. The advantages of this pressure system comprise better lubrication due to initial pressure on edges of oil films; reduction in necessary size of leakage return ducts whereby leakage past main piston and valve seats is returned to pressure chamber; suppression of tendency in oil to volatilize under high temperature, thereby preventing formation of gas bubbles. The ports G^4, G^5 in the ends of cylinders preferably have equal or greater area than the cross section of cylinders themselves. This provides large port area, thereby permitting great speed and great efficiency. In order to compensate for the enlarged ports which prevent pistons from holding cylinder barrel against valve seat, we introduce plungers integral with shaft and closely fitting in the pressure chambers, which are formed in the self-alining shaft bearings. The driving pressure is automatically maintained in these pressure chambers through ducts in the shafts and the check valve therein. The shafts are mounted in self-alining end bearings which permit a close fit between shaft and bearing to prevent excessive oil leakage from the pressure chambers, and at the same time prevent cramping in bearings due to slight shaft deflections. The drivers K^1 are keyed to the shafts behind the end thrust shoulders and the balance pressure from the chambers E^5 is communicated to the barrels G-G^1 through pairs of compensating washers L^1 L^3. This gives perfect valve face bearing independent of shaft deflections. The barrels are compelled to rotate with the driver by the driving pins L^4 which transmit only the torque of valve face friction. The compound universal joint consists in a driver and a driven ring, each carrying a pair of pins on the transverse axes respectively. On these two pairs of pins are respectively mounted two connecting rings. These connecting rings are pin connected together on a transverse axis which intersects the axis of the shaft to which the driver is connected and is preferably perpendicular to the planes of the axes of the driving and driven rings when they occupy neutral positions. The plane in which this transverse axis revolves bisects the angle between the shaft and swash plate axes. There is a slight axial motion as the joint revolves which in the present invention is permitted by a small sliding movement of a sliding block at one trunnion at the lower side of the ring thus preventing binding or distortion. In order to take up all wear in the driving parts, and to prevent backlash to as great an extent as possible, it is necessary to provide means for holding the ball ends of the connecting rods firmly back in the pistons or in the driving blocks on the swash plates. The blocks and the swash plate all rotate, but in the same plane are held by a single annular plate I of spring brass or

spring steel, having seven equally pitched holes which are slipped over projecting flanges on the follower rings which hold the ball ends of the connecting rods close into the sockets. This plate is held down by seven screws which are tapped into the socket ring. These screws pass through the spring plate at points between the connecting rods where the plate is unsupported and the screws spring the plate sufficiently to cause it to automatically follow up any wear in the ball ends, or in the sockets. The arrangement for following up the wear in balls or sockets at the piston ends of the connecting rods is obtained by the spring latches, consisting of a single coil of spring wire G^{14}, one end of which is hooked into a drilled hole in the piston, while the other end engages a drilled hole in the follower nut. This spring wire keeps the follower nut continually screwed up tight. In order to hold the socket ring H^6 in position on the bearings, a spring ring I^3 is secured to the bearing quill or sleeve J. The end of this bearing quill is faced off slightly shorter than the corresponding face on the socket ring, thereby giving the spring ring a deflection which always holds the socket ring tightly back against the ball thrust bearings. These three devices, which together we term a spring harness, absolutely prevent any backlash in the movement of the pistons. With this arrangement there is no excess pressure in the exhaust port to keep the pistons forced outward, and the spring harness supplies this need. This is a distinguishing point between the present system of returning leakage by casing pressure and the system of returning leakage by a pump, which has been embodied in various other machines.

Referring again to Fig. 6, it will be noted that the ports or terminations of the discharge passages G^4 leading from the cylinders to the valve plate form segments of a ring bounded by two concentric circles g, g', each segment being separated from its neighbor on either side by a thin partition wall bounded by adjacent radial lines, g^2. Each port thus has two straight and two curved sides, the straight sides radiating from the center of the valve plate, and the curved sides formed by concentric circles drawn about the center of the valve plate. Each port resembles in shape a truncated pie segment. The opposed surfaces between the outer rim of the valve face and the concentric circle forming the outer side of the ports, constitute an oil seal. The distance between the two surfaces must not be any greater than is absolutely necessary to prevent the too rapid leakage along the sealing surfaces. The circles bounding the outside and the inside of the valve plate port are of equal diameter with those bounding the cylinder ports and are drawn about the same center. There is an appreciable pressure in the film of oil forced out between these surfaces and this pressure tends to wedge the cylinder barrel away from the plate so that the smaller the surface the smaller the wedging effect. The substantially radial lines bounding the ends of the ports are about the same distance apart as the concentric lines above mentioned, so that the oil seal at the ends of the ports is substantially the same as at the side. When once the necessary width of surface to provide an adequate oil seal has been determined, and when once the area of the ports and the cylinder passages have been selected, the remainder of the valve seat must be made to conform in such wise that for any given mean radius of the valve ports, and for any given oil seal width, the port bounded as described will give the maximum possible port area and the minimum possible unbalanced wedging area. It will be understood that the unbalanced wedging or thrust area forming a part of the oil seal supports a pressure which must be overcome by some suitable external or internal means, as preferably the balancing plunger described at another place.

We claim:

1. A hydraulic transmission comprising a motor and a pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said closed housing completely full of oil under pressure.

2. A hydraulic transmission comprising a motor and a pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said closed housing completely full of oil under pressure, a connection between said pressure chamber and said housing, and means responsive to the operation of motor and pump for controlling said connection.

3. A hydraulic transmission comprising a motor and a pump, a circulating system connecting them having a pressure and a suction side, a closed housing surrounding them, and means for keeping the closed housing constantly full of oil under pressure, separate connections between the pressure and suction sides of the circulating system and the housing, and means for controlling them.

4. A hydraulic transmission comprising a motor and a pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said closed housing completely full of oil under pressure, a connection between said pressure chamber and said housing, and means responsive to the operation of motor and pump for controlling said connection, said means comprising a series of passages, a

pressure relief valve controlling one of them and a check valve controlling another.

5. A hydraulic transmission comprising a motor and a pump, a circulating system connecting them having a pressure and a suction side, a closed housing surrounding them, and means for keeping the closed housing constantly full of oil under pressure, separate connections between the pressure and suction sides of the circulating system and the housing, and means for controlling them, said means comprising a series of passages, a pressure relief valve controlling one of them, and a check valve controlling another.

6. A hydraulic transmission comprising a motor and a pump, a circulating system connecting them having a pressure and a suction side, a closed housing surrounding them, and means for keeping the closed housing constantly full of oil under pressure, separate connections between the pressure and suction sides of the circulating system and the housing, and means for controlling them, said means comprising passages leading from the pressure and suction sides, a relief valve controlling the passage from the pressure side, and a check valve controlling the passage from the suction side.

7. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing independent of conditions in the pressure chamber.

8. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing independent of conditions in the pressure chamber, said means comprising a reservoir and means for pumping oil from the reservoir into said housing.

9. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing independent of conditions in the pressure chamber, said means comprising a reservoir and means for pumping oil from the reservoir into said housing, and pressure relief means discharging from said housing to said reservoir.

10. In a hydraulic transmission a fixed valve plate, a cylinder barrel mounted for rotation having its discharge end closed by said plate, cylinders contained within said barrel, discharge ports leading from said cylinders to the plate larger in cross sectional area than the cylinders, and means removed from the barrel for holding it against the plate.

11. In a hydraulic transmission a valve plate, a cylinder barrel mounted for rotation with respect to said plate, discharge ports leading from the cylinders therein and controlled by the valve plate said cylinder ports being larger in cross sectional area than the respective cylinders, means for maintaining a hydraulic pressure within such cylinders and plate, and means responsive to such pressure for holding the cylinders firmly against the plate.

12. In a hydraulic transmission a valve plate, a cylinder barrel mounted for rotation with respect to said plate, discharge ports leading from the cylinders therein and controlled by the valve plate said cylinder ports being larger in cross sectional area than the respective cylinders, means for maintaining a hydraulic pressure within such cylinders and plate, and means responsive to such pressure for holding the cylinders against the plate, said means comprising a plunger, a connection between the plunger and the barrel, a cylinder in which said plunger operates, and a connection from the pressure system to said cylinder.

13. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing independent of conditions in the pressure chamber, said means comprising a reservoir and means for pumping oil from the reservoir into said housing, and pressure relief means discharging from said housing to said reservoir, said pressure relief being provided with means responsive to variations in the pressure of the oil in the housing for controlling the amount of oil discharged therethrough.

14. In a hydraulic transmission a fixed valve plate, a cylinder barrel mounted for rotation having its discharge end closed by said plate, cylinders contained within said barrel, discharge ports leading from said cylinders to the plate larger in cross sectional area than the cylinders, and means removed from the barrel for holding it against the plate responsive to conditions prevailing within the cylinders.

15. In a hydraulic transmission a fixed valve plate, a cylinder barrel mounted for rotation having its discharge end closed by said plate, cylinders contained within said barrel, discharge ports leading from said cylinders to the plate larger in cross sectional area than the cylinders, and yielding means for holding the barrel against the plate.

16. In a hydraulic transmission, a fixed valve plate, a cylinder barrel mounted for rotation having its discharge end closed by said plate, cylinders contained within said barrel, discharge ports leading from said cylinders to the plate larger in cross sectional area than the cylinders, and hydraulic means for holding the barrel against the plate.

17. A hydraulic transmission comprising a valve plate having ports serving alternately as intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto and having its discharge end closed and controlled thereby, a shaft concentric with the barrel and having driving connection therewith, pistons and means for reciprocating them within the cylinder barrel as the shaft and barrel are rotated, and hydraulic means removed from the barrel for yieldingly holding it against the plate, the shaft being perforated and communicating respectively with the ports of the valve plate and with the said hydraulic means whereby pressure for operating the latter is taken from the pressure port of the valve plate through the shaft.

18. A hydraulic transmission comprising a valve plate having ports serving alternately as intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto and having its discharge end closed and controlled thereby, a shaft concentric with the barrel and having driving connection therewith, pistons and means for reciprocating them within the cylinder barrel as the shaft and barrel are rotated, hydraulic means removed from the barrel for yieldingly holding it against the plate, the shaft being perforated and communicating respectively with the ports of the valve plate and with the said hydraulic means whereby pressure for operating the latter is taken from the pressure port of the valve plate through the shaft, and valve means for selectively closing the connection with the exhaust port of the valve plate and opening that with the pressure port.

19. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders of greater diameter than the radial width of the ports leading from said cylinders to said ports in the valve plate, said cylinder ports where they discharge into the valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles and narrow dividing walls between said cylinder ports.

20. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders of greater diameter than the radial width of the valve plate ports, cylinder ports, leading from the cylinders to the valve plate, such ports where they discharge into valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles.

21. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders and ports leading from said cylinders to said valve plate ports, said cylinder ports where they discharge into the valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles and narrow dividing walls between said ports.

22. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders and ports leading from said cylinders to the valve plate ports, said cylinder ports where they discharge into the valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles.

23. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders of greater diameter than the radial width of the ports and ports leading from said cylinders to the valve plate ports, said cylinder ports where they discharge into the valve plate ports being of substantially the same radial width as such ports and being rounded at their ends by radial lines and at their sides by concentric circles and narrow dividing walls between said ports, the cross sectional area of each cylinder port at the point where it is intersected by the plane of the valve plate being larger than the cross sectional area of its respective cylinder.

24. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders of greater diameter than the radial width of the ports and ports leading from said cylinders to the valve plate ports, said cylinder ports where

they discharge into the valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles, the cross sectional area of each cylinder port at the point where it is intersected by the plane of the valve plate being larger than the cross sectional area of its respective cylinder.

25. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders and ports leading from said cylinders to the valve plate ports, said cylinder ports where they discharge into the valve plate ports being of substantially the same radial width as such ports and being bounded at their ends by radial lines and at their sides by concentric circles and narrow dividing walls between said cylinder ports, the cross sectional area of each cylinder port at the point where it is intersected by the plane of the valve plate being larger than the cross sectional area of its respective cylinder.

26. A hydraulic machine comprising a valve plate having annularly arranged intake and exhaust ports, a cylinder barrel mounted for rotation with respect thereto having axially arranged cylinders and ports where they discharge into the valve plate ports of substantially the same radial width as the valve plate ports and being bounded at their ends by radial lines and at their sides by concentric circles, the cross sectional area of each cylinder port at the point where it is intersected by the plane of the valve plate being larger than the cross sectional area of its respective cylinder.

27. In a hydraulic transmission having pump cylinders, pistons therein and means for operating them, motor cylinders, pistons therein and a member driven thereby, an oil-tight housing containing the cylinders and moving parts, a reservoir in communication with said housing and means responsive to the operating means of the pump cylinders for forcing fluid from said reservoir into said housing.

28. In a hydraulic transmission having pump cylinders, pistons therein and means for operating them, motor cylinders, pistons therein and a member driven thereby, an oil-tight housing containing the cylinders and moving parts, a reservoir in communication with said housing and means responsive to the operation of the pump cylinders for forcing fluid from said reservoir into said housing and a pressure relief discharge valve controlling the discharge of fluid from said housing back to said reservoir.

29. A hydraulic transmission comprising a closed chamber, power transmitting means contained therein, a housing comprising a series of separate assembly casing parts and means for holding them together, packing surfaces between them, said housing containing the chamber, a reservoir also within said housing, bleeder passages disposed within said packing surfaces between the pressure side and the holding means and connections between said bleeder passages and the reservoir.

30. A hydraulic transmission comprising a closed chamber, power transmitting means contained therein, a housing comprising a series of separate assembly casing parts and means for holding them together, packing surfaces between them, said housing containing the chamber, a reservoir also within said housing, bleeder passages disposed within said packing surfaces between the pressure side and the holding means and connections between said bleeder passages and the reservoir and means for forcing oil from said reservoir into said closed chamber.

31. A hydraulic transmission comprising a closed chamber, power transmitting means contained therein, a housing comprising a series of separated assembly casing parts and means for holding them together, packing surfaces between them, said housing containing the chamber, a reservoir also within said housing, bleeder passages disposed within said packing surfaces between the pressure side and the holding means and connections between said bleeder passages and the reservoir and means for forcing oil from said reservoir into said closed chamber and means for controlling the discharge of oil from said closed chamber back to said reservoir.

32. In a hydraulic machine a valve plate, a sleeve projecting therefrom, a shaft rotatably mounted therein, a cylinder barrel rotatably mounted thereon, a housing for the shaft, sleeve and barrel, a thrust bearing interposed between said shaft and said housing and a thrust connection between said shaft and said cylinder barrel.

33. In a hydraulic machine a valve plate, a sleeve projecting therefrom, a shaft rotatably mounted therein, a cylinder barrel rotatably mounted thereon, a housing for the shaft, sleeve and barrel, a thrust bearing interposed between said shaft and said housing and a thrust connection between said shaft and said cylinder barrel, said thrust connection and thrust bearing each having spherical bearing surfaces to permit relative displacement of the parts without binding.

34. In a hydraulic machine an apertured valve plate, a sleeve projecting outwardly therefrom, a hollow shaft rotatably mount-

ed therein, a cylinder barrel rotatably mounted on the sleeve, a connection between the apertures in the valve plate and the interior of the hollow shaft, a thrust plunger mounted on said shaft, a cylinder in which it is mounted, a connection between the cylinder and the interior of the shaft and a thrust connection between the shaft and the cylinder barrel.

35. In a hydraulic machine a packing joint between opposed members comprising smooth contacting surfaces means for holding said surfaces together the joint between said members being exposed on one side to a high and on the other side to a low pressure a bleeding duct located between such surfaces and thus between the areas of high and low pressure and a bleeder pipe communicating with such duct a storage reservoir in which such pipe discharges.

36. A housing, a shaft therein, a sleeve in rotatable engagement with the shaft, a cylinder therein, a self-alining bearing between the sleeve and the housing, a plunger mounted on the shaft in said cylinder and means for exerting a pressure within said cylinder against said plunger.

37. In a hydraulic transmission a valve plate having exhaust and intake ports, a hub centrally supported by said plate, hollow shafts contained rotatably within said hub, a plug within said hub between the ends of said shafts, a passage connecting said plug and each of said ports, tubular members extending from said plug and projecting into the ends of each of said shafts, said shafts being hollow, plungers on said shafts, thrust cylinders surrounding said shafts in which said plungers are located and a communication between the interior of said shafts and the interior of said cylinders.

38. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing.

39. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing, said means comprising a reservoir and means for pumping oil from the reservoir into said housing.

40. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing, said means comprising a reservoir and means for pumping oil from the reservoir into said housing, and pressure relief means discharging from said housing to said reservoir.

41. A hydraulic transmission comprising a motor and pump, a pressure chamber contained within and connecting them, a closed housing surrounding them, and means for keeping said housing constantly full of oil under pressure, and for circulating said oil through said housing, said means comprising a reservoir and means for pumping oil from the reservoir into said housing, and pressure relief means discharging from said housing to said reservoir, said pressure relief being provided with means responsive to variations in the pressure of the oil in the housing for controlling the amount of oil discharged therethrough.

42. In a hydraulic transmission a fixed ported valve plate, a cylinder barrel mounted for rotation thereon containing a plurality of cylinders and discharge passages leading therefrom, said passages extending to and controlled by the valve plate, pistons and means for reciprocating them within said cylinders toward and from the valve plate, the relative areas of the cylinders, the discharge passages at the valve plate and the bearing surfaces between the barrel and the plate being such that the force exerted by the pistons is insufficient to hold the barrel firmly against the plate and separate pressure controlled means for holding the barrel firmly against the plate.

43. In a hydraulic transmission a fixed ported valve plate, a cylinder barrel mounted for rotation thereon containing a plurality of cylinders and discharge passages leading therefrom, said passages extending to and controlled by the valve plate, pistons and means for reciprocating them within said cylinders toward and from the valve plate, the relative areas of the cylinders, the discharge passages at the valve plate and the bearing surfaces between the barrel and the plate being such that the force exerted by the pistons is insufficient to hold the barrel firmly against the plate, means separate from the cylinder barrel for holding it against the valve plate.

44. In a hydraulic transmission a fixed ported valve plate, a cylinder barrel mounted for rotation thereon containing a plurality of cylinders and discharge passages leading therefrom, said passages extending to and controlled by the valve plate, pistons and means for reciprocating them within said cylinders toward and from the valve plate, the relative areas of the cylinders, the discharge passages at the valve plate and the bearing surfaces between the barrel and the

plate being such that the force exerted by the pistons is insufficient to hold the barrel firmly against the plate, hydraulic means separate from the cylinder barrel for holding it against the valve plate.

45. In a hydraulic transmission a fixed ported valve plate, a cylinder barrel mounted for rotation thereon containing a plurality of cylinders and discharge passages leading therefrom, said passages extending to and controlled by the valve plate, pistons and means for reciprocating them within said cylinders toward and from the valve plate, the relative areas of the cylinders, the discharge passages at the valve plate and the bearing surfaces between the barrel and the plate being such that the force exerted by the pistons is insufficient to hold the barrel firmly against the plate, hydraulic means responsive to the conditions prevailing within the cylinders and associate parts for holding the cylinder barrel firmly against the valve plate.

46. In a hydraulic transmission a fixed ported valve plate, a cylinder barrel mounted for rotation thereon containing a plurality of cylinders and discharge passages leading therefrom, said passages extending to and controlled by the valve plate, pistons and means for reciprocating them within said cylinders toward and from the valve plate, the relative areas of the cylinders, the discharge passages at the valve plate and the bearing surfaces between the barrel and the plate being such that the force exerted by the pistons is insufficient to hold the barrel firmly against the plate, hydraulic means responsive to the conditions prevailing within the cylinders and associate parts for holding the cylinder barrel firmly against the valve plate, said means comprising a plunger, a cylinder in which it is mounted, a hydraulic connection between the interior of said cylinder and the interior of the cylinder barrel.

47. In a hydraulic transmission a hydraulic system comprising a ported valve plate, a cylinder barrel, a shaft about which the barrel is mounted, and in response to which it turns and operating members mounted for movement within said cylinder barrel, means surrounding said shaft removed from the barrel but communicating therewith, for holding the barrel against the valve plate, said means comprising a plunger, a cylinder in which it reciprocates, a communication between such means and the system comprising a central channel through the said shaft through which hydraulic pressure is transmitted from the system to the cylinder.

48. In a hydraulic transmission a fixed valve plate with ports formed therein and a valve face, a cylinder barrel mounted for rotation on the valve plate and having its discharge end closed by said valve face, cylinders contained within said barrel and having discharge passages leading to valve face, said discharge passages, ports and valve face being so large that hydraulic pressure within the cylinders will not hold the barrel against the valve face, and means removed from the barrel for holding barrel against the valve face.

49. A hydraulic transmission comprising a valve plate having an annular valve face with ports therein, a cylinder barrel having a corresponding annular valve face, axially arranged cylinders, with means for forcing fluid under hydraulic pressure from the cylinders and valve ports, the valve faces being of such area that the hydraulic pressure within the cylinders is not sufficient to maintain them in contact, auxiliary means for maintaining valve faces in contact and cylinder ports from the respective cylinders to the valve face bounded at their ends by concentric circles and radial lines, whereby the maximum port area is obtained with the minimum valve seat area, equal widths of oil seal surfaces being maintained all around each cylinder port.

50. A hydraulic transmission comprising a valve plate having an annular valve face with ports therein, a cylinder barrel having a corresponding annular valve face, axially arranged cylinders, with means for forcing fluid under hydraulic pressure from the cylinders and valve ports, the valve faces being of such area that the hydraulic pressure within the cylinders is not sufficient to maintain them in contact and cylinder ports from the respective cylinders to the valve face bounded at their ends by concentric circles and radial lines, whereby the maximum port area is obtained with the minimum valve seat area, equal widths of oil seal surfaces being maintained all around each cylinder port, the width of the oil seal surfaces being sufficient only to prevent appreciable outflow of oil.

51. A hydraulic transmission having a rotary cylinder barrel, a driver secured thereto and swash plate, a universal driving joint for the swash plate comprising two rings articulated respectively to the barrel controlling driver and swash plate and articulated to each other on an axis transverse to the axes of articulation between the rings and the barrel and swash plate.

52. A hydraulic transmission having a swash plate and cylinder barrel and means comprising a shaft, a driver secured to the shaft and directly driving the barrel and a universal joint between the driver and swash plate for driving one from the other at a constant angular velocity.

53. A hydraulic transmission having a

driving and a driven part, a connecting rod interposed between them mounted for universal movement and means for yieldingly holding the bearing end of said connecting rod to prevent backlash.

54. A piston, a cylinder in which it reciprocates, a driving member, a connecting rod interposed between the driving member and the cylinder, a spherical bearing at one end of the connecting rod and means for holding said spherical bearing yieldingly in snug operative position.

55. A driving member comprising a rotary swash plate, a series of bearing blocks therein, a series of connecting rods mounted one in each of said bearing blocks and a spring harness mounted in the driving member for yieldingly taking up the backlash between the bearing blocks and the connecting rod ends.

56. A hydraulic transmission having an oil tight housing, joints in the wall of said housing, bleeder ducts within said joints, a reservoir outside of said housing, pipes leading from said bleeder ducts to said reservoir, means for pumping a fluid from said reservoir into said housing and maintaining a predetermined pressure within said housing.

57. A hydraulic tranmission having an oil tight housing, joints in the wall of said housing, bleeder ducts within said joints, a reservoir outside of said housing, pipes leading from said bleeder ducts to said reservoir, means for pumping a fluid from said reservoir into said housing and maintaining a predetermined pressure within said housing and means for cooling oil during its passage through said pipes.

58. A hydraulic tranmission mechanism, having a power pump mounted in a closed operating chamber, said pump comprising a high pressure port, a low pressure port and a passage from operating chamber into said low pressure port whereby leakage from the high pressure port and cylinders communicating therewith is returned into the low pressure port and means for maintaining pressure in the operating chamber.

59. A hydraulic transmission mechanism, having a power pump mounted in a closed operating chamber, said pump comprising a high pressure port, a low pressure port and a passage from operating chamber into said low pressure port whereby leakage from the high pressure port and cylinders communicating therewith is forced back into the low pressure port and means for maintaining pressure in the operating chamber.

60. A hydraulic transmission, having a power pump mounted in a closed operating chamber, said pump comprising a high pressure port and a group of cylinders communicating therewith, a low pressure port and a group of cylinders communicating therewith, and a passage from operating chamber into said low pressure port through which leakage from the high pressure port and cylinders is forced to return into the low pressure port and means for maintaining pressure in the operating chamber.

61. A hydraulic transmission, having a power pump mounted in a closed operating chamber, said pump comprising a high pressure port and a group of cylinders communicating therewith, a low pressure port and a group of cylinders communicating therewith, and a passage from operating chamber into said low pressure port through which leakage from the high pressure port and cylinders is returned into the low pressure port and means for maintaining pressure in the operating chamber.

62. A hydraulic transmission mechanism, having a power pump mounted in a closed operating chamber, said pump comprising a high pressure port and a plunger, driving mechanism and a connecting rod, a low pressure port, a passage from operating chamber to low pressure port and spring harness to prevent back-lash in the plunger movement, whereby the excess of pressure in the operating chamber above pressure in low pressure port necessary to force the leakage into the low pressure port may be maintained without causing loss of plunger movement.

63. In a hydraulic transmission mechanism, a casing dividing the contained liquid into three zones of varying pressure, a power pump operating in the high pressure and intermediate pressure zones, and another pump operating between the intermediate pressure and lower pressure zone, said pump adapted to maintain the pressure in the intermediate pressure zone.

64. A hydraulic transmission mechanism, comprising a casing, a power pump and an auxiliary pump, so arranged that the contained liquid is separated into three pressure zones, the total combined volume of the highest and intermediate pressure zone being constant and limited by a closed operating chamber, means whereby the leakage from the highest to the intermediate pressure zone is automatically returned, and means for maintaining the pressure in the intermediate zone.

65. A hydraulic transmission mechanism comprising a casing, a power pump and an auxiliary pump, so arranged that the contained liquid is separated into three pressure zones, the total combined volume of the highest and intermediate pressure zones being constant and limited by a closed operating chamber, and an auxiliary pump adapted to return the leakage from the lowest

pressure zone to the intermediate pressure zone, and adapted thereby to maintain the pressure in the intermediate pressure zone.

66. In a hydraulic transmission, a casing dividing the contained liquid into three zones of varying pressures, a power pump operating in the high pressure and intermediate pressure zone, and another pump operating between the intermediate pressure and low pressure zone, and a wall between said intermediate and low pressure zone, said wall being pierced only by leakage passages and by the auxiliary pump passage.

Signed at Milwaukee, county of Milwaukee and State of Wisconsin, this 7 day of February, 1916.

WALTER FERRIS.

In the presence of witnesses:
GEO. H. RONDEAU,
KATHRYN O'CONNELL.

Signed at South Milwaukee, county of Milwaukee and State of Wisconsin, this 7 day of February, 1916.

WILLIAM E. MAGIE.

In the presence of witnesses:
GEO. H. RONDEAU,
KATHRYN O'CONNELL.