United States Patent [19]

Hartley

[11] **3,834,840**

[45] **Sept. 10, 1974**

[54] **COMPACT RECIPROCATING PISTON MACHINE**

[76] Inventor: **Ezra Dale Hartley**, 2700 Jalmia Dr., Los Angeles, Calif. 90046

[22] Filed: **June 7, 1972**

[21] Appl. No.: **260,480**

[52] **U.S. Cl.** **417/535**

[51] **Int. Cl.** **F04b 25/00**

[58] **Field of Search** 74/50; 92/182, 241; 417/534

[56] **References Cited**

UNITED STATES PATENTS

734,595	7/1903	Olin	74/50
997,480	7/1911	Twombly	74/50
1,190,949	7/1916	Phillippe	74/50
1,749,212	3/1930	Elliott	92/74
2,295,160	9/1942	Christenson	92/241
2,366,237	1/1945	Clausen	74/50
2,562,639	7/1951	Platner	92/74
2,613,651	10/1952	Herreschoff	92/74
2,637,606	5/1953	Pielop, Jr.	92/241
2,686,402	8/1954	Samuel	92/182
2,727,471	12/1955	Martin	92/182
3,744,936	7/1973	Sadler	417/536

FOREIGN PATENTS OR APPLICATIONS

654,331	12/1962	Canada	417/534
588,341	5/1947	Great Britain	417/534
496,190	10/1950	Belgium	92/182

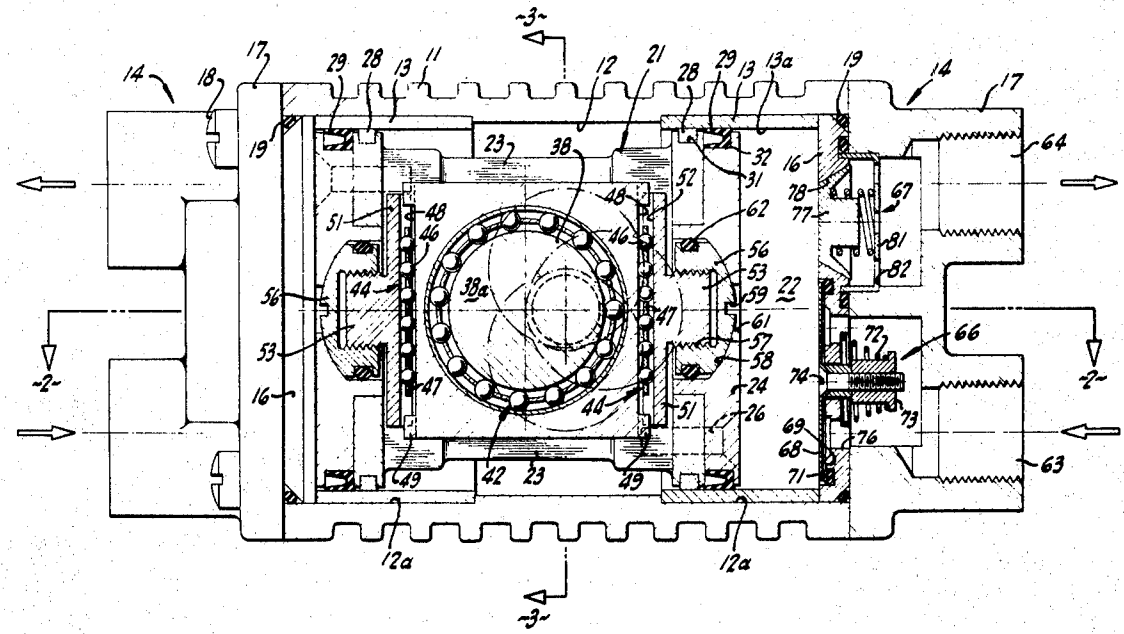
Primary Examiner—William L. Freeh

Attorney, Agent, or Firm—Flehr, Hohbach, Test, Albritton & Herbert

[57] **ABSTRACT**

Reciprocating piston machine in which a yoke member reciprocates within a piston in a direction normal to the direction of piston movement. Roller bearings are provided between the yoke member and piston, and means is provided for preloading the bearings and adjusting the position of the piston. A reversible sealing ring utilizes the pressure differential across the piston to enhance the seal in one direction, and each end of a double-ended piston can be operated in either a vacuum or a pressure mode.

8 Claims, 7 Drawing Figures



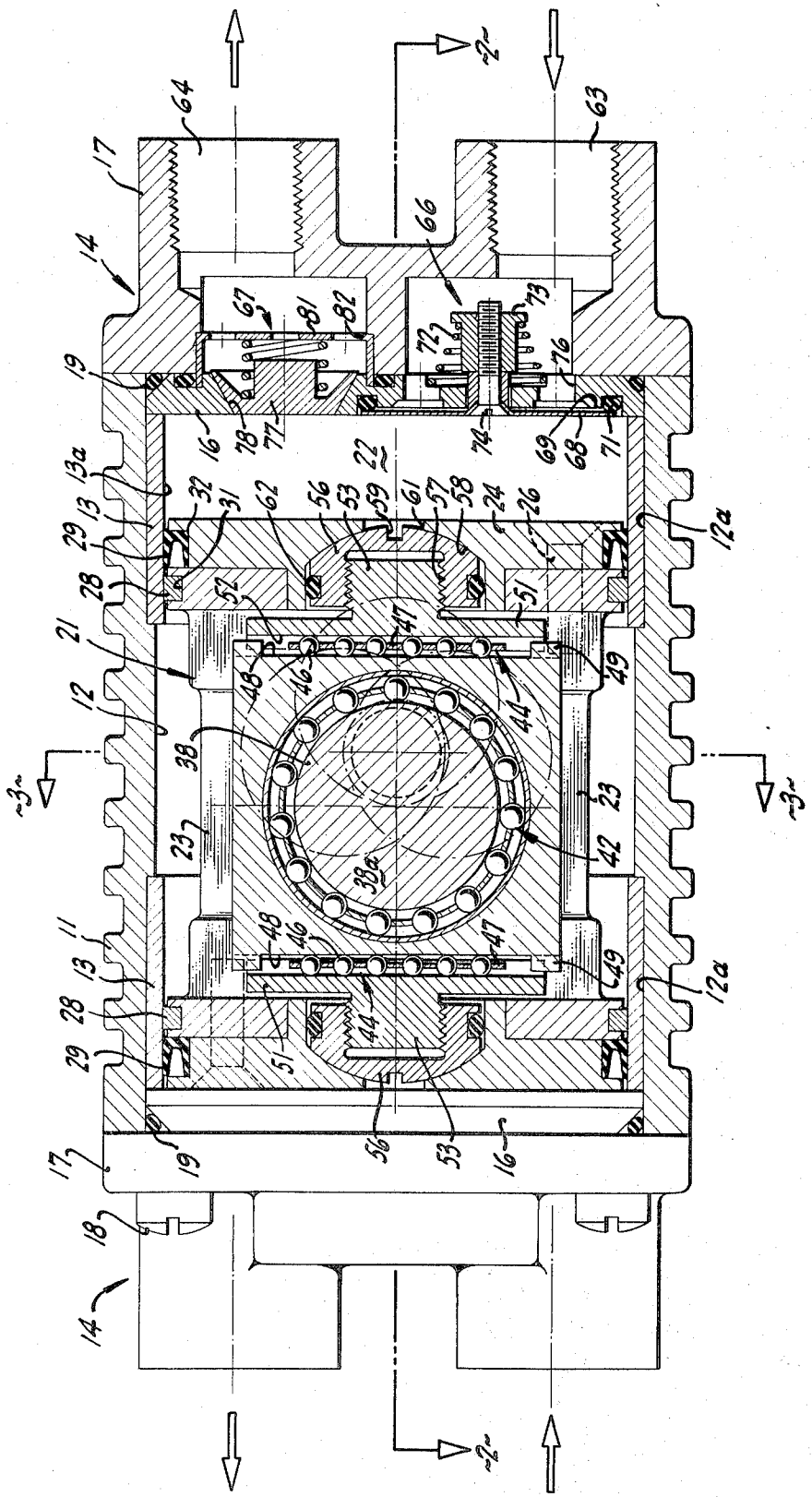


FIG. 1

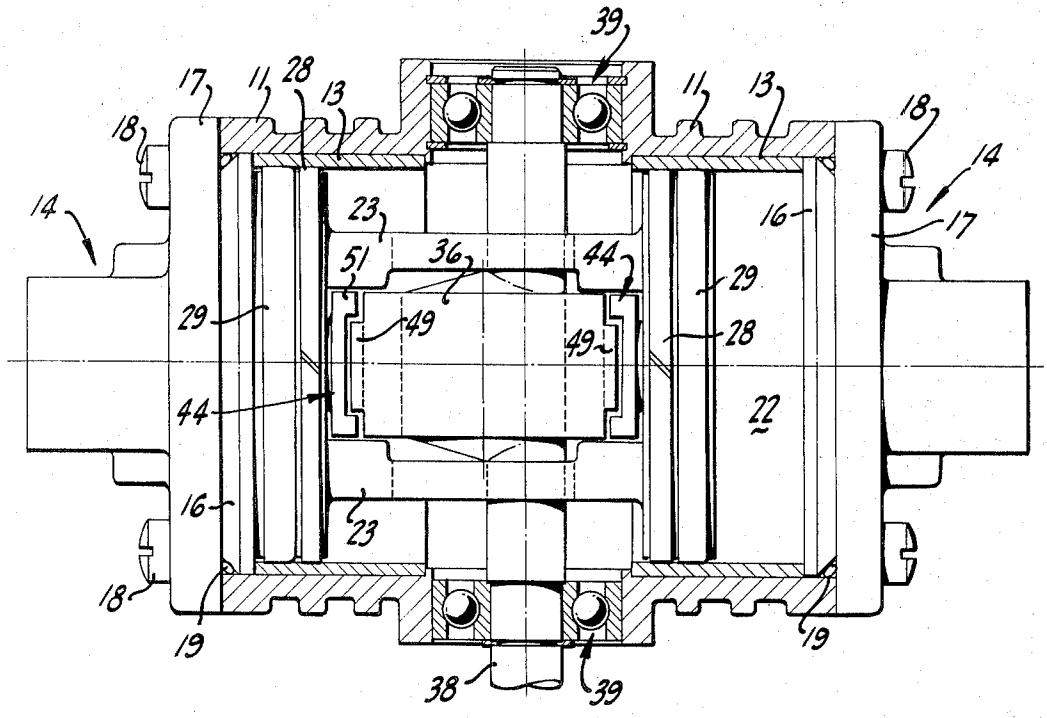

39
17
11
28
13
11
13
18
14
18
14
23
16
17
51
36
44
29
29
49
49
28
44
22
16
23
18
19
19
38
39

FIG. 2

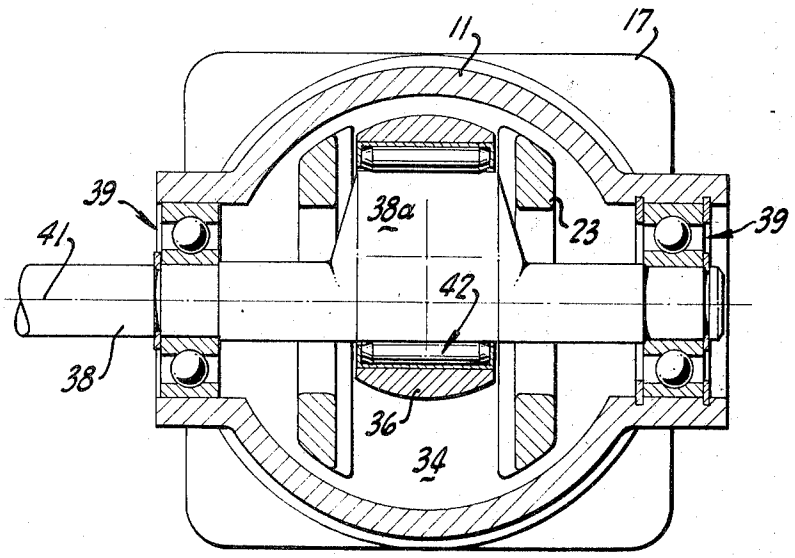

11
17
39
38a
23
39
41
42
38
36
34

FIG. 3

FIG-6

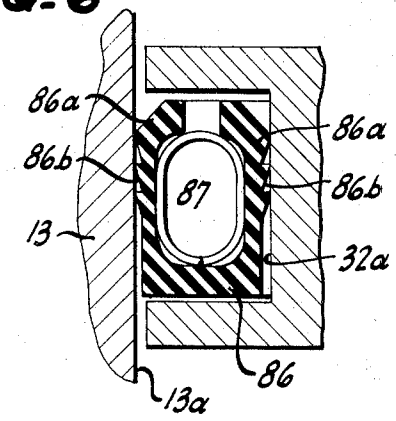


FIG-5

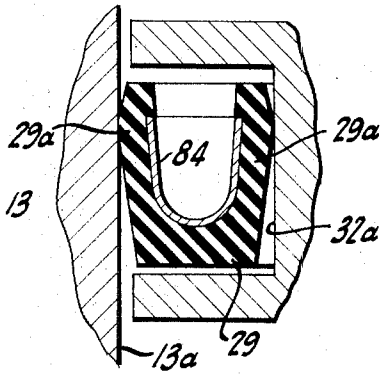
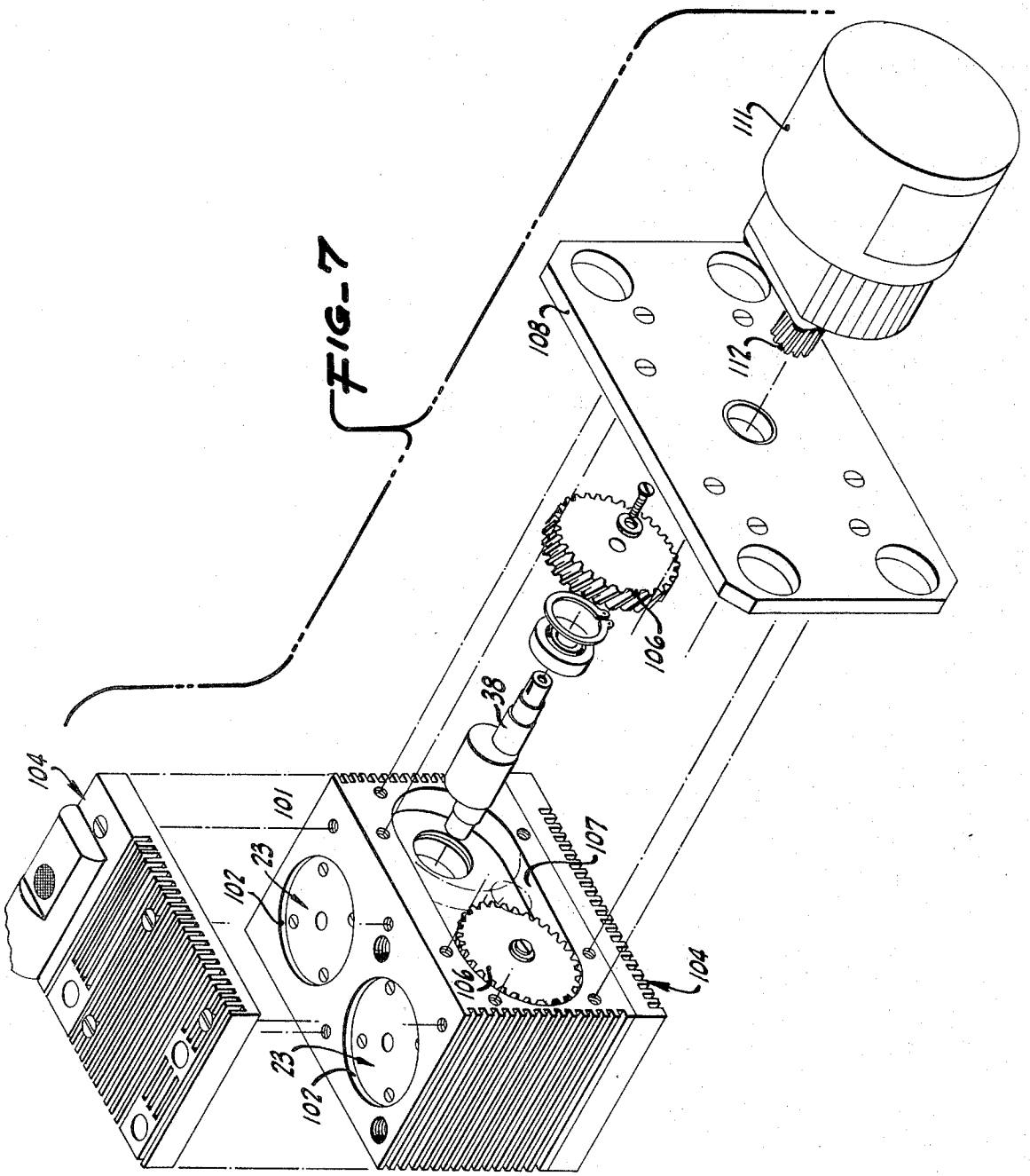


FIG-4

FIG_7



COMPACT RECIPROCATING PISTON MACHINE

BACKGROUND OF THE INVENTION

This invention pertains generally to reciprocating piston machines and more particularly to a compact machine without connecting rods.

Reciprocating piston machines, whether operated as pumps or engines, commonly have connecting rods and wrist pins for transferring the power between the pistons and a crankshaft. Heretofore, in order to reduce size, there have been some attempts to construct a reciprocating piston machine with a slider mechanism, such as a Scotch yoke, instead of connecting rods and wrist pins. In mechanisms of this type, an eccentric drive shaft or output shaft rotates in a slider or yoke member which is slidably mounted in a piston assembly for reciprocating movement in a direction normal to the direction of piston movement. Slider mechanisms heretofore provided have been subject to certain disadvantages such as high frictional losses and limited load capacity. In addition, the prior slider mechanisms have required a finite amount of clearance to prevent lock up of the mechanism, and this clearance has resulted in undesirable backlash.

SUMMARY AND OBJECTS OF THE INVENTION

In the compact machine of the present invention, bearings are provided between the yoke member and piston, and all loads are supported on rolling surfaces. Means is provided for preloading the bearings to eliminate backlash and align them in such manner that the load is distributed evenly among them. The position of the piston assembly can be adjusted at the time the bearings are preloaded, and head clearance can be equalized between both ends of a double-acting piston. Bumpers limit the travel of the bearings and make proper positioning of them an automatic procedure. A reversible sealing ring carried by the piston utilizes the pressure difference across the piston to provide a more efficient seal in one direction, and this permits either end of a double-ended piston to function equally well in a pressure or vacuum environment.

It is in general an object of the present invention to provide a new and improved compact reciprocating piston machine.

Another object of the invention is to provide a machine of the above character in which all loads are supported on rolling surfaces and frictional losses are minimized.

Another object of the invention is to provide a machine of the above character which includes means for preloading the rolling elements and adjusting the position of a piston in its cylinder.

Another object of the invention is to provide a machine of the above character which includes a reversible seal ring which is aided by pressure differences across the piston.

Additional objects and features of the invention will be apparent from the following description in which the preferred embodiments are set forth in detail in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational view, partially sectioned, of one embodiment of a double-acting pump incorporating the present invention.

FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1.

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 1, with the drive shaft rotated 90° in a clockwise direction.

FIG. 4 is an exploded isometric view of a portion of the piston and yoke assembly of the machine shown in FIG. 1.

FIG. 5 is an enlarged cross-sectional view of the reversible sealing ring of the machine shown in FIG. 1.

FIG. 6 is an enlarged cross-sectional view of an alternative embodiment of a reversible sealing ring for use in the machine of FIG. 1.

FIG. 7 is an exploded isometric view of one embodiment of a pump having a pair of double-acting pistons incorporating the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The pump illustrated in FIGS. 1–4 includes a housing **11** in which a longitudinally extending bore **12** is provided. Cylindrical sleeves **13** are mounted in counterbores **12a** at each end of bore **12.** The ends of the bore are closed by means of head assemblies **14** comprising valve plates **16** and covers **17.** The covers are secured to housing **11** by means of screws **18,** and the valve plates are clamped between sleeves **13** and the covers. O-rings **19** provide seals between the valve plates, covers and housing.

A longitudinally movable piston assembly **21** is disposed within housing **11** and cooperates with sleeves **13** to form chambers of variable volume **22** at the ends of bore **12.** The piston assembly includes a body or skirt member **23** and a pair of head members **24** which are attached to body member **23** by means of screws **26.** A pair of sealing rings **28, 29** are provided at each end of the piston assembly. The rings **28** are conventional annular rings fabricated of a resilient rigid material, and they are mounted in annular grooves **31** in piston body **23.** Rings **29** are made of a resilient material such as Teflon, they are generally U-shaped in cross section and they are mounted in annular grooves **32** formed in the sides of piston head members **24.** Rings **28** and **29** provide slidable seal between the piston assembly and the inner walls **13***a* of sleeves **13.** As is discussed more fully hereinafter, rings **29** are reversible in their grooves, and they can be oriented according to the type of pumping action desired at each end of the piston assembly.

Piston body member **23** is formed to include an aperture **34** in which a yoke member **36** is mounted. The yoke member has a cylindrical bore **37** through which a drive shaft **38** extends. Shaft **38** is mounted in ball bearing assemblies **39** carried by housing **11** and is thereby adapted for rotation about an axis **41** extending normally of the direction of piston movement. Shaft **38** includes an enlarged cylindrical portion **38a** eccentric to axis **41.** This portion of the shaft is rotatably mounted in bore **37** of the yoke member by means of a roller bearing assembly **42.**

Generally planar roller bearing assemblies **44** provide rolling movement of yoke member **36** in piston aperture **34.** Each of these bearing assemblies includes a plurality of rollers or needle bearings **46** and a cage **47.** Rollers **46** engage generally planar bearing surfaces **48** which are provided on yoke member **36.** Bumpers **49** are provided at the ends of bearing surfaces **48,** and

they limit the travel of the bearing assemblies **44.** These bumpers are preferably spaced apart by a distance slightly greater than the sum of the length of cage **47** and one-half of the eccentricity of drive shaft **38.** Rollers **46** also engage race members **51** which are carried by the piston assembly. Each of these race members includes an inwardly facing surface **52** and an outwardly extending threaded stem **53.**

Means is provided for preloading bearing assemblies **44** and adjusting the position of yoke member **36** in piston aperture **34.** This means includes adjusting nuts **56** having internal threads **57** which engage threaded stems **53** of race members **51.** The adjusting nuts are seated in sockets **58** formed in head members **24** of the piston assembly. Slots **59** are provided in the adjusting nuts, and access to these slots is provided by means of openings **61** in the piston head members. O-rings **62** provide seals between the adjusting nuts and head members.

Inlet ports **63** and discharge ports **64** are provided in covers **17,** and check valve assemblies **66** and **67** control communication between these ports and chambers **22.**

Each inlet valve assembly **66** includes a generally planar valve member **68** movable between open and closed positions and a recessed seat **69** formed in the inner wall of valve plate **16.** An O-ring **71** provides a seal between valve member **68** and seat **69** when the valve member is in its closed position. A compression spring **72,** constrained between the outer wall of valve plate **16** and a keeper **73** attached to valve member **68** by a screw **74,** urged the valve member toward its closed position. A plurality of flow passageways **76** in the valve plate provide communication between port **63** and chamber **22** when valve assembly **66** is opened.

Each discharge valve assembly **67** includes a conically tapered poppet member **77** and a matching seat **78** formed in valve plate **16.** A compression spring **79,** constrained between poppet member **77** and a retainer **81,** urges the poppet member into its closed position. Flow passageways **82** formed in retainer **81** provide communication between discharge port **64** and chamber **22** when valve assembly **67** is opened.

It should be noted that when the inlet and discharge valve assemblies at one end of the piston are closed, the valve plate and valve members present a substantially flat surface. There are no voids or dead spaces, and a high volumetric efficiency or compression ratio are possible.

As indicated previously, seal rings **29** are generally U-shaped in cross section. Referring now to FIG. **5,** it can be seen that each of these seal rings includes a pair of spaced apart annular lip portions **29a** which engage the inner wall of cylindrical sleeve **13** and bottom wall **32a** of groove **32.** A resilient member **84** is provided within seal ring **29.** This member has a generally U-shaped cross section, and it urges the lip portions of the seal ring against the walls of the sleeve and groove. The open end of the seal ring is oriented toward the high pressure end of the piston, and the pressure differential across the piston serves to further urge the lip portions of the ring into sealing engagement with the walls of the sleeve and groove. With seal rings **29** oriented as shown in FIG. **1,** the right end of the pump is particularly adapted for vacuum service, and the left end is particularly adapted for pressure service. As indicated previously, the rings can be reversed in their grooves to reverse the modes of operation for which the ends of the pump are best suited.

FIG. **6** illustrates a seal ring **86** which is generally similar to the ring shown in FIG. **5.** Ring **86** is generally U-shaped, and it has a pair of spaced apart annular lip portions **86a** which engage the walls of sleeve **13** and groove **32.** The lip portions of this ring have inclined ridges which further enhance the effectiveness of the seal in one direction. A resilient member **87** disposed within seal ring **86** urges the annular lip portions against the walls of the sleeve and groove. This seal ring is also reversible within the groove, and the open portion of the ring is generally oriented toward the high pressure end of the piston.

Operation and use of the pump shown in FIGS. **1–4** can be described briefly. When drive shaft **38** is rotated, piston assembly **21** moves longitudinally, alternately enlarging and decreasing the volumes of chambers **22,** and yoke member **36** moves back and forth in piston aperture **34.** As chambers **22** are enlarged and decreased, inlet and outlet valve assemblies **66** and **67** open and close, and air or another fluid can be pumped from inlet ports **63** to discharge ports **64.** Connections can be made to the inlet and discharge ports as desired, and depending upon the manner in which the connections are made, the pump may be operated as either a single two-stage pump or as two single-stage pumps for either pressure or vacuum service. It can also be operated as a vacuum pump at one end and a pressure pump at the other.

The bearings can be preloaded and the longitudinal portion of the piston assembly can be adjusted by turning adjusting nuts **56** on the threaded stems of race members **51.** Before these adjustments are made, however, drive shaft **38** should be rotated at least one full revolution to assure that bearing assemblies **44** are positioned correctly. If they are not positioned correctly, they will strike bumpers **49** and skid until they are in the correct position whereupon they will roll back and forth between the bumpers without striking them. Once the bearing assemblies are positioned properly, adjusting nuts **56** are adjusted to eliminate backlash and provide the desired preloading. By turning both of the adjusting nuts equally in the same direction, the position of the piston assembly can be adjusted without affecting the preloading of the bearings.

The pump illustrated in FIG. **7** is generally similar to the pump described above, but it has two double-acting piston assemblies. This pump includes a block **101** in which a pair of longitudinally extending bores **102** are formed. Piston assemblies **21** are slidably mounted in the bores, and these piston assemblies are driven in the manner described above. The ends of the bores are closed by means of head assemblies **104** which carry inlet and discharge valve assemblies similar to valve assemblies **66** and **67.** Drive gears **106** are affixed to drive shafts **38** and mounted in a recessed area **107** in one side of block **101.** A cover plate **108** is mounted on this side of the block and encloses the recessed area. A drive motor **111** is mounted on the side plate, and a pinion gear **112** is affixed to the motor shaft and engages drive gears **106.** The operation and use of this pump are generally similar to the operation and use of the pump described above.

The invention has several important advantages. All loads are supported on rolling surfaces, rather than

sliding elements. This permits a greater load capacity than was possible with slider mechanisms of the prior art, and it greatly reduces frictional losses inherent in the prior art. The bearings can be preloaded to eliminate backlash and to distribute loads evenly among them. The bearings are maintained in the proper position by the bumpers on the yoke member, and the position of the piston assembly can be adjusted to provide proper head clearance at both ends of the piston. The piston is sealed by a ring which utilizes the pressure difference across the piston to form a more efficient seal in one direction. This ring is reversible, permitting each end of the double-acting piston to function equally well in a pressure or vacuum mode. When closed, the valves present a substantially flat surface, free of voids or dead spaces, thereby assuring a high compression ratio or volumetric efficiency. While the invention has been described with specific reference to pumps, it is equally applicable to machines operated as engines.

It is apparent from the foregoing that a new and improved compact reciprocating piston machine has been provided. While only the presently preferred embodiments have been described, as will be apparent to those familiar with the art, certain changes and modifications can be made without departing from the scope of the invention as defined by the following claims.

I claim:

1. In a reciprocating poston machine, means defining a longitudinally extending cylinder having a side wall and at least one closed end, a longitudinally movable piston disposed in the cylinder and cooperating with the means defining the cylinder to form a chamber of variable volume at the closed end of said cylinder, inlet and discharge valve means providing communication with said chamber, means forming a slidable seal between the piston and the side wall of the cylinder, said piston being formed to include a transversely extending aperture, a yoke member disposed in the aperture and movable transversely of the piston, said yoke member being formed to include a cylindrical bore extending normally of both the direction of movement of the piston and the direction of movement of the yoke member within the piston, a shaft mounted for rotation about a fixed axis parallel to the axis of the yoke bore, said shaft having a cylindrical portion eccentric to the shaft axis and rotatably disposed in said bore, bearing means extending transversely between the yoke member and piston to provide rolling movement of the yoke member in the aperture, said bearing means including a pair of generally planar roller bearing assemblies each comprising a plurality of rollers engaging longitudinally spaced-apart bearing surfaces formed on said yoke member and generally planar bearing race members carried by the piston and engaging the rollers opposite the bearing surface of the yoke member, and means for exerting a longitudinal force on the bearing means and positioning the yoke member longitudinally in the aperture.

2. A machine as in claim **1** wherein the means forming the slidable seal includes a ring of resilient material disposed in an annular groove in the side of the piston, said ring having a generally U-shaped cross section defined in part by a pair of spaced apart annular lip portions engaging respectively the side wall of the cylinder and the bottom wall of the groove, the open portion of said seal ring facing toward the high pressure end of the piston.

3. A machine as in claim **1** together with roller bearing means between the yoke member and the cylindrical portion of the shaft.

4. A machine as in claim **1** together with means carried by the yoke member for limiting movement of the rollers transversely of said member.

5. A machine as in claim **1** wherein the cylinder is closed at both ends to form two chambers of variable volume, separate inlet and discharge valve means being provided for each of said chambers.

6. In a reciprocating piston machine, a block having a pair of longitudinally extending bores disposed side-by-side, head assemblies closing the ends of said bores, longitudinally movable pistons disposed in said bores to provide chambers of variable volume at the ends of said bores, inlet and discharge valve means carried by the head assemblies to provide communication with the chambers, said pistons being formed to include transversely extending apertures, yoke members disposed in the apertures and movable transversely of the pistons, bearing means between the yoke member and the bodies of the pistons, bearing means between the yoke members and the bodies of the pistons to provide a rolling movement of the yoke members in the apertures, the bearing means for each piston including a pair of generally planar roller bearing assemblies each comprising a plurality of rollers engaging longitudinally spaced-apart bearing surfaces formed on the yoke member disposed in the piston aperture and generally planar bearing race members carried by the piston and engaging the rollers opposite the bearing surface of the yoke member, means carried by the pistons for preloading the bearing means and positioning the yoke members longitudinally in the apertures, said yoke members being formed to include cylindrical bores extending normally of both the direction of piston movement and the direction of yoke movement within the pistons, shafts mounted for rotation about fixed axes parallel to the axis of the yoke bores, said shafts having cylindrical portions eccentric to the shaft axis and rotatably disposed to the yoke bores, and drive means engaging the shafts for rotating the same.

7. In a reciprocating piston machine, means defining a longitudinally extending cylinder, a piston disposed in the cylinder, said piston having a pair of longitudinally spaced end walls and an aperture intermediate the end walls, a yoke member having a transversely extending bore and a pair of longitudinally spaced bearing surfaces disposed in the aperture, an eccentric member rotatively mounted in the bore in the yoke member, a pair of bearing pads disposed in the aperture between the bearing surfaces of the yoke member and the end walls of the piston, said bearing pads having bearing surfaces facing the bearing surfaces of the yoke member and longitudinally extending threaded portions facing toward the ends of the piston, a plurality of rollers disposed between the bearing surfaces of the yoke member and bearing pads, and threaded members engaging the threaded portions of the bearing pads, said threaded members having semispherical heads received in semispherical sockets formed in the end walls of the piston.

8. A machine as in claim **7** further including roller bearing means mounting the eccentric member in the bore in the yoke member.

* * * * *