

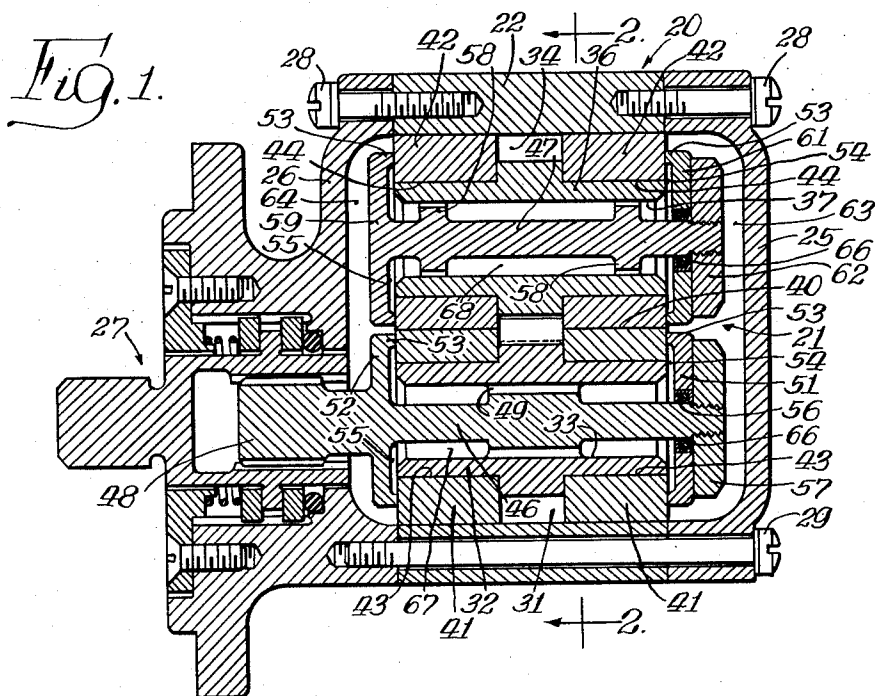
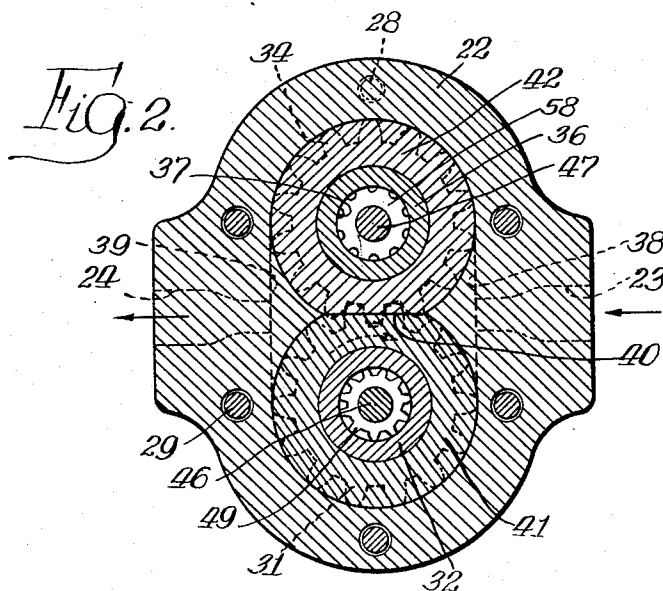
Aug. 26, 1958

J. L. NAGELY
GEAR PUMP OR MOTOR

2,848,953

Filed Nov. 27, 1956

4 Sheets-Sheet 1



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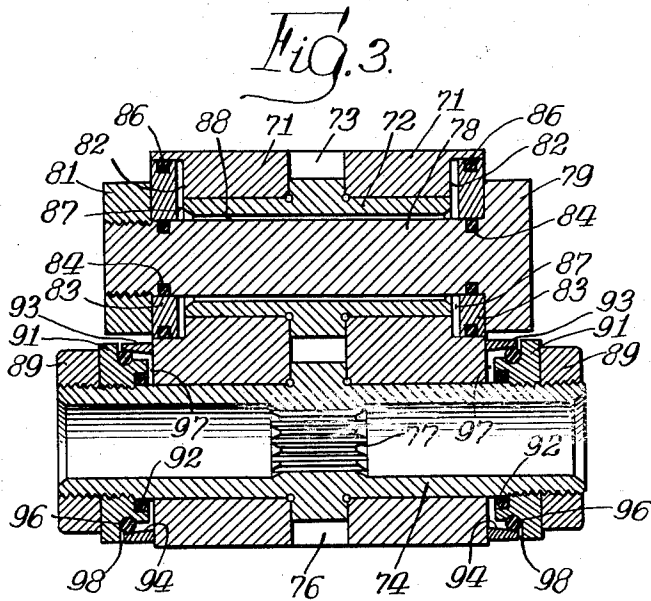
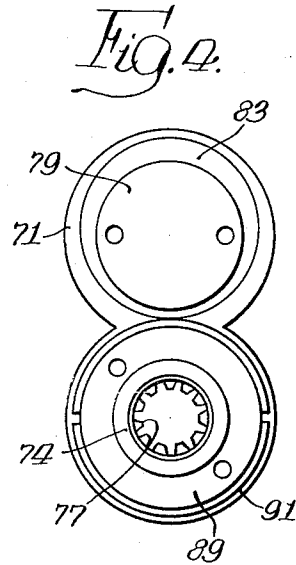
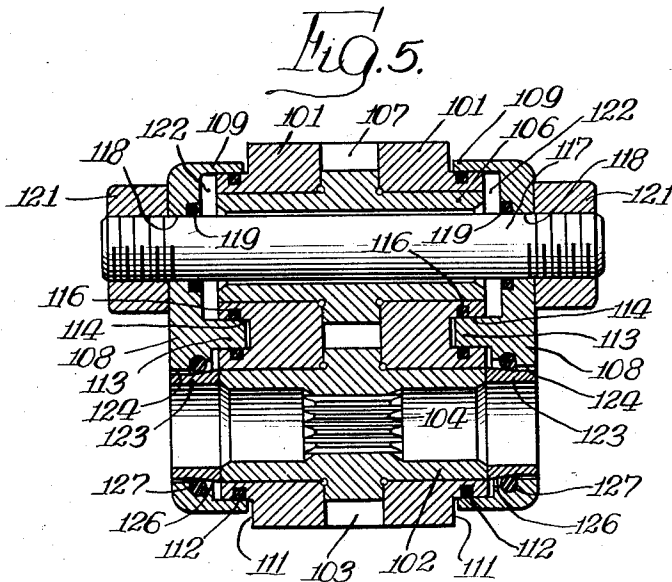
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4 Sheets-Sheet 2



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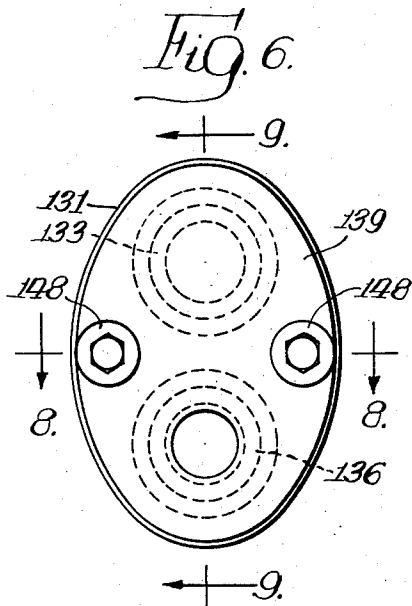
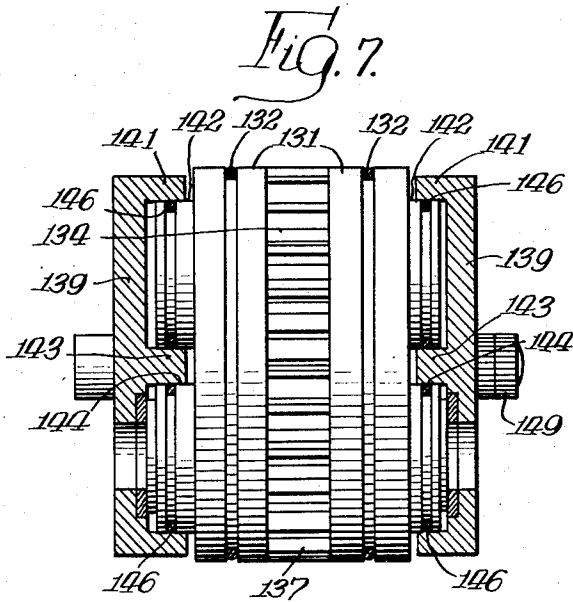
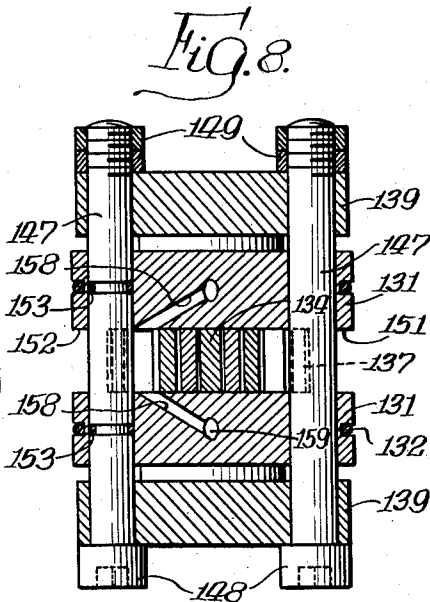
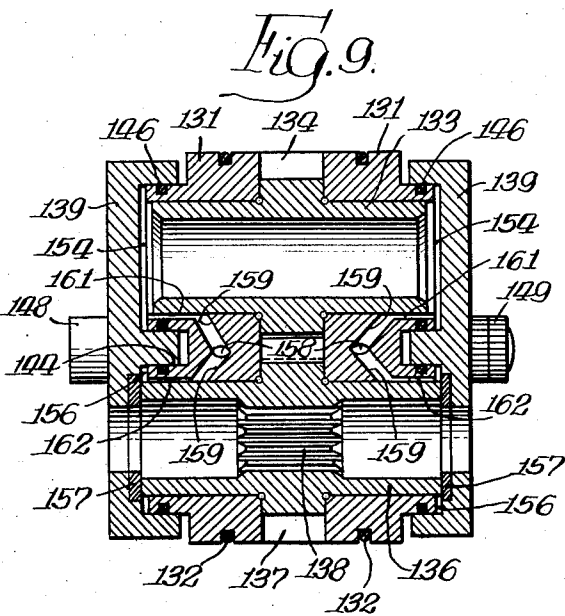
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GEAR PUMP OR MOTOR

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4 Sheets-Sheet 3



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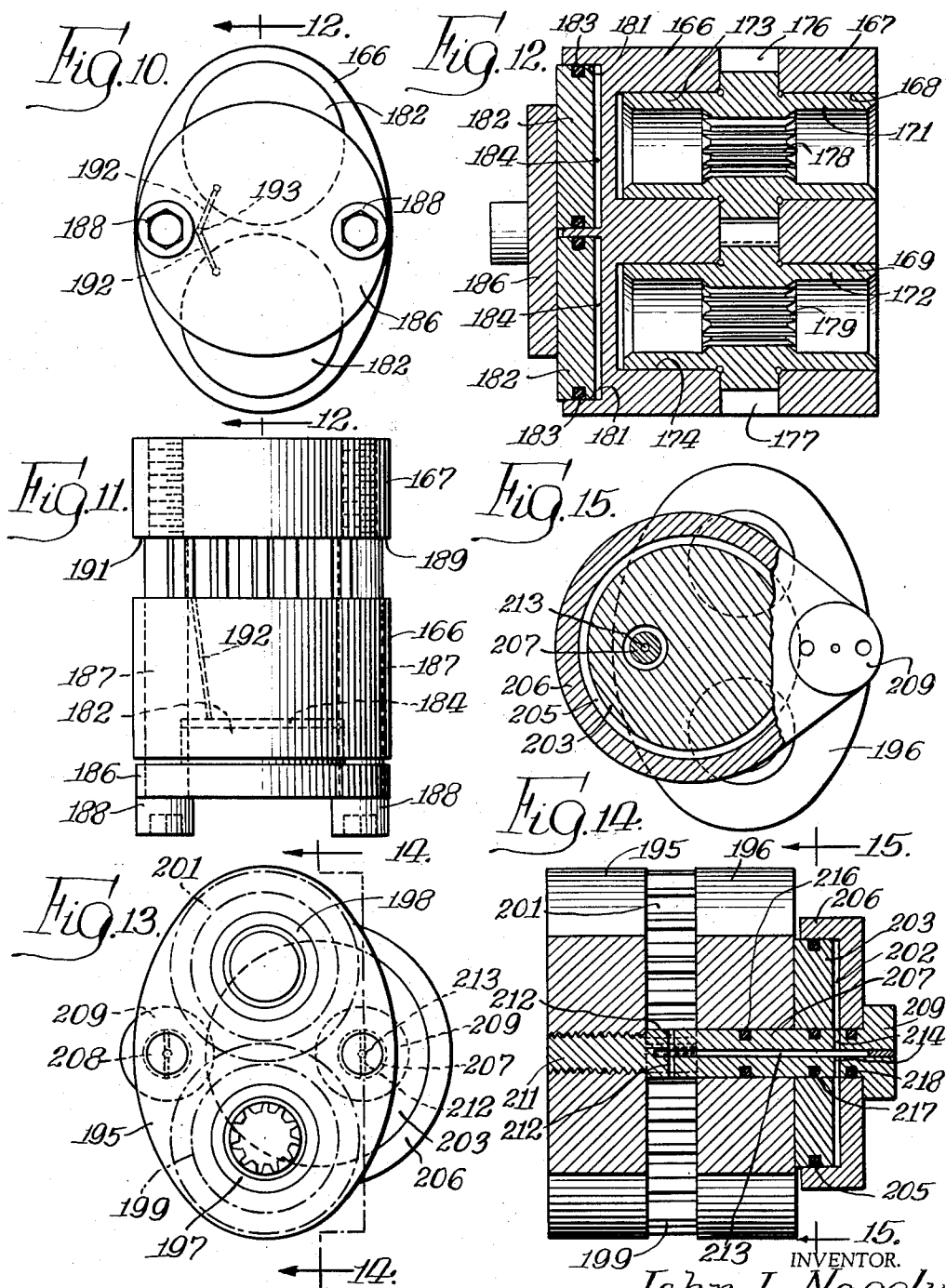
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4 Sheets-Sheet 4



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GEAR PUMP OR MOTOR

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Application November 27, 1956, Serial No. 624,584

9 Claims. (Cl. 103—126)

This invention relates to high pressure gear-type liquid displacement devices such as hydraulic pumps or motors.

In the high pressure gear pump art, many arrangements have been proposed for utilizing the discharge pressure of the pump to maintain a pumping seal between axially adjustable end plates or bushings and the associated gears. In such prior art arrangements, pressure loading chambers are usually provided between the outer faces of the end plates or bushings and the adjacent portions of the pump casing or housing, and high pressure discharge fluid is supplied to these pressure chambers whereby to effect the desired pressure loading of the end plates. As a result, the pump casing in the areas adjacent the end plates or bushings is subjected to extremely high pressures and must, therefore, possess a high degree of structural strength.

In my copending application Serial No. 184,612, filed September 13, 1950, and now U. S. Patent No. 2,772,638, I have described and claimed an improved construction wherein the pressure loading chambers are separate from and substantially independent of the external pump casing with the result that the desired pressure loading of the end plates or bushings is obtained without pressures of high magnitude being imposed against the adjacent portions of the pump casing. In the embodiments of the invention specifically illustrated in my aforementioned prior patent, the reaction forces from the pressure loading of the end plates are taken up by the gear shafts or gear supports. In other words, the gear shafts are designed so that they coact with other structural elements to function also as tension members for receiving and resisting the axial forces tending to displace the end plates or bushings outwardly relative to the side faces of the gears.

The present invention is based on the same broad principles described and claimed in my aforementioned prior patent but is directed specifically to certain designs in which one or all of the tension members are separate from and independent of the gear shafts. Although the provision of combined gear shafts and tension members is a highly useful construction for many applications of gear-type liquid displacement devices, there are also other applications for such devices in which it would be advantageous to utilize separate elements for gear shafts and for tension members.

Accordingly, a primary object of my invention is to provide a novel and improved pressure loading arrangement for a gear-type liquid displacement device wherein movable end plates or bushings are effectively maintained in desired sealed relation with the adjacent gears by means of high pressure working fluid.

Another object of the invention is to provide a novel pressure loading arrangement as described above wherein the casing of the device in the areas adjacent the end plates or bushings is not subjected to the high counterbalancing pressure.

A further object of the invention is to provide a novel

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pressure loading arrangement as described above wherein the reaction is taken up by internal tension members which are separate from the gear supports or shafts.

Other objects and advantages of the invention will become evident from the subsequent detailed description taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a longitudinal sectional view of a gear pump comprising one specific embodiment of the invention;

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

Fig. 3 is a longitudinal sectional view of the internal unit assembly portion of another embodiment of the invention;

Fig. 4 is an end view of the device shown in Fig. 3;

Fig. 5 is a longitudinal sectional view of the internal unit assembly portion of another embodiment of the invention;

Fig. 6 is an end elevational view of the internal unit assembly portion of still another embodiment of the invention;

Fig. 7 is a side elevational view of the device shown in Fig. 6 with parts thereof in section;

Fig. 8 is a horizontal sectional view as taken along the line 8—8 of Fig. 6;

Fig. 9 is a longitudinal sectional view as taken along the line 9—9 of Fig. 6;

Fig. 10 is an end view of the internal unit assembly portion of still another embodiment of the invention;

Fig. 11 is a top plan view of the device shown in Fig. 10;

Fig. 12 is a longitudinal sectional view taken along the line 12—12 of Fig. 10;

Fig. 13 is an end elevational view of still another embodiment of the invention;

Fig. 14 is a longitudinal view partly in section and partly in elevation as taken along the line 14—14 of Fig. 13; and

Fig. 15 is a transverse partial sectional view as taken along the line 15—15 of Fig. 14.

Although for the sake of simplicity the invention is described hereinafter primarily with reference to a gear pump, it will be understood that the principles involved are applicable to gear-type liquid displacement devices generally, including both hydraulic gear pumps and motors.

Referring first to Figs. 1 and 2 of the drawings, one embodiment of my invention shown merely by way of illustration comprises a gear pump having an external casing or housing, indicated generally at 20, and an internal unit assembly, indicated generally at 21, the latter constituting the operating mechanism of the pump and being readily removable as a unit from the housing 20. The housing 20 consists of a high strength central body portion 22 having a fluid inlet port 23 and an outlet port 24 (Fig. 2), a cover portion 25 at one end of the body portion 22, and a cover portion 26 at the opposite end of the device including a driving means and seal means, indicated generally at 27. The cover portions 25 and 26 are removably secured to the body portion 22 by means of a plurality of screws 28 and 29. Inasmuch as the details of the driving and sealing means 27 do not constitute any part of the present invention, further description of this portion of the device is unnecessary.

The internal unit assembly 21 comprises a driving gear 31 carried integrally on a gear shaft 32 having an axial bore 33, and a driven gear 34 meshed with the gear 31 and carried integrally on a gear shaft 36 having an axial bore 37. The gears 31 and 34 are surrounded by the body portion 22 of the pump casing 20 to provide an inlet or low pressure pump chamber 38 (Fig. 2) adjacent

the port 23 and an outlet or high pressure pump chamber 39 adjacent the port 24.

In order to provide a pumping seal with the gears 31 and 34, a pair of end plate structures are disposed at the opposite side faces of the meshed gears, each end plate structure having in this instance a two-piece construction including a lower end plate member 41 and an upper end plate member 42 provided with bores 43 and 44, respectively. The bores 43 and 44 constitute bearing journals through which the gear shafts 32 and 36 extend at their opposite ends. Each end plate member 41 and 42 has a substantially circular outer contour except for a pair of flat chordal edge surfaces which fit closely together, as at 40, so that each pair of end members 41-42 constitutes a single figure eight shaped end plate structure having its upper and lower halves independently pressure loaded as hereinafter described. The outermost semi-circular peripheral edges of the end plate structures 41-42 are formed to provide a close clearance sliding fit in the body portion 22 of the housing so that the entire internal unit assembly may be removed from the housing when desired.

The pressure loading and tension resisting arrangement which constitutes the principal feature of the present invention includes a pair of elongated tension members 46 and 47 which, in this instance, are disposed coaxially through the gear shaft bores 33 and 37, respectively. Inasmuch as the tension member 46 is associated with the driving gear shaft 32, the left-hand end of the tension member 46 (as viewed in Fig. 1) extends axially beyond the gear shaft 32 and its associated end plate structure 41-42 and is formed with an integral male drive spline 48 which is detachably fitted into a complementary female spline connection in the drive means 27. Likewise, the center portions of the drive gear shaft 32 and the tension member 46 are formed with complementary interfitting splines, as at 49, for transmitting the rotational drive from the drive means 27 through the splined connections 48 and 49 on the tension member 46 to the gear shaft 32. Disposed at the outer axial end portions of the gear shaft 32 are a pair of annular thrust collars 51 and 52, each having an inwardly extending rim or lip portion 53 in operative engagement with the outer face of the adjacent end plate structure 41-42 whereby to provide a pair of annular pockets or pressure loading chambers 54 and 55 adapted to receive high pressure working fluid for urging the end members 41 inwardly toward the gears 31 and 34. The thrust collar 52 is formed integrally with the tension member 46, but the thrust collar 51 has a central aperture 56 through which the right-hand end of the tension member 46 extends, as seen in Fig. 1. A retainer nut 57 is threaded to the projecting right-hand end portion of the tension member 46 for adjusting and maintaining the desired working clearances between the thrust collars 51 and 52 and their associated end plate structures and also for adjusting and establishing the desired maximum clearance between the end members 41 and the side faces of the gears.

The same general arrangement is provided in the case of the uppermost tension member 47 except that this tension member is associated with the driven gear shaft 36. Inasmuch as the tension member 47 does not have to rotate with the gear shaft 36, there is no positive driving connection provided therebetween and in this particular instance I have shown merely a pair of integral radially projecting pilot and bearing elements 58 for maintaining a general coaxial alignment between the tension member 47 and the gear shaft 36. The left-hand end of the tension member 47 as viewed in Fig. 1 is provided with an integral thrust collar 59, and an apertured thrust collar 61 is provided at the right-hand end of the tension member 47 with an adjusting nut 62 threadably secured to this end of the tension member for adjusting and maintaining the clearances as heretofore described. Of course, the thrust collars 59 and 61 likewise have inwardly extending rim or lip portions 53 engaging the outer faces of the end

members 42 and provide confined annular pressure loading chambers 54 and 55. The dimensions of the internal unit assembly relative to the dimensions of the external housing are such that a pair of cover chambers 63 and 64 are provided for receiving working fluid under relatively low pressures so that the end cover portions 25 and 26 of the housing are not subjected to high fluid pressures.

Annular seals, indicated at 66, are disposed between each of the thrust collars 51 and 61 and their respective tension members 46 and 47 so as to prevent leakage of fluid from the chambers 54 through the central apertures in the thrust collars 51 and 61. By suitable means which need not be described in detail, working fluid under discharge pressure is supplied from the high pressure or discharge chamber 39 of the pump through suitable internal passageways (not shown) in the end plate structures 41-42 to the annular pressure chambers 54 and 55. As will be evident from Fig. 1, the chambers 54 and 55 at opposite ends of each tension member are in fluid communication with each other, e. g. through the annular space 67 between the tension member 46 and its gear shaft 32 and also through the annular space 68 between the tension member 47 and its gear shaft 36. Thus, each of the end members 41 and 42 is urged inwardly against the side faces of the gears 31 and 34 to provide a pumping seal therewith and the reaction against the end members is transmitted through the thrust collars 51, 52, 59, and 61, and the nuts 57 and 62 to the opposite ends of the tension members 46 and 47. Consequently, it will be seen that the covers 25 and 26 of the pump casing are not subjected to the high discharge pressure of the pump and, therefore, do not require the high structural strength material employed in the body portion 22 of the pump casing. By proper correlation of the effective exposed areas of the end plate members 41 and 42 in the confined pumping space therebetween and also in the annular pressure chambers 54 and 55, the pressure within the chambers 54 and 55 results in a total unbalanced force exerted inwardly on the end plate structures which is always greater than the total force exerted outwardly against the end plate structures. This area relationship may be selected to provide any desired predetermined unit pressure loading between the inner faces of the end plate structures and the rotating side faces of the gears.

During operation of the pump, the thrust collars 51 and 52 and the nut 57 rotate with the tension member 46 and the gear shaft 32. The rotating thrust collars are lubricated by leakage of high pressure fluid radially from the chambers 54 and 55 between the end members 41 and the rotating thrust collar lip portions 53 into the cover chambers 63 and 64 which are vented through suitable passageways (not shown) in the end plate structures 41-42 to the low pressure or inlet chamber 38 of the pump so that the cover chambers are subjected only to relatively low fluid pressures and the rotating thrust collars 51 and 52 operate while surrounded by low pressure working fluid. By adjustment of the thrust collars 51 and 52 by means of the nut 57, the maximum clearance between the end members and the gears is determined, and in addition the clearance between the outer faces of the end members and the thrust collar lip portions 53 is controlled in order to minimize leakage of high pressure fluid at this point. By restricting the extent of leakage of high pressure fluid to the cover chambers 63 and 64 to a relatively small amount, adequate lubrication of the thrust collars is maintained without materially affecting the volumetric efficiency of the pump. Although the thrust collars 59 and 61 and the nut 62 need not rotate with the tension member 47 and the gear shaft 36, they may so rotate and in such case lubrication is provided in the same general manner by leakage of high pressure fluid from the associated pressure loading chambers 54 and 55. Lubrication of the radial bearing surfaces or journals of the gear shafts 32 and 36 may be accomplished by leakage of high pressure working fluid from

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the annular pressure chambers 54 and 55 axially along the bearing journals 43 and 44 toward the gear faces and thence into the low pressure chamber 38 at the inlet side of the pump. If desired, metering grooves may also be provided in the end plate structures so as to permit a controlled flow of high pressure fluid along the bearing journals 43 and 44 which is in excess of the normal leakage through the pumping seal at the end plate-gear face surfaces.

Many different arrangements of internal fluid passages are well known in the gear pump art for the purpose of pressure loading one or more bushings or end plates at the side faces of the gears and also for providing lubrication for the gear shaft journals. Inasmuch as such details are well known to those skilled in the art and do not constitute any part of the present invention, a detailed illustration and description of this aspect of my invention is not necessary. However, as an illustration of a typical arrangement of fluid passages for pressure loading and radial bearing lubrication, reference is again made to my U. S. Patent No. 2,772,638 which shows an arrangement of fluid passages involving a double set of uni-directional check valves so as to permit reversible operation of the pump. Obviously, however, any other suitable arrangement of fluid passages and the like may be used within the scope of the present invention.

In Figs. 3 and 4 I have illustrated an internal unit assembly comprising a modified embodiment of the invention which differs from the previously described embodiment in that only one tension member is separate from and disposed coaxially with a gear shaft. In this instance, the other tension member comprises the gear shaft as disclosed in my aforementioned U. S. patent. For the sake of convenience in Figs. 3 and 4 and also in the remaining figures of the drawings I have omitted the external housing or casing of the gear pump but it will be understood that in use the internal unit assembly shown in each case will be contained within an outer housing in the same general manner as illustrated in Figs. 1 and 2.

As seen in Fig. 3, the internal unit assembly comprises a pair of one-piece end plates 71 having journaled therebetween a driven gear shaft 72 carrying a gear 73 and a driving gear shaft 74 carrying an intermeshing gear 76 and provided in this instance with an involute or internal spline arrangement 77 adapted to receive an inwardly extending male drive member (not shown). An elongated tension member 78 extends coaxially through the gear shaft 72 in the same general manner described in connection with Figs. 1-2 and is provided with an integral head portion 79 at one end and a threadedly attached retainer nut 81 at its other end.

In order to provide fluid pressure loading chambers for the tension member 78, the upper portions of the end plates 71 are each formed with a pair of recesses 82 extending inwardly from the outer faces of the end plates. An annular apertured thrust member 83 is disposed within each of the recesses 82 with the tension member 78 extending through the thrust members 83 and with inner and outer seal rings 84 and 86 being provided in order to seal the thrust members 83 with respect to the end plates 71 and the tension member 78. As seen in Fig. 3, the thrust members 83 are retained by the head 79 and the nut 81 at the opposite ends of the tension member 78 and are spaced axially outwardly from inner walls of the recesses 82 so as to define a pair of confined pressure loading chambers 87 which are in fluid communication with each other through the annular space, designated at 88, between the tension member 78 and the gear shaft 72.

Inasmuch as the pressure loading chambers 87 and the thrust members 83 are recessed in the end plates 71 at the driven gear shaft 72 and its tension member 78, it will be understood that the thrust members and the seals 84 and 86 are non-rotating or static with respect to the tension member 78. However, as hereinafter described

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in detail, the pressure loading chambers and the corresponding seals associated with the driving gear shaft 74 are rotating or dynamic, and in order to provide the maximum diameter for such rotating seals and their accompanying confined pressure chambers, I prefer to locate the chambers 87 eccentrically or non-coaxially with respect to the axis of the tension member 78 or the axis of the gear shaft 72 or both. In the embodiment illustrated in Figs. 3 and 4, the tension member 78 and the gear shaft 72 are coaxial, and the chambers 87 are located eccentrically with respect to this common axis. However, it will be understood that these chambers could also be concentric with respect to the axis of the tension member and eccentric with respect to the gear shaft axis.

As previously pointed out, the gear shaft 74 for the driving gear 76 also constitutes the tension member, and for this purpose the opposite ends of the gear shaft 74 extend outwardly beyond the end plates 71 and are threaded for receiving a pair of retaining nuts 89. The pressure loading chambers and the seal mechanism comprises a pair of adjustment nuts 91 threaded on the ends of the gear shaft 74 and disposed inwardly of the retaining or lock nuts 89. A static seal ring 92 is interposed between each of the adjusting nuts 91 and the shaft 74 for providing a static seal therebetween. Coacting with each of the adjusting nuts 91 is a floating ring or annular element 93 having its inner axial end disposed in bearing engagement with the adjacent outer surface of the corresponding end plate 71 and having a tapered or conical inner periphery, as at 94. A ring 96 of resilient material, such as a rubber O-ring, is interposed between the adjusting nut 91 and the floating seal ring 93 so that upon tightening of the adjusting nut 91 to a predetermined degree, the innermost seal face or inner axial end of the floating ring 93 is forced against the corresponding surface of the end plate 71 by the action of the resilient ring 96 bearing against the angular inner surface 94. Thus, a confined annular space or pressure loading chamber 97 is defined at the outer face of each side plate 71 by means of the cooperating elements 91-92-93-96. Under operating conditions, working fluid under discharge pressure is supplied to the pressure loading chambers 87 and 97 so that the end plates 71 are urged inwardly against the side faces of the gears 73 and 76 for maintaining a pumping seal therebetween.

When the dynamic seal chambers 97 are filled with high pressure fluid, the resilient ring 96 will be compressed or crowded so as to expose more of the inner conical surface of the floating ring 93 to the effect of the high pressure fluid so as to increase the seal pressure between the inner axial end of the ring 93 and the corresponding seal face of the end plate 71. Of course, it will be understood that there is a throttling action or leakage of high pressure fluid at the seal interface between the ring 93 and the end plate 71 so as to provide lubrication for the dynamic seal. The high pressure fluid thus leaking from the chambers 97 passes into the low pressure cover chambers between the internal unit assembly shown in Fig. 3 and the corresponding end portions of the external pump housing (not shown). As will be seen from Fig. 3, the only interconnection between the adjusting nut 91 and the floating ring 93 is through the resilient ring 96 and at all times there is a slight clearance, as designated at 98, between the adjusting nut 91 and the ring 93 so as to accommodate dimensional changes due to thermal expansion or tensile elongation. Thus, the dynamic seal arrangement shown in Fig. 3 has the important advantages of readily accommodating slight misalignment or relative inaccuracies between the sealing surfaces and also compensates for changes in operating clearance due to unequal thermal expansion or tensile elongation of the gear shaft. Reference is made to my copending application Serial No. 709,045, filed January 15, 1958, wherein the compensating dynamic

seal arrangement is described in greater detail and is also claimed.

Fig. 5 represents a further modification of the internal unit assembly arrangement shown in Fig. 3. In this case only a single tension member is used extending through the driven gear shaft in coaxial relation therewith whereby to provide what might be referred to as a cantilever construction. Thus, the unit assembly has the usual pair of side plates 101 having journaled therebetween a driving gear shaft 102 having a drive gear 103 with internal splines 104 and a driven gear shaft 106 carrying a gear 107. The thrust means in this case comprises a pair of thrust plates 108 disposed at the outer sides of the end plates 101. Each thrust plate 108 has a peripheral skirt or rim portion 109 which fits in an edgewise groove 111 in the corresponding end plate 101. Each plate 108 also has an integral central projection or plunger portion 113 having sliding fit in an opening 114 in the adjacent side plate 101. O-ring seals 112 and 116 are provided between the plate 108 and the cooperating parts of the end plates 101. An elongated tension member 117 extends coaxially through the gear shaft 106 and through suitable apertures 118 in the thrust plates 108. O-ring seals 119 are mounted at the openings 118 to provide static seals with the tension member 117. A pair of retainer nuts 121 are threadably secured at the outer projecting ends of the tension member 117. Thus, it will be seen that the thrust plates 108 are adjustably secured at the outer faces of the end plates 101 and have spaced portions so as to define a pair of enlarged confined pressure loading chambers 122 which extend along the full length of the end plates 101.

As will be apparent, the tension member 117 is non-rotating or fixed with respect to the gear shaft 106. However, a rotating or dynamic seal must be provided with respect to the drive gear shaft 102. In view of the one piece thrust plates 108 extending across both the driving gear shaft and the driven shaft, a somewhat different dynamic seal arrangement is necessary. In this instance, I provide a pair of annular elements 123 of short axial length which are disposed in openings 124 provided in the thrust plates 108. Each element 123 has a tapered outer periphery which is engaged by a resilient O-ring 27 seated in a groove in the thrust plate 108 and surrounding the aperture 124. Thus, the elements 123 are restrained against rotation but the innermost axial ends thereof abut against the axial ends of the rotating driving gear shaft 102 so as to provide a rotating seal therebetween. As will be evident, a certain amount of high pressure fluid may leak through the rotating seal face from the pressure loading chambers 122 into the low pressure cover chambers of the pump.

Coming now to Figs. 6 to 9, a somewhat different embodiment of the invention is illustrated wherein a plurality of separate tension members are employed, i. e. separate from and independent of the gear shafts, but in each case the tension member is located externally of and non-coaxially with respect to the gear shafts. Again, only the internal unit assembly of the device is shown but it will be understood that a suitable external casing or housing will be used in much the same manner as heretofore described in connection with Fig. 1. In this instance the assembly comprises a pair of generally oval shaped end plates 131 having peripherally extending O-ring seals 132 adapted to coact with the housing (not shown). The end plates 131 have aligned bores in which are journaled a driven gear shaft 133 carrying a gear 134 and a driving gear shaft 136 carrying a drive gear 137 and provided with internal splines 138 for making a driving connection with a suitable driving element. In the same general manner as heretofore described in connection with Fig. 5, a pair of one-piece thrust plates 139 are adjustably mounted at the outermost faces of the end plates 131. The thrust plates 139 each have a peripheral skirt or rim portion 141 coacting with a

groove portion 142 on the corresponding end plate, and a central inwardly extending protuberance 143 from each thrust plate 139 has a slidable fit in a recess 144 in the end plate. A plurality of O-ring seals 146 are provided for sealing the end plates 131 with respect to the portions 141 and 143 of the thrust plates 139. The thrust plates 139 are maintained in predetermined spaced relation with respect to the end plates 131 by means of a pair of elongated tension members 147 having enlarged head portions 148 and extending through the thrust plates 139 and the end plates 131 along axes parallel to but spaced from the axes of the gear shafts 133 and 136. The opposite projecting ends of the tension members 147 are threaded for receiving a pair of lock nuts 149.

As will be evident from Figs. 6 and 8 in particular, the tension members 147 extend through the spaces, designated at 151 and 152 in Fig. 8, which comprise the inlet or low pressure side and the outlet or high pressure side of the pump, respectively. Consequently, it is necessary to provide the tension member 147 which extends through the high pressure area 152 with a pair of small O-ring seals 153 in order to seal this particular tension member with respect to the end plates 131.

By reason of the adjusted positions of the thrust plates 139 relative to the end plates 131, a plurality of confined pressure loading chambers 154 and 156 are thereby defined at the opposite ends of the gear shafts 133 and 136, respectively. Just as in Fig. 5, the seals adjacent the ends of the driven gear shaft 133 are, of course, static, but the seals at the ends of the driving gear shaft 136 are dynamic. Thus, a pair of thrust rings 157 are mounted in stationary relation in the respective thrust plates 139 at the opposite axial ends of the gear shaft 136, and the rotating gear shaft 136 abuts these thrust rings 157 to provide a dynamic or rotating seal therebetween. In this instance, high pressure fluid is supplied to the pressure loading chambers 154 and 156 by means of a pair of diverging internal bores or passages 158 (Fig. 8) extending angularly within the end plates 131 from the discharge zone 152 of the pumping chamber. As seen in Fig. 9, each of the channels 158 then diverges through branch passages 159 which communicate with grooves 161 and 162 for supplying high pressure fluid to the pressure loading chambers 154 and 156, respectively. Of course, it will again be understood that leakage of high pressure fluid through the rotating seal face at 157 allows the pressure loading fluid to pass into the low pressure cover chambers.

Figs. 10 to 12 illustrate still another modification of the invention involving the use of tension members separate from and independent of the gear shafts, but in this case only one of the end plates is pressure loaded. The end plates of the internal unit assembly are designated at 166 and 167. The end plate 167 has a pair of bores 168 and 169 for receiving gear shafts 171 and 172 in journaled relation therein in the usual manner. However, the oppositely disposed end plate 166 is formed with a pair of recesses 173 and 174 for journaling the opposite ends of the gear shafts 171 and 172. The gear shafts are formed with integral intermeshing gears 176 and 177 and also with internal splines 178 and 179.

The outer face of the end plate 166 is formed with a pair of circular recesses 181 in which are fitted a pair of thrust disks 182 with O-ring seals 183 being interposed therebetween. As will be evident from Fig. 12 the thrust disks 182 have a predetermined spaced relation from the inner surfaces of the recesses 181 so as to define a pair of confined pressure loading chambers 184 therebetween. For retaining the thrust disks 182 in desired position, a retainer plate 186 overlies a major portion of both of the thrust disks 182, and a pair of elongated tension members 187 having head portions 188 extend through the retainer plate 186 and the end plate 166 and are threaded at their opposite ends into the end plate 167, as best seen in Fig. 11. Just as hereto-

fore described in connection with Figs. 6 to 9, the tension members 187 extend through the inlet or low pressure and the discharge or high pressure areas of the pumping chambers as indicated at 189 and 191, respectively in Fig. 11.

In this case the fluid passage means for supplying high pressure discharge fluid to the pressure loading chambers 184 comprises a pair of angularly disposed channels 192 extending from a common inlet 193 at the inner face of the end plate 166 in the high pressure discharge area 191. These passages 192 extend in opposite directions to the confined pressure loading chambers 184 for supplying high pressure fluid to the latter. As will readily be understood, the pressure provided by the fluid in the chambers 184 urges the end plate 166 toward the side faces of the gears 176 and 177. At the same time, the reaction from this thrust is transmitted through the retainer plate 186 and the tension members 187 to the oppositely disposed end plate 167 so that the latter is likewise urged inwardly toward the opposite side faces of the gears. Although the seal chambers are in this instance provided with static seals, leakage of high pressure fluid along the bearing journals of the gear shafts 171 and 172 is transmitted to the low pressure cover chambers as in the previous forms of the invention.

Figs. 13 to 15 constitute still another modification of the general principle involved in Figs. 10 to 12, namely, the provision of pressure loading chambers at only one of the end plates. In this case, the internal unit assembly comprises a pair of end plates 195 and 196 with a pair of gear shafts 197 and 198 journaled therebetween and carrying intermeshing gears 199 and 201. The pressure loading arrangement in this instance comprises a single annular chamber 202 defined between a disk member 203 seated against the outer face of the end plate 196 and an external thrust plate 204 having an inwardly extending skirt portion 206 fitted around the periphery of the disk 203 with an O-ring seal 205 therebetween. The thrust plate 204 is retained in predetermined adjusted position by means of a pair of elongated tension members 207 and 208 having enlarged head portions 209 engaging the thrust plate 204. The tension members 207 and 208 extend through the disk 203 and the end plate 196 and have a threaded connection, as at 211, in the opposite end plate 195. Again, it will be understood that the tension members 207 and 208 extend through the high and low pressure sides of the pumping chamber, respectively.

In this embodiment, the channel means for supplying high pressure fluid to the pressure loading chamber 202 is located within the tension member 207 which extends through the high pressure side of the pumping chamber. Thus, high pressure fluid enters through a plurality of radial bores 212 in the tension member 207 and thence passes through an axial bore 213 to another set of radial bores 214 which communicate with the annular pressure loading chamber 202. O-ring seals are provided around the tension member 207 as at 216, 217, and 218 in order to seal the tension member with respect to the side plate 196, the disk 203, and the thrust plate 204, respectively. As described in connection with Figs. 10 to 12, the pressure of the fluid in the chamber 202 urges the end plate 196 inwardly toward the side faces of the gears, and the thrust reaction is transmitted from the thrust plate 204, through the tension members 207 and 208 to the oppositely disposed end plate 195 for urging the latter in the opposite direction toward the side faces of the gears.

From the foregoing, it will be seen that my present invention provides a wide variety of alternative design features involving the same general internal unit assembly concept of my prior patent No. 2,772,638 but at the same time making it possible to employ one or more tension members which are separate from and independent of the gear shafts. In addition, the invention provides

a number of alternative arrangements for the separate tension members to accommodate different types of pressure loading arrangements.

Although the invention has been described with particular reference to certain specific structural embodiments thereof, it is to be understood that various modifications and equivalent structures may be resorted to without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a gear-type liquid displacement device of the character described, a housing having a fluid inlet and outlet with a gear chamber therebetween, a pair of meshed gears mounted in said gear chamber, a pair of coaxing end plate structures mounted in said housing in sealing relation therewith and with opposite side faces of said gears, a pair of gear shafts carrying said gears and journaled at their ends in said end plate structures, thrust means having a portion thereof spaced from and co-operable with at least one of said end plate structures to provide a fluid pressure loading chamber therebetween, means for supplying fluid under pressure to said loading chamber for urging said one end plate structure inwardly toward said gears, and at least one tension member separate from said gear shafts extending between said end plate structures and operatively coaxing between said thrust means and the other of said end plate structures whereby the fluid pressure in said loading chamber also urges said other end plate structure inwardly toward said gears and whereby the reaction forces from the pressure loading of said end plate structures are imposed on said tension member without applying the same to said housing, said tension member being independent of and having no tension-resisting connections with said gear shafts.

2. The device of claim 1 further characterized in that said tension member extends coaxially through one of said gear shafts.

3. The device of claim 1 further characterized in that said gear shafts have axial bores and a pair of tension members are provided extending coaxially through said gear shafts.

4. In a gear-type liquid displacement device of the character described, a housing having a fluid inlet and outlet with a gear chamber therebetween, a pair of meshed gears mounted in said gear chamber, a pair of coaxing end plate structures mounted in said housing in sealing relation therewith and with opposite side faces of said gears, a pair of gear shafts carrying said gears and journaled at their ends in said end plate structures, thrust means having a portion thereof spaced from and co-operable with at least one of said end plate structures to provide a fluid pressure loading chamber therebetween, means for supplying fluid under pressure to said loading chamber for urging said one end plate structure inwardly toward said gears, and tension-resisting means operatively coaxing between said thrust means and the other of said end plate structures whereby the fluid pressure in said loading chamber also urges said other end plate structure inwardly toward said gears, said tension-resisting means comprising one of said gear shafts and a separate elongated tension member extending coaxially through the other of said gear shafts.

5. In a gear-type liquid displacement device of the character described, a housing having a fluid inlet and outlet with a gear chamber therebetween, a pair of meshed driving and driven gears mounted in said gear chamber, a pair of coaxing end plate structures mounted in said housing in sealing relation therewith and with opposite side faces of said gears, thrust means disposed at the outer sides of said end plates and having portions spaced from and co-operable with said end plate structures to provide fluid pressure loading chambers therebetween, means for supplying fluid under pressure to said chambers for urging said end plate structures inwardly toward said gears, a first tubular gear shaft car-

rying said driven gear and journaled at its ends in said end plate structures, a single elongated tension member extending coaxially through said first gear shaft and operatively coacting between said thrust means for resisting the reaction forces from the pressure loading of said end plate structures, a second gear shaft carrying said driving gear and journaled at its ends in said end plate structures, and rotatable seal means provided at the ends of said second gear shaft.

6. In a gear-type liquid displacement device of the character described, a housing having a fluid inlet and outlet with a gear chamber therebetween, a pair of meshed gears mounted in said gear chamber, a pair of coacting end plate structures mounted in said housing in sealing relation therewith and with opposite side faces of said gears, a pair of gear shafts carrying said gears and journaled at their ends in said end plate structures, thrust means having a portion thereof spaced from and cooperable with at least one of said end plate structures to provide a fluid pressure loading chamber therebetween, means for supplying fluid under pressure to said loading chamber for urging said one end plate structure inwardly toward said gears, and a plurality of elongated tension members separate from said gear shafts and disposed with their longitudinal axes parallel to but transversely spaced from the axes of said gear shafts in non-coaxial relation therewith, said tension members extending between said end plate structures and operatively coacting between said thrust means and the other of said end plate structures whereby the fluid pressure in said loading chamber also urges said other end plate structure inwardly toward said gears and whereby the reaction forces from the pressure loading of said end plate structures are imposed on said tension members without applying the same to said housing.

7. The device of claim 6 further characterized in that a pair of tension members are provided extending transversely through said gear chamber at the inlet and outlet sides thereof.

8. In a gear-type liquid displacement device of the

character described, a housing having a fluid inlet and outlet with a gear chamber therebetween, a pair of meshed gears mounted in said gear chamber, a pair of coacting end plate structures mounted in said housing in sealing relation therewith and with opposite side faces of said gears, a pair of gear shafts carrying said gears and journaled at their ends in said end plate structures, thrust means operatively coacting with one of said end plate structures and having a portion thereof spaced from the latter to define a pressure loading chamber therebetween, means for supplying fluid under pressure to said loading chamber for urging said one end plate structure inwardly toward said gears, and a pair of elongated tension members separate from said gear shafts extending between said end plate structures and operatively coacting between said thrust means and the other of said end plate structures whereby the fluid pressure in said loading chamber also urges said other end plate structure inwardly toward said gears and whereby the reaction forces from the pressure loading of said end plate structures are imposed on said tension members without applying the same to said housing, said tension members extending through said gear chamber adjacent said inlet and outlet, and said means for supplying fluid under pressure to said loading chamber comprising internal fluid passages within the tension member extending through the fluid outlet side of the gear chamber whereby high pressure discharge fluid is supplied from the outlet side of the gear chamber through said internal passages to said pressure loading chamber.

9. The device of claim 1 further characterized in that said gears comprise a driving gear and a driven gear, and the gear shaft for the driving gear is provided with means for making a driving connection with a drive means and has rotatable fluid seal means operatively associated therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

2,758,548	Rockwell	Aug. 14, 1956
2,772,638	Nagely	Dec. 4, 1956