

March 15, 1966

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3,240,158

HYDRAULIC PUMP OR MOTOR

Filed May 8, 1962

2 Sheets-Sheet 1

FIG. 1

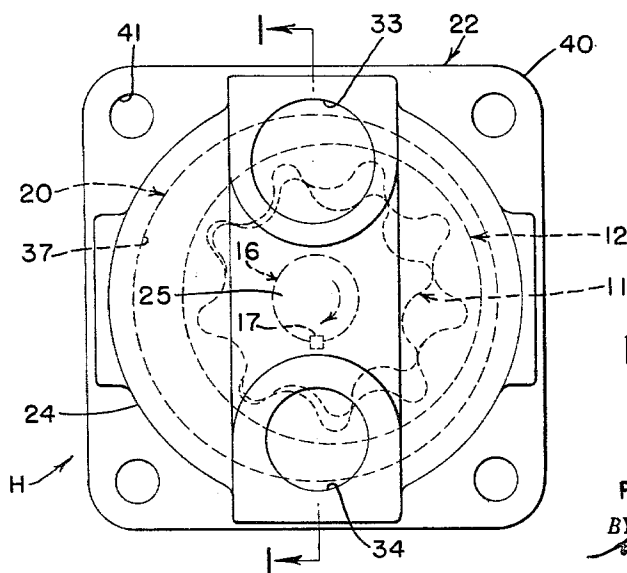
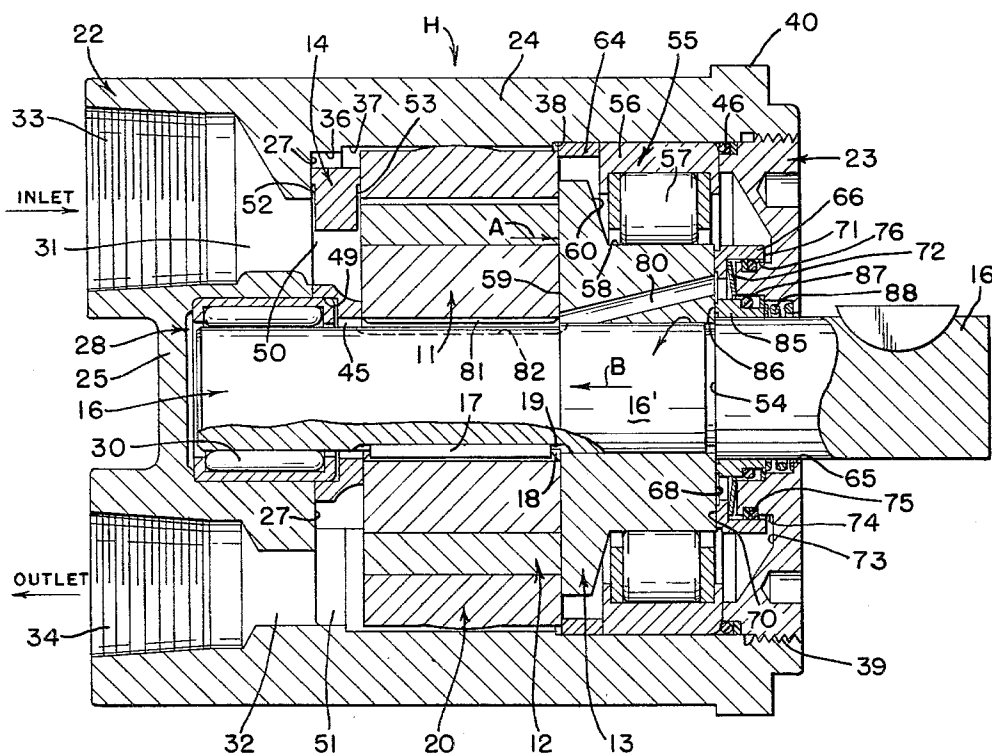


FIG. 2

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2 Sheets-Sheet 2

FIG. 3

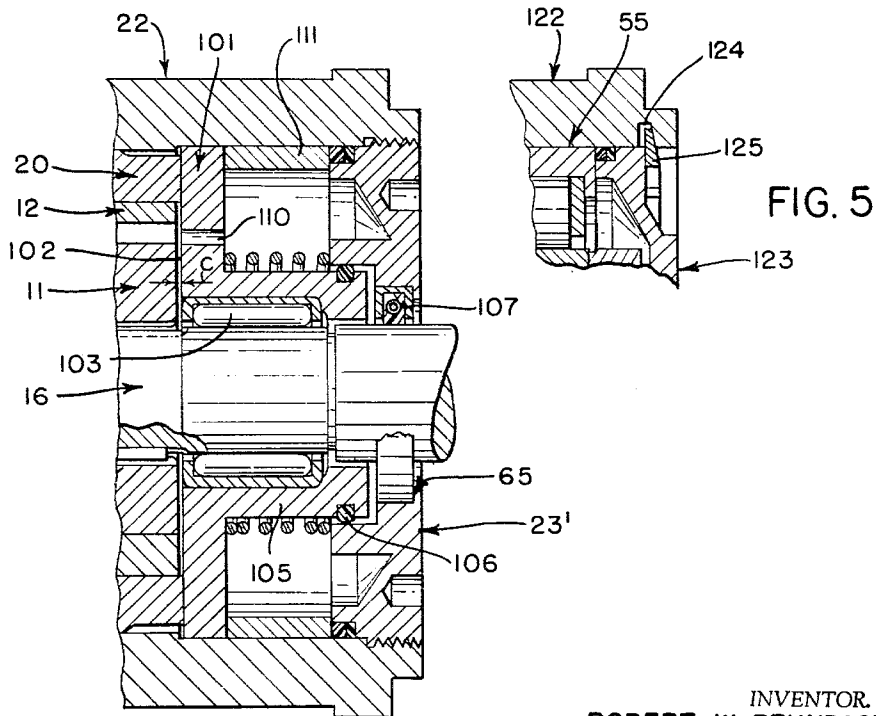
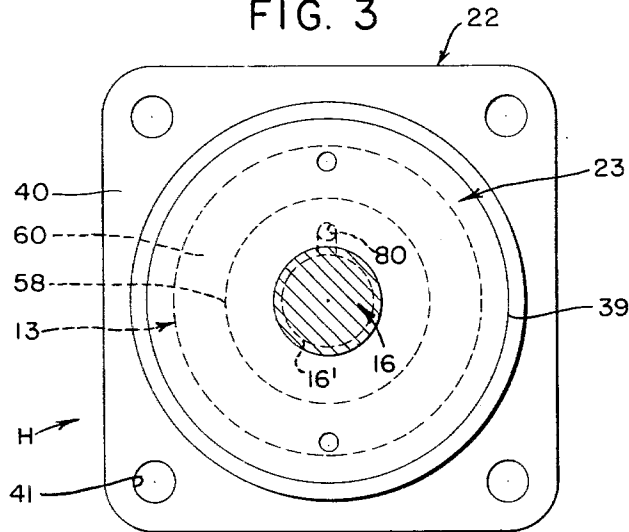


FIG. 4

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3,240,158

HYDRAULIC PUMP OR MOTOR

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17 Claims. (Cl. 103—126)

This application is a continuation-in-part of my co-pending applications Serial No. 682,501, filed September 6, 1957, now Patent No. 3,034,446, issued May 15, 1962; Serial No. 814,319, filed May 19, 1959, now Patent No. 3,034,447, issued May 15, 1962, and Serial No. 814,320, filed May 19, 1959, now Patent No. 3,034,448, issued May 15, 1962, which latter application is a continuation-in-part of application Serial No. 613,235, filed October 1, 1956, now Patent No. 3,011,447 issued December 5, 1961.

This invention pertains to the art of hydraulic devices and more particularly to a hydraulic pump or motor.

The present invention is particularly applicable to a hydraulic pump of the internal gear type and will be described with particular reference thereto although it will be appreciated that the invention, in many instances, is equally applicable to other types of hydraulic pumps and/or hydraulic motors, e.g., of the conventional gear type, rotating vane type, or rotating-cylinder-axially-reciprocable piston type.

The invention is also particularly applicable to hydraulic devices operable at what may be termed very high hydraulic pressures; that is to say, above 1,000 pounds per square inch and oftentimes approaching or exceeding 4,000 pounds per square inch. At such pressures, constructions and expedients usable at the lower pressures are often unsatisfactory and inapplicable to the problems where the higher pressure encountered.

For the purpose of simplicity, the invention will be described only in relation to a pump and reference will be made to inlet and outlet ports, inlet and outlet manifolds and increasing and decreasing volume chambers, all of which will be at low and high pressures respectively. The description may be applied to a hydraulic motor by reversing the relationship of the high and low pressures.

In the art of internal gear type hydraulic pumps, it has been conventional in the past to make the housing in two pieces, namely, of a main housing member generally in the shape of a cup and a cover member extending across and abutting against the end of the cup.

The cover member was held in place by high tensile strength bolts extending either through a flange on the outer periphery of the main member or, and more usually, through openings drilled longitudinally through the walls of the main member. Also, in some instances and particularly in high pressure high precision pumps, it was customary after final assembly to drill and dowel the cover member in position on the main member. This held the cover member accurately in position and enabled it to be removed and replaced with the original accuracy.

These drilling and dowing operations, and the price of the dowels and high tensile bolts considerably added to the cost of manufacture of the housing. Beyond this however, the drilled openings in the wall of the main housing member reduced the effective thickness of the wall such that for the high pressure pumps where the interior housing cavity is at a high pressure, the wall thickness had to be increased in an amount to compensate for the absence of metal caused by the bolt holes. Thus the housing was much heavier and bulkier than necessary if the holes were not present.

In my co-pending application Serial No. 682,501, it was proposed to have a threaded fastening engagement between the two members such that there would be no need

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for bolt holes, bolts, flanges or drilling and dowing. Such arrangement was satisfactory for low pump pressures, but where the pressures were higher, it was found impossible to maintain the close clearances between the pumping members and internal leakages and low volumetric efficiencies developed. Analysis of this showed that even the most accurate threads had a slight clearance which permitted a slight shifting or cocking of the cover member relative to the housing member as the pressures on the inside of the housing increased. Then any of the pumping members which depended on the cover member for physical support also shifted or cocked relative to the other members of the pump, resulting in misalignment of the parts, changes in clearances between the sealing surfaces, and an undue strain on the supporting bearing.

Another problem with hydraulic devices of the type to which this invention pertains has been that of obtaining a high degree of accuracy of alignment of the inner housing surfaces which support the rotating members with the outer housing surfaces which are used to mount the device on a suitable base and hold it in alignment with either its driving motor or the device which it itself is driving. Thus in previous designs, the housing had to be mounted in several types of machine tools for the purpose of finish machining all the supporting surfaces. Extremely accurate remounting or rechucking of a part to be machined has always been extremely difficult and only at great cost because of the time required for the alignment operation.

Still another problem with hydraulic devices of the type to which this invention pertains has been in sealing the opening through the housing through which the rotating shaft passes against the leakage of the high pressure fluids on the inside of the housing. Various means have been proposed in the past for this purpose, but all have had relatively high friction and have been expensive to manufacture.

The present invention contemplates a new and improved hydraulic device which overcomes all of the above referred-to-problems and provides a housing arrangement in combination with the arrangement of the rotating parts on the inside thereof, which eliminates the need for bolts and dowels to hold the main housing and cover members in assembled relationship, which provides a housing arrangement wherein all of the machined surfaces on the inside and the outside of the housing may be machined with a single chucking operation in a single machine tool and which has a simple, inexpensive substantially friction-free shaft seal where the shaft passes through an opening in the housing.

In accordance with one aspect of the present invention, the cover member fits into the open end of the main cup shaped housing member and they are then held in final assembled relationship by circumferentially extending axially abutting surfaces, e.g., a screw threaded engagement, snap rings or the like. By screw threaded is meant where the parts must be relatively rotated when assembled.

Further in accordance with the present invention, all the rotating parts are mounted in and supported solely by the main cup shaped housing member, the parts are held in axial sealing engagement by a hydraulically created force and all members of the device depending on the cover member for physical support are so arranged that shifting or cocking of the cover member relative to the housing member does not affect the alignment of that depending member with the rotating parts.

In another aspect of the invention, the shaft passes through an opening in the cover member and the cover member is free to move relative to the seal for such opening around the shaft.

Further in accordance with the invention, a seal for

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a rotating shaft extending through an opening into a housing having high pressures on the inside thereof is provided comprising in combination: an axially facing sealing surface on the shaft inside the housing; a radially outwardly facing surface on the inside of the housing surrounding the opening; a sealing ring loosely fitted over such cylindrical surface and axially movable relative thereto; and, a flexible packing means between the ring and cylindrical surface. The sealing ring has an axially facing sealing surface in engagement with the shaft sealing surface and an opposite axially facing surface exposed to the high pressures to be sealed, the areas of the two surfaces being so proportioned such that the sleeve surface is urged against the shaft surface with a pressure at least equal to or greater than one half the difference between the hydraulic pressures on the inside of the housing and the hydraulic pressures on the outside of the housing. With this arrangement the force urging the surfaces together is at least equal to or in excess of the force created by the pressures being sealed to prevent the pressures forcing the surfaces apart and leaking therepast. Furthermore, as the pressures increase, the sealing means is axially compressed to help urge the sealing surfaces into pressure engagement.

The principal object of the invention is the provision of a new and improved hydraulic device of the type described which is cheaper to manufacture and for a given maximum pressure of operation is lighter in weight and smaller in external dimensions.

Another object of the invention is the provision of a new and improved hydraulic device for the type described wherein all of the surfaces on the inside of the housing for supporting the rotating parts and the surfaces on the outside of the housing for mounting the device can be finished machined in a single chucking operation on a single machine tool.

Another object of the invention is the provision of a new and improved hydraulic device for the type described having improved accuracy on the inner and outer surfaces.

Still another object of the invention is the provision of a new and improved hydraulic device which does not require the use of bolts or dowels for holding the cover in position.

Still another object of the invention is the provision of a new and improved hydraulic device wherein the cover for the housing may be held in place by simple economically manufactured fastening means.

Another object of the invention is the provision of a new and improved seal for rotating shafts extending into high pressure housings which is simple in construction, economical to manufacture, and which gives an improved sealing action.

Another object is the provision of a seal for a shaft opening in a housing having high pressures on the inside wherein the housing may shift or cock relative to the shaft without interfering with the sealing action.

Another object of the invention is the provision of a high pressure seal for rotating shafts wherein the force urging the seal against the shaft is always just equal to the force urging the sealing surfaces apart.

Another object of the invention is the provision of a pressure seal for a rotating shaft wherein the sealing member is slidably mounted on the housing and urged by the pressure to be sealed into sealing engagement with the shaft and a nonmetallic seal between the sealing member and housing is so arranged that increases in pressure compress the nonmetallic seal in a direction to aid the pressure seal.

The invention may take physical form in certain parts and arrangements of parts, the preferred embodiments of which will be described in detail in this specification and illustrated in the accompanying drawings which are a part hereof and wherein:

FIG. 1 is a side cross sectional view of a hydraulic

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pump illustrating a preferred embodiment of the invention, the section being taken approximately in the line 1—1 of FIG. 2;

FIG. 2 is a left hand end view of FIG. 1;

FIG. 3 is a right hand end view of FIG. 1;

FIG. 4 is a fragmentary cross sectional view corresponding to the right hand end of FIG. 1 but showing an alternative embodiment of the invention; and,

FIG. 5 is a fragmentary cross sectional view of the housing showing an alternative embodiment for retaining the cover member in place.

Referring now to the drawings wherein the showings are for the purpose of illustrating preferred embodiments of the invention only, and not for the purposes of limiting same, FIGS. 1 and 2 show a hydraulic pump comprised of a two-piece housing H defining an internal pumping cavity in which are mounted a plurality of pumping members defining a plurality of closed chambers which progressively increase and decrease in volume as the members move relative to each other. While such members may take a number of conventional forms, such as a rotating cylinder with axially reciprocating pistons, rotating and radially reciprocating vanes or the like, in the embodiment of the invention shown, they comprise generally an externally toothed gear member 11, an internally toothed gear member 12, sealing and manifold members 13, 14, one engaging the right and the other the left hand axial faces of the gears 11, 12 respectively.

The gear member 11 is supported for rotation on and keyed to a shaft 16 by a key 17 fitting into keyways 18, 19 on the gear 11 and shaft 16 respectively. The internally toothed gear member 12 is supported for rotation on an axis spaced from the shaft axis in an eccentric bearing member 20 in turn supported in the housing H. The gear member 12 has one (or a plurality) tooth more than that of the gear member 11 and these teeth are in sliding sealing engagement such that as the gear members 11, 12 rotate, they along with the sealing and manifold members 13, 14, define a plurality of closed pumping chambers which revolve on a closed path of movement and progressively increase in volume from a point of minimum volume corresponding to the closed mesh point of the gears to a point of maximum volume corresponding to the open mesh point of the gears and then decrease to the point of minimum volume.

Housing

The construction and arrangement of the housing H forms an important part of the present invention and in the embodiment shown, is formed in two parts, namely, a main housing member 22 generally in the shape of a cup and a closure or cover member 23 extending across and sealing the open end of the cup.

The main housing member 22 generally includes a cylindrical side wall 24 and an end or base wall 25 and may be formed of any desired material, such as aluminum, steel or the like, by any desired manufacturing process, although it will be noted that with the design of the housing shown, it is possible to manufacture the housing by what is known as impact extrusion processes. Taking into consideration the strength of the materials used, the side walls 24 and base 25 must have a thickness sufficient to withstand the radial forces developed by the very high hydraulic pressures which, as will appear, exist directly in the cavity defined by the housing H. It will be obvious, however, that the total wall thickness may be a minimum because there are no bolt holes extending longitudinally through the walls which would otherwise weaken the wall and which would thus require an increase in the total wall thickness beyond that required when no bolt holes are present.

The base wall 25 has an inwardly axially facing surface 27 perpendicular to the axis of the shaft 16 and a counterbore 28 opening through this surface into which the left hand end of the shaft 16 extends and is rotatably

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supported in a suitable bearing member 30 which, in the embodiment shown, consists of a plurality of needle bearings engaging the outer surface of the shaft 16 and an outer sleeve fitting partway into the counterbore 28 and extending slightly beyond the surface 27 for purposes which will appear hereinafter.

The base wall 25 has a port 31 formed in the surface 27 communicating with an opening 33 suitably threaded to receive a hydraulic fitting (not shown) which forms the inlet port for the pump. In a like manner, the base wall 25 has an opening 32 through the surface 27 which communicates with an opening 34 also suitably threaded to receive a hydraulic fitting (not shown) which forms the outlet port for the pump. It is to be noted that the openings 31 and 32 are diametrically opposite one from the other and are generally arranged so as to be approximately 90° displaced from the open and closed mesh points of the gears 11, 12.

The inner surface of the side wall 24 is so formed as to be exactly coaxial with the axis of the shaft 16 and to locate the various parts of the pump relative to this axis. While this inner surface could be a single continuous cylindrical surface, in the embodiment of the invention shown, the side wall 24 has a plurality of radially inwardly facing generally cylindrical surfaces 36, 37 and 38, each of which is progressively larger in diameter than the surface immediately to its left and they are all coaxial with the counterbore 28. The reason for the stepped diameter is for ease of manufacture, it being noted that the diameter of the surface 36 is not critical while the diameter of the surface 37 is critical in relation to the outer diameter of the eccentric bearing ring 20 and the diameter of the surface 38 is also critical in that it must receive and accurately locate a bearing for rotatably supporting the shaft 16. The inside of the housing as will appear, is at the high pressure.

The cover member 23 in accordance with the invention is held in assembled relationship with the main housing member 22 by abutting circumferentially-extending axially-facing surfaces. Such surfaces may take a number of different forms, e.g., a snap ring fitting into a groove in the cup member, a threaded ring, a so-called bayonet type fitting or threads of any desired cross sectional shape and these surfaces may be either on the inner surface or outer surface of the side wall 24, but in the embodiment of the invention shown, the right hand end of the cylindrical surface 38 is threaded with conventional V threads to receive and coast with conventional V threads on the outer periphery of the cover member 23 all as is generally shown at 39. The threads shown have a maximum strength, are economically machined, and support the cover member uniformly around its entire periphery against the very high axial forces of the hydraulic pressures on the inside of the housing. Such threads do not give the accurate positioning of the cover member that the conventional ground surfaces held together by bolts do, but as will appear by virtue of the construction employed, such accuracy is unnecessary.

An O-ring 46 positioned in a rabbet formed on the inner end of the cover member 23 and engaging the surface 38 provides a seal to prevent leakage through the threads.

FIG. 5 shows an alternative fastening arrangement. Here the housing member 122 has a groove 124 on its inner surface adjacent the open end and the cover member 123 is slidably inserted into this open end past the groove. A snap ring 125 is positioned in the groove 124 and provides the axially facing surface against which the cover member abuts to prevent same from being forced out of the housing member 122. This ring 125 and the groove have a complementary wedge shape as shown. A threaded ring could also be employed.

Returning now to the preferred embodiment FIG. 1, the main housing member 22 also is provided with means

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for mounting the pump to a supporting base. Such means may take a number of different forms, but in the embodiment of the invention shown, comprises a mounting flange 40 which in end view is generally square such that the corners of this flange may be provided with bolt holes 41 for receiving bolts fastening the housing to a supporting base (not shown).

In the embodiment of the invention shown, the axially facing surfaces of the flange 40 and the surface 27 must be exactly perpendicular to the axis of the shaft 16 while the surfaces 37 and 38 must be exactly coaxial with the shaft 16. With the construction shown, it is possible to machine all of these surfaces with a single chucking operation in a single machine tool. This may be distinguished from manufacturing methods for pump housings heretofore where it was necessary to mount the housing in one machine tool, machine one set of surfaces, then remove the housing from that machine tool, mount it in another machine tool, and machine another set of surfaces. It is well recognized that the process of remounting the housing in the second machine tool in a manner so as to be sure that the already machined surfaces are accurately aligned with the second machine tool is an expensive and time consuming operation.

Manifold member

The manifold member 14 is fixedly mounted between the gear members 11, 12, the eccentric bearing member 20 and the surface 27 of the housing. It may be located in the housing in any suitable manner, but in the embodiment of the invention shown, has a cylindrical surface 49 fitting over the outer surface of the bearing 30 which as heretofore been pointed out, projects slightly beyond the surface 27. The manifold member 14 is generally in the shape of a disk having an inlet port 50 communicating the increasing volume chambers of the gears with the inlet port 31 and a diametrically opposite outlet port 51 communicating the decreasing volume chambers of the gears with the outlet port 32. The portions of the manifold member 14 between the ends of the ports 50, 51 form the lands for the pump. These lands are located, as is conventional, adjacent the open and closed mesh points of the gears and a pin (not shown) extends through the manifold member 14 into the base 25 of the housing to locate these lands relative to the open and closed mesh points of the gear. It is to be noted that the outlet port 51 opens through the outer periphery of the manifold member 14 so as to communicate the discharge pressures of the pump to the interior of the housing.

It is to be noted that the left hand surface of the manifold member 14 is in pressure sealing engagement with the surface 27 and the right hand surface is in pressure sealing engagement with the left hand face of the eccentric bearing member 20. Portions of the surfaces of the manifold member 14 around the inlet port 50 are slightly relieved as at 52, 53 so that the unit pressure between these manifold member surfaces is higher than the hydraulic pressures on the inside of the cavity so that a sealing action between these surfaces will take place at all times.

Eccentric bearing member

The eccentric bearing member 20, its mode of operation and its geometry are fully described and claimed in my copending application Serial No. 814,320, filed May 19, 1959, and will not be further described herein other than to state that the outer diameter of the member 20 is slightly less by a predetermined amount than the diameter of the surface 37 so that the member 20 is free to move a limited amount radially within the housing for purposes as described in said copending application. As heretofore stated, this clearance communicates the pressure in the outlet port 51 to the right hand side of the gears.

Sealing member

The sealing member 13 is mounted on the shaft 16 for rotation therewith and as is described in my copending application Serial No. 16,765, now Patent No. 3,127,843, is in effect an integral part of the shaft 16 for reasons as pointed out in said copending application. Thus the sealing member 13 can be made integral with the shaft 16, but as is shown in the drawings, has an interference fit with a portion 16' of the shaft 16 which has a diameter slightly larger than portions of the shaft immediately to the left thereof and a diameter slightly less than portions of the shaft immediately to the right thereof, the difference in the diameters in the two last mentioned portions forming a left hand facing shoulder 54 against which the right hand end of the sealing member 13 bears, such shoulder serving the purpose of accurately locating the member 13 on the shaft 16 and preventing it from working along the shaft 16 in an axial direction while the pump is operating.

The sealing member 13 and shaft 16 which as indicated are in effect, integral, are mounted for limited axial movement within the housing and relative to the gears, 11, 12 by a bearing 55 which may take any suitable form, but in the embodiment shown is comprised of a roller bearing consisting of an outer ring 56 having interference fit with the surface 38 and a plurality of circumferentially spaced cylindrical rollers 57 engaging an outer cylindrical surface 58 on the sealing member 13. Obviously other types of bearings may be employed so long as they have the requisite radial load carrying ability and so long as the shaft 16 in the sealing member 13 has a limited axial movement relative to the gears 11, 12.

The sealing member 13 has a left hand facing axial surface 59 in sealing engagement with the right hand axial faces of the gears 11, 12 and the eccentric bearing member 20. This sealing member 13 closes the right hand axial ends of the pumping chambers. As is known, when the pump is operating, the high pressure fluids in the high pressure chambers exert a radially offset force A to the right on the sealing member 13.

The sealing member 13 also has a right hand axially facing pressure surface 60 radially outwardly of the surface 58 which is exposed to this same high pressure. This surface 60 is symmetrical relative to the axis of the shaft 16 and this pressure therefore exerts a resultant coaxial force B to the left of the sealing member 13 which force biases the shaft 16 with sealing member 13 to the left in opposition to the force A to hold the sealing member 13 in sealing engagement with the right hand surfaces of the gears 11, 12 and also the left hand surfaces of the gears 11, 12 in sealing engagement with the manifold member 14. This pump may thus be described as a zero clearance pump wherein the members are all in pressure balanced relationship.

A spacer ring or washer 64 is positioned between the left hand end of the bearing ring 55 and the right hand end of the eccentric bearing member 20 such that when the cover member 23 is threaded into the housing, it forces the roller bearing 55, the eccentric bearing member 20, and the manifold member 14 to the left to thus hold these members in firm side-by-side pressure engagement. It is to be noted that when the pump is operating at high hydraulic pressures, the housing has sufficient axial elongation that the bearing member 20 will be free to move radially within the housing to adjust itself to its desired radial position as is described in my copending application Serial No. 814,320.

It is to be noted that if the high hydraulic pressures on the inside of the cavity exerted a force to the left over the entire axial cross sectional area of the sealing member 13, the force B created would be greatly in excess of the force A and thus provides means for limiting the axially facing cross sectional area of the sealing member 13

exposed to this high hydraulic pressure. Such means, in the embodiment of the invention shown, is in the form of a metal or rigid sealing ring 66.

Sealing ring

The sealing ring 66 forms an important part of the present invention in that it limits the area of the sealing member 13 exposed to the hydraulic pressures, seals such fluid against leakage and at the same time, is the only part of the pump dependent upon the cover member 23 for any kind of physical support, but is so mounted on the cover member 23 that any turning or cocking of the cover member 23 does not adversely affect the sealing action of the ring 66 on the sealing member 13.

Thus in the embodiment of the invention shown, the sealing member 13 has a right hand facing surface 68 which because the sealing member 13 is in effect an integral part of the shaft 16, may thus be considered an axially facing surface on the shaft 16. The sealing ring 75 has both a left hand axially facing surface 70 abutting against this surface 68 and a right hand axially facing surface 71 exposed to the high pressures on the inside of the housing H. The area of the surface 71 is proportioned so as to be at least one half or slightly more than one half of the area of the surface 70 such that the hydraulic pressure on the surface 71 will urge the sealing ring 66 to the left with a force just equal to or slightly in excess of the force to the right created by the pressure differential across the inner and outer peripheries of the surface 70. The pressure at the inner periphery is usually inlet pressure so that this pressure differential is the fuel pump discharge pressure. Spring means 72, which in the embodiment shown, is in the shape of a dished resilient washer, biases the sealing ring 66 against the surface 68 when the pump is operating at zero discharge pressure.

It is also to be noted that the outer diameter of the surface 70 is so proportioned to the total diameter of the sealing member 13 that the area of the sealing member 13 radially beyond the surface 70 and thus exposed to the high pressures results in a force B to the left being just equal to or slightly in excess of the force A. The sealing member 13 and shaft 16 are thus hydraulically force balanced in an axial direction.

The sealing ring 66 has a sealing engagement with the cover member 23 such as to prevent the leakage of the high pressure fluid therepast and through the opening 65. This sealing engagement in accordance with the invention is also such that the sealing ring 66 may move axially relative to the cover member 23 and also so that the cover member 23 may turn angularly relative to the sealing ring 66 without having such angular movement transmitted to the sealing ring 66.

Such an arrangement may take a number of different forms, for example, a flexible bellows type seal between the sealing ring 66 and cover member 23, but in the embodiment of the invention shown, the cover member 23 has a counterbore 73 on its inner surface forming a radially outwardly facing cylindrical surface 74 over which the inner surface 76 of the sealing ring 66 is axially movable, it being noted that the diameter of the surface 76 is slightly greater than the outer diameter of the surface 74 so that the sealing ring 66 can twist relative to the cover member 23. An O-ring 75 is positioned in a groove in the cylindrical surface 74 and engages the inner surface 76.

It is to be noted that in the embodiment of the invention shown, the O-ring 75 is positioned so as to engage the inner surface of the sealing ring 66. This may be distinguished from the construction shown in my copending application Serial No. 814,320 and others wherein the O-ring engages the outer surface of the sealing ring.

Thus if the O-ring engages the outer surface of the sealing ring, as the hydraulic pressures increase, this O-ring is axially compressed and as it is axially compressed,

it tends to draw the sealing ring 66 away from the axially facing surface on the sealing member thus permitting leakage. In order to prevent the sealing ring from being drawn away from the sealing member, the biasing spring must be relatively heavy. If the pump operates at zero pressure, the pressure between the sealing surfaces created by this spring is sufficiently great to cause damage to the sealing surfaces. On the other hand, using the present embodiment of the invention, as the pressures increase and the sealing ring 75 is axially compressed, it tends to urge the sealing ring toward the sealing member 13 and thus assists in creating the sealing pressure between the two surfaces. The biasing spring 72 can thus be substantially smaller and at zero pressure, no damage results.

Another desirable result of placing the O-ring so as to engage the inner surface of the sealing surface 66 is that when the hydraulic pressures are reduced, the O-ring expands and tends to draw the sealing ring to the right away from the sealing member 13 with the result that in some instances a small slug of oil can pass between the surfaces to thus flush out the pump and the space radially inwardly of the surface 70. Such oil is drained by a passage 80 extending generally axially through the sealing member 13 to a groove 81 formed on the inner surface of the gear 11 and a groove 82 on the outer surface of the shaft 16 which communicates with the bearing 30. This hydraulic oil thus tends to lubricate the bearing 30.

Sealing means are provided for the opening 65 radially inwardly of the right hand opening of the passage 80, which sealing means may take a number of different forms, but in the invention shown, is comprised of a rigid or metallic ring 85 loosely mounted in a counterbore of the opening 65 and having a surface 86 in pressure sealing engagement with the surface 60 and of the sealing member 13.

An O-ring 87 is positioned in the rabbet in the outer surface of the sealing ring 85 and engages the inwardly facing surface of the counterbore generally as is shown. A spring 88 biases the sealing ring 85 into engagement with the sealing member 13.

In operation, the shaft drives the gears 11, 12 for rotation on spaced axes, the spacing of the axes being determined by the eccentricity of the eccentric bearing ring 20. The chambers formed by the gears 11, 12 increase in volume when in communication with the inlet manifold 50 to draw fluid thereinto. The chambers at the maximum volume point of the chambers pass a land and then come into communication with the discharge manifold 51. The chambers then commence to decrease in volume to discharge fluid outwardly at high pressure through the outlet 34. This high pressure is communicated to the interior of the housing cavity. This hydraulic fluid at high pressure lubricates the bearing space between the outer surface of the gear 11 and the inner surface of the eccentric bearing member 20. Because the sealing member 13 extends radially outwardly beyond the outer surface of the gear 12 and is in sealing engagement with the end of the eccentric bearing member 20, this lubricated area between the gear 11 and member 20 may be considered as closed at one axial end.

The fluid at high pressure passes axially around the outside of the eccentric bearing member 20 to the inside of the housing to the right of the gears 11, 12 and lubricates the bearing 55. This high pressure also exerts a force to the left on the bearing member 13 in an amount proportional to the pressure to hold the sealing member 13 against the right hand surface of the gears 11, 12 and the gears 11, 12 against the right hand surface of the manifold member 14. This high pressure also urges the sealing ring 66 against the axially facing surface 68 on the sealing member 13. The force urging these members against each other is just in excess of the forces tending to separate them and a perfect or near perfect sealing

action results. The pressure as it increases, tends to compress the O-ring 75 which also assists in urging the sealing ring 66 against the sealing member 13. However, as the pressure decreases, the O-ring 75 tends to expand drawing the sealing ring 66 away from the sealing member 13 to thus allow a small amount of the high pressure oil to pass the surface 70 and thence the discharge to the passages 80, 81, 82 to the bearing 30. This fluid may then discharge to the inlet manifold in a normal way.

The pump just described is, as previously indicated, what may be termed a pressure-sealed, zero clearance pump. The invention is also equally applicable to what may be termed a fixed clearance pump, and a preferred embodiment of such a fixed clearance pump is shown in FIG. 4. In this embodiment, like parts will be designated by like numerals and similar parts by like numerals with a prime mark added. Thus, in this embodiment of the invention, the cover 23' is held in position on the main housing member 22 in the same manner as the preferred embodiment. The shaft 16 extends into the housing through an opening 65 in the cover member 23' and rotatably supports gear 11 thereupon. Gear 12 is rotatably supported in eccentric bearing member 20.

A sealing member 101 has an outer diameter to snugly fit in the housing and has a left hand facing surface 102 engaging the right hand end of the eccentric bearing member 20 which has an axial length just slightly greater than the axial length of the gears 11, 12 to space the surface 102 therefrom by a small clearance *c*, e.g., 0.002 inch (shown greatly exaggerated in the drawing). A needle bearing 103 supports the shaft 16 for rotation in this sealing member 101. The sealing member 101 has a cylindrical flange 105 which extends into a counterbore of the shaft opening 65. An O-ring 106, which is mounted in a groove on the flange 105, engages the walls of the opening and slidably seals the two members. A conventional shaft seal 107 is also provided for any slight leakage past the ring 106. It is to be noted that the outer diameter of the flange 105 is slightly less than the diameter of the counterbore of the opening in which it is slidably mounted so that the cover member 23' may twist angularly relative to the sealing member 101 without transferring such angular movement to the member 101 and destroying its sealing action with the gears 11, 12. The ring 106 must be flexible. The sealing member 101 has an opening 110 extending axially therethrough and so located as to communicate the high pressure chambers with the housing cavity immediately to its right. This high pressure exerts a force to the left on the member 101 and holds it in firm engagement with the right end of the eccentric bearing member 20. Thus the sealing member does not rely on the cover member 23' for its sealing force. A ring 111 may sometimes be used to hold the sealing member 101 in its normal position. However, in some instances it may be dispensed with. It is to be noted that in operation the housing elongates axially sufficiently as to relieve any force of the cover member 23' on the ring 111.

It is to be noted that in both embodiments of the invention, all of the rotating and sealing parts are physically supported by the main housing member 22 and any parts of the pump in any way associated with the cover member 23 are so arranged as to be loosely associated therewith such that the cover member 23 can turn or twist relative to the main housing member 22 without transferring such twist to the sealing rings and adversely affecting the sealing action between the various parts of the pump. In fact the cover member 23 or 23' simply serves as a plug for the open end of the main housing member to seal in the high pressures. All the axial sealing forces for the moving pumping members are created hydraulically. In the first embodiment zero clearances are provided and the axial forces are controlled to just counterbalance the separating or leakage forces or pressures by controlling areas. In the second embodiment, the axial forces are

greater but the clearances are finite and physically maintained.

The arrangement shown permits the manufacture of a very high pressure, precision type, hydraulic pump at a very substantial savings in cost and with improved operating characteristics, particularly with reference to internal leakage and internal friction, both of which decrease the overall efficiency of any hydraulic pump.

The invention has been described with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon a reading and understanding of this specification and it is my intention to include all such modifications and alterations insofar as they come within the scope of the appended claims.

Having thus described my invention, I claim:

1. In a hydraulic pump comprised of a housing having a shaft opening, a shaft extending through said opening and rotatably supported in said housing, a plurality of chamber forming members rotatable with said shaft and defining a plurality of axially open ended chambers which progressively increase and decrease in volume as said shaft rotates to take in and discharge hydraulic fluid, at least one of said chambers being at high pressure, means communicating the high pressure to the inside of said housing, the improvement which comprises a sealing member rotatable with said shaft and being axially movable relative to said chamber forming members, said sealing member having a first axially facing surface in sealing engagement with an axial end of said chamber forming members to sealingly close the ends of said chambers and also having at least a second opposite axially facing surface facing toward said shaft opening and exposed to the high pressures, a sealing ring surrounding said shaft and having a first axially facing surface in engagement with said sealing member second surface, said sealing ring also having a second opposite axially facing surface also exposed to said high pressures to create a force urging said first sealing ring surface into engagement with said second sealing member surface.

2. The improvement of claim 1 wherein means are provided for movably and sealingly mounting said sealing ring relative to said housing around said shaft opening.

3. The improvement of claim 1 wherein said housing has a cylindrical surface surrounding said shaft opening and said sealing ring has a cylindrical surface coaxial with and in sealed relationship with said housing cylindrical surface.

4. The improvement of claim 3 wherein compressible sealing means are positioned between said surfaces.

5. The improvement of claim 1 wherein said housing member has a radially outwardly facing cylindrical surface generally coaxial with said shaft opening and said sealing ring has a radially inwardly facing cylindrical surface coaxial and in sealed relationship with said housing cylindrical surface.

6. The improvement of claim 5 wherein said cylindrical surfaces have a slight radial spacing and flexible packing means are positioned between said surfaces.

7. The improvement of claim 1 wherein said sealing member second surface is at least in part radially outwardly of said sealing ring and is exposed to the high pressures to create a force urging said sealing member axially toward said chamber forming members.

8. In a hydraulic device of the general type described comprised of a generally cylindrical cup-shaped housing member having a transverse base and axially extending side walls; a cover member closing the open end of said cup-shaped member, said cover member having an axially extending shaft opening therethrough; a shaft extending into said housing through said opening in spaced relationship thereto; bearing means mounted only in said cup-shaped member and rotatably supporting said shaft; a plurality of members rotatable with said shaft and defining axially open ended chambers which revolve around the axis of said shaft and progressively increase

and then decrease in volume as they revolve, some of said chambers being at high hydraulic pressure; manifold means on the side of said chamber forming members remote from said cover engaging an axial end thereof and closing one axial end of said chambers; a sealing member mounted on and rotatable with said shaft on the side of said chamber forming members adjacent to said cover and engaging the axial end of said chamber forming members and closing the other axial end of said chambers; means communicating the high pressure of said device to the side of said sealing member remote from said chamber forming members whereby to create an axial force on said sealing member urging it toward said chamber forming members, the area of the surface of such sealing member exposed to the high pressures being greater than the area of the open end of the high pressure chambers closed by said sealing member and means at least part of which is flexible extending between said cover member and said sealing member and surrounding said opening for sealing said opening against the flow of the high pressure fluid through said shaft opening.

9. The improvement of claim 8 wherein said means include a cylindrical portion on said sealing member extending into spaced coaxial relationship with a surface on said cover member and flexible sealing means therebetween.

10. The improvement of claim 8 wherein said sealing means include a sealing ring having a sealing surface in engagement with the surface of said sealing member remote from said chamber forming members and also having a pressure surface facing in the opposite axial direction exposed to the high hydraulic pressures and flexible sealing means between said sealing ring and said cover member.

11. The combination of claim 10 wherein said sealing means are comprised of a radially outwardly facing surface on the inner surface of said cover member surrounding said shaft opening and said sealing ring loosely surrounds said surface and flexible sealing means are positioned therebetween.

12. In a hydraulic device of the general type described comprised of: a generally cup shaped housing member having a transverse base and axially extending side walls; a cover member having a shaft opening therethrough, a shaft extending through said opening into the interior of said housing, bearing means mounted in said transverse base and rotatably supporting said shaft in said housing, said base having inlet and outlet ports formed therein, means forming inlet and outlet manifolds communicating with said ports, an externally toothed gear rotatably supported on said shaft, an internally toothed gear surrounding said externally toothed gear and having teeth in sliding sealing engagement therewith to define a plurality of chambers which revolve as said shaft rotates and progressively increase and decrease in volume, an eccentric bearing ring surrounding said internally toothed gear and rotatably supporting same, said bearing ring being supported by the inner surface of said side walls, a sealing member having a sealing surface in engagement with the axially facing surfaces of said gears and closing the axially open end of said chambers remote from said manifold means, said sealing member having an axially facing pressure surface facing and spaced from said cover member and defining therewith a pressure cavity, means communicating the high pressure of said device to said cavity and flexible sealing means surrounding such shaft opening and extending between said cover member and said sealing member for sealing said shaft opening from said cavity.

13. The device of claim 12 wherein said cover member is inserted into the open end of said housing member and said housing member and cover member have circumferentially-extending, axially-abutting surfaces retaining said cover member in said housing member.

14. The device of claim 12 wherein said sealing means

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include a cylindrical surface on said cover member surrounding said shaft opening and a cylindrical member is arranged coaxially therewith in spaced relationship thereto and flexible sealing means are positioned therebetween.

15. The device of claim 14 wherein said cylindrical member is integral with said sealing member.

16. The device of claim 14 wherein said cylindrical member is in the form of a sealing ring having a sealing surface in sealing engagement with the pressure surface of said sealing member and the opposite axial surface is exposed to said high pressures and said sealing ring is coaxial with but spaced from the cylindrical surface on said cover member and flexible sealing means are positioned therebetween.

17. In a hydraulic device of the general type described comprised of a generally cup shaped housing member having a transverse base and axially extending side walls and a cover member closing the open end of said cup shaped member, said cup shaped member having formed therein inlet and outlet passages, a shaft extending through a shaft opening in said cover member into said housing, bearing means mounted only in said cup shaped member rotatably supporting said shaft in said housing, a plurality of members rotatable about said shaft and defining a plurality of axially open ended chambers some of which are at high pressure, means engaging the end of said members remote from said cover member and closing the axial end of said chambers, a sealing member rotatable with said shaft engaging the opposite axial end of said plurality of members and closing the opposite axial end of said chambers,

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and means communicating the high pressure of said device to the side of said sealing member axially opposite from said plurality of members whereby to create a hydraulic force on said sealing member urging it towards said plurality of members, and flexible sealing means between said sealing member and said cover member and surrounding said shaft opening for sealing said shaft opening against the flow of high pressure fluid through said shaft opening.

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