

July 31, 1956

D. S. OLIVER

2,756,681

PRESSURE LOADED PUMP

Filed June 16, 1950

5 Sheets-Sheet 1

Fig. 1

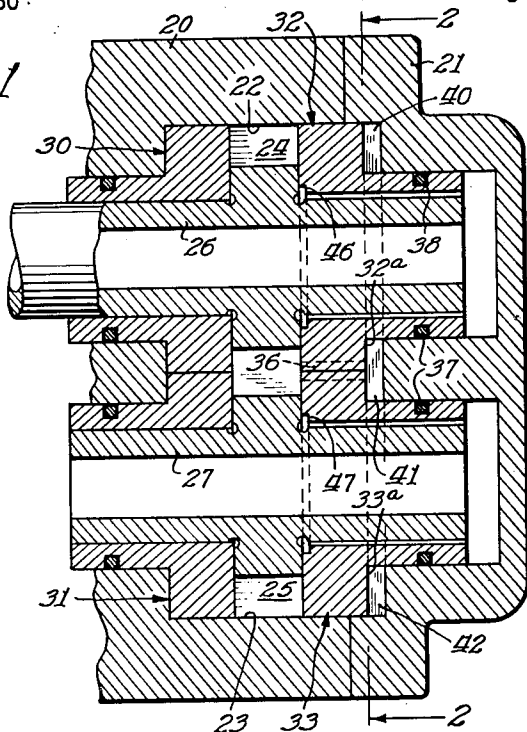


Fig. 2

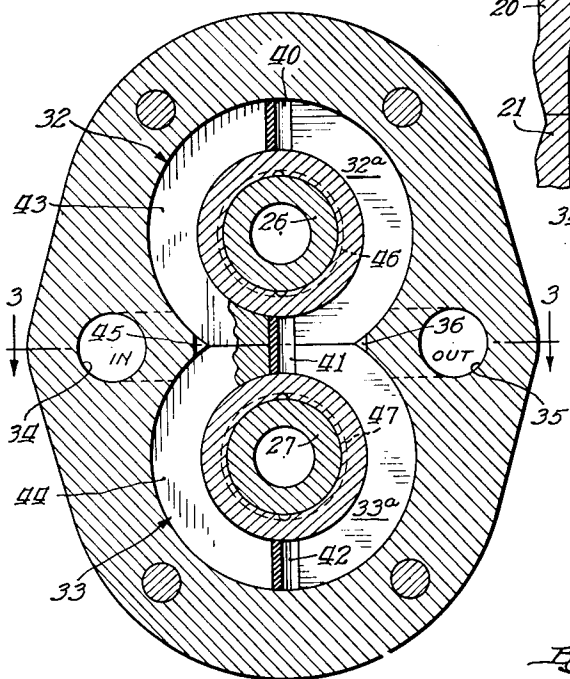


Fig. 3

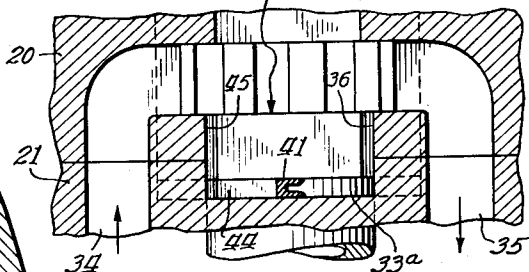
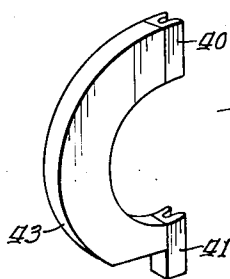


Fig. 4



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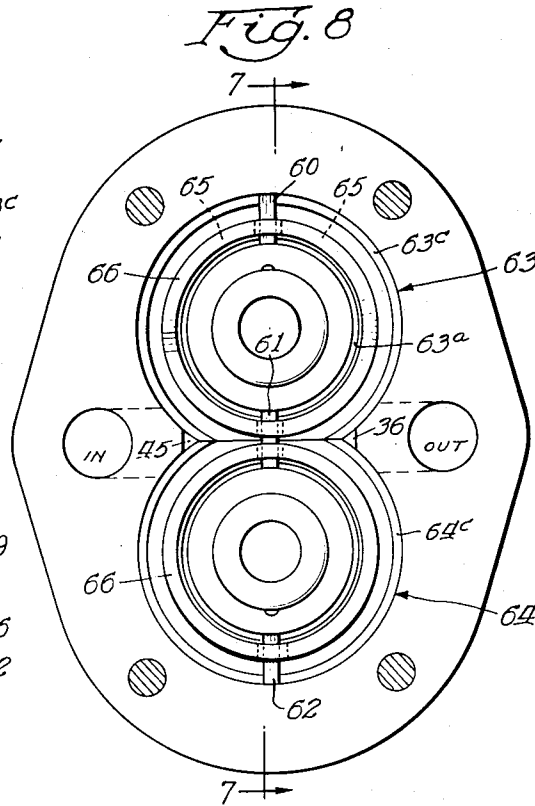
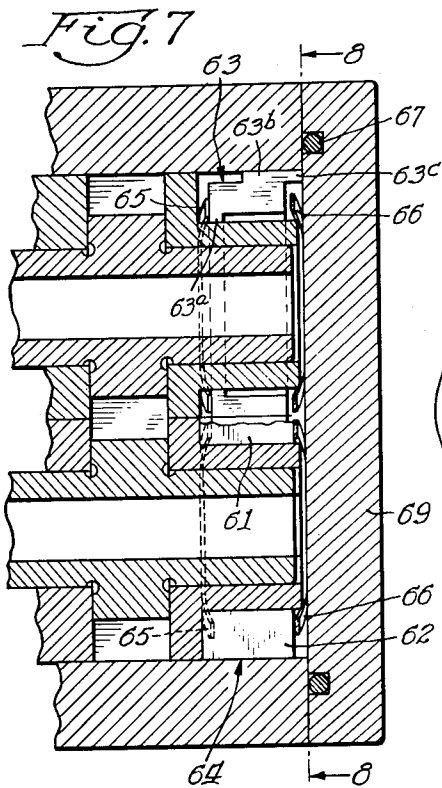
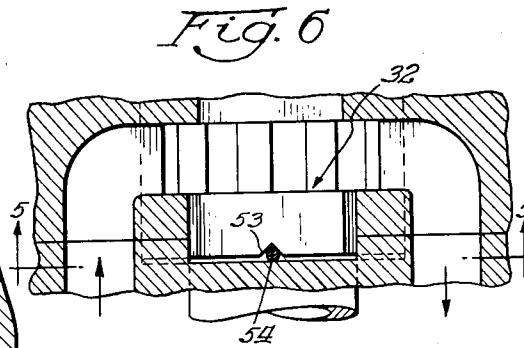
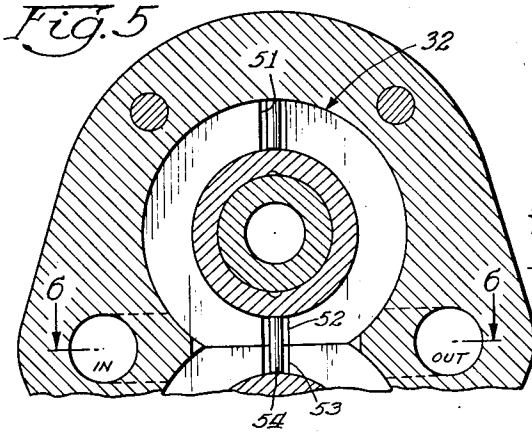
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Fig. 9

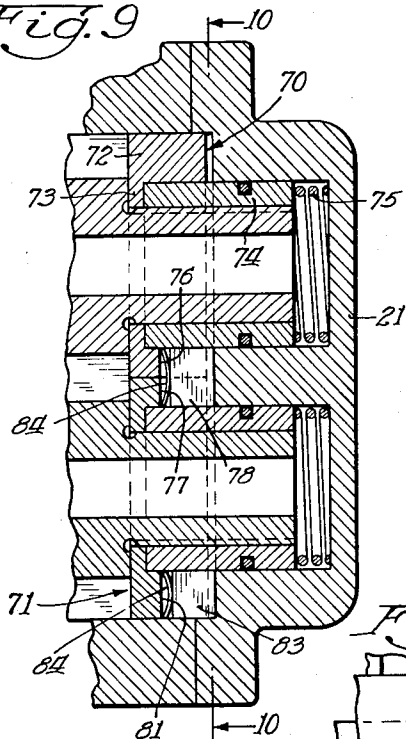


Fig. 10

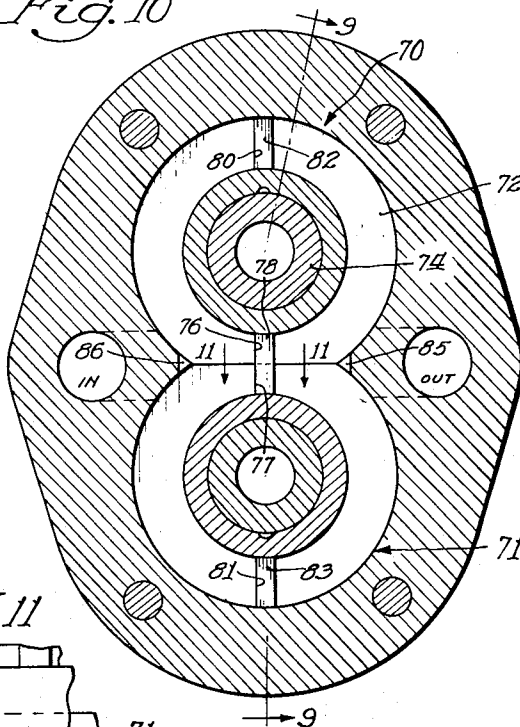


Fig. 11

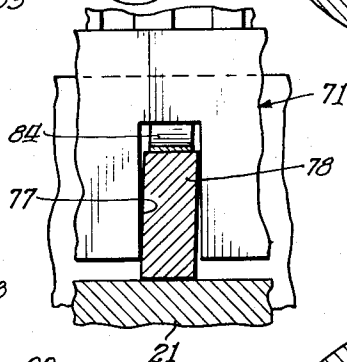


Fig. 12

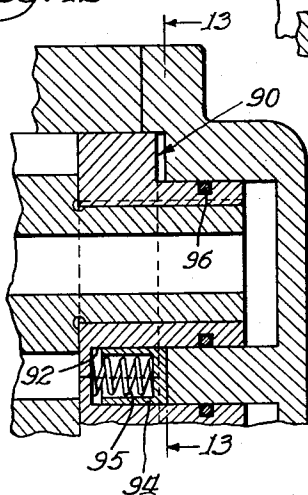
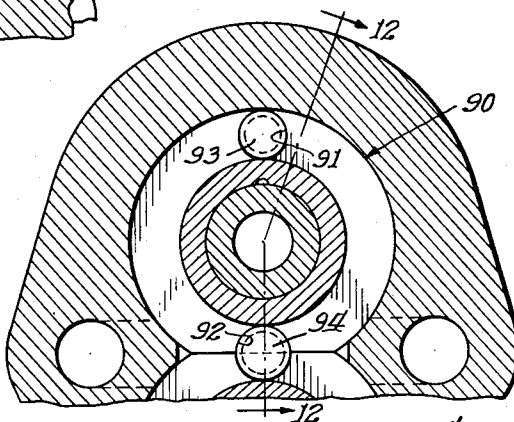


Fig. 13



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Fig. 14

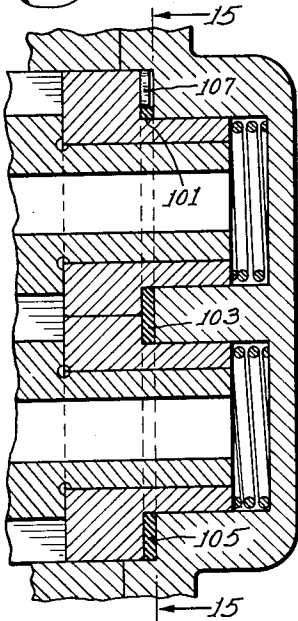


Fig. 15

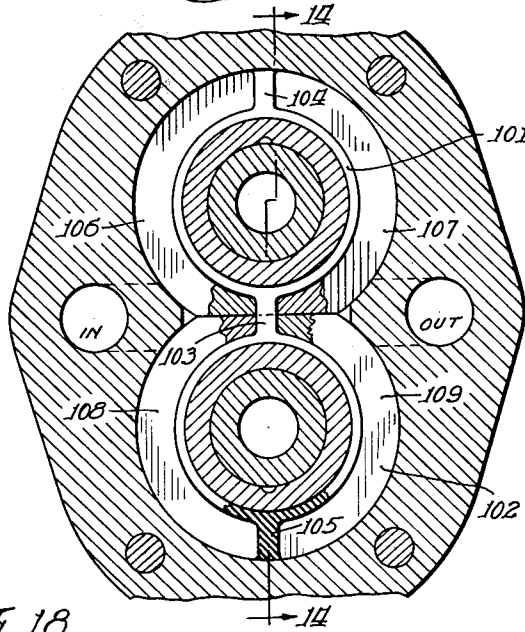


Fig. 18

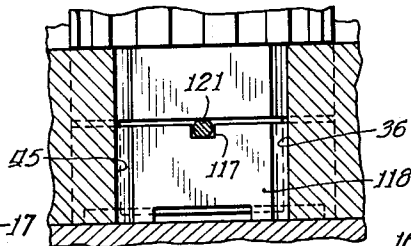


Fig. 16

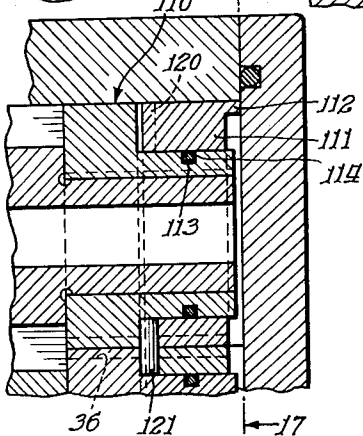
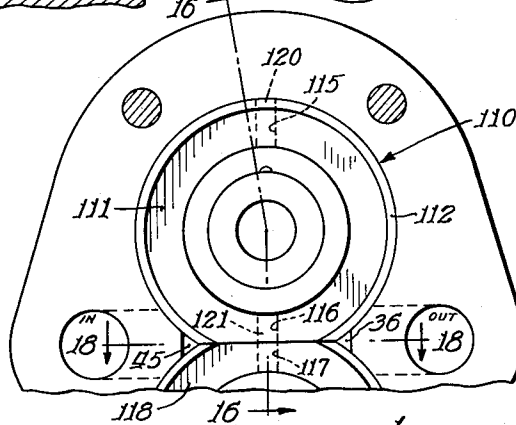


Fig. 17



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Fig. 19

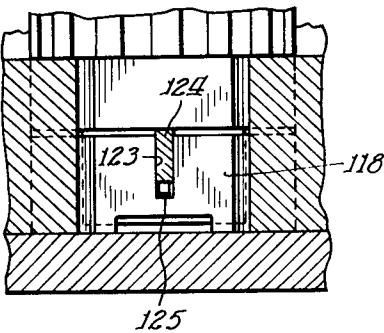


Fig. 20

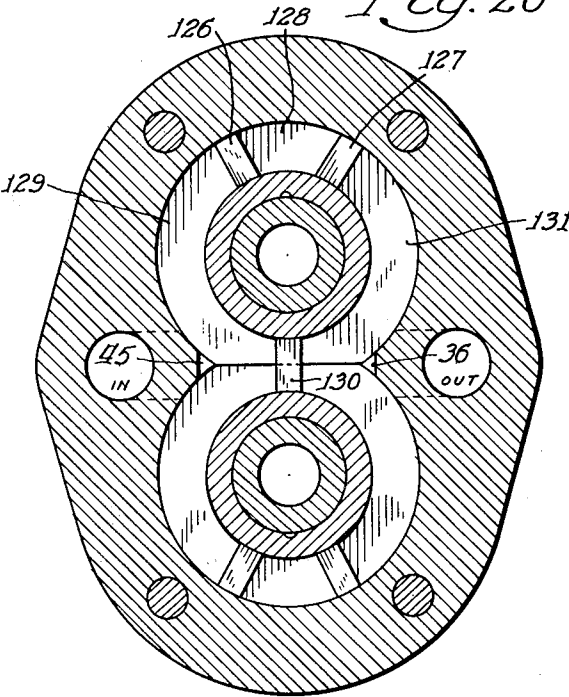


Fig. 21



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2,756,681

PRESSURE LOADED PUMP

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Application June 16, 1950, Serial No. 168,622

4 Claims. (Cl. 103—126)

This invention relates to a gear pump, and more particularly to a gear pump of the type employing pressure loaded bushings, such gear pumps sometimes being referred to as pressure loaded gear pumps.

In a pressure loaded gear pump of the type having one set of axially movable pressure loadable bushings, a part of the output pressure is applied to the rear or motive surfaces of the axially adjustable bushings to urge these bushings into sealing engagement with their associated gears. As disclosed in U. S. Patent No. 2,420,622 to Roth et al., by carefully selecting the relative areas of the forward surfaces of the bushings and of the motive surfaces of the bushings, it is possible to control within very close limits the actual sealing pressure provided. In practice, this requires a somewhat higher effective pressure in the direction of seal than in the direction tending to open the seal.

In the usual form of pressure loaded pump, the pressure loading motive chamber to which output pressure is supplied will be substantially uniformly subjected to the output pressure. That is to say, at any point on the motive surfaces at the rear of the bushing, the same pressure will exist. This is not true of the forward or gear side face engaging surface of the bushing. This forward surface is normally subjected to a distinct pressure gradient extending from the inlet pressure in the area adjacent the pump inlet, which is the lowest pressure of the gradient, to the outlet pressure in the area adjacent the discharge side of the pump, at which area the pressure gradient is at its highest level. Accordingly, it will be evident that while the total pressure forces acting on the motive surfaces of the bushing may be made to equal the total pressure forces acting on the forward surfaces of the bushing, or to exceed these latter forces, the pressures acting on particular areas of the forward surfaces will not be uniform and the portion of the forward bushing surface nearer the inlet will be subjected to a lesser pressure tending to break the seal than the portion of the forward bushing surface nearer the outlet of the pump. This unbalanced pressure condition tends to twist the bushing in the pump and results in uneven wear, thereby increasing the power required to turn the pump. Wear is, of course, concentrated on the inlet side of the pump.

It has been found that this unbalanced condition can to some extent be reduced by providing balancing grooves in the gear side face engaging surfaces of the pressure responsive bushings, these balancing grooves communicating at one end with the discharge side of the pump and extending coaxially of the bushings toward the inlet port of the pump, but terminating short thereof. The balancing grooves, tend to render the pressure uniform over a larger area of the gear surface than without the grooves. It will be evident, however, that it is not possible to extend the balancing grooves completely around

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the pump without providing a leakage path to the inlet side of the pump from the outlet side with consequent loss of pressure. Thus, while balancing grooves are helpful, they do not result in a perfectly balanced pump.

It has also been proposed to employ eccentrically disposed bushings whereby the pressure area at the back of the bushings is offset with respect to the uniformly disposed surface at the forward surface of the bushings so as to compensate, in effect, for the pressure gradient extending across the forward surfaces of the bushings. This is disclosed and claimed in Haberland application Serial No. 130,904 filed December 3, 1949. Alternatively, it has been proposed to restrict the area exposed to loading pressure at the back of the bushings. This is disclosed and claimed in the Compton application, Serial No. 163,011 filed May 19, 1950. The present invention is directed to various seal arrangements for restricting the loading area at the back of the pressure loadable bushings to compensate for the pressure gradient across the forward surfaces of the bushings.

An object of the present invention is to provide a new and improved pressure loaded type, intermeshing gear pump.

A further object of the present invention is to provide a pressure loaded type, intermeshing gear pump wherein the motive surface areas of the pressure loadable bushings are controlled to establish a loading force having an effective gradient substantially equivalent to the pressure gradient across the forward surfaces of the loadable bushings.

In accordance with one embodiment of this invention, a pressure loaded type, intermeshing gear pump having one set of axially movable, pressure loadable bushings, may be provided with sealing means disposed across the motive surface areas of the bushings in such manner as to restrict or confine the high pressure area, so that the pressure loading area occupies a preselected fraction of the total surface area and so that this preselected area is so located as to establish a loading force matching substantially the pressure gradient across the forward or gear side face engaging surfaces of the bushings. By suitably locating the sealing means, a proper balance can be reached whereby the gradient of the forces tending to hold the bushing against the gear side face is closely balanced and uniformly disposed with respect to the gradient of the forces tending to move the bearing away from the gear side faces, that is, to unload the pump.

Other objects and advantages of the present invention will be apparent from the following detailed description taken in conjunction with the drawings wherein:

Fig. 1 is a fragmentary, axial, sectional view of a pressure loaded type, intermeshing gear pump in which the pressure loading areas of one set of bushings are restricted in accordance with one embodiment of this invention;

Fig. 2 is a transverse, sectional view taken substantially along the line 2—2 of Fig. 1;

Fig. 3 is a detail, sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a detail, perspective view of a suitable seal retaining plate;

Fig. 5 is a fragmentary, sectional view similar to Fig. 2 showing, however, the pressure loading surfaces of a bushing provided with a seal arrangement in accordance with a second embodiment of this invention, the view being taken substantially along the line 5—5 of Fig. 6;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 5;

Fig. 7 is a fragmentary, axial, sectional view, similar

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to Fig. 1, showing, however, a third sealing arrangement in accordance with this invention, the view being taken substantially along the line 7—7 of Fig. 8;

Fig. 8 is a transverse, sectional view taken substantially along the line 8—8 of Fig. 7;

Fig. 9 is a view similar to Fig. 7 showing, however, a fourth embodiment of this invention employing a different type of seal arrangement, the view being taken substantially along the line 9—9 of Fig. 10;

Fig. 10 is a sectional view taken substantially along the line 10—10 of Fig. 9;

Fig. 11 is an enlarged, detail, sectional view taken substantially along the line 11—11 of Fig. 10;

Fig. 12 is a fragmentary view similar to Fig. 9 showing a fifth embodiment of this invention, the view being taken substantially along the line 12—12 of Fig. 13;

Fig. 13 is a sectional view of the fifth embodiment of this invention taken substantially along the line 13—13 of Fig. 12;

Fig. 14 is a sectional view similar to Fig. 9 showing, however, a sixth embodiment of this invention, the view being taken substantially along the line 14—14 of Fig. 15;

Fig. 15 is a sectional view taken substantially along the line 15—15 of Fig. 14 showing the sixth embodiment of this invention;

Fig. 16 is a view similar to Fig. 12 showing, however, a seventh embodiment of this invention, the view being taken substantially along the line 16—16 of Fig. 17;

Fig. 17 is a sectional view taken along the line 17—17 of Fig. 16 showing this seventh embodiment of this invention;

Fig. 18 is a view partially in section taken along the line 18—18 of Fig. 17;

Fig. 19 is a view similar to Fig. 18 showing, however, a blade type seal in place of the pin type seal of Fig. 18;

Fig. 20 is a view similar to Fig. 2 showing, however, a modification thereof permitting the pump to be operated in either direction; and

Fig. 21 shows various cross-sectional configurations which may be employed for the seal, particularly in the embodiment shown in Fig. 20.

Referring now to the drawings, and particularly to Figs. 1, 2 and 3 thereof, a pump similar to that shown in the aforementioned Roth et al. patent, except for the bushing loading arrangement, is there illustrated having a sectional housing comprising a main body portion 20 and a right closure member 21. These sections are securely bolted together and cooperate to define therewithin a pair of parallel axis, intersecting bores or pumping gear chambers 22 and 23 which are arranged to receive in complementary relationship intermeshing pumping gears 24 and 25 respectively. In the embodiment illustrated, the pumping gears have integrally formed therewith hollow journal shafts 26 and 27, respectively, and the left portions of the journal shafts 26 and 27 are received in conventional flanged bushings 30 and 31 mounted in the left portion of the pumping gear chambers 22 and 23. The right portions of the gear journals 26 and 27 are received, respectively, in axially adjustable, pressure loadable, flanged bushings 32 and 33 mounted in the right side of the pumping gear chambers 22 and 23. The bushings 32 and 33 are provided with specially designed sealing means in accordance with the present invention and this will be described in detail hereinafter. In the embodiment illustrated the upper pumping gear 24 is the driving gear and is rotated in a clockwise direction, as viewed in Fig. 2. In accordance with conventional pump design practice, the journal shaft 26 of the gear 24 may be extended to the left, as viewed in Fig. 1, and coupled to a suitable power source. Low pressure liquid is introduced into the pump housing at inlet 34, formed in the left side of the pump housing as viewed in Fig. 2, and high pressure liquid is discharged through outlet 35, formed in the right side of the housing, as viewed in Fig. 2, the inlet and outlet

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sides communicating with the inlet and discharge areas of the intermeshing pumping gears. The pressure loadable bushings 32 and 33 are fitted into the bores 22 and 23 with sufficient clearance to permit slight axial movement of the bushings with respect to the bores.

In the operation of a pump of this type, discharge pressure generated by the intermeshing gears may be communicated from the outlet or discharge side thereof to the annular pressure loading areas at the back of the bushings, designated 32-a and 33-a in the drawings, through an axially extending passage 36 formed between the peripheries of the flanged portions of the bushings on the discharge side of the pump at the point of convergence of the flanged portions of the bushings. The passage 36 extends from the discharge side of the gears to the right, as viewed in Fig. 1, to the intercommunicating portions of the pressure loading areas at their point of juncture. Escape of discharge pressure rearwardly from the pressure loading surfaces is substantially prevented by means of an O-ring seal 37 disposed about the periphery of the rear or barrel portion of each bushing in an annular groove 38 formed in the periphery of the bushing. Alternatively, the groove 38 may be formed in the housing bore wall and an O-ring 37 then of slightly greater size would be positioned in the groove in the housing wall and engage at its inner periphery the periphery of the barrel portion of each bushing. Pressure leaking past the O-ring seal may be vented to inlet pressure or to a zone of intermediate pressure in accordance with conventional pressure loaded pump practice as set forth in the above referenced Roth et al. patent.

In the operation of a gear pump of the type herein shown, a pressure gradient exists across the faces of the bushings adjacent the gears, the pressure gradient extending from a low pressure value corresponding to the inlet pressure of the pump on the inlet side thereof to a pressure value corresponding to the discharge pressure of the pump at the outlet side thereof. On the other hand, the pressure applied to the motive surfaces 32-a and 33-a is normally substantially uniform over the full extent thereof. It will be apparent, therefore, that since the gear side face pressure acting against the loading pressure in the area adjacent the discharge side of the pump exceeds the gear side face pressure acting against the loading pressure in the area adjacent the inlet side of the pump, the axially movable bushings 32 and 33 will tend to engage the gear side faces with a correspondingly greater force adjacent the inlet side. This unbalanced arrangement results in increased wear and more particularly uneven wear, resulting in accelerated deterioration of the pump. The present invention is designed to overcome this unbalanced condition.

In accordance with the first embodiment of this invention, three elongated seals 40, 41 and 42 of U-shaped cross-section are employed to restrict the area at the back of the bushings exposed to loading pressure. These seals may be formed of neoprene, rubber or other suitable resilient material. Seal 41 is disposed between the barrel portions of the upper and lower bushings, substantially along the vertical center line of the pump, as viewed in Fig. 2, with the open or lip portion of the seal facing toward the right, and its inner side laying against the flanged portions of the bushings. The terminal ends of the seal touch in sealing relation the adjacent barrel portions. Seal 40 is positioned so that its lower end touches the upper side of the barrel portion of bushing 32 and its upper end touches the inner wall of the housing bore, the lip portion also facing to the right. The seal is thus disposed radially of the bushing barrel and, while shown in Fig. 2 as aligned with the vertical center line of the pump, may be located to the right or to the left thereof to increase or to reduce the area lying to the right of the seal which is exposed to discharge pressure. Seal 42 is located against the

flanged portion of the lower side of the bushing in complementary location to the seal 40, the seal 42 having its upper end touching the barrel of bushing 33 and its lower end the inner side wall of bore 23. The lip portions of all seals face to the right as viewed in Fig. 2. In order to prevent the seals from being moved to the left in response to application of discharge pressure, semi-annular retainer plates 43 and 44, respectively, are associated with the upper and lower bushings, the plates 43 and 44 being disposed against the left sides of the flanged portions of the bushings, that is, against the left surfaces 32-a and 33-a as viewed in Fig. 2 and supporting at their ends the left sides of the seals. The retainer plates 43 are made slightly smaller in axial thickness than the normal spacing between the right end of the flanged portion of each bushing and the adjacent end of the bore in which the bushing is positioned so that the seals, which are made somewhat thicker so that an initial seal is provided, may be placed under slight compression even in the absence of loading pressure being applied to the seals.

In the operation of the pump in accordance with the invention disclosed in Figs. 1, 2, 3 and 4, loading pressure is communicated to the loading areas of the bushings through the passage 36. This causes expansion of the lip portions of the seals thereby preventing escape of pressure to the left, as viewed in Fig. 2, and thus restricting the pressure loading area in accordance with the disposition of seals 40 and 42. Pressure leaking past the seals to the left, as viewed in Fig. 2, may be vented to inlet pressure through a passage 45, similar to passage 36, but formed on the opposite side of the bushings at their point of convergence.

It will be apparent from the foregoing that by selecting the location particularly of seals 40 and 42 it is possible to closely control the actual area on the back of each bushing exposed to discharge pressure. By preventing application of discharge pressure to a portion of the area at the back of the bushings adjacent the inlet side of the pump, the pressure gradient may, therefore, be closely compensated. Annular recesses 46 and 47 formed in the forward surfaces of each of the bushings radially inwardly of the gear teeth may be vented to inlet pressure in accordance with usual pressure loaded pump practice, as set forth in the aforementioned Roth et al. patent, to control the extent of the area exposed to discharge pressure at the forward surfaces of the bushings. Where the seals 40, 41 and 42 are employed, however, it is not ordinarily necessary to employ the vented recesses 46 and 47.

As pointed out in the co-pending application of John A. Lauck, Serial No. 168,587 filed June 16, 1950, these recessed areas may be offset to compensate for the pressure gradient, and this feature may be employed, of course, in combination with the various embodiments of the present invention disclosed herein.

Referring now to Figs. 5 and 6, a second embodiment of this invention is there illustrated which avoids the use of the retaining plates 43 and 44. In accordance with this embodiment of the present invention, the flanged portions of each of the bushings are provided with grooves in which are received sealing pins whereby the area exposed to discharge pressure is limited, the pins functioning similarly to the seals 40, 41 and 42.

More particularly, a groove 51 is formed in the upper side portion of the rear or pressure loadable surface of the flanged part of upper bushing 32, the groove extending radially from the barrel portion of the bushing to the periphery of the flanged portion. Preferably, the groove has a V-shaped cross-section, as shown in Fig. 6. As with the seal 40 and the seal 42, the groove 51 may be located either to the right or to the left of the vertical center line of the pump to increase or reduce the area exposed to loading pressure. A groove 52 is formed at the lower side of the flanged portion, the groove extending from

the barrel of the bushing and formed in the flange and extending to the periphery of the flange at the point of juncture thereof with the adjacent flanged portion of the lower bushing where it is in communication and alignment with a third groove 53 similarly formed in the upper side of the flanged portion of the lower bushing. Grooves 52 and 53 are preferably formed along the vertical center line of the bushings, but this may also be varied without departing from the present invention. A single pin 54 is positioned in the grooves 52 and 53 and a further pin, not shown, is positioned in a groove corresponding to groove 51 but formed in the lower side of the flanged portion of the lower bushing. The seal pins may be made either of metal or of a resilient material such as rubber or neoprene. Where the pins are made of metal, it is preferable that the pins be under no initial compression in the absence of loading pressure. That is to say, that when the bushings are assembled in the pump housing there must be sufficient clearance between the back of the housing bore and the flanged portion of the bushing, and more particularly of the grooves 51, 52 and 53 so that the pins are free to move from right to left therein. Thus, upon application of discharge pressure from passage 36, the metal pins are, in effect, rolled to the left in a wedging action to establish a seal between the back of the housing bore and the flange of each bushing.

On the other hand, where rubber pins are employed, it has been found in practice that it is desirable that there be slight initial compression of the rubber pins upon assembly of the bushings in the housing. In the absence of such initial compression, extrusion of the rubber pins may occur upon application of high discharge pressure. The operation of the rubber pins in response to discharge pressure is slightly different than that of the metal pin in that the rubber will change shape in response to the application of pressure tending to fill the left side of the grooves, as viewed in Fig. 5, although the pins will tend to roll somewhat also.

While this embodiment of the invention has been described in connection with V-shaped grooves, grooves having a curved cross-section can also be employed, although this latter configuration ordinarily involves an increase in manufacturing cost.

Referring now to Figs. 7 and 8, a third embodiment of the present invention is there illustrated wherein blade type seals are employed. This embodiment of the invention requires a modification of the housing bore on the right side thereof comprising making the right portion of the housing bore the same in diameter as the mid-portion, rather than being reduced as shown in Fig. 1. In the embodiment shown in Figs. 1 to 4 and the embodiment shown in Figs. 5 and 6, no modification of the housing bore over the standard pressure loaded pump housing bore configuration disclosed in the Roth et al. patent is required. However, in the present embodiment, conventional flanged bushings similar to those described in conjunction with Figs. 1 to 4 are employed and the same reference numerals have been used to designate corresponding parts.

As with the two previously described embodiments of the present invention, in this embodiment of the invention three seals are employed in conjunction with the flanged bushings, these seals being designated 60, 61 and 62 in Fig. 8 and having, as may be seen best in Fig. 7, a generally rectangular configuration. The location and arrangement of these seals on the back of the flanged portions of the bushings is substantially identical to that of the various seals described in accordance with previous embodiments. However, because the blade type seals extend axially to the rear of the flange portions of the bushings a substantially greater amount than the U-type seal shown, for example, in Figs. 1, 2, 3 and 4, a special supporting or retainer arrangement is employed in accordance with the present embodiment comprising

two pairs of half rings, the upper set of rings being designated 63 and the lower set 64. These rings are utilized in a manner similar to the retainer plate 43 shown in Fig. 4 but because operation in either direction is provided in this embodiment and in order to provide a better support for the seal blades, instead of having only one half ring associated with each bushing, a pair of rings are employed. The terminal ends, that is, the adjacent ends of each of the half rings of a pair are, of course, slightly spaced to receive therebetween one of the seal blades.

Referring particularly to Fig. 7, it will be seen that the rings have a generally rectangular cross-sectional configuration but that the upper half ring 63 has integrally formed therewith a downwardly protruding shoulder 63-a at its left lower side, the lower edge of which bears against the barrel portion of the upper side of the bushing in sealing relation, and an upwardly extending shouldered portion 63-b, the upper edge of which bears against the bore side wall in sealing relation, and a rightwardly protruding portion 63-c which bears against the end wall or cover 69 of the housing. Rings 64 are similarly constructed. The annular passages provided by this shouldered ring configuration permit discharge pressure to be applied to the sealing blades. A pair of semi-annular, washer-type springs 65 are associated with each pair of half rings, being positioned at the left ends thereof, as viewed in Fig. 7. These springs 63-c and 64-c load the blades against the bushings to provide an initial loading pressure on the bushings against the gear side faces and at the same time cause contact of the half rings and the cover 69 to provide a seal. Circular washer-type springs 66 positioned at the right end of each bushing and loaded within the protruding portions 63-c and 64-c load the blades against the bushings. A large O-ring seal 67 is carried in a groove formed in the cover 69 which surrounds both bushings as shown.

Depending on the direction of operation of the pump, discharge pressure will be applied to the blades at their side faces either from the passage 36 or from the passage 45. This embodiment, as will be readily apparent to those skilled in the art, permits of considerable savings in construction in view of the simplification of the cover 69. At the same time the center distance of the pump body bores is less critical and since the bushings locate in the body bores only, misalignment is substantially completely avoided. The seal afforded by the half rings makes unnecessary the provision of the usual O-ring seals about the barrel portions of the bushings.

Referring now to Figs. 9, 10 and 11, a fourth embodiment of this invention is there illustrated wherein a two-piece bushing assembly is employed in conjunction with sealing blades to effect a restriction of the area exposed to loading pressure. In these drawings, the upper and lower bushing assemblies are designated 70 and 71, respectively, and are identical in construction. The housing bore construction and configuration is substantially the same as that illustrated in conjunction with Figs. 1 through 4.

Referring now particularly to Fig. 9, it will be seen that the upper bushing assembly 70 comprises an annular bushing member 72 having an inwardly flanged ring portion 73 formed at its forward surface and the inwardly flanged portion is made to have an inner diameter such that it engages closely the journal portion of the associated pumping gear. A tubular or barrel portion 74 of the bushing assembly 70 fits around the journal portion of the pumping gear and its left portion is received within the body portion of the front member 72, the left end of the barrel butting against the right side wall of the flange 73. In order to hold the bushing member 72 against the gear side face in initial sealing relation, a coiled spring 75 is positioned between the right end of the barrel portion 74 and the inner side of the cover 21.

A similar arrangement is employed in conjunction with the lower bushing assembly. The use of the two-piece bushing assembly facilitates the formation of the slots, best shown in Figs. 10 and 11 to receive the sealing blades. As shown in Fig. 11, a first rectangularly shaped slot 76 is formed in the bushing member 72 of the bushing assembly, the slot extending from the right side, as viewed in Fig. 9, toward the left or gear side face engaging surface so that the open end of the slot is disposed at the back of the bushing member. A second slot 77 similar to that shown in Fig. 11 is formed in the upper side of the bushing member associated with the lower bushing assembly. These two slots are aligned to receive a single blade seal 78. A third slot 80 is formed in the upper side of the upper cover member, and a fourth slot 81 in the lower side of the lower cover member, and these latter two slots may be located to the right or to the left of the vertical center line of the bushings, as viewed in Fig. 10, to increase or reduce the area exposed to pressure. While a single blade 78 may be used with the two communicating slots 76 and 77 formed at the junction of the two bushings, separate blades 82 and 83 are provided in the upper and lower slots 80 and 81, respectively.

In order to provide an initial seal, a leaf type spring 84 is positioned between the upper ends of each blade and the end wall of the associated slot in which it is positioned, as shown in Fig. 11. This assures an initial contact. Immediately upon application of discharge pressure through the passage 85 formed at the convergence of the two flanged or cover members 70 and 71, pressure will be effective to force the exposed lower end, as viewed in Fig. 11, of the blade to the left by pivoting it slightly about the lower left corner of the slot which causes the upper right edge of the blade to engage the right side wall of the slot and, because the spring 84 urges the blade downward, as viewed in Fig. 11, the lower right corner of the blade is held in engagement with the cover. In practice this has been found to provide a very satisfactory seal. By varying the location of the slot and the positions of the blades, the area exposed to discharge pressure may be closely controlled. Any pressure leaking past the seal may be vented to inlet pressure through passage 86, corresponding to passage 45 in Fig. 2. It also will be apparent that in the event higher than normal inlet pressure is used with the pump, then inlet pressure will be effective on the area lying to the left of the sealing blades, as viewed in Fig. 10. The advantages of so utilizing inlet pressure are described in detail in the application of James A. Compton, Serial No. 163,012 filed May 19, 1950, now U. S. Patent No. 2,695,566.

Referring now to Figs. 12 and 13, a fifth embodiment of this invention is illustrated wherein the sealing means for restricting the area to which discharge pressure is applied at the back of the bushings consists of spring-loaded pistons.

In this embodiment of the invention no modification of the housing or bores is required over that shown in Fig. 1, but a bushing 90 having a somewhat thicker flange, viewed in an axial direction as in Fig. 12, is preferably employed since the flanged portion of the bushing is provided with cylindrical recesses 91 and 92 extending from its back surface to a point adjacent its forward surface to receive the piston-type seals 93 and 94. Alternatively, of course, the seals may be contained in bores or apertures formed in the cover instead of in the bushings, this involving a modification of the housing. Springs 95 are associated with each of the pistons and urge them outwardly against the cover. The peripheries of the piston must fit closely with the barrel and housing side walls to provide the required seal. The springs 95 avoid the use of loading springs such as shown in Fig. 9. However, it is desirable to employ O-ring seals 96 about the barrel portions of the bushings behind the piston seals, as illus-

trated. By locating the piston seals in accordance with the principles of the previously described embodiments of this invention, it will be apparent that the surface exposed to inlet pressure and the surface exposed to discharge pressure at the back of each of the axially movable bushings may be closely controlled to compensate for the pressure gradient across the gear side face engaging surface of the bushings.

Referring now to Figs. 14 and 15, a sixth embodiment of this invention is there illustrated wherein a unitary seal of somewhat figure-8-like configuration is employed to restrict the pressure loading area at the back of the axially movable bushings. This arrangement has the advantage of not requiring any modification of either the bushings or of the housing bore. The seal comprises two circular sections **101** and **102** which are disposed around the barrel portion of the upper and lower bushings, respectively, and are joined by a straight portion **103** lying along the vertical center line of the pump between the two barrels, as viewed in Fig. 15. A rod-like extension **104** is integrally formed with the seal at the upper side of the upper circular portion **101** and extends radially thereof while a similar rod-like portion **105** extends downward radially from the lower edge of the lower portion of the ring seal. The seal may be made of rubber, neoprene, or other similar suitable material.

In order to prevent distortion of the seal under high discharge pressure, flat, half ring retainer plates **106**, **107**, **108** and **109** are employed and are disposed around the seal in such manner as to support particularly the upwardly extending portion and the downwardly extending portion as well as the central joining portion. These half ring plates may be similar to the plate **43** shown in Fig. 4. The upwardly extending portion **104** and the downwardly extending portion **105** may, of course, be moved to the right or the left of the vertical center line to increase or reduce the area exposed to discharge pressure. At the same time inlet pressure is applied to the remaining area at the back of the bushing.

This type of seal arrangement has the further advantage of making unnecessary the use of an O-ring seal between the barrel portion of the bushing and the adjacent housing, as shown particularly in Fig. 1 and Fig. 12, for example. It will be appreciated that the seal must be under initial compression upon assembly of the bushings in the pump housing so that immediately upon application of discharge pressure to the seal, the seal will be pressed outwardly to establish a leak-proof seal. The plates **106**, **107**, **108** and **109** may be made either of metal or plastic material and must, of course, be slightly thinner in an axial direction than the seal so as not to cause mechanical compression against the bushings when the bushings are initially assembled in the pump housing. By counterboring the back of the flanged portions of the bushings to provide recesses in which the seal would be positioned, it is possible to avoid use of the supporting retainer plates. However, this expedient, while practical, is somewhat more expensive involving, as it does, several additional manufacturing operations.

Referring now to Figs. 16, 17 and 18, a seventh embodiment of this invention is there illustrated wherein a two-piece bushing assembly is employed together with pin-type sealing means, similar to those discussed in connection with the embodiment of the invention illustrated in Figs. 5 and 6. Because of the two-piece bushing assembly construction the housing bore is not reduced in the area adjacent the barrel portion of the flanged bushing so that the housing bore in the embodiment shown in Figs. 16, 17 and 18 is generally similar to that shown in Figs. 7 and 8, that is to say, the bore or chamber in which the pump gears and in which the flanged portion of the bushing is disposed is uniform throughout its length to the right.

Referring now particularly to Figs. 16 and 17, a conventional flanged bushing **110** is there illustrated as the

upper pressure loadable bushing of the pump, together with a ring member **111** which is disposed around the barrel portion of the bushing **110** and has provided thereon at its outer, rear edge a rearwardly extending annular flange **112** which engages the left side of the cover. An O-ring seal **113** is disposed between the periphery of the barrel portion of the bushing **110** and the ring member **111**, the O-ring seal being received in a recess **114** formed in the periphery of the barrel portion. Alternatively, the ring seal might be positioned in an annular groove formed in the inner periphery of the ring member **111**.

Referring now to Figs. 17 and 18, it will be seen that a groove **115** is formed in the upper side of the ring member **111** on the face thereof adjacent the rear of the flanged surface of the bushing and the groove extends radially outwardly from the inner to the outer periphery of the ring member. A second groove **116** is formed in the ring member on the same face thereof as the first groove but positioned on the opposite side of the barrel portion of the bushing, and this slot is aligned with a third groove **117** formed in a second ring member **118** associated with the lower bushing assembly. A fourth groove (not shown) is formed in the lower side of the ring member **118**, the lower bushing assembly being substantially identical in construction with the upper bushing assembly. In the upper groove **115** is positioned a pin seal **120** which may be made either of metal or a resilient material and which, if resilient, is placed under slight compression upon assembly of the bushing in the pump housing. A similar pin seal **121** is positioned in the two aligned grooves **116** and **117**, and a third pin seal (not shown) is positioned in the fourth groove. The grooves may be V-shaped in cross-sectional configuration or curved.

Upon application of discharge pressure through passage **36** the pin seals are compressed against the left sides of the grooves and establish the requisite seal between the ring members and the flanged rear surface of the bushings. The pin seals and grooves may, of course, be located to the right or to the left of the center line as with the other embodiments of the invention. This embodiment possesses the advantages of cover simplification described in conjunction with Figs. 7 and 8 and may also be operated in either direction. The initial clearance between the rings and the adjacent flanged surfaces must, of course, be critically selected with reference to the seal means to prevent extrusion.

In Fig. 19 a modification of the sealing arrangement shown in Fig. 18 is illustrated. Deep slots **123** similar to the slots shown in conjunction with Figs. 9, 10 and 11 are provided, the slots being formed in the ring member **118** on the side thereof adjacent the flanged portion of the bushing rather than in the back of the ring member, as in Figs. 9, 10 and 11. These slots correspond to the relatively shallow grooves in which the pin seals of Figs. 16, 17 and 18 are positioned. In these slots are positioned blades **124** and between the back of each slot and the associated blade is positioned a leaf spring **125** or other suitable resilient means to urge the blade into sealing relation with the bearing flange. The operation of the blades is similar to that of the blade type seals shown in Fig. 11 and the same considerations as to angular disposition apply.

The embodiment shown in Fig. 20 is illustrative of a modification of the present invention which is applicable to each of the previously described embodiments. With the exception of the particular arrangement shown in Figs. 1 through 4, each of the embodiments of this invention described will operate equally well in either direction of rotation of the pumping gears insofar as the provision of a seal to restrict the pressure loading area is concerned. Of course, if the pressure loading area is made larger than the area exposed to or vented to inlet pressure or a zone of low pressure, then the pump will not work equally well in either direction. That is to say, that in order for

the pumps to work equally well in either direction the pressure loading area must be the same for either direction of rotation of the pumping gears.

Broadly, the modification shown in Fig. 20 comprises providing an additional seal means at the upper side of the flanged portion and an additional seal means at the lower side of the flanged portion to provide two alternative loading areas. The centrally disposed seal is located as with the previously described embodiments, but referring to the upper bushing, in Fig. 20, a first, radially extending seal 126 disposed against the flanged portion is located to the left of the vertical center line of the bushings and a second radially extending seal 127 is located to the right of the vertical center line, both seals being located at the upper portion of the bushing. Between these seals is positioned an arcuate retainer plate 128 generally similar to the plate 43 shown in Fig. 4 except that it is much shorter. Arcuate retainer plate 129 positioned between the left seal 126 and the central seal 130 corresponds in function to the seal 43 of Fig. 4. Arcuate retainer plate 131 positioned between the right seal 127 and the central seal 130 prevents movement of the seal 127 and the seal 130 when discharge pressure is applied through the passage 45 rather than the passage 36. A similar arrangement is employed with the lower bushing. It will be understood that whether the seal be a pin seal or a blade seal, or a bushing assembly be employed with the supporting rings as, for example, shown in Fig. 8, the principle of balanced loading areas disclosed in this embodiment is equally applicable. By increasing or by reducing the angular spacing between the seals 126 and 127 and correspondingly increasing or reducing the length of the retainer plate 128, the areas exposed to loading pressure and the areas vented to low pressure may be varied as to both size and location and will be equal for either direction of operation so long as symmetry of disposition of the seals is maintained. Because the lip type seal shown in Fig. 4 works best when pressure is applied to the lip from the right, as viewed in Fig. 2, the pin type or blade type seals are usually preferable when the modification shown in Fig. 20 is employed in conjunction with any of the previously described embodiments.

The embodiment illustrated in Fig. 20 also permits controlling the area exposed to inlet pressure independently of the area exposed to discharge pressure within considerable limits.

In Fig. 21 various cross-sectional configurations have been illustrated which may be employed for the pin type seals, particularly those used in conjunction with pumps for operation in either direction. The seal pin 133 is of circular configuration while the seal pin 134 is of rectangular configuration. The seal ring 135 is indented on either side so that the configuration is that of opposed V's. The cross-sectional configuration of the pin seal 136 is similar in character to that of 135 except that rather than V-shaped notches the seal is longitudinally grooved to define more or less rectangular cross-sectioned grooves, thus providing a pair of spaced lips on either side of the body portion. These seal configurations are merely illustrative and any suitable seal may be employed.

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

What is claimed is:

1. A pressure loadable bushing for a pressure loaded type gear pump having a tubular body portion and a flanged forward portion adapted to engage a pumping gear at its forward flanged surface, sealing means adapted to sealably engage a portion of the pump housing to provide sealing between said bushing and the pump housing positioned at the back surface of said flanged por-

tion for dividing said flanged portion back surface into a plurality of isolated areas, said sealing means comprising a plurality of elongated seal members of resilient material extending radially with respect to the tubular portion of said bushing and having a first lip portion disposed flatly against said flanged portion and a second integral lip portion extending parallel to but spaced from the first lip portion, and retainer means for preventing movement of said sealing means.

2. A liquid pump comprising: a housing having a pump chamber and an inlet leading to and an outlet leading from said pump chamber; means including a rotatable member received in said pump chamber for forcing liquid from said inlet out of said housing through said outlet; an end-plate in said pump chamber having a back face normally spaced from the adjacent end wall of said pump chamber and having portions cooperable with said housing to provide a pressure chamber, said end plate also having a front face subject to the pressures in said pump chamber and cooperable with the adjacent side face of said rotatable member to provide a pumping seal therewith, one of said two last-mentioned faces having a relief recess formed therein inwardly of its outer periphery to limit the sealing area between said side face and said front face; means establishing communication between said relief recess and said inlet; and means establishing communication between said pressure chamber at the back face of said end plate and said outlet; the relation of the area of said back face to said sealing area being such that the force acting upon said back face of said end plate always slightly exceeds the force acting upon said front face of said end plate, whereby to maintain said pumping seal without excessive friction, wear or loss in volumetric efficiency, characterized by a plurality of sealing partition elements located in said pressure chamber and dividing said pressure chamber into at least two contiguous, complementary, isolated portions at least one of which is exposed to pump outlet pressure, the major axis of the sealing plane of said partition elements extending radially of the axis of rotation of said rotatable member and extending from the radially inner to the radially outer wall of said pressure chamber.

3. In a high pressure pump, a housing having an inlet and an outlet and providing a pumping cavity, a rotatable pumping element in said cavity, and a backing plate means for said cavity in said housing, said backing plate means having a pressure receiving back surface forming together with means including a portion of said housing a pressure control chamber, and means placing said pressure control chamber in pressure communication with said outlet, said means including a portion of said housing further including a sealing means comprising a plurality of elongated seal members of resilient material extending radially with respect to the axis of rotation of said rotatable member and having a first lip portion disposed flatly against said back surface and a second integral lip portion extending parallel to but spaced from the first lip portion and disposed against a portion of said housing, and retaining means for preventing movement of said sealing means.

4. In a high pressure pump, a housing having an inlet and an outlet and providing a pumping cavity, a rotatable pumping element in said cavity, and a backing plate means for said cavity in said housing, said backing plate means having a pressure receiving back surface forming together with means including a portion of said housing a pressure control chamber, said means including a portion of said housing further including a plurality of sealing partition elements located in the control chamber and dividing said chamber into at least two contiguous complementary portions at least one of which is exposed to pump outlet pressure, the major axis of said sealing partition elements extending radially of the axis of the rotatable member and extending from the radially inner to the radially outer wall of said pressure control cham-

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ber whereby the pressure force urging the backing plate means toward the pump cavity balance the unequal pressure forces in the cavity, and means placing said pressure control chamber in pressure communication with said outlet.

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