Aug. 29, 1950 J. GREENHUT 2,520,632

HYDRAULIC PUMP OR MOTOR

Filed March 22, 1945 4 Sheets-Sheet 1

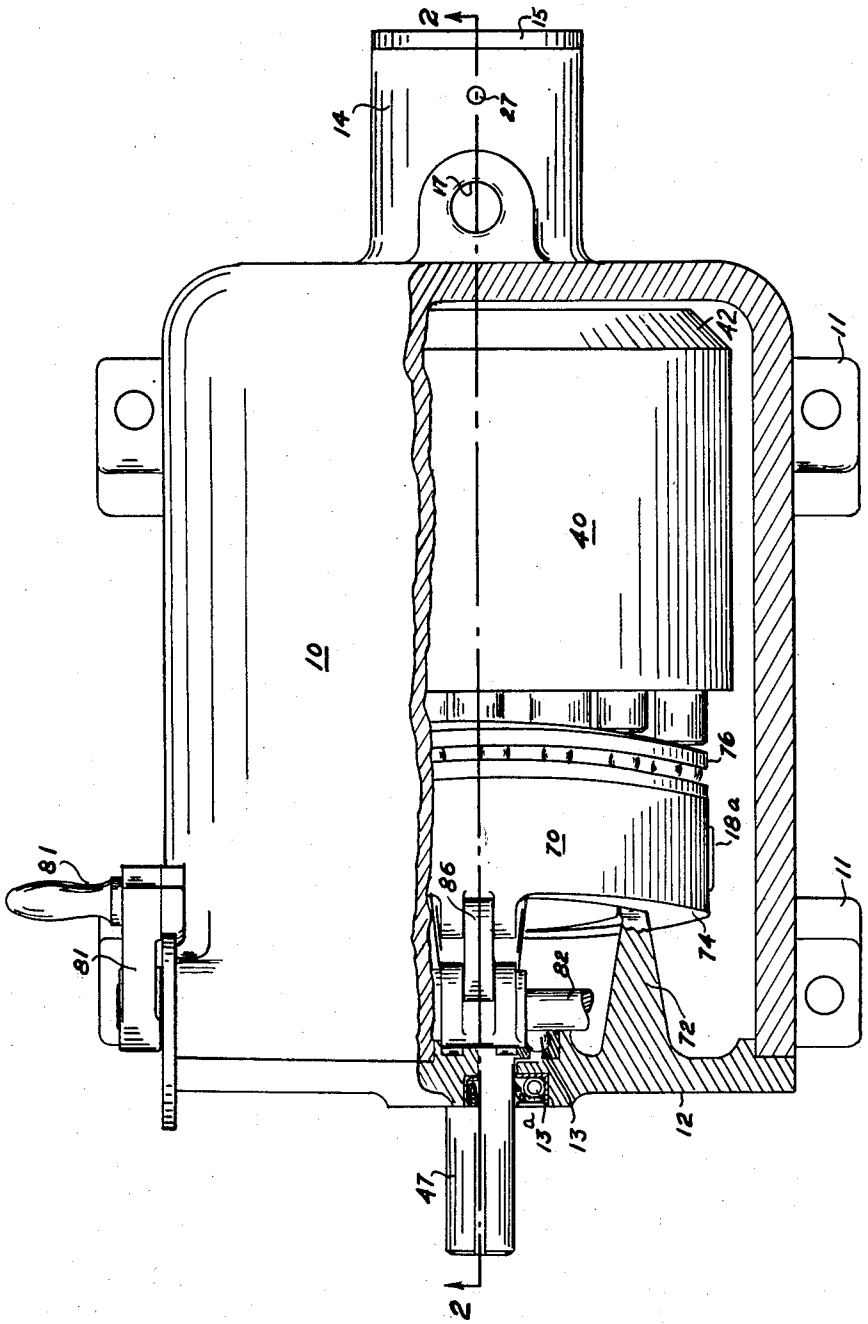


Fig 1

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HYDRAULIC PUMP OR MOTOR

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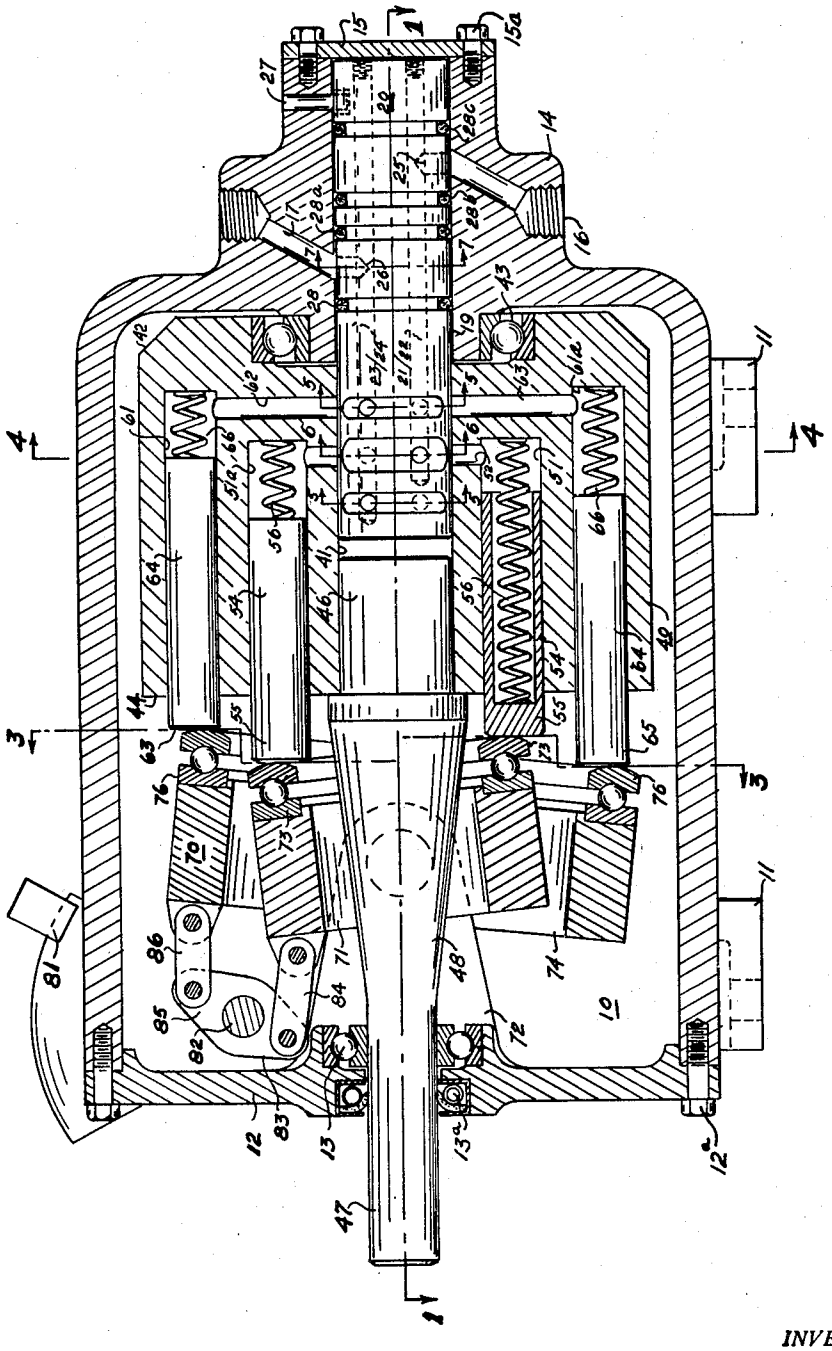


Fig 2

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HYDRAULIC PUMP OR MOTOR

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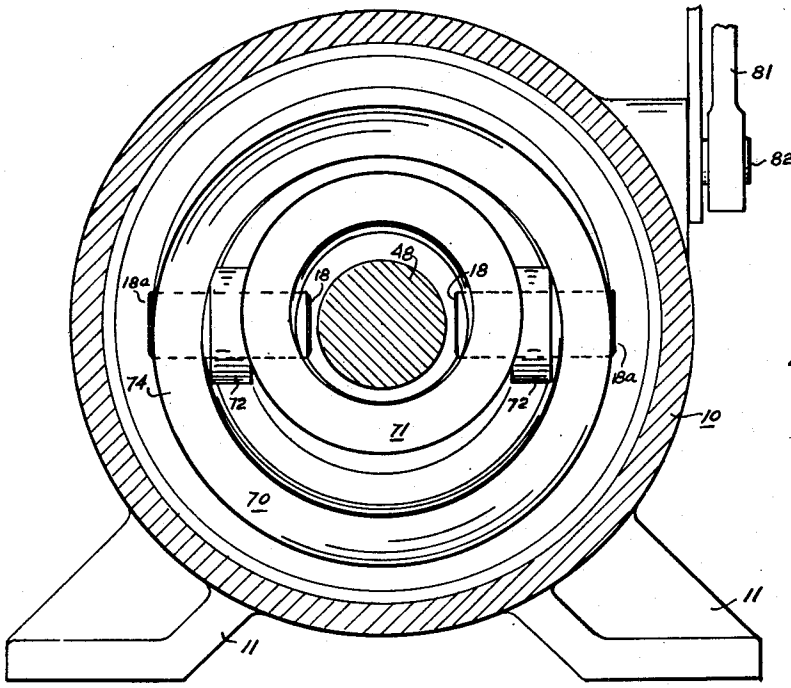


Fig 3

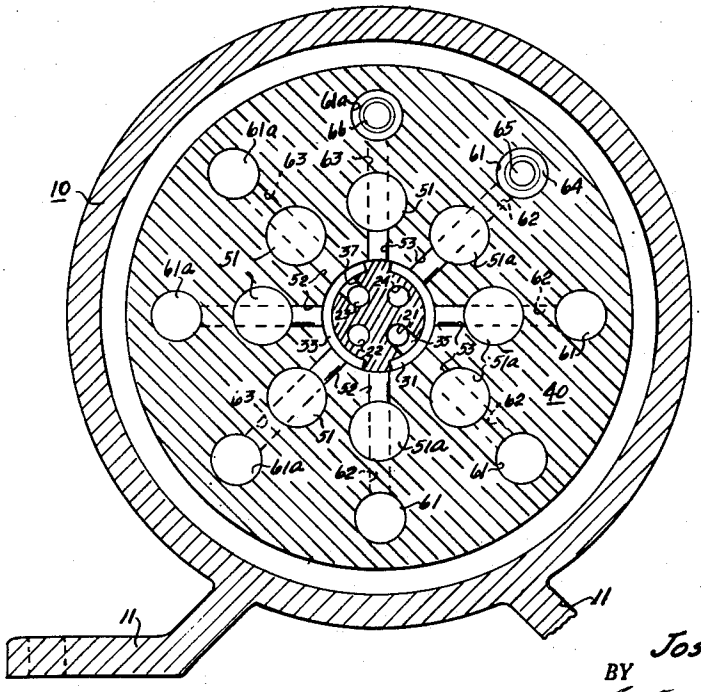


Fig 4

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HYDRAULIC PUMP OR MOTOR

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Fig. 5

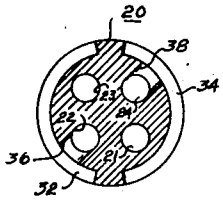


Fig. 6

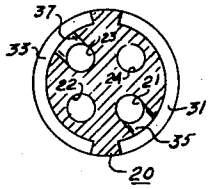
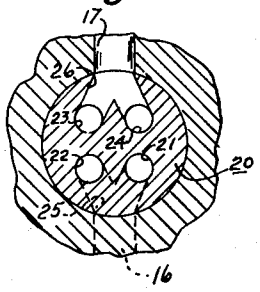


Fig. 7



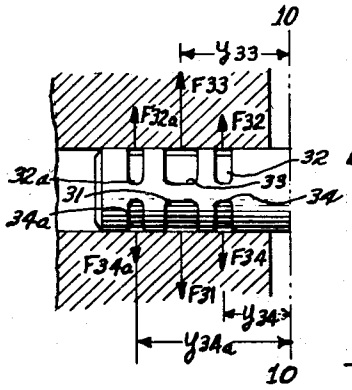


Fig. 10

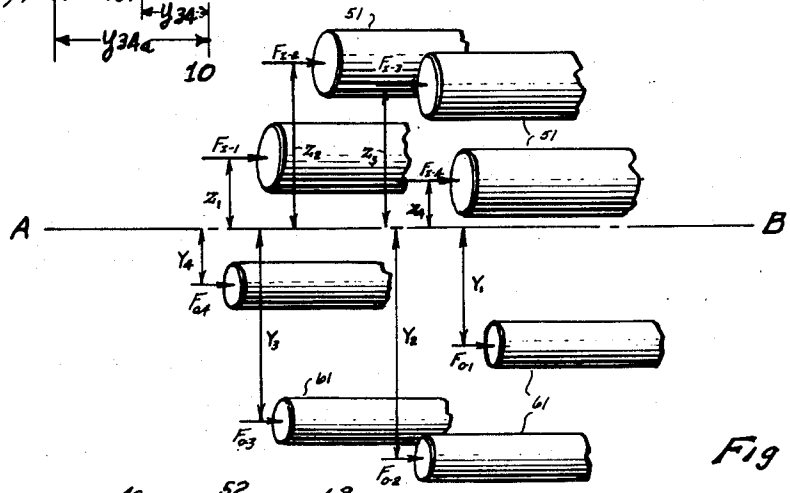


Fig 8

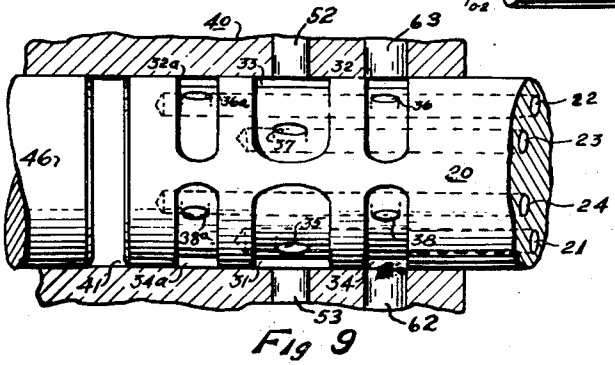


Fig 9

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Patented Aug. 29, 1950 2,520,632

UNITED STATES PATENT OFFICE

2,520,632

HYDRAULIC PUMP OR MOTOR

Joseph Greenhut, University Heights, Ohio, assignor to The Torq Electric Manufacturing Company, Cleveland, Ohio

Application March 22, 1945, Serial No. 584,172

12 Claims. (Cl. 103—162)

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This invention relates to hydraulic pumps or motors, and particularly to devices of this type which embody a multiplicity of parallel cylinders having reciprocating pistons therein mounted in a rotating barrel.

The primary object of this invention is to provide a more durable pump or motor of the type mentioned which is evenly balanced and which eliminates transverse stresses and strains therein.

Another object is to provide a device of this type that has plungers or pump units of balanced capacity simultaneously exerting pressure and causing suction equally around an aligned pintle and drive shaft and on the same plane therewith.

A further object is to provide a rotating and reciprocating piston type pump with adjustable concentric swash plates which regulates the length of piston stroke.

Still another object of the invention is to provide a rotary fluid valve means for a pump or motor of the type stated which permits a simultaneous feeding and exhausting of balanced rotating pump units or cylinders.

A still further object is to construct a hydraulic pump or motor with a rotating barrel which has an inner series and an outer series of concentrically arranged plungers and cylinders of balanced capacity.

These and other objects, features and advantages of the invention will become apparent from a reading of the following description and claims, together with the accompanying drawings, in which like parts are referred to and indicated by like reference characters and wherein:

Figure 1 is a top or plan view of the motor or pump, partly in section;

Figure 2 is a vertical longitudinal sectional view of the device, taken along the line and in the direction of the arrows 2—2 of the Figure 1;

Figure 3 is a vertical cross-sectional view of the device, taken along the line and in the direction of the arrows 3—3 of the Figure 2;

Figure 4 is a vertical cross-sectional view of the device, taken along the line and in the direction of the arrows 4—4 of the Figure 2;

Figure 5 is a vertical cross-sectional view of a part of the device, taken along the line and in the direction of the arrows 5—5 of the Figure 2;

Figure 6 is a vertical cross-sectional view of a part of the device, taken along the line and in the direction of the arrows 6—6 of the Figure 2;

Figure 7 is a vertical cross-sectional view of a part of the device, taken along the line and in the direction of the arrows 7—7 of the Figure 2;

Figure 8 is a diagrammatic view of the concentric series of plunger portions in the device, and particularly showing how forces thereof are balanced;

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Figure 9 is an enlarged elevational view of a portion of the pintle member, slightly distorted, showing conduits, grooves and channels therein; and

Figure 10 is a schematic illustration of the summation of forces exerted against the barrel member at certain grooves in the pintle member.

Conducive to a clearer understanding of this device, it should be pointed out that the invention may be used either as a variable displacement type motor, as a pump, or for any other similar hydraulic power transmission. For clarity and simplicity, it will be referred to hereinafter as a pump and its elements as well as its operation will be described accordingly.

The device broadly consists of four main members; namely, the housing member, the pintle or valve member, the barrel member, and the swash plate member. Each of these members are broadly indicated by the reference characters 10, 20, 40 and 70 respectively and each will be described in detail hereinafter and in the order set forth.

The housing member 10 consists of a hollow case which is provided with legs or supports 11 for mounting the pump on any suitable base. The front end of the case is closed with the cover or end plate 12 which is securely held in place by the bolts 12a as shown, which engage the edge of the case. This closure 12 has a central opening therein and has thereat a bearing 13 for the hereinafter described shaft portion 41. This cover plate 12 also has integral therewith a yoke 72. This yoke is provided with a pair of laterally extending aligned pins or bearings, indicated by the reference characters 18 or 18a, which support the hereinafter described swash plate member 70. It also has a fluid seal 13a slightly forward of the bearings 13 and concentric therewith.

The rear end 14 of the case has a central axial opening which is aligned with the aforesaid central opening in the front cover 12 and which may be securely closed by the plate 15 and bolts 15a. The rear end 14 also has a channel or passage therethrough for admitting fluid to the pump. This is indicated and referred to as the fluid entrance 16. Above it there is a similar passage referred to and indicated as the fluid egress 17. Both the entrance 16 and the egress 17 are threaded to receive suitable ducts or conduits. The passages 16 and 17 open into the axial opening or bore 19, which extends longitudinally

through the rear portion 14 of the housing member. The inner end wall of the case adjacent to the end portion 14 is provided with a support for the bearing 43 which in turn supports the hereinafter described barrel member 40. This bearing 43 is concentric with and fits around the axial opening or bore 19.

The pintle or valve member 20 consists of a short length of metal rod which extends through the rear portion 14 of the housing and projects a short distance inside of the case. This member 20 fits easily in the axial opening or bore 19 and has a small amount of play which allows it to take up any misalignment of the housing and barrel members 10 and 40 respectively. Since the barrel member 40 is accurately lapped on and fitted to the pintle 20 on which it rotates, and since it is an extremely difficult matter, while manufacturing, to precisely align the axial opening or journal 41 with the longitudinal bore 19, considerable wear and stress will be avoided if the pintle member 20 fits rather loosely in the bore 19. The life of the pump is prolonged considerably and a smoother operation of the device is obtained. The pintle member 20 is held in place and prevented from making excessive longitudinal movement or rotation by the small key or pin 27 which extends radially through the end portion 14 of the housing, as shown in the Figures 1 and 2.

Four parallel ducts or channels, referred to herein as conduits 21, 22, 23 and 24, extend longitudinally through the pintle member 20. The two conduits 23 and 24 are referred to as pressure conduits and have a joint and somewhat radially extending channel 26 which leads or opens into the egress passage 17, as is shown in the Figure 7. The two conduits 21 and 22, known as suction conduits, similarly have a joint radially extending channel 25 which connects with the fluid entrance 16.

At this point it should be noted that the Figure 9 is somewhat exaggerated and distorted to more clearly show the conduits 21, 22, 23 and 24. Actually the said conduits are evenly spaced apart somewhat as illustrated in the Figures 5, 6 and 7.

The forward end of the first suction conduit 21 opens into a first arcuate or peripheral groove 31 in the pintle member 20 by way of the radial channel 35. The first pressure conduit 23 similarly opens at its forward end into a second arcuate groove 33 by way of the radial channel 37. The second suction conduit 22 opens at its forward end into a first pair of arcuate or peripheral grooves 32 and 32*a* by way of the radial channels 36 and 36*a*, as is shown in the Figures 5 and 9. Similarly, the second pressure conduit 24 opens into a second pair of peripheral grooves 34 and 34*a* by way of the radial passages 38 and 38*a*. Each of the arcuate peripheral grooves 31 and 33, and each of the grooves 32, 32*a*, 34 and 34*a*, are of the same length and cover an arc a little less than 180 degrees. The grooves 31 and 33 are diametrically aligned and are opposite each other as shown, and similarly the grooves 32 and 34 are aligned opposite each other, as also are the grooves 32*a* and 34*a*. The channels 31/33 are between the channels 32/34 and 32*a*/34*a*.

At this point it should be noted that by providing two sets of grooves 31, 32 and 32*a* and 33, 34 and 34*a* and ducts thereto instead of only one set, and by having the large grooves 31 and 33 between the small grooves 32 and 32*a* and 34 and 34*a* respectively, a better balance of forces is obtained. The barrel member 40 will wear less as it rotates on the pintle member 20. It will be observed also, from a study of the operation of the pump as hereinafter set forth in detail, that if only grooves 32 and 34 and related ducts are used, with the large grooves 31 and 33, and if grooves 32*a* and 34*a* were eliminated entirely the pressure or lack of pressure of the fluid in the radial grooves and ducts 35 and 37 would tend to force the barrel member 40 out of line or askew, and in time wear of the parts would be noticeable.

The area of the large groove 31 is equal to the sums of the areas of the two small grooves 32 and 32*a*. Similarly the area of the large groove 33 is equal to the areas of the two small grooves 34 and 34*a*. In the preferred form of the device as illustrated, it is desirable to have the areas of the small grooves 32 and 34 equal to the areas of the small grooves 32*a* and 34*a* respectively. However, it is not essential that the areas of the small grooves 32 and 34 be the same. The areas thereof may be varied depending upon their distance from the corresponding or interconnected large groove. The fact to be noted is that the algebraic sum of the moments or torques about the pivotal axis of the pintle member 20 proximate to the large grooves 31 and 33, should be zero. As defined in the claims the sum of the moments produced by the fluid pressure in each set of grooves acting against the barrel member about a plane perpendicular to the axis of the pintle member is zero.

In other words, the hydraulic pressure in the large groove 31, is equal at all times to the hydraulic pressure in the two opposed grooves 32 and 32*a*. Similarly at all times the hydraulic pressure in the large groove 33 is equal to the pressure in the two opposed grooves 34 and 34*a*. However it should be clearly understood that the hydraulic pressure in the two sets consisting of grooves 31, 32 and 32*a* in grooves 33, 34 and 34*a* need not be equal. For example, the device when used as a pump may have a positive pressure of one hundred pounds per square inch applied to the set of grooves 31, 32 and 32*a* and at the same time the set of grooves 33, 34 and 34*a* may have a negative pressure or suction of ten pounds per square inch therein.

In the preferred construction the set of grooves which are in hydraulic communication with the discharge of the pump are of such size and location that no unbalanced forces or moments are produced by the forces exerted on the barrel by the hydraulic pressure in these grooves. This is likewise true of the set of grooves which are in hydraulic communication with the suction of the pump.

Assuming that the groove 33 is collecting the fluid being pumped out of certain cylinder bores, this fluid then, through a radial channel 37 and the first suction conduit 23 is conducted to the discharge port 17. Grooves 34 and 34*a* are also connected to the port 17. The fluid passes from grooves 34 and 34*a* through the radial channels 38 and 38*a* into the second suction conduit 24 which also opens in to the discharge port 17. Thus the hydraulic pressure is substantially the same in the grooves 33, 34 and 34*a*.

In the preferred form of my invention, the grooves are symmetrical about the horizontal axis, and also the area of the groove 33 exposed to the bore of the barrel, is substantially equal to the sum of the areas of grooves 34 and 34*a*. F33 in the Figure 10 represents the resultant of the forces acting against the bore of the barrel

and due to the hydraulic pressure in the groove 33. Likewise F34 and F34a represent the resultants of the forces due to the hydraulic pressures in grooves 34 and 34a. Now from the above, it will be seen that F33 is substantially equal to F34 plus F34a. Thus there is no unbalanced force acting on the barrel due to the hydraulic pressure in this set of grooves.

Now I also contemplate, in the preferred form of my invention, making the area of grooves 34 and 34a of such magnitude and so locating these grooves so that the moment of F34 about any plane 10—10 perpendicular to the axis of the pintle, plus the moment of F34 about the same plane is equal to the moment of F33 about this same plane. Or in other words:

$$F33 \times y33 = F34 \times y34 + F34a \times y34a$$

From this it will be seen that there is also no unbalanced moment exerted on the barrel by the hydraulic pressure in this set of grooves.

Now in a similar manner the other set of grooves 31, 32 and 32a are also subjected to a balanced hydraulic pressure because of their respective areas, design and location. Specifically assuming that the groove 31 is collecting fluid entering the certain cylinder bores, the fluid passes from the port 16 through the first pressure conduit 21 through the radial channel 35 into the groove 31. On the other side of the pintle the fluid passes from the entrance port 16 into the second pressure conduit 22 into the radial channel 36 and 36a into the grooves 32 and 32a.

Specifically, the conduits 23 and 24 which contain fluid under pressure are on one side of the pintle, while the conduits 21 and 22 which contain fluid on suction are on the other side of the pintle. The forward set of grooves 32a/34a are blind and are closed by the rotating journaled portion 41. Nevertheless, the pressure exerted therein by the fluid which also came from the pressure conduits 21 and 22 by way of the radial channels 36a and 38a is equal to the pressure in the corresponding grooves 32/34. The barrel member 40 is thus caused to rotate evenly on the pintle member 20 and its dynamic balance is better preserved at high speeds.

The portion of the pintle 20 in the housing end 14 also has four spaced parallel peripheral grooves which receive the fluid seals or rings 28, 28a, 28b and 28c. These grooves extend completely around the pintle. The first ring 28 engages the pintle 20 slightly forward of the said radial channel 26. The second ring 28a is mounted in the second groove a slight distance to the rear of the radial channel 26. The third seal or ring 28b engages the pintle a short distance in front of the radial channel 25, and similarly the fourth ring or seal 28c fits into the last groove a short distance behind the radial channel 25. These rings 28, 28a, 28b and 28c prevent the fluid from passing at these points and flowing into the bore 19 and ultimately into the journaled portion 41, but they still are resilient enough to permit the pintle 20 to move laterally slightly as aforesaid within the rear portion 14 of the housing to take up undesired wear or misalignment.

The barrel member 40 has an outside diameter slightly less than the inside diameter of the housing 10. It has an axial opening therethrough which is referred to and indicated as the journaled portion 41. This is aligned as closely as possible with the axial opening or bore 19 in the rear end 14 of the housing. The rear portion of

the barrel member 40 is mounted on and rotates on the bearings 43 and also rotates around the forward or front portion of the pintle member 20, the portion having the aforementioned peripheral grooves 31, 32, 32a, 33, 34 and 34a therein.

The forward portion of the barrel member 40 has a protruding shaft mounted therein which is in substantial alignment with, but spaced slightly from, the pintle member 20. This shaft has a portion 46 which tightly fits the axial opening or journal 41. It has a constricted end 47 on which any suitable driving wheel or pulley may be mounted. This constricted portion 47 extends through the front wall or cover 12 and rides on the bearing 13 and in the fluid seal 13a. Between the constricted portion 47 and the engaging portion 46 there is a tapered portion 48 which passes between the rearwardly extending arms of the heretofore mentioned yoke 72 and on which the hereinafter described swash plates 70 are mounted.

The barrel member 40 is provided with two series of plungers. Each series of plungers consists of several cylinders and reciprocating pistons. The drawings show each series containing eight plungers but the invention is not restricted to the number shown. Any odd or even number of plungers may be used in either series provided a proper balance can be obtained between the two sets or series of plungers.

The inner series of plungers 51 as shown in the drawings are shorter and larger in diameter than the plungers of the outer series 61. The relative sizes, however, need not be the same or as illustrated. It is important only that all of the plungers have a diameter in a fixed relation to their distances from the axial center of the barrel member. The areas of the pistons are adjusted in diameter in relation to their radii so that the summation of the moments produced by the forces acting on all the pistons about any plane through the horizontal axis of the device is equal to zero. One series of plungers or pistons being of such number, diameter and position that the summation of the moments produced by their reaction forces on the rotatable barrel about any plane through the axis of rotation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of plungers or pistons about the same plane.

This is schematically illustrated in the Figure 8, wherein the summations of the forces of the pistons under pressure at any instant are taken around the plane A—B. Thus the forces of the outer set of pistons 61 under pressure and the forces of the inner set of pistons 51 under pressure times their respective moment arms to plane A—B, when algebraically totaled, are equal to zero. Specifically,

$$(F_{x-1} \times Z_1) + (F_{x-2} \times Z_2) + (F_{x-3} \times Z_3) + (F_{x-4} \times Z_4) = (F_{o-1} \times Y_1) + (F_{o-2} \times Y_2) + (F_{o-3} \times Y_3) + (F_{o-4} \times Y_4)$$

At any time during the operation of the pump, one-half of the outer series of plungers 61 are on the pressure side of the pump and the other half are on the suction side of the pump. Similarly, one half of the inner series of plungers are on the pressure side and the other half are on the suction side. And it should be noted that the feature that makes this pump distinct and novel is that the pressure half of the outer series is at all times opposite the pressure half of the inner series.

In the drawings, the half of the plungers of the inner series on the pressure side of the pump are indicated by the reference character 51 and the other half on the suction side are indicated by the reference character 51*a*; and similarly the half of the outer series on the pressure side of the pump are indicated by the reference character 61, while the other half on the suction side are indicated by the character 61*a*. The plungers 51 of the pressure side of the inner series are directly opposite the plungers 61 of the pressure side of the outer series, and similarly the plungers 51*a* are opposite and balance the plungers 61*a*.

While the drawings, for the sake of clarity and simplicity, show specific oppositely disposed plungers in balance, they need not be so arranged. If desired, the inner series may consist of an even number of plungers while the outer series may have an odd number or vice versa. The number of plungers in each respective series may be different. However, it is apparent that the smoothest and best operation would be obtainable by having the device in equilibrium as much as possible. This condition could most easily be obtained by having the design thereof in balance as much as possible.

Each plunger or piston works in a cylindrically shaped longitudinal hole or bore drilled in the housing member 40 parallel with the axis thereof. These cylinder bores may be spaced and aligned somewhat as indicated in the Figure 4 of the drawings. Each cylinder bore of the inner series has a movable piston 54 which piston has a substantial head portion 55 and a hollow portion to the rear thereof in which there is mounted the spring 56. The springs 56 tend to drive the pistons 54 outward and cause the piston heads 55 thereof to ride smoothly on the hereinafter described inclined swash plate rings 71. Each inner cylinder bore 51 connects with the axial opening 41, which in turn opens into either of the peripheral grooves 31 or 33 on the pintle member 20, depending upon the position of the barrel member 40 thereon. The radial ducts or ports connecting the half of the cylinder bores 51 on the pressure side of the pump and which opens into the groove 33 are indicated by the reference character 52. Similarly the radial ducts or ports which connect half of the inner series of cylinder bores 51*a* on the suction side of the pump and which open into the peripheral groove 31 are indicated by the reference character 53. In a similar manner, half of the outer series of cylinder bores 61 on the pressure side of the pump have radial ducts or ports 62 which open into the peripheral groove 34 in the pintle member, and the other half of the cylinder bores 61*a* on the suction side of the pump each have a radial duct or port 63 which opens into the peripheral groove 32. Each cylinder bore 51 or 51*a* of the inner series successively connects with the peripheral grooves 31 and 33 as the barrel member rotates around the pintle 20 and thereby either causes a suction or exerts a pressure on the fluid flowing through the device, depending upon the direction of movement of the piston 54. Similarly, each cylinder bore 61 or 61*a* of the outer series alternately and successively opens into either of the peripheral grooves 32 or 34 as it moves from the suction to the pressure side of the pintle 20.

This construction and the manner of rotating the special barrel member 40 around the special pintle member 20 forms a novel valve means

which permits fluid to flow into and out of each of the cylinder bores and to react with the movable pistons 54 or 64 to a degree and in accordance with certain relative positions of the following described swash plates 71 and 74.

The swash plate member, broadly indicated by the reference character 70, consists of two rings 71 and 74 which are pivotally and laterally mounted on the arms of the horizontal yoke 72. The smaller ring 71 has two diametrically aligned holes therein which permit it to be pivoted and inclined with respect to the front end of the barrel member 40 on the pin portions 18 of the yoke. The diameter of the small ring 71 is substantially the same as the diameter of the inner series of plungers 51/51*a* of the barrel member 40. The larger ring 74 also has diametrically aligned holes therethrough which permit it to be tilted on the bearings or outer pin portions 18*a* of the yoke 72. The larger ring 74 fits around the smaller ring 71, is concentric therewith, and has a diameter substantially the same as the diameter of the outer series of plungers 61/61*a* of the barrel member. The swash plates or rings 71 and 74 have rounded edges 73 and 76 as shown. The faces thereof on which the plungers ride are provided with suitable rollers in order to minimize the friction thereagainst of the piston heads 55 and 65.

Each of the rings or swash plates 71 and 74 are inclined in opposite directions as shown, and in order to provide a convenient means for adjusting the angle at which the respective plates 71 and 74 are tilted, a simple but durable adjusting lever 81 and means 82 are provided. This makes it possible to conveniently adjust the device to regulate its capacity or force from outside of the housing and while it is in operation. The Figure 2 of the drawings shows the plates 71 and 74 inclined in opposite directions and at about the same relative angles. However, the two plates need not be so inclined or adjusted. They may both be inclined in the same direction or they might be inclined at angles of different degrees. However, as before stated, the smoothest and best operation and results are obtained when the device is balanced and the plates positioned somewhat as shown.

The control mechanism consists of a short shaft 82 rotatably mounted on and made to extend through the side wall of the housing member 10. The outer end of the shaft 82 is firmly connected to the lever 81 as shown. The inner end of the shaft 82 has mounted thereon two reciprocating arms 83 and 85. The arm 83 is connected to the smaller ring or inner swash plate 71 by the link 84, and similarly the arm 85 is connected to the larger ring or outer swash plate 74 by means of the link 86. The arms 83 and 85 are spaced and mounted on the shaft 82 so that the movement of the lever 81 will cause the rings 71 and 74 to move inwardly or outwardly simultaneously. Separate arms and links may be used if desired to produce certain results.

The lever 81 is provided with a means for locking it in position so that the swash plates constantly retain the angles at which they are set. By referring to the Figure 2 of the drawing, it will be observed that by inclining the swash plates more or less, the capacities of the plungers will be increased or decreased accordingly, and by this means a very fine adjustment may be obtained for the pump regardless of mechanical imperfections or unavoidable unbalance of certain parts therein.

Among the many advantages that this pump or motor has over prior art devices is the fact that it may be used at relatively high pressures since practically all transverse or cross tension is substantially eliminated or at least reduced to a minimum. It is therefore less noisy than the prior art pumps and since it may be well balanced, it is relatively free from incidental vibration and undue wear. The flow of fluid is practically constant and is noticeably free from pulsations which characterize the operation of many prior art pumps of this general type. A pump constructed in accordance with this invention, being practically free of transverse or cross thrusts, eliminates the necessity of repairing the pump at frequent intervals or of replacing the bearings, valves and drive shafts therein.

Furthermore, since the pintle member 20 is free to adjust itself to the barrel member 40 as aforestated, due to the pintle member being free to adjust itself within the housing member 10, a longer lasting unit is obtainable than would be the case if the pintle member were rigidly mounted in the housing. Vibration and shock due to misalignment are thus automatically absorbed and remedied.

It will also be noted that this particular design of pump has relatively few moving parts under stress or strain and since its members and parts are easier to align, its ultimate cost of manufacture and assembly is therefore reduced considerably.

It will now be clear that there is provided by this invention a device which accomplishes the objects heretofore set forth. While the invention has been disclosed in its preferred form, it is to be understood that the specific embodiment thereof as illustrated and described is not to be construed in a limiting sense as there may be other forms or modifications of the invention which could also be considered to come within the scope of the appended claims.

I claim:

1. A device of the class described, comprising in combination, a housing member, a pintle member mounted in the housing member, a rotatable barrel member having cylinder bores therein journaled on the pintle member, an inner series of plunger portions and an outer series of plunger portions in the said bores, the said inner and outer series of plunger portions being concentrically arranged, one series of plunger portions being of such number, diameter and position that the summation of moments produced by their reaction forces on the aforesaid rotatable barrel member about any plane through the axis of rotation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of plunger portions about the same plane, concentric swash plates mounted in the housing member and engageable with the plunger portions, and means in the said members for intermittently feeding and exhausting a fluid to and from each of the said plunger portions.

2. A device of the class described, comprising in combination, a housing member, a pintle member mounted in the housing member, a rotatable barrel member journaled on the pintle member, the said barrel member having a multiplicity of longitudinal cylinder bores therein arranged to form an inner series and an outer series of bores concentric with the axis thereof, each cylinder bore of each of the said series having a piston therein, one series of pistons being of such number, diameter and position that the summation of moments produced by their reaction forces on the aforesaid rotatable barrel member about any plane through the axis of rotation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of pistons about the same plane, a pair of swash plates mounted in the housing member including a small plate inclined in one direction and being engageable with the pistons of the inner series of cylinders and a large plate inclined in the opposite direction and being engageable with the pistons of the outer series of cylinders, and means in the said members for intermittently feeding and exhausting a fluid to and from each of the said cylinders.

3. A device of the class described, comprising in combination, a housing, a pintle member mounted in the housing and having a pair of pressure conduits and a pair of suction conduits therein, a rotatable barrel member journaled on the pintle member, the said barrel member having a multiplicity of longitudinal plunger portions therein arranged to form an inner series and an outer series concentric with the axis thereof, one half of the inner series and one half of the outer series of plunger portions being connectable with the pair of pressure conduits during the time when the other half of the inner series and the other half of the outer series of plunger portions are connectable with the pair of suction conduits, one series of plunger portions being of such number, diameter and position that the summation of moments produced by their reaction forces on the aforesaid rotatable barrel member about any plane through the axis of rotation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of plunger portions about the same plane, and concentric swash plates mounted in the housing member and engageable with each concentric series of plunger portions.

4. A device of the class described, comprising in combination, a housing having a fluid entrance and a fluid egress therein, a pintle mounted in the housing and having two pressure conduits connected to the said egress and two suction conduits connected to the said entrance, a barrel member rotatably mounted in the housing and journaled on the pintle, the said barrel member having a multiplicity of longitudinal cylinder bores therein arranged to form an inner series and an outer series concentric with the axis thereof, one half of the inner series of cylinder bores being in fluid communication with one of the said pressure conduits, one half of the outer series of cylinder bores being in fluid communication with the other of the pressure conduits, the other half of the inner series of cylinder bores being in fluid communication with one of the said suction conduits and the other half of the outer series of cylinder bores being in fluid communication with the other of the suction conduits, each of the said cylinder bores having a piston therein, and concentric swash plates mounted in the housing member and engageable with each concentric series of cylinder bore pistons.

5. A device of the type defined in claim 4 and further characterized by one series of pistons being of such number, diameter and position that the summation of moments produced by their reaction forces on the aforesaid rotatable barrel member about any plane through the axis of ro-

tation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of pistons about the same plane.

6. A device of the class described, comprising in combination, a housing having a fluid entrance and a fluid egress therein, a pintle mounted in the housing and having two pressure conduits connected to the said egress and two suction conduits connected to the said entrance, a barrel member rotatably mounted in the housing and journaled on the pintle, the said barrel member having a multiplicity of longitudinal cylinder bores therein arranged to form an inner series and an outer series concentric with the axis thereof, one half of the inner series of cylinder bores having ports connectable with one of the said pressure conduits, during the time when one half of the outer series of ports are connectable with the other pressure conduit, the other half of the inner series having ports connectable with one of the said suction conduits during the time when the other half of the outer series of ports are connectable with the other suction conduit, the said inner and outer series of cylinder bores being concentrically arranged and in a manner such that an inner cylinder bore and a port thereof are on the same plane as the axis of the barrel and an outer cylinder bore and a port thereof, and oppositely inclined concentric swash plates mounted in the housing and engageable with the barrel member.

7. A device of the class described, comprising in combination, a housing having a fluid entrance and a fluid egress therein, a pintle mounted in the housing and having two pressure conduits connected to the said egress and two suction conduits connected to the said entrance, a barrel member including a shaft rotatably mounted in the housing and journaled on the pintle, the said barrel member having a multiplicity of longitudinal cylinder bores therein arranged to form an inner series and an outer series concentric with the axis thereof, one half of the inner series of cylinder bores having ports connectable with one of the said pressure conduits during the time when one half of the outer series of ports are connectable with the other pressure conduit, the other half of the inner series having ports connectable with one of the said suction conduits during the time when the other half of the outer series of ports are connectable with the other suction conduit, the said inner and outer series of cylinder bores being concentrically arranged and in a manner whereby an inner cylinder bore and a port thereof are on the same plane as the axis of the barrel and an outer cylinder bore and a port thereof, the said inner and outer series of cylinder bores having pistons therein, one series of pistons being of such number, diameter and position that the summation of moments produced by their reaction forces on the aforesaid rotatable barrel member about any plane through the axis of rotation thereof is substantially equal to the summation of moments produced by the reaction forces of the other series of pistons about the same plane, and two oppositely inclined concentric swash plates adjustably mounted in the housing member around the drive shaft, one of the said plates being engageable with the pistons of the inner series of cylinder bores and the other of the plates being engageable with the pistons of the outer series of cylinder bores causing the pistons in the same plane to reciprocate harmoniously.

8. A device of the class described, comprising in combination, a housing member having a fluid entrance and a fluid egress therein, a pintle mounted in the housing member and having two pressure conduits connected to the said egress and two suction conduits connected to the said entrance, a barrel member rotatably mounted in the housing member and journaled on the pintle, the said barrel member having a multiplicity of longitudinal cylinder bores therein arranged to form an inner series and an outer series concentric with the axis thereof, one half of the inner series of cylinder bores having ports connectable with one of the said pressure conduits during the time when one half of the outer series of ports are connectable with the other pressure conduit, the other half of the inner series having ports connectable with one of the said suction conduits during the time when the other half of the outer series of ports are connectable with the other suction conduit, each of the said cylinder bores having a piston therein, the said inner and outer series of cylinder bores being concentrically arranged and in a manner whereby an inner cylinder bore and a port thereof are on the same plane as the axis of the barrel and an outer cylinder bore and a port thereof, a means for reciprocating the pistons of the two series of cylinder bores, and a valve in the said members synchronized with the reciprocation of the said pistons.

9. A pump of the swash plate type comprising a casing, a cylindrical barrel rotatable within said casing and having two concentric rows of cylinders therein, a port communicating with each cylinder, a spring retracted plunger in each of said cylinders, a fluid inlet including a passageway for communicating with a series of ports of one concentric row of cylinders and simultaneously with a series of ports of diametrically opposite cylinders of the second concentric row, a fluid outlet including a passageway for communicating with a second series of ports of said one row of cylinders and simultaneously with a series of ports of diametrically opposite cylinders of the second concentric row, means for rotating the cylindrical barrel about its axis, whereby the ports of said cylinders are brought into successive communication with said passageways, and a pair of swash plates positioned in engagement with the ends of the plungers in each of said rows respectively, said swash plates being inclined in opposite directions with respect to the axis of the cylindrical barrel, whereby the pistons of the cylinders in communication with the inlet passageway draw in fluid while the pistons in communication with the outlet passageway eject fluid and the forces are opposite in respect to opposite cylinders in one row and in respect to adjacent cylinders in the other row so that the sum of the moments on the swash plate structure is substantially zero.

10. A pump of the swash plate type comprising a casing, a cylindrical barrel rotatable within said casing and having two concentric rows of cylinders therein, a port communicating with each cylinder, a spring retracted plunger in each of said cylinders, a fluid inlet including a plurality of arcuate passageways for communicating respectively with a series of ports of one concentric row of cylinders and simultaneously with a series of ports of diametrically opposite cylinders of the second concentric row, a fluid outlet including a plurality of arcuate passageways for communicating respectively with a second series

of ports of said one row of cylinders and simultaneously with a series of ports of diametrically opposite cylinders of the second concentric row, means for rotating the cylindrical barrel about its axis, whereby the ports of said cylinders are brought into successive communication with said passageways, and a pair of swash plates positioned in engagement with the ends of the plungers in each of said rows respectively, said swash plates being inclined in opposite directions with respect to the axis of the cylindrical barrel, whereby the pistons of the cylinders in communication with the inlet passageways draw in fluid while the pistons in communication with the outlet passageways eject fluid and the forces are opposite in respect to opposite cylinders in one row and in respect to adjacent cylinders in the other row so that the sum of the moments on the swash plate structure is substantially zero.

11. A pump of the swash plate type comprising a casing, a cylindrical barrel rotatable within said casing and having two concentric rows of cylinders therein, a port communicating with each cylinder, a spring retracted plunger in each of said cylinders, a fluid inlet including a passageway for communicating with a series of ports of one concentric row of cylinders and simultaneously with a series of ports of oppositely disposed cylinders of the second concentric row, a fluid outlet including a passageway for communicating with a second series of ports of said one row of cylinders and simultaneously with a series of ports of oppositely disposed cylinders of the second concentric row, means for rotating the cylindrical barrel about its axis, whereby the ports of said cylinders successively are brought into communication with said passageways in series, a pair of swash plates positioned in engagement with the ends of the plungers in each of said rows respectively, said swash plates being inclined in opposite directions about a common axis transverse to the axis of the cylindrical barrel, whereby the pistons of the cylinders in communication with the inlet passageway draw in fluid while the pistons in communication with the outlet passageway eject fluid, and means interconnected to said swash plates and operable simultaneously to move said plates in opposite directions about their common axis to vary the stroke of said pistons.

12. A pump of the swash plate type comprising a casing, a cylindrical barrel rotatable within said casing and having two concentric rows of cylinders of equal number therein, the cylinders of each row being substantially in alignment radially and the cylinders of the outer row having smaller diameters than those of the inner row, a port communicating with each cylinder, a spring retracted plunger in each of said cylinders, a fluid inlet including a passageway for communicating with a series of ports of one concentric row of cylinders and simultaneously with a series of ports of oppositely disposed cylinders of the second concentric row, a fluid outlet including a passageway for communicating with a second series of ports of said one row of cylinders and simultaneously with a series of ports of oppositely disposed cylinders of the second concentric row, means for rotating the cylindrical barrel about its axis, whereby the ports of said cylinders successively are brought into communication with said passageways in series, and a pair of swash plates positioned in engagement with the ends of the plungers in each of said rows respectively, said swash plates being inclined in opposite directions with respect to the axis of the cylindrical barrel, whereby the pistons of the cylinders in communication with the inlet passageway draw in fluid while the pistons in communication with the outlet passageway eject fluid.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,297,734	Rayburn	Mar. 18, 1919
1,714,148	Weldy	May 21, 1929
1,822,064	Sorensen	Sept. 8, 1931
2,129,828	Dunn	Sept. 13, 1938
2,205,913	Stacy	June 25, 1940
2,237,430	Higgins	Apr. 8, 1941
2,328,717	Glasner	Sept. 7, 1943
2,426,588	Benedek	Sept. 2, 1947
2,427,224	Morton	Sept. 9, 1947
2,445,281	Rystrom	July 13, 1948