

United States Patent

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 [33] **Germany**
 [31] **P1653470.6**

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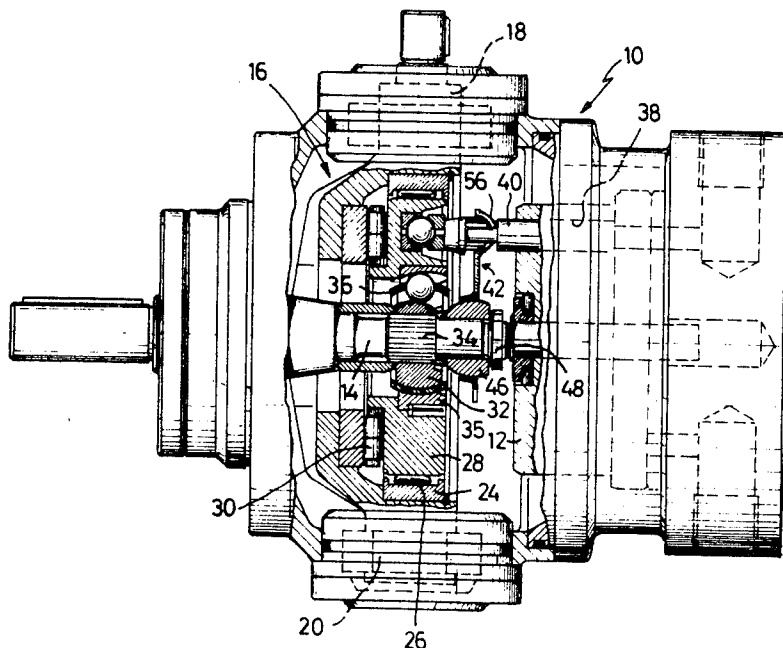
[54] **AXIAL PISTON PUMP**
 12 Claims, 7 Drawing Figs.

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91/507
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F04b 1/02
 [50] Field of Search **103/162;**
230/178; 91/198, 199; 92/57; 123/43 A, 43 A1;
74/60

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ABSTRACT: A variable-delivery axial piston pump wherein the heads of pistons are biased toward the wobble plate by a star-shaped plate spring which is free to swivel on the drive shaft. Followers which engage balls provided in the wobble plate abut with their flat rear faces against flat end faces provided on the heads of pistons so that the followers can move radially with reference to the pistons when the inclination of the wobble plate is changed to change the delivery of the pump.



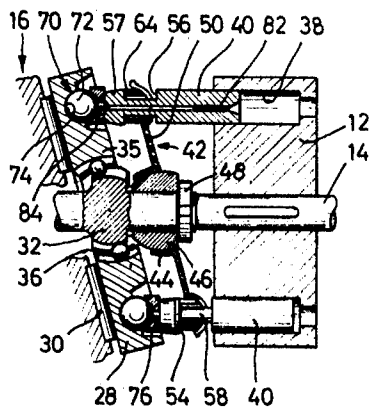
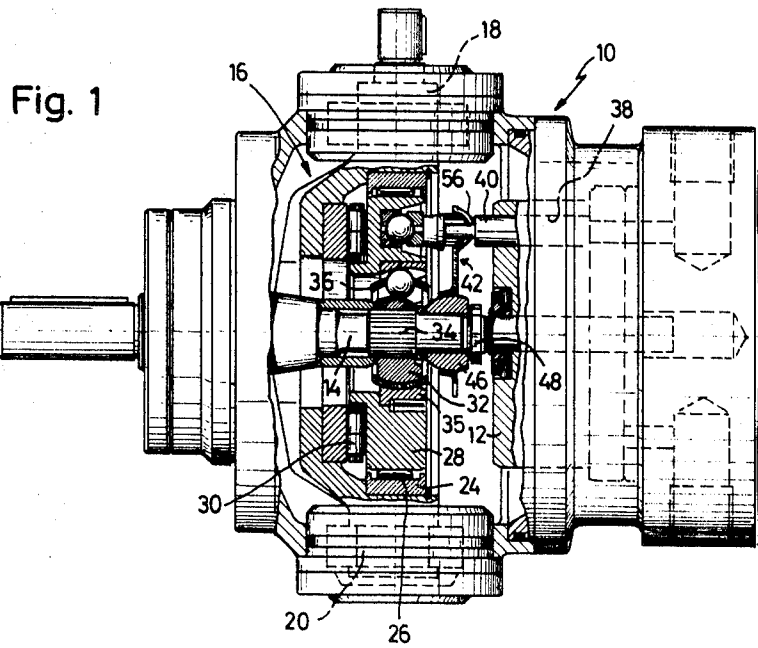


Fig. 2

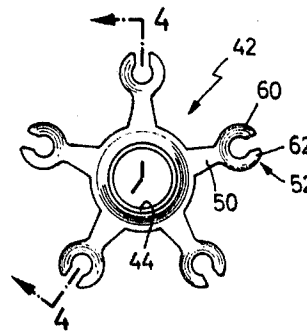


Fig. 3

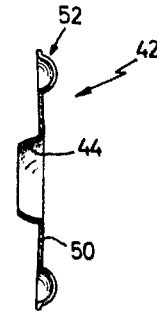


Fig. 4

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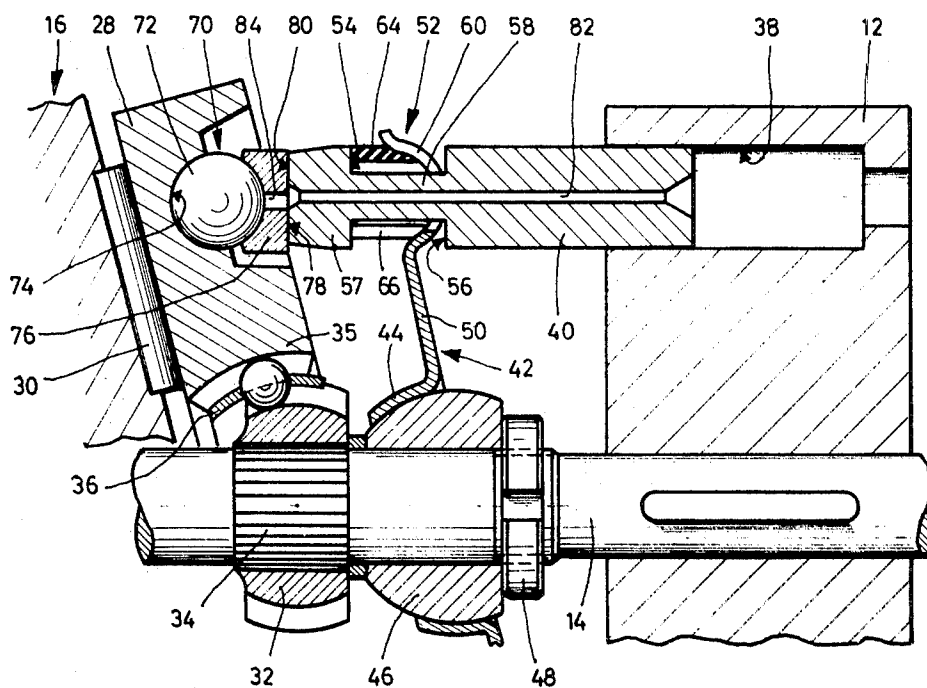


Fig. 5

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Fig. 6

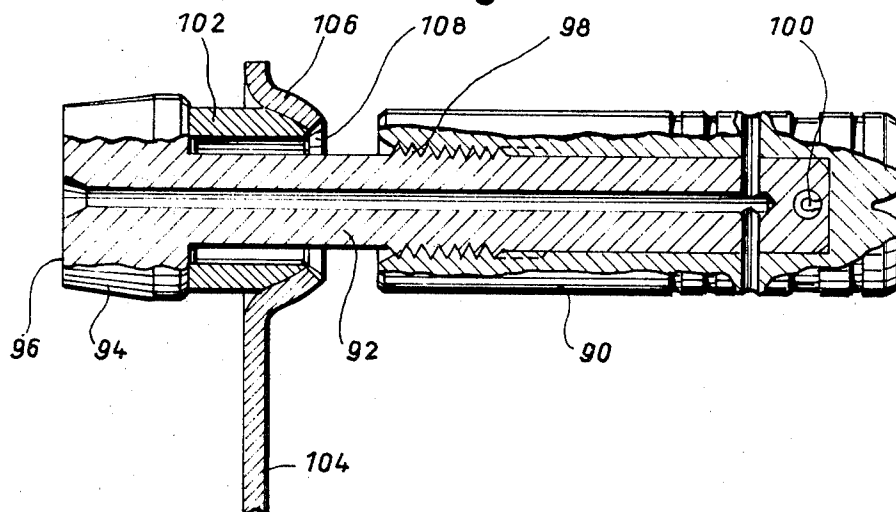
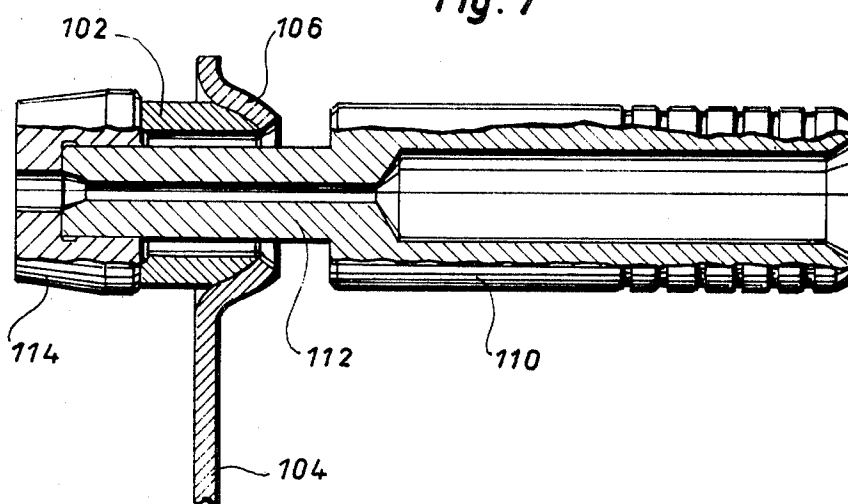


Fig. 7



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AXIAL PISTON PUMP

BACKGROUND OF THE INVENTION

The present invention relates to axial piston machines in general, especially to variable-delivery axial piston pumps of the type wherein a revolving wobble plate causes a set of pistons to reciprocate in chambers provided therefor in a cylinder block or barrel which rotates with the wobble plate.

It is well known that an axial piston pump must be provided with means for insuring that the pistons are operatively connected with the wobble plate in all positions of the tilting box which changes the inclination of the wobble plate and in each angular position of the wobble plate. This presents a number of problems. As a rule, the heads of the pistons are anchored in the wobble plate and, to this end, the heads form spheres which are received in composite sockets fixed to the wobble plate. This necessitates the machining of piston heads and sockets with a high degree of precision. Reference may be had, for example, to German DAS No. 1,220,735. Moreover, such connections invariably undergo rapid wear so that the pistons do not share all such movements of adjoining portions of the wobble plate which take place in the axial direction of the cylinder barrel. Readily detectable noise is but one of several consequences of wear upon the just described connections between the wobble plate and the pistons.

SUMMARY OF THE INVENTION

One of several objects of my invention is to provide an axial piston machine, particularly a variable-delivery axial piston pump, with novel means for insuring satisfactory motion receiving engagement between the pistons and the wobble plate in all angular positions and also in each position of inclination of the wobble plate.

Another object of the invention is to provide the machine with means which insure satisfactory motion receiving engagement between the pistons and the wobble plate regardless of wear upon such parts in response to extensive use of the machine.

A further object of the invention is to provide an axial piston machine with simple, compact, easy-to-install and inexpensive means for establishing and maintaining long-lasting satisfactory motion receiving engagement between the pistons and the wobble plate.

An additional object of the invention is to provide a connection which permits unobstructed changes in inclination of the wobble plate, either when the machine is idle or when the machine is in use.

Still another object of the invention is to provide novel pistons for use in a machine of the above-outlined character.

The invention is embodied in an axial piston machine, particularly in a variable-delivery axial piston pump, which comprises a cylinder barrel having a plurality of axially parallel or inclined cylinder chambers, pistons reciprocably extending into the cylinder chambers, a wobble plate adjacent to the pistons, drive means for rotating the wobble plate with the barrel whereby the plate wobbles to an extent which depends on its inclination with reference to the axis of the drive means, and biasing means (preferably comprising a single one-piece biasing member) operatively connected with and arranged to permanently urge all of the pistons toward the wobble plate so that the pistons reciprocate in their chambers in response to rotation and wobbling of the plate.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved axial piston pump itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partly elevational and partly axial sectional view of an axial piston pump which embodies the invention;

FIG. 2 is an axial sectional view of a detail in the pump of FIG. 1, with the tilting box shown in a different angular position;

FIG. 3 is a front elevational view of a biasing member in the pump of FIG. 1;

FIG. 4 is a sectional view of the biasing member as seen in the direction of arrows from the line 4-4 of FIG. 3;

FIG. 5 is an enlarged view of a detail in the structure of FIG. 2;

FIG. 6 is a fragmentary sectional view of a second axial piston pump; and

FIG. 7 is a similar fragmentary sectional view of a third axial piston pump.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a variable displacement axial piston pump which comprises a housing or body 10 accommodating a cylinder barrel or block 12 which is affixed to a rotary drive shaft 14. The cylinder barrel 12 cooperates with an adjustable tilting box 16 provided with coaxial trunnions 18, 20 which are journaled in the housing 10. The trunnion 20 extends from or is accessible at the outer side of the housing 10 and can be turned by a suitable tool to thereby change the displacement of the pump. The tilting box 16 comprises a cupped casing which is rigid with a ring 24 surrounding a needle bearing 26 for a disc-shaped wobble plate 28. The drive shaft 14 extends through the wobble plate 28 and the bottom wall of the tilting box 16 carries a thrust bearing 30 for the adjoining end face of the plate 28. The bearing 30 transmits tilting movements of the box 16 to the wobble plate 28, such tilting movements taking place about the common axis of the trunnions 18, 20 when the operator decides to change the angular position of the trunnion 20. FIG. 1 shows the tilting box 16 in a neutral position in which the displacement is zero, and FIG. 2 illustrates the tilting box in a rather strongly inclined or tilted position.

The drive shaft 14 rotates the wobble plate 28 with reference to the casing of the tilting box 16 by way of a special transmission which includes a spherical driving element 32 having internal teeth which mate with the teeth of a pinion 34 on the drive shaft 14. The peripheral surface of the driving element 32 is formed with arcuate grooves separated by ribs and accommodating spherical rolling elements in a cage 36 (shown only in FIG. 1). These rolling elements also extend into arcuate grooves provided in an annular driven element 35 installed in the wobble plate 28. As can be readily seen in FIGS. 1, 2 and 5, the rolling elements in the cage 36 transmit torque from the driving element 32 to the driven element 35 in each angular position of the tilting box 16 with reference to the common axis of trunnions 18, 20.

The barrel or block 12 is formed with a set of axially parallel cylinder chambers 38 for pistons 40 which are reciprocated in their chambers in response to wobbling of the plate 28 when the tilting box 16 is moved away from the neutral position shown in FIG. 1 and when the shaft 14 is driven by an electric motor or another prime mover, not shown. For example, the barrel 12 may carry five equidistant pistons 40 and a portion of each piston extends beyond the corresponding chamber 38 in a direction toward the tilting box 16. In accordance with a feature of my invention, the end portions or heads 57 of the pistons 40 are urged toward spherical motion transmitting members or balls 72 which rotate with the wobble plate 28 by a single biasing member 42 which is preferably a plate spring and is best shown in FIGS. 3 and 4. The biasing member 42 consists of elastic metallic or plastic material and has five elastic metallic or plastic material and has five elastic arms 50 each of which urges one of the heads 57 toward the respective ball 72. This biasing member 42 comprises a concavo-convex central portion or socket 44 which is free to swivel on a spheri-

cal member 46 provided on or forming an integral part of the drive shaft 14 in the region between the barrel 12 and wobble plate 28. In the illustrated embodiment, the member 46 is an annulus which is held on the shaft 14 in the illustrated axial position by a nut 48 threaded onto the drive shaft. The outer end portions 52 of the arms 50 are bifurcated and transmit pressure indirectly to annular shoulders 54 on the heads of the corresponding pistons 40 (see particularly FIG. 5 which shows clearly that the shoulders 54 face away from the wobble plate 28). The exposed portions of the pistons 40 are provided with relatively wide annular peripheral grooves 56 which surround relatively short piston rods 58 and connect the cylindrical main portions of pistons 40 with the end portions or heads 57. The prongs 60, 62 of bifurcated end portions 52 of the arms 50 on the biasing member 42 straddle the respective piston rods 58 and transmit pressure to the shoulders 54 on the heads 57 of the respective pistons 40. As shown in FIG. 2, the biasing member 42 swivels in synchronism with the wobble plate 28 when the latter is rotated by the shaft 14 and when the box 16 is inclined with reference to the neutral position shown in FIG. 1. During such swiveling of the biasing member 42, the distance between the outer end portions 52 of the arms 50 and the axis of the shaft 14 varies continuously and the pump is therefore provided with means for compensating for such changes. Such compensating means comprises washers or cushions 64 which are applied around the piston rods 58 and extend between the shoulders 54 and the prongs 60, 62 of the respective arms 50. These washers or cushions 64 preferably consist of elastomeric material, such as polyamide. Each washer 64 resembles a short substantially cylindrical sleeve and is preferably provided with an axially extending slit 66 (see particularly FIG. 5) to facilitate its application around the corresponding piston rod 58. The internal diameters of the washers or cushions 64 are preferably selected in such a way that each thereof surrounds the corresponding piston rod 58 with at least some radial clearance. Thus, when the arms 50 oscillate in response to rotation of the drive shaft 14 in an inclined position of the tilting box 16, the washers 64 move radially with reference to the pistons 40. In order to insure uniform stressing of shoulders 54, the prongs 60, 62 of each end portion 52 preferably resemble a small cup which is provided with a hole in the middle and with a radial slot for the corresponding piston rod 58. The washers 64 have convex end faces which extend into the concave sides of such cups. The length of washers 64 is selected in such a way that the arms 50 are stressed in each position of inclination of the biasing member 42. This insures that the heads 57 are urged toward the adjoining balls 72.

Each ball 72 forms with an adjoining follower 76 an articulate connection 70 between the corresponding piston 40 and the wobble plate 28. The balls 72 extend into equidistant sockets 74 machined into the adjoining end face of the wobble plate 28. The followers 76 are also provided with rather shallow sockets which accommodate portions of the corresponding balls 72 as best shown in FIG. 5. The rear faces 78 of the followers 76 are flat and abut against similar flat end faces 80 of the heads 57. Such indirect abutment between the pistons 40 and the wobble plate 28 is desirable and necessary because the distance between the axis of the drive shaft 14 and the balls 72 varies when the barrel 12 and plate 28 rotate with the drive shaft in inclined position of the tilting box 16. Thus, the parts which are provided between the pistons 40 and the wobble plate must permit radial movement of the followers 76. Each flat rear face 78 then slides relative to the adjoining end face 80. These faces are located in planes which are normal to the axis of rotation of the barrel 12.

In accordance with a further feature of my invention, each piston 40 is provided with an axially extending bore or channel 82 which communicates with a bore or channel 84 in the corresponding follower 76 and with the respective cylinder chamber 38. The diameter of each bore 84 is selected in such a way that these bores continue to communicate with the adjoining bores 82 even though the followers 76 are caused to

move radially with reference to the adjoining heads 57. The fluid (e.g., oil) can flow from the chambers 38 through the bores 82, 84 and between the abutting faces 78, 80 to form therein a thin layer which reduces friction when the followers 76 move radially with reference to associated pistons 40. Also, such fluid lubricates the balls 72.

The manner in which the pistons 40 draw fluid into and expel such fluid from the corresponding cylinder chambers 38 in response to rotation of the drive shaft 14 in an inclined position of the tilting box 16 is well known and need not be described here. If desired the axes of the cylinder chambers 38 may be inclined with reference to the axis of the drive shaft 14.

Since it is rather simple to design and shape the biasing member 42 in such a way that each of its arms 50 biases the corresponding piston 40 with the same force, and since it is easy to install the biasing member 42 in such a way that each of its arms 50 remains at least slightly stressed in each position of the corresponding piston 40 and in each position of inclination of the tilting box 16, the wear upon the articulate connections 70 between the wobble plate 28 and the pistons 40 exerts negligible influence upon optimum transmission of axial movement from the wobble plate 28 to the pistons. Another important advantage of the improved machine is that it can employ a simple and inexpensive wobble plate because this plate need not be provided or coupled with specially machined parts to serve as sockets and as retaining means for spherical ends of pistons in conventional axial piston pumps. The sockets or depressions 74 are preferably machined directly into the wobble plate 28 and these sockets can be made rather shallow, i.e., they need not hold the corresponding balls 72 against movement away from the wobble plate. The balls 72 are permanently urged into such sockets by the corresponding arms 50 of the biasing member 42.

It is also within the purview of my invention to employ a rigid biasing member which is mounted on the drive shaft 14 and/or on the barrel 12 and is provided with discrete springs each of which urges one of the heads 57 against the corresponding follower 72.

FIG. 6 illustrates a portion of a second axial piston pump wherein the biasing member comprises several equidistant radially extending elastic arms 104 (only one shown) each of which comprises a circumferentially complete cupped end portion 106 provided with a central opening 108. Thus, the end portions 106 do not have prongs corresponding to the prongs 60, 62 shown in FIG. 3. In order to permit assembly of arms 104 with the cushions 102, the pump of FIG. 6 comprises composite pistons each of which includes an internally threaded plunger 90, an externally threaded piston rod or reduced-diameter portion 92 which meshes with the plunger 90, as at 98, and an end portion or head 94 which is integral with one end of the piston rod. The head 94 has a flat front end face 96 which corresponds to the end face 80 shown in FIG. 5 and abuts against the rear face of a follower (not shown). The cushion 102 is preferably a circumferentially complete sleeve having a spherical rear end portion which abuts against the concave side of the cupped end portion 106 on the corresponding arm 104. A diametrically extending pin 100 is provided to hold the piston rod 92 against rotation with reference to the plunger 90 or vice versa. It is clear that the cushion 102 can be replaced with a cushion of the type shown in FIG. 5. It is also clear that the internal diameter of the cushion 102 and the diameter of the central opening 108 exceed the diameter of the piston rod 92, at least the diameter of that portion of the piston rod which extends between the plunger 90 and head 94.

In assembling the piston of FIG. 6 with the parts 104 and 102, the cushion 102 is slipped onto the right-hand end of the piston rod 92 and is moved toward the head 94. The piston rod is thereupon caused to pass through the central opening 108 of the end portion 106 and is threadedly connected with the plunger 90 at 98. In the next step, the pin 100 is introduced through registering bores of the plunger 90 and piston rod 92 to thus complete the assembly.

The fluid-conveying bore or channel of the piston shown in FIG. 6 includes an axially extending portion which passes centrally through the head 94 and through the major part of the piston rod 92, and radially extending portions provided in the rear end of the piston rod and in the plunger 90.

Referring finally to FIG. 7, there is shown a portion of a third axial piston pump which comprises a biasing member having several elastic arms 104 (not shown), cushions 102 and modified composite pistons each of which comprises a plunger 110 integral with a piston rod or reduced-diameter portion 112 and a head or end portion 114 which is threaded onto or a press-fit on the forward end of the piston rod. In assembling the biasing member with the pistons, the front ends of piston rods 112 are passed through the central openings in the end portions 106 of corresponding arms 104 and through the cushions 102 and are thereupon connected with the heads 114. Such heads can be shrunk onto the corresponding pistons rods 112.

The fluid-conveying bore in the piston of FIG. 7 comprises a larger-diameter portion in the plunger 110 and a smaller-diameter portion in the piston rod 112 and head 114.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art.

What I claim as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an axial piston machine, particularly in a variable-displacement axial piston pump, a combination comprising a cylinder barrel having a plurality of cylinder chambers; pistons reciprocally extending into said chambers; a wobble plate adjacent to said pistons; an annular shoulder on each of said pistons and facing away from said plate; drive means for rotating said wobble plate with said barrel; resilient biasing means operatively connected with and arranged to constantly urge all of said pistons toward said wobble plate so that the pistons reciprocate in their chambers in response to rotation and wobbling of said plate, said biasing means comprising a plurality of substantially radially extending elastic arms each of which surrounds one of said pistons in a region adjacent to the respective shoulder; and compensating members interposed between said arms and the respective shoulders.

2. A combination as defined in claim 1, wherein each of said arms comprises a cupped end portion and wherein each of said compensating members comprises a spherical portion extending into the respective cupped end portion.

3. A combination as defined in claim 1, wherein said compensating members are elastic washers movable radially with reference to said pistons.

4. A combination as defined in claim 1, wherein said arms comprise bifurcated end portions which straddle reduced-diameter portions provided on the respective pistons adjacent to said shoulders.

5. A combination as defined in claim 1, wherein each of said arms comprises a circumferentially complete annular end por-

tion which surrounds a reduced-diameter portion of the respective piston and wherein each of said compensating members is a circumferentially complete sleeve surrounding the reduced-diameter portion between the corresponding shoulder and the respective annular end portion.

6. A combination as defined in claim 5 wherein each of said pistons is a composite piston comprising a plurality of separate portions to facilitate the introduction of said reduced-diameter portions through the respective sleeves and annular end portions.

7. In an axial piston machine, particularly in a variable-displacement axial piston pump, a combination comprising a cylinder barrel having a plurality of cylinder chambers; pistons reciprocally extending into said chambers; a wobble plate adjacent to said pistons; articulate connections interposed between said pistons and said wobble plate, each of said connections comprising a ball having a first portion extending into a socket provided in said wobble plate and a follower having a socket receiving a second portion of the respective ball and abutting with freedom of radial movement against the respective piston; drive means for rotating said wobble plate with said barrel; and resilient biasing means operatively connected with and arranged to constantly urge all of said pistons toward said wobble plate so that the pistons reciprocate in their chambers in response to rotation and wobbling of said plate.

8. A combination as defined in claim 7, wherein each of said pistons is provided with a flat fixed end face adjacent to and abutting against a complementary flat face of the respective follower.

9. A combination as defined in claim 8, wherein each of said pistons is provided with a bore extending between said end face thereof and the respective cylinder chamber.

10. A combination as defined in claim 9, wherein each of said followers is provided with a bore communicating with the socket therein and with the bore of the corresponding piston.

11. In an axial piston machine, particularly in a variable-displacement axial piston pump, a combination comprising a cylinder barrel having a plurality of cylinder chambers; pistons reciprocally extending into said chambers, each of said pistons being provided with a relatively wide circumferential groove surrounding a smaller-diameter portion of the respective piston; a wobble plate adjacent to said pistons; drive means for rotating said wobble plate into said barrel; resilient biasing means operatively connected with and arranged to constantly urge all of said pistons toward said wobble plate so that the pistons reciprocate in their chambers in response to rotation and wobbling of said plate, said biasing means comprising elastic arms having end portions at least partly surrounding the smaller-diameter portions of said pistons; and sleeve-like elastic cushions interposed between said end portions of said arms and shoulders provided on said pistons in said grooves thereof and facing away from said wobble plate.

12. A combination as defined in claim 11, wherein each of said cushions is an axially split sleeve which surrounds the respective small-diameter portion with at least some freedom of radial movement with reference to the corresponding piston.