June 2, 1964 F. ABEL 3,135,217

FLUID PUMP OR MOTOR

Filed Aug. 1, 1962 3 Sheets-Sheet 1

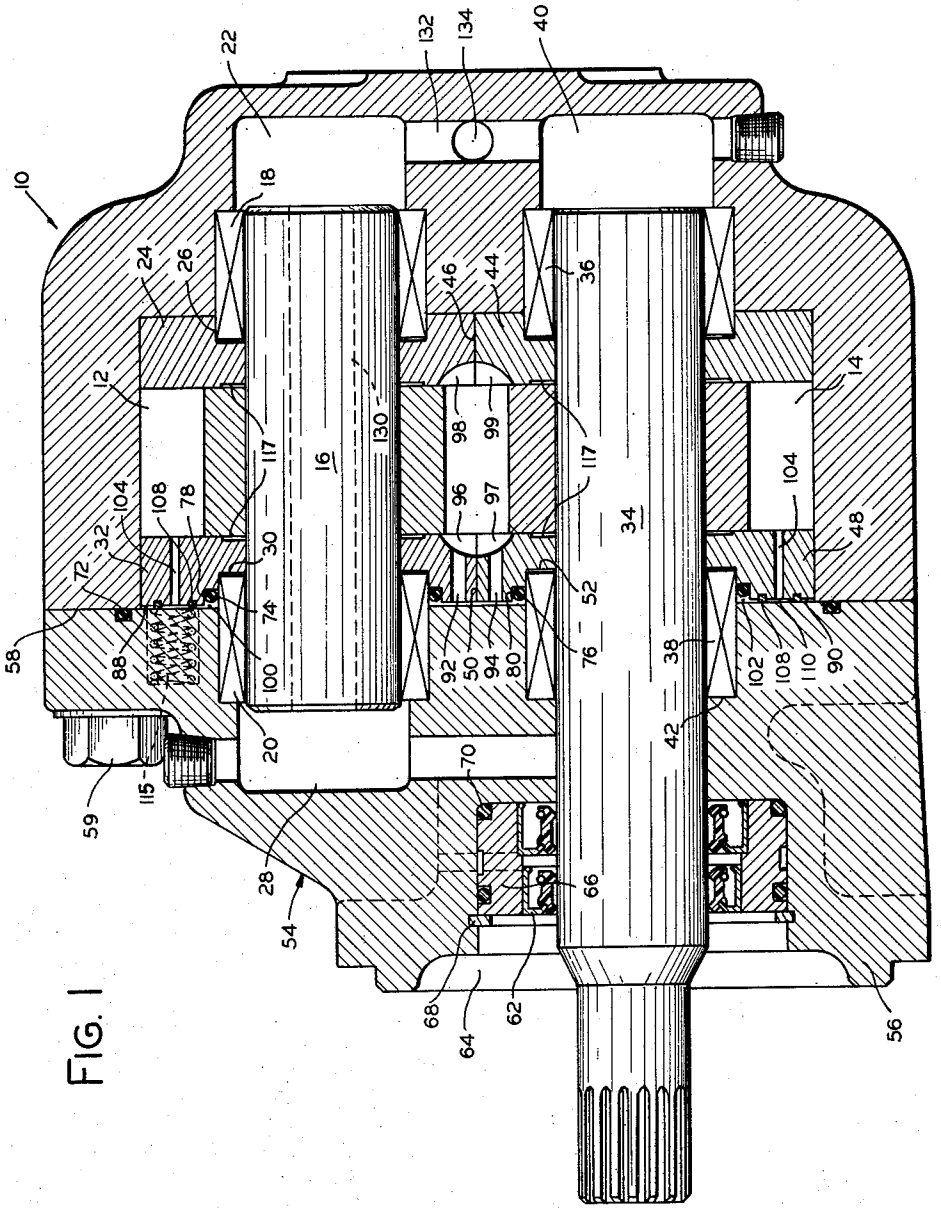


FIG. 1

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June 2, 1964 F. ABEL 3,135,217

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Filed Aug. 1, 1962 3 Sheets-Sheet 2

FIG. 2

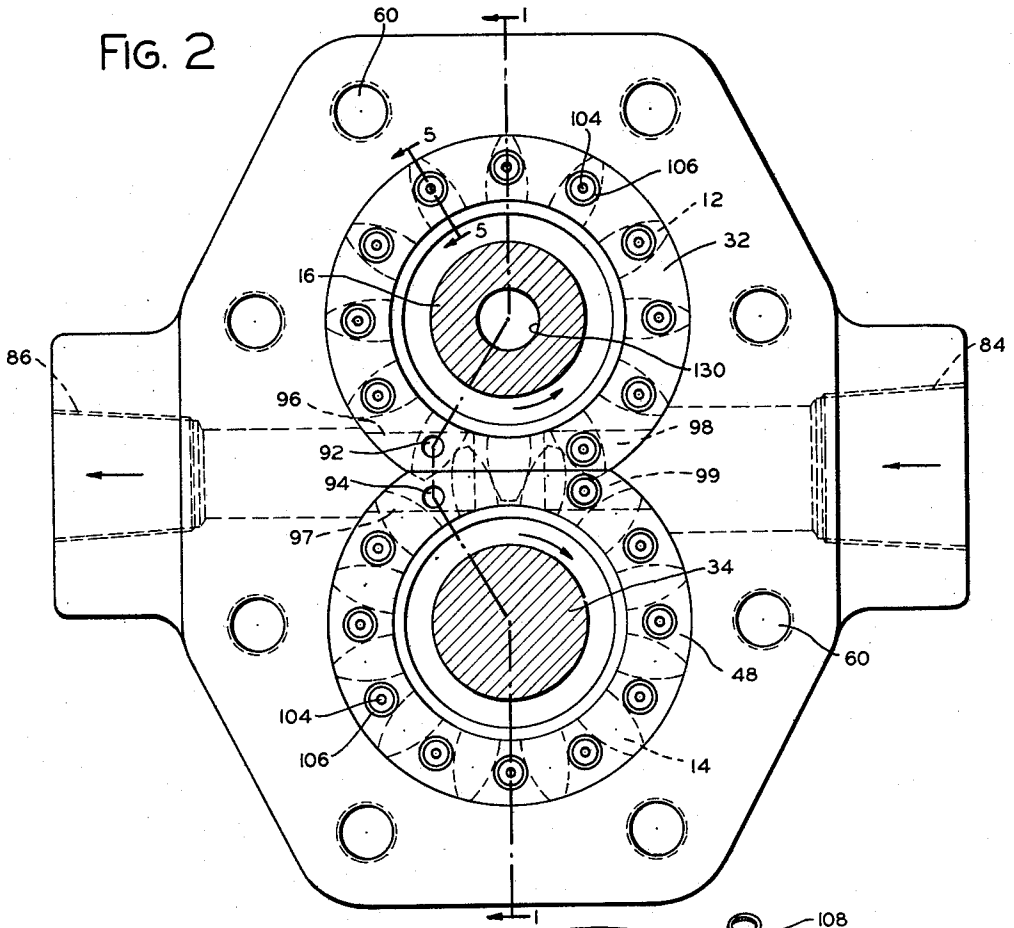
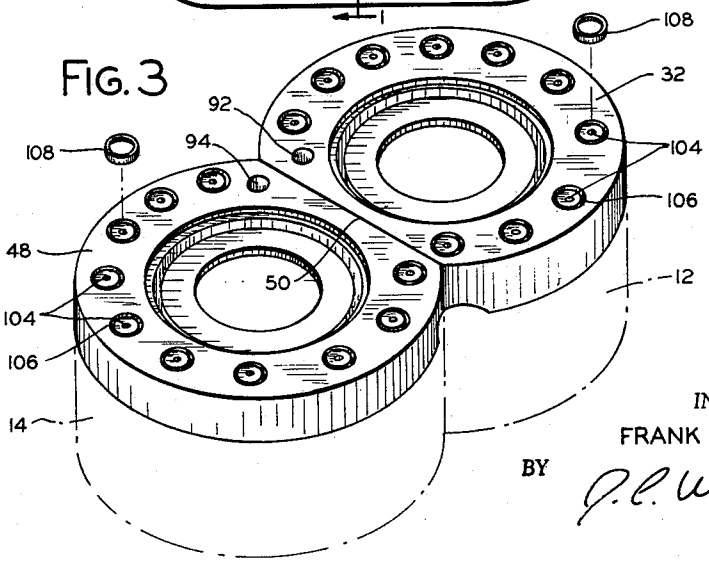


FIG. 3



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June 2, 1964 F. ABEL 3,135,217

FLUID PUMP OR MOTOR

Filed Aug. 1, 1962 3 Sheets-Sheet 3

FIG. 4

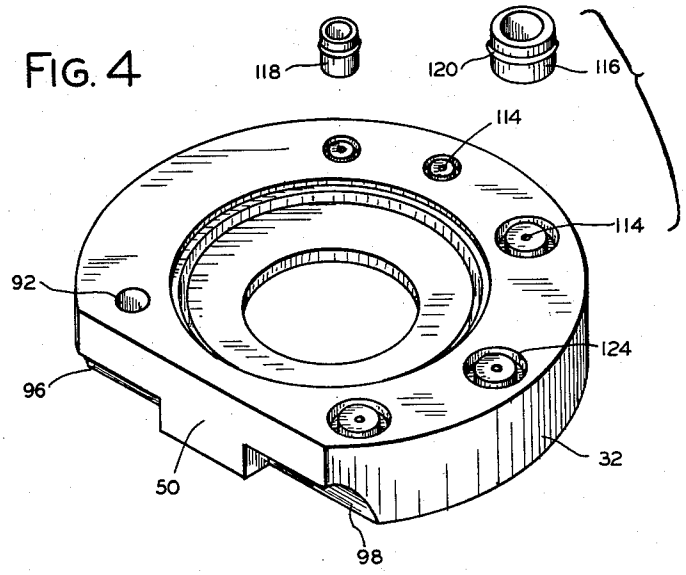


FIG. 5

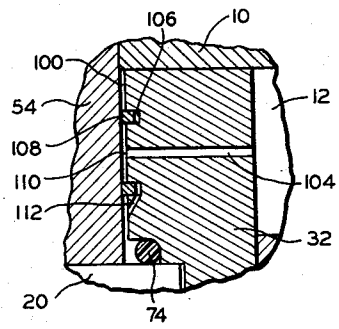


FIG. 6

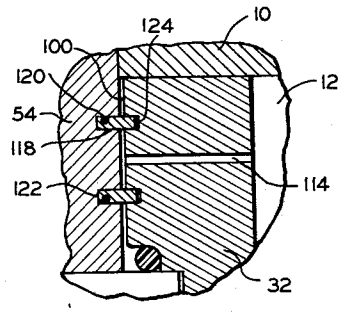
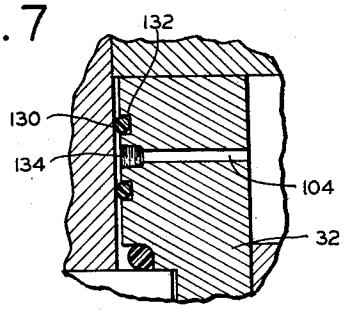


FIG. 7



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FLUID PUMP OR MOTOR

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6 Claims. (Cl. 103—126)

This invention relates to fluid displacement pumps and motors, and more particularly to pressure loaded pumps and motors. It comprises an important variation from the invention disclosed in U.S. copending application Serial No. 158,362, filed December 11, 1961, in the name of Richard O. Gordon (common assignee).

My invention provides in pumps and motors of the types contemplated, such as gear or vane type pumps and motors, a novel thrust plate construction which is adapted to communicate with discharge pressure fluid across the entire back or motive pressure side of the thrust plate except for selected areas of said thrust plate which are sealed from communication with said discharge pressure and which communicate with an adjacent area in the pump by way of pressure gradient openings formed in the thrust plate. The factors which influence the pressure gradient around the gears of an intermeshing gear pump, for example, are discussed in detail in the forementioned copending application. I have provided an important variation in the concept of pressure gradient control in pumps and motors of the types contemplated, as will become apparent hereinafter.

It is a primary object of the present invention to provide an improved pump or motor construction which continuously compensates for varying pressure gradient conditions in the unit during operation thereof.

Another object of the invention is to provide a plurality of spaced pressure gradient openings which are located radially outwardly of the root diameter of the gear teeth and which are adapted to communicate a plurality of sealed chambers on the one side of the thrust plate with pressure fluid in the pump adjacent each such opening while also providing a selected pump generated fluid pressure, such as discharge pressure, throughout the remaining motive pressure side of the plate which surrounds the plurality of sealed chambers.

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

FIGURE 1 is a sectional view of a pressure loaded type, intermeshing gear pump taken along the line 1—1 of FIGURE 2 in accordance with one embodiment of the present invention;

FIGURE 2 is an elevational view of the pump taken from the left end of FIGURE 1 with the cover body removed;

FIGURE 3 is a view in perspective taken from the motive surface side of the thrust plate of FIGURE 1 with the gears shown in broken lines and certain parts in exploded relation to the thrust plate;

FIGURE 4 is a view in perspective taken from the motive surface side of a modified version of the thrust plate shown in FIGURES 1–3;

FIGURE 5 is a broken-away, enlarged sectional view taken along line 5—5 of FIGURE 2;

FIGURE 6 is a broken-away, enlarged sectional view of the thrust plate shown in FIGURE 4 as it would appear installed in a gear pump or motor; and

FIGURE 7 is a broken-away, enlarged sectional view of a modification of the thrust plate constructions shown in FIGURES 5 and 6.

Referring now in detail to FIGURES 1–3 and 5, numeral 10 denotes a suitably chambered gear pump housing in which are rotatably mounted a driven gear 12 and an intermeshing driving gear 14. Driven gear 12 is supported on a shaft 16 journaled on its right side in a roller bearing 18 and on its left side in a roller bearing 20. Roller bearing 18 is located in a chamber 22 and is maintained in position by a fixed thrust plate 24 located intermediate bearing 18 and gear 12 and providing an annular recess 26 in registry with the left end portion of the bearing. The bearing member 20 is located in a housing chamber 28 and is located in registry with an annular recess portion 30 of an axially movable or floating thrust plate 32 intermediate said bearing and the one side face of gear 12. Driving gear 14 is mounted for rotation upon a drive shaft 34 journaled on its right side in a roller bearing 36 and intermediate its ends in a roller bearing 38, said roller bearings being mounted in chambers 40 and 42, respectively, in a manner similar to the mounting of bearings 18 and 20. A fixed thrust plate 44 is mounted intermediate gear 14 and bearing 36 in a manner similar to the mounting of thrust plate 24, said plates 24 and 44 mating in sealing relationship along complementary flat surfaces thereof indicated at numeral 46. An axially movable or floating thrust plate 48 is mounted intermediate gear 14 and bearing 38 in a manner similar to the mounting of movable thrust plate 32, said movable thrust plates abutting in sealing relationship along complementary flat surfaces thereof as indicated at numeral 50. A recess 52 is formed in thrust plate 48 and receives one end portion of bearing 38. The construction of thrust plates 32 and 48 will be described in greater detail hereinafter.

A cover body 54 having an adaptor connecting flange 56 and a mating surface 58 is secured to the pump body 10 by means of a plurality of bolts 59 adapted to be received in threaded openings 60 in pump body 10. Shaft sealing means 62 is located in an enlarged chamber 64 of cover body 54 between a seal retainer member 66, the shaft 34, and a portion of the cover body 54. A snap ring 68 locates seal retainer 66 in chamber 64. A plurality of O-rings are mounted in annular grooves formed in various parts of the pump construction to provide sealing means. The O-ring 70 provides a seal between the retainer member 66 and cover body 54; O-ring 72 provides a seal between the pump body 10 and the cover body 54; O-rings 74 and 76 are located in recesses 78 and 80 of thrust plates 32 and 48, respectively, and provide seals between the thrust plates and bearing members 20 and 42, respectively.

As shown in FIGURE 2, the pump body 10 has an inlet 84 formed in its right side and an outlet 86 formed in its left side. Pressure generated by the gears is communicated from the outlet or discharge side of the pump to rear or motive surfaces 88 and 90 of the thrust plates 32 and 48, respectively, through discharge pressure connected openings 92 and 94 in said thrust plates. The passages 92 and 94 open into discharge trapping recesses 96 and 97 on the discharge side of the pump, said recesses being formed in the forward or sealing side surfaces of the thrust plates 32 and 48. Similar trapping recesses 98 and 99 are formed in the sealing side surfaces of fixed thrust plates 24 and 44. These recesses insure continuous communication of openings 92 and 94 with full discharge pressure. The discharge pressure fluid is directed through passage 92 into a pressure chamber 100 which is formed between surface 58 of cover body 54 and the rear surface 88 of thrust plate 32, and is directed through passage 94 into a chamber 102 which is formed between the cover body and the rear surface 90 of thrust plate 48. A plurality of pressure gradient openings 104 are located in each of thrust plates 32 and 48 in circumferentially spaced relation to each other and to discharge pressure openings 92 and 94. The pressure gradient openings 104 are located radially outwardly of the root diameter of the gear teeth of gears 12 and 14 so that said openings are adapted to communicate continuously with pressure fluid gener-

ated in the gear teeth pockets in the area of each opening 104. A circular groove 106 is formed in the motive surface side of each thrust plate 32 and 48 around each of openings 104 for receiving a metal ring 108 which is adapted to seal the area in each chamber 110 immediately surrounding each opening 104 from the remaining area of the motive surface side of the thrust plate. Each chamber 110 communicates with the adjacent pressure in the gear pocket of gear 12 or 14 through an opening 104. Each groove 106 is connected at the bottom thereof by a small passageway 112 which communicates high pressure fluid from discharge chamber 100 to said groove whereby to maintain each ring 108 in sealing relation to the adjacent wall of cover body 54.

A plurality of circumferentially spaced coil spring members, one of which is shown at numeral 115, may be located in recesses formed in cover body 54 for providing an initial seal between the thrust plates 32 and 48 and the gear side faces. An annular recess 117 is formed inwardly of the root diameter of the sealing surface of each of fixed thrust plate 24 and 44 and movable thrust plates 32 and 48 for the purpose of relieving galling and burning of the metal of the thrust plates and gear side faces in these areas. Pressure fluid which leaks between the gear side faces and the thrust plate sealing surfaces during operation passes along the shafts 16 and 34 through the various bearing members and is collected in chambers 22, 28 and 40 and thence vented back to pump inlet through passageways 130, 132 and 134.

In operation, it will be appreciated that the force which tends to push each thrust plate 32 and 48 away from the gear side faces is equal to the pressure or pressures of fluid between the teeth from thhe inlet around to the outlet times the area of the sealing surface of each thrust plate which is subjected to this pressure or pressures. The area which is subjected to the pressure between the gear teeth is approximately the total annular area from the root of the gear teeth to the outside diameter of each gear. There is a film of oil carried across the side of each tooth which is essentially at the same pressure as the pressure of the fluid between the gear teeth, so that the effective area of the thrust plate on which such pressure acts includes the entire aforementioned annular area between the root diameter and the tips of the teeth. No difficulty in respect of surges of pressure adjacent the gradient openings 104 as the gear teeth are rotated past these openings has been encountered. Under any given pressure gradient condition the pressure in any localized area on the sealing side remains substantially constant as the gear is rotated at a given speed. If the pump speed is increased substantially, the pressure gradient will become apparent in the area on the sealing side of each thrust plate because the fluid under high r.p.m. operation cannot readily cascade back around the pump between the tips of the gear teeth and the bore of the housing to fill the gear teeth pockets with discharge pressure fluid. Under this condition, as well as under other operating conditions which affect said pressure gradient such as cavitation or an excess of air entrained in the fluid, the pressure with which each gradient opening communicates on the sealing side of each thrust plate will tend to be different than the pressure with which other gradient openings communicate. Under such conditions the tendency will be that the pressure gradient will increase from a location of a gradient opening 104 near inlet trapping recesses 98 and 99 progressively around each gear until discharge pressure is generated adjacent trapping recesses 92 and 94. As the pressure in each localized area on the sealing side of each of thrust plates 32 and 48 in the area of each of pressure gradient openings 104 varies, this local pressure variation is communicated through each opening 104 to the respective ones of chambers 110 and results in a corresponding sealing force acting upon the annular area between each sealing ring 108 and each opening 104. The resultant force which acts on the motive surface side of plates 32 and 48 in chambers 100 and 102 is always greater than the pressure force acting in the opposite direction on the sealing side thereof since the motive surface side is subjected to discharge pressure throughout the area surrounding the plurality of sealing rings 108, pressure changes in the gradient on the sealing side being reflected on the motive surface side only in changes in the forces which act upon the aforementioned annular areas inside sealing rings 108.

As shown in FIGURES 2 and 3, the gradient openings are approximately equally spaced circumferentially of each of the thrust plates and the annular areas within sealing rings 108 are substantially equal to each other. This arrangement, of course, is subject to a large number of variations depending upon the particular nature of the problems to be encountered in any particular application of the gear pump. In the modification of the thrust plate construction which is shown in FIGURES 4 and 6, for example, one variation of gradient opening and sealing ring construction is illustrated wherein the distribution and spacing of the circumferentially spaced gradient openings 114 is different than in the previous embodiment. Moreover, no gradient openings are provided in the terminal portion of the thrust plate on the discharge side, and a substantial variation exists between the annular areas inside sealing rings 116 on that side of the thrust plate which is relatively near the inlet side of the pump and sealing rings 118 on that side which is relatively near the discharge side. Sealing rings 116 and 118 are shown of modified form in FIGURES 4 and 6 in that an O-ring 120 is provided in the outer wall of each ring and an annular groove 122 is formed in the inner wall of cover member 54 which is adapted to be aligned with each groove 124 which surrounds each gradient opening 114 so that each of sealing rings 116 is received in grooves 122 and 124 as shown in FIGURE 6. The sealing rings 116 and 118 remain stationary during axial movement of the thrust plate to establish sealing relation with the side faces of the respective gears. Again, discharge pressure opening 92 is provided in thrust plate 32 for communicating chamber 100 with discharge pressure fluid which acts upon the motive surface side of the thrust plate except for those areas sealed by rings 116 and 118 which are vented by way of openings 114 to local pressure in the adjacent area on the sealing side of the plate. This embodiment of the invention would be particularly useful, for example, in any application of the pump wherein the pressure on the sealing side remains at a relatively low pressure throughout the first portion of pump rotation, which tends to be compensated by the areas within the relatively large sealing rings 116 whereby the area on the motive surface side adjacent the pump inlet upon which discharge pressure acts is minimized. In such an application of the gear pump it may be that discharge pressure will be present continuously during operation throughout the terminal portion of rotation of the gears on the discharge side of the pump, and gradient control is therefore not required as indicated by the absence of gradient control areas circumferentially adjacent opening 92. A relatively small amount of gradient control may be required in the central portion of the thrust plate, and relatively small pressure gradient responsive areas as defined within sealing rings 118 are provided. It is intended, of course, that in this modification the design of thrust plate 48 be the same as that of thrust plate 32, which is the only one illustrated.

In FIGURE 7 another modification is illustrated wherein the sealing means provided between that portion of the motive surface of the thrust plate swhich is subjected to discharge pressure and the plurality of annular areas thereof which communicate with the gear pockets through the gradient openings is provided by resilient O-rings 130 mounted in a groove 132 surrounding each gradient opening 104. If desired, and for maximum flexibility in the use of any given thrust plate design, a threaded end 134 may be provided in each gradient opening 104 which is adapted to receive flush with the motive surface of the

thrust plate a plug, not shown, for interrupting communication between opposite sides of the thrust plate through the pressure gradient openings. This arrangement may, of course, be provided in any of the embodiments of this invention. Any of sealing rings **108**, **116**, **118** or **130** may be removed following plugging of the corresponding gradient opening as aforementioned, whereupon the addiitonal non-sealed area thus provided is subjected to discharge pressure in chamber **100** or **102**.

It will be appreciated by persons skilled in the art that different applications of a given pump design may require a different manner of compensation for the different pressure gradient which may result. My present invention provides a very flexible arrangement both in the original design of the thrust plate and in the provision for variation in the location and number of sealed areas in the thrust plate which are subjected to local pressure on the gear side of the plate.

Although only a few embodiments of my invention have been illustrated and described, it will be apparent to those skilled in the art that various changes in the structure and relative arrangement of parts may be made to suit individual requirements without departing from the scope of the invention. For example, although the foregoing description has been primarily directed to gear pumps of the intermeshing type, it will be recognized by persons skilled in the art that the present invention may be equally applicable to gear type fluid motors and to vane type fluid pumps and motors.

I claim:

1. In a pressure generating pump of the type including a housing containing intermeshing gears and having an inlet leading to and an outlet leading from said housing, an axially movable floating rigid thrust plate having a sealing surface in sealing relationship with the side face of one of said gears, a portion of the side of said thrust plate opposite from said sealing surface comprising a primary motive surface, a pump housing member forming with said motive surface a motive pressure chamber, a passageway communicating pump generated pressure to said pressure chamber, a pressure gradient opening located radially outwardly of the root diameter of the gear teeth and extending through said thrust plate from said motive surface side to said sealing surface side, a continuous circular groove in the motive surface side of said thrust plate surrounding said gradient opening and defining with said opening a secondary annular motive surface on said motive surface side, a circular sealing member located in said groove and cooperating with said pump housing member and said thrust plate for sealing said secondary motive surface from the primary motive surface which surrounds the secondary motive surface, said gradient opening being adapted to continuously communicate pressure fluid to said secondary motive surface from a localized pressure area adjacent said gradient opening on the sealing side of the thrust plate, whereby said primary and secondary motive surfaces are subjectable to different pump generated pressures during operation for balancing the thrust plate sealing force on the side face of the gear under varying pressure gradient conditions.

2. A pump as claimed in claim 1 wherein a plurality of said pressure gradient openings are provided in said thrust plate in circumferentially spaced relation, each having a groove and sealing ring defining therewith and with the pump housing an annular secondary motive surface which is subject during operation to the pressure condition existent on the sealing side of the thrust plate, said gradient openings being located radially outwardly of the root diameter of the gear teeth.

3. A pump as claimed in claim 2 wherein the area of said secondary motive surfaces decreases in the direction of rotation of the gear.

4. A gear pump as claimed in claim 1 wherein means is provided for closing said gradient opening to prohibit communication between the secondary motive chamber and the gear side of the thrust plate.

5. In a fluid pump or motor of the type including a housing contining a chamber and an inlet and an outlet to said chamber, a rotary element in said chamber for moving pressure fluid from the inlet to the outlet including circumferentially spaced projections forming fluid containing pockets therebetween, a floating rigid thrust member having a sealing surface for abutting one side of said rotary element and forming with an adjacent portion of said housing a motive pressure chamber on the side opposite said sealing surface, passage means communicating pressure fluid generated by said rotary element to said pressure chamber for activating said thrust member into sealing relationship with said one side of said rotary element, a plurality of circumferentially spaced openings extending through said thrust plate communicating with different ones of said fluid containing pockets, a circular sealing ring in said motive pressure chamber surrounding each of said openings and forming therewith and with said thrust member and adjacent portion of said housing a secondary pressure chamber which communicates with the respective opening, a circular recess in the thrust member surrounding each of said openings and receiving corresponding ones of said sealing rings, and an annular area in said thrust member formed between each sealing ring and opening subject to pressure in the respective ones of said secondary chambers for activating the thrust member toward sealing relationship with said rotary element with a force derived from the pressure communicated to each said secondary chamber by each said opening.

6. A fluid pump or motor as claimed in claim 5 wherein each of said sealing rings comprises a substantially nondeformable member responsive to a pressure fluid generated by said rotary element for causing pressure contact between each sealing ring and the adjacent portion of said housing.

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