June 15, 1965 R. W. BRUNDAGE 3,188,969

HYDRAULIC PUMP OR MOTOR

Original Filed Sept. 6, 1957 2 Sheets-Sheet 1

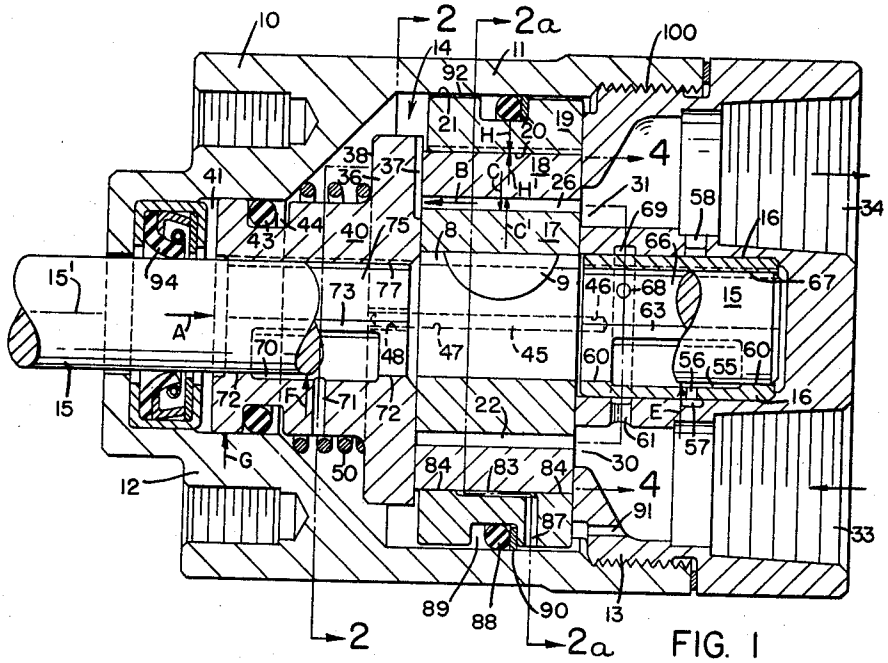


FIG. 1

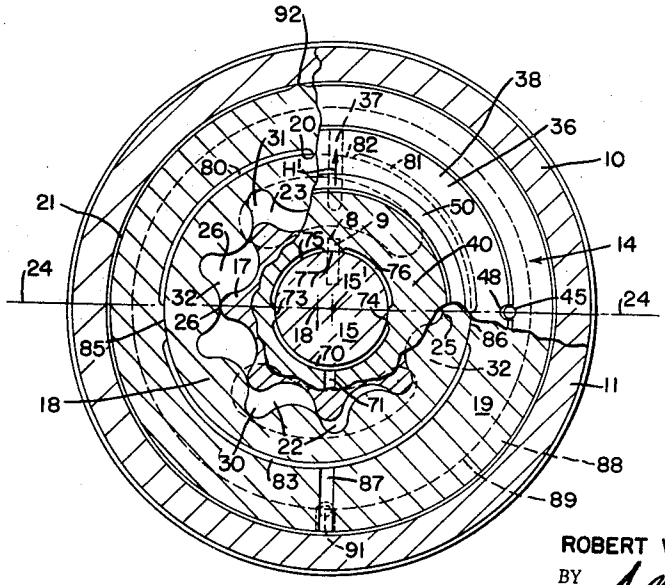


FIG. 2

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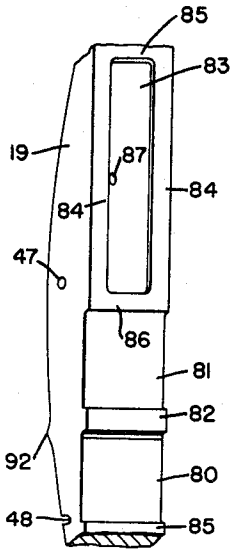


FIG. 3

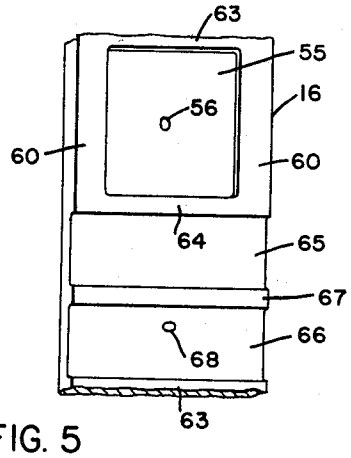


FIG. 5

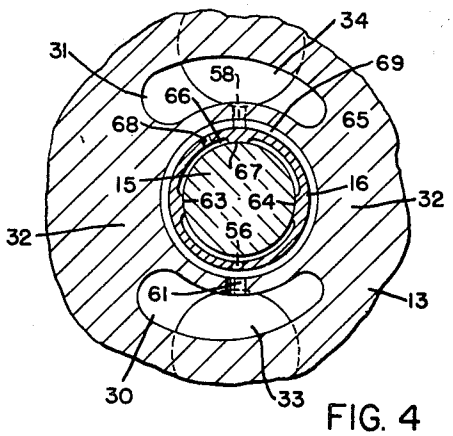


FIG. 4

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HYDRAULIC PUMP OR MOTOR

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Original application Sept. 6, 1957, Ser. No. 682,501, now Patent No. 3,034,446, dated May 15, 1962. Divided and this application Feb. 26, 1962, Ser. No. 175,722
2 Claims. (Cl. 103—126)

This application is a division of application Serial No. 682,501, filed September 6, 1957, now United States Letters Patent No. 3,034,446.

This invention pertains to the art of hydraulic pumps or motors and more particularly to a hydraulic pump or motor of the positive displacement type intended for high pressure and high efficiency applications.

The 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, or at least portions thereof, is equally applicable to other types of hydraulic pumps or motors. In a pump, high and low pressures correspond to discharge and inlet pressures. If the invention is to be considered in relation to a motor, such high and low pressures will then become the inlet and discharge pressures.

Hydraulic pumps of the type to which this invention pertains are normally comprised of a housing, a shaft extending into the housing and rotatably supported therein in suitable bearings. A plurality of members, such as intermeshed, internally-toothed and externally-toothed gears, rotate with the shaft in a bearing surface eccentric to the axis of the shaft to define a plurality of increasing and decreasing volume pumping chambers. Inlet and outlet manifolds communicating with these chambers are formed in the housing.

In these high pressure pumps, the high pressure in the chambers is on one side of the shaft only. The mechanical forces created by such pressures are unsymmetrical and must be transmitted through the shaft and its supporting bearings to the housing. Because of the size of the forces, it has heretofore been conventional to support the shaft in either roll or ball bearings of the precision type which are not only very expensive, but are also relatively bulky.

The present invention contemplates a new and improved hydraulic pump or motor, hereinafter generally referred to as a hydraulic device, of the general type described which overcomes all of the above referred to difficulties and others, and provides a high efficiency, high pressure positive displacement hydraulic device which is simple in construction, is very economical to manufacture, has a maximum useful life and has high hydraulic and mechanical efficiency throughout its life.

In accordance with the present invention, a hydraulic device of the general type described is provided wherein the shaft supporting bearings are in the form of conventional sleeve bearings with portions of the bearing surfaces being recessed and communicated with the high pressure and other portions communicated with low pressure, the recessed portion being so proportioned in area and so circumferentially positioned that the high pressures therein exert hydraulic forces on the shaft generally equal and opposite to the hydraulic forces on the shaft created by the high pressures in the pumping chambers. With this arrangement, the shaft in effect is hydraulically floated, and relatively cheap bearing members may be employed as distinguished from the roller or ball bearings heretofore employed.

The principal object of the invention is the provision of a new and improved hydraulic device of the general

type described which is economical to manufacture, and which has a high mechanical and hydraulic efficiency.

Another object of the invention is the provision of a new and improved hydraulic device, including a rotating shaft member wherein the shaft is in effect hydraulically floated in the pump housing.

Another object of the invention is the provision of a new and improved arrangement for journaling the shaft of a hydraulic pump having substantial radial forces thereon which includes exposing portions of the shaft to the high pressures whereby to create equal and opposite radial forces thereon.

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

FIG. 1 is a cross-sectional view perpendicular to the neutral axis of a hydraulic device illustrating a preferred embodiment of the present invention;

FIG. 2 is a cross-sectional view of FIG. 1 taken partially on the line 2—2 and partially on the line 2*a*—2*a*;

FIG. 3 is a perspective plan layout of the eccentric ring;

FIG. 4 is a cross-sectional view of FIG. 1 taken approximately on the line 4—4 thereof; and

FIG. 5 is a perspective plan layout of the shaft bearing.

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, the figures show a pump including a housing **10** having generally cylindrical side walls **11** and a pair of end walls **12, 13**, all defining a closed cavity **14**. A shaft **15** coaxial with the side walls **11** extends through the end wall **12** and is supported for rotation in a bearing sleeve **16**, in turn, mounted in the right end wall **13**.

Immediately adjacent the end wall **13**, an externally-toothed gear **17** is mounted for rotation with the shaft **15** by means of a key **9** in a keyway **8**. This gear is in turn surrounded by and intermeshed with the teeth of an internally-toothed gear **18** supported for rotation in a ring **19** having an inner surface **20** eccentric to the outer surface **21**.

The gear **18** may have one or more teeth than the gear **17** and is mounted for rotation on an axis **18'** eccentric to the axis **15'** of the shaft **15** so as to define a plurality of increasing and decreasing volume chambers **22, 23**, separated by what may be termed a neutral axis **24** passing through the points of chamber minimum and maximum volume **25, 26** respectively.

The end wall **13** is in sealing engagement with the sides of the gears **17, 18** and is provided with arcuately extending inlet and discharge manifolds **30, 31** separated by stops or lands **32** and in turn communicating with inlet and outlet ports **33, 34** threaded to receive pipe fittings, not shown.

The inlet and outlet manifolds **30, 31** as shown, have a substantial arcuate extent, and are continuously in communication with the increasing or decreasing volume chambers **22, 23** as the case may be. These manifolds increase slightly in radial width toward the maximum volume point **26**.

A sealing disc **36**, both rotatably supports the shaft **15** and is axially movable relative thereto to bear against the left hand side of the gears **17, 18** to close this axial end of the chambers **22, 23**. The sealing disc **36** has a cylindrical portion **50** which surrounds the shaft **15** and extends into an opening **41** in the end wall **12**. Pliable sealing means in the form of an O-ring **43** positioned

in a groove 44 in the cylindrical portion 40 closes the opening 41.

A pin 45 extends axially through an opening 47 in the eccentric ring 19 into an opening 46 in the end wall 13 and a notch 48 in the outer periphery of the sealing disc 36. This pin locates the eccentricity of the ring 19 with the piece of the housing having the inlet and outlet manifolds therein and is an important part of the present invention. The pin incidentally holds the disc 36 against rotation. A passage 37 in the face of the disc 36 communicates the cavity 14 with the high pressure chamber 23. This high pressure exerts a force A against a pressure surface 38 on the sealing disc 36 remote from the gears 17, 18 so as to continuously urge the sealing disc 36 into sealing engagement with the gears.

The hydraulic pressures in the decreasing volume chambers 23 exert an unsymmetrical radial force C and C' on the axial center of gears 17, 18 respectively. This force C on the gear 17 is transmitted to the shaft 15 and thence to the housing through both the bearing 16 and the sealing disc 36. The force between bearing 16 and the shaft 15 is indicated by the radial force E on the axial center of the bearing surfaces and the force between the sealing disc 36 and the shaft 15 is indicated by the radial force F on the axial center of the bearing surfaces, and the force between the sealing disc 36 and the housing 10 is indicated by the radial force G.

The forces E and F in a high pressure hydraulic pump are very substantial forces which would normally require the use of expensive roller or ball bearings if maximum wear is to be obtained. In accordance with the present invention, however, the shaft 15 is in effect hydraulically floated in the bearing 16 and the sealing disc 36.

Thus the bearing sleeve 16 (see FIG. 5) has a recess 55 on its inwardly facing surface communicated with the high pressures through a radial opening 56 in the sleeve 16, an annular groove 57 in the end wall 13 and an opening 58 leading to the high pressure outlet port 34. This high pressure recess 55 is closed in on each axial side by a land 60, and on each circumferential end by lands 63, 64 all of which are in sealing contact with the surface of the shaft 15. The inner surface of the bearing sleeve 16 is also provided with a pair of low pressure recesses 65, 66 separated from each other by a land 67, and from the high pressure recess 55 by means of the lands 63, 64 respectively. The low pressure recesses 65, 66 extend axially the full length of the bearing sleeve 16, and are communicated with the low pressure by means of a radial opening 68 in the sleeve 16, a circumferentially extending groove 69 surrounding the sleeve, a passage 61 to the inlet port 33. The land 67 engages the surface of the shaft 67 and prevents it from moving radially in the bearing when the shaft is started in rotation.

The circumferential width of the recess 55 alone or taken with the lands 63, 64 is preferably less than 180° and the circumferential midpoint is diametrically opposite to the high pressure chamber midpoint. The recess 55 has a radially facing area such that the hydraulic pressure therein exerts a force opposite to the force E and just slightly less than such force so that the shaft 15 rubs against the lands 63, 64 with a slight pressure to seal the high pressure in the recess 55 from the low pressure recesses 65, 66.

The shaft 15 is also journaled inside the sealing disc 36 and its shaft facing surface is formed substantially identical to a bearing sleeve 16; thus the bearing surface of the sealing disc 36 has a high pressure recess 70 communicated with the cavity 14 through a radial passage 71, and surrounded on each axial side by lands 72, and on each circumferential side by lands 73, 74. Low pressure recesses 75, 76 are separated by a land 77 and communicate with recesses 65, 66 which are at low pressure, through keyway 8.

The function, location and dimensions of the recesses in the shaft supporting surface of the disc 36 are identical to that of the bearing sleeve 16, and will not be described further herein.

The unbalanced radial force C' on the inner surface of the outer ring gear is almost totally opposed by an almost equal and opposite unsymmetrical radial force on the outer surface thereof. In accordance with the invention, this is accomplished by providing the inner bearing surface 20 of the sealing ring 19 with a low pressure recess 83 bounded on each axial side by lands 84 and on the circumferential ends by lands 85, 86. The circumferential width of the recess and the lands 85, 86 is preferably equal to or less than 180°. The recess 83 may be communicated with the low pressure in any desired manner, but in the preferred embodiment a radial passage 87 extends to the outer surface of the sealing ring 19 to the right or low pressure end of a pliable sealing member in form of an O-ring 88 positioned in a circumferentially extending groove 89 in the outer surface of the eccentric ring 19. A back-up washer 90 is provided to prevent the high pressure in the cavity 14 forcing the pliable ring 88 between the outer surface of the ring 19 and the inner surface of the housing 11.

The space to the right of the packing ring 18 is communicated with the inlet port 33 by means of an axially extending passage 91 formed in the end well 13.

The bearing surface 20 also has formed therein high pressure recesses 80, 81 of a total 180° circumferential width separated from each other by a land 82 and from the low pressure recess 83 by the lands 85, 86. These recesses 80, 81 extend the full axial length of the surface 20 and thus communicate with the high pressure in the cavity 14. It is to be noted that the high pressure in the cavity 14 holds the eccentric ring member 19 in sealing engagement with the left hand surface of the member 13.

The high pressures in the recesses 80, 81 exert an unsymmetrical radially inward force H on the outer surface of the ring gear 18. The size of this force may be varied by changing the size of the low pressure recess 83 in the course of design or manufacture, and in accordance with the invention, the area of the low pressure recess 83 is so formed that the force H will be slightly greater than the force C' so that the outer surface of the ring gear 18 will be held in sealing engagement with the lands 85, 86 to thus prevent leakage between the high and low pressure areas of the bearing surface 20.

It will thus be seen that an embodiment of the invention has been described which accomplishes all of the objects heretofore set forth and others to provide a hydraulic pump which may be manufactured at a minimum cost, which will have a high efficiency, which is simple in construction, which will have a long useful life.

It will be appreciated that 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 present invention. In particular, it will be apprecited that the pump could be designed with a radial discharge other than axial as shown. Further, it will be appreciated that many of the features described herein are equally applicable to vane type devices, while some of the features described herein are applicable to any type of hydraulic device.

Having thus described my invention, I claim:

1. A hydraulic device comprised of a housing, a single shaft rotatably supported in said housing in a pair of spaced bearings, carried by said housing, a plurality of members rotatable with said single shaft and positioned between said bearings, said members defining a plurality of chambers which increase and decrease in volume as the shaft rotates, some of said chambers containing hydraulic fluid at a high pressure thereby creating an unsymmetrical radial force which is transmitted to said shaft and from said shaft to said bearings and then from

said bearings to said housing, the improvement which comprises said bearings being in the form of a sleeve having a shaft facing inner surface, portions of said inner surface being in sealing engagement with said shaft and other portions of said inner surface being radially spaced therefrom to define, with the inner surface of the sleeve, a high pressure recess and a low pressure recess circumferentially spaced from each other around the sleeve and sealed from each other by the sealing portions on the sleeve, means communicating said high and low pressure recesses respectively to high and low pressure areas of the device, said high pressure recess being located on the side of said shaft diametrically opposite from said chambers containing high pressure fluid thereby creating a hydraulic force on said shaft opposite to said first-mentioned hydraulic force, said low pressure recess extending arcuately for at least 180° and being positioned on the diametrically opposite side of said shaft from said chambers containing low pressure fluid, said high pressure recess having an arcuate extent less than 180° whereby the sealing portions engaging said shaft on each circumferential end of said high pressure recess are located on the side of the shaft remote from the high pressure chambers, said high pressure recess having an area such as to create a hydraulic force on said shaft slightly less than said first-mentioned hydraulic force whereby said shaft is held in slight pressure engagement with the last mentioned sealing portions.

2. The improvement as defined in claim 1 wherein said low pressure recess has portions intermediate its circumferential ends above the base of the recess and adapted to engage the surface of the shaft when said device is started into rotation.

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