Nov. 18, 1969 W. J. BANGS 3,478,693

LOBE GEAR PUMP

Filed April 29, 1968 2 Sheets-Sheet 1

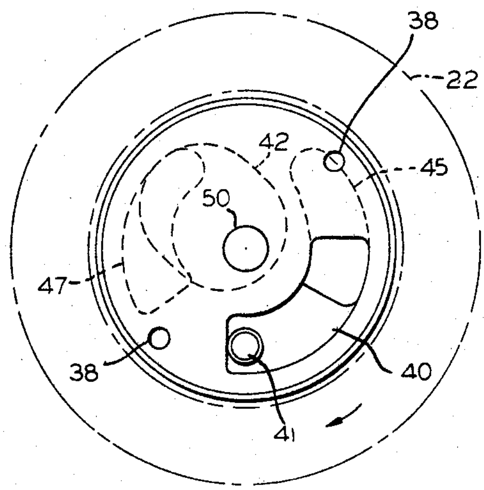

FIG.3

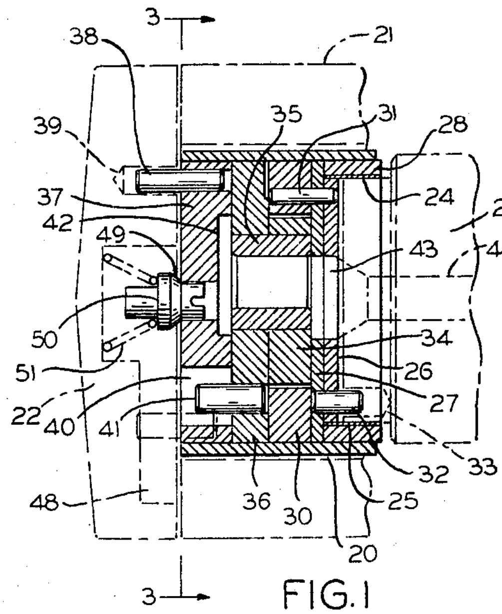

FIG.1

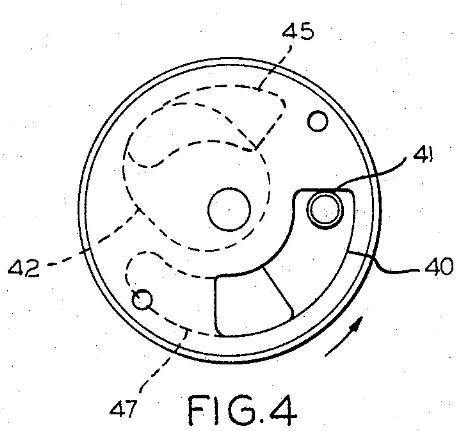

FIG.4

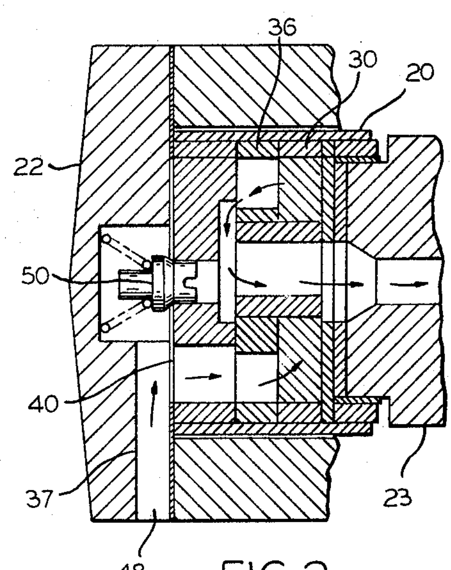

FIG.2

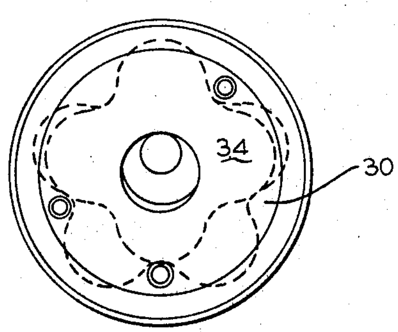

FIG.5

INVENTOR
WALTER J. BANGS

BY
Mann, Brown & McWilliams
ATTORNEYS

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LOBE GEAR PUMP

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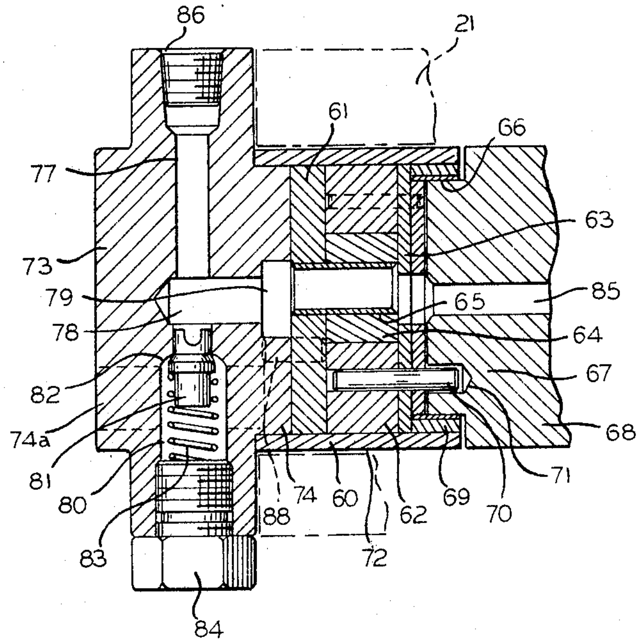

FIG.6

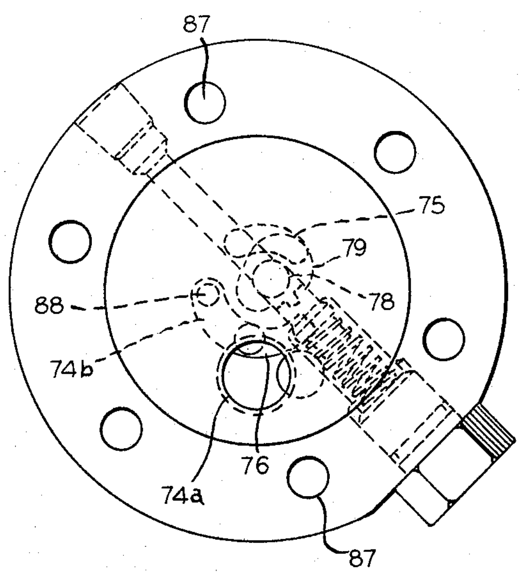

FIG.7

INVENTOR
WALTER J. BANGS

BY
Mann, Brown & McWilliams
ATTORNEYS

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LOBE GEAR PUMP

Walter J. Bangs, Chicago, Ill., assignor to Tuthill Pump Company, a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

Unidirectional flow lobe gear pump which is in cartridge form and which is mounted for limited axial movement between a cover element and a drive shaft. This compensates for unsquare ends of drive shafts and also compensates for end play in the drive shaft during rotation thereof. A porting arrangement reduces impact forces in the pump during shifting of the ports by a port plate and provides for better reversing reliability.

The present invention is directed to new and useful improvements in unidirectional flow lobe gear pumps.

Pumps of this general type have been known for many years and characteristically include an outer gear and an inner gear positioned eccentrically with respect to the outer gear so that upon rotation of the gears, pressure developed between the lobes of the inner and outer gears impel fluid therebetween and from an inlet to the intergear spaces to an outlet therefrom. Pumps of this type sometimes have a rotatable port plate which is adapted to change the direction of the porting upon a change in direction of the drive of the gear so as to maintain the same direction of flow from the inlet to the outlet irrespective of the direction of rotation of the drive shaft. In this type of pump, the port plate rotates through approximately 180° upon a shift in the direction of drive shaft rotation. Some stop means must necessarily be provided to limit the rotation of the port plate and the inertia developed through this relatively long (180°) travel of the port plate can result in damaging shock forces to be absorbed by the pump elements. Also, in pumps of this general class some provision must be made for aligning the pump with the drive shaft and accommodating the thrust forces developed in the pump due to the eccentric mounting of the inner gear with respect to the outer gear.

With the foregoing in mind, the major purposes of the present invention are to form a unidirectional flow lobe gear type of pump in such a manner that the elements of the pump may be assembled as a cartridge and mounted easily within a surrounding housing and cover member with relatively loose tolerances therebetween, to so arrange a pump cartridge of this type that it is supported over the drive shaft to insure alignment between the main axis of the pump and main axis of the drive shaft, to so arrange a pump cartridge of this type that it is easily connected to and disconnected from a drive shaft, to so arrange a pump of this class as to minimize shock forces in the pump during shifting of the port plate within the pump, and to so arrange pumping elements that the pumping unit may be simply and economically manufactured, these and other purposes being more apparent in the course of the ensuing specification and claims when taken with the accompanying drawings, in which:

FIGURE 1 is a sectional view of a pump incorporating the principles of the present invention;

FIGURE 2 is a diagrammatic view of the pump elements illustrated in FIGURE 1 to illustrate the flow through the pump and with certain elements displaced from their normal position to illustrate the flow;

FIGURE 3 is an end view of the pump of FIGURE 1 taken along the section lines 3—3 of FIGURE 1 and illustrating one position of a rotatable port plate corresponding to a clockwise direction of rotation of the drive shaft;

FIGURE 4 is an end view similar to FIGURE 3 but illustrating the position of the port plate and other passages when the drive shaft drives the pump in a counterclockwise direction;

FIGURE 5 is an end view of the pump looking from the drive shaft side of the pump;

FIGURE 6 is a sectional view of a modified form of pump assembly; and

FIGURE 7 is an end view of pumps made in accordance with the showing of FIGURE 6.

Like elements are designated by like characters throughout the specification and drawings. With specific reference now to the drawings, and in the first instance to FIGURE 1, the numeral **20** designates a cylindrical sleeve-like support for the pump elements of the present invention. The sleeve **20** is adapted to be received within a housing indicated by the dash lines at **21**. The opening or cavity in the housing which receives the sleeve **20** may be closed by a suitable cover **22**. A drive shaft **23** is adapted to be coupled to the pump elements carried by the sleeve **20**. The drive shaft **23**, for example, may include a reduced end portion **24** which is received within a short ring or sleeve **25** in a slip fitting relation. Ring **25** is fixed to and fitted over a pressure plate assembly consisting of first and second plates **26** and **27**. It should be understood that the plates **26** and **27** may be formed as one integral member although it is convenient to form the plates separately from metal stampings and then position them together as illustrated in the drawings. The outer plate **26** may have a smaller diameter than plate **27** so that the connecting sleeve **25** is received over plate **26** and in abutting relation to plate **27**. An adapting ring **28** is received over the ring or sleeve **25** and fills the space between the reduced portion of the shaft and the sleeve **20**. The adapting ring **28** is fixed to the sleeve **20**. It should be understood that the adapting ring **28** may be of varying thicknesses in order to accommodate varying diameters of drive shafts.

The pumping elements of the pump include an outer ring gear **30** which is fixed to the pressure plates as by means of a coupling pin **31**. The pressure plates are in turn fixed to the drive shaft by means of a pin **32** which is carried by the pressure plates and which is received within a bore **33** in the reduced end of the drive shaft. It should be noted that the bore **33** is longer than the pin **32** so that the pin **32** is slidably received in the bore **33**. An inner gear **34** has lobes which are engageable with inwardly facing lobes on the outer ring gear. The inner gear is supported for rotation on an idler shaft **35**. Idler shaft **35** has its axis offset from the axis of the drive shaft and the axis of the outer ring gear and is supported by a port plate **36**. Port plate **36** as well as the outer ring gear **30** are rotatably supported by the sleeve **20**. A stationary port plate **37** is press fitted within the sleeve **20** and is positioned adjacent to the side of the port plate remote from the outer gear. One or more pins **38** are fixed to the plate **37** and are received within elongated bores **39** in the cover **22** so that the pins **38** are slidable with respect to the cover **22** in a direction parallel to the axis of the pump while at the same time holding the plate **37** and sleeve **20** against rotation. It should be understood that suitable cap screws or the like are utilized to fix the cover **22** to the housing and these elements are not shown because they are more or less conventional in apparatus of this general class.

The fixed port plate **37** has an arcuate recess **40** formed therein and this recess extends for an arc of approximately 90°. This provides an inlet recess in the fixed plate **37**.

The port plate 36 carries a stop pin 41 which is received within this recess and may rotate with the port plate 36 to and from the extreme positions illustrated in FIGURES 3 and 4. The fixed plate 37 also has a central passage 42 formed in the face thereof which faces the port plate so that this passage may communicate through the hollow portion of the idler shaft 35, through apertures 43 in the pressure plates, and thence with an outlet 44 formed through the drive shaft. Outlet 44 may lead to any suitable point of use (as for lubricating the bearings for shaft 23).

The port plate has a pair of generally arcuate passages 45 and 47 formed therethrough and on radii generally equal to the radii used to form the passage 40 and generally equal to the outer portion of the enlarged passage 42 in the fixed plate 37. These arcuate passages 45 and 47 in the port plate are adapted to selectively overlap the passage 40 or the passage 42 in the fixed plate 37 as is illustrated in FIGURES 3 and 4. FIGURES 3 and 4 illustrate different operative positions of the port plate to insure unidirectional flow from the passage 40 and to one or the other of the arcuate passages 45 and 47 and to the outlet passage 42 of the fixed plate.

An inlet passage 48 is formed in the cover 22 and may lead to a suitable source of liquid to be pumped. This may be supplied through a conduit fitting which leads to housing 21 and to the inlet passage 48. Inlet passage 48 is adapted to communicate also with a relief valve passage 49 which is formed centrally of the stationary port plate 37. This relief passage is normally closed by a spring biased valve 50. When pressure within the pump builds up beyond a predetermined desired maximum, the valve 50 may yield against a spring 51 so as to allow return of fluid to the inlet passage 48 from the outlet passage 42 of the fixed plate.

During operation of the pump, the drive shaft drives the pressure plates 26 through the pin connection 32 and drives the outer ring gear through the pin connection 31. During rotation of the shaft and outer ring gear in one direction, as for example clockwise, in FIGURE 3, the frictional engagement between the outer ring gear and port plate will insure rotation of the port plate to the position illustrated in FIGURE 3. The clockwise frictional forces simply force the pin 41 of the port plate to a position of abutment with the end of the passage 40 in the fixed plate 37. In this position, fluid flows from the inlet 48 through the fixed plate passage 40, then through the port plate passage 45 in overlapping relation therewith and to the spaces between the lobes of the gears. Rotation of the gears impels the fluid around the axis of the pump to a position circumferentially spaced from the port 45 and to the port 47 where the pressure forces it through the port 47 and into the outlet passage 42 of the fixed plate. The pressure so developed results in directing the fluid through the hollow idler shaft 35, then through the apertures 43 in the pressure plates and to the outlet 44.

If for some reason the drive shaft is rotated in the opposite direction as, for example, clockwise as illustrated in FIGURE 4, the frictional forces on the port plate are then counterclockwise and cause rotation of the port plate to the position illustrated in FIGURE 4 where the stop pin 41 abuts against the other end wall of the passage 40 in the fixed plate. This shifts the connections of the ports in the fixed plate and the port plate in that it brings the passage 47 into overlapping relation with the passage 40 while the passage 45 is then in overlapping relation to the passage 42. Thus, under either direction of rotation, the inlet passage 40 of the fixed plate is always in communication with a passage in the port plate leading to the lobes of the gears, while the outlet passage 42 in the fixed plate is always in communication with a passage in the port plate on the pressure side of the lobes of the gears.

During the operating condition of the pump, the fluid pressure in the apertures 43 is directed against the end face of the drive shaft and this causes the space between the end of the drive shaft and the plate 26 to be filled with fluid under pressure. This forces the entire pump cartridge comprised of the sleeve and all of the elements in the sleeve to the left in FIGURE 1 and tightly against the cover 22. This insures that the cartridge assembly is square to the face of the cover and helps to properly maintain alignment between the pump cartridge axis and the axis of the drive shaft.

When the pump is idle and no pressure condition is in the pump, the spring 51 may force the cartridge away from the cover and against the end of the pump shaft.

In FIGURES 6 and 7 a modified form of pump assembly is illustrated. In these figures, a pump cartridge is defined by a sleeve 60 which rotatably supports a port plate 61, outer gear 62, and pressure plate 63 for rotation therein. An inner gear 64 is journaled for rotation on a hollow shaft 65 which is fixed to and carried by the port plate 61. The pressure plate may be defined by two separate plates as illustrated, or may be formed as a single element. The pressure plate 63 carries a projecting sleeve 66 which is adapted to be snugly received over the reduced end portion 67 of the drive shaft 68. An adapting ring 69 is fixed to the sleeve 60 and fills the space between ring 66 and the sleeve. It should be understood that the adapting ring 69 may be made of varying sizes and ring 66 may have varying diameters depending upon the diameter of the end connecting portion of the shaft. A pin 70 is carried by the outer gear 62 and projects through the pressure plate 63 and into a bore 71 formed in the end of the drive shaft so as to connect the drive shaft, pressure plates, and outer gear for rotation together as in the case of the pump illustrated in FIGURES 1–5.

Sleeve 60 is adapted to be received within a pump cavity 72 formed in some housing member as at 21. The pump sleeve 60 is slidably received in this cavity and relatively loose tolerances may be employed between the sleeve 60 and the wall defining the cavity.

In FIGURES 6 and 7 a cover 73 has a boss 74 which is slidably received within the end of sleeve 60 opposite to the drive shaft. The boss 74 defines the port plate which is stationary. Cover 73 has an inlet 74*a* which is adapted for selective communication with arcuately shaped and spaced passages 75 and 76 formed in the port plate 61 through an arcuate recess 74*b* formed in the face of boss 74.

A passage 77 is formed through the side wall of the cover member and communicates with a passage 78 which is formed in the center of the cover member and which includes a portion 79 overlapping one or the other of the passages 75 and 76, as appears in FIGURE 7. A second passage 80 is formed through the side wall of the cover and is aligned with passage 77. Passage 80 intersects passage 78. A spring biased relief valve 81 is seated in the passage 80 and bears against a valve seat 82 formed therein. The valve may be biased towards closed position as illustrated by the spring 83. Spring 83 is held in position by plug 84.

In FIGURES 6 and 7, the outlet from the pump may be formed through a shaft passage 85 whereby fluid under pressure developed by the gears 62 and 64 passes from the space 79 through the hollow shaft 65 and through the pressure plate to the outlet passage 85. On the other hand, the outlet 85 in the shaft may be eliminated and the passage 77 may then be used as a discharge passage. When using the outlet through the shaft, passage 77 is closed to the exterior as by means of a plug which is screw-threaded into the threaded fitting 86 at the outer end of this passage or a gauge may be fitted into fitting 86 to measure the pump pressure.

In either event, the pressure developed by the pump passes through the shaft 65 into the space between the end of the shaft and the pressure plate so as to bias the cartridge assembly towards the cover. This allows longer tolerances between the sleeve and the wall of the cavity in the housing as is the case with the pump of FIGURES 1–5.

The embodiment of FIGURES 6 and 7 may also be used without the use of the pressure within the pump to bias the pump elements towards the cover member while eliminating the advantage gained thereby. In this event, the boss of the cover member is press-fitted within the sleeve **60** or welded thereto, in which case the pump cartridge as a whole is held in position by the action of bolts or cap screws passed through bolt holes **87** in the cover member.

In this event, the passage opening through the pressure plate **63** may also be closed.

In operation, the pump of FIGURES 6 and 7 operates in substantially the same manner as the pump of FIGURES 1–5. Rotation of the drive shaft in one direction as, for example, the counterclockwise direction as in FIGURE 7, causes rotation of port plate **61** (through the frictional forces developed between the port plate **61** and the outer gear **62**) to a position where stop pin **88** abuts one end of the arcuate slot or passage **74*b*** in the cover member to thereby overlap the passage **75** with the passage **74*a*** while passage **76** is overlapped with passage **79**. Upon rotation of the drive shaft in the opposite direction, inlet port **74*b*** is overlapped with the arcuate port plate passage **76** which leads to the intergear spaces while passage **75** is connected to passage **79**. Thus, one or the other of the ports **75** or **76** of the port plate is always in communication with the inlet port **74*b*** while the other is in communication with the outlet passage **79** in the cover member. The arrangement of FIGURES 6 and 7 is also such as to limit the amount of rotation of the port plate to on the order of 90°.

In both embodiments the thrust forces developed in the gears, which tend to act radially outwardly from the axis of the pump, are transmitted through the connecting ring **66** to the drive shaft. This minimizes the effect of forces which might otherwise cause binding of the outer gear and port plate within the supporting sleeve.

It may be noted that the travel of the stop pin for the port plate in both forms of the invention covers an arc of approximately 90°. This is made possible by having the arcuate inlet passage in the stationary port member relatively long as, for example, on the order of 90° as illustrated in both embodiments, while the outlet passage in the stationary port plate is also made sufficiently large to enable proper selective connection to the passages in the rotatable port plate. The actual travel of the stop pin may be minimized by placing the arcuate passages relatively close to the central axis of the rotatable port plate, as illustrated in FIGURE 6. The enlargement of the passages in the stationary port plate as well as the placement thereof inwardly of the outer marginal portions of the rotatable port plate and stationary port plate enables this reduction of travel of the stop pin. The amount of travel required of the stop pin may be further reduced by enlarging the inlet passage in the stationary port plate to more than 90°; but in this event the stop pin carried by the port plate must then fit within a groove in the stationary port plate which is separate from the inlet passage because, when the stop pin is positioned within the inlet passage of the stationary port plate, the amount of travel of the stop pin is determined by the arcuate length of the inlet passage. It is preferred to have this amount of travel on the order of approximately 90° as is illustrated in the drawings.

The reduction in travel of the stop pin reduces the inertia effects and shock forces when the port plate is shifted from that found in pumps using approximately 180° of travel.

Whereas I have shown and described an operative form of the invention, it should be understood that this showing and description thereof should be taken in an illustrative or diagrammatic sense only. There are modifications to the invention which will fall within the scope and spirit

thereof and which will be apparent to those skilled in the art. The scope of the invention should be measured only by the scope of the hereinafter appended claims.

I claim:

1. A unidirectional flow cartridge assembled lobe gear pump including a cylindrical supporting sleeve having pump elements including a stationary port member, rotatable port plate, inner gear, and outer ring gear positioned therein, said stationary port member being fixed to said sleeve, said rotatable port plate being positioned between said stationary port plate and said outer ring gear, said rotatable port plate and said ring gear being supported for rotation by said sleeve, said rotatable port plate carrying a bearing for said inner gear, said bearing being positioned eccentrically with respect to the axis of the outer gear, a pressure plate positioned within said sleeve and opposed to said outer ring gear, and means for fixing said outer ring gear and pressure plate together for unitary rotation thereof and for connecting said pressure plate to the end of a drive shaft, said stationary port plate and rotatable port plate having inlet and outlet passages communicating with the spaces between the lobes of the inner gear and outer gear and being shiftable to provide the same direction of flow of fluid through an outlet of said pump irrespective of the direction of rotation of the outer ring gear.

2. A unidirectional flow cartridge assembled lobe gear pump including a supporting sleeve having pump elements including a stationary port member, rotatable port plate, inner gear, and outer ring gear positioned within said sleeve, said rotatable port plate being positioned between said said stationary port plate and said outer ring gear, said rotatable port plate carrying a bearing for said inner gear, said bearing being positioned eccentrically with respect to the axis of the outer gear, a pressure plate assembly positioned within said sleeve and opposed to said outer ring gear, means for fixing said outer ring gear and pressure plate assembly together for unitary rotation thereof and for connecting said pressure plate assembly to the end of a drive shaft, said stationary port plate and rotatable port plate having inlet and outlet passages communicating with the spaces between the lobes of the inner gear and outer gear and being shiftable to provide the same direction of flow of fluid through an outlet of said pump irrespective of the direction of rotation of the outer ring gear, a shaft-adapting ring carried within said sleeve and on the side of said pressure plate opposite to the outer ring gear, said shaft-adapting ring being adapted to fit over the end of a drive shaft and being fixed to said pressure plate, and supporting means for said sleeve, said supporting means allowing a limited amount of axial movement of said sleeve and pump elements assembled therein relative thereto and relative to said drive shaft.

3. A unidirectional flow cartridge assembled lobe gear pump including an outer sleeve and pump elements including a stationary port member, rotatable port plate, inner gear, and outer ring gear within said sleeve, said stationary port member being fixed to said sleeve, said rotatable port plate being positioned between said stationary port plate and said outer ring gear, said rotatable port plate carrying a bearing for said inner gear, said bearing being positioned eccentrically with respect to the axis of the outer gear, a pressure plate assembly positioned within said sleeve and opposed to said outer ring gear, and means for fixing said outer ring gear and pressure plate assembly together for unitary rotation thereof and for connecting said pressure plate assembly to the end of a drive shaft, said stationary port plate and rotatable port plate having inlet and outlet passages communicating with the spaces between the lobes of the inner gear and outer gear, said rotatable port plate being rotatable within said sleeve to provide the same direction of flow of fluid through an outlet of said pump irrespective of the direction of rotation of the outer ring gear, a housing surrounding said sleeve and the end of said stationary port plate, and means aligning said sleeve and stationary port plate within said housing and preventing relative rotation thereof while allowing axial movement of said sleeve and pump elements relative to said housing.

4. The structure of claim **3** wherein said last named means includes pins carried by said stationary port plate and received within bores in a portion of the housing opposed thereto.

5. The structure of claim **3** wherein said pump has an outlet passage communicating through the pressure plate and against the end of a drive shaft opposed thereto and fixed to the pressure plate to thereby create pressure between the end of the drive shaft and pressure plate and force said assembled pump elements away from said drive shaft for a limited extent.

6. The structure of claim **5** wherein the means for connecting said pressure plate and outer ring gear to said drive shaft includes a pin carried by said pressure plate and received within a bore in the end of said drive shaft while allowing relative axial movement between the drive shaft and sleeve and elements therein.

7. The structure of claim **6** characterized by and including a shaft-connecting ring carried by said pressure plate and received over the end of said drive shaft, said ring being positioned between the shaft and said sleeve.

8. A unidirectional flow gear pump assembly including a housing having a pump cavity therein with a cover at an end of the cavity, a pumping element supporting sleeve within said cavity in confronting relation to said cover, said sleeve having gear means rotatably supported therein for pumping fluid during rotation of said gear means and porting means therein for delivering fluid from an inlet in the housing to an outlet therefrom irrespective of the direction of rotation of said gear means, a drive shaft for said gear means for rotating said gear means, means connecting the shaft and gear means for rotation together while allowing limited axial relative movement between said shaft and said gear means to thereby allow definition of a space at the end of said shaft, means establishing communication between said outlet and said space, and means holding said sleeve against rotation relative to said cover and housing while allowing axial movement of said sleeve relative to said cover and housing, whereby pressure in said space forces said sleeve into square relation with said cover.

9. The structure of claim **8** wherein said shaft has an outlet passage formed therein and in communication with said space.

10. The structure of claim **8** wherein an outlet passage is formed in said cover and in communication with the outlet side of said porting means irrespective of the direction of rotation of said gears.

11. The structure of claim **8** wherein said cover includes a boss projecting within said sleeve.

12. A unidirectional flow cartridge assembled lobe gear pump including a support and a stationary port member, rotatable port plate, inner gear, and outer ring gear positioned with said support, said rotatable port plate being positioned between said stationary port plate and said outer ring gear, said rotatable port plate carrying a bearing for said inner gear, said bearing being positioned eccentrically with respect to the axis of the outer gear, means for connecting said outer ring gear to the end of a drive shaft, said stationary port plate and rotatable port plate having inlet and outlet passages in selective communication with one another and communicating with the spaces between the lobes of the inner gear and outer gear, said rotatable port plate being shiftable to provide the same direction of flow through an outlet of said pump irrespective of the direction of rotation of the outer ring gear, said passages being formed inwardly of the outer marginal portions of the stationary port plate and the rotatable port plate, means limiting the rotation of said rotatable port plate to substantially less than 180°, said passages having arcuate lengths such as to provide said communication.

13. The structure of claim **12** wherein said stationary port plate has an inlet passage therein alignable selectively with a pair of spaced passages in said rotatable port plate, said rotatable port plate having a stop pin projecting within said inlet passage, said inlet passage being formed as an arc on the order of 90° thereby to limit the travel of the stop pin and rotatable port plate to on the order of approximately 90°.

14. The structure of claim **12** wherein said stationary port plate has an inlet passage therein formed as an elongated arcuate passage, said rotatable port plate and stationary port plate having stop pin and elongated groove means receiving said stop pin for limiting rotation of said rotatable port plate, the arcuate length of said groove means being such as to limit travel of the rotatable port plate to on the order of approximately 90°, the length of said inlet passage being such as to selectively connect with one of a pair of passages in said rotatable port plate when said rotatable port plate is rotated to one of its extreme positions.

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WILLIAM L. FREEH, Primary Examiner

W. J. GOODLIN, Assistant Examiner

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