

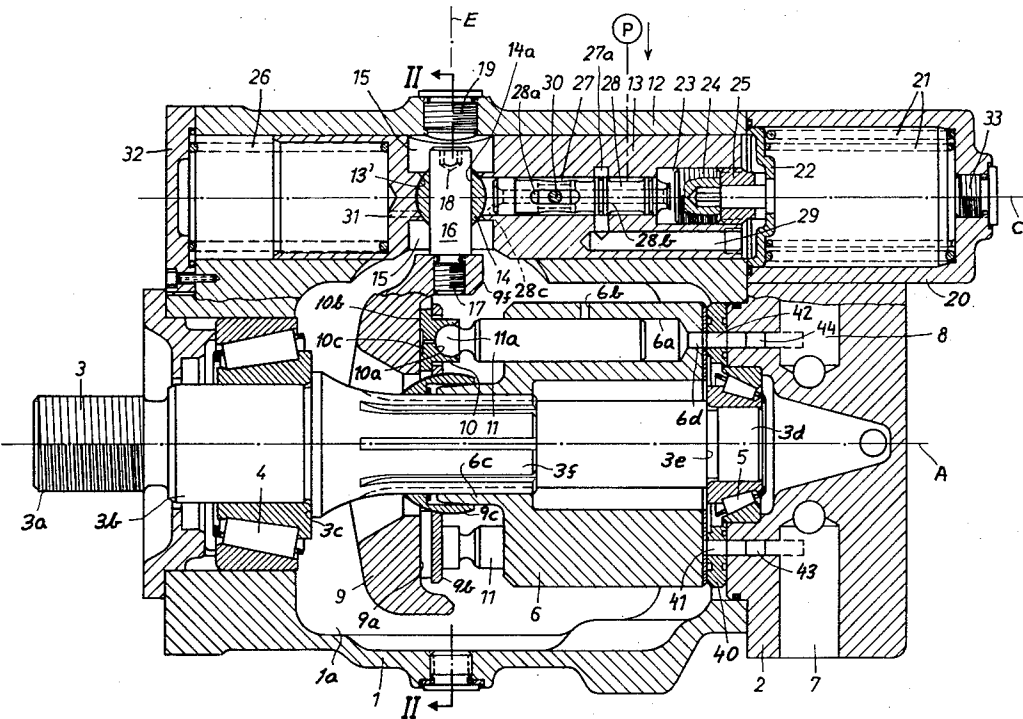
- [54] CONTROL SYSTEM FOR AXIAL-PISTON MACHINES AND THE LIKE
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- [58] Field of Search 91/377, 378, 422, 466,
91/506; 417/222; 92/131
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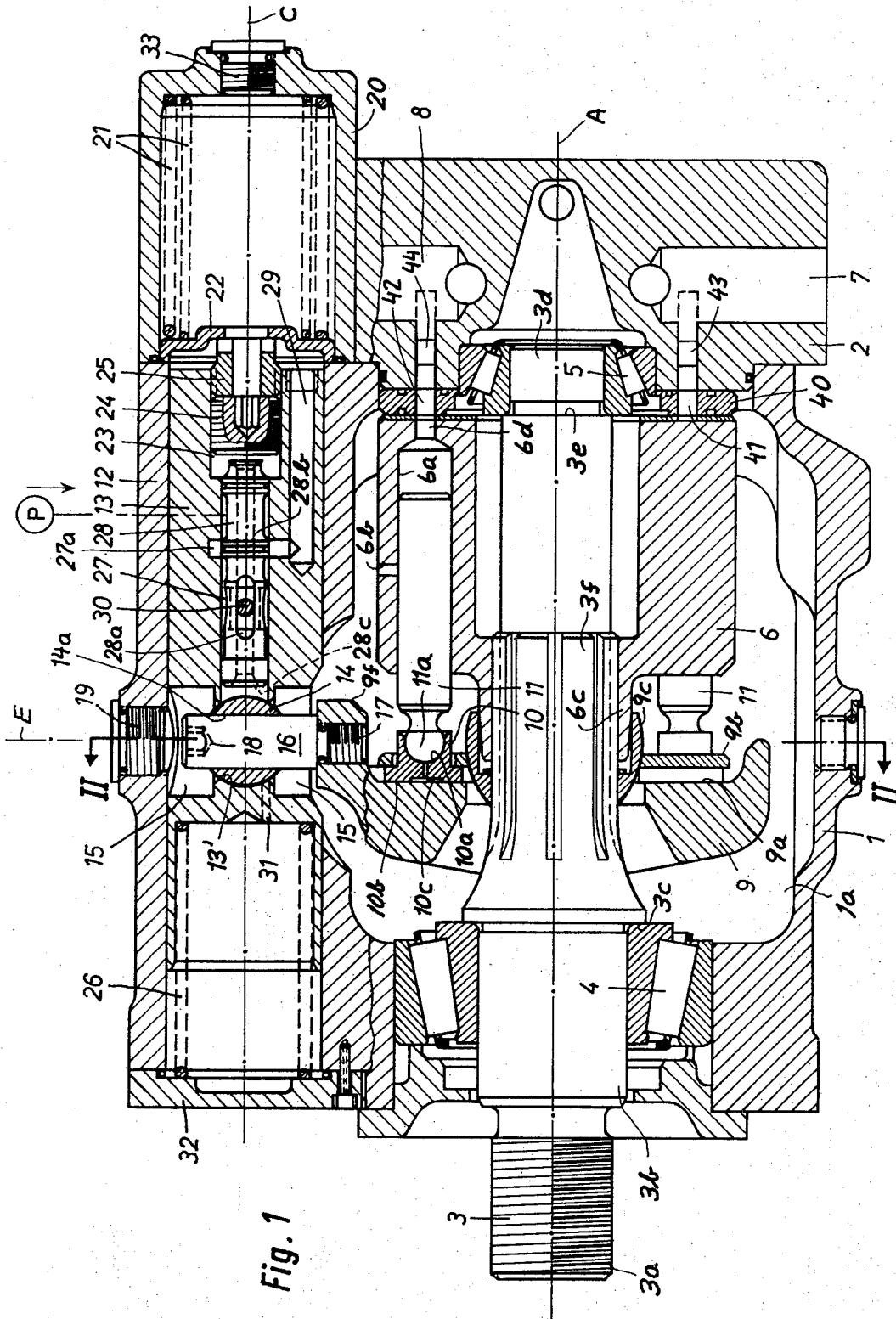
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Primary Examiner—William L. Freeh
Attorney, Agent, or Firm—Karl F. Ross; Herbert Dubno

[57] **ABSTRACT**
A motion-transmitting system for converting linear actuating movement into a pivotal movement of a controlled member, especially for the control of an axial-piston machine having a tiltable controlled member by a working piston capable of linear movement, comprises a cylindrical guide body rotating in a cylindrical bore of a working piston and connected to the control member by a cylindrical pin received in a transverse bore of the cylindrical guide body. The pin is preferably threaded directly to the controlled member of the axial piston machine.

8 Claims, 5 Drawing Figures





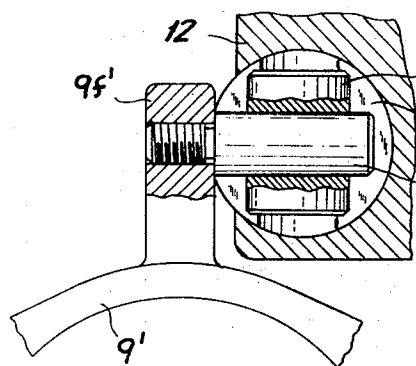


FIG. 5

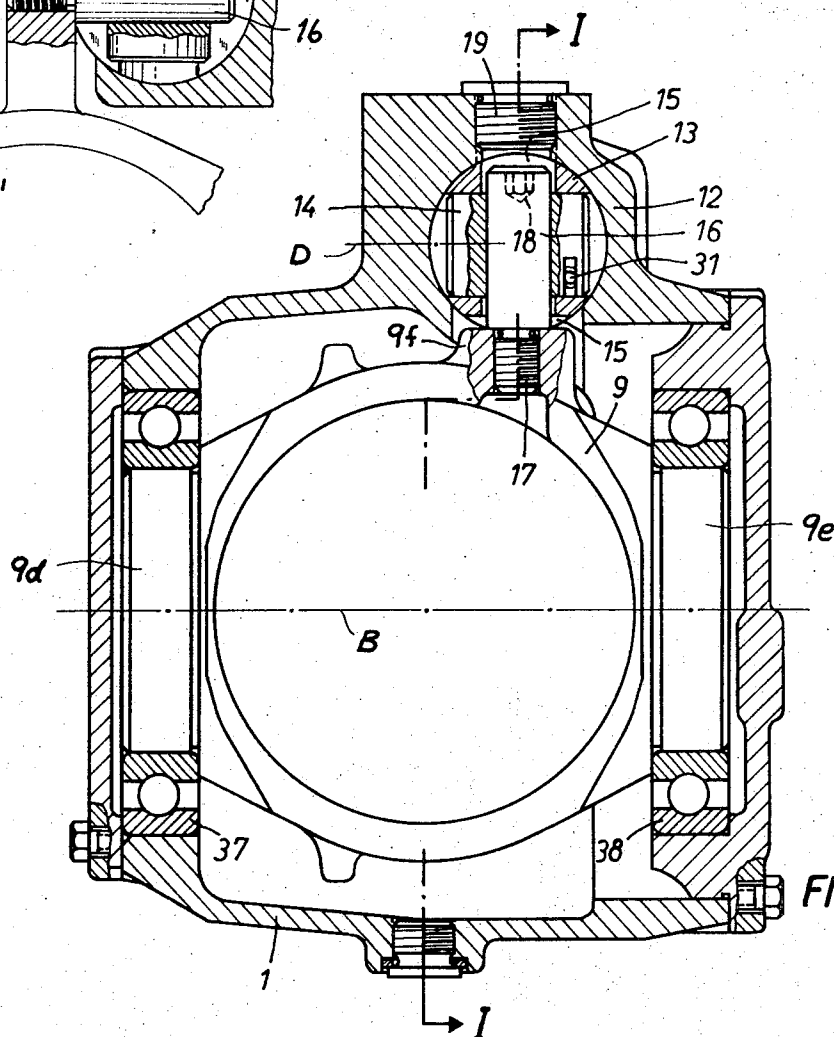


FIG. 2

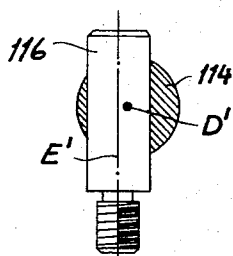


FIG. 4

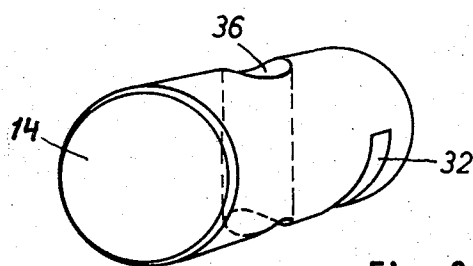


Fig. 3

CONTROL SYSTEM FOR AXIAL-PISTON MACHINES AND THE LIKE

FIELD OF THE INVENTION

The present invention relates to a motion-transfer mechanism and more particularly to a mechanism for converting linear displacement of a control member into angular displacement of a controlled member; the invention especially relates to axial-piston machines using such mechanisms, e.g. for the pivotal operation of a flow control member by a working piston.

BACKGROUND OF THE INVENTION

The term "axial-piston machine" is used generally in the art of fluid mechanics to indicate broadly a hydraulic pump or hydraulic motor having a plurality of pistons parallel to an axis of rotation of a cylinder block or drum and angularly equispaced therearound, the drum being rotated by an applied force in the case of a pump or driving a shaft in the case of a motor.

Usually an axial-piston machine can operate either as a pump or as a motor, depending upon whether an external force is applied to the shaft or the shaft is to be driven by the supply of fluid from an external source. Hence the expression axial-piston machine is intended to identify machines of the general configuration described below and which can either be a pump or a motor or which can operate both as a pump or as a motor.

Axial-piston machines of this general type comprise a fluid-distribution surface, generally lying in a plane perpendicular to the axis of the drum or cylinder block and provided directly, or through the intermediary of a valve or distribution plate, with arcuate or kidney-shaped fluid distribution ports. The cylinder drum, barrel or block may be rotatable with a shaft extending perpendicular to this surface and can be urged against the surface while being provided with a plurality of bores extending axially within the cylinder drum and angularly equispaced therearound, the cylinder bores communicating by axially extending passages with the kidney-shaped ports. These passages open at a face of the drum which bears against the fluid distribution or fluid collection surface. The pistons, which are reciprocable within these cylinder bores, extend from the cylinder drum into engagement with an inclined plate or control plate which may lie generally transverse to the axis of the drum at an angle other than 90° therewith so that, with rotation of the drum, pistons in the region of closest approach of the plate to the drum are urged inwardly and pistons as they approach the region of greatest distance from the drum move outwardly, thereby alternately contracting and expanding the chambers within each of the cylinders. When the machine is operated as a pump, fluid is forced under pressure from the cylinder bores as the compartments contract and is drawn into the cylinder bores as the compartments expand. When fluid under pressure is forced into a contracted compartment of a machine operated as a motor, the piston is driven outwardly and the system rotates to expand the compartments.

In hydrostatic or axial-piston transmissions, for example, the output of an axial-piston pump may be connected to the inlet of an axial-piston motor while the outlet of the motor is connected to the input of the pump, thereby creating a relatively close fluid-

transmitting system between the two. As the pump displaces fluid, the motor operates. Axial-piston machines of the type with which the invention is concerned, are generally of the variable-displacement type, the displacement being a function of the angle at which the control plate intersects the drum axis. By varying this angle it is possible to reduce the displacement to zero, increase the displacement or reverse the direction to flow substantially continuously and thus a transmission of this type is generally a continuously variable torque-transmission system.

Variation of the output of the machine can be accomplished by pivoting the control plate or disk or by pivoting the barrel or cylinder drum about a swing axis perpendicular to but coplanar with the drum axis and the shaft axis. In a position of the control plate in which it is perpendicular to the drum axis and to the shaft axis, there is zero displacement. An axial-piston hydraulic machine of this type is disclosed in the commonly owned U.S. Pat. No. 3,678,804.

Various means have been proposed for swinging the control plate and the cylinder drum and, unless otherwise stated herein, any description with respect to swinging movement of a control plate can be considered as equally applicable to the swinging of the cylinder barrel when the control plate is held stationary. Of interest to the present application, however, are servotype control systems for the swingable control plate of an axial machine and which employ a working piston connected to this control member. In prior-art control mechanisms, which must convert the substantially linear movement of the working piston into a pivotal movement or angular movement of the controlled member, e.g., the control plate, a pin or the like was threaded into a bore of the control plate and was received in a sliding block, slot or other camming system of the piston. This has the disadvantage that the camming arrangement must be manufactured at high cost with low or no tolerances to eliminate play. Furthermore, the forces applied to the system were invariably of the type which could cause excessive wear or even jamming of the device. Finally, it should be mentioned that many of these prior art systems allowed only point or line contact between the bearing surfaces, thereby increasing wear and creating the possibility of excessive play.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved motion-transmitting mechanism, especially for axial-piston machines, which can be produced at low cost, has improved force transmitting properties and low wear, is free from play, and is of simple, reliable, adjustable and replaceable construction.

It is another object of the invention to provide an axial-piston machine embodying an improved motion-transmitting mechanism having the attributes set forth immediately above.

Another object of the invention is to provide an improved controlled system for an axial-piston machine whereby the disadvantages of the earlier systems set forth above can be eliminated.

It is also an object of the invention to provide a motion-transmitting mechanism which, at low cost, is substantially free from locking or jamming and is capable of transmitting force by surface-to-surface contact

rather than the line contact or point contact characterizing earlier systems.

SUMMARY OF THE INVENTION

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention with a motion-transmitting mechanism between a linear actuator and a swingable controlled member, the linear actuator having a working piston provided with a transverse bore of cylindrical configuration. Within this bore there is received a cylindrical guide body, snugly fitting within and at least rotatable in this bore in substantially all-around contact with the wall thereof. According to an essential feature of the invention, this guide body is provided with a cylindrical guide bore transversely to the axis of the cylindrical body and intersecting same or somewhat offset therefrom. Preferably, the axis of the guide bore is perpendicular to the axis of the cylindrical body and receives a cylindrical pin fixed to the swinging member.

Upon swinging movement of the latter member with axial displacement of the working piston, this pin slides axially within the guide bore and/or rotates about its axis while the cylindrical guide body rotates about its axis and forces transmit between the piston and the angularly adjustable member by surface-to-surface contact without the danger of jamming.

When the axis of the bore in the piston (receiving the cylindrical guide body) is not parallel to the axis about which the controlled member swings (hereinafter referred to as the swinging axis), the pin will rotate in the guide body.

The position of the piston axis with respect to the swing axis is not of significance since the relatively movable force transmitting elements, namely, the cylindrical guide body and the cylindrical pin, can shift relatively to compensate for any relative position of the two axes.

An important advantage of the system described above is found in the fact that all relative movement between the piston and the swingable control member can be compensated by relative displacement of the pin and the cylindrical guide body so that the piston need not be rotated in its bore. It will be understood that such pistons frequently are provided with bores co-operating with bores in the cylinder wall or with seats which are detrimentally affected by relative rotation of the working piston and its cylinder. In addition, the nonrotatability of the working piston allows the latter to accommodate a pilot piston or valve which can be actuated by a pin extending laterally into the working piston. The pin, which can be connected to a lever or other control mechanism, thus serves to limit rotation of the working piston but, because of the cylindrical force transmitting elements described above, does not need to withstand stress. Moreover, the use of cylindrical force-transmitting elements permits the system to be manufactured easily, inexpensively and with small manufacturing tolerances.

Yet another advantage of the system, especially important for the large-scale production of axial-piston means, is the fact that the force-transmitting elements allow various orientations of the piston- and -cylinder arrangement with respect to the axis of the machine and the swing axis. For example, the axis of the pin may intersect the swing axis or may be substantially parallel thereto. In the latter case, during the swinging move-

ment, the guide body also may shift axially in the working piston because the axis of the pin describes a circular arc-segmental path about the swinging axis.

The system of the present invention permits one and the same working piston, with its associated working cylinder, to be positioned in various configurations with appropriate modification of position of the guide body. This is especially significant when the motion-transmitting mechanism is used as the control device for different axial-piston pumps.

For example, the same control mechanism can be used with axial-piston pumps with adjustable control disks since the axis of the cylindrical bore is at least approximately parallel to the axis of the shaft and to the cylinder drum.

The pin can lie precisely in the plane of the axis of the shaft and the axis of the piston, when the latter axes are parallel, or can be offset from this plane when its arrangement is more desirable for space considerations. With the lateral offset of the pin from the shaft axis large enough, we may provide an arrangement such that the axis of the pin may be parallel to the swing axis. Of course, the axis of the pin may be swung through 90° so that the axis of the pin lies parallel to the swing axis but the guide-body axis is swung through 90° as well. The axis of the piston can thus be parallel to the axis of the motor shaft or the right angles thereto so that the axis of the piston lies in a plane to which the axis of the shaft is perpendicular. This latter arrangement has been found to be most desirable for swinging-drum axial-piston machines. Furthermore, the bore in which the pin is threaded, e.g., on a pivoting control plate, may be tilted in one way or another during manufacture, the force-transmitting assembly compensating for it.

It has also been found to be advantageous to provide the guide body with an arc-segmental recess through which fluid is fed to one of the compartments of a double-acting piston for the purposes described. This arrangement has also been found to be advantageous in reducing oil-and pressure-leakage or rendering the same ineffective in limiting efficient operation of the system. Also, the assembly and adjustment of the device are simple, economical and designed to facilitate mass production of the parts.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is an axial cross-sectional view taken generally along the line I—I of FIG. 2, showing an axial-piston machine provided with a motion-transmitting mechanism according to the invention;

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

FIG. 3 is an enlarged perspective view of the guide body of the mechanism shown in FIG. 2;

FIG. 4 is a cross-sectional view through a guide body according to another embodiment of the invention; and

FIG. 5 is a view similar to FIG. 2 of a fragment of another embodiment of the invention.

SPECIFIC DESCRIPTION

In FIGS. 1 through 3 of the drawing, we show an axial-piston machine, e.g., an axial-piston pump, which

may form part of a power transmission in accordance with conventional principles discussed above.

This pump comprises a housing 1 closed at one end by a cover plate 2 and provided with a shaft 3 journaled in self-aligning roller bearing 4 and 5. The shaft 3 may be coupled at its threaded end 3a to an electric, internal combustion or other motor or engine, has a cylindrical portion 3b receiving the inner race of roller bearings 4 and a shoulder 3c abutting this inner race to form a thrust-resisting member therewith. At the opposite end of the shaft 3, a cylindrical portion 3d receives the inner race of roller bearings 5 and a shaft has a shoulder 3e which axially abuts this inner race. A central portion 3f is splined to rotatably entrain a cylindrical drum 6 in which pistons 11 are reciprocable, the pistons being angularly equispaced about the axis A of the drum.

Each of the pump pistons 11 is received within a cylindrical bore 6a extending axially in the cylinder drum or block 6 and vented at 6b to the chamber 1a surrounding the cylinder drum. Each piston 11 is also provided with a generally spherical head 11a which is received with two degrees of freedom in the generally spherical socket 10a of a shoe 10 whose surface 10b slidably engages the annular face 9a of a swingable control disk 9. A retaining ring 9b which rests upon a hub 9c of spherical outer configuration, centered upon the axis of swing B of the disk 9, retains the shoes 10 axially against the surface 9a. The hub 9c is seated upon a boss 6c of the cylinder drum so that the latter is urged to the right by the spring disk 9b.

The shoes 10 are provided with passages 10c connecting the socket interfaces with the surface interfaces 9a, 10b to insure lubrication of the sliding parts.

At their ends, remote from the control disk 9, the cylinders 6a communicate via axial passages 6d with registering passages formed in a valve plate 40 whose apertures 41 and 42 may have the kidney-shaped configuration customarily used to distribute fluid to or receive fluid from the cylindrical drum of an axial piston machine.

Apertures 41 and 42, in turn, communicate with passages 43 and 44 of the cover 2 and these passages terminate in ports 7 and 8 for the entry of fluid 2 and its discharge from the pump.

The control disk 9 (FIG. 2) has a pair of hubs 9d and 9e diametrically opposite locations along its pivot axis B and journal in roller bearings 37 and 38 of the housing. A threaded boss 9f is also provided for connection to the control piston as will be apparent hereinafter. It will be evident that, when the disk 9 lies in a plane perpendicular to axis A, there is no axial displacement of the pistons 11 and rotation of the drum by a motor does not displace fluid. When the disk 9 is canted or tilted about its swing axis B in one sense from this perpendicular position, rotation of the drum will cause certain pistons 11 to be drawn axially out of the cylinder and certain pistons to be placed further into the respective cylinders as the drum rotates, thereby alternately drawing fluid into each cylinder and discharging fluid therefrom, effecting a pumping action.

Along the upper side of housing 1, there is provided a means for actuating the control disk 9, in the form of a fluid-responsive servomechanism. The servomechanism comprises a cylinder housing 12 which is mounted on the top of the housing 1 and which slidably receives a working piston 13 whose axis C is here shown to lie

parallel to the axis A of the cylinder drum and in the section plane of FIG. 1. The piston 13 is formed with a transverse cylindrical bore 13' in which a cylindrical guide body 14 is rotatably received, this guide body having an axis D which is generally parallel to the axis B and is perpendicular to the axis C. On opposite sides of the cylindrical bore 13', there are provided recesses or openings 15 in the piston 12, into which the opposite ends of a pin 16 projects. The pin 16 is axially shiftable and rotatable in a bore 14a of the cylindrical guide body 14, the axis E of pin 16 lying perpendicular to the axis C (in one position as illustrated of the pin 16) and perpendicular to the axis D. Thus, the axis of pin 16 is perpendicular (in the latter position) to the plane defined by the axes C and D of the working piston 13 and the cylindrical guide body 14, respectively.

At its lower end, the pin 16 is provided with a thread 17 screwed into the boss 9f of the complementarily threaded control disk 9, while the other end of the pin 16 is provided with an internal hexagonal socket 18 adapted to receive an Allen wrench. The Allen wrench may be inserted in a threaded bore in cylinder 12, in axial alignment with the pin 16, which is closed by a plug 19. This enables the pin to be screwed into the disk or to be removed therefrom.

Cylinder 12 is closed at its right-hand end by a cylindrical housing 20 forming a seat for a pair of springs 21 of the coil compression type, the springs being seated against a plate 22.

The working piston 13 is provided with a threaded axially extending bore receiving a pair of counterlocking screws 24 and 25 having Allen-wrench hexagonal sockets and adapted to be rotated counter to one another to lock an adjustment of the working piston into the system. The screw 25 rests against the spring seat 22 when the working piston 13 is in the position shown in FIG. 1 and the swinging control disk 9 is perpendicular to the shaft 3.

A spring 26 whose spring force is only about half the spring force of springs 21 bears upon the working piston 13 from the left, i.e., in the direction opposite the applied force of springs 21. Spring 26 thus biases the working piston 13 to the right so that its screw 24 rests against the spring seat 22 as long as neither the right nor the left hand effective faces of the piston 13 are under fluid pressure.

The piston 13 is also provided with a throughgoing axially extending control bore 27 in which a control piston 28 is longitudinally shiftable. The piston 28, constituting a valve member, is, in turn, selectively shiftable by a control pin 30 which extends into a lost-motion slot 28a of this valve member and is controlled by mechanical means not illustrated in the drawing, e.g., by a transmission-ratio or reversing lever. The piston 13 is provided with a bore 29 communicating with an annular chamber 27a surrounding the valve portion 28b of this valve member which is also formed with an axially extending bore 28c for servo-operation of the main piston 13. Hydraulic fluid can be admitted to the cylinder 12 through a port not structurally illustrated in the drawing to supply the actuating fluid for the control piston. Consequently, when the pin 30 shifts the control piston 28 to the left (FIG. 1), hydraulic fluid is permitted to flow through the chamber 27a past the valve member 28b and through the passage 29 to the right-hand side of the piston 13 and into the cylinder housing 20, thereby shifting the piston 13 to the left. Con-

versely, if the piston 28 is shifted by pin 30 to the right, the valve is unblocked to permit fluid to flow through the bore of piston 28 and a bore 31 therein to the left-hand side of piston 13, thereby shifting it to the right to follow the movement of valve member 28. Member 28 thus constitutes a pilot piston for the working piston 13. The left-hand side of bore 12 is closed by a plate 32 to constitute one of the working chambers, effective in the direction opposite that of the working chamber formed by cylinder housing 20.

The connecting bore or passage 31 terminates at the transverse bore 13' receiving the guide body 14 and to permit the control fluid to pass this body, it is formed with a sectoral recess or groove 32 which communicates with bore 31 and the axial bore 27. Thus, the control fluid from pilot valve 28 can flow through the recess 32 and passage 31 into the working chamber closed by plate 32.

A threaded plate 33 in cylinder housing 20 can be removed, when necessary, to provide an axial aperture through which the second screws 24 and 25 can be adjusted with Allen wrenches, thereby adjusting the position of the working piston 13 in the neutral position of the system as illustrated.

When the working piston 13 is shifted in cylinder 12, the control disk 9 is swung about its axis B by the cylindrical pin which is rotatable and axially shiftable within the cylindrical guide body 14. The pin 16 thus describes a circular arc about the common axis of the bearings 37 and 38 at its end 17 threaded into the control disk 9. During this movement, the pin 16 and the cylindrical guide body 14 swing about the axis D, the pin being slightly canted from its position as illustrated in FIG. 1. Should the thread 17 in the boss 9f be slightly inclined as a result of a manufacturing error, this will mean that the pin 16 will be slightly inclined to the section plane II—II illustrated in FIG. 1 and the guide body 14 slightly rotated angularly about its axis D. The compensation may be effected by adjusting the position of the piston 13 as previously described. Should the thread 17 of the boss 9f be manufactured with a slight deviation out of the plane of the drawing in FIG. 1, a slight rotation of the piston 13 is all that is required to compensate.

In FIG. 4 we show an arrangement in which the cylindrical guide body 14 receives the pin 116 with an offset between the axis D' of guide body 114 and E' of the axis of pin 116. Of course, the pin 16 can be rotated through 90° from its position as illustrated with a corresponding rotation of the guide body 14. This has been shown in FIG. 5 in which the cylindrical body 14 received the pin 16 which engages a lug 9f of the control disk 9'. A similar modification can provide an arrangement in which the swinging axis of the control disk 9 is approximately parallel to the axis of the working piston and the axis of the bore-receiving pin 16 is approximately perpendicular to the plane of the swing axis and parallel to the axis of the working piston.

We claim:

1. A motion-transmitting mechanism for an axial piston machine comprising:

- a linearly shiftable working piston formed with a first cylindrical bore;
- a cylindrical guide body rotatably received in said cylindrical bore and snugly surrounded by said piston, said body being provided with a second cylin-

dricul bore having an axis transverse to the axis of said first cylindrical bore and said body;

a cylindrical pin rotatably received in said second cylindrical bore and shiftable therein while being snugly surrounded by said body, said pin having an end projecting from said body along the axis of said second cylindrical bore;

a swingable controlled member having a swing axis and connected to said end for pivoting motion about said swing axis upon axial displacement of said piston, said axial-piston machine comprising a cylindrical drum rotatable about an axis perpendicular to said swing axis and provided with a plurality of axially reciprocable pump pistons, and a control disk acting upon ends of said pump pistons, one of said drum and said control disks constituting said controlled member, said pin threadedly engaging said control member;

a cylinder receiving said working piston; and

a pilot piston controllable to feed fluid selectively to opposite sides of said working piston for driving same in opposite direction, said first bore lying between said opposite sides, said working piston being formed with a passage leading from said pilot piston to one side of said working piston, said passage communicating with said first bore, said guide body being formed with a recess at least along an arc of its circumference and communicating with said passage.

2. The mechanism defined in claim 1 wherein said swing axis lies in a plane at least substantially perpendicular to the axis of said working piston and the axis of said first bore is at least approximately parallel to said swing axis.

3. The mechanism defined in claim 1 wherein said swing axis is at least approximately parallel to the axis of said working piston and the axis of said first bore is at least approximately perpendicular to a plane of said swing axis parallel to the axis of said working piston.

4. The mechanism defined in claim 1 wherein said controlled member is said disk.

5. The mechanism defined in claim 4 wherein said axial-piston machine comprises a housing receiving said drum and said disk, said mechanism further comprising means forming a cylinder for said piston in said housing substantially parallel to the axis of said drum and laterally offset therefrom, said piston being received in said cylinder and defining at opposite ends of said piston working chambers pressurizable to shift said working piston in opposite directions, said working piston being formed with an axially extending bore communicating with a source of control fluid and a pilot piston received within said axially extending bore of said working piston from controlling fluid flow to said chambers; and a control pin extending laterally into said working piston and engaging said pilot piston for shifting the latter and thereby inducing said working piston to follow the motion of said pilot piston.

6. A mechanism defined in claim 5 wherein said working piston is provided with a passage extending through said first bore and formed at least in part by a sectoral recess in said guide body for communicating between one of said chambers and said pilot piston.

7. The mechanism defined in claim 6 further comprising oppositely effective spring means on either side of said working piston for yieldably biasing same against displacement.

8. The mechanism defined in claim 7 wherein the axis of said first bore is perpendicular to the axis of said working piston, the axis of the pin received in said second bore is perpendicular to the axis of said first bore and said swing axis is parallel to a plane defined by the axis of said piston and the axis of said first bore.

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