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BUSHING FOR PRESSURE LOADED GEAR PUMP HAVING
A TAPERED JOURNAL SURFACE

Filed Oct. 4, 1955 3 Sheets-Sheet 1

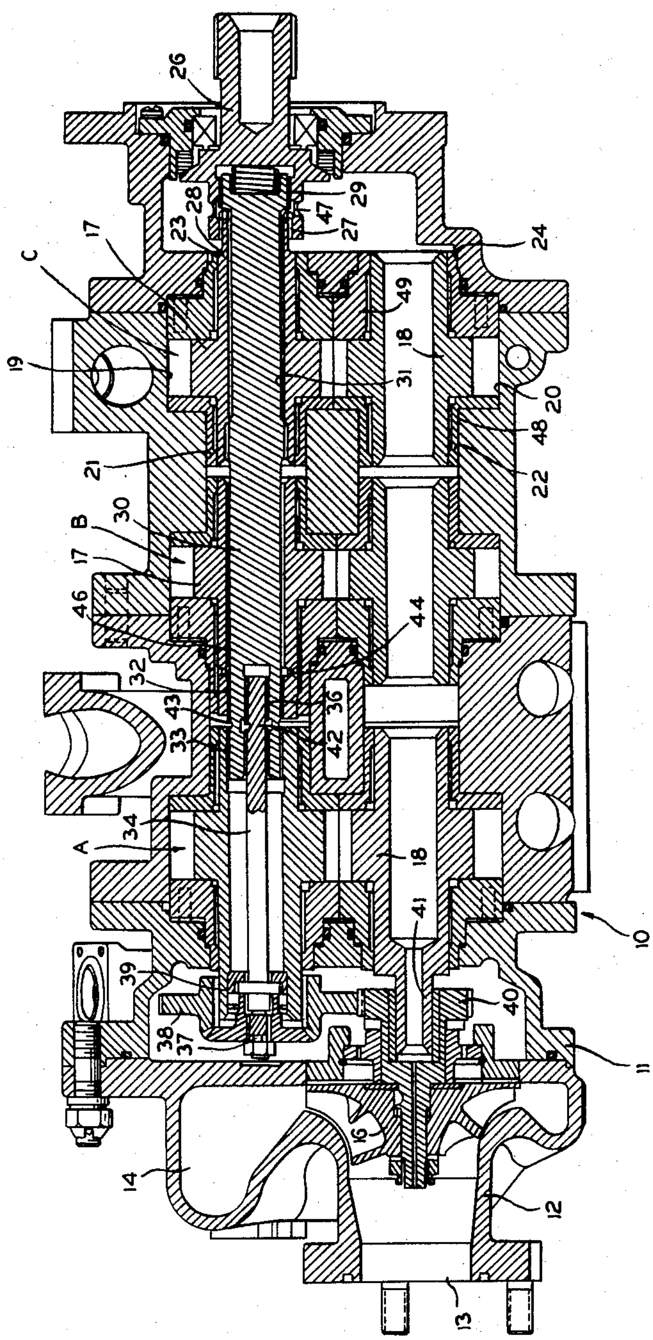

Fig-1

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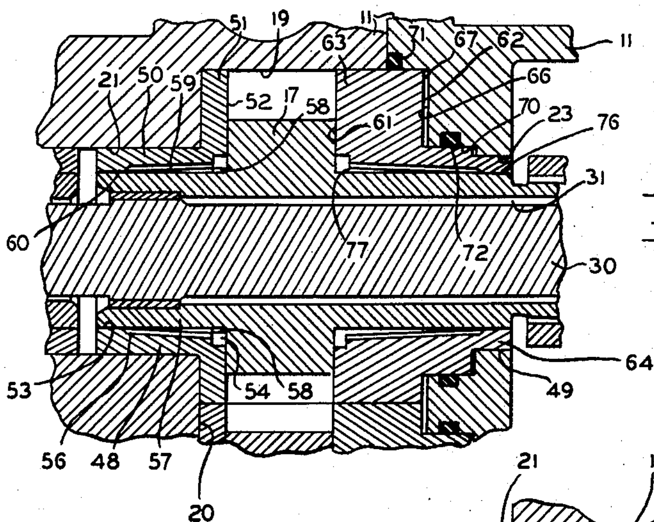

Fig. 2

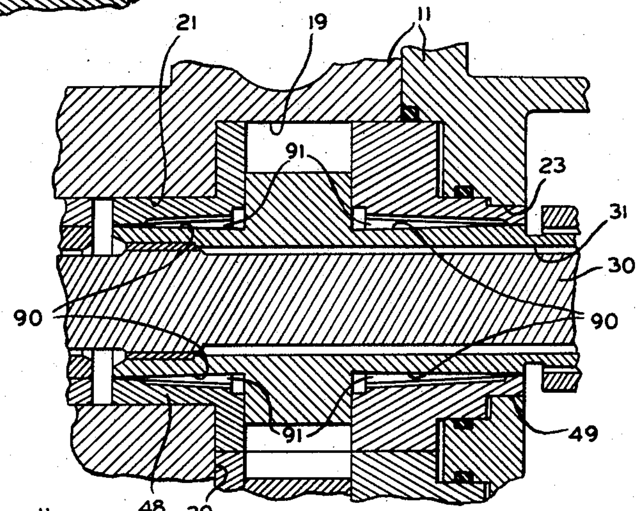

Fig. 3

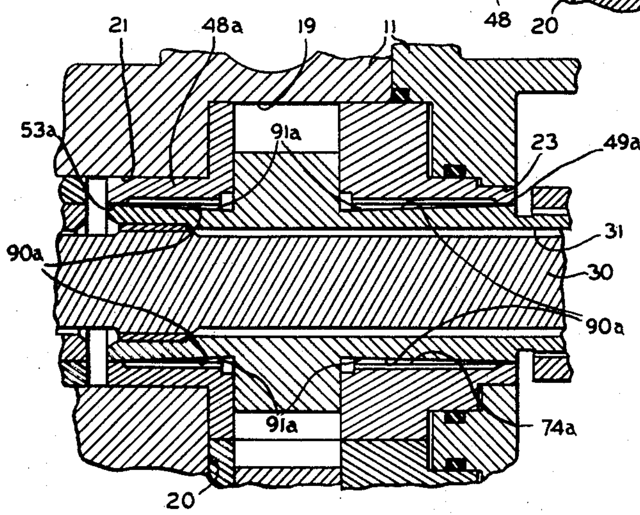

Fig. 4

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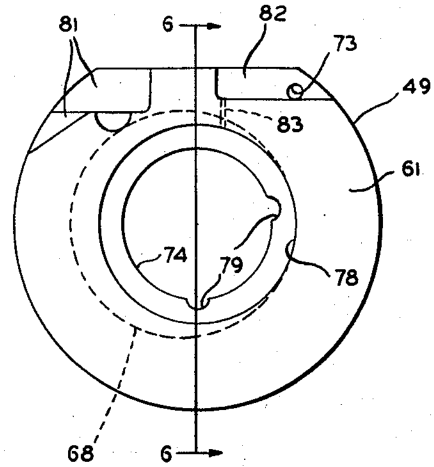

Fig. 5

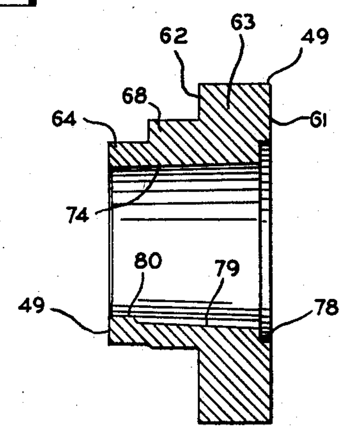

Fig. 6

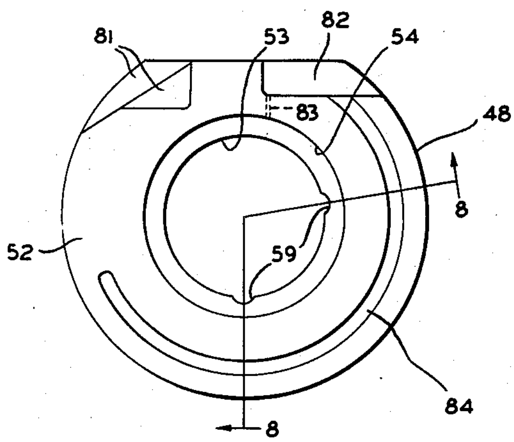

Fig. 7

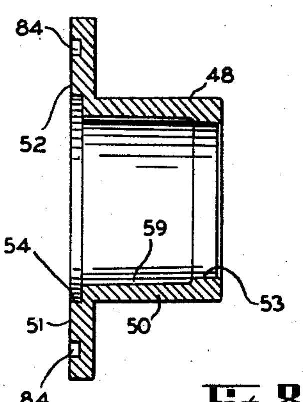

Fig. 8

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BUSHING FOR PRESSURE LOADED GEAR PUMP HAVING A TAPERED JOURNAL SURFACE

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20 Claims. (Cl. 103—126)

This invention relates generally to pressure loaded gear pumps and more particularly to a pressure loaded gear pump having a movable end plate means loaded by pressurized fluid at pressures generated by the pump and specifically characterized by the provision of bearing surfaces between end plate means and pump gears divergent in the direction of the adjoining gear face, thereby to provide a gradually increasing clearance space along the length of the gear shaft.

In one form of pressure loaded gear pump, the rotatable pumping member takes the form of a gear having tubular shaft extensions rotatably journaled in axially spaced bearings. Thus, the gear shaft is supported in the manner of a beam.

In pumping fluid, the load which is imposed upon the gears is transmitted to a portion of the assembly corresponding to the center of the beam. Accordingly, the stress concentrations which are present in the pump produce a deflection of the beam. Additionally, there may be some tendency to a slight misalignment in end to end direction.

Because the operating phenomena referred to in the foregoing remarks are present in gear pump structures, increased capacity requirements and higher operating speeds have produced problems which are directly attributable to the foregoing characteristics. For example, there may be a concentration of load at the inner portion of the supporting member which results in the generation of heat and which further results in increased friction and wear.

According to the principles of the present invention, means are provided wherein bearing surfaces are formed between a bushing or end plate means and a gear. The bearing surface is provided with a divergent inclination in the direction of the adjoining gear side face, thereby providing a gradually increasing clearance space along the length of the gear shaft.

There is thus provided a clearance space which is generally annular in configuration and somewhat conical, having its widest opening at the inner portion of the support. By virtue of such provision, load concentration is cut down at the inner portion of the supporting member. Additionally, the clearance space facilitates the introduction of coolant and lubricant into the journal surface and greatly facilitates the dissipation of thermal energy.

It is an object of the present invention, therefore, to provide an improved pressure loaded gear pump.

Another object of the present invention is to provide improved support means for the impeller of the pressure loading gear pump.

Yet another object of the present invention is to provide a beam type support for a gear type impeller wherein the concentration of load at the inner portion of the supporting member is reduced.

A further object of the present invention is to provide a bearing support means for a pressure loaded gear pump

which has improved means to facilitate the dissipation of heat energy.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows and the accompanying sheets of drawings in which a preferred structural embodiment of a pressure loaded gear pump embodying the principles of the present invention is shown by way of illustrative example.

On the drawings:

Figure 1 is a cross sectional view of a pressure loaded gear pump incorporating the improved bushing or end plate means of the present invention;

Figure 2 is a fragmentary cross sectional view showing in greatly exaggerated form the structural characteristics of the bushings or end plate means provided in accordance with the principles of the present invention;

Figure 3 is a view similar to Fig. 2 but illustrating an alternative embodiment of the invention disclosed herein;

Figure 4 is a view similar to Figs. 2 and 3 but showing yet another structural embodiment of the principles of the present invention;

Figure 5 is an end elevational view of a movable pressure loaded bushing provided in accordance with the principles of the present invention;

Figure 6 is a cross sectional view taken substantially on line VI—VI of Fig. 5;

Figure 7 is an end elevational view of a fixed bushing provided in accordance with the principles of the present invention;

Figure 8 is a cross sectional view taken substantially on line VIII—VIII of Figure 7.

As shown on the drawings:

In order to most clearly demonstrate the operating environment in which the principles of the present invention find greatest utility, the principles of the present invention are disclosed in connection with a pressure loaded gear pump indicated generally by the reference numeral **10** and having a casing **11** formed from a plurality of fastened together sections. At one end of the casing **11** there is provided a housing section **12** forming a pump inlet **13** and providing a volute pumping chamber **14** in which is rotated a centrifugal impeller **16** for initially pressurizing inlet fluid. From the centrifugal impeller **16**, the fluid is discharged through the casing **11** to the respective inlet portions of a plurality of gear pumps all operatively enclosed within the casing **11** and indicated generally by the reference characters A, B and C.

With minor exceptions, each respective gear pump, A, B and C is identical in structure and operation and, accordingly, description of a single unit will suffice for purposes of this disclosure and like reference numerals will be applied wherever possible.

Each of the gear pumps includes a driver gear **17** and a driven gear **18** rotatably intermeshed and operated within a pumping chamber formed by a pair of overlapping generally circular bores **19** and **20** formed within corresponding sections of the casing **11**. The pumping chambers have an inlet supplied with fluid initially pressurized by the impeller **16** and an outlet through which fluid is delivered.

Adjacent the bores **19** and **20** are smaller sized bores **21** and **22** respectively, on one side and **23** and **24** respectively, on the other side.

All of the driver gears **17** of the pumps A, B and C and the impeller **16** of the centrifugal inlet stage are driven by a common driving means which includes a separate driving member **26** splined as at **27** to a shaft extension **28** formed on the driver gear **17** of the pump C and splined as at **29** to a quill shaft **30** which extends freely through a bore **31** formed in the driver gear **17**.

The quill shaft **30** is splined as at **32** to a driver gear of the pump B and is splined as at **33** to the gear of the pump A.

A second quill shaft **34** is splined as at **36** to the quill shaft **30** and is connected as at **37** to a gear **38** journaled on a shaft extension **39** formed on the end of the driver gear **17** of the pump A. The gear **38** is part of a gear train and meshes with a gear **40** journaled on a shaft extension **41** formed on the driven gear **18** of the pump A and connected to the centrifugal impeller **16**. By virtue of such relation, the centrifugal impeller **16** is rotatably driven at a higher speed than the gears of the pumps A, B and C.

A shear section **42** is formed in the quill shaft **34**, a shear section **43** is formed in the quill shaft **30**, a shear section **44** is formed in the shaft extension **46** of the driver gear **17** of the pump B, and a shear section **47** is formed in the driving member **26** to permit continued operation of different pump units in the event of binding or seizure of one of the pump units.

Received within the bores **21** and **22** of the casing **11** for each respective pump A, B and C and for each respective driver gear **17** and driven gear **18** is a fixed bearing indicated generally at **48**.

Received within each respective bore **23** and **24** of each pump A, B and C for a corresponding driver gear **17** and a driven gear **18** is a movable pressure loaded bearing or bushing indicated at **49**. The structural details which characterize the fixed and movable bearings or bushings **48** and **49** will be more clearly understood upon making reference to Figs. 2–8.

Referring first of all to Figs. 7 and 8, it will be noted that the fixed bushings **38** each comprise a generally tubular body portion **50** terminating at one end in a radially outwardly extending flange **51** having a front sealing face **52** formed thereon for engaging an adjoining side face of a corresponding driver or driven gear **17** and **18**.

As shown in Fig. 7, the sealing face **52** is intersected by a bore **53** counterbored as at **54**. The walls of the bore **53** provide a bearing surface for journaling the confronting bearing surface **56** formed on a shaft extension **57** of the corresponding driver or driven gear **17** and **18**. As is most clearly illustrated in Fig. 2, the bearing surfaces provided by the walls of the bore **53** are divergently inclined as at **58** in the direction of the adjoining gear side face, thereby providing a gradually increasing clearance space along the length of the gear shaft. The gradually increasing clearance space **58** provided in the bearing surface has the effect of removing center stress concentration on the beam supported gears and is preferably at an inclination in the order of 5 to 15 ten thousandths of an inch.

The tapered clearance space **58** terminates in the annular counterbore **54** cut of a large enough diameter to completely eliminate radial load on the fixed bearings **48** immediately adjacent the adjoining side faces of the gears **17** and **18**.

The clearance space **58** will have the effect of facilitating the dissipation of heat by permitting coolant and lubricant in the form of the fluid medium being pumped to flow into the space and flood the bearing surface. To further assist in this action, one or more axially extending grooves **59** are formed in the bearing surfaces. The grooves **59** may be blind ended as at **60** to insure that an adequate supply of coolant and lubricant is maintained at the journal surface.

The movable pressure loaded bushing **49** has a front sealing face **61** and a rear motive surface **62** formed on a flange **63** integrally formed on the end of a tubular extension **64**. The sealing face **61** engages in adjoining side face of a corresponding gear **17** or **18** while the motive surface **62** is spaced from an adjoining wall **66** provided by the casing **11**, thereby to form a pressure control chamber **67**.

The outer periphery of the flange **63** and the outer periphery of the tubular extension **64** are generally concentric, thereby facilitating formation of the corresponding recesses **19** and **23** and **20** and **24** in the casing **11** in concentric disposition.

In order to proportionately modify the effective area on the motive surface **62** so that the pressure forces developed in the pumping chamber will be exactly balanced by the thrust pressure exerted against the movable pressure loaded bushings **49** in the pressure control chamber **67**, the motive surface **62** is particularly characterized by the provision of a generally circular axial extension or shoulder **68** which has its center eccentrically offset towards the inlet side of the pump, thereby to prescribe the inner periphery of the annular motive surface **62** which is offset towards the inlet side of the pump. Thus, the motive surface **62** is divided into a major area on the discharge side of the pump and a minor area on the inlet side of the pump, the total effective area of the motive surface **62** increasing proportionately from the inlet side of the pump to the discharge side of the pump so that a balancing thrust will be exerted upon the movable bushing **49**.

A corresponding recess **70** is formed in the casing **11** to receive the axial extension or shoulder **68**, however, a wide tolerance variation is afforded because the pressure in the control chamber **67** is sealed by the provision of O-ring members indicated at **71** and **72** respectively.

To transmit fluid at pump generated pressure to the pressure control chamber **67**, the flange **63** is apertured as at **73** on the discharge side of the bushing **49**.

The sealing face **61** of the movable bushing **49** is intersected by a bore **74**, the walls of which provide a bearing surface for engaging and journaling a confronting bearing surface **76** formed on a corresponding shaft extension of a gear **17** or **18**. The bearing surfaces are particularly characterized by the provision of a divergent inclination in the direction of the adjoining gear side face, thereby providing a gradually increasing clearance space along the length of the gear shaft to reduce the center load concentration. The tapered clearance space indicated in Fig. 2 by the reference numeral **77** terminates in an annular counterbore **78** formed in the sealing surface **61**, thereby to remove all radial load from the movable bushing **49** adjacent the gear side face.

The tapered clearance space **77** will have the effect of distributing coolant and lubricant to the bearing and journaling surface, however, to further facilitate the flooding of the bearing and journaling surface with coolant and lubricant, one or more grooves **79** blind ended as at **80** may be formed in the bearing surface **74** of the movable bushing **49**.

It will be noted upon referring to Figs. 5 and 7 that each of the sealing faces **52** and **61** of the fixed and movable bushings **48** and **49** has formed on the inlet side a chamfered clearance indicated at **81** to facilitate filling of the spaces between the gear teeth and to improve the flow characteristics through the pump. Additionally, on the discharge side, the bushings **48** and **49** have trapping reliefs indicated at **82**. To insure the adequate supply of coolant and lubricant to the counterbores **54** and **78** and the blind ended grooves **59** and **79** of the fixed and movable bushings **48** and **49**, respectively, each is provided with a generally radially extending passageway **83** (Figs. 6 and 7) extending from the trapping relief **82** to the corresponding counterbores **54** and **78**. Thus, fluid at full discharge pressure is flooded into the bearing and journaling surfaces for cooling and lubricating purposes.

The sealing surfaces **52** and **61**, if desired, may also be provided with an annular groove such as is indicated at **84** on the sealing surface **52** illustrated in Fig. 7. The groove **84** extends from the trapping relief **82** and is located radially outwardly of the root diameter of the gear teeth, thereby to intercommunicate the spaces between the gear teeth and tending to even out the distribution of pressure load.

In the alternative embodiment of Fig. 3, all of the structure thus far described is provided, however, to further increase the annular clearance space **58** and **77**, the shaft extensions of the gear are provided with bearing surfaces **90** and which taper in a direction of the gear side faces, thereby to provide an enlarged annular conical clearance space as indicated at **91**.

Although shown in greatly exaggerated form in Figs. 2 and 3, it will be appreciated by those versed in the art that the degree of inclination provided to afford the clearance space **77** on the movable bushing **49** and the clearance space **91** on the tapered surfaces **90** is preferably in the order of 5 to 15 ten thousandths of an inch.

In the alternative embodiment of Fig. 4, fixed bushings **48*a*** are provided and movable bushings **49*a*** are provided. The bearing surfaces **53*a*** and **74*a*** of the respective fixed and movable bushings **48*a*** and **49*a*** are not specifically tapered, however, the confronting bearing surfaces **90*a*** on the shaft extension are divergently inclined thereby to provide clearance spaces **91*a***.

Although various minor structural modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution of the art.

We claim as our invention,

1. A fluid pump of the type including a housing having an inlet and an outlet port formed therein, a rotatable pumping member journaled in said housing for transferring fluid from said inlet to said outlet, axially movable end plate means adapted to engage said pumping member in sealing relation and movable independently of said rotatable pumping member, a continuous generally annular motive surface on said end plate adapted in response to application of pressure thereto to urge said end plate toward said rotatable member to establish said sealing relation, conduit defining means for continuously communicating pressure generated by said pump to said motive surface, said motive surface having a generally circular outer periphery concentrically disposed with respect to the axis of rotation of the pumping member and a generally circular inner periphery eccentrically disposed with respect to the axis of said pumping member, said inner periphery having its center offset toward said inlet port, and means forming bearing and journaling surfaces between said rotatable pumping member and said movable end plate means provided with a divergent inclination extending in the direction of the engaging portions of said pumping member and said end plate means to provide an annular generally conical clearance space, reducing center load concentration.

2. A fluid pump having a suction side, a discharge side, a rotatable pumping member, an axially movable, pressure loadable end plate having a continuous graduated discharge pressure responsive motive surface, said motive surface having a major area and a minor area, said end plate being movable with respect to said pumping member and engageable in a surface opposite to said motive surface with an adjacent side face of said pumping member in sealing relation, the major area of said motive surface being located on said discharge side and the minor area of said motive surface being located on said suction side, conduit defining means for continuously communicating pressure generated by said pump to said motive surface, and means forming bearing and journaling surfaces between said end plate and said pumping member provided with a divergent inclination extending to said adjacent side face of said pumping member and forming an annular clearance space of divergent configuration to reduce center load concentration and facilitate heat dissipation.

3. In a pressure loadable bushing for establishing a sealing relation with the side face of an associated rotatable pumping member mounted on a shaft journaled in said bushing, said bushing being axially movable with respect to said rotatable pumping member, a sealing surface on said bushing generally concentric with said shaft and said pumping member and adapted to engage said pumping member side face in sealing relation, a unitary pressure responsive motive surface on said bushing oppositely located with respect to said sealing surface and asymmetrically disposed with respect to said sealing surface, said motive surface embracing the axis of said pumping member, conduit defining means for continuously communicating pressure generated by said pump to said motive surface, and a bearing surface on said bushing for journalling the pumping member, said bearing surface particularly characterized by the provision of a divergent inclination extending in the direction of said pumping member side face and forming a divergent annular clearance space at the journal for reducing center load concentration and for facilitating the dissipation of thermal energy.

4. In a pressure loaded pump of the type comprising a housing having an inlet and an outlet formed therein, a pair of intermeshing pumping gears rotatably journaled in said housing, an axially movable pressure loadable plate associated with each of said gears to rotatably journal said gears in said housing and having a forward sealing surface thereon adapted to engage the associated gear side face in sealing relation, each plate being axially movable with respect to its associated pumping gear, a motive surface on each plate oppositely disposed with respect to said sealing surface, conduit defining means for continuously communicating pressure generated by said pump to said motive surfaces to urge said plate forward surfaces into said sealing relation, and motive surface area defining means for restricting the area of each said motive surface so arranged that the area thereof exposed to pressure generated by said pump and lying adjacent the outlet of the pump is greater than the area exposed thereof adjacent the inlet side of the pump, and means forming bearing surfaces between said gears and said end plates rotatably journaling said gears in said housing, said bearing surfaces being characterized by the provision of a divergent inclination therein extending in the direction of said forward sealing surface to reduce center load concentration.

5. In a fluid pump of the type including a housing having an inlet and an outlet port formed therein, a rotatable pumping member in said housing for transferring fluid from said inlet to said outlet and having bearing surfaces, axially movable end plate means having bearing surfaces for journaling said pumping member in said housing and having a sealing surface engageable with one side of said pumping member in sealing relation, said end plate being axially movable with respect to said pumping member, a motive surface on said end plate oppositely located with respect to said rotatable pumping member engaging surface and adapted in response to application of loading pressure thereto to urge said end plate toward said rotatable member to establish said sealing relation, and conduit defining means for continuously communicating loading pressure generated by said pump to said motive surface, said motive surface being generally annular and having a substantially circular outer periphery concentrically disposed with respect to the axis of rotation of the pumping member, said motive surface having an axial extension formed thereon having an outer periphery eccentrically disposed with respect to said axis and having its center offset towards said inlet port whereby said motive surface has a substantially lesser radial dimension adjacent said inlet port than adjacent said discharge port so that upon applica-

tion of a uniform fluid pressure per unit area to said motive surface a graduated sealing force is provided having a minimum value adjacent said inlet and a maximum value adjacent said outlet, said bearing surfaces of said gears and said end plates means together forming a gradually increasing clearance space divergently inclined in the direction of said sealing surface to reduce center load concentration.

6. A high pressure pump including a body providing a pumping cavity with an inlet and an outlet, bearing means in said pumping cavity each defining an end plate portion and a tubular bearing portion eccentrically offset relative to said end plate portion toward the inlet of the pump to provide a face outwardly of the pumping cavity on the end plate portion which increases in width towards the pump outlet, said bearing means and said body together forming a chamber behind said end plate portions, means providing a passage in communication with the pump discharge and said chamber, whereby pressure forces in the pumping cavity tending to shift the end plate portions away from the pumping cavity will be balanced by pressure forces in said chamber which increase from the inlet to the outlet sides of the pump, and a bore in said bearing means for journaling a rotatable pumping member providing a bearing surface divergently inclined from said tubular bearing portion in the direction of said end plate portion to form a gradually increasing clearance space for reducing center load concentration.

7. In a high pressure pump including a body having a pumping cavity with an inlet and an outlet, a bearing means in said cavity having an end plate portion and a tubular bearing portion eccentrically displaced relative to said end plate portion toward the inlet of the pump to decrease the extent of exposed plate area in the region of the pump inlet, said bearing means and said body arranged to define a chamber behind said end plate portion, and means providing a passage in communication with the pump discharge and said chamber, whereby balancing pressure loads are provided on both sides of the plate portion, and a bore in said bearing means for journaling a rotatable pumping member providing a bearing surface divergently inclined from said tubular bearing portion in the direction of said end plate portion to form a gradually increasing clearance space to reduce center load concentration.

8. In a high pressure pump, a housing having an inlet and an outlet and providing a pumping cavity, and a backing plate for said cavity in said housing, said backing plate having a pressure receiving back surface forming together with means including a portion of said housing a pressure control chamber, and means placing said pressure control chamber in pressure communication with said outlet, said back surface increasing proportionately in area from the pump inlet to the pump outlet for balancing unequal pressure forces in the cavity, said backing plate having an annular bearing surface formed therein for journaling said rotatable pumping member, said surface being divergently inclined in the direction of the pumping cavity to provide a gradually increasing clearance space to reduce center load concentration.

9. In a pump, a housing having an inlet and an outlet and providing a pumping cavity, a shiftable plate closing one end of said cavity in said housing and being subject to pressures in the cavity which increase towards the outlet side of the cavity, said shiftable plate forming together with means including a portion of said housing a pressure control chamber adjacent said cavity, a back face on said shiftable plate forming a wall of said pressure control chamber and having an effective area increasing in size from the inlet to the outlet sides of the pump to produce balancing forces urging the plate towards the cavity in proportion to the unequal forces urging the plate away from the cavity, and an annular journaling surface formed on said plate for journaling a rotatable pumping member, said annular journaling surface having a divergent inclination formed therein in the direction of said cavity to form a gradually increasing clearance space to reduce center load concentration.

10. In a pump, a rotatable impeller having a hub portion and oppositely extending shaft extensions having cylindrical journal surfaces, bearing means providing bearing surfaces for beam support and journaling of said impeller at its journal surfaces, and a divergent inclination formed in said surfaces forming diverging clearance spaces between said journal and bearing surfaces extending towards the impeller to reduce center load concentration adjacent said hub portion of said impeller.

11. In a pump as defined in claim 10, said divergent inclination being formed in said bearing surfaces of said bearing means.

12. In a pump as defined in claim 10, said divergent inclination being formed in said journal surfaces of said rotatable impeller.

13. In a pump as defined in claim 10, said divergent inclination being formed in both of said bearing and journal surfaces.

14. A fluid pump of the type including a housing having an inlet and an outlet port formed therein, a rotatable pumping member journaled in said housing for transferring fluid from said inlet to said outlet, end plate means adapted to engage said pumping member in sealing relation, and means forming bearing and journaling surfaces between said rotatable pumping member and said end plate means provided with a divergent inclination extending in the direction of the engaging portions of said pumping member and said end plate means to provide an annular clearance space of gradually increasing size to reduce center load concentration.

15. In a gear pump, rotatable intermeshing gears having oppositely extending axial journals, bearing means providing a beam type support for each respective gear journal, and a divergent inclination formed in said bearing means extending in the direction of the gear to provide a gradually increasing clearance space for reducing center load concentration between the bearing and the journal adjacent the gears.

16. In a gear pump, a rotatable gear having axially extending journals, bearing means providing a beam type support for said gear journals, said bearing means and said gear journals having bearing and journal surfaces provided with a divergent inclination extending in the direction of said gear to reduce center load concentration.

17. In a gear pump, a rotatable gear having oppositely extending axial journals, bearing means providing a beam type support for said gear journals, said bearing means and said gear having bearing and journal surfaces provided with a divergent inclination extending in the direction of said gear to reduce center load concentration, said clearance space terminating in an annular recess formed to remove all radial load from the bearing and journal means immediately adjacent the adjoining gear side face.

18. In a gear pump, a rotatable gear having oppositely axially extending journals, bearing means providing a beam type support for said gear journals, said bearing means and said gear journals having bearing and journal surfaces provided with a divergent inclination extending in the direction of said gear to reduce center load concentration, said clearance space terminating in an annular recess formed to remove all radial load from the bearing and journal means immediately adjacent the adjoining gear side face, and passage means communicating pump generated pressure into said annular recess to flood said clearance space with coolant and lubricant.

19. In a gear pump, a rotatable gear having oppositely extending axial journals, bearing means providing a beam type support for said gear journals, said bearing means and said gear journals having bearing and journal sur-

faces provided with a divergent inclination extending in the direction of said gear to reduce center load concentration, said clearance space terminating in an annular recess formed to remove all radial load from the bearing means immediately adjacent the adjoining gear side face, and passage means communicating pump generated pressure into said annular recess to flood said clearance space with coolant and lubricant, said bearing surfaces being further provided with axially extending grooves to assist in flooding the bearing surfaces with coolant and lubricant.

20. In a pump, a rotatable impeller having axially spaced journal surfaces on opposite sides of a point of load concentration, bearing means including a bushing on one side of said point of load concentration providing bearing surfaces for beam support and journaling of said impeller at its journal surfaces, and a taper formed in said bearing surface of said bushing forming diverging clearance spaces extending towards the impeller to reduce center load concentration, said taper terminating in an annular recess adjacent said impeller to remove locally bearing load on said bearing surface and means communicating fluid at pressure generated by the pump to said recess for flooding the bearing surface with coolant and lubricant.

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