Sept. 6, 1966 R. L. ALLEN 3,270,674

VARIABLE DISPLACEMENT PUMP

Original Filed Dec. 19, 1957 3 Sheets-Sheet 1

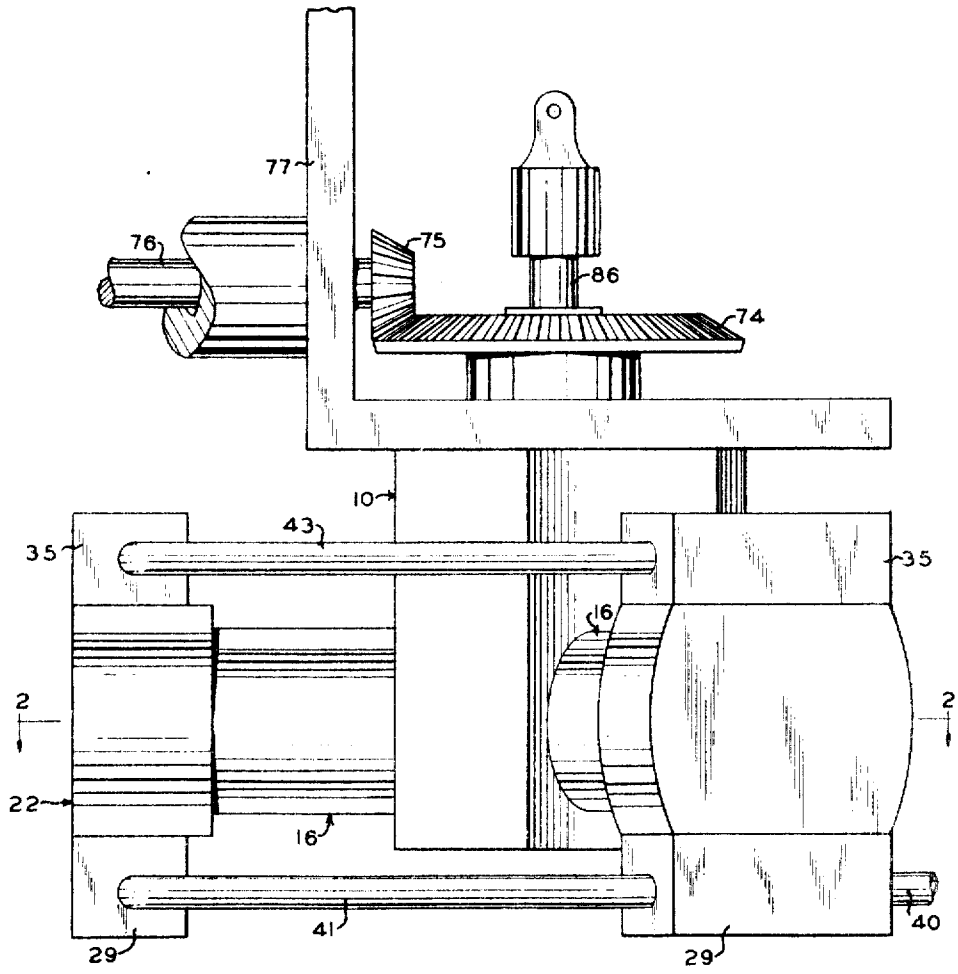


FIG. 1

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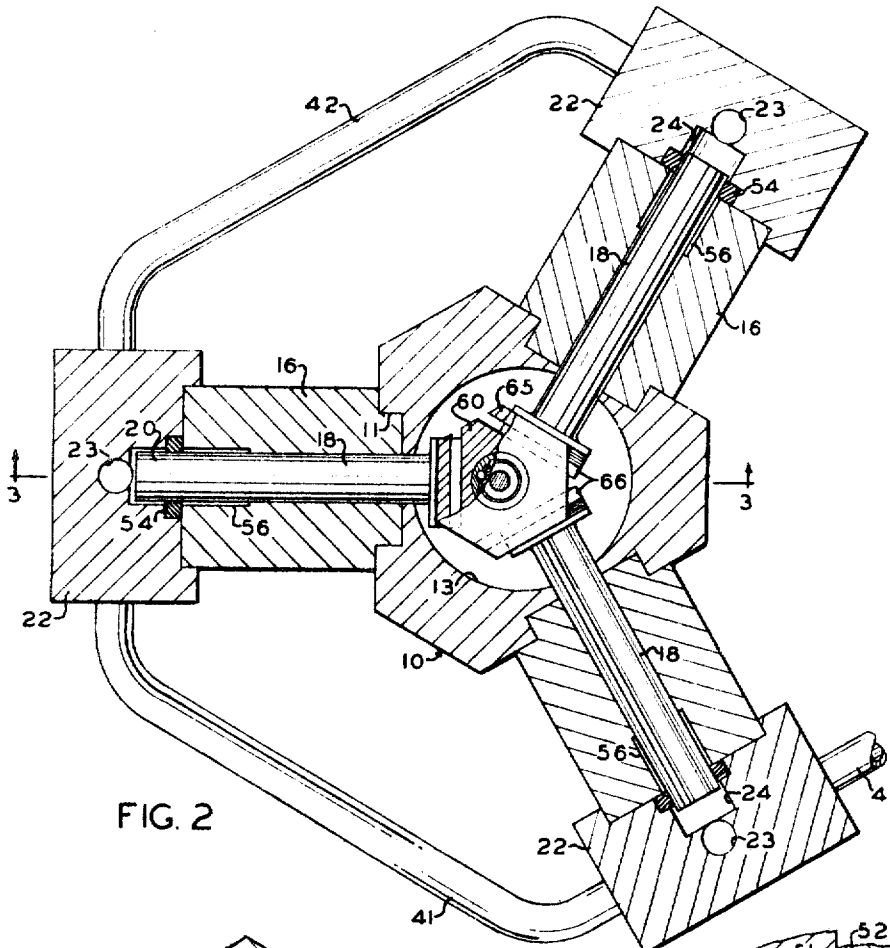


FIG. 2

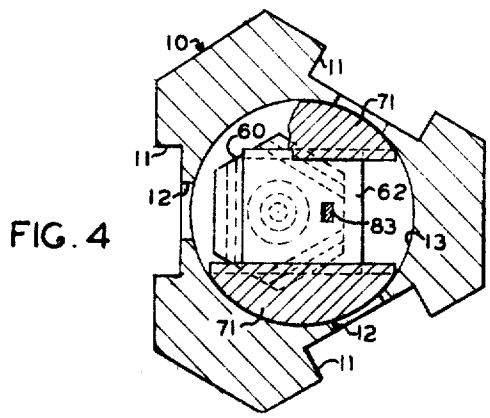


FIG. 4

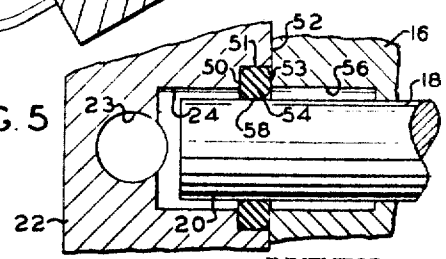


FIG. 5

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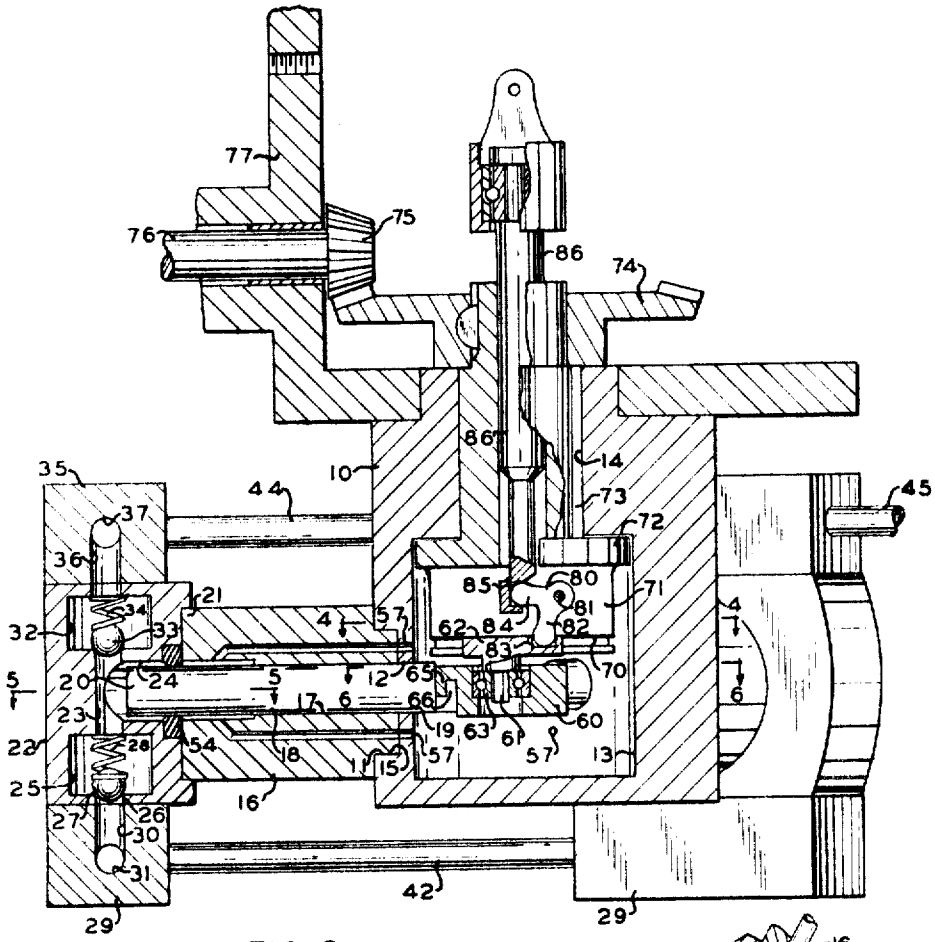


FIG. 3

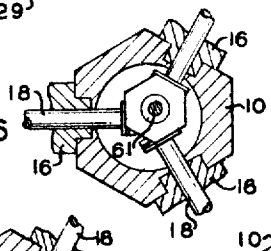


FIG. 6

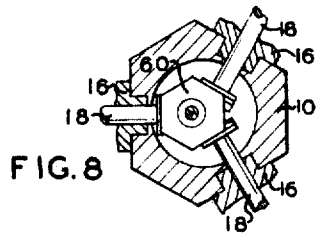


FIG. 8

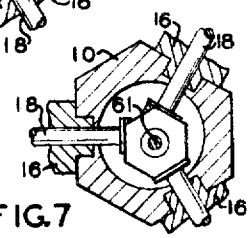


FIG. 7

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United States Patent Office 3,270,674 Patented Sept. 6, 1966

3,270,674

VARIABLE DISPLACEMENT PUMP

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Continuation of application Ser. No. 703,898, Dec. 19, 1957. This application May 31, 1963, Ser. No. 284,492
2 Claims. (Cl. 103—38)

This invention relates to a variable displacement pump, and is particularly concerned with rotary-driven multiple-piston pumps wherein the volumetric output may be readily varied during operation and independently of driven speed.

This application is a continuation of my copending application, Serial No. 703,898, filed December 19, 1957, for Variable Displacement Pump, now abandoned.

It is of course recognized that there are many and various types of rotatably driven piston type pumps. For the most part such pumps are of constant displacement by virtue of the constantly uniform pump piston stroke. Furthermore, it is customary in such pumps to have but a single piston and cylinder, or tandem type multiples thereof, and hence the load imposed from the driving shaft fluctuates between the peak pump stroke load and the return movement of the piston. Such fluctuation of course imposes a spasmodic load, causing chatter, vibration and undue wear. Problems also arise with respect to the effect of an efficient sealing and/or packing of the cylinder or piston in such pumps.

While the present inventive concept may be widely varied as to structure and design to meet differing requirements, that form of the invention here shown by way of illustration may be generally defined as including a central body and an odd number of radially disposed piston and cylinder units, here shown as three, arranged at equal radial angularity about said central body. It will of course be recognized that an even number of radial piston assemblies may be used. The odd number, however, is preferable as providing harmonic balance. Five pistons have been successfully employed where the pump has been used as a fuel pump for an eight cylinder engine. Coaxially arranged within said body there is provided a rotary drive member which mounts and rotates therewith a radially adjustable slide including a driving stud. For adjusting the radial relation of the slide and drive stud with respect to the center of rotation of said member, a vertically reciprocable thrust control rod is mounted for rotation with, and axial movement with respect to, the rotary drive member. At the lower end of the control rod, means are provided by which the radial disposition of the stud will respond to the vertical position of the thrust control rod. The stud is engaged with a piston operating head mounted for orbital movement in response to like movement of the stud, the radius of such movement being under the control of the thrust control rod. The head is formed with three piston engaging ways, each engaging a radially reciprocating piston mounted in equally angular radial cylinders. Thus as the drive member rotates, the head will move in its orbital path to reciprocate the pistons, the amplitude of such piston movement being determined by the radial setting of the plate stud and head. In the present form of the invention, each of the piston and cylinder units is supplied from a single source, and the outlet for each cylinder is connected so that the three pump units act to pump fluid from such single source to a single outlet. However, it will be understood that the invention is in no way limited to this particular arrangement; and, if desired, each pump may be individually supplied with fluid and each pump may individually deliver fluid.

It is among the general objects of the invention to provide a novel and improved pump of the class described which will be simple in construction, effective and efficient in operation and well designed to meet the demands of economic manufacture.

A further and more specific object of the invention is to provide a multiple-piston, rotary driven pump so constructed and arranged as to provide for uniform distribution of load on the driving shaft thereof.

Another and important object of the present invention is to provide a pump of the class described, the volumetric output of which may be readily varied to meet varying demands for fluid, and in particular a pump in which said variations may be attained without cessation of the pumping operation.

Another important object of the present invention is to provide a novel and improved packing means for sealing the pump, piston and cylinder so as to provide a uniform seal with a minimum of parts and complication of structure.

These and other objects, features and advantages of the present invention will be apparent from consideration of the following specification, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a side elevation of one form of the pump of the present invention.

FIG. 2 is a horizontal cross sectional view taken on line 2—2 of FIG. 1.

FIG. 3 is an enlarged detail cross section taken on the line 3—3 of FIG. 2.

FIG. 4 is a detail horizontal cross section taken on line 4—4 of FIG. 3 with pistons, piston housings and rocker arm removed.

FIG. 5 is an enlarged detail cross section taken on line 5—5 of FIG. 3.

FIGS. 6, 7 and 8 are reduced cross sectional views taken on line 6—6 of FIG. 3 showing successive positions of the piston driving head during operation.

Referring more particularly to the drawings, it will be seen that the pump may include a central, stationary, generally hexagonal, hollow body **10**, three alternate spaced surfaces of which are formed with circular recesses **11** each having a central pump piston aperture **12**. Internally, the body **10** is formed with a cylindrical operating chamber **13** and a communicating central vertical shaft bore **14**. Mounted in each of the individual recesses **11** is a reduced inner end **15** of one of the three generally cylindrical, hollow, radially extending, pump piston housings **16**. Each housing defines a central open ended piston bore **17** within which is reciprocatively mounted an elongate pump piston rod **18** of uniform diameter. The inner end **19** of each rod extends into the chamber **13** through its aperture **12**. The outer end **20** of each rod **18** constitutes the pumping head of the piston.

Mounted on the outer end **21** of each piston housing **16** there is a pump casing **22** including a central pump cavity **23** in which the pumping head **20** of the piston reciprocates. The cavity **23** is open to the piston by way of a lateral bore **24**. Below the cavity **23** and communicating therewith is an enlarged inlet valve chamber **25** having an inlet port **26** controlled by a ball valve **27** normally urged in closed position by spring **28** adapted to seat the ball against the port **26**. Below each casing **22** is secured fluid supply block **29** defining a fluid supply duct **30** leading to chamber **25** and communicating with a through fluid supply passage **31**. Similarly, above the cavity **23** there is an enlarged outlet valve chamber **32** communicating with the cavity **23**. Fluid passage between cavity **23** and chambers **32** is under the control of a ball valve **33** normally urged in seating position against the upward opening of the cavity **23** by spring **34**. Above the chamber **32** is mounted a fluid discharge block **35** defining a fluid discharge duct **36**

leading to chamber **32** and communicating with a through fluid discharge passage **37**. By this arrangement it will be seen that as the piston rods **18** reciprocate within their housings **16**, the pumping heads **20** will move inwardly and outwardly of the cavity **23** causing pressure increase upon outward movement, thus forcing fluid from the cavity **23** past the valve **33** and thence outwardly through passages **36** and **37**. On the inward stroke of the piston, the fluid from the passage **31** will be drawn past the valve **27** and into the cavity **23** for expulsion upon the subsequent outer movement of the piston.

The fluid flow arrangement of the pump here illustrated includes a supply tube **40** leading from some suitable fluid source (not shown) and connected with the fluid feed block **29** of a first pump unit, here shown as the lower right hand unit of FIG. 2. Irrespective of the pumping action of the first unit, fluid will flow freely through the passage **31** thereof to a first intercommunication fluid supply tube **41** connected between the blocks **29** of the first and second pump units. Similarly, fluid can flow freely through the block **29** of the second or intermediate unit, regardless of the pumping action of that unit, to pass through a second intercommunication fluid supply tube **42** to the block **29** of the terminal unit, here shown as the right hand unit of FIGURE 2, where the supply line for the pump units terminates. Fluid pumped by the first unit passes through its block **35** to a second unit. Fluid pumped by both the first and second units passes from the block **35** of the second unit through the second intermediate fluid discharge tube **44** between the blocks **35** of the second and third units. From the block **35** of the third unit, the total pumped fluid passes through a final fluid delivery pipe **45**. Obviously, if desired, the tubing arrangement may be such as to supply each unit separately and/or to discharge fluid separately from each unit.

An important feature of the invention is the construction and method of packing and lubricating the pistons to insure an optimum seal of the pump cavity, insuring constant accuracy of the increment of fluid supplied by each piston stroke while minimizing friction and wear of the sealing element. These improved advantages are achieved in the present construction by providing an annular and angular counterbore, recess or rabbet between each casing **22** and its pump piston housing **16**, surrounding and opening into the pump piston bore. The counterbore forms a radial, transverse, flat wall **50** and a right angularly related annular wall **51**, coaxially encircling the piston head. The outer face **52** of the housing **16** forms a confining, radial, flat wall **53** parallel with the wall **50** to form a rectangular seating recess for a normally round elastic O ring **54**. The more conventional types of O ring packing assemblies usually seat the ring in a recess substantially wider than the normal diameter of the O ring. Such a mounting permits a lateral or rolling motion of the O ring in its seat in response to relative axial movement between the sealed elements. Even though the depth of the recess may be quite small and the O ring tightly engaging the inner element, a tendency for such lateral motion will cause distortion and wear, not only precluding long life of sealing effectiveness but also precluding efficient sealing by which volumetric efficiency is insured. In the present construction, the width of the O ring recess is substantially less than the diameter of the ring, so that a conventional O ring of appropriate size when forced into the recess will conform to the flat side walls, thus securely locking the ring against lateral rolling or deformation.

Lubrication of the piston is provided by a slightly enlarged counterbore **56** extending inwardly from the outer end of the piston rod housings to increase the bore **17** for a distance not less than the maximum stroke of the piston and providing a lubrication clearance space out to the O ring **54**. Lubricating oil is supplied to the clearance space by lubrication ducts **57** leading from the clearance space to extend in upper and lower parallel relation to the operating chamber **13** of the body **10** from which lubrication is supplied. By this construction it will be seen that while ample lubrication is supplied for the pump rods, the O ring effectively seals the head end of the rods against loss of lubrication to the pump cavity or loss of pumped fluid to the clearance space. The O ring **54** extends radially inwardly from its tight securement in the recess to bear against the head ends of the pistons, while the relative internal diameter of the ring and the external diameter of the rods is such as to compress the internal O ring surface to a flat face **58** providing a broad sealing surface.

For reciprocating the pistons to produce the pumping action of the head ends thereof, there is provided within the chamber **13** a bodily rotating driving head **60** movable in an orbital path, the radius of which is determined by the radial setting of the stud **61** of the slide **62** upon which the head is mounted by way of bearings **63**. The head **60** is generally hexagonal, having alternate faces located in planes normal to the axes of the three pump units. Parallel with such faces, the head **60** is formed with downwardly facing piston engaging ways **65**, each of which slidably receives the upwardly projecting driving flange **66** at the inner end **19** of each piston rod **18**. Thus as the head revolves in its orbital path, as driven by the rotation of the plate **62** and stud **61**, the pistons will be reciprocated with a 120° difference in phase and with a thrust length determined by the relative radial location of the plate and stud. The plate **62** is slidably mounted in transverse ways **70** of a driving box, the side wall **71** of which depends from the circular flange **72** at the lower end of tubular shaft **73** rotatably mounted in the bore **14** of the body **10**. The shaft **73** is adapted to be rotated through gear **74** driven by a companion bevel gear **75** which is mounted on shaft **76**, and journaled in the mounting bracket **77** of the pump.

Variations in the radial setting of the head **60** and its stud **61** with respect to the center of rotation of the shaft **73** is provided by a bell crank **80** rotatably mounted on a stud **81** horizontally disposed between the walls **71** and rotatably therewith. The lower arm **82** of the crank **81** engages a recess **83** in the plate **62**. The upper, generally horizontal arm **84** of the bell crank engages a recess **85** at the lower end of a vertically reciprocable control rod **86**, rotatable with, but slidable within, shaft **73**. By this arrangement it will be seen that as the rod **86** moves vertically within the shaft **73**, such vertical movement will be translated into a rocking movement of the crank **80** which in turn will induce transverse movement of the plate **62**, thus altering the radial relation of the stud **61** with respect to the center of rotation of the shaft **73**.

From the foregoing, it will be seen that when the stud **61** is located at the center of rotation of the shaft **73**, and hence the axis of the rod **86**, rotation of the shaft will impart no reciprocatory movement to any of the pistons, since the stud will revolve on its center of rotation. However, upon vertical movement of the control rod **86**, the bell crank **80** will rock to move the head **60** laterally in the ways **70**, and thus radially with respect to the center of rotation of the shaft **73**. After such vertical adjustment of the rod **86**, rotation of the shaft **73** will provide an orbital path of movement for the stud **61** on a radius corresponding to the adjustment imparted by the rod. Such orbital movement will provide for an effective reciprocation of the pistons, and thus each piston will be reciprocated with a stroke corresponding to the radial displacement of the stud **61** with respect to the center of rotation of the shaft **63**, and equal in length to twice the distance of such radial displacement, to correspondingly vary the volumetric output of the cylinders.

From the foregoing, it will be seen that the present invention provides a novel, simple and improved rotary-driven, multiple-piston, variable displacement pump. It

will also be seen that the multiple pistons are so arranged as to uniformly disperse the load on the pump drive shaft, and that the displacement may be readily varied, while the pump is in operation, in accurate and faithful response to adjusting means. Furthermore, a more efficient sealing means is provided in combination with effective lubrication of the pistons. While structural details here presented provide one form of the invention, it will be understood that in the practice thereof numerous changes, modifications, and the full use of equivalents may be resorted to without departure from the spirit or scope of the invention as defined in the appended claims.

What is claimed as invention is:

1. A variable-displacement metering pump including a hollow body defining an operating chamber containing a lubricant, a central rotary power shaft, a piston driving head in said chamber for rotation by said shaft, driving means movably mounted with respect to said head and transversely displacable with respect thereto to be moved in an orbital path of varying radius in response to rotation of said shaft, a pump piston housing mounted on said body and defining an open ended piston bore communicating at its inner end with said operating chamber, a pump casing mounted on said housing and defining a pump cavity, a piston mounted for reciprocation in said piston bore and having a pumping head extending into said pump cavity, means for reciprocating said piston commensurate with the orbital movement of said driving means and responsive to the radius of such movement, together with means to transversely displace said head during rotation of said shaft, said pump piston housing being counterbored from its outer end inwardly for a distance at least as great as the maximum stroke of the piston and providing lubrication clearance space between the piston and the pump piston housing, intercommunicating means for circulating lubricant from said operating chamber to said piston at said clearance space and thence back to said operating chamber, and sealing means about the pumping head of the piston at the juncture of said pump piston housing and said pump casing for sealing the piston and the pumping chamber against the escape of lubricant and pumped fluid along the piston.

2. In a variable-displacement pump of the type having a hollow central body with a central operating chamber for containing lubricant and a piston with a pumping head which is variably reciprocated from said central body, the combination therewith of a pump piston housing mounted on said body and defining an open ended piston bore receiving said piston and communicating at its inner end with said operating chamber, a pump casing mounted on said housing and defining a pump cavity, said pumping head extending into said pump cavity, said pump piston housing being provided with a counterbore from its outer end inwardly for a distance at least as great as the maximum stroke of the piston and providing a lubrication clearance space between said piston and said pump piston housing, intercommunicating means for circulating said lubricant from said operating chamber to said piston at said clearance space and thence back to said operating chamber, and sealing means about the pumping head of said piston at the juncture of said pump piston housing and said pump piston housing and said pump casing for sealing the piston and the pumping chamber against the escape of lubricant and pumped fluid along said piston.

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