Feb. 2, 1971 G. L. NOELL 3,560,121

GEAR PUMP WITH MOVABLE ELEMENT HAVING CONTIGUOUS CYCLIC UNLOADING SUPPRESSION MEANS

Filed Feb. 28, 1969 2 Sheets-Sheet 1

FIG. 1

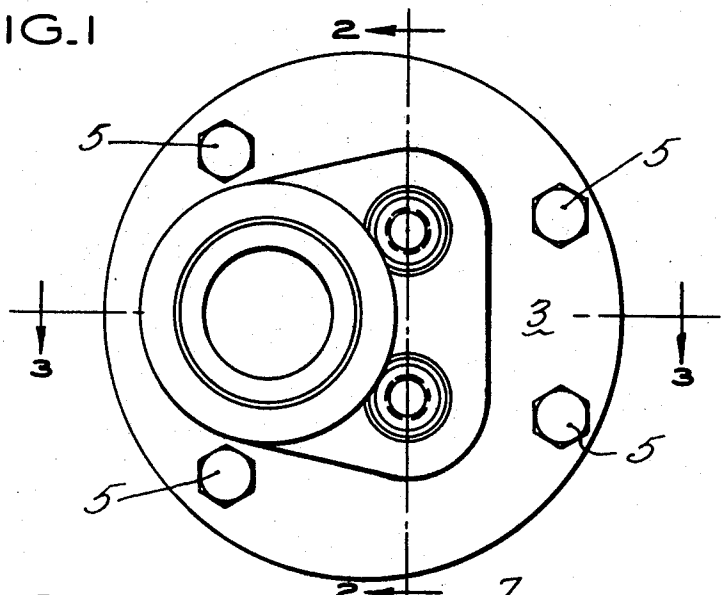


FIG. 2

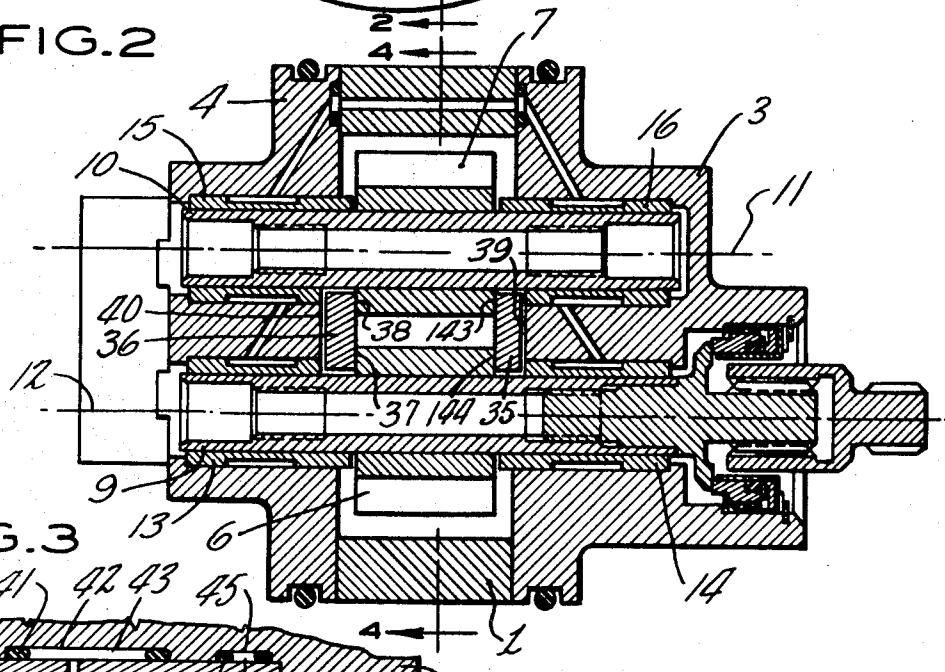
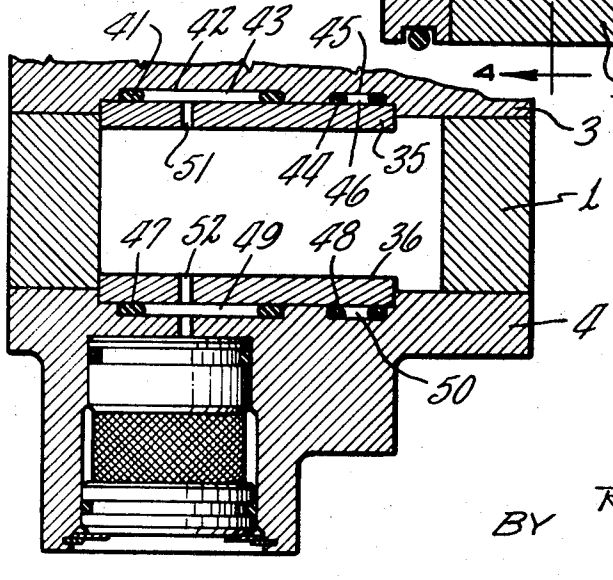


FIG. 3



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FIG_4

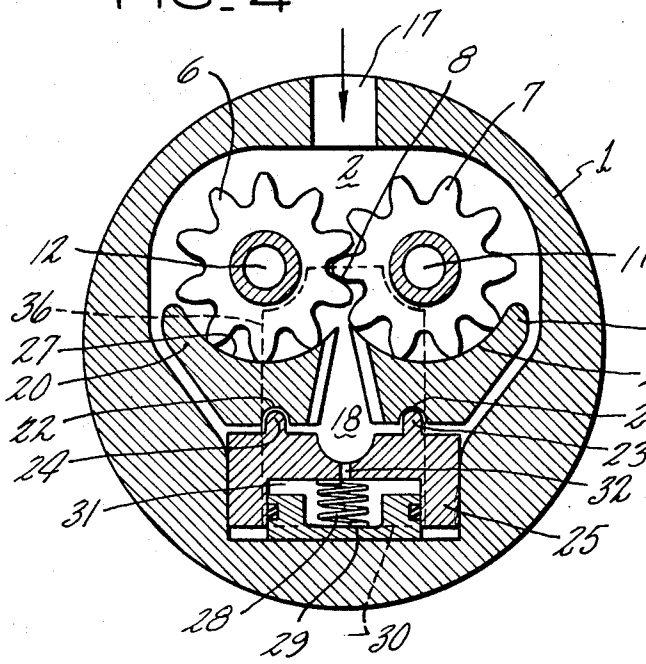


FIG_5

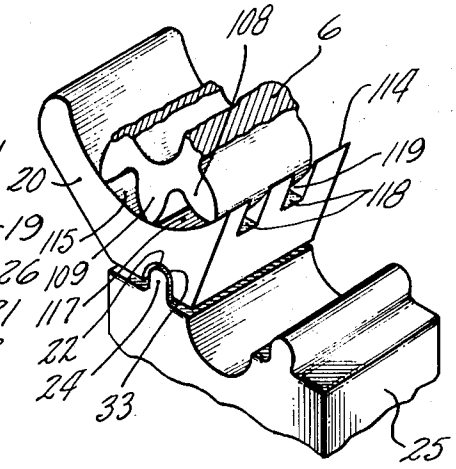


FIG_6

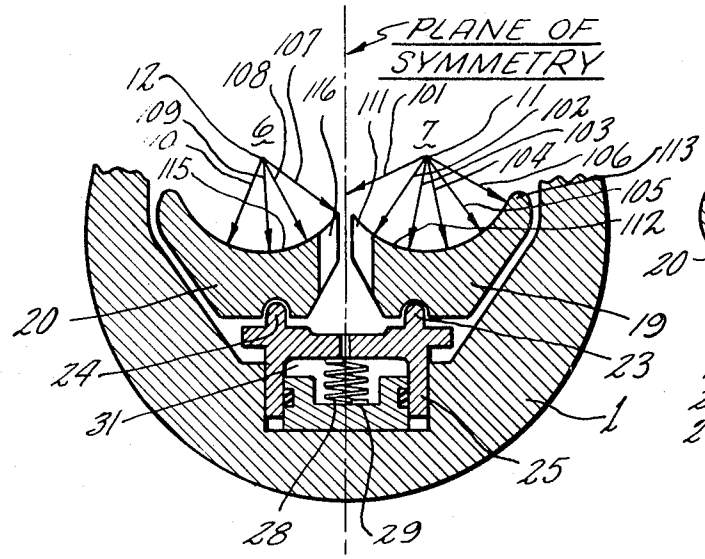
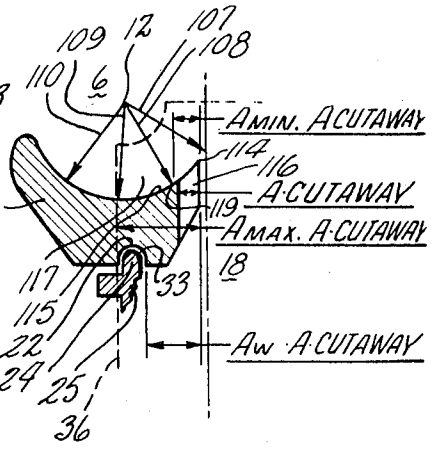


FIG_7



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3,560,121

GEAR PUMP WITH MOVABLE ELEMENT HAVING CONTIGUOUS CYCLIC UNLOADING SUPPRESSION MEANS

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U.S. Cl. 418—129 10 Claims

ABSTRACT OF THE DISCLOSURE

A gear pump having first and second intermeshing gears capable of pumping fluids containing highly abrasive contaminants, separate pivotably movable elements engaging the periphery of said first and second gears respectively adjacent the pump discharge such that high pressure is introduced into the gear tooth intertices next to the innermost gear teeth prior to the disengagement of said gear teeth to thereby maintain continuous peripherial sealing engagement of the outboard extremity of each movable element under all pump operating conditions.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention pertains to gear pumps capable of delivering output pressures of exceptionally high volumetric efficiencies wherein the pump comprises a housing with a pair of meshed toothed gears disposed therein having separate movable elements adjacent the pump outlet engaging the periphery of each gear in a one-to-one relationship to maintain continuous peripherial sealing engagement of the outboard extremities of each element under all pump operating conditions.

(2) Description of the prior art

The reduction in volumetric efficiency of a gear pump caused by the resultant wear when pumping fluids containing abrasive contaminants and the lifting of the outer extremities of the movable elements due to the gear pump cyclic lifting phenomena have been continual problems with gear pumps.

The problem of gear wear has been minimized by the utilization of separate movable elements engaging the periphery of the intermeshing gears. The construction of a gear pump having separate movable elements trackably engaging the periphery of each of the intermeshing gears respectively is described in U.S. patent application Ser. No. 659,426 of inventors Godwin L. Noell, John E. Cygnor and Jack G. Sundberg, entitled "Gear Pump," filed Aug. 9, 1967, now U.S. Pat. No. 3,437,048, and assigned to the same assignee as the instant application, which disclosure is incorporated by reference into this disclosure.

The cyclic lifting phenomena experienced by the outer extremity of the pivotable movable elements is described in detail in U.S. patent application Ser. No. 659,398 of inventors Godwin L. Noell and Leroy A. Difford, entitled "Gear Pump With Movable Elements Having a Plurality of Sealing Forces," filed Aug. 9, 1967, now U.S. Pat. No. 3,429,270, and assigned to the same assignee as the instant application, which disclosure is incorporated by reference into this disclosure.

An example of prior art structure wherein separate independent force producing means, positioned outboard of the pivot contact point of each movable element, are utilized to produce a moment to compensate the moment that tends to lift the outer extremity of the pivotable movable element from engagement with the periphery of the gear teeth is shown in U.S. patent application Ser. No. 659,398 of inventors Noell and Difford, entitled "Gear Pump With Movable Elements Having a Plurality of Sealing Forces," filed Aug. 9, 1967, now U.S. Pat. No. 3,429,270, with disclosure is incorporated by reference into this disclosure.

These prior art approaches have been suitable for maintaining high volumetric efficiency when pumping contaminated fluids. However, they utilize a large number of moving parts which of necessity increase the weight and complexity of the pumping system. The problem is especially serious in pumping systems for aircraft wherein reduction in weight and the increase in reliability that accompanies a less complex system are paramount considerations. The structure of the instant invention prevents the cyclic lifting of the outer extremeities of the pivotable movable elements without the use of independent load means engaging the outer extremities of said elements.

SUMMARY OF THE INVENTION

The present invention discloses a gear pump that has separate movable sealing elements engaging the periphery of each gear in a one-to-one relationship with passageways constructed at the inner extremity of each movable peripherial sealing member such that said passageways are in continuous fluid communication with discharge pressure to thereby introduce discharge pressure into the outboard gear tooth cavities next to the innermost gear teeth prior to the disengagement of said innermost gear teeth to thereby utilize the physical presence of said innermost gear teeth to preclude the lifting of the outer extremities of said movable elements caused by the cyclic lifting phenomena.

The relationship of the passageways beginning at the inner extremity of each movable sealing element and the cyclic lifting phenomena can best be described by referince to FIG. 6 wherein the structure to the right of the plane of symmetry graphically represents the most severe loading conditions that the movable element can experience. The structure to the left of the plane of symmetry is a mirror image of that shown on the right. Lines **101** through **106**, both inclusive, each graphically represent a tooth on the gear shown generally at **7**. Similarly, lines **107** through **110**, both inclusive, each graphically represents a tooth on the gear shown generally at **6**. As gear **7** rotates about axis **11** with respect to movable element **19**, at one instant in time gear tooth **102** moves past the outer extremity of passageway or cavity **111**, thus permitting high pressure fluid to enter the interstice **112** between gear teeth **102** and **103**. At this particular instant in time the volume of fluid confined between teeth **102** and **103** is instantaneously transformed from pump inlet pressure to pump discharge pressure, and the surface of element **19** directed towards the plate of symmetry from the point of contact of element **19** and tooth **103** creates a force that tends to pivot element **19** about tooth **103**. This is a transient condition that exists at the instant tooh **102** uncovers passageway **111** and is due to the pressure response caused by the compressability of the fluid being pumped. However, since tooth **102** is still in engagement with the wiping surface **112** of element **19**, the force tending to pivot element **19** about tooth **103** is counteracted by a resistive force acting through tooth **102**, thus preventing element **19** from pivoting about tooth **103** and hence preventing the cyclic lifting phenomena from disengaging the outer extremity **113** of element **19** from the periphery of teeth **105** and **106**.

Accordingly, it is an object of the present invention to provide an improved gear pump having pivotably movable elements adjacent the pump outlet for pumping fluids

containing a highly abrasive contaminant wherein the outer extremities of the pivotably movable elements are maintained in engagement with the periphery of the mating gear teeth under all conditions of pump operation without the use of independent load means positioned outboard of the pivot contact point.

Another object of this invention is to provide a gear type pump wherein separate pivotably movable elements are positioned adjacent the pump outlet and each element has at least one cavity or passageway positioned at its inner extremity such that discharge fluid is communicated to gear teeth interstices next to the innermost gear teeth such that the innermost gears react to counter the cyclic lifting force and thus prevent the outer extremities of the movable elements from being lifted from engagement with the periphery of the gear teeth due to the cyclic lifting phenomena.

A specific object of this invention is to provide a gear pump having a separate pivotably movable element for each gear located adjacent the pump outlet, each element engaging the periphery of its respective gear and having at least one cavity or passageway positioned at the innermost extremity of each element, said cavity or passageway in continuous fluid communication with pump discharge pressure such that pump discharge pressure is introduced into the interstice next to the innermost gear tooth prior to the disengagement of said innermost gear tooth from the wiping surface of its respective movable element such that the forces generated by the introduction of high pressure fluid into said gear tooth interstices are cancelled by the reaction of said innermost gear and its continued contact with the wiping surface of said element.

Another object is to eliminate the use of means for independently applying a force to the outer extremity of each movable element to maintain said outer extremities in peripheral sealing engagement with their respective gear teeth responsive to the cyclic lifting phenomena by introducing discharge pressure into the gear tooth interstices next to the innermost gear tooth of each gear prior to the disengagement of said innermost gear tooth to thereby utilize said innermost gear tooth as a means to counteract said cyclic lifting force.

DESCRIPTION OF THE DRAWINGS

The following is a brief description of the drawings accompanying the detailed description of the instant invention.

FIG. 1 is a front view of one form of pump incorporating the instant invention.

FIG. 2 is a longitudinal sectional view along line 2—2.

FIG. 3 is a sectional view along line 3—3.

FIG. 4 is a cross-sectional view along line 4—4.

FIG. 5 is a detailed perspective view of a fragmentary portion of a gear pump showing the relative positions of the gear teeth and the cavities located at the inner extremities of the movable elements.

FIG. 6 is a fragmentary section of a gear pump showing a graphical representation of the instantaneous position of the gear teeth with respect to the movable elements.

FIG. 7 is a fragmentary graphical representation showing the relative position of the gear teeth, the engaging movable elements and the high pressure areas relative thereto.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, in the following general description, like parts are designated throughout by like numerals for all forms shown.

Referring to the example shown in FIGS. 1, 2, 3 and 4, there is provided a pump having a housing **1** defining therein a cavity **2** and a pair of end plates **3** and **4** positioned on opposite sides of housing **1** and secured in fluid tight relation to said housing by a plurality of bolts **5**. Rotatably mounted about axes of rotation **11** and **12** in

cavity **2** of housing **1** are a pair of intermeshing gears **6** and **7** engaging one another at an area of intermesh indicated generally at **8**. Shaft **9** drives gear **6** through a key (not shown). Shaft **10** is keyed to driven gear **7** such that shaft **10** and gear **7** rotate in unison responsive to rotative movement of driver gear **6**. Shafts **9** and **10** are journaled in bearings **13**, **14**, **15** and **16** respectively with a close running fit such that axes of rotation **11** and **12** are maintained substantially parallel. Gears **6** and **7** are disposed in cavity **2** such that an inlet **17** is formed on one side of the intermesh **8** and an outlet **18** is formed on the opposite side of the intermesh **8** so that the rotary fluid displacement means comprising the intermeshing gears **6** and **7** will operate to move the fluid medium acted upon by the pump from the inlet **17** to the outlet **18**. As is clearly indjcated in FIGS. 2 and 4, the outer diameter of the gears **6** and **7** at the tips or periphery of the gear teeth are disposed in relation to the peripherial wall of cavity **2** adjacent the pump inlet such that there is a pronounced clearance between the periphery of each of the gear teeth and the adjacent cavity wall. This clearance is provided to reduce the possibility of cavitation at the pump inlet when the pump is operated at high speed. The movable peripherial sealing means take the form of first and second movable members **19** and **20** positioned adjacent outlet **18** and peripherially sealingly engage gears **6** and **7** respectively.

In this particular embodiment, pivotably movable sealing elements **19** and **20** have elongated depressions **21** and **22** that pivotably engage protuberances **23** and **24** respectively of loading element **25**.

Peripherial sealing elements **19** and **20** are continuously urged into peripherial sealing engagement with at least three teeth of gears **6** and **7** respectively in the areas **26** and **27** by spring **28** received by depression **29** of sealing spacer **30**. Spring **28** also urges protuberances **23** and **24** into engagement with mating depressions **21** and **22** respectively to thereby provide the initial fluid sealing contact between the protuberances and their mating depressions until the build-up of fluid pressure in chamber **18**. Discharge pressure is communicated from chamber **18** into chamber **31** via passageway **32** to provide a fluid pressure responsive force supplemental to that provided by spring **28**. Said combined fluid pressure responsive and spring force is transmitted through pivotable protuberances **23** and **24** to elements **19** and **20** to generate vectored forces through elements **19** and **20** that are continuously positioned in substantial proximity respectively to axes of rotation **11** and **12** such that movable elements **19** and **20** are continuously positioned in peripherial tooth sealing engagement with at least three teeth of gears **6** and **7** respectively.

Side members **35** and **36** are positioned intermediate the lateral faces **37** and **144** of gear **6**, the lateral faces **38** and **143** of gear **7**, and the side surfaces **39** and **40** of end plates **3** and **4** respectively. Seal **41** is located in recess **42** of end plate **3** to form cavity **43**. Seal **44** is positioned in recess **45** intermediate side plate **35** and end plate **3** to form cavity **46**. Similarly, seals **47** and **48** are positioned intermediate end plate **4** and side plate **36** to form chambers **49** and **50**. Fluid at discharge pressure is directed through passageways **51** and **52** into chambers **43** and **49** respectively, and thence via interconnecting passageway (not shown) to chambers **46** and **50**. Side plates **35** and **36** responsive to discharge pressure contained in chambers **43**, **46**, **49** and **50** are urged into sealing engagement with the lateral faces of gears **6** and **7** and the end faces of elements **19** and **20** to form a discharge pocket for outlet **18** bounded by the intermesh **8** of the teeth of the two gears, peripherial sealing contact areas **26** and **27** comprising the periphery of the teeth of gear **6** and element **20**, and the periphery of the teeth of gear **7** and element **19**. It has been found that the peripherial sealing between the periphery of the gear teeth and the mating arcuate surfaces of the movable elements **19** and

20 is the critical leakage path with respect to the operation of a gear pump when pumping a fluid medium containing highly abrasive contaminants. This critical peripherial sealing engagement is represented by areas 26 and 27 of FIG. 4. Accordingly, it is to be understood that the embodiment shown utilizing the two side plates 35 and 36 is representative of but one form of providing the fluid sealing discharge pocket 18. It has been found that any form of pressure loaded side plate that will urge the lateral surfaces of the gears and the end surfaces of the movable elements into fluid sealing engagement so as to form the fluidly sealed discharge pocket 18 will perform satisfactorily when pumping highly abrasive contaminant fluids. Accordingly, side plate mechanisms having surfaces in contact with 100% of the lateral surfaces of the pump gears, as exemplified by Roth, Pat. No. 2,420,-622; intermediate housing pressure loading, as exemplified by Gordon, Pat. No. 3,292,550; selective side plate loading, as exemplified by Banker, Pat. No. 2,742,862; or free floating side plates, as exemplified by Trautman, Pat. No. 2,996,999, may all be used with equally satisfactory results so long as the side plate or plates urge the latreal surfaces of the gears and the end surfaces of the movable elements into sealing engagement with the side plates or the mating surfaces of the end plates such that afluidly sealable discharge pocket 18 is formed.

It may be desired to design the pump such that the side plates, as shown in FIG. 4, will seal only an inboard portion of the peripherial sealing surfaces 26 and 27. Such an arrangement would subject only the inboard portion of the peripherial wiping surfaces of elements 19 and 20 to discharge pressure.

Referring to FIG. 7, the minimum area of movable element 20 subjected to discharge pressure $A_{MIN.}$ is defined as that area of the wiping surface 115 subject to discharge pressure at the instant gear tooth 107 disengages from the inner extremity 114 of movable element 20. The maximum area of movable element 20 subjected to discharge pressure $A_{MAX.}$ is defined as that area of the wiping surface 115 subjected to discharge pressure at the instant innermost tooth 108 uncovers cavity 116 at the terminus point 119 to admit discharge pressure into interstice 117. The area of element 20 constantly subjected to discharge pressure A_W is defined as that area opposite the wiping surface 115 of said element 20 commencing at the point of sealing contact 33 of pivot members 22 and 24 and extending toward said plane of symmetry to the point of disengagement 114. Said area is positioned in discharge outlet chamber 18 and is constantly subjected to pump discharge pressure.

It can be seen that the portion of the gears subjected to discharge pressure should be as small as is possible in order to minimize the gear shaft bearing loads. From FIG. 7 it follows that the minimum bearing loads result when simultaneously: (1) $A_W - A_{MIN.} = 0$, and (2) $A_{MAX.} - A_W = 0$. Since it is apparent such a condition is geometrically impracticable, a configuration of movable element 20 is generated where $A_W - A_{MIN.}$ is substantially zero, and $A_{MAX.} - A_W$ results in a net wiping surface area subjected to discharge pressure such that a force is generated whose vector is directed away from the axis of rotation of the mating gear 6. Simultaneously, the contact of gear tooth 108 with the wiping surface during its movement from point 119 to point 114 cancels the moment generated by the sudden introduction of discharge pressure into interstice 117 that tends to pivot movable element 20 about tooth 109. It is clearly apparent if contact pivot point 33 is moved outboard relative to the plane of symmetry the net area producing a force whose vector is directed away from the axis of rotation is decreased, and in the extreme case where A_W exceeds $A_{MAX.}$ a force will be generated whose vector is directed towards the axis of rotation, thus producing an undesirable increase in journal bearing load.

FIG. 5 shows one embodiment of a movable element

20 having a plurality of passageways in continuous fluid communication with outlet discharge chamber 18. The preferred construction, shown in FIG. 5, comprises a movable element 20 having an elongated depression 22 that pivotably engages a mating protrusion 24 that is an integral part of loading member 25 to form pivotable fluid sealing contact point 33. The teeth 108 and 109 of gear 6 engage the wiping surface 115 of movable element 20 to form a fluid sealing contact therebetween. A series of parallel spaced apart slots 118 are formed at the inner extremity 114 of element 20 and extend away from the plane of symmetry to a terminus point 119 to form a fork-like structure at the inner extremity 114 of element 20. Said fork-like structure is so constructed that high pressure fluid is introduced into the outboard gear teeth interstice 117 next to innermost gear tooth 108 as gear tooth 108 passes terminus point 119 and prior to the disengagement of said innermost gear tooth 108 at disengagement point 114. Gear tooth 108 during its movement along wiping surface 115 from point 119 to point 114 as a restraining member to counteract the moment applied to element 20 tending to pivot element 20 about gear tooth 109; the restraining action of gear tooth 108 thereby eliminating the moment tending to lift the outer extremity of element 20 from sealing engagement with the periphery of the mating gear teeth.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made without departing from the spirit and scope of this invention. Accordingly, it is to be understood that this invention has been described by way of illustration rather than limitation.

What I claim is:

1. A gear pump comprising a housing having a bore positioned therein;

intermeshing gears disposed in said bore,

each of said gears having parallel lateral surfaces positioned transverse the peripherial surface of the teeth of said gears,

a low pressure inlet on one side of said intermesh and a high pressure outlet on the opposite side of said intermesh,

a plurality of movable peripherial sealing members each of said movable sealing members having a wiping surface, an oppositely positioned pivot point and a pair of end surfaces positioned transverse said wiping surface,

said plurality of movable peripherial sealing members positioned adjacent said outlet engaging said gears on a one-to-one correspondence and having each of said wiping surfaces fluidly sealingly contacting tips of a plurality of the teeth of said corresponding gear,

at least one pressure loaded side plate urged into engagement with said lateral surfaces of said gears and said end surfaces of said movable peripheral, sealing members to partially form a fluidly sealingly enclosed high pressure outlet with said housing,

each of said pivot points positioned intermediate the point of disengagement of each of said wiping surfaces and the corresponding innermost gear tooth and the simultaneous point of engagement of said wiping surfaces and the corresponding gear tooth located less than the fourth tooth outward from said point of disengagement,

at least one passageway beginning at said point of disengagement of each of said movable peripherial sealing members and extending outboard to a point intermediate said point of disengagement and said pivot point, said passageways in continuous fluid communication with said high pressure such that high pressure is introduced into the outboard gear tooth cavities next to said innermost gear teeth prior to the disengagement of said innermost gear teeth.

2. A gear pump, in accordance with claim 1, includ-

ing loading means responsive to said high pressure urging said movable peripherial sealing members into fluid sealing engagement with the teeth of said gears.

3. A gear pump, in accordance with claim 2, including additional resilient load means independent of pump pressure continuously urging the arcuate wiping surfaces of said movable sealing members into sealing engagement with the teeth of said gears.

4. A gear pump, as defined in claim 2, including loading means having separate integral elongated protuberances contacting each of said movable members, said elongated protuberances engaging mating recesses in said movable sealing members to form said pivot points and produce a line contact high pressure fluid seal at said pivot points.

5. A gear pump, as defined in claim 4, wherein said movable sealing members are continuously urged by spring means toward said gears for peripherial sealing engagement therewith.

6. A gear pump as defined in claim 5, wherein the passageways beginning at said point of disengagement of said movable sealing members comprise a series of parallel spaced apart slots such that said inner extremities of said movable sealing members form a fork-like structure.

7. A gear pump, as defined in claim 6, wherein said pivot points are positioned intermediate said point of disengagement and the point simultaneously generated by the contact of said third outward positioned tooth from said point generated at the instant of tooth disengagement.

8. A gear pump, as defined in claim 3, wherein the tips of at least four teeth of each gear are simultaneously in contact with the wiping surface of their respective movable members.

9. A gear pump, as defined in claim 8, wherein the passageways in said movable members extend outward from said inner extremity to a terminus positioned such that high pressure is introduced into said outboard gear tooth cavity for at least one-half the arcuate distance of a gear tooth interstice prior to the disengagement of said innermost gear tooth.

10. A gear pump of the type described comprising a housing enclosing a chamber;

an intermeshing driver and a driven gear supported on parallel axes of rotation and disposed in said chamber;

each of said gears having a pair of lateral surfaces positioned transverse said axes of rotation;

a plane of symmetry located intermediate and equidistant said axes of rotation containing said point of intermesh and positioned transverse a plane containing said axes of rotation;

a plurality of movable peripherial sealing members

each of said sealing members having a wiping surface, an oppositely positioned pivot point and a pair of end surfaces positioned transverse said wiping surface;

first and second movable peripherial sealing members engaging said driver and driven gears respectively such that the wiping surface of said first member fluidly sealing engages the tips of a plurality teeth of said driven gear and is positioned on one side of said plane of symmetry, said second sealing member and driver gear a mirror image of said first member, and said driven gear is positioned on the opposite side of said plane of symmetry;

at least one pressure loaded side plate urged into engagement with said lateral surfaces of said gears and said end surfaces of said peripherial sealing members to partially fluidly sealingly divide said chamber on opposite sides of said intermesh into a high pressure portion and a low pressure portion;

each of said movable sealing members having a point of disengagement positioned substantially adjacent the high pressure point of said intermesh and wiping surfaces extending from said point of disengagement away from said plane of symmetry along the circumference of said gear teeth to a terminus to thereby form a continuous wiping surface circumscribing an arc of less than 180°, said pivot points positioned intermediate said points of disengagement and the point established by the instantous point of engagement of the third tooth from said disengagement tooth away from said plane of symmetry;

at least one opening extending from said point of disengagement and providing continuous fluid communication with said high pressure chamber such that high pressure is introduced into the gear interstices next to said innermost gear teeth away from said plane of symmetry prior to the disengagement of said innermost gear teeth.

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HENRY F. RADUAZO, Primary Examiner

U.S. Cl. X.R.

91—87; 123—12; 418—108