

Sept. 27, 1966

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3,274,950

AXIAL PISTON FLUID PUMPS OR MOTORS

Filed Jan. 11, 1965

2 Sheets-Sheet 1

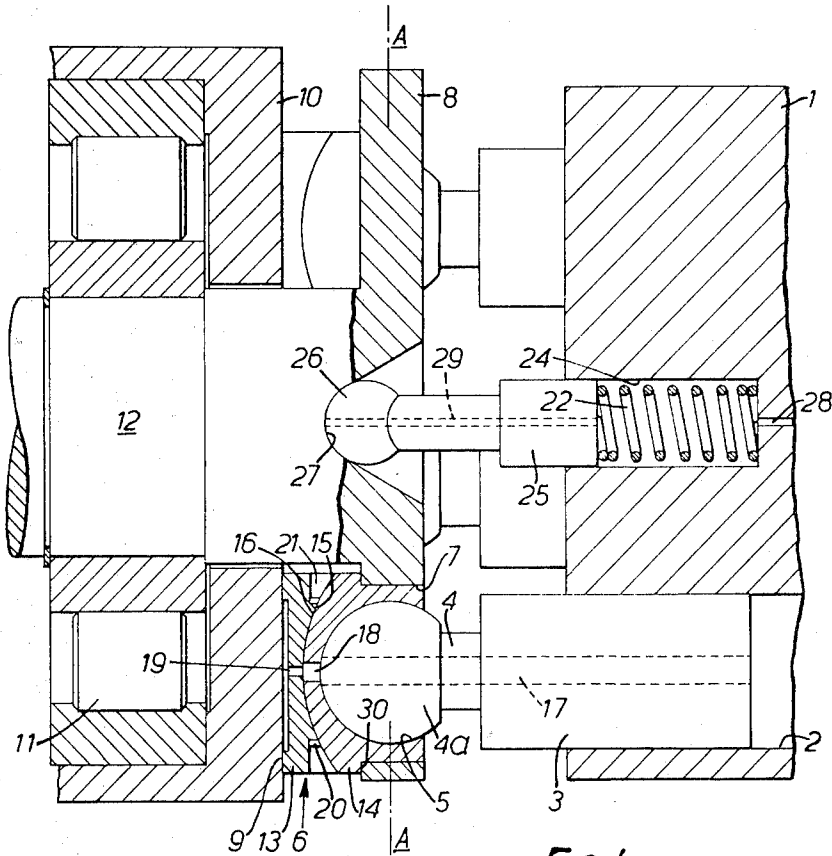


FIG. 1.

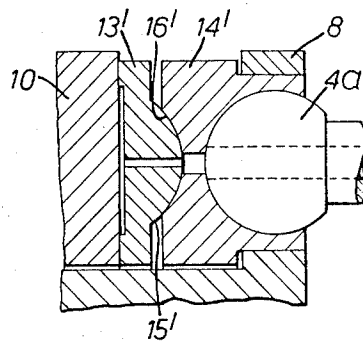


FIG. 2.

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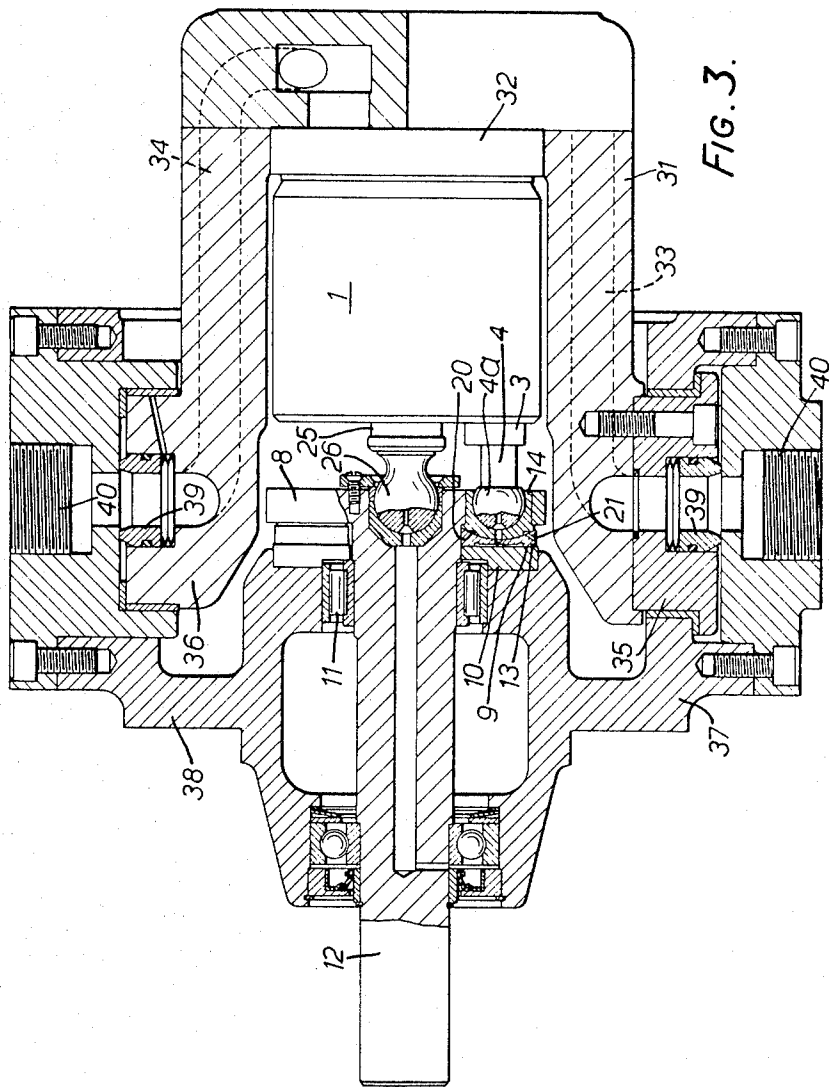


FIG. 3.

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AXIAL PISTON FLUID PUMPS OR MOTORS

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Filed Jan. 11, 1965, Ser. No. 424,638

Claims priority, application Germany, Jan. 14, 1964, T 25,423

8 Claims. (Cl. 103—162)

This invention relates to axial piston fluid machines, which term includes pumps and motors, of the type in which each piston is pivotally connected to a sliding shoe, which is located by a rotary drive member, and which engages a slanting plane surface on a thrust member so that relative rotation between the pistons and the thrust member is accompanied by reciprocating movement of the pistons in their cylinders. One example of such a machine is commonly known as a "tilting head" machine since it is convenient to form the cylinders for the pistons in a rotary block or head which can be tilted about a transverse axis relative to the axis of the rotary drive member. In such machines, the main useful torque reaction developed by the engagement of the shoes with the thrust member is transmitted directly to or from the rotary drive member. This is to be contrasted with machines in which the main useful torque reaction developed at the shoes is transmitted through the side surfaces of the pistons and their respective cylinders, each piston acting as a cantilever. One example of the latter type of machine is the so-called swash plate pump or motor. In both types the angle of the slanting plane surface on the thrust member may be either fixed, providing a constant displacement machine, or adjustable, providing a variable displacement machine.

In machines of both types proper relative positioning of each shoe on the plane surface of the thrust member is particularly necessary as otherwise no satisfactory lubricant film can develop between the shoe and the plane surface, and metallic interaction and seizure can result. Moreover in machines operating at very high pressures it is particularly important to eliminate as far as possible the effects of elastic deformations of the components, so that the working life of the machine, or of its parts, is not seriously reduced.

It is possible to provide proper contact and alignment between the sliding shoe and the slanting plane surface by supporting the sliding shoe in a non-rigid manner relative to a guiding plate, for example by affording some play between the shoe and a locating bore in this guiding plate, so that the shoe can move freely into proper alignment with the slanting plane. In machines of the swash-plate type there would be little difficulty in providing for such alignment of the shoes, since this guiding plate does not constitute a rotary drive member to which the torque reaction is transmitted from the shoes and only serves for piston return purposes. Such an arrangement with a non-rigid support of the shoe has disadvantages however in machines in which the main useful torque reaction is transmitted directly between a rotary drive member and the sliding shoes, since any play between each sliding shoe and its locating bore in the rotary drive member would result in damaging the bore, with consequent generation of wear, noise, and may also tend to cause the shoe to jam in its bore. To transmit the useful torque directly between the shoes and a rotary drive member brings however other substantial advantages, particularly the avoid-

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ance of piston side forces and cantilever bending moments in the pistons, so that operating pressures can be increased.

According to the invention an axial piston fluid machine comprises a number of pistons arranged in generally parallel cylinder bores, each piston being pivotally connected to a sliding shoe, which is circumferentially and radially located with axial or longitudinal freedom of movement by a rotary drive member, and engages a thrust member having a plane surface which is inclined or capable of being inclined relative to the axis of the pistons to transmit axial force, each sliding shoe being formed in at least two parts of which one part is located in the rotary drive member and restrained against circumferential, radial or pivotal movements, and pivotally connected to the respective piston, and another part bears against the plane surface and is pivotally connected to the first part.

By means of the invention, although the first sliding shoe part is located in the rotary drive member without circumferential or radial play, it transmits the useful torque without wear and the part of the shoe which engages the plane surface of the thrust member is allowed to adjust itself automatically to take up the proper attitude of alignment with the plane surface of the thrust member.

Preferably a lubricating channel for each sliding shoe extends through the respective piston to the pivotal connection between the two parts of the shoe, and thence to the sliding surface of the shoe which bears against the plane thrust surface.

According to another preferred feature of the invention the adjacent surfaces of the said two shoe parts are part-spherical.

To prevent excessive build-up of fluid pressure between these surfaces, preferably at least one of the mutually cooperating surfaces of the two shoe parts is provided with an annular oil outlet groove. This groove limits the total effective area of the oil film between the parts to a value which is preferably less than the piston area of the associated piston.

In a particular preferred embodiment each piston is connected to a piston rod having ball joints at both ends, and the ball end adjacent the rotary drive member is mounted in a part spherical seat within the first mentioned shoe part, this part being formed as a generally cylindrical sleeve which is a close sliding fit in a cylindrical bore in the rotary drive member. Thus the force which provides the torque reaction of the machine, and which can be treated as originating at the centres of those ball ends of the piston rods, is transmitted directly to the rotary drive member through these cooperating cylindrical surfaces. The pivotal connection between the two shoe parts in this preferred embodiment, takes the form of cooperating part-spherical surfaces lying generally perpendicular to the respective pistons. This arrangement lends itself to the provision of hydrostatic lubrication of these part-spherical surfaces, which are not subject to the side thrust involved in the main torque reaction of the machine.

The invention may be performed in various ways and a number of specific embodiments will now be described by way of example with reference to the accompanying drawings, in which—

FIGURE 1 is a longitudinal sectional view through the main parts of an axial piston tilting head hydraulic pump according to the invention,

FIGURE 2 is a fragmentary longitudinal section

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through a different sliding shoe construction according to the invention, and

FIGURE 3 is a longitudinal elevation, partly in section, through another form of tilting head pump according to the invention.

In FIGURE 1 the pump comprises a revolving cylinder drum 1, which is formed with a number of axial cylinder bores 2 in each of which lies a sliding piston 3. From each piston 3 projects a piston rod 4 having an inner ball head (not shown) forming an articulated joint with the piston, and an outer ball head 4a, which is pivotally mounted in a spherical socket 5 in a first part 14 of a sliding shoe assembly 6. The part 14 is a close sliding fit in a bore 7 of a rotary flange 8 connected to a shaft 12, but is axially movable in the bore. The sliding surface 9 of the shoe assembly bears against a plane surface on a non-rotary thrust member 10 which in this example of the invention is formed integral with a cylindrical housing and supports a bearing 11 for the driving shaft 12 connected to the rotary driving flange 8. The cylinder drum 1 can be tilted about the transverse axis A—A, and by rotation of the shaft 12 and of the driving flange 8 the cylinder drum 1 is also rotated through the sliding shoes 6 and the pistons 3, thus causing reciprocation of the pistons 3 in their cylinder bores 2, whereby pumping action is exerted on the fluid in the cylinder bores, the fluid being admitted to and discharged from the bores through ports in a stationary port block (not shown) of conventional design, arranged in close contact with the cylinder drum. As illustrated in FIGURE 1 the drum 1 is coaxial with the shaft 12 and flange 8, so that the effective altitude of the plane surface 9 is zero, and the pump is in its neutral or zero displacement condition.

In order to ensure proper engagement of the sliding shoe 6 on the plane surface 10, independently of production tolerances and elastic strain occurring during operation, each sliding shoe is in two parts, and consists of a first part 13 on which is formed the sliding surface 9 and a second part 14 in which is formed the socket 5. The adjoining surfaces 15 and 16 of both parts 13 and 14 are part-spherical, and generally perpendicular to the associated pistons, and thus the part 13 can tilt slightly relative to the driving flange, and the sliding surface 9 automatically adjusts itself relative to the plane surface 10 so that proper contact and the formation of a lubricant film can be obtained.

An oil channel 17 extends through each piston 3 and the corresponding piston rod 4, the channel terminating at the ball head 4a. A further channel 18 continues through the sliding shoe part 14 to the spherical surfaces 15, 16, and another channel 19 extends thence to the sliding surface 9. As a result of the pumping action of the piston 3, oil is forced into the channel 17, lubricates the surfaces of the ball joint 4a and 5, and continues through the channel 18 to the ball surfaces 15, 16, the oil pressure tending to force the sliding shoe parts 13, 14 apart from one another. An annular outlet or pressure relief groove 20 is provided in the surface 15 and communicates with vent ports 21, thus effectively limiting the total area of the hydrostatic oil film to less than the area of the respective piston 3.

Further, to avoid separation of the sliding shoe 6 from the slanting plane 10, and separation of the sliding shoe parts 13, 14, on the suction stroke of the piston 3, the flange 8 with its shaft 12 is arranged to be axially movable and a spring 22 is arranged in a central bore 24 in the cylinder drum 1 and receives a plunger 25 with a ball-shaped end 26 which is situated in a recess 27 in the flange 8. Pressure oil is admitted through a channel 28 in the cylinder drum and through a channel 29 in the plunger 25 to the operative surfaces of the recess 27. The sliding shoe part 14 is formed with a shoulder 30 which abuts against the moving flange 8 so that the spring 22 acts to hold the sliding shoe parts together, and also urges the sliding shoe against the slanting plane.

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It will be noted that the sliding shoe part 13 does not itself transmit any of the radial or circumferential component of the reaction force between the ball head 4a of the piston rod and the rotary drive flange 8, this force being transmitted directly from the non-pivoting shoe part 14 to the bore 7 in which it is located. This reaction force, which produces or results from the main useful torque transmitted through the machine, is very considerable, and originates in effect at the centre of each of the ball heads 4a. Only the axial component of the reaction force is transmitted from the shoe part 14 to the shoe part 13 through the cooperating part-spherical surfaces and the intervening hydrostatic oil film.

Instead of the spring 22 a hydraulic actuator could be provided.

In FIGURE 2 an alternative embodiment of the invention is shown, and here the part 14' has a hollow spherical seating 16' and the part 13' has a corresponding spherical dome 15'. The operation of this construction is essentially the same as in FIGURE 1.

In FIGURE 3 the construction of the shoe assemblies is basically similar to that illustrated in FIGURE 1, and other parts of the machine, particularly the stationary valve block and the pivots for the tilting head are illustrated in some detail. Corresponding parts are indicated by the same reference numerals as used in FIGURE 1. It will be seen that the cylinder drum 1 is contained within a tilting head casing 31 and engages a non-rotary valve timing block 32 having ports which communicate with a pair of fluid inlet and outlet conduits 33, 34 in the wall of the casing. The casing has bearing spigots 35, 36, mounted in stationary bracket members, 37, 38, and provided with internal rotary oil seals 39. Ports 40 in the bracket members constitute the external oil supply and return connections.

In the examples illustrated the plane surface on the thrust member 10 is stationary and the cylinder drum is rotated and is tiltable about the axis A—A. The invention can however also be used with axial piston machines where the rotary axis of the cylinder drum is not tiltable but where the attitude of the thrust member is adjusted in order to change the stroke and displacement of the pump. Also the invention can be used for machines with fixed displacements.

I claim:

1. An axial piston fluid machine having a plurality of generally parallel cylinder bores, pistons slidably disposed in said cylinder bores, a sliding shoe to which each piston is pivotally connected, a rotary drive member which circumferentially and radially locates the shoes with axial or longitudinal freedom of movement, a thrust member having a plane surface which is inclinable relative to the axis of the pistons to transmit axial thrust, the shoes engaging the thrust member, each shoe being formed in at least two parts of which one part is located in the rotary drive member and restrained against circumferential, radial or pivotal movements, and pivotally connected to the respective piston, and another part bears against the plane surface and is pivotally connected to the first part.

2. An axial piston machine as claimed in claim 1, said two shoe parts having adjacent surfaces that are part-spherical.

3. An axial piston machine as claimed in claim 1, said first-mentioned shoe part being in the form of a sleeve which has freedom of movement in an axial direction relative to the rotary drive member.

4. An axial piston machine as claimed in claim 1, and means constraining the rotary drive member to lie in a plane parallel to the plane of the surface of the thrust member.

5. An axial piston machine as claimed in claim 1, and a piston rod having articulated joints at both ends thereof, by which each piston is connected to the respective shoe.

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6. An axial piston machine as claimed in claim 1, there being a lubricating channel for each sliding shoe which extends through the respective piston to the pivotal connection between the parts of the shoe and thence to the sliding surface of the shoe which bears against the surface of the thrust member. 5

7. An axial piston machine as claimed in claim 6, there being an annular oil outlet groove in at least one of the mutually cooperating surfaces of the shoe parts, said groove limiting the total effective area of said one surface to a value not greatly exceeding that of the associated piston. 10

8. An axial piston machine as claimed in claim 1, and

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means yieldably urging the rotary drive member in a direction to hold each pair of sliding shoe parts together and to urge the sliding shoes into engagement with the plane surface.

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