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FLUID TRANSLATING DEVICE

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Fig. 1.

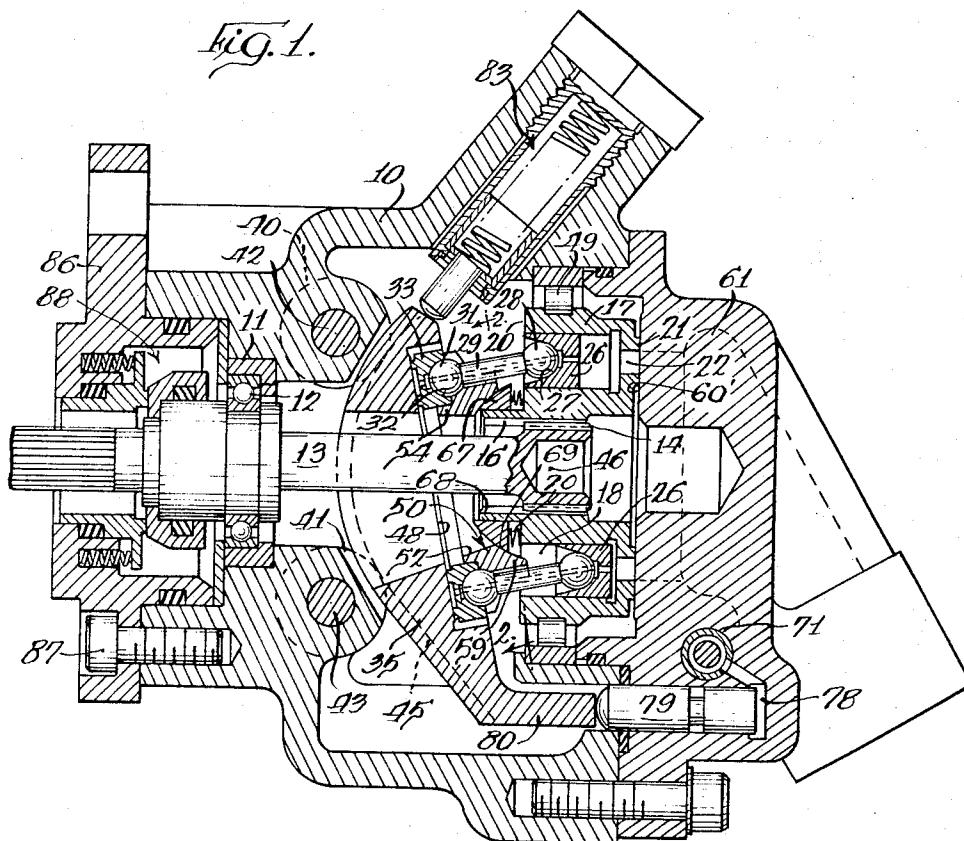
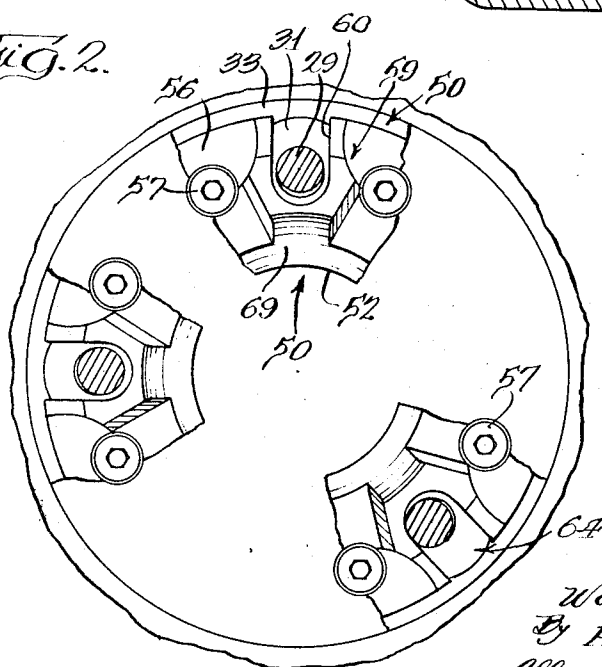


Fig. 2.



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FLUID TRANSLATING DEVICE

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The present invention relates to hydraulic energy translating devices and more specifically to axial piston pumps and motors wherein valving is accomplished by rotation of a cylinder block against a stationary valve member.

In axial piston units of the type described above, a cam member reciprocates the pistons in a rotating cylinder block and the pistons receive and discharge fluid through arcuate ports in a stationary valve member engaging one end of the cylinder block. In most prior art units, optimum speeds for obtaining high power-to-weight ratios with good efficiency are about 120 inches per second average piston velocity. It is desirable to be able to run faster than this in order to obtain higher power-to-weight ratios.

One approach in improving these operating characteristics lies in the development of what is commonly known as an articulated piston hydraulic unit. A device of this character is disclosed in the Baits et al. copending application Ser. No. 409,130, filed Nov. 5, 1964, assigned to the assignee of the present invention. This device includes a relatively short cylinder block with the pistons disposed completely within the block so that there are no overhung loads on the pistons tending to tilt the cylinder block. Articulated rods have one end pivotally connected to the pistons and the other end pivotally received in sockets in a unitary annular ring which slidably engages a camming surface on the cam member to effect reciprocation of the pistons. Provision is made for maintaining the articulated rods substantially perpendicular to this camming surface.

In hydraulic units of this type it is highly desirable to accurately locate the path of movement of the cam-connected ends of the articulated rods, both with respect to the camming surface and also with respect to the pistons. The present device maintains a relationship such that the rods remain substantially perpendicular to the camming surface in both a tangential plane taken through the path of movement of the rods and in a radial plane through the rods, and in this manner the side loads on the rod timing member are significantly reduced, and the mechanical transfer of movement efficiency between the cams and the pistons is significantly increased. If the cam-connected ends of the rods were permitted to lag behind the piston-connected ends of the rods there would be an increase in sideload between the rods and the rod timing member. The same would be true if the cam-connected ends of the pistons were permitted to move in a radial plane, and this would further impose deleterious side loads on the rod timing member.

It is, therefore, a primary object of the present invention to provide a new and improved axial piston pump design.

Another object of the present invention is to provide an articulated axial piston hydraulic unit of the type described in which new and improved means are provided for positively locating the path of travel of the cam-connected ends of the articulated rods.

A more specific object of the present invention is to provide an articulated piston hydraulic unit of the type described above in which the means for accurately defining the path of travel of the cam-connected ends of the articulated rods functions independent of means to transmit timing torque from the pistons to the cam-connected ends of the rods to prevent those ends from lagging behind the pistons.

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A still further object of the present invention is to provide a new and improved hydraulic unit of the type described above in which the timing and locating means also serve to retain the bearing means on the ends of the articulated rods in sliding engagement with the camming surface on the cam member.

A more specific object of the present invention is to provide a device as described above in which the multi-function means includes a generally annular member fixed to a unitary annular bearing ring in sliding engagement with the camming surface and pivotally receiving one end of each of the articulated rods. This member has slots for receiving the articulated rods, and the sides of the slots serve to transmit timing torque through the unitary ring by the intermittent engagement of the rods therewith which result inherently from the geometry of the articulated rod design. This timing member is supported on a spherical retainer ball which acts as a pilot for the timing member to accurately locate the center of the unitary ring with respect to the camming surface. The ball is closely fitted on a rearward projection from the cylinder block, and also serves as a holddown means for retaining the unitary ring in sliding engagement with the cam member.

Other and further objects of the present invention will become readily apparent from the following detailed description taken in connection with the drawings in which:

FIG. 1 is a longitudinal section of a hydraulic unit according to the present invention;

FIG. 2 is an enlarged fragmentary view taken generally along line 2—2 of FIG. 1 showing orientation of the articulated rods at three positions in the present device, the other positions being eliminated for simplicity.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail an embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

It should be understood that, while the hydraulic unit described in this specification is referred to as a pump, the principles of the invention are equally applicable to a hydraulic unit acting as a motor.

Referring now to FIG. 1, a pump housing 10 may comprise a unitary metal casting having a bushing 11 press-fitted within a counterbore in one end of the housing 10 for seating the outer race of bearing 12. The bearing 12 supports a pump input shaft 13 within the housing 10. One end of shaft 13 has splines 14 thereon which engage drive splines in a central bore 16 in pump cylinder block 17.

The cylinder block 17 is a cylindrical metal body having, for example, seven cylinders 18 formed therein opening directly to end face 20 of the cylinder block and communicating with the cylinder block port face 21 through cylinder block ports 22. Radially inwardly of and angularly disposed intermediate the cylinders 18 are closed end bores (not shown) formed in annular array in the cylinder block 17 and opening at the cylinder block face 20 to receive springs 70 for a purpose described hereinafter. As shown in FIG. 1, the axial length of the cylinder block 17 along the axis of rotation of shaft 13 is less than the radius of the block in a plane perpendicular to the axis of shaft 13.

Slidably mounted in each of the cylinders 18 are pistons 26 each having a semispherical socket 27 which surrounds and captures a spherical ball 28 of one of a plurality of connecting rods 29. Spherical balls 31 are integrally formed on the other ends of the connecting rods 29 respectively, and are seated within semispherical sockets 32

in a unitary annular ring 33. The connecting rods 29 are therefore pivotally connected to both the pistons 26 and the unitary annular ring 33.

The annular ring 33 serves to transfer the camming force from a swashplate or cam member 35 to the pistons 26 and has a plurality of the sockets 32 formed in one face thereof on a circle drawn about the axis or center of the annular ring 33. The swashplate or cam member 35 is pivotally mounted in the housing 10 by rollers 40 and 41 rotatably mounted on shafts 42 and 43 fixed in the housing 10, there being two rollers on each of the shafts. Parallel arcuate surfaces 45 are formed on the back of the swashplate 35 to receive rollers 40 and 41 so that the swashplate pivots about point 46. As shown, a counterbore is formed in the face of the swashplate 35 and receives annular ring 33 with radial clearance. The bottom of the counterbore defines a camming surface 48 which serves to cam the unitary annular ring 33 and the pistons 26 to drive the pistons to the right and expel fluid from the cylinders 18.

In the specific construction illustrated, the swashplate 35 is pivotable from the maximum stroke position illustrated in FIG. 1 to a neutral, no-stroke position in which the cam face 48 is parallel to the end of the cylinder block, but it will be understood that in other embodiments, the swashplate may be fixed or pivotable in opposite directions from a neutral, no-stroke position. The center 46 about which the swashplate pivots is usually located near the point where the shaft axis pierces the plane containing the spherical connections of rod ends 28 with pistons 26. The pivot axis 46 may be located directly at such point, but it is preferably displaced from such point axially and radially in order to modify the nature of the forces required to control the swashplate angle.

The cylinder block 17 is supported by a bearing 49 in the housing 10, and the point where the shaft axis pierces the plane containing the spherical rod ends 28 preferably bisects the axial length of the bearing 49 supporting the cylinder block in the housing 10.

In order to cause rotation of the annular ring 33 with the cylinder block 17 and to maintain the proper timing between the ring and the cylinder block so that the pistons remain substantially perpendicular to the camming surface 48 in a plane taken through the piston rods 29 tangent the path of travel of the rod ends 31, a retaining ring or timing member 50 is provided fixed to the annular ring 33. As will appear hereinbelow, the ring 50 is suitably supported radially in a novel manner to maintain the rotational center of ring 33 fixed with respect to the cam 35.

Viewing FIGS. 1 and 2, the timing members 50 is seen to be a one-piece member of generally annular configuration with an axial bore 52 therethrough for freely receiving the input shaft 13. Member 50 has a reduced annular portion 54 which fixedly receives the annular ring 33. A flat radial surface 56 substantially parallel to the ring 33 receives a suitable fastening means such as Allen head screws 57 which extend into the ring 33 thereby fixing member 50 securely thereto.

Extending axially from the surface 56 are a plurality of projecting lands 59 having radial slots 60 for receiving the rods 29. Slots 60 extend axially completely through the member 50.

The slots 60 provide a sufficient radial clearance for the rods 29 to permit unrestricted radial pivoting of the rods as shown by the relative positions of the rods in FIG. 2. This radial pivoting, i.e., pivotal movement in a plane extending through the rods 29 and the axis of the ring, is inherent in the present device due to the fact that the ring-connected ends of the rods, i.e., balls 31, describe a circular path while the piston-connected ends of the rods, i.e., balls 28, appear from ring 33 to describe an elliptical path. As the cylinder block 17 rotates, the rods 29 will intermittently engage the sides of the slots 60 as shown at 64 in FIG. 2 to drive the timing ring 50 and the annular

ring 33 in rotation. While the slots permit some limited tangential pivoting of the rods 29, they fit closely enough to maintain the rods substantially perpendicular to the camming face 48 in any tangential plane, that is, a plane tangent to a circle through rod ends 31.

A spherical retainer member 67 is provided for supporting the timing member 50 and constraining the annular ring 33 so that it rotates about a stationary axis with respect to the cam 35. The spherical retainer 67 is closely fitted on a rearwardly extending axial projection 63 on the cylinder block. Some limited axial sliding movement is permitted, however, between the spherical member 67 and the projection 63 for a purpose described below. Formed within the timing member 50 is a spherical surface 69 which is piloted on the spherical outer surface of the retainer 67. This permits pivotal adjustment of the cam 35 and the retainer ring 50 with respect to the retainer ball 67, but the ball 67 radially supports the ring 33 and absorbs radial loads therefrom.

Furthermore, the supporting function of the retainer ball 67 serves to maintain the rods 29 substantially perpendicular to the camming face 48 in a radial plane extending through the axis of shaft 13 and rods 29.

It should be noted that it is the spherical retainer 67 which radially locates the rods 29, and that the slots 60 have sufficient radial clearance with respect to the rods so that they do not restrain the rods in a radial direction. Thus, the projecting lands 59 on member 50 serve to transmit only timing torque from the pistons 26 to the unitary ring 33, while the rods are radially or laterally located by the spherical retainer 67 which is immovable radially.

In addition to the locating and constraining function of the retainer 67, it also provides a piston return function by maintaining sliding engagement between the unitary ring 33 and the camming surface 48. Toward this end, springs 70 seated within the aforementioned bores in the cylinder block 17 bear against the spherical member 67 urging it axially away from the cylinder block toward the camming member so that ring 33 is urged against the camming surface 48. This biasing of the spherical ball 67 furthermore gives it the ability to resist the side thrusts generated by the rotating unitary ring 33 and the associated elements.

At the full displacement position of the swashplate member 35, the connecting rods have substantial angular relationship with the pistons 26 and therefore exert side loads on the pistons through the spherical balls 28, but the connecting rods remain substantially perpendicular to the camming surface 48 in all adjusted positions of the swashplate 35 and therefore exert no side loads, or loads parallel to the surface 48 on the cam member or swashplate 35. Each of the connecting rods 29 exerts a lateral force on the pistons 26, the centroid of which substantially bisects the axial length of the cylinder block bearing 49 as described above, and lies close to the port face 21 a distance therefrom less than the radius of the block. In this manner the side forces on the block 17 are located close to the porting face 21 of the cylinder block and are effectively opposed by the bearing 49, the proper location of which is facilitated by the present construction.

The port plate 61 has arcuate ports opening to the seating surface 60' that serve either as high or low pressure ports depending upon the direction of rotation of input shaft 13 and operation as a pump or a motor.

The angle of the swashplate may be controlled in a suitable manner. An exemplary control may include a constant pressure valve 71 mounted in valve plate 61. The details of this valve form no part of the present invention and therefore will only be described generally. The valve serves to effectively port fluid to and from a chamber 78 which communicates with a displacement control piston 79 in turn engaging a projection 80 on the cam member 35. A swashplate return mechanism 83 biases the swashplate or cam member toward maximum displacement, while system pressure in chamber 78 selective-

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ly moves the cam toward minimum displacement as described in more detail in the copending application of Baits et al.

An end cap 86 bolted to the left end of housing 10 as at 87 supports a shaft seal assembly generally designated by the numeral 88 described in more detail in the copending application of Baits et al.

I claim:

1. A hydraulic energy translating device comprising: a valve member having inlet and outlet ports therein, a rotatable cylinder block member slidably engaging said valve member and having a plurality of cylinders therein serially communicating with said ports upon relative rotation of said block member and valve member, pistons slidable in said cylinders, a shaft member connected to said cylinder block member, a cam member having a camming surface, rods pivotally connected at one end thereof respectively to each of said pistons, bearing means on the other ends of the rods slidably engaging said camming surface, means for transmitting timing torque between said pistons and said bearing means including a member engaging said bearing means and restraining tangential pivotal movement of the rods with respect to the bearing means, and means separate from said rods for radially supporting said bearing means.

2. A hydraulic energy translating device as defined in claim 1, wherein said timing member has a portion fixed to said bearing means, said radial supporting means engaging and radially supporting said timing member.

3. A hydraulic energy translating device as defined in claim 2, wherein said bearing means includes a unitary annular ring pivotally receiving the other end of each of said rods.

4. A hydraulic energy translating device as defined in claim 2 wherein said radial supporting means is radially fixed with respect to one of the cylinder block members and shaft member.

5. A hydraulic energy translating device as defined in claim 2, wherein said rods each have spherical ends engaging the pistons and the bearing means, said bearing means including a unitary annular ring engaging said camming surface, said cam member having radial clearance said unitary ring, said ring having a plurality of sockets receiving the spherical portions on the other ends of said rods, said timing member including a generally annular member fixed to said unitary ring and having generally radial slots for receiving said rods, said slots being formed so that the rods intermittently engage the sides thereof to transmit timing torque to the unitary ring, said timing member having a clearance radially inwardly of said rods to prevent restraining pivotal movement of the rods in a radial plane about the center of said other end spherical portions, said radial supporting means for the timing member being fixed with respect to one of the cylinder block member and the shaft member.

6. A hydraulic energy translating device as defined in claim 5, wherein said radial supporting means for said timing member includes an annular member having a spherical outer surface engaging said timing member, a rearwardly extending projection on said cylinder block, said annular member being closely received on said projection to radially support the timing member and the annular ring so that the ring rotates about an axis fixed with respect to the camming surface of the camming member.

7. A hydraulic energy translating device as defined in claim 6 wherein said annular member is axially slidable on said projection, resilient means for urging said annu-

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lar member toward said cam member to maintain sliding engagement between said unitary annular ring and said camming surface.

8. A hydraulic energy translating device as defined in claim 5, wherein said slots in the timing member have tangential clearance with respect to said rods to permit intermittent limited pivotal movement of the rods in a tangential direction about the other spherical portions of the rods.

9. A hydraulic energy translating device comprising: a valve member having inlet and outlet ports therein, a rotatable cylinder block member slidably engaging said valve member and having a plurality of axial cylinders therein serially communicating with said ports upon relative rotation of said cylinder block and valve member, pistons slidable in the cylinders, a shaft member connected to said block member, a cam member having a camming surface, a plurality of rods each having a spherical portion at one end thereof engaging one of said pistons, a unitary annular ring slidably engaging said camming surface and having sockets therein, the other ends of said rods each having a spherical portion received in the sockets in said ring, said cam member having radial clearance for said ring, said cam member being pivotally mounted about an axis to vary the displacement of the unit, said pivot axis being located a sufficient distance toward said valve member so that the piston rods remain substantially perpendicular to the camming surface in all adjusted positions of the cam member, a member for transmitting timing torque from said pistons to said ring, said timing member having a portion thereof connected to said ring and second portions constructed to intermittently engage said rods in a tangential direction, said second portions being formed to permit pivotal movement of the rods in radial planes, the cylinder block member having an annular projection extending rearwardly therefrom, a spherical retainer member mounted for axial sliding movement on said rearward projection and closely fitting said projection to provide radial support for said spherical retainer, said timing member being supported on said spherical retainer, said spherical retainer and timing member being constructed to maintain the rods substantially perpendicular to said camming surface, and resilient biasing means engaging said spherical member for urging said unitary ring into engagement with said camming surface.

10. A hydraulic energy translating device as defined in claim 9, wherein said second portions of said timing member include radial slots therein each receiving one of said rods, said slots having radial clearance inwardly and outwardly of said rods, said radial clearance being sufficient so that the rods do not radially contact the timing member, said slots also having tangential clearance with respect to the rods to permit limited tangential pivotal movement of the rods.

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