Oct. 1, 1968 H. M. CLARK ET AL 3,403,630

POWER STEERING PUMP

Filed Dec. 22, 1966 4 Sheets-Sheet 1

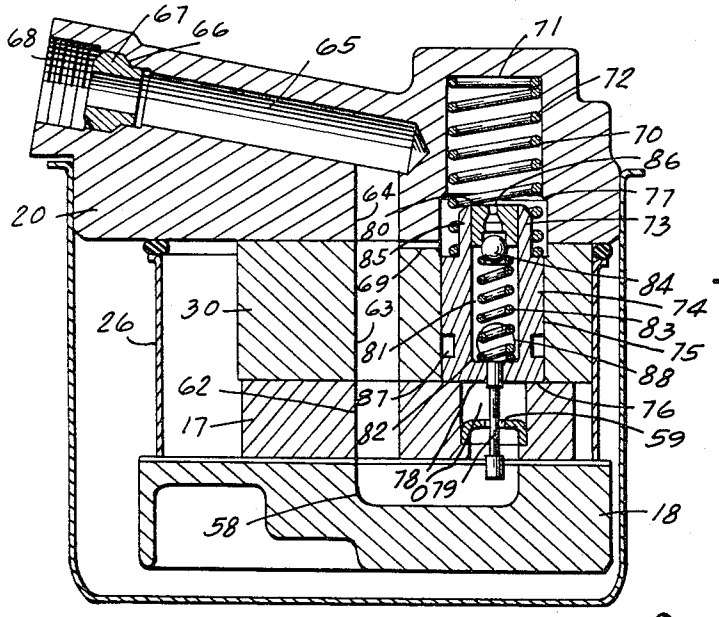


Fig. 2

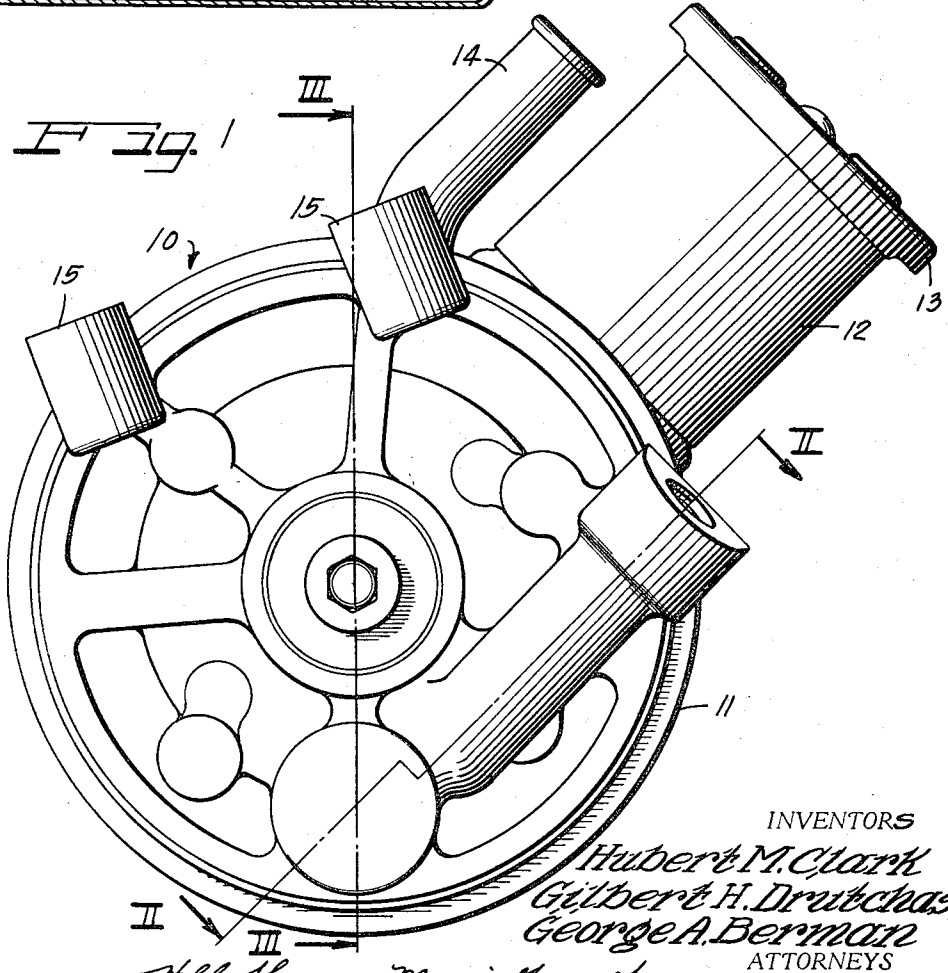


Fig. 1

INVENTORS
Hubert M. Clark
Gilbert H. Drutchas
George A. Berman

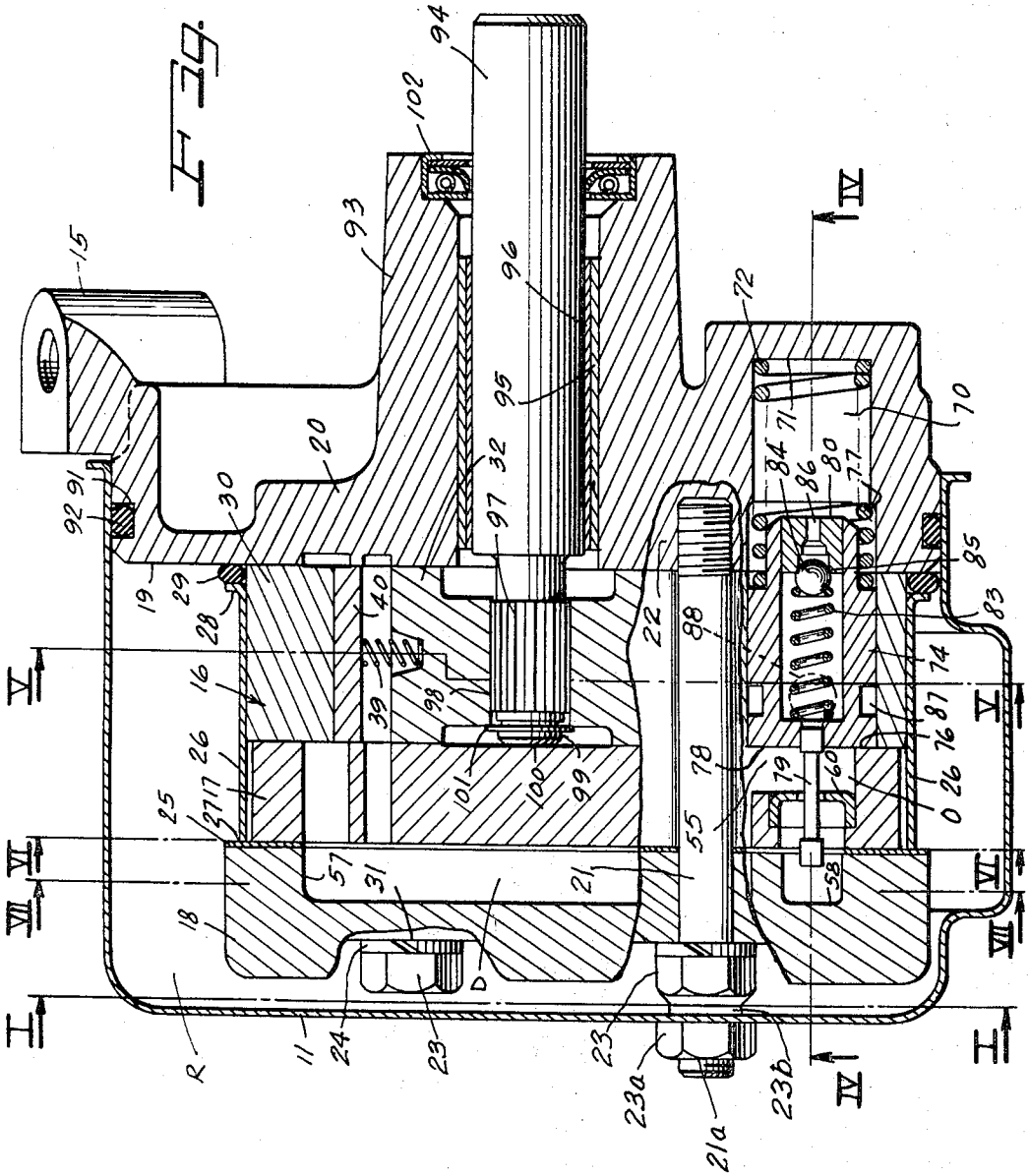
BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Oct. 1, 1968 H. M. CLARK ET AL 3,403,630

POWER STEERING PUMP

Filed Dec. 22, 1966 4 Sheets-Sheet 2

Fig. 3



INVENTORS

Hubert M. Clark

Gilbert H. Drutchas

George A. Berman

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Oct. 1, 1968 H. M. CLARK ET AL 3,403,630

POWER STEERING PUMP

Filed Dec. 22, 1966 4 Sheets-Sheet 3

Fig. 4

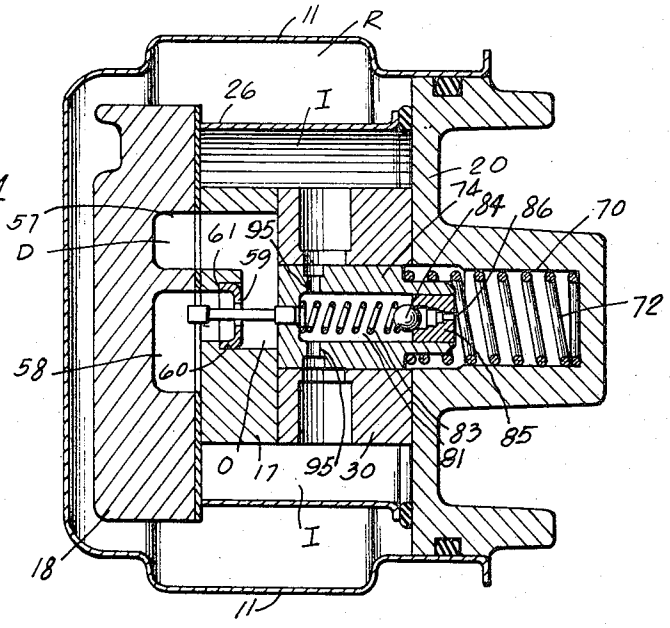
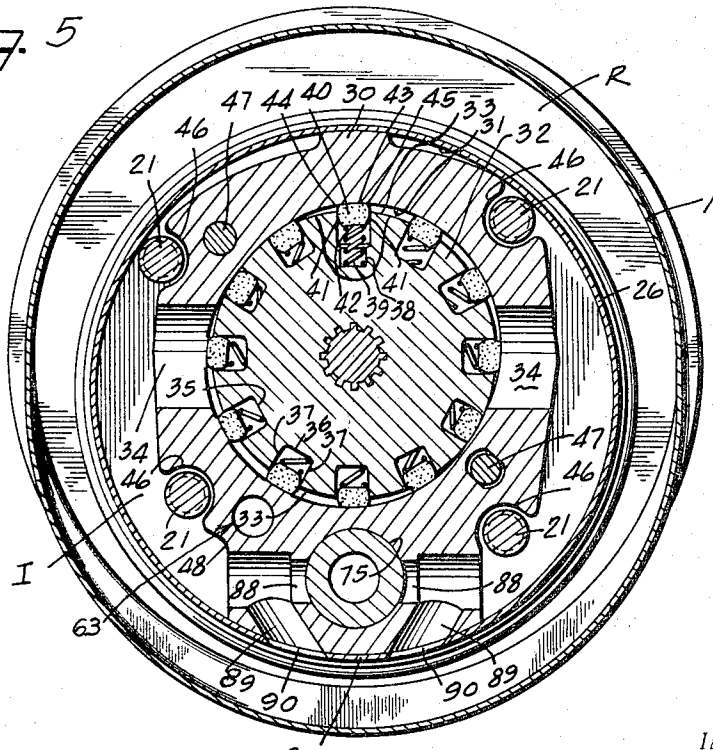


Fig. 5



INVENTORS
Hubert M. Clark
Gilbert H. Drutchas
George A. Berman

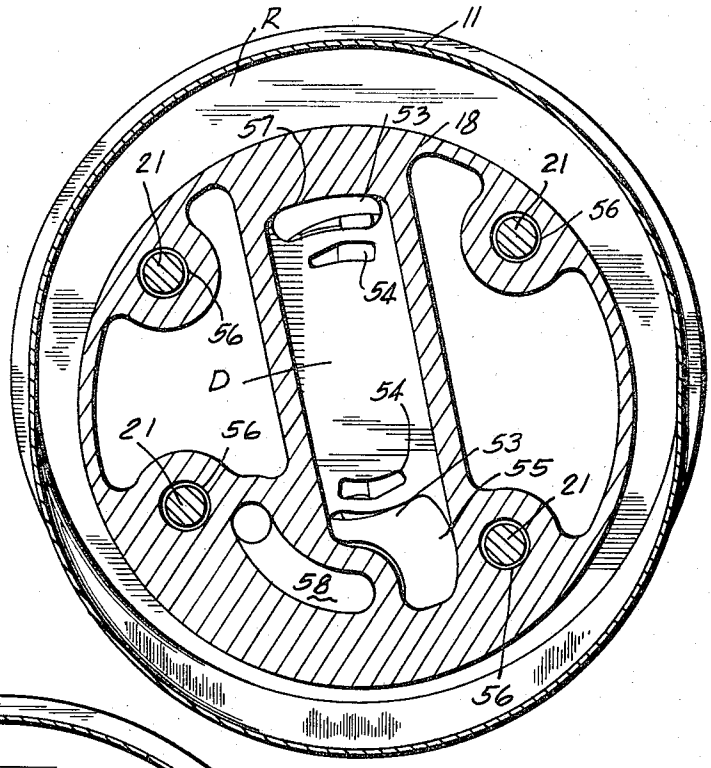
BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

Oct. 1, 1968 H. M. CLARK ET AL 3,403,630

POWER STEERING PUMP

Filed Dec. 22, 1966 4 Sheets-Sheet 4

Fig. 7



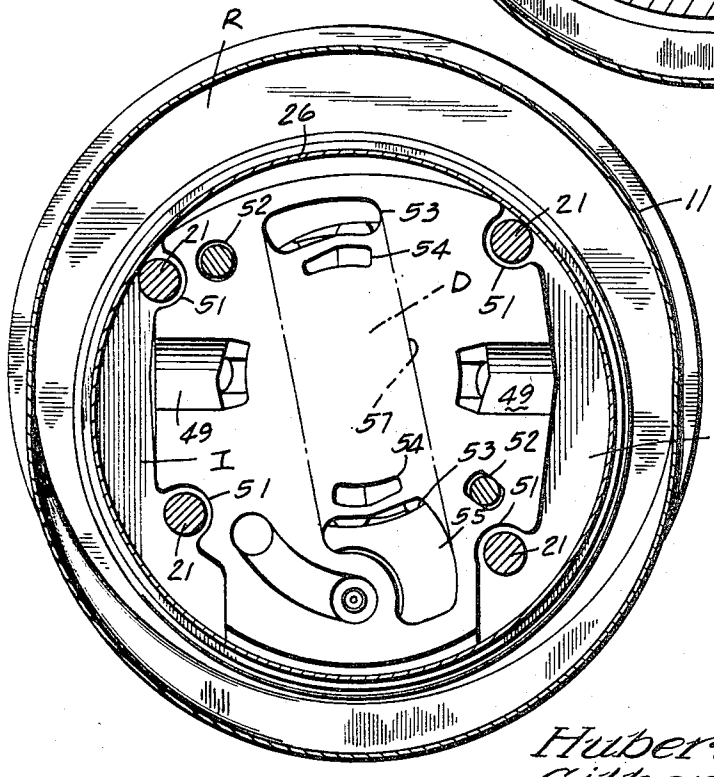


Fig. 6

INVENTORS
Hubert M. Clark
Gilbert H. Drutchas
George A. Berman

BY Hill, Sherman, Meroni, Gross & Simpson ATTORNEYS

United States Patent Office 3,403,630 Patented Oct. 1, 1968

3,403,630

POWER STEERING PUMP

Hubert M. Clark and Gilbert H. Drutchas, Birmingham, and George A. Berman, Detroit, Mich., assignors to TRW, Inc., Cleveland, Ohio, a corporation of Ohio

Filed Dec. 22, 1966, Ser. No. 603,808
12 Claims. (Cl. 103—42)

ABSTRACT OF THE DISCLOSURE

This invention relates generally to pumps of the so-called slipper-type utilizing peripherally notched rotor carrying slippers which are free to move radially and rock angularly in following the cylinder wall of a pumping chamber and more specifically to a multiple pumping element pump wherein slipper engagement with the cylinder wall is provided by the slippers between the working chambers of the pump, thereby eliminating the necessity of a tangent seal between the rotor and the pump body. The pump is further characterized by a pressure-loaded stackup of parts wherein the strain on the components of the stackup of parts is relieved by axially extending retainer bolts. The end cap of the stackup has a crossover passage affording a balanced pump arrangement.

Background of the invention

(1) *Field of the invention.*—The invention pertains to improvements in positive displacement pumps having a variable chamber operating characteristic.

(2) *Description of the prior art.*—The prior art pertinent to the present invention is exemplified by the Clark and Drutchas Patent 3,200,752, issued Aug. 17, 1965, and also the Clark and Drutchas Patent 3,273,503, issued Sept. 20, 1966. The present invention distinguishes over such earlier developments through the provision of a slipper-type pump wherein the pressure seal between the pump inlet and outlet is accomplished by slipper position afforded through a multiple pumping element slipper arrangement. The slippers of the present invention are also of a simple symmetrical construction so they can be readily cut from a continuous extrusion. Strain on the components of the pressure-loaded stackup of parts is relieved by axially extending retainer bolts and the end cap of the stackup has a crossover passage affording a balanced pump arrangement.

Summary

The pump of the present invention is particularly characterized by a stackup of parts arranged in an axial row relative to a housing flange having a flat face and a plurality of axial bolts extend through the stackup of parts and are attached to the housing for absorbing hydraulic reaction of the pump. A large number of slippers of simple symmetrical construction are provided so that at least two slippers are in sealing engagement with the bore wall between the inlets and outlets of a double-lobed pump, thereby eliminating the necessity of a tangent seal between the rotor and the casing.

Brief description of the drawings

FIGURE 1 is an end view of a pump provided in accordance with the principles of the present invention taken on the plane of line I—I of FIGURE 3;

FIGURE 2 is a cross-sectional view taken on line II—II of FIGURE 1;

FIGURE 3 is a cross-sectional view taken generally on line III—III of FIGURE 1;

FIGURE 4 is a reduced cross-sectional view taken generally on line IV—IV of FIGURE 3;

FIGURE 5 is a reduced cross-sectional view taken generally on line V—V of FIGURE 3;

FIGURE 6 is a reduced cross-sectional view taken generally on line VI—VI of FIGURE 3;

FIGURE 7 is a reduced cross-sectional view taken generally on line VII—VII of FIGURE 3.

Description of the preferred embodiment

For the purpose of illustrating the principles of the present invention, a particularly useful application is made when the pump is incorporated in a hydraulic power assisting arrangement such as a power steering system of a dirigible vehicle. Thus, it is contemplated that a power steering pump shown generally at **10** is provided and the pump has a can reservoir **11** formed with a filling spout **12** closed by a cap **13**, thereby permitting the can reservoir **11** to be filled with a requisite supply of fluid. The pump is further characterized by an oil return spout **14** which is adapted to return spent fluid from a point of utilization back to the reservoir, and a pair of threaded bosses **15** for mounting the pump in a vehicle.

As will be noted upon referring to FIGURE 3, the pump of the present invention is particularly characterized by a stackup of parts including in a longitudinal row a pumping element cartridge **16**, a pressure plate **17** and a cover plate **18**. The pumping element cartridge **16** and the pressure plate **17** are held in axial alignment in a sandwiched arrangement between the cover plate **18** and a flat face **19** of a housing flange **20** by means of a bolted assembly which includes a stud bolt **21** extending through the stackup of parts and threadedly connected to the housing flange **20**, as generally shown at **22**. The other end of the stud **21** carries a nut **23** and a lock washer **24** which snugly fit against the cover plate **18** for maintaining the sandwiched arrangement at the stackup of parts. One of the studs **21** has a portion **21***a* extending through the can reservoir **11** and carrying a nut **23***a* for maintaining the position of the can reservoir **11** relative to the stackup of parts. A boss **18***a* is provided on the cover plate **18** and a gasket **23***b* is shown between the boss **18***a* and the can **11** as well as under the nut **23***a*.

The cover plate **18** and the pressure plate **17** are separated by a thin gasket member **25** which may consist of any suitable gasketing material with the requisite elasticity and physical properties contemplated by the present invention. A thin, flexible shell member **26** surrounds the peripheries of the pumping element cartridge **16** and the pressure plate **17** and has one of its ends sealingly abutting the gasket member **25** as generally shown at **27**, and has its other end **28** formed as a radially outwardly turned portion engaging a sealing member **29** which effects a pressure seal between the housing flange **20** and the shell member **26**. The primary function of the stud bolt arrangement is to absorb any hydraulic reaction of the pump. The bolt torque tension in sandwiching the pumping element cartridge **16** and the pressure plate **17** between the cover plate **18** and the flat surface **19** of the housing flange **20** need be only such as to prevent bolt loosening. The use of the bolts eliminates the necessity of using a strong thick casing since the bolts **21** take the strain off of the parts of the stackup.

In accordance with the principles of the present invention, leakage between the components of the stackup of parts is not dependent upon the axial force created by the bolt tension.

Referring specifically to FIGURE 5, the pumping element cartridge **16** is shown in greater detail and constitutes a generally ring-shaped member **30** having an irregularly shaped axial bore forming a bore wall or cylinder wall **31**. The axial bore or cylinder wall **31** assumes the general cross sectional configuration of an

oval and, in cooperation with a circular rotor **32** disposed therein, prescribes pumping chambers at the respective oblong ends as shown generally at **33**.

The rotor **32** is generally cylindrically shaped and has a plurality of peripheral notches shown generally at **35**. Each specific notch includes a bottom wall **36** and substantially parallel side walls each indicated at **37**. The bottom wall **36** has a recess **38** in which is bottomed a coil spring **39** adapted to continuously bias a slipper element shown generally at **40** radially outwardly to a sealing engagement with the adjoining cylinder wall **31**.

In accordance with the principles of the present invention, the slippers **40** are of a specific structural shape in that each slipper member is an elongated extrusion which in cross section is somewhat rectangular and having a pair of curved walls shown at **41** which are oppositely disposed and an arcuate inner wall **42** for bottoming one end of the bias spring **39**, and permitting the spring to move freely and an arcuate outer wall **43**. Thus the inner side walls **41** and the outer wall **43** of each respective slipper meet at points indicated at **44** and **45**. Referring now to the inner walls **41**, it will be noted that the diameter of curvature is substantially equal to the width of a corresponding notch **35**. The size of the slipper is controlled so that each slipper **40** is free to move radially and rock angularly with respect to the notch **35** and the rotor **32** in following the contour of the cylinder wall **31**.

Each arcuate surface **43** extending between the points **44** and **45** is of a curvature substantially the same as the curvature of the cylinder wall **31**. However, the curvature of the arcuate surface **43** is just slightly less than the curvature of the joining cylinder wall **31** in order to attain the classic Kingsbury effect, namely, a film of oil is introduced under the leading edge of the slipper, thereby permitting the arcuate surface to ride on a film of oil. The cross section of the slipper **40** is further characterized as being entirely symmetrical from top to bottom, and may be formed by merely cutting an extrusion to the proper selected length.

As contemplated by the present invention, a multiple pulse arrangement is achieved since there is alway a slipper **40** in sealing engagement with the cylinder wall **31** exposed in the pumping chamber **33** at any rotatable position of the rotor **32** between the inlet and the outlet. This provides a good seal and eliminates the necessity of providing tangential seals between the rotor and the adjoining pumping chamber wall, thereby allowing greater tolerances between the rotor **32** and the cylinder wall **31**.

It will be noted that the ring member **30** has peripheral recesses shown generally at **46** for receiving the studs **21** and is further provided with openings for receiving dowel pins shown generally at **47**.

The outer peripheral surface of the ring **30** also has a portion **48** which projects radially outwardly at one side and in which are formed the discharge passages and flow control valve cavity in accordance with the principles of the present invention. Peripheral portions of the ring member **30** are surrounded by the shell member **26**, thereby forming a pump inlet zone I which is filled with pumping media.

Referring to FIGURES 2, 3, 4 and 6, the peripheral extent of the pressure plate **17** is such that the inlet zone I surrounds portions thereof. The pressure plate **17** is provided with a pair of radially inwardly projecting openings **49** to provide side inlets to the notches **35** at a point radially inwardly of the slippers **40**. A plurality of peripheral recesses **51** accommodate the stud bolts **21** and a pair of openings **52** receive corresponding dowel pins. The dowel pins extend substantially throughout the stack of parts and anchor in the flange member **20** thereby providing means for maintaining axial alignment of the stackup of parts.

The pressure plate **17** also has a major and minor pumping chamber outlet designated at **53** and **54**, respectively, and which communicate with the pumping chamber **33** and the notches **35**, respectively. One of the major ports **53** is formed with a radially outward extension shown generally at **55**.

Referring to FIGURE 7 the cover plate **18** is of substantially circular construction having sufficient diameter to protrude radially outwardly beyond the end of the flexible shell member **26** as best seen in FIGURE 6, thereby providing an end wall for the inlet zone I. Circumferentially spaced openings **56** are provided through which pass the axial stud bolts **21**. The cover plate **18** is provided with a recess or crossover passage **57** which in cooperation with the underlying pressure plate **17** prescribes a discharge zone D and interconnects the diametrically opposed outlets **53** and **54**. The discharge zone D is of sufficient extent whereby the pressure acting upon the exposed portion of the pressure plate **17** will pressure load the stackup of parts into a nonleaking assembly.

Referring to FIGURE 4, it will be seen that the pressure zone D in the recess **57** formed in the cover plate **18** is in fluid communication with an outlet zone designated at O which is formed by the passage **55** in the pressure plate **17**. The outlet zone O has an orifice outlet formed in an orifice plate member **60** which is press fit in a recess formed in the pressure plate **17** as shown generally at **61**. The outlet orifice **59** opens to a discharge passage opening in the cover plate **18** as a passage **58**. An opening **63** formed in the ring member **30** is in alignment with the opening **62**. The discharge passage is further defined by a recess **64** formed in the housing flange **20** which is intersected by an angled passage **65** counterbored at **66** to receive a fitting **67** and partially threaded as at **68** so that a conduit may be connected thereto for carrying pump generated pressure to a point of utilization.

The ring member **30** has formed therein a notch **69** which intersects with a separate series of passages formed in the stackup of parts and provided for housing a control valve assembly. In this regard it will be noted that the flange **20** has formed therein a recess **70** having a flat bottom **71** for bottoming one end of a coil spring **72**. The other end of the coil spring **72** overlaps a shoulder **73** of a valve member **74** which is slidably guided in an axial opening **75** formed in the ring member **30**. It will be noted that a valve stop is provided by the abutting surface of the pressure plate **17** which forms a shoulder relative to the opening **75**, as shown at **76**. A valve shoulder **77** is formed in the recess **70** on the other side of the valve member **74**.

The valve member **74** has formed therein a flat surface as shown at **78** from which projects a valve stem **79** which extends through the outlet orifice **59**. The slotted passage **69** communicates discharge pressure to the chamber defined by recess **70** and to a side **80** of the valve member **74**.

Pump generated pressure in discharge zone D is communicated to the outlet zone O which acts upon surface **78** of the valve member **74**. Thus, it will be appreciated that the pressure upstream of the outlet orifice is in communication with surface **78** of the valve member **74** while the downstream pressure is in pressure communication with the other side of the valve member **74**.

The valve member **74** has formed therein a recess **81** having a flat bottom **82** for bottoming one end of a coil spring **83**. The other end of the coil spring **83** engages a ball valve **84** which normally engages a plug adjustably press fit in the valve member **74** to form a valve seat **85** thereby to regulate flow of fluid through a passage **86**.

The valve member **74** is peripherally recessed to form an annulus at **87** to provide a control land for regulating the intercommunication of the outlet zone O with a pair of outwardly extending openings designated at **88**. As best seen in FIGURE 5 the openings **88** discharge into inlet zone I.

In this regard the ring member is provided with a pair of angularly disposed aspirating passages **89**, each of which intersects a corresponding passage **88**, and angles downwardly into a convergent disposition so that the

opposite ends of the aspirating passages **89** lie in register with an opening **90** formed in the shell member **21**. The aspirating flow which results assists in keeping the inlet zone I filled with fluid to be acted upon by the pumping unit.

As shown in FIGURE 3, the housing flange **20** is recessed at **91** to receive and seat a sealing gasket **92** which engages and seals against the reservoir can **11** and against the flange **20**. Thus, a reservoir R surrounds the stackup of parts. It will be understood that a spout **14** (FIGURE 1) can be provided for connection to a return line so that spent fluid may be returned to the reservoir from the point of utilization.

Referring specifically to FIGURE 3, the housing flange is seen to have a boss means **93** which along with a main body portion has formed therein an opening **94** for carrying a shaft bushing shown generally at **95** and characterized by a sleeve-like shell having a bearing liner **96**. The shaft **94** has a splined portion shown generally at **97** connected to the rotor **32** at **98** and has an extension **99** which has a flat radial surface **100**. The flat surface **100** engages one radial wall of the pressure plate **17** thereby permitting the pressure plate **17** to absorb thrust loads. The shaft **94** is retained in assembly with the rotor **32** of the pumping element cartridge by means of a snap ring **101**.

A shaft seal is shown generally at **102** and is contained in the end of the boss **93**. The outer end of the shaft **94** may be connected to a driving source for example a pulley having a drive connection to the V-belt drive of an automotive engine.

In operation, the outlet flow from the pumping chambers **33**, passes through the pressure plate outlets **53** and **54** which lie in register with the cover plate recess **57** prescribing the discharge zone D. The flow from one of the diametrically opposed pairs of outlets comprising openings **53** and **54** crosses over through the passage formed by the recess **57** to the other outlets where the flow commingles and passes to the outlet zone O which is formed by the radially outwardly extending portion **55** of the outlet **54**.

From the outlet zone O where the fluid is in pressure communication with one side **78** of the valve member **74**, the fluid passes through the outlet orifice **59** into the discharge passage formed by openings **58, 62, 63, 64, 65** and hence to the discharge opening **68**. Fluid under pressure downstream from the outlet orifice is communicated to the other side **80** of the valve member **74** through the notched opening **69**.

Thus, it will be understood that upstream and downstream pressures referred to the outlet orifices **59** are communicated to opposite sides of the valve member **74**. The movement of the valve member **74** in response to the differential pressure opens or closes the bypass passage **88**. Since the differential pressure is a function of flow through the orifice **59**, the valve response thereto provides an effective means for regulating the flow through the orifice outlet **59** and hence to the point of utilization as, for example, a power steering unit.

Excess flow causes a pressure buildup on the flat side **78** of the valve member **74** forcing the valve member **74** against the bias spring **72** until the bypass passages **88, 88** are cleared causing the excess flow to dump into the bypass passages **88, 88** and to the return inlet zone I.

The bypass passages **88, 88** are intersected by aspirating passages **89, 89** which are in register with makeup passages **90, 90**. There is thus produced an aspirator effect which insures filling from the inlet areas of the inlet zone I with sufficient supply of fluid. The combined makeup oil and bypass flow discharges into the inlet zone I which floods the radial inlets **34, 34** and the side inlets **49, 49**.

Fluid at pump generated pressure in the discharge zone acts on the exposed pressure plate **17** which forms the bottom of the pressure zone D thereby assisting in holding the stackup of parts together and eliminates the necessity for additional sealing means since the parts can be retained in face to face sealing engagement with one another. In other words, as soon as the pump begins to operate and pump generated discharge pressure is communicated to the pressure zone D, it will be evident that sealing, accomplished by surface-to-surface face seals, is actuated by the pressure in the pressure zone D squeezing the parts of the cartridge assembly together thereby minimizing the need for elastic sealing members to prevent leakage and bolts or other fasteners to hold the stackup assembly together.

A relief valve function is developed by the valve construction as shown specifically in FIGURE 4. Thus, the pressure in the recess **70** acts through the passage **86** and the valve seat **85** on the ball **84** against the spring **83** when the spring force, suitably adjusted by press fitting the plug **85**, is overcome, pumping fluid flows through the passage **86** around the ball **84** and into the annulus **87**. From thence the fluid passes through the bypass passages **88, 88** and zone I. Since all of the passages are greater in area than the notch or slotted passage **69** which feeds the recess **70**, the pressure will drop in recess **70** below that of the zone O. Thus, the valve member **74** will move against its loading spring **72** and will open the zone O to the zone I through the bypass passages **88, 88**, thereby bypassing excess oil.

Although various minor 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 to the art.

We claim as our invention:

1. In a pump,

a stackup of parts including:

a housing flange having a flat face,

a ring part having one side axially abutting said housing flange and having a contoured bore wall forming a pump chamber,

said ring part having inlet areas to said pump chamber,

a pressure plate on the other side of said ring part having formed therein outlet areas,

a cover plate abutting the other side of said pressure plate and having recesses in register with said outlet areas for directing fluid from said outlet areas to a discharge passage,

a thin sheet form member shaped to form a shell surrounding the said ring part and the said pressure plate and cooperatively arranged with the said ring part and said pressure plate to form an inlet zone, and having its respective ends in abutment with the said flat face and the said cover plate,

a notched rotor in said ring part having a slipper means in the notched portion free to move radially and rock angularly in following the bore contour to move fluid from the said inlet areas to the said outlet areas,

means to rotate said rotor comprising a rotatable shaft connected to said rotor,

and support means for journalling said rotor.

2. In a pump as defined in claim **1**,

said pressure plate having radially inwardly extending passages for directing fluid from the said inlet zone to the said pumping chamber at a point radially inwardly of the said slipper means,

the said ring member having radial inlet passages for directing fluid from the said inlet zone to said inlet area of the said pumping chamber.

3. In a pump as defined in claim **1**,

said pressure plate having pairs of outlets extending axially therethrough,

one of said outlets disposed to receive pump generated fluid from the periphery of the said rotor,

the other of the said outlets disposed to receive pump generated fluid from the said notches.

4. In a pump as defined in claim 1,
said ring parts having a portion radially outwardly of said bore wall formed with an axial opening, and
a flow regulator valve in said axial opening.

5. In a pump as defined by claim 1,
said pressure plate being piloted on the end of said shaft and abutting the end of said shaft to absorb shaft thrust loads,
and a plurality of axial bolts extending through the said stackup of parts and attached to the said housing flange for absorbing hydraulic reaction of the pump.

6. A pump comprising:
a ring member formed with a cylinder wall prescribing a pumping chamber,
said ring member having radial inlets in communication with said pumping chamber,
a rotor in said pumping chamber having peripheral notches formed therein,
slipper means in said peripheral notches free to move radially and rock angularly in following the cylinder wall upon rotation of the rotor,
a housing member providing a flat radial wall abutting one side of said ring member,
a pressure plate having one side abutting the other side of said ring member and having axial outlet ports formed therein,
said outlet ports in register with said pumping chamber,
a cover plate having a radial wall abutting the other side of the said pressure plate,
said cover plate having recesses formed therein in register with said outlet and cooperably arranged with said pressure plate to form a pressure zone adjacent the said pressure plate,
a thin shell member surrounding the peripheries of the said ring member and the said pressure plate and having its respective ends abutting the said housing member and the said cover plate,
said shell member spaced radially outwardly of portions of said ring member and said pressure plate wherein the space prescribed by the interior of said shell member and the peripheries of said ring member and said pressure plate constitutes an inlet zone,
a shaft journalled in said housing and corotatably connected to said rotor for rotatably driving said rotor to move fluid from said inlets in said ring member to said outlet ports,
said ring member and said pressure plate having an axially extending discharge passage formed therein,
said housing having a radially directed outlet port formed therein for connection to a point of utilization,
means forming a reservoir around said ring member, said pressure plate and said cover plate,
said shell member having makeup openings in communication with said inlet zone to supply pumping fluid thereto,
and means for maintaining axial alignment of the said housing member, said ring member and said pressure plate and said cover plate.

7. A pump as defined in claim 6,
said ring member having bypass passages formed therein,
said pressure plate and said ring member having a valve bore extending axially therethrough,
said valve bore having a valve axially movable therein to control the discharge of overflow excess from said discharge zone into said bypass passages and said discharge passage having a flow restricting orifice contained therein,

the downstream side of said orifice being in communication with one side of said valve thereby to control the operation of the valve as function of flow.

8. A pump comprising:
a ring member and a pressure plate sandwiched between a housing flange and a cover cap member, all disposed in an axial row,
a shaft journalled in said housing flange and having a peripherally notched rotor in said ring member,
said rotor carrying slipper means in the peripherally notched portion free to move radially and rock angularly in following the cylinder wall of the ring member,
a thin shell member surrounding the said ring member and said pressure plate and having its respective ends abutting the said housing flange and said cover cap member,
the interior of said shell member prescribing an inlet zone surrounding said plate members,
said cover cap member having recesses therein prescribing a high presure discharge zone adjacent said pressure plate,
said pressure plate having an outlet port extending in an axial direction communicating said pump chamber with said discharge zone to discharge pump generated pressure into said discharge zone,
said plate members and said housing flange having an axially extending discharge passage formed therein for conducting fluid from said discharge zone to a point of utilization,
a flow control valve extending axially through said plate members and having one end thereof subject to said discharge pressure zone and having the opposite end thereof communicating with the pressure in said discharge passage,
said discharge passage having a flow orifice therein, whereby said flow control valve regulates the flow of fluid from said discharge zone to said inlet zone as a function of flow through the discharge passage,
and means for maintaining axial alignment of the said plate members with respect to the said housing flange and the said cover cap member.

9. A pump as defined in claim 6,
said shell member having a makeup opening formed therein,
one of said plate members having bypass passages formed therein controlled by said flow control valve and further including aspirating passages formed therein intersecting said bypass passages and opening adjacent said makeup passage to induce an aspirating flow through said makeup passage into said inlet zone, and
means forming a reservoir surrounding said plate members and said cover cap member and flooding said makeup opening with fluid.

10. In a pump as defined in claim 1,
said rotor having sufficient number of slippers and disposed to provide at least two slippers in sealing engagement upon the said bore wall between the said inlets and the said outlets at any rotatable position of the rotor relative to the said bore wall.

11. In a pump as defined in claim 1,
said slippers formed in the configuration of elongated extrusions having a symmetrical cross section and having an arcuate face disposed to follow the contour of the said bore wall.

12. In a pump, stackup of parts comprising in an axial row:
a housing plate,
a pumping element cartridge,
a pressure plate,
a cover plate having recesses formed therein and co-

operatively arranged with the said pressure plate to form a high pressure zone,

means for maintaining axial alignment of the said stack-up of parts,

a thin sheet form member surrounding the said pumping element cartridge and said pressure plate and forming in cooperation with the peripheries of said pumping element cartridge in said pressure plate a low pressure inlet zone,

said stackup of parts being maintained in axial position by means of a bolted assembly arrangement including:

a plurality of studs extending axially through the said stackup of parts and each respective stud having one end fixedly attached to said housing,

a nut adjustably carried by the other end of each of the said studs,

and wherein the alignment of parts of the said stackup of parts is maintained by dowel pins extending axially through the said stackup of parts,

whereby pressure in the high pressure zone squeezes the parts comprising the stackup of parts into an operative assembly without the need of additional fasteners.

References Cited

UNITED STATES PATENTS

3,125,028	3/1964	Rohde	103—42
3,175,506	3/1965	Erdmann	103—136
3,184,156	5/1965	Welch et al.	103—136 X
3,273,503	9/1966	Clark et al.	103—42

FRED C. MATTERN, JR., *Primary Examiner.*

W. J. KRAUSS, *Assistant Examiner.*