Dec. 5, 1961 D. S. OLIVER 3,011,448

PRESSURE LOADED PUMP

Filed Nov. 6, 1957

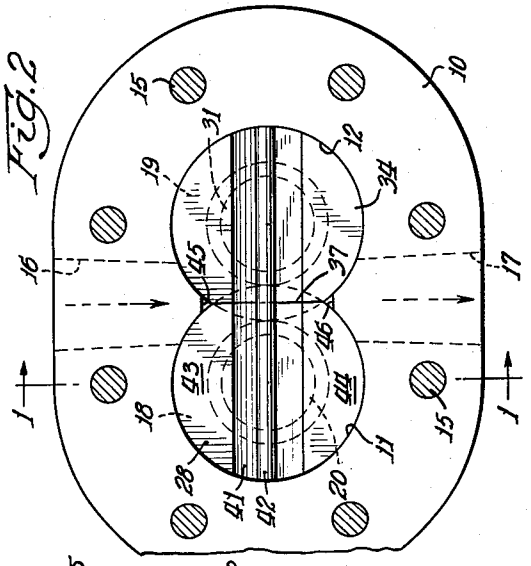


Fig. 2

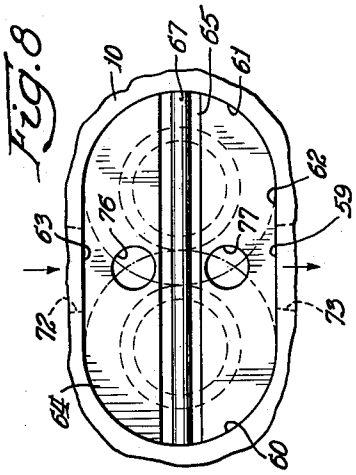


Fig. 8

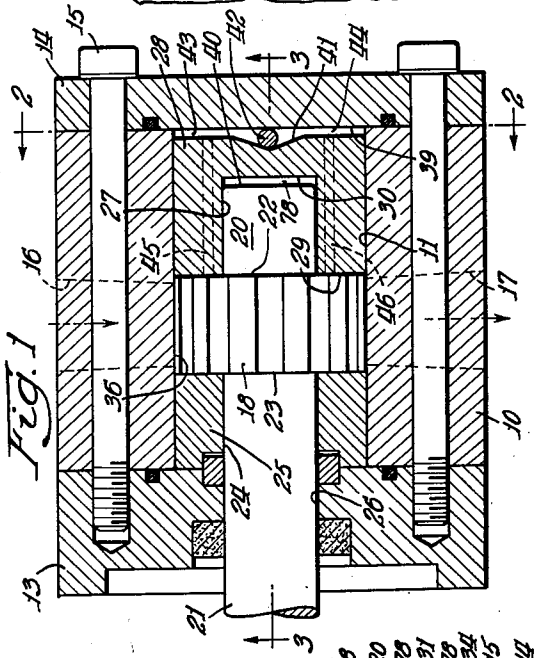


Fig. 1

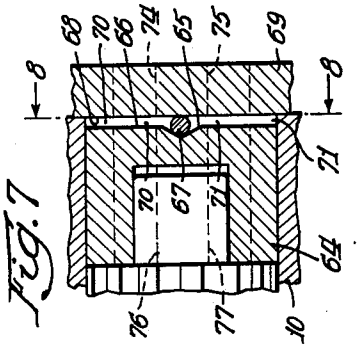


Fig. 7



Fig. 5

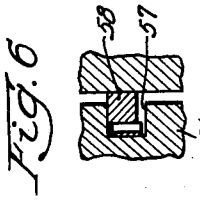


Fig. 6

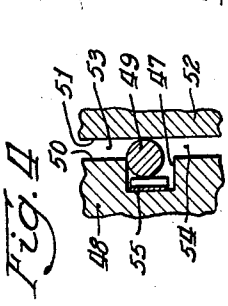


Fig. 4

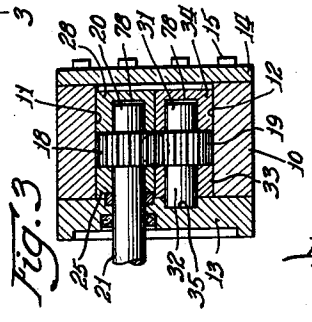


Fig. 3

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United States Patent Office 3,011,448 Patented Dec. 5, 1961

3,011,448
PRESSURE LOADED PUMP

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Filed Nov. 6, 1957, Ser. No. 694,820
11 Claims. (Cl. 103—126)

This invention relates to a high pressure gear-type pump or fluid motor and more particularly to an arrangement for maintaining axially adjustable end plates or bushings in sealing relation with the rotatable gears and providing a pumping seal therewith.

In normally constructed pressure loaded gear-type pumps at least one pair of end plates or bushings therein, adjacent to a pair of intermeshing rotatable gears, are adapted to be axially movable with respect to the adjacent side faces of the gears whereby the front faces of the end plates engage the side faces of the rotatable gears to provide a pumping seal therewith. As disclosed in United States Patent No. 2,420,622 to Roth et al., the axially movable end plates or bushings have back face portions formed thereon which are spaced from the adjacent end wall, thereby providing a chamber between the axially movable end plates and the adjacent end wall. This chamber is interconnected with the outlet pressure fluid delivered by the rotated gears, whereby a portion of the outlet pressure fluid is communicated to the end plate chamber. The force of the pressure fluid present in the end plate chamber acting against the back face portions of the end plates causes movement of the end plates axially toward the rotatable gears, thereby providing a pump seal therewith in opposition to the force of the pressure fluid acting on the front faces of the end plates, the force of the pressure fluid acting on the front faces being created by the fluid carried from the inlet to the outlet by the rotating gears.

It has been found that a pressure gradient condition exists within the pumping chamber whereby the pressure value of the fluid passing therethrough increases from the inlet to the outlet. The force of the pressure fluid existing across the front faces of the end plates tending to axially move the end plates away from the adjacent side faces of the rotatable gears may be balanced or overcome by the force of the pressure fluid in the chamber behind the end plates tending to axially move the end plates toward the gears, thereby maintaining the pumping seal. However, due to the previously mentioned pressure gradient condition existing in the pump chamber, the force of the pressure fluid acting on portions of the front faces of the end plates nearer the inlet side thereof is smaller in magnitude than the force of the pressure fluid acting on portions of the front faces adjacent or nearer the outlet side thereof. Since the force of the pressure fluid in the chamber behind the end plates acting on the back face portions of the end plates is constant in magnitude throughout different portions of area thereof, the force of the pressure fluid acting on the back face portions nearer the inlet side of the end plates is substantially greater in magnitude than the magnitude of the force of the pressure fluid acting on the front faces in the same region, whereas a much smaller differential in magnitude of force exists between the opposing forces acting on the end plates in the regions thereof adjacent the outlet side. This unbalanced condition causes skewing or twisting of the end plates about the axes of the rotatable gears toward the inlet side of the gears and results in uneven wear on the inlet side of the front faces of the end plates.

Many means have been found to substantially compensate for this unbalanced feature of pressure loaded end plates or bushings resulting from the pressure gradient condition existing across the front faces of the end plates. One such means is to provide separate isolated

chambers between the back faces of the end plates and the adjacent end wall which are subject to pressurized fluids of different pressure values whereby the pressure fluid of the lesser pressure value is communicated to the chamber adjacent the inlet side and the pressure fluid of the higher pressure value to the chamber adjacent the outlet. It has also been proposed to provide off-set back face surfaces whereby the majority of the effective area of the back face surfaces is located adjacent the outlet side of the end plates. The latter structure is disclosed in Haberland application, Serial No. 130,904 filed December 3, 1949, now Patent No. 2,823,615.

One of the means proposed for providing separate chambers between back faces of the end plates and the adjacent end wall, which chambers are subject to different fluid pressures and consequently provide different forces acting on different regions of the back faces of the end plates tending to move the end plates axially toward the rotatable gears, is disclosed in the United States Patent No. 2,756,681 to Oliver. This means comprises sealing means disposed radially on the end plates or bushings within the chamber defined by the back faces of the end plates and the adjacent end wall, thereby creating a plurality of isolated chambers behind the end plates which are each subject to pressure fluid having different pressure values from that in the other chambers.

In all of the aforementioned types of pressure loaded end plates or bushings, each end plate is provided with a tubular or stepped portion formed on the back face thereof. The tubular portion is received in a complementary bore in the adjacent end wall or bores in a closed housing, which bores, cooperating with a respective tubular portion, maintain coaxial alignment of the opposed pairs of end plates. Each end plate and tubular portion thereof is provided with a bore therethrough that is utilized to receive and carry a journal of the adjacent rotatable gear. This present invention relates to pressure loaded end plates in which the back face of each end plate is not provided with the aforementioned tubular or stepped portion thereby eliminating any precision boring of the end wall or housing to carry and maintain the opposed sets of end plates in coaxial alignment, and it is, therefore, such an object of this invention.

It is still another object of this invention to provide a pressure loaded axially movable end plate or bushing that has the maximum cross-sectional thickness thereof defined by the front and back faces thereof.

It is another object of this invention to provide a pressure loaded gear-type pump in which the pressure loaded end plate is provided with means to balance the forces of a pressure gradient condition existing across the front face of the end plate.

It is another object of this invention to provide a pressure loaded gear-type pump in which the chamber between the axially movable end plates and the adjacent end wall is divided into separate chambers which separate chambers are each subject to pressurized fluids of different pressure values to thereby balance the result of the pressure gradient condition existing across the front faces of the end plates and maintain a pumping seal with the adjacent sides of the rotatable gears.

It is a further object of this invention to provide a pressure loaded gear-type pump where the chamber formed between the adjacent axially movable end plates or bushings and the adjacent end wall is divided into a plurality of chambers by sealing means disposed within a longitudinal recess means formed in the back faces of the end plates which cooperate with the adjacent end wall to thereby isolate the plurality of chambers from each other, the chambers each being subject to pressurized fluids of different pressure values to thereby

balance the result of the pressure gradient condition existing across the front faces of the end plates and maintain a pumping seal with the adjacent sides of the rotatable gears.

A further object of this invention is to provide such a pressure loaded gear-type pump as recited in the above objects that is reversible in flow therethrough by the inlet and outlet of the pump being adapted to be interchanged, one for the other.

Other objects, advantages, and uses of the present invention will be apparent from a reading of the following detailed description taken in conjunction with the drawing wherein:

FIGURE 1 is a fragmentary cross-sectional view of a pump incorporating features of this invention and having a pair of intermeshing rotatable gears therein taken on line 1—1 of FIGURE 2.

FIGURE 2 is an end view of FIGURE 1 taken on line 2—2 thereof illustrating the end plates or bushings according to one embodiment of this invention.

FIGURE 3 is an axial cross-sectional view of the gear pump in FIGURE 1 taken on line 3—3 thereof.

FIGURE 4 is a fragmentary cross-sectional view illustrating another embodiment of the end plate sealing means of this invention.

FIGURE 5 illustrates a corrugated spring utilized in the end plate sealing means disclosed in FIGURE 4.

FIGURE 6 is a fragmentary cross-sectional view of another embodiment of the sealing means of this invention.

FIGURE 7 is a fragmentary cross-sectional view taken on lines 7—7 of FIGURE 8 illustrating still another embodiment of the pressure loaded axially movable end plate or bushing of this invention.

FIGURE 8 is an end view showing of the end plate in FIGURE 7 taken on line 8—8 thereof.

Reference is now made to FIGURES 1 to 3 of the drawing, wherein like reference numerals are used throughout to designate like parts, illustrating an intermeshing rotatable gear type pump incorporating various features of this invention. The pump comprises a housing 10 having a pair of parallel intersecting bores 11 and 12 passing therethrough. A pair of end walls 13 and 14 are securely fastened to the housing 10 by a plurality of headed bolts 15 passing through the end wall 14, housing 10, and a portion of end wall 13 where the bolts 15 are threadably attached thereto. The housing 10 is also provided with a pair of opposed bores 16 and 17 which interconnect perpendicularly the respective junctures of the bores 11 and 12 with the exterior of the housing 10. These bores 16 and 17 are utilized respectively as an inlet and an outlet for the pump and may be respectively connected to a source of supply by a supply line and a utilization system or return line in any well known manner.

A pair of rotatable gears 18 and 19 are disposed respectively in the bores 11 and 12 and are so arranged that they intermesh at the juncture of the bores 11 and 12. The gear 18 is provided with a pair of opposed coaxial journals 20 and 21 disposed respectively and centrally on the side faces 22 and 23 of the gear 18. The journals 20 and 21 may be formed integrally with the gear 18 or may be suitably fastened thereto. Further, the journals 20 and 21 may be hollow, although not shown. The lefthand journal 21 of the gear 18, as viewed in the drawing, passes through a bore 24 formed in an end plate or bushing 25, disposed between the gear face 23 and end wall 13, and a corresponding coaxial bore 26 formed in the end wall 13. The free end of the journal 21 is adapted to be connected to and rotated by a source of power (not shown) in a manner that is well known in the art. The righthand journal 20 is disposed within a bore 27 formed in a bushing or end plate 28 disposed

between the side face 22 and the end wall 13. As can be seen, the bore 27 only passes through the side or front face 29 of the end plate 28 and terminates within the interior of the end plate 28 at 30.

The gear 19 is also provided with a pair of coaxial and opposed journals 31 and 32 fastened to or formed integrally with the respective sides 23 and 22 of the gear 19. Journal 32 is carried by a lefthand end plate 33 constructed similar to the adjacent end plate 25 and journal 31 is carried by a righthand end plate 34 constructed similar to the adjacent end plate 28. The end of the lefthand journal 32 is received in a counterbore 35 formed in the end wall 13.

As can be seen, upon rotation of the journal 21, the gear 18, intermeshing with gear 19, drives gear 19 whereby the rotating gears 18 and 19 carry and force fluid from the inlet 16 to the outlet 17. The gears 18 and 19 and the respective pairs of adjacent end plates 25, 33 and 28, 34 are all disposed within the bores 11 and 12 of the housing 10, which bores 11 and 12 together with the end walls 13 and 14 define a pumping chamber 36 through which the passage of fluid flows upon the rotation of the gears 18 and 19.

Each end plate, 25, 33, 28, and 34 is formed with a flat chordal surface 37 whereby the surface 37 of each end plate mates with the surface 37 of the respective adjacent end plate when assembled in the pump. In this manner the end plates completely seal the pump chamber 36 therebetween in the bores 11 and 12.

The end plates or bushings 28, 34, 25, and 33 are different from the end plates utilized in normally constructed pressure loaded gear-type pumps in that they have no tubular portions extending from the back faces thereof. Therefore, the maximum cross-sectional thickness of the end plates 28, 34, 25, and 33 is defined by the back and front faces thereof.

The adjacent pair of end plates 28 and 34 are so formed that the back faces 38 thereof are spaced from the adjacent surface 39 of the end wall 14 whereby a chamber is defined therebetween. End plates 28 and 34 are adapted to be moved axially relative to the journals 20 and 31 respectively within this chamber as the ends 40 of journals 20 and 34 remain spaced from the ends 30 of the bores 27 even when the end plates are in their extreme left position.

In normally constructed pressure loaded gear-type pumps, this chamber is adapted to receive pressure fluid, the force of which tends to axially move the end plates 28 and 34 toward the left and cause the front faces 29 thereof to engage the adjacent side faces 22 of the gears 18 and 19 to form a pumping seal therewith. As previously mentioned, in normally constructed pressure loaded gear-type pumps a pressure gradient condition exists across the front faces 29 of the end plates 28 and 34, the result of which tends to cause skewing of the end plates and subsequent wearing of the front faces on the inlet sides thereof. The elimination of this feature is one of the main purposes of this invention and the structure relating thereto will now be described.

The back faces 38 of the end plates 28 and 34 are each formed with a V-shaped recess 41 that extends substantially perpendicularly to the axes of rotation of the gears 18 and 19 and divides the surface area of the combined back faces 38 into two substantially equal areas. Although the recesses 41 have been described as V-shaped, any other configuration may be utilized such as arcuately-shaped, etc. A pin 42 or other suitable sealing means is disposed within the recess 41 throughout the entire cross-sectional length of bores 11 and 12 and divides the chamber between the back faces 38 and the end wall 14 into two separate chambers 43 and 44.

Chamber 43 is adapted to be interconnected with the inlet side of the pump chamber 36 by means of a passage 45 formed in the housing 10 at the juncture of bores 11 and 12 thereof. Similarly, chamber 44 is intercon-

nected with the outlet side of the pump chamber 36 by a passage 46 formed in the housing 10.

The end walls 13 and 14 are suitably fluid sealed with respect to the housing 10 by O-ring seals and the journal 21 is suitably fluid sealed to the end wall 13 by any well known pilot pressure loaded sealing means such as is disclosed in the patent to Roth et al. 2,420,622.

The operation of the pump is as follows: upon rotation of the gears 18 and 19, by means of the rotation of journal 21 by a suitable power source, fluid entering the inlet 16 is carried by the gears 18 and 19 through the pump chamber 36 to the outlet 17. As the pressure value of the fluid carried by the gears 18 and 19 increases from the inlet 16 to the outlet, the output pressure fluid delivered to chamber 44 by means of passage 46 causes the pin 42 to be wedged between the sides of the recesses 41 and the surface 38 of the end wall 14 and thereby completely isolates chamber 44 from chamber 43. The force of the pressure fluid in chamber 44 also tends to move the bushings 28 and 34 axially to the left on the outlet side thereof whereby the front faces 29 thereof engage the adjacent side faces 22 of the gears 18 and 19 to provide a pumping seal therewith. Chamber 43 receives inlet pressure fluid through passage 45 whereby the force of the pressure fluid within chamber 43 also tends to axially move the bushings 28 and 34 to the left on the inlet side thereof. The combined forces acting on the back faces 38 overcome the force of the pressure fluid within the pump chamber acting on the front faces 29 causing the end plates 28 and 34 to maintain the pumping seal throughout the operation range of the pump.

As previously described, the fluid pressure within the chamber 36 increases in value from the inlet 16 to the outlet 17 providing a pressure gradient condition existing across the front faces 29 of the bushings 28 and 34. Because of this pressure gradient condition, the pressure fluid force action on portions of the front faces 29 adjacent the inlet side thereof and tending to urge and axially move the end plates 28 and 34 to the right is a lesser value force than the value of the force of the pressure fluid adjacent the outlet 15 tending to move the end plates 28 and 34 to the right. The forces provided by the pressure fluid in each chamber 43 and 44 imparted to regions adjacent the inlet and outlet of the back faces 38 of the end plates 28 and 34 tending to axially move the end plates 28 and 34 to the left is substantially equal and slightly greater than the opposing forces acting on the front faces 29 adjacent the regions of chambers 43 and 44. As can be seen, the above configuration of the chambers 43 and 44 behind the end plates 28 and 34 provides a balanced pressure loading thereof which eliminates any skewing or tilting of the end plates due to the pressure gradient condition existing across the front faces 29 thereof.

Should it be desired to reverse flow through the pump, all that is required is to change the direction of rotation of the power take off journal 21, thereby making the outlet 17 an inlet and inlet 16 an outlet. In this reversed arrangement the function of the chambers 43 and 44 are now reversed whereby the inlet pressure fluid is directed to chamber 44 and the outlet pressure fluid is directed to chamber 43, the pin 42 isolating the two chambers 43 and 44 in the same manner heretofore described.

As can be seen, this invention provides a reversable pump of the pressure loaded type in which it is relatively simple to produce a change of direction of flow therethrough. This feature is not available in normally constructed pressure loaded gear-type pumps of the types previously mentioned in which the tubular portion of the end plate is offset or eccentrically mounted to compensate for the pressure gradient condition existing across the front faces of the end plates.

As previously stated, the recesses 41 could have any cross-sectional configuration other than V-shaped, as illustrated in FIGURES 1 to 3, and one such configuration may be rectangular as shown in FIGURE 4. In the FIGURE 4 embodiment, a rectangular recess 47 is formed in a pressure loadable axially movable end plate 48. A pin 49 is disposed in the recess 47 separating the space between the back face 50 of the bushing or end plate 48 and the adjacent side face 51 of the end wall 52 into chambers 53 and 54. A corrugated spring 55 is disposed between the pin 49 and the bottom of the recess 47 to initially preload the pin 49 against the surface 51 of the end wall 52. This preloading of the pin 49 assures that when outlet pressure fluid is in chamber 53 or 54, whichever the case may be, the force of the higher pressure value fluid will act on a majority of the surface of the pin 49 to sufficiently cause wedging and a sealing thereof between the end plate 48 and end wall 52. A side view of spring 55 is illustrated in FIGURE 5.

Another embodiment of the sealing means of this invention is disclosed in FIGURE 6 wherein the pressure loadable axially movable end plate 56 is provided with a rectangularly-shaped recess 57. Disposed within recess 57 is a rectangular or square-shaped pin 58 which performs the same function as pins 49 and 42 previously described. It should be understood that the particular cross-sectional configuration of the sealing means interposed between the end plates and the end wall is not critical.

It is to be further understood that, although, as heretofore described, the recesses 41, 47, and 57 have been formed in the end plates 28 to 34, 48, and 56 respectively, it is obvious that the recesses could be formed in the end wall instead to retain the sealing means. Further, both the end plates and adjacent end wall could each be formed with a recess with the same results. The essential purpose of the invention being to provide some means for retaining a sealing means between the back faces of the end plates and the adjacent end wall to provide a plurality of chambers therebetween.

Another embodiment of this invention is disclosed in FIGURES 7 and 8 wherein a housing 10 is provided with a bore 59 having semi-circular end portions 60 and 61 and substantially parallel side portions 62 and 63 tangentially connected to the end portions 60 and 61. Only one pressure loadable axially movable end plate 64 is required, it serving the same function as end plates 28 and 34 as disclosed in FIGURES 1 to 3. The end plate 64 is adapted to be inserted within the bore 59 whereby the outer periphery of the end plate 64 substantially fills the bore 59 at all points thereof throughout the cross-section of the end plate 64. A recess 65 is formed throughout the entire length of the back face 66 of the end plate 64, dividing the back face 66 into two substantially equal areas. A pin 67 is disposed within the recess 65 dividing the space between the back face 66 and the adjacent side face 68 of the end wall 69 into two substantially equal chambers 70 and 71. Chambers 70 and 71 are utilized in the same manner as chambers 43 and 44 heretofore described.

The pump, as shown in FIGURE 8, may be provided with a conventional inlet 72 formed in housing 10 and an outlet 73 also formed in housing 10.

In the embodiment of the pump shown in FIGURE 7 the end wall 69 may be provided with an inlet 74 and outlet 75 whereby the inlet 74 is interconnected with chamber 70 and the outlet is interconnected with the chamber 71. In the latter form the end plate 64 is also provided with bores 76 and 77 formed therein interconnecting the respective chambers 70 and 71 with the adjacent inlet and outlet sides of the pumping chamber. In this manner fluid enters the pump through inlet 74, fill chamber 70, and passes through bore 76 in the end plate 64 to the pumping chamber at a point where the intermeshing gears are separating during rotation, which gears carry the fluid around the pump chamber to a point where the gears begin to intermesh, discharging the fluid through

bore 77 in the end plate 64. The output pressure fluid passes from bore 77 into chamber 71 and from chamber 71 out through outlet 75. As can be seen, inlet pressure fluid is present in chamber 70 and outlet pressure fluid is present in chamber 71 just as in chambers 43 and 44 of FIGURES 1 to 3 and function in the same manner.

The intermeshing gear pump as disclosed in FIGURES 7 and 8 may also have the flow of fluid reversed whereby the inlet 72 or 76 becomes an outlet and the outlet 73 or 75 becomes an inlet. The sealing pin 67 serves the same function regardless of the direction of fluid flow.

It is also to be understood that the pumps heretofore described incorporating features of this invention could also serve as fluid motors.

As can be seen, the pressure loaded gear-type pump disclosed incorporating features of this invention is relatively simple to manufacture and provides a pump in which the end wall is not required to have accurately machined bores therein to receive a portion of the end plates which would cause misalignment of the pump assembly if inaccurately machined. Further, the axially movable end plates serve as the sole supporting and carrying means for the journals of the rotatable gear members received therein. Therefore, a pump made in accordance with this invention is less likely to fail due to misalignment of the rotating gear assemblies.

Referring again to FIGURE 1, it should be noticed that chambers 78 are formed between the ends 40 of the journals 20 and 31 and the ends 30 of the bores 27 in the end plates 28 and 34. The purpose of this clearance space or chamber 78 is to permit the end plates 28 and 34 to be axially moved into engagement with the side faces 22 of the gears 18 and 19. Therefore, if any wear results on the front faces 29, there is additional room for the end plates 28 and 34 to be axially moved toward the left. If any of the fluid pressure within the pumping chamber 36 should seep through bores 27 into chambers 78, suitable vents (not shown) could be provided eliminating any dash pot effect of chambers 78. One such vent could be formed by making the journals of the pumping units hollow, thereby permitting the chambers 78 to be vented therethrough to the inlet or atmosphere.

It should be further understood that the bores 11 and 12 in the housing 10, as shown in FIGURE 2, could be substituted by a single bore such as is provided in FIGURE 8 by the bore 59 whereby the parallel sides of the substituted bore would serve the same function as the channels or passages 45 and 46.

Heretofore the back faces of the axially movable end plates have been described as being divided into only two substantially equal areas. It should be understood that the back faces could be divided into more than two areas in much the same manner as is disclosed in the aforementioned United States patent to Oliver 2,756,681 without departing from the scope of this invention. Further, the end plates 25 and 32 could also be made to be pressure operated and axially movable in the same manner as the axially movable end plates disclosed by the patent to Oliver whereby the journals 21 and 32 serve the same purpose as the tubular portions of the end plates described in that patent.

Where herein the various parts of this invention have been referred to as being located in a right or left position or moved to the right or left, it will be understood that this is done solely for the purpose of facilitating the description and that such references relate only to the relative positions of the parts as shown in the accompanying drawing.

While this invention has been disclosed in connection with certain specific embodiments thereof, it is to be understood that these are by way of example rather than limitation, and it is intended that the invention be defined by the appended claims which should be given a scope as broad as consistent with the prior art.

What is claimed is:

1. A hydraulic apparatus comprising: a housing including means defining a chamber therein; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; rotatable means disposed in said chamber for receiving liquid from said inlet and delivering the same out through said outlet; bushing means disposed in said chamber for rotatably mounting said rotatable means therein and comprising opposed flat and axially spaced front and rear surfaces defining the maximum radial thickness of said bushing means which extends continuously throughout its length, said chamber being continuous throughout its length to substantially conform with said bushing means, said front surface being interrupted by cylindrical bore means for rotatably mounting said rotatable means and the remaining flat portion thereof being cooperable with adjacent side face means of said rotatable means to provide a seal therewith, said bore means terminating within said bushing means, said rear surface being spaced from and cooperable with an adjacent end wall of said chamber; means defining recess means in one of said rear surface and said adjacent end wall; sealing means disposed in said recess means in sealing engagement with said rear surface and said cooperable adjacent end wall and effective to divide the space therebetween into a plurality of cavities, one of said cavities being disposed adjacent said inlet and in fluid communication therewith, another of said cavities being disposed adjacent said outlet and in fluid communication therewith whereby liquid from said inlet is supplied to said one cavity and liquid from said outlet is supplied to said another cavity so that the force of the respective liquid acting on said rear surface in the region of the respective cavity balances the respective opposition force acting on said front surface in the same region thereof and causes said bushing to cooperate with said rotatable means to provide said seal.

2. A hydraulic apparatus comprising: a housing including means defining a chamber therein; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; a gear disposed in said chamber for receiving liquid from said inlet and delivering the same out through said outlet, said gear having a flat side and a journal extending therefrom; bushing means disposed in said chamber for rotatably mounting said gear therein and comprising opposed flat and axially spaced front and back surfaces defining the maximum radial thickness of said bushing means which extend continuously throughout its length, said chamber being continuous throughout its length to substantially conform with said bushing means, said front surface being interrupted by a cylindrical bore for receiving said journal and the remaining flat portion thereof being cooperable with said side face of said gear to provide a seal therewith, said bore terminating in said bushing means and permitting axial movement of said bushing means relative to said gear, said back surface being spaced from and cooperable with an adjacent end wall of said chamber; means defining a recess means in said back surface; pin means disposed in said recess means in sealing engagement with said back surface and said cooperable adjacent end wall and effective to divide the space therebetween into two substantially equal cavities, one of said cavities being adjacent said inlet and in fluid communication therewith, the other of said cavities being adjacent said outlet and in fluid communication therewith whereby liquid from said inlet is supplied to said one cavity and liquid from said outlet is supplied to said other cavity so that the force of the respective pressure liquid acting on said back bushing surface in the region of the respective cavity balances the respective opposition force acting on said front bushing surface in the same region thereof and causes said bushing to cooperate with said gear to provide said seal.

3. A hydraulic apparatus as recited in claim 2 wherein

said recess means in the back surface of said bushing has a substantially V-shaped cross-sectional configuration.

4. A hydraulic apparatus as recited in claim 2 wherein said recess means in the back surface of said bushing has a substantially arcuately-shaped cross-sectional configuration.

5. A hydraulic apparatus as recited in claim 2 wherein said recess means in the back surface of said bushing has a substantially rectangularly-shaped cross-sectional configuration.

6. A hydraulic apparatus comprising: a housing including means defining a chamber therein; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; a pair of meshing gears disposed in said chamber for receiving liquid from said inlet and delivering the same out through said outlet, said gears each having a flat side and a journal extending therefrom; bushing means disposed in said chamber for rotatably mounting said gears therein and comprising opposed substantially flat and axially spaced front and back surfaces defining the maximum radial thickness of said bushing means which extends continuously throughout its length, said chamber being continuous throughout its length to substantially conform with said bushing means, said front surface being interrupted by a pair of cylindrical bores for respectively receiving said journals and the remaining flat portion thereof being cooperable with said side faces of said gears to provide a seal therewith, said bores terminating within said bushing means and permitting axial movement of said bushing means relative to said gears, said back surface being spaced from and cooperable with an adjacent end wall of said chamber; means defining recess means in said back surface; sealing means disposed in said recess means in sealing engagement with said back surface and said cooperable adjacent end wall and effective to divide the space therebetween into two substantially equal cavities, one of said cavities being adjacent said inlet and in fluid engagement therewith, the other of said cavities being adjacent said outlet and in fluid communication therewith whereby liquid from said inlet is supplied to said one cavity and liquid from said outlet is supplied to said other cavity so that the force of the respective pressure liquid acting on said back bushing surface in the region of the respective cavity balances the respective opposition force acting on said front bushing surface in the same region thereof and causes said bushing means to cooperate with said gears to provide said seal.

7. A hydraulic apparatus comprising: a housing having an internal peripheral continuous and uninterrupted surface defining a chamber therein and a pair of end walls closing off said chamber; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; rotatable means disposed in said chamber for receiving fluid from said inlet and delivering the same out through said outlet; axially movable bushing means disposed in said housing for rotatably supporting said rotatable means, said bushing means having flat front and rear surfaces defining the maximum radial thickness of said bushing means which thickness is continuous throughout its length and substantially conforms to the peripheral surface of said chamber, said front surface being adapted to cooperate with said rotatable means to provide a seal therewith, said rear surface being spaced from and cooperable with an adjacent end wall of said chamber; sealing means disposed between said rear surface and said adjacent end wall and dividing the space therebetween into a plurality of cavities, said sealing means extending across said rear surface from a first portion of said internal peripheral surface to another portion of said internal peripheral surface; and means for conveying pressure fluid to at least one of said cavities whereby the force of the fluid acts against said rear surface and causes said front surface to cooperate with said rotatable means to provide said seal.

8. A hydraulic apparatus comprising: a housing having an internal peripheral continuous and uninterrupted surface defining a chamber therein and a pair of end walls closing off said chamber; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; rotatable means disposed in said chamber for receiving fluid from said inlet and delivering the same out through said outlet; axially movable bushing means disposed in said housing for rotatably supporting said rotatable means, said bushing means having flat front and rear surfaces defining the maximum radial thickness of said bushing means which thickness is continuous throughout its length and substantially conforms to the peripheral surface of said chamber, said front surface being adapted to cooperate with said rotatable means to provide a seal therewith, said rear surface being spaced from and cooperable with an adjacent end wall of said chamber; means defining recess means in one of said rear surface and said adjacent end wall; sealing means disposed in said recess means and dividing the space between said rear surface and said adjacent end wall into a plurality of cavities, said sealing means extending from a portion of said internal peripheral surface to another portion of said peripheral surface; and means for conveying pressure fluid to at least one of said cavities whereby the force of the fluid acts against said rear surface and causes said front surface to cooperate with said rotatable means to provide said seal.

9. A hydraulic apparatus comprising: a housing having an internal peripheral continuous and uninterrupted surface defining a chamber therein and a pair of end walls closing off said chamber, said chamber defining an internal peripheral surface of said housing; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; rotatable means disposed in said chamber for receiving fluid from said inlet and delivering the same out through said outlet; axially movable bushing means disposed in said housing for rotatably supporting said rotatable means, said bushing means having flat front and rear surfaces, said bushing means further having a continuous and uninterrupted outer periphery to substantially conform with the internal peripheral surface of said chamber, said front surface being adapted to cooperate with said rotatable means to provide a seal therewith, said rear surface being spaced from and cooperable with an adjacent end wall of said chamber; means defining recess means in one of said rear surface and said adjacent end wall, said recess means being disposed perpendicularly with respect to the axis of rotation of said rotatable means; sealing means disposed in said recess means dividing the space between said rear surface and said adjacent end wall into a plurality of cavities, said sealing means extending from a portion of said internal peripheral surface to another portion of said peripheral surface; and means for conveying pressure fluid to at least one of said cavities whereby the force of the fluid acts against said rear surface and causes said front surface to cooperate with said rotatable means to provide said seal.

10. A hydraulic apparatus comprising: a housing having an internal peripheral continuous and uniniterrupted surface defining a chamber therein and a pair of end walls closing off said chamber, said chamber defining an internal peripheral surface of said housing; means defining an inlet and an outlet in said housing leading respectively to and from said chamber; a pair of intermeshing gears disposed in said chamber for receiving fluid from said inlet and delivering the same out through said outlet; axially movable bushing means disposed in said housing for rotatably supporting said gears, said bushing means having flat front and rear surfaces defining the maximum radial thickness of said bushing means which thickness is continuous throughout its length and substantially conforms to the peripheral surface of said chamber, said

front surface being adapted to cooperate with said gears to provide a seal therewith, said rear surface being spaced from and cooperable with an adjacent end wall of said chamber; sealing means disposed between said rear surface and said adjacent end wall and dividing the space therebetween into a plurality of cavities, said sealing means extending from a portion of said internal peripheral surface to another portion of said peripheral surface; and means for conveying pressure fluid to at least one of said cavities whereby the force of the fluid acts against said rear surface and causes said front surface to cooperate with said gears to provide said seal.

11. A hydraulic apparatus comprising: a housing having a pair of parallel intersecting bores formed therein and a pair of end walls closing off said bores, said bores defining an internal peripheral continuous and uninterrupted surface of said housing; means defining an inlet and an outlet in said housing leading respectively to and from said bores; a pair of intermeshing gears disposed respectively in said bores for receiving fluid from said inlet and delivering the same out through said outlet; a pair of axially movable bushing means disposed respectively in said bores for respectively rotatably supporting said gears, said bushing means each having flat front and rear surfaces defining the maximum radial thickness of said bushing means which thickness is continuous throughout its length and substantially conforms to the peripheral surface of said chamber, said front surface being adapted to cooperate with an adjacent gear to provide a seal therewith, said rear surface being spaced from and cooperable

with an adjacent end wall of said housing; sealing means disposed between said rear surfaces and said adjacent end wall and dividing the space therebetween into a plurality of cavities, said sealing means extending from a portion of said internal peripheral surface defined by one of said bores to another portion of said peripheral surface defined by the other of said bores; and means for conveying pressure fluid to at least one of said cavities whereby the force of the fluid acts against said rear surfaces and causes said front surfaces to cooperate with said gears to provide with seal.

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