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Hallberg

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[54] **HYDROSTATIC BEARING FOR RADIAL PISTON PUMP**

[75] Inventor: **Daniel F. Hallberg,** Minneapolis, Minn.

[73] Assignee: **FMC Corporation,** San Jose, Calif.

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[52] **U.S. Cl.** **91/488**

[51] **Int. Cl.** **F01b 1/00**

[58] **Field of Search** 91/488; 92/157, 153, 158, 159; 418/225; 308/236

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Primary Examiner—William L. Freeh
Assistant Examiner—Gregory LaPointe
Attorney, Agent, or Firm—Robert S. Kelly and C. E. Tripp

[57] **ABSTRACT**

A radial piston pump is provided with pistons which utilize a hydrostatic bearing between the body of the piston and the crosshead rollers, i.e., the thrust accommodating elements that contact the rotor reaction ring in the pump assembly. In order to provide for this bearing, holes are drilled longitudinally through the piston into the bore in the head of the piston where a crosshead pin is mounted. The crosshead pin extends transversely through the body of the piston, and the crosshead rollers are keyed to the ends of the pin which project laterally from the head of the piston. Interconnected grooves are provided about the bore in the piston body which grooves are in communication with the holes through the piston to receive the lubricating medium being pumped, and the area circumscribed by the grooves is such that the pressure load on the piston is generally balanced, i.e., the hydrostatic loading on the rearward end of the piston is balanced by the hydrostatic loading on the crosshead pin.

3 Claims, 6 Drawing Figures

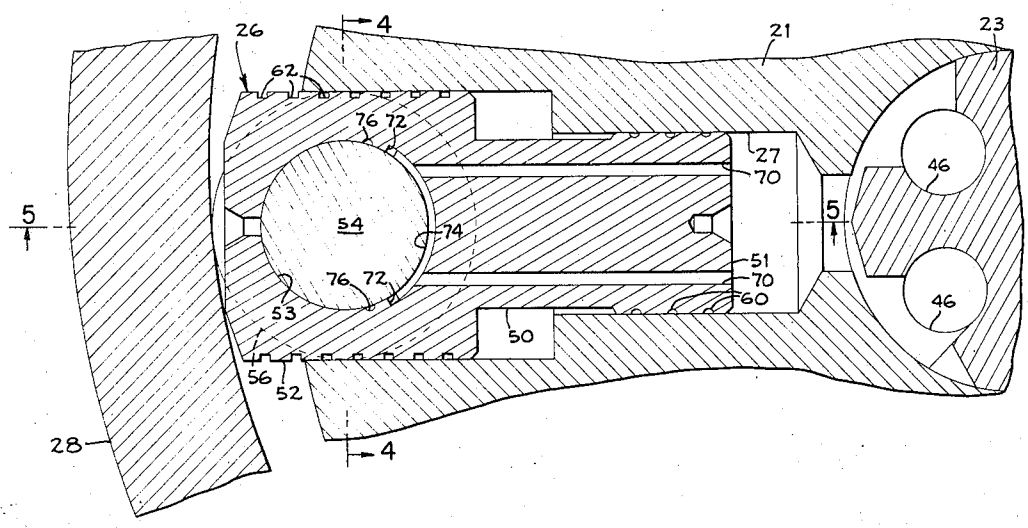


FIG_2

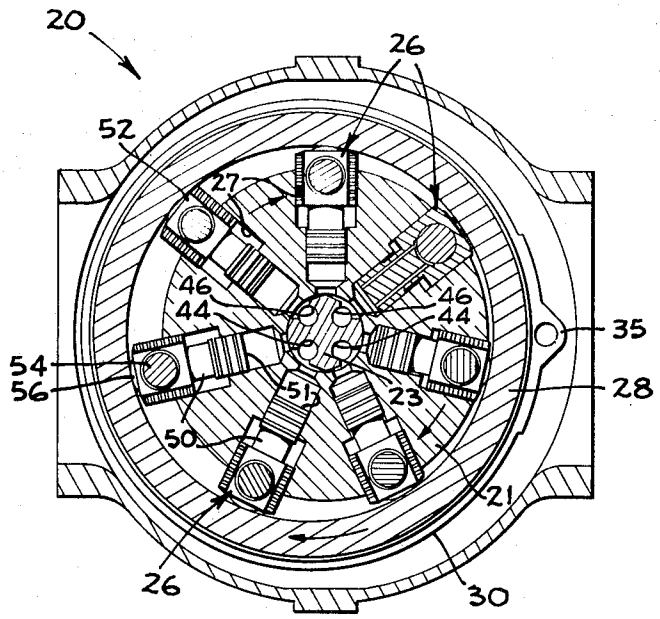
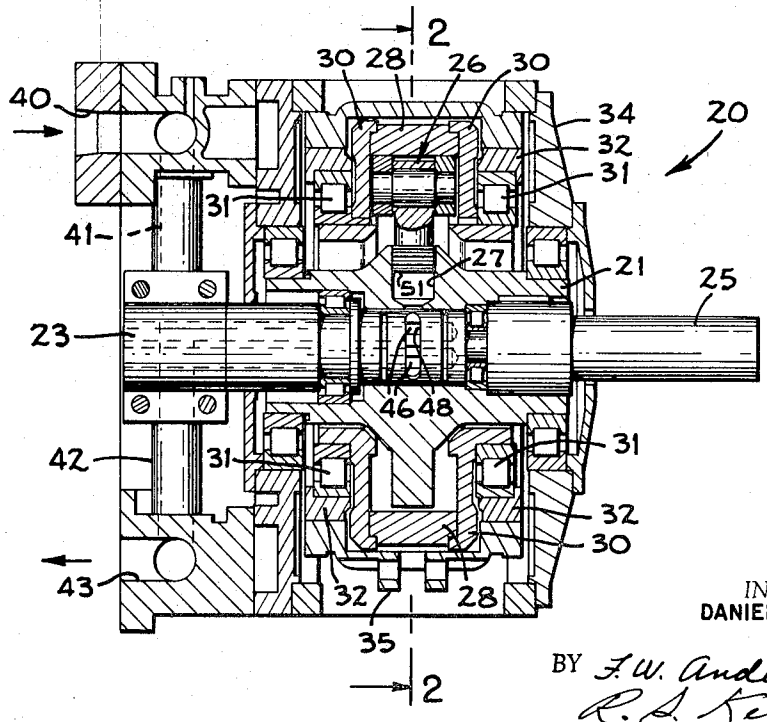


FIG_1



INVENTOR.
DANIEL F. HALLBERG

BY F. W. Anderson
R. A. Kelly

ATTORNEYS

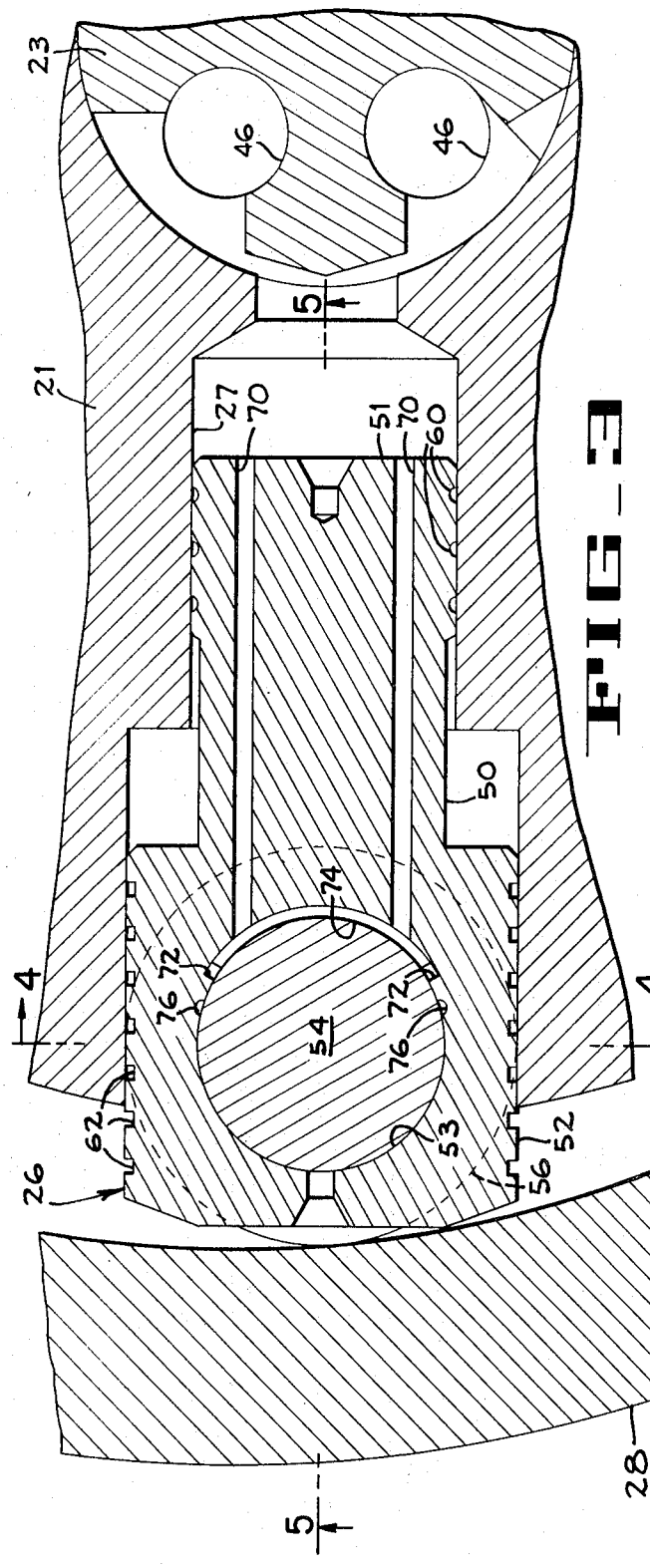


FIG_3

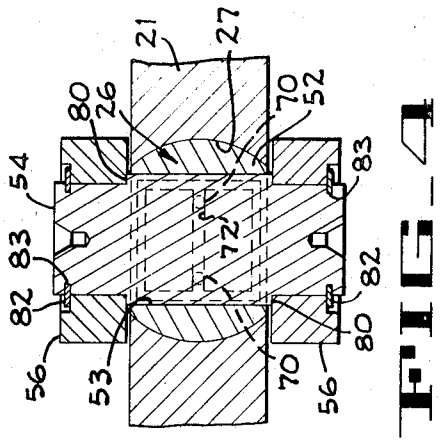


FIG_4

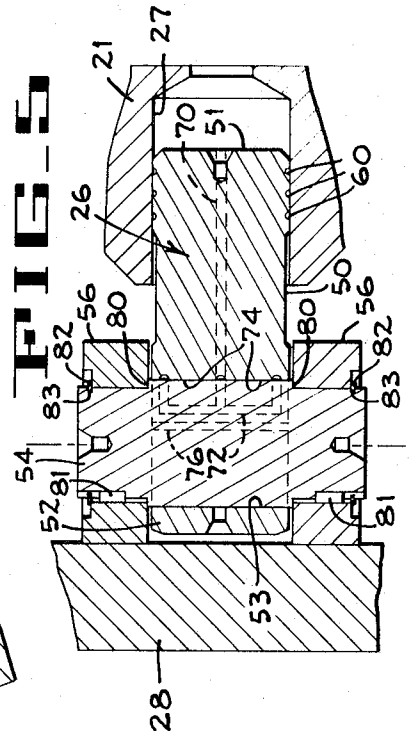
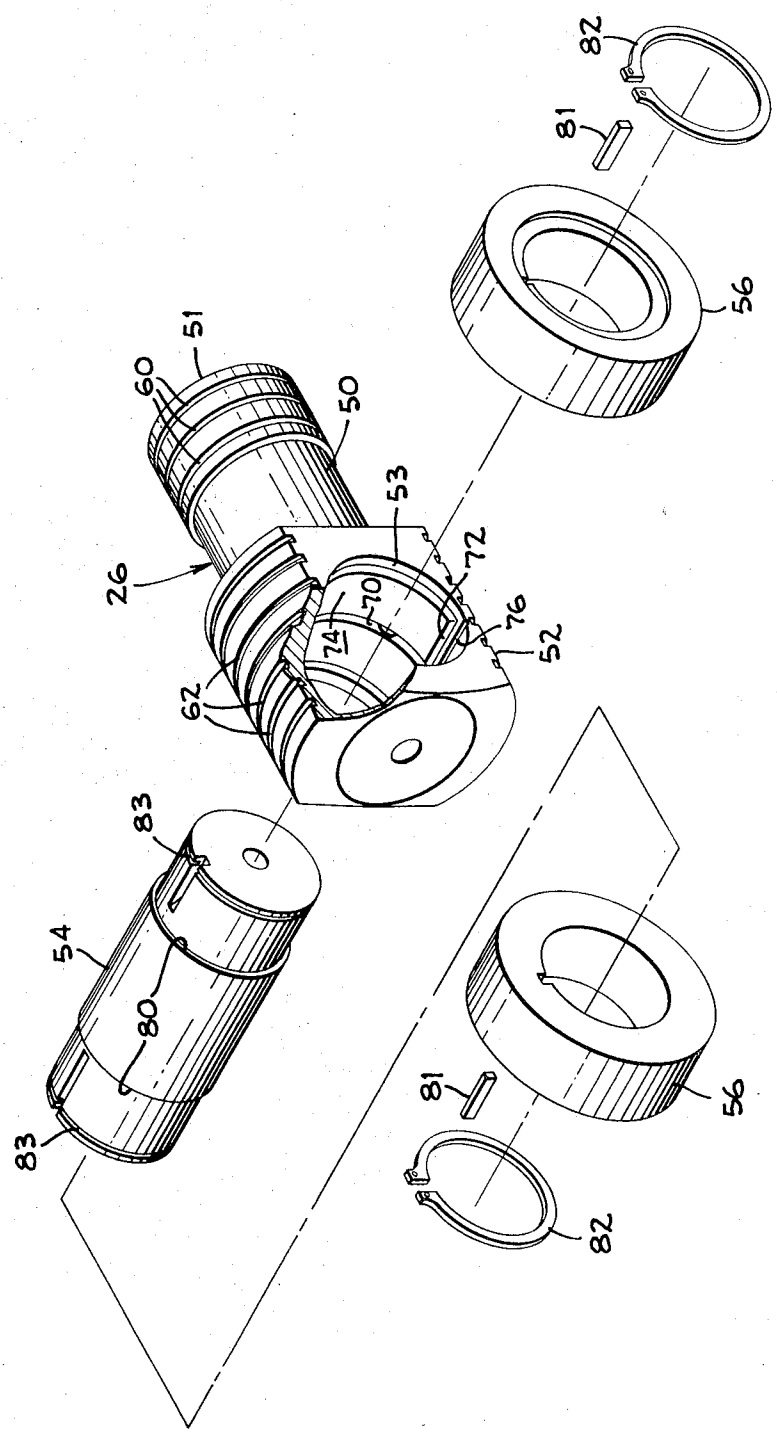


FIG_5

FIG_6



HYDROSTATIC BEARING FOR RADIAL PISTON PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to radial piston pumps, and more particularly, it pertains to the piston assemblies for use in radial piston pumps.

2. Description of the Prior Art

As is well known, a radial piston pump is a positive displacement pump which utilizes the action of a plurality of pistons mounted in radially extending bores in a cylinder block and reacting against a rotor ring that is eccentrically mounted with respect to the cylinder block. The cylinder block is adapted to be continuously driven and is mounted upon a pintle or timing shaft having valved ports for directing fluid into and out of the cylinder bores. Since the cylinder block and the rotor ring have non-coincident centers and since the bores in the cylinder block are directed along radii having as their center the axis of rotation of the cylinder block, the pistons will describe a reciprocating motion as the cylinder block rotates and the piston heads contact the inner face of the rotor ring. During their suction stroke, the piston heads will be urged into contact with the rotor ring because of the centrifugal forces acting thereon, and, as the pistons are urged inwardly by the ring on the pressure or pumping stroke, fluid will be pumped through the ports in the timing shaft.

Radial piston pumps, because of their construction, are typically used in high pressure pumping applications, and thus the pistons and the individual elements thereof must be capable of withstanding substantial stress. In a typical piston assembly, the piston will include a longitudinally extending body member arranged to reciprocate within the radially extending bore in the cylinder block and a piston head at the outer end of the body member which head rotatably mounts a crosshead pin carrying a pair of rollers. The crosshead pin provides the drive link between the rotor ring and the pistons with the rollers, which are affixed to the pin, being arranged to react against the inner surface of the rotor ring. The pin is rotatably received in the piston head so as to allow for some relative rotational movement between the rotor ring and the cylinder block and to permit the translation of the rollers with respect to the rotor ring as the spacing of the piston heads is cyclically varied.

The mounting of the crosshead pin in the piston head has posed a considerable problem in the design of prior art radial piston pumps. In one prior art design, a needle roller bearing assembly was mounted within a bore in the piston head to rotatably receive the crosshead pin. However, due to space limitations, conventional needle roller bearing assemblies required that the crosshead pin be of a relatively small cross section. The aforedescribed high pressure pumping conditions have led to excessive bending moments in the relatively small pin, and the bending of the pin has resulted in excessive radial loading at the inner edges of the rollers. These conditions have resulted in failures in the roller bearing assembly and in the breakdown of the rollers after a relatively short period of pump operation at high pumping pressures.

SUMMARY OF THE INVENTION

With the present invention a radial piston pump is provided which incorporates a hydrostatic bearing for the reaction rollers carried by the piston heads so that, even when the pump is used under high pressure conditions over long periods of time, no appreciable wear can be observed.

Basically the invention comprises a passage drilled in an axial direction through the body of the piston through which passage the lubricating medium being pumped can be applied to the inner face of the crosshead pin that mounts the rollers bearing against the rotor ring. The crosshead pin then can rotate freely on this trapped fluid medium, and the area of the engagement of the pin with the fluid medium is carefully calculated so that a pressure balance on the piston is achieved, i.e., so that the pressure of the fluid medium acting on the rearward end of the piston will be generally equal to the pressure of the fluid medium acting on the crosshead pin. The hydrostatic bearing thereby not only provides positive lubrication for the crosshead pin but also transfers the piston load directly to the crosshead pin. By using this pressurized thin layer of lubricating fluid medium on one face of the crosshead pin as the sole bearing means therefor, a rather large pin can be provided for a radial piston pump of a given size and capacity. With a large crosshead pin the amount of bending due to pressure loading of the rollers is negligible and is easily accommodated by the hydrostatic bearing, and pumps utilizing such piston assemblies have been found to have a considerably longer operating life than the prior art radial piston pumps constructed in the manner aforedescribed.

A special feature of the hydrostatic bearing of the present invention is that the number of required parts in the piston assembly has been considerably reduced over the prior art conventional piston assemblies. It will therefore be apparent that the manufacturing costs can be reduced, and that considerable assembly time can be saved because of the fewer number of machining and assembling operations required. Since the hydrostatic bearing permits looser tolerances than with conventional mechanical bearings, the machining costs are even further reduced.

One further feature of the present invention is the fact that the hydrostatic bearing of the present invention permits the use of a shouldered pin without seriously decreasing the strength of the pin so that the crosshead rollers can be attached to the pin with a conventional key and snap ring assembly. This is of importance, not only in the obvious reduction of the time required for assembly of the pistons, but also in the ease of disassembly when it is desired to repair or check the condition of the pump after a given number of hours of service.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a section through a radial piston pump incorporating the piston assemblies of the present invention.

FIG. 2 is a section taken along the line 2—2 of FIG. 1.

FIG. 3 is an enlarged axial section through one of the piston assemblies of the pump shown in FIG. 1.

FIG. 4 is a reduced section taken along the line 4—4 of FIG. 3.

FIG. 5 is a reduced section taken along the line 5—5 of FIG. 3.

FIG. 6 is an exploded isometric illustration of one of the piston assemblies of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to the drawings, FIGS. 1 and 2 illustrate the structure of a generally conventional radial piston pump **20.** A cylinder block **21** is rotatably mounted by roller bearings in the pump casing and rotates about a fixed timing shaft **23.** Axially aligned with and spaced from the shaft **23** is a drive shaft **25** which is keyed to the cylinder block for joint rotation therewith. A plurality of pistons **26** are mounted within bores **27** in the cylinder block that extend radially outward from the rotary axis of the block, and the outer ends of the pistons are adapted to react against the inner surface of a rotor ring **28.** The rotor ring is attached to side plate members **30** which are rotatably supported, by means of roller bearings **31,** within a slide block **32** that is, in turn, mounted for lineal movement within an outer casing **34** of the pump. The slide block is arranged to be moved in a direction perpendicular to the rotary axis of the pump, and a clevis **35** is provided at one side of the slide block so that the block can be attached to a stroking arm (not shown) which provides a variable displacement output for the pump by modifying the relative positioning of the rotor ring with respect to the cylinder block.

The radial piston pump **20** is operated in the conventional manner by shifting the slide block **32** within the casing **34** so as to locate the rotary axis of the rotor ring **28** eccentrically from the rotary axis of the cylinder block **21.** As shown in FIGS. **1** and **2,** the slide block is shifted within the casing by the maximum amount in one direction so as to offset the axes of the rotor ring **28** and the cylinder block **21** by a maximum amount. With this structural arrangement of the operative components of the pump, when the drive shaft **25** is rotated, the joint rotation of the rotor ring and the cylinder block will result in the desired reciprocating movement of the pistons. On the suction stroke of the pistons during one-half of each operating cycle (as illustrated by those pistons in the lower half of FIG. **2**), the centrifugal force on the pistons will urge them outwardly against the rotor ring. On the subsequent half-cycle, (as illustrated by the pistons in the upper half of FIG. **2**), the heads of the pistons will react against the rotor ring to pump the fluid out of the respective cylinder bores **27.**

Fluid is directed into the casing **34** of the pump through a fluid inlet passage **40** and a connecting conduit **41** into the timing shaft **23.** The timing shaft is also arranged for fluid communication with an outlet conduit **42** and a fluid discharge port **43.** In the interior of the timing shaft two axially extending passageways **44** are connected to the conduit **41** and the inlet side of the pump and two axially extending passageways **46,** hydraulically separated from the passageways **44,** are connected to the conduit **42** and the outlet side of the pump. The passageways **44** are connected so as to communicate with the pistons through a slot **48** (FIG. **1**) in the side of the timing shaft in the plane of the bores **27** in the cylinder block. In a similar manner (not shown) the passageways **46** are connected to communicate with the pistons on the discharge side of the pump.

As the cylinder block **21** is rotated, fluid that flows into the timing shaft through the inlet **40** and the passages **44** will be sucked into the bores **27** of the block as the pistons **26** move outwardly under centrifugal force. As the pistons move past the sealed edges of the timing shaft to the discharge side of the shaft the pistons will rotate past the point of maximum axial offset between rotor ring and cylinder block and the reaction between the pistons and the ring will cause the fluid to be forced out of the bores **27** of the cylinder block and into the discharge passages **46** of the timing shaft to the outlet port **43.**

While the foregoing apparatus has been described as a pump, it will be obvious to those skilled in the art that the structure could be operated as a hydraulic motor by merely reversing the input and output means. That is to say, fluid could be pumped to the inlet passage **40** and through the timing shaft structure to the discharge passage **43** which pumping action would result in a forced rotation of the drive shaft **25.**

The radial piston pump structure, as aforedescribed, is entirely conventional. The invention, to be described hereinafter, pertains to the structure and assembly of the pistons **26** one of which is shown in detail in FIGS. **3, 4, 5** and **6.** Referring first to FIG. **3,** it will be noted that each piston **26** has a cylindrical body portion **50** sealingly engaged within the associated cylinder bore **27** with the rearward end face **51** of the piston body being arranged to force the hydraulic fluid medium in the cylinder bore through the discharge passages **46** in the timing shaft. At the outer, or forward, end of the piston an enlarged head portion **52** is provided. Rotatably mounted within a bore **53** in the head portion of the piston is a generally cylindrical crosshead pin **54** which has firmly attached at the outer ends thereof a pair of rollers **56** (FIGS. **4** and **5**) which are adapted to bear against the inner cylindrical face of the rotor ring **28.** As is conventional, pressure balancing grooves **60** are provided about the body portion **50** of the piston in order to balance the lateral forces thereon and insure a good reciprocating motion in the cylinder. Lubricating grooves **62** are also provided in the exterior partially cylindrical surfaces of the head portion **52** of the piston where the head portion is slidably mounted in the cylinder block in order to further insure the free reciprocatory motion of the piston.

The present invention is particularly concerned with the bearing for the aforementioned crosshead pin **54.** This bearing is provided by a pair of passageways **70** which are drilled through the body portion **50** of the piston in a direction parallel to axis thereof and which passageways are of a sufficiently large enough diameter so that no significant pressure drop will occur within the fluid that passes therethrough. These passageways **70** are located approximately midway between the axis of the piston body and the periphery thereof and terminate in a pair of interconnected rectangular grooves **72** which are cut into the wall of the bore **53** in which the crosshead pin is mounted. The grooves define a closed loop path on the wall of the bore **53** which surrounds a pair of lands **74.** Thus, it will be appreciated that the fluid medium being pumped will be directed through the body of the piston from the bearing face **51** thereof to the rearward face of the crosshead pin so as to place the rear surface of the pin in communication with the grooves under the same pressure as that of the pumping pressure on the fluid medium. The grooves, or recesses,

72 and the lands 74 which they surround define a pressurized area on the wall of the bore 53 and are designed to have a projected area approximately equal to the area of the bearing surface 51 at the trailing end of the piston body so that the pressure forces on the piston will be balanced. In this manner a smooth bearing surface is provided for the crosshead pin so that it may accommodate the loading on the crosshead rollers 56 and rotate with respect to the body of the piston without binding and without a wear load other than that imposed by the centrifugal forces on the piston during the suction cycle of its operating stroke. It should be noted that such relative rotational movement between the crosshead pin and the body of the piston will always occur in a radial piston pump since the center-to-center distances between the piston heads will be constantly changing as the pistons reciprocate in the cylinder block. Also, there is some relative rotational movement between the rotor ring 28 and the cylinder block 21 which must be taken up by rotation of the crosshead pins in the piston heads.

In order to provide a proper bearing for the crosshead pin, the hydraulic medium being pumped must obviously be a lubricating medium. However, since radial piston pumps are typically used in high pressure hydraulic applications including especially the pumping of oil or other viscous fluid mediums, this condition will generally be obtained.

In order to prevent the fluid within the grooves 72 from working its way about the face of the crosshead pin to the forward face thereof and thereby destroying the bearing and pressure balance of the piston assembly, a pair of bleed-off grooves 76 are provided in the bore 53 which grooves extend parallel to the transversely extending side portions of the grooves 72 and are slightly circumferentially spaced therefrom (FIGS. 3 and 5). Fluid which leaks past the grooves 72 along the face of the crosshead pin will be drained off through the bleed-off grooves 76 to the casing 34 of the pump. The pressure drop across the cylindrical face of the crosshead pin will therefore move from maximum pressure (or pumping pressure) within the grooves 72 to zero pressure, or case pressure, at the bleed-off grooves 76. While this pressure differential will impose some outward thrust on the crosshead pins which may tend to upset the pressure balance, this should be counterbalanced by the centrifugal force exerted upon the piston body as it rotates about the axis of the pump so that a good pressure balance is maintained when the piston is under pumping pressure.

A special feature of the present invention, which is particularly provided by the aforedescribed hydrostatic bearing, is the fact that this type of bearing occupies very little space and allows an enlarged crosshead pin to be used which is better able to withstand the high stresses imparted to the piston assembly. Also, the enlarged pin permits a special mounting structure for the crosshead rollers 56. This structure can perhaps best be understood with reference to the exploded view of FIG. 6. It will be noted that the crosshead pin 54 is large enough so that it can be provided with a pair of shoulders 80 which secure one transverse face of the rollers and prevent inward axial movement of the rollers. The rollers are fixed to the pin by keys 81 and are secured against outward axial movement by snap rings 82 which are mounted within narrow grooves 83 adjacent the ends of the pin. It will be seen that the piston may be readily assembled without requiring close machining tolerances, shrink fitting, or special shims, etc. Also, during periodic inspections of the pump or in the event of repair, the pistons may be readily disassembled by removing the snap rings and thereby permitting the rollers and crosshead pin to be removed from the body of the piston.

It will be appreciated that the hydrostatic bearing of the present invention provides a piston assembly which may operate under extremely high pressure conditions without being subjected to undue wear or to failure because of overstressing of its component parts. The bearing for the crosshead pin in the piston assembly has been found to have a considerably longer life than the conventional roller bearings or other mehanical bearings used previously in piston assemblies of the same general type. Furthermore, the absence of parts which require machining and the ease of assembly provide additional advantages for the piston structure of the present invention.

Although the best mode contemplated for carrying out the present invention has been herein shown and described, it will be apparent that modification and variation may be made without departing from what is regarded to be the subject matter of the invention.

What is claimed is:

1. For use in a radial piston pump, a piston assembly comprising a piston having a cylindrical body portion with a rearwardly located end face for receiving a fluid medium and applying pumping pressure thereto and a head portion at the forward end of said body portion, said head portion having a cylindrical bore therethrough extending transversely to the longitudinal axis of said body portion, a cylindrical pin received in said bore and extending at each end thereof from the head portion of the piston, and a pair of rollers fixed to said pin at the said ends thereof, said body portion of the piston having a pair of passageways extending from said end face to said bore in the head portion of the piston, and said bore being provided with a recess defining a pressurized area communicating with said passageways with the size of said passageways being such that no significant pressure drop occurs between the fluid being pumped by said end face of the piston and the fluid within said recess, said passageways extending in a direction parallel to the longitudinal axis of the piston and being spaced equal distances from said axis in a common plane which extends through said axis, said common plane extending perpendicularly to the axis of said pin so that the stress concentrations due to changing pumping pressure conditions will be concentrated over a relatively large area due to the curvature of the pin at the outlets of said passageways, the projected area of said pressurized area being generally equal to the area of said end face so that a pressure balance on said pin is maintained when said piston is pumping whereby a hydrostatic bearing is provided for said pin within the head portion of said piston permitting said pin to rotate within said head portion without undue wear.

2. In a radial piston pump comprised of a cylinder block having at least one radially extending bore, means for rotating said cylinder block about a first rotary axis, a ring positioned about said cylinder block and having a second rotary axis parallel to but spaced from said first rotary axis, and valving means for directing fluid to and removing fluid from said bore in said

cylinder block, the improvement comprising a piston assembly arranged for reciprocating movement within said bore in the cylinder block and engagement with said ring at the outer end thereof to pump said fluid through said valving means, said piston assembly including a piston having a body portion slidably received in the bore in the cylinder block, said body portion of the piston having an end face for applying pumping pressure to said fluid, said piston further including a head portion at the outer end thereof which is provided with a bore therethrough extending transversely to the longitudinal axis of said body portion, a cylindrical pin rotatably received in said bore and extending at each end thereof from the head portion of the piston, and a pair of rollers fixed to said pin at the said ends thereof and arranged to contact the inner face of said ring, said body portion of the piston having a passageway therethrough which extends from said end face to said bore in the head portion of the piston, and said bore being provided with a groove defining a pressurized area communicating with said passageway with the size of said passageway being such that no significant pressure drop occurs between the fluid being pumped by said end face of the piston and the fluid within said groove whereby a hydrostatic bearing is provided for said pin within the head portion of said piston permitting said pin to rotate within said head portion as said rollers rotate with respect to said ring face, said groove including a first section extending in a plane which includes said longitudinal axis of the piston and a second section extending in a closed loop path in said bore in the head portion of the piston and centered upon said axis with the ends of said first section being connected with said second section for fluid communication therebetween, said passageway in the body portion of the piston being in direct fluid communication with said first section of said groove, the projected area of said pressurized area being generally equal to the area of said end face of the piston so that a pressure balance on said pin is maintained when said piston assembly is pumping said fluid from the bore in the cylinder block.

3. In a radial piston pump, a piston assembly according to claim **2** wherein said body portion of the piston is provided with a pair of passageways extending from said end face to said first section of said groove, said passageways extending in a direction parallel to the longitudinal axis of the piston and being spaced equal distances from said axis in said plane of said first section of said groove, said plane extending perpendicularly to the axis of said pin so that stress concentrations due to changing pumping pressure conditions will be concentrated over a relatively large area due to the curvature of the pin at the outlets of said passageways.

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