

March 10, 1959

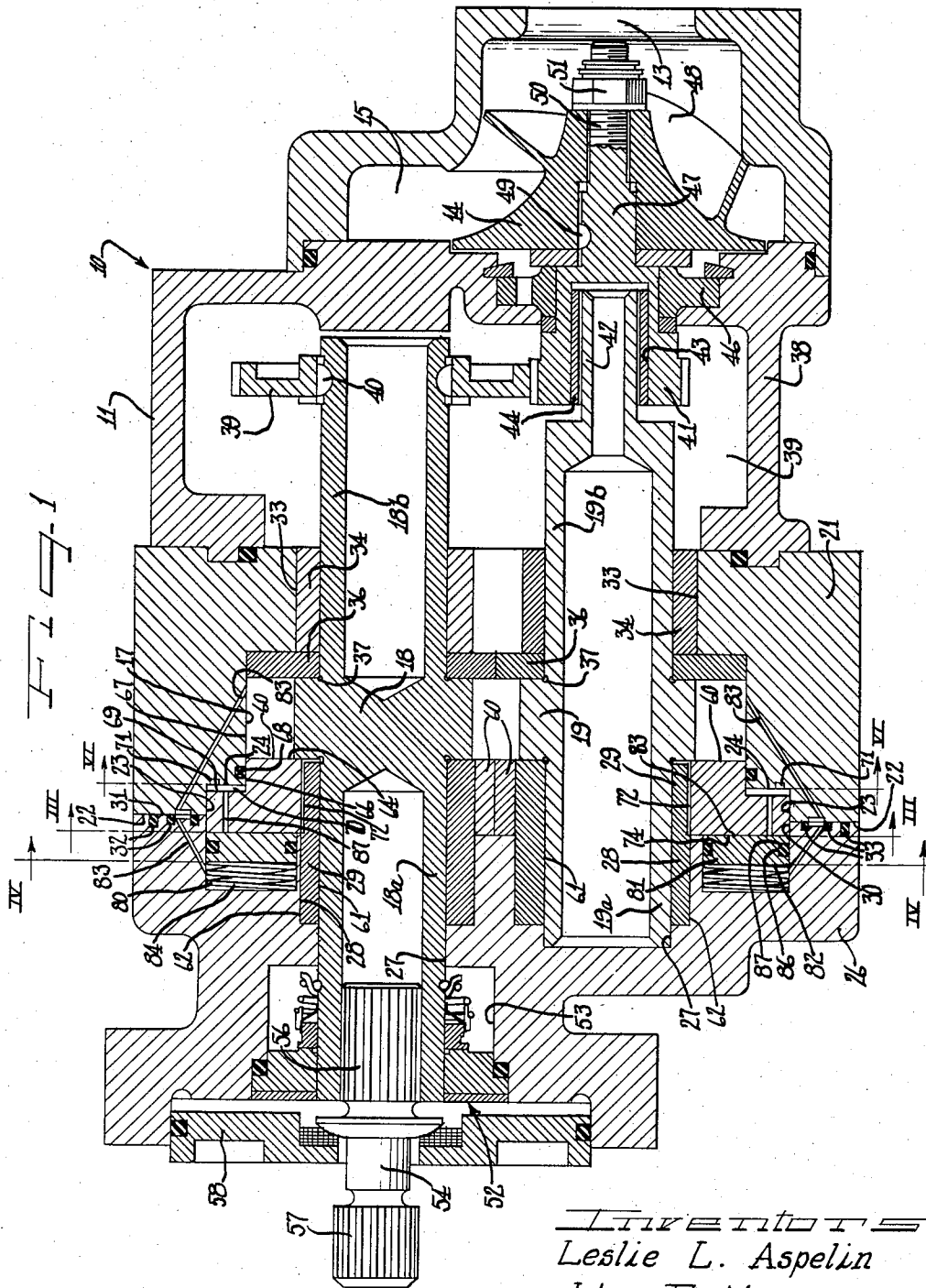
L. L. ASPELIN ET AL

2,876,705

PRESSURE LOADED GEAR PUMP

Filed May 29, 1953

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

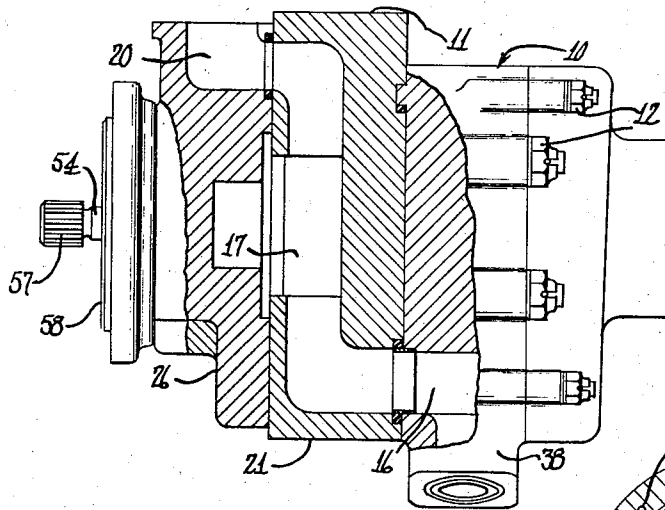


Fig. 2

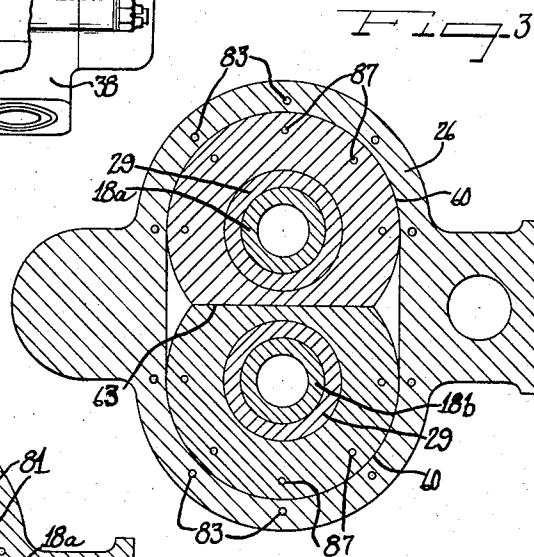


Fig. 3

Fig. 4

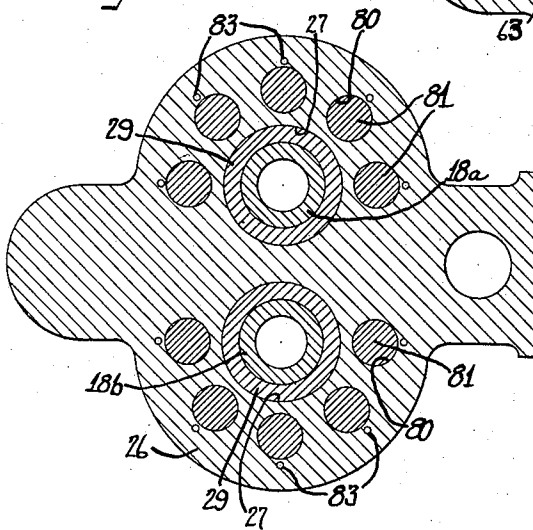
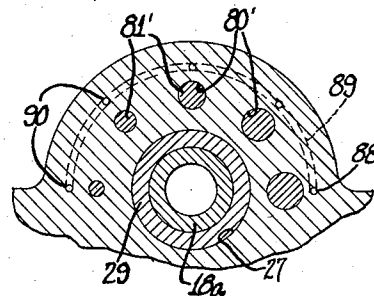


Fig. 5



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3 Sheets-Sheet 3

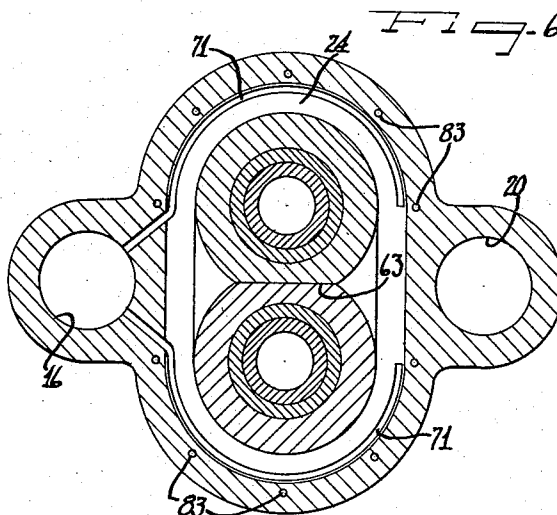
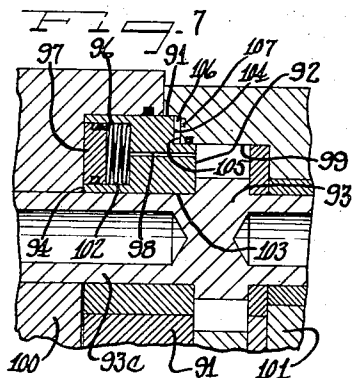


Fig. 8

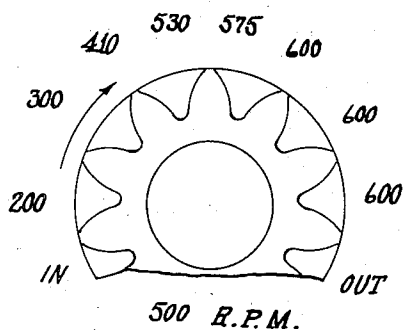


Fig. 9

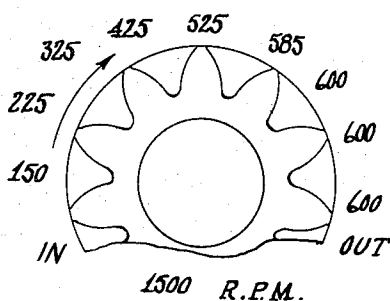


Fig. 10

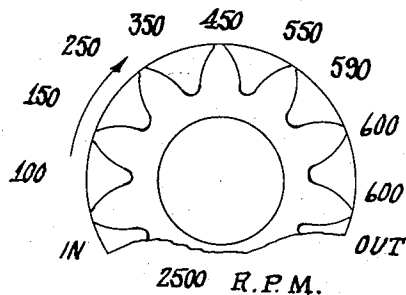
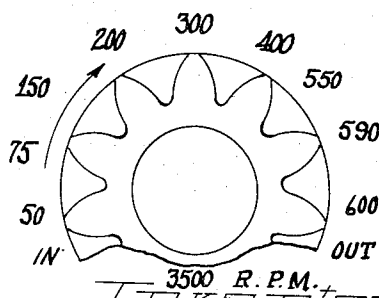


Fig. 11



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1

2,876,705

PRESSURE LOADED GEAR PUMP

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Application May 29, 1953, Serial No. 358,453

35 Claims. (Cl. 103—126)

This invention relates generally to gear pumps and, more particularly, to a gear pump having pressure loaded movable end plate means.

It has been determined that developed pressures around the periphery of a rotary fluid displacement means of a gear pump vary as a function of the rotational speed of the pump and as a function of the discharge pressure. Accordingly, with a pressure loaded gear pump of the type using pressure loaded movable end plate means, the total force tending to separate the mating gear and end plate and the line of action of that force tends to change with the speed of rotation of the gear impellers. To provide a loading force acting on the movable end plate which will be equal and opposite to a varying load, it would be necessary to change not only the quantitative value of the loading force, but it would also be necessary to apply such force at different locations.

According to the principles of the present invention, a plurality of circumferentially spaced cylinders and pistons are provided for axially loading the movable end plates into sealing engagement with the side faces of the gear impellers. Each of the respective cylinders is referenced to a correspondingly circumferentially spaced location in the pumping chamber so that the respective areas which are utilized for pressure loading the movable end plate will be referenced to pressures generated by the pump varying as a function of the pump speed and discharge pressure, thereby to balance unequal pressure forces developed in the pumping cavity of the pump. Thus, in its broadest aspect, the present invention contemplates the application of non-uniform fluid pressures to selected uniform areas of a movable end plate. It is further contemplated to provide a plurality of circumferentially spaced non-uniform areas which, in accordance with the principles of the present invention, function as reactive pressure surfaces subject to a uniform pressure. In accordance with either provision, the unequal pressure forces developed in the pumping cavity will be balanced by the reactive pressure forces loading the movable end plate means into sealing engagement with the side faces of the gears.

It is further contemplated in accordance with the principles of the present invention to provide a two-piece bushing-end plate means whereby a bearing sleeve member having a journal surface adapted to journal the shaft extension of a rotary gear cooperates with a movable end plate member forming a relatively axially movable radial extension of the bearing sleeve member. The provision of such a construction permits the use of an end plate member affording an unusually large motive surface. The two part construction further affords flexibility insofar as axial and radial alignment of the gears and the bushing-end plate part are concerned.

It is an object of the present invention, therefore, to provide means for loading an end plate of a gear pump wherein the loading force will vary as a function of the pump speed and discharge pressure.

Yet another object of the present invention is to pro-

2

vide movable end plate means for a gear pump variably loaded as a function of pump speed and discharge pressure for balancing unequal pressure forces in a gear pump pumping chamber.

Yet another object of the present invention is to provide an improved two-piece bushing-end plate construction for a pressure loaded gear pump.

Another object of the present invention is to provide movable end plate means for a gear pump wherein a back motive surface is at least coextensive in size with, or preferably larger than, a front sealing face adapted to engage the side face of an adjoining rotatable gear impeller member.

Another object of the present invention is to provide means for balancing unequal pressure forces developed in the pumping cavity of a gear pump.

A further object of the present invention is to provide movable end plate means for a gear pump having a motive surface of sufficiently large area to accommodate the application of loading force sufficient to overcome the separating force between the gear side face and the end plate sealing face.

Many other advantages, features, and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which a preferred structural embodiment of a pressure loaded gear pump incorporating the principles of the present invention is shown by way of illustrative example.

On the drawings:

Figure 1 is a cross sectional view of a pumping unit including a centrifugal pump in series with a gear pump incorporating the principles of the present invention.

Figure 2 is a plan elevational view with parts broken away and shown in cross section and with parts removed for the sake of clarity illustrating additional details of construction of the pumping unit shown in Figure 1.

Figure 3 is a cross-sectional view, somewhat reduced, taken substantially on line III—III of Figure 1.

Figure 4 is a cross sectional view, somewhat reduced, taken substantially on line IV—IV of Figure 1.

Figure 5 is a fragmentary cross sectional view generally similar to the view of Figure 4 but showing an alternative modification provided in accordance with the principles of the present invention.

Figure 6 is a cross sectional view taken substantially on line VI—VI of Figure 1.

Figure 7 is a fragmentary cross sectional view somewhat similar to Figure 1 but showing an alternative embodiment provided in accordance with the principles of the present invention.

Figures 8, 9, 10 and 11 are diagrammatic views depicting one of a pair of rotatable intermeshing gears and showing how peripheral pressures vary with speed in a pressure loaded gear pump having movable pressure loaded end plate means.

As shown on the drawings:

As shown in Figure 1, the principles of the present invention are advantageously incorporated in a pumping unit indicated generally by the reference numeral 10 comprising a sectionalized casing 11, the spaced sections being held in firm assembly with one another by a plurality of fasteners indicated generally at 12 (Figure 2).

The pumping unit 10 is provided with an inlet 13 through which a fluid pumping medium is delivered to a centrifugal impeller 14 rotatable in a volute pumping chamber 15. The outlet of the volute pumping chamber 15 forms the inlet 16 of a pumping chamber 17 provided in the sectionalized casing 11 and housing rotatable fluid displacement means comprising a driver gear 18 and a driven gear 19. The pumping chamber 17 is further pro-

3

vided with an outlet 20. Thus, it will be appreciated that the centrifugal pump is integral and in series with the gear pump.

Making particular reference to Figures 1 and 2, it will be noted that the sectionalized casing 11 comprises a housing member 21 having a radially extending face indicated at 22 and in which is formed a pair of intersecting bores which, together, form the pumping chamber 17.

The housing member 21 is further characterized by the provision of a counterbore 23 which provides adjacent the pumping chamber 17 a radially extending shoulder indicated at 24.

The sectionalized casing 11 is further provided with a cover member 26 having a pair of spaced bores 27, 27 for receiving the shaft extensions 18a and 19a of the driver and driven gears 18 and 19, respectively.

Additionally, the cover member 26 is provided with a pair of counterbores 28, 28 in assembly therewith, a bearing sleeve member 29, the detailed construction of which will be described presently.

The cover member 26 is further provided with an additional counterbore indicated at 30 of complementary size and shape to the counterbore 23 provided in the housing member 21.

The cover member 26 is also provided with a radially extending face 31 complementary in size and shape to the radial face 22 on the housing member 21 and particularly characterized by the provision of a plurality of radially spaced apart grooves 32, each receiving seal rings 33 for establishing sealed areas between the abutting radial faces 22 and 31.

The housing member 21 is provided with a pair of spaced apart bores 33 adjacent the pumping chamber 17 and each bore 33 receives a bearing sleeve 34 providing a bearing journal surface for a shaft extension 18b and 19b of the driver gear 18 and the driven gear 19, respectively.

A stationary end plate 36 is received in one end of each of the overlapping bores providing the pumping chamber 17 and abuts against the respective ends of the bearing sleeves 34, 34 along one radially disposed face, the other oppositely disposed radial face providing a radially extending sealing face for sealingly engaging the mating side face of the driver gear 18 and the driven gear 19.

In order to prevent galling, binding and seizure between the relatively rotatable components, a conventional annular machining relief indicated at 37 is provided in the driver and driven gears 18 and 19, respectively.

The sectionalized casing 11 includes a housing member 38 which provides a gear box 39 for receiving the shaft extensions 18b and 19b of the driver and driven gears 18 and 19. It will be noted that the shaft extension 18b has a gear 39 keyed thereto as at 40, which gear 39 is rotatable with the driver gear 18 and intermeshingly engages in driving relationship with a gear 41.

The shaft extension 19b has a stub extension indicated at 42 received in a recess 43 formed in the gear member 41. A bearing sleeve 44 is interposed between the shaft stub 42 and the walls of the recess 43 thereby to provide journal support for the gear member 41.

Further journal support for the gear member 41 is provided by a bearing retainer 46 mounted in the housing member 38 and engaging the peripheral surface of an axial extension provided on the gear member 41. The gear member 41 is further provided with a hub 47 to which a centrifugal impeller 48 is keyed as at 49 for rotation in the volute chamber 15. The hub 47 is threaded as at 50 for receiving additional fastening means indicated at 51 serving to retain the centrifugal impeller 48 in corotatable assembly with the gear member 41.

The shaft extension 18a on the driver gear 18 extends through a shaft seal assembly indicated generally at 52 and received in a recess 53 provided in the cover member 26. The shaft extension 18a is internally splined to

4

provide a mating coupling with a stub shaft 54, one end of which is splined as at 56 for mating engagement with the shaft extension 18a and the other end of which is splined as at 57 to effect coupling engagement with a suitable power source (not shown). A cover plate 58 engages the end of the cover member 26 as is shown in Figure 1.

Upon applying rotational force to the stub shaft 54, the driver gear 18 will be rotated whereupon the centrifugal impeller 48 will also be rotated through the gear train 41, 39. Fluid will thus be pumped through the inlet 13 through the pumping chamber 15, the centrifugal outlet and gear pump inlet 16, the pumping chamber 17 and thence through the outlet 20.

The present invention particularly contemplates the provision of improved movable end plate means for effectivly sealing the gears 18 and 19 in the pumping chamber 17. In effecting this end, there has been heretofore provided combination bearing bushings and end plates formed as integral members. In accordance with the principles of the present invention, a two-piece bushing-end plate means is provided including the bearing sleeve 29 and an end plate member indicated at 60.

As noted hereinabove, each of the bearing sleeve members 29 is received in a corresponding counterbore 28 in the cover member 26. Each bearing sleeve member 29 provides an internal bore forming a bearing journal surface 61 journalling the shaft extensions 18a and 19a of the driver gear 18 and the driven gear 19, respectively.

Each bearing sleeve member 29 further includes a peripheral surface indicated at 62 which is spaced radially outwardly of the bearing journal surface 61 and which is adapted to seat against the walls of the counterbores 28 provided in the cover member 26.

The end plate member 60 provided for each respective gear 18 and 19 comprises an annular ring member sized and shaped to be slidably received in the counterbores 23 and 30 of the housing member 21 and the cover member 26, respectively.

As shown in Figure 3, each of the end plate members 60 has a flat chordal surface so that adjacent end plate members 60 abut one another to form a joint indicated at 63, thereby preventing rotation of the end plate members relative to the casing 11.

Each end plate member 60 is provided with a reduced diameter portion forming, in effect, a reduced tubular extension of an outer diameter equal to the outer diameter of the corresponding driver gear 18 and driven gear 19. Thus, there is provided a front sealing face 64 on each end plate member 60 which extends radially and which is equal in diameter to the gears and to the intersecting bores forming the pumping chamber 17, thereby to provide a continuous generally annular sealing face for engaging the corresponding side faces of the gears 18 and 19.

The inner diameter of the sealing face 64 is preferably less than the root diameter of the gear teeth on the driver gear 18 and the driven gear 19 so that the radial sealing face 64 extends radially inwardly of the gear teeth diameter.

By virtue of the construction of the end plate member 60, there is provided an axially extending peripheral face indicated at 66 which slidably engages the walls indicated at 67 defining the confines of the pumping chamber 17. It will be understood that the surface 66 and the walls 67 are slidably interrelated and sealing means are provided therebetween which can conveniently take the form of an O ring seal indicated at 68. In the embodiment shown in the drawings, the O ring seal member 68 is received in a groove formed in the walls 67.

The end plate member 60 also provides a radially extending wall indicated at 69 which confronts and is spaced from the radially extending wall 24 on the housing member 21 thereby to form a chamber 70. As is shown in Figure 6, the radially extending wall 24 is particularly

characterized by a circumferentially extending groove 71, which groove communicates with the inlet 16, thereby serving to minimize any dash pot action which would impede movement of the end plate members toward the gears 18 and 19.

As will be appreciated by those versed in the art, the end plate members 60 form a relatively axially movable radial extension of the bearing sleeve members 29. Each bearing sleeve member 29 and a corresponding end plate member 60 together provide confronting circumferential peripheral and bore surfaces, respectively, which are indicated by the common reference character 72 and which are spaced radially outwardly of the journal bushing surface 61 so as to slidably relate the end plate member 60 to the corresponding bearing sleeve member 29 for relative axial reciprocation toward and away from the corresponding gear member.

Each end plate member 60 also provides a radially extending back face 74, the outer diameter of which is equal to the diameter of the counterbores 23 and 30 formed in the housing member 21 and the cover member 26, respectively, and the inner diameter of which being equal to the outer diameter of each bearing sleeve member 29. Accordingly, because the sealing face 64 is provided on the reduced tubular extension of the end plate member 60, it will be appreciated that the back face 74 will always be at least coextensive in area with the sealing face 64. As shown in the drawings, the back face 74 will be considerably larger in area than the sealing face 64, which provision is particularly advantageous for the purposes of the present invention.

In accordance with the principles of the present invention, a plurality of circumferentially spaced reactive areas are provided to load the back face 74 and means are provided to reference each respective reactive pressure area to fluid pressures generated by the pump 10 in the pumping cavity 17 varying as a function of pump speed and discharge pressure for balancing unequal pressure forces in the pumping cavity.

Before describing in detail the pressure loading means, advantageous reference may be made to the diagrammatic views shown in Figures 8, 9, 10 and 11. If developed pressures are checked at various points around the periphery of a pumping gear in a pressure loaded gear pump, it will be found that such pressures vary as a function of the speed of rotation and the discharge pressure. The views of Figures 8-11 exemplify such variance. The numbers around the periphery of each gear express in pounds per square inch the developed fluid pressure around the periphery of a pumping gear in a gear pump rated at 600 pounds per square inch.

In Figure 8, the rotary fluid displacement means are rotated at approximately 500 revolutions per minute and it will be noted that pressure distribution indicates a rapid increase adjacent the inlet side of the pump.

Comparable pressure values are indicated on Figure 9 for a rotational speed of 1500 R. P. M. It will be noted that the line of action of the forces tending to separate a floating bearing from the mating gear has shifted since the high pressure values have generally shifted towards the outlet side.

In Figure 10, for a 2500 R. P. M. speed, the shift is even more pronounced and, in Figure 11, at 3500 R. P. M., it will be noted that decided changes both as to quantitative pressure value and line of action of pressure force have occurred.

The loading means provided in accordance with the principles of the present invention compensate for the variations in separating force due to pump speed and discharge pressure.

In the form of the invention shown in Figure 1 and the views based thereon, the cover member 26 is provided with a plurality of circumferentially spaced recesses each indicated at 80. Means are provided to confine fluid pressure generated by the pump in each of the recesses 80

so as to apply a reactive pressure force against the back face 74 of the end plate member 60. In the form of Figure 1, each of the recesses 80 comprises a cylinder receiving a piston 81, one face of each piston 81 indicated at 82 being exposed to fluid pressure confined in the recess 80 and the opposite face of each piston 81 indicated 83 abuttingly engaging the back face 74 of the end plate member 60.

Fluid pressures generated by the pump are referenced to the respective recesses 80 and in this connection, a separate fluid passage 83 is provided for each respective recess 80 referenced to the pumping chamber 17 at circumferentially spaced points around the periphery of the pumping chamber 17. In other words, the back face 74 of each end plate member 60 is acted upon by a plurality of cylinder and piston means which are circumferentially spaced between the inlet and outlet sides of the pump. Each passage 83 extends from each respective recess 80 to a correspondingly spaced point in the pumping chamber 17 directly adjacent axially the corresponding portion of the sealing face 64 acted upon by the pressure forces in the pumping chamber 17. By proper proportioning of the pistons 81, for any segment of the end plate member 60 there will be a force of equal magnitude working on both sides of the plate, namely, the sealing face 64 and the back face 74. Moreover, the fluid pressures working in the cylinders or recesses 80 will change in proportion to the pressure distribution around the periphery of the pumping gears as the rotational speed of the pump changes.

A continuous biasing means conveniently taking the form of a coil spring 84 is provided in each recess 80, one end of each spring 84 being bottomed against the cover member 26 and the opposite end being bottomed against a corresponding piston 81, thereby to provide initial loading of the end plate member 60 against the corresponding gear. With perfect hydraulic balance of the end plate member 60, the springs 84 provide the only positive force holding the end plate members 60 against their corresponding gears.

It will be noted that each respective piston 81 is provided with an annular groove 86 receiving an O-ring 87 so that fluid pressure in the cylinders or recesses 80 will be positively sealed.

In the form of the invention illustrated in Figure 1, the passages 83 are provided by a first passage section which is inclined radially outwardly in the cover member 26 between each respective recess 80 and the radial face 31. A second passage section is formed in each housing member 21 and consists of an outwardly inclined passage extending between the pumping chamber and the radial face 22 on the housing member 21. In order to afford a manufacturing tolerance, the intersection of the passage sections at the abutting radial faces 22 and 31 are characterized by enlarged recesses isolated between radial inner and outer sealing members 31 in the radially spaced grooves 32.

An axially extending passage 87 is provided through each end plate member 60 between the chamber 70 and the radial face 83 on each respective piston 81 to insure full engagement between each respective piston 81 and the back face 74 of the end plate member 60.

The sectional view of the form of the invention shown in Figure 1 and illustrated in Figure 4 illustrates how each recess 80 and the corresponding piston 81 establishes a plurality of circumferentially spaced reactive pressure areas of uniform size. Although the reactive pressure areas are of uniform size, it will be appreciated that a different fluid pressure will exist in each cylinder or recess 80 so that the pressure forces tending to load the end plate member 60 will vary proportionately from the inlet to the outlet sides of the pump. Moreover, the pressure in each cylinder will not only differ from that in adjoining cylinders, but in any one cylinder or recess 80, the hydraulic pressure will vary with the changes in

7

pressure around the periphery of the gear and such variations will occur as a function of the pump speed and the pump discharge pressure.

In the embodiment of Figure 5, the structural arrangement is generally similar to that shown in Figures 1-4, however, each of the cylinders is indicated at 80' and each of the pistons is indicated at 81', the respective cylinders and pistons being of non-uniform size and increasing in effective area proportionately from the inlet side of the pump toward the outlet side of the pump. Instead of referencing the respective cylinders 80' to varying pressure, a passage 88 communicates discharge pressure to a feeder passage 89, thereby referencing a uniform quantitative value of pressure to each respective cylinder 80', namely, the pressure in the feeder passage 89, by means of a separate passage 90. There is thus provided a plurality of circumferentially spaced reactive areas of non-uniform size, each increasing in effective area from the pump inlet to the pump outlet so that the respective areas can be referenced to pressures generated by the pump for balancing unequal pressure forces in the pumping chamber.

In the form of the invention shown in Figure 7, the end plate member is indicated at 91 and comprises a generally ring shaped member having a reduced section providing a radial front face 92 sealing against the side face of a gear member 93 and a radially extending back face 94 characterized by a plurality of circumferentially spaced cylinders 96, each receiving a piston 97. An axially extending passage 98 is provided between each cylinder 96 and the front face 92, the passage 98 intersecting the front face 92 radially outwardly of the root diameter of the gear teeth so as to communicate the respective cylinders 96 to pressures generated by the pump at circumferentially spaced points around the periphery of the pumping chamber 99 varying as a function of the speed of the gear 93 and the discharge pressure of the pump. Since the piston 97 engagingly abuts against the casing 100 and since the end plate member 91 is slidably movable in the casing member 100 and the casing member 101, the fluid pressure confined in the cylinder 96 by the piston 97 will act on the reactive pressure surface formed at the bottom of the cylinder 96 to impart an axial thrust to the end plate member 91 loading the end plate member into sealing engagement with the side face of the gear 93.

A coil spring 102 is bottomed at one end against the piston 97 and is bottomed at the other end against the end plate member 91 to initially load the end plate member into sealing engagement with the gear 93.

In the form of the invention illustrated in Figure 7, the separate bearing sleeve member 29 may be eliminated if desired and the end plate member 91 may be provided with a bore providing a journal bearing surface 103 for journaling the shaft extension 93a of the gear 93.

As described in connection with the form of the invention shown in Figure 1, the back face 93 of the end plate member 91 is of considerably larger area than the front face 92 and the end plate member 91 is also provided with a radially extending shoulder 104 which confronts and is spaced from a complementary shoulder 105 provided by the casing member 101 thereby to form a chamber 106 referenced to a zone of lower pressure such as inlet pressure by a groove 107 to minimize dash pot action.

Although various minor structural modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In a pump, a casing providing intersecting bores forming a pumping chamber and having an inlet and an outlet at opposite sides thereof, intermeshing gears ro-

8

tatable in said pumping chamber, a movable end plate for each bore having a first end face to sealingly engage the side face of a corresponding gear and a second end face providing a motive surface of larger area than said first end face, said first end face being subject to non-uniform fluid pressure forces in said pumping chamber varying in quantitative amount from the inlet to the outlet sides of the pump, circumferentially spaced loading means exerting loading forces on said second end face to balance the unequal pressure forces in said chamber acting on said first end face, said loading means comprising pressure reactive areas of non-uniform size and receiving fluid pressure generated by the pump applied over the respective areas to balance the unequal pressure forces in the pumping chamber.

2. In a pump, a casing providing intersecting bores forming a pumping chamber and having an inlet and an outlet at opposite sides thereof, intermeshing gears rotatable in said pumping chamber, a movable end plate for each bore having a first end face to sealingly engage the side face of a corresponding gear and a second end face providing a motive surface of larger area than said first end face, said first end face being subject to non-uniform fluid pressure forces in said pumping chamber varying in quantitative amount from the inlet to the outlet sides of the pump, and circumferentially spaced loading means exerting loading forces on said second end face to balance the unequal pressure forces in said chamber acting on said first end face, said loading means comprising pressure reactive areas of uniform size and of means communicating fluid pressure generated by the pump varying in quantitative amount from the respective areas nearest the inlet side of the pump to the respective areas nearest the outlet side of the pump, thereby to balance the non-uniform pressure forces in the pumping chamber.

3. In a pump, a casing providing intersecting bores forming a pumping chamber and having an inlet and an outlet at opposite sides thereof, intermeshing gears rotatable in said pumping chamber, a movable end plate for each bore having a first end face to sealingly engage the side face of a corresponding gear and a second end face providing a motive surface of larger area than said first end face, said first end face being subject to non-uniform fluid pressure forces in said pumping chamber varying in quantitative amount from the inlet to the outlet sides of the pump, and circumferentially spaced loading means exerting loading forces on said second end face to balance the unequal pressure forces in said chamber acting on said first end face, said loading means comprising fluid pressure reactive members engaging said motive surface, and means communicating pressure generated by the pump thereto, each of said fluid pressure reactive members having an effective reactive area varying from an adjacent pressure reactive member and increasing from the inlet side of the pump to the outlet side of the pump for balancing unequal pressure forces in the pumping chamber.

4. In a pump, a casing providing intersecting bores forming a pumping chamber and having an inlet and an outlet at opposite sides thereof, intermeshing gears rotatable in said pumping chamber, a movable end plate for each bore having a first end face to sealingly engage the side face of a corresponding gear and a second end face providing a motive surface of larger area than said first end face, said first end face being subject to non-uniform fluid pressure forces in said pumping chamber varying in quantitative amount from the inlet to the outlet sides of the pump, and circumferentially spaced loading means exerting loading forces on said second end face to balance the unequal pressure forces in said chamber acting on said first end face, said loading means comprising fluid pressure reactive members engaging said motive surface and providing spaced uniform areas between the inlet and the outlet of the pump, and means communicating pressures generated by the pump which vary in quantitative amount in correspondingly spaced areas in the pumping chamber

9

between the inlet and the outlet of the pump to the respective uniform areas to balance the non-uniform pressures in the pumping chamber.

5. In a pump, a casing providing intersecting bores forming a pumping chamber having an inlet and an outlet at opposite sides thereof, intermeshing gears rotatable in said pumping chamber, said casing having radially extending walls adjacent said bores, a movable end plate member for each bore, each end plate member having an end face received in a corresponding one of said bores to sealingly engage the side of a corresponding gear, an annular radially outwardly extending face on said end plate member overlying said casing walls, and a second end face on said end plate providing a motive surface coextensive with both of said faces, said first mentioned end face being subject to non-uniform fluid pressure forces in said pumping chamber varying from the inlet to the outlet sides of the pump, and loading means exerting a non-uniform loading force on said second end face varying from the inlet to the outlet sides of the pump, thereby to move said end plate into sealing engagement with the gears.

6. In a pump, a casing providing intersecting bores forming a pumping chamber having an inlet and an outlet, rotatable intermeshing gears in said pumping chamber for moving fluid from said inlet to said outlet, said casing having a radially extending wall adjacent said bores, a movable end plate member for each bore, each end plate member having an end face received in a corresponding one of said bores to sealingly engage the side of a corresponding gear, a second end face on said end plate member providing a motive surface greater in area than said first end face, and means communicating and confining fluid pressures generated by the pump which vary in quantitative amount in spaced areas in the pumping chamber between the inlet and the outlet of the pump to correspondingly spaced and selected areas of said motive surface to balance the non-uniform unit pressures acting on said first end face in said pumping chamber.

7. In a pump, a casing providing a pumping cavity having an inlet and an outlet and an end plate member movable toward and away from the cavity comprising a substantially tubular portion having a radial pressure sealing face of the same outer dimension as and received in said cavity and adapted to sealingly engage rotary fluid displacement means in the cavity, and a radially extending flange at the opposite end of said end plate member of larger dimension than said cavity and providing a substantially annular face overlying said casing and a radial face spaced therefrom providing a motive pressure loading surface of larger sized area than said sealing face.

8. In a pump, a casing having an inlet and an outlet, a bore in said casing providing a pumping cavity and a counterbore in said casing adjacent said pumping cavity, intermeshing rotatable gears in said pumping cavity for moving fluid from the inlet to the outlet and providing radial side faces spanning said bore, shaft extensions on said gears projecting from said radial side faces and extending from one side of said gears through said counterbore, a movable bushing in said counterbore and around said shaft extensions for journalling said shaft extensions on said one side of said gears in said casing, said bushing having a reduced tubular portion received in said bore, said reduced tubular portion having an annular end face providing a sealing face for engaging a corresponding gear radial side face, said bushing having means forming a motive pressure face on its opposite end of larger area than said sealing face to load said bushing into sealing engagement with said gears.

9. In a pump, a casing having a bore providing a pumping cavity, a movable bushing having a small end of generally tubular configuration received in said bore, said small end having a radial sealing face spanning said pumping cavity, a radially outwardly extending flange at the opposite end of said bushing providing a radial end wall at the end of said bushing and on one side of said

10

flange, and a radially extending generally annular wall on the other side of said flange, said casing having a counterbore for receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall on said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, and pressure fluid means communicating with said pressure space.

10. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counterbore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall and said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, means providing a passageway to the pump inlet from said pressure space to minimize dash pot action and loading means exerting a force varying from the inlet to the outlet sides of the pump and acting on said radial end wall to move said bushing toward said pumping cavity.

11. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial end wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counterbore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall on said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, and means communicating pressures generated by said pump to said radial end wall to move said bushing toward said pumping cavity.

12. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial end wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counterbore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall on said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, means providing a passageway to the pump inlet from said pressure space to minimize dash pot action, and means communicating pressures generated by said pump to said radial end wall to move said bushing toward said pumping cavity.

13. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial end wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counterbore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall on said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, a plurality of circumferentially spaced

11

pressure reactive means acting on said radial end wall to move said bushing toward said pumping cavity and a corresponding plurality of passages in said casing between said pressure reactive means and a plurality of corresponding circumferentially spaced areas in said pumping cavity to communicate respective pressures generated by said pump at said spaced areas to each respective reactive means for loading said bushing toward said pumping cavity and for balancing unequal pressure forces in said pumping cavity.

14. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial end wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counterbore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall on said bushing and spaced therefrom to provide a pressure space isolated from opposite ends of said bushing, a plurality of circumferentially spaced pressure reactive means acting on said radial end wall to move said bushing toward said pumping cavity and a corresponding plurality of passages in said casing between said pressure reactive means and a plurality of corresponding circumferentially spaced areas in said pumping cavity to communicate respective pressures generated by said pump at said spaced areas to each respective reactive means for loading said bushing toward said pumping cavity and for balancing unequal pressure forces in said pumping cavity, and means providing a passageway to the pump inlet from said pressure space to minimize dash pot action.

15. A pump comprising a pair of meshing rotatable gears, a housing having two intersecting bores providing a pumping cavity for said gears and further including an inlet and an outlet, said gears having axially spaced radial side faces on opposite sides thereof, fixed end plate means in said housing sealingly engaging the side faces on one side of said gears, floating end plate means in said housing sealingly engaging the side faces on the other side of said gears, said floating end plate means having a motive surface, means including said floating end plate means forming a plurality of circumferentially spaced cylinders each having a piston movable therein and engaging said motive surface to move said floating end plate means relative to said housing into sealing engagement with said gears, and means providing separate passages for said cylinders referenced to said pumping cavity at circumferentially spaced points on the periphery of the corresponding gear axially adjacent the floating end plate, whereby the loading pressures are different for each piston.

16. A pump comprising a pair of meshing rotatable gears, a housing having two intersecting bores providing a pumping cavity for said gears and further including an inlet and an outlet, said gears having axially spaced radial side faces on opposite sides thereof, fixed end plate means in said housing sealingly engaging the side faces on one side of said gears, floating end plate means in said housing sealingly engaging the side faces on the other side of said gears, said floating end plate means having a motive surface, means including said floating end plate means forming a plurality of circumferentially spaced cylinders each having a piston movable therein and engaging said motive surface to move said floating end plate means relative to said housing into sealing engagement with said gears, and means providing separate passages for said cylinders referenced to said pumping cavity at circumferentially spaced points on the periphery of the corresponding gear axially adjacent the floating end plates, whereby the loading pressures are different for each piston, and a continuous biasing means acting on said floating

12

end plate means to maintain an unbalance on the floating end plate means in the direction of the pumping cavity.

17. In a pump, a pair of meshing rotatable gears having radial side faces, pressure loaded movable end plate means comprising an end plate member providing a sealing face equal in diameter to the outside diameter of the gears, and a radial extension on said end plate member providing a radially extending motive surface spaced axially from the gear and having a larger area than the area of the sealing face, and means including said end plate member forming a plurality of circumferentially spaced cylinders and pistons working on said motive surface to move said sealing face into sealing engagement with a corresponding gear side face, and means communicating different fluid pressure to said cylinders to work on said pistons comprising passage means referencing each respective cylinder to pressures generated by the pump at axially adjacent circumferentially spaced points around the periphery of the gears.

18. In a gear pump, a pair of meshing rotatable gears each having shaft extensions, pressure loaded movable end plate means comprising a generally annular end plate member for each gear spaced radially outwardly of the shaft extension and providing a sealing face equal in diameter to the outside diameter of the gear and extending radially inwardly of the root diameter of the teeth on the gear, and a bearing separate from said end plate member having an outer peripheral surface slidably supporting said end plate member and an inner bore surface in said bearing providing a journal bearing surface for the shaft extension, a radial extension on said end plate member providing a motive surface having a larger area than the area of said sealing face and fluid pressure motor means working on said motive surface to move said end plate into sealing engagement with the gear.

19. In a gear pump, a pair of meshing rotatable gears each having shaft extensions, pressure loaded movable end plate means comprising a generally annular end plate member for each gear spaced radially outwardly of the shaft extension and providing a sealing face equal in diameter to the outside diameter of the gear and extending radially inwardly of the root diameter of the teeth on the gear, and a bearing separate from said end plate member having an outer peripheral surface slidably supporting said end plate member and an inner bore surface in said bearing providing a journal bearing surface for the shaft extension, a radial extension on said end plate member providing a motive surface having a larger area than the area of said sealing face and fluid pressure motor means working on said motive surface to move said end plate into sealing engagement with the gear, said fluid pressure motor means comprising a plurality of circumferentially spaced cylinder and piston means communicating pressures generated by the pump at correspondingly circumferentially spaced and axially adjacent points around the periphery of the gear to circumferentially spaced points on said end plate member.

20. In a gear pump, a pair of meshing rotatable gears each having shaft extensions, pressure loaded movable end plate means comprising a generally annular end plate member for each gear spaced radially outwardly of the shaft extension and providing a sealing face equal in diameter to the outside diameter of the gear and extending radially inwardly of the root diameter of the teeth on the gear, and a bearing separate from said end plate member having an outer peripheral surface slidably supporting said end plate member and an inner bore surface in said bearing providing a journal bearing surface for the shaft extension, a radial extension on said end plate member providing a motive surface having a larger area than the area of said sealing face and fluid pressure motor means working on said motive surface to move said end plate into sealing engagement with the gear, said fluid pressure motor means comprising a plurality of circumferentially spaced cylinder and piston means communicating pres-

13

tures generated by the pump at correspondingly circumferentially spaced and axially adjacent points around the periphery of the gear to circumferentially spaced points on said end plate member, and a spring to load each piston with a continuous biasing force, thereby to maintain an unbalance on said end plate member in the direction of said gears.

21. In a pump, a pair of meshing rotatable gears having radial side faces, pressure loaded movable end plate means comprising an end plate member having a sealing face equal in diameter to the outside diameter of one of the gears, a radial extension on said end plate member providing a motive surface on the side of said end plate member oppositely disposed from the gear having a larger area than the area of said sealing face, a casing having a bore providing a pumping cavity for the gears and a counterbore receiving the end plate member, there being a radial wall between said bore and said counterbore spaced from said radial extension on said end plate member and forming together therewith an annular pressure space, and means communicating said pressure space to an area at low pressure to minimize dash pot action, and a plurality of circumferentially spaced cylinders and pistons working on said motive surface to move said sealing face into sealing engagement with a corresponding gear side face, and means communicating fluid pressure to said cylinders to work on said pistons.

22. In a pump, a pair of meshing rotatable gears having radial side faces, pressure loaded movable end plate means comprising an end plate member providing a sealing face equal in diameter to the outside diameter of one of the gears, and a radial extension on said end plate member providing a motive surface on the side of said end plate member oppositely disposed from the gear and having a larger area than the area of said sealing face, means providing a plurality of circumferentially spaced recesses at said motive surface, means confining fluid pressure in said recesses to apply pressure thrusts to said end plate member at circumferentially spaced points for moving said sealing face into sealing engagement with a corresponding gear side face.

23. In a pump, a pair of meshing rotatable gears having radial side faces, pressure loaded movable end plate means comprising an end plate member providing a sealing face equal in diameter to the outside diameter of one of the gears, and a radial extension on said end plate member providing a motive surface on the side of said end plate member oppositely disposed from the gear and having a larger area than the area of said sealing face, said end plate member having a plurality of circumferentially spaced recesses opening in said motive surface, a plug member in each recess confining fluid pressure therein, a spring in each recess acting on said end plate member, and a passageway extending axially from each recess through said end plate member and intersecting said sealing face outside the root diameter of the gears to reference each respective recess to pressures generated by the pump at circumferentially spaced points around the periphery of the gears which pressures vary as a function of pump speed and pump discharge pressure.

24. In a pump, a pair of meshing rotatable gears having radial side faces, pressure loaded movable end plate means comprising an end plate member providing a sealing face equal in diameter to the outside diameter of one of the gears, and a radial extension on said end plate member providing a motive surface on the side of said end plate member oppositely disposed from the gear and having a larger area than the area of said sealing face, casing means providing a plurality of circumferentially spaced recesses at said motive surface and providing a pumping chamber for said gears, a plug member in each recess confining fluid pressure therein, a spring in each recess acting against said end plate member, and a passageway extending axially from each recess through said end plate member to said pumping chamber at circum-

14

ferentially spaced points around the periphery of the gears to reference each respective recess to pressures generated by the pump, such pressure varying as a function of pump speed and pump discharge.

25. In a pump, a housing having an inlet and an outlet and providing a pumping cavity, a backing plate for said cavity in said housing having a pressure force receiving back surface forming together with said housing, a plurality of circumferentially spaced reactive pressure areas of uniform size and means providing a passageway from each respective reactive pressure area axially through said backing plate to said pumping cavity referencing said areas to pressures generated by the pump at circumferentially spaced points around the periphery of the pumping cavity, such pressures varying as a function of pump speed and discharge pressure for balancing unequal pressure forces in the pumping cavity.

26. In a pump, a housing having an inlet and an outlet and providing a pumping cavity, a backing plate for said cavity in said housing having a pressure force receiving back surface forming, together with said housing, a plurality of circumferentially spaced reactive pressure areas of uniform size, and means formed to operatively extend axially between said areas and said pumping cavity and referencing each respective area to pressures generated by the pump at circumferentially spaced portions in the pumping cavity, such pressures varying as a function of pump speed and discharge pressure for balancing unequal pressure forces in the pumping cavity.

27. In a pump, a housing having an inlet and an outlet and providing a pumping cavity, a backing plate for said cavity in said housing having a pressure force receiving back surface forming together with said housing, a plurality of circumferentially spaced reactive pressure areas of uniform size and means referencing each respective pressure area to circumferentially spaced portions of said pumping cavity each containing fluid pressure varying in quantitative amount from the inlet to the outlet sides of the cavity to balance unequal pressure forces in the cavity.

28. A fluid pump having a suction side, a discharge side, a rotatable pumping member, an axially movable, pressure loadable end plate having a motive surface, means including said motive surface forming a plurality of uniformly sized circumferentially spaced pressure reactive areas disposed in a circumferential row extending from the suction to the discharge sides of the pump, and means referencing the respective areas to correspondingly circumferentially spaced portions of said pumping member each at different pressures generated by the pump at circumferentially spaced points around the periphery of the pumping member and such pressures varying as a function of pump speed and discharge pressure for balancing unequal pressure forces on the end plate.

29. In a pump, a housing having an inlet and an outlet and providing a pumping cavity, a shiftable plate closing one end of said cavity in said housing and being subject to pressures in the cavity which increase toward the outlet side of the cavity, said shiftable plate having a radial extension providing a back face of a larger area than the side of said plate in said cavity, and means forming together with said back face a plurality of uniformly sized circumferentially spaced pressure reactive areas each having means referencing same to pressures generated by the pump at correspondingly circumferentially spaced points around the periphery of the pumping cavity and varying as a function of pump speed and discharge pressure to produce balancing forces urging the plate toward the cavity in proportion to the unequal forces urging the plate away from the cavity.

30. In a pump, a casing providing intersection bores forming a pumping chamber having an inlet and an outlet at opposite sides thereof, intermeshing gears rotatable in said pumping chamber, said casing having radially extending walls adjacent said bores, a movable

15

end plate member for each bore, each end plate member having an end face received in a corresponding one of said bores to sealingly engage the side of a corresponding gear, an annular radially outwardly extending face on said end plate member overlying said casing walls, and a second end face on said end plate providing a motive surface coextensive with both of said faces, said end face being subject to non-uniform fluid pressure forces in said pumping chamber varying from the inlet to the outlet sides of the pump, and loading means exerting a non-uniform loading force on said second end face varying from the inlet to the outlet sides of the pump to move said end plate into sealing engagement with the gears.

31. In a pump as defined in claim 30, said loading means comprising pressure-reactive areas of non-uniform size and receiving fluid pressure generated by the pump applied over the respective areas to balance the unequal pressure forces in the pumping chamber.

32. In a pump as defined in claim 30, said loading means comprising pressure-reactive areas of uniform size and of means communicating fluid pressure generated by the pump varying in quantitative amount from the respective areas nearest the inlet side of the pump to the respective areas nearest the outlet side of the pump, thereby to balance the non-uniform pressure forces in the pumping chamber.

33. In a pump, a movable bushing having a generally tubular configuration and providing a radially outwardly extending flange at one end providing a radial wall at one end of said bushing and on one side of said flange, and a radially extending generally annular wall on the other side of said flange, said bushing having a radial sealing face at the other end of said bushing, a casing having a bore providing a pumping cavity spanned by said radial sealing face, said casing having a counter-bore receiving said flange, said casing having a radial wall between said bore and said counterbore confronting said annular wall and said bushing and spaced therefrom to provide a pressure space isolated from opposite ends

16

of said bushing, means providing a passageway to the pump inlet from said pressure space to minimize dash-pot action and loading means exerting a force varying from the inlet to the outlet sides of the pump and acting on said radial end wall to move said bushing towards said pumping cavity and against the unequal pressure forces existing in said pumping cavity.

34. In a pump as defined in claim 33, said loading means comprising pressure-reactive areas of non-uniform size and receiving fluid pressure generated by the pump applied over the respective areas to balance the unequal pressure forces in the pumping chamber.

35. In a pump as defined in claim 33, said loading means comprising pressure-reactive areas of uniform size and of means communicating fluid pressure generated by the pump varying in quantitative amount from the respective areas nearest the inlet side of the pump to the respective areas nearest the outlet side of the pump, thereby to balance the non-uniform pressure forces in the pumping chamber.

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