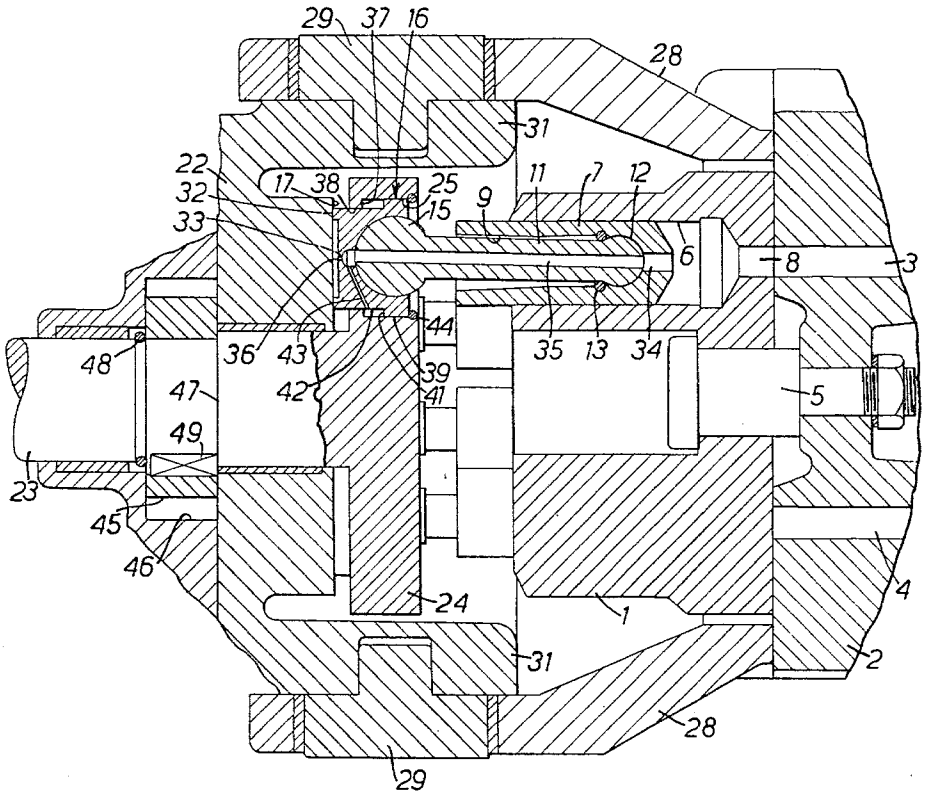
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HYDRAULIC APPARATUS

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HYDRAULIC APPARATUS

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This invention relates to slipper bearings for use in conjunction with a cam or equivalent surface to produce a reciprocating movement with substantial thrust. Such slippers may be used in swash plate and tilting head pumps or motors to effect reciprocation of the pistons in the cylinders in synchronism with rotation of the drive shaft.

The invention is illustrated as embodied in a known type of pump or motor, hereinafter referred to as an hydraulic unit of the type referred to, wherein a drive member is rotatable in close parallel spacing to a cam surface that may be rotatable, is in the Patent No. 3,180,-276 to the present applicants, or that may be non-rotatable, and slippers that bear on that cam surface are mounted for axial sliding movement within bores equidistantly spaced about the axis of the drive member, these slippers being each articulated with respect to a piston that is reciprocable within its bore in a cylinder barrel that rotates conjointly with the drive member, provided the rotation axis of the barrel is tilted relative to the rotation axis of the drive member.

The slippers extend completely through driving member, but differing from known pumps or motors of this general type, according to this invention the slippers are shouldered, as is the bore within which they reciprocate. Thereby there is formed a small annular working space, accessible to pressure liquid, within which is created a certain pressure resisting the thrust of the piston urging the slipper onto the cam surface. By this pressure alone, or in conjunction with pressure developed within a recess in the bearing face of the slipper upon the cam surface, which recess is pressurized, that piston thrust is resisted to the extent that wear at the bearing surfaces of the slipper and the cam is a minimum, the arrangement being such that the sum of the two resisting pressures, when the two are used, cannot exceed the piston's thrust, but approaches the same.

The pressure resistance within the annular working space produces an axial thrust upon the drive member and upon a drive shaft integral therewith. Means are provided for absorbing this thrust, in effect supplementing the resistance at the cam surface, and dividing the wear between those means and the cam surface. This lengthens the effective working life of the pump or motor.

One embodiment of the invention comprising a tilting head hydraulic pump will now be described with reference to the accompanying cross sectional drawing through the pump.

In this pump a rotary cylinder block 1 is rotatably carried on a valve plate 2 having a pair of ports 3 and 4 of the conventional type such that when seen in cross section perpendicular to the plane of the drawing they are of kidney shape. The cylinder block 1 is mounted for rotation by means of a fixed shaft 5 extending centrally from the valve plate 2. Within the cylinder block 1 a plurality of equally spaced cylinders 6 are formed whose axes are parallel to the axis of rotation. Within each cylinder 6 an elongated piston 7 is located for sliding movement. Into the valve plate end of the cylinder block a port 8 extends from each cylinder for co-operation with the ports 3 and 4 in known manner during rotation of the cylinder block. A deep bore 9 extends

within each piston 7 from the end thereof opposite to the valve plate 2 and within this bore a connecting rod 11 is located. The connecting rod 11 is adapted to exert thrust on the piston through a spherical seating 12 which permits of articulation of the connecting rod 11 relative to the piston 7. In order to retain the connecting rod 11 within the piston circlip 13 engages a groove round the periphery of the bore 9 and loosely engages within a groove around the connecting rod 11. For the purpose of reciprocation of the pistons the opposite end of each connecting rod 11 is formed with a ball joint 15 engaged within a slipper 16 which in turn engages on a flat surface 17 forming part of a bearing housing 22. The bearing housing 22 accommodates the drive shaft 23 which within the pump is integrally formed with a drive member in the form of a flange 24. Within the flange 24 a plurality of bores 25 are formed extending inwardly from the face of the flange facing the cylinder block 1. The bores 25 are equal in number to the cylinder 6 and are spaced at equal intervals to agree with the spacings of the cylinder 6. Each bore 25 accommodates a slipper 16.

Valve plate 2 and cylinder block 1 are secured to the body member 22 by means of a pair of arms 28 extending from the valve plate 2 and pivoted by pivot pins 29 within lugs 31 extending from the bearing housing 22. Pivotal movement of the valve plate 2 and cylinder block 1 about the pins 29 is arranged (by known means not herein shown) to adjust the inclination between the rotation axes of the flange 24 and the cylinder block 1 in order to determine the stroke of the pistons 7 within their cylinders 6. The common axis of the pins 29 is arranged to form a diameter of the circle on which the centers of the ball joints 15 are located.

The surface 32 of each slipper engaging against surface 17 is of circular form enclosing a central circular recess 33. A passage 34 extends from the working space of each cylinder 6 through piston 7 and connects with a passage 35 extending axially through the associated connecting rod 11. Within the ball joint 15 the passage 35 communicates with the restrictor 36 opening into the recess 33. The recess 33 will thus receive liquid under pressure when the working space of the associated cylinder 6 is under pressure and will form a hydaulic bearing means acting between the surface 17 and the slipper.

Each bore 25 within the flange 24 terminates at a shoulder 37 from which a bore 38 of reduced diameter extends to the opposite side of the flange 24. The outer surface of each slipper 16 comprises a large diameter surface 39 interconnected by a shoulder 41 to a smaller diameter surface 42. The diameters of the surfaces 39 and 25 are the same and the diameters of surfaces 38 and 42 are the same to the extent that the slipper 16 is a sliding fit in the axial direction within the flange 24. When the slipper 16 is in position a hydraulic working space of annular form is formed between the shoulders 37 and 41, the surface 42 of the slipper, and the bore 25 of the flange 24. Within the slipper a passage 43 is formed extending from the entrance to the restrictor 36 into the part of the surface 42 so as to enter the working space previously defined. Each slipper is prevented from leaving the bore 25 at the side facing the cylinder block by means of a circlip 44 extending around the bore 25.

It is necessary that the drive shaft 23 and the flange 24 are located in the bearing housing 22 against endwise movement and for this purpose an end thrust bearing is conveniently formed by the location on the shaft 23 of a gear 45 forming part of a gear pump. The gear pump may be used for supplying liquid to one or the other of the ports 3 or 4 at low pressure. The gear 45

rotates within a suitable recess 46 within the housing 22. The gear 45 is located on the shaft 23 between a shoulder 47 of the shaft and a circlip 48 fitted around the shaft on the opposite side of the gear 45. The fact that the gear is located on the shaft and that it fits closely within its housing 46 ensures endwise location of the shaft 23 and flange 24. A key 49 is employed to secure the gear 45 for rotation with the shaft 23.

Rotation of the drive shaft 23 will cause rotation of the flange 24 which in turn will drive the slipper 16 and the ball joints 15 in a circular path around the axis of the shaft 23. Such rotation will cause slight inclination of the connecting rods 11 within their piston 7 until one connecting rod contacts the side of its piston bore to apply rotational drive to the cylinder block 1. The rotational drive to the cylinder block will then depend on successive engagements between connecting rods and their associated piston bores during rotation. In order to cause reciprocation of the pistons 7 within their cylinder 6 the cylinder block 1 and valve plate 2 are moved about the pivot pins 29 to an inclined position relative to the drive shaft 23. Reciprocation of the pistons 7 will then take place within the cylinder 6 as a result of rotation of the drive shaft 23. Liquid will enter the pump at one of the ports 3 or 4 and will be delivered from the pump under pressure at the other of the ports 3 or 4. Some pressure liquid in each of the cylinders 6 where the piston is descending will pass through the passage in the associated connecting rod and through the restrictor 36 to the recess 33 in the slipper. The action of pressure on each piston will produce a thrust in its associated connecting rod and the slipper to cause the slipper surface 32 to press against the surface 17 of the bearing housing. The feeding of pressure to the recess 33 will provide a part of a balancing force which opposes the component of the piston thrust parallel to the drive shaft axis. The area of the recess 33 is slightly smaller than the cross-sectional area of the piston 7. The pressure liquid passing through the passage 35 will also pass through passage 43 into the working space defined for each slipper between the shoulder, 37 and 41 and to the cylindrical surfaces 25 and 42 to produce a thrust on the slipper 16 which will also oppose in part the component of the piston thrust parallel to the drive shaft axis. The thrust produced by hydraulic pressure within the recess 33 will depend on the leakage flow over the surface 32 and the pressure drop occurring at the restrictor 36. With increase in clearance at the surface 32 there will be a greater escape flow of liquid which will cause a greater reduction of pressure within the recess 33 and vice versa. The effect is that the component of piston thrust on the slipper parallel to the drive shaft axis is exactly balanced by the sum of the hydraulic thrusts produced in the working space previously mentioned and in the recess 33.

The hydraulic pressure within the working space previously mentioned in addition to producing a thrust on the slipper will also produce an equal and opposite thrust on the drive flange 24. The total of these thrusts for all of the slippers 16 connected to pistons under pressure will act in an endwise sense on the shaft 23 and will be absorbed by engagement of the gear 45 within its housing 46.

The advantage gained by the invention is that the hydraulic thrust exerted on the pistons 7 under pressure is effectively divided between the slippers 16 connected to the pistons under pressure and the end thrust bearing of the drive shaft 23 formed by the gear 45. In this way the load exerted on the pistons under pressure is spread and wear will occur both at the slipper surfaces 32 and at the gear 45. Spreading the wear in this way will give a longer effective life to the pump.

The function of the circlips 44 is to ensure that the slippers 16 cannot leave the bores 25. This in turn ensures that there is a positive means to pull the pistons outwardly on the suction part of their reciprocating movement. This may be necessary in the case where the pump must operate without a supply of liquid at low pressure at its suction port.

Whilst the described embodiment of the invention provides a hydraulic leakage bearing to operate between each slipper 16 and the flat cam surface 17 with which it co-operates it will be appreciated that it is within the scope of the invention to provide any form of bearing inbetween each slipper and the associated cam surface. For example, the bearing might comprise a hydrodynamic bearing where liquid is dragged into the space between each slipper and the surface 17 as a result of rotation of the slippers over the surface 17. In other words the slippers can be arranged to act as Michell pads.

Whilst in the described embodiment of the invention the slippers are rotatably driven by a driving member over a flat cam surface, it will be appreciated that it is equally possible within the scope of the present invention for the driving member and the slippers to be fixed against rotation and for the cam surface to rotate. Further, whilst the described embodiment shows the cam surface as being flat it will be appreciated that it is equally within the scope of the invention for this surface to be spherical.

We claim as our invention:

1. For use in a hydraulic unit of the type referred to, such as includes a cam surface and a drive member rotatable in a plane generally parallel to and close to such surface, and formed with equiangularly spaced and axially directed bores, a slipper reciprocable in and bearing within each bore, and bearing at its end surface upon said cam surface, a rotative cylinder barrel, a piston in each cylinder of the barrel and operatively connected to the corresponding slipper for conjoint rotation, and reciprocable to receive and discharge fluid, and thereby to produce thrust from the piston to urge the slipper onto the cam's bearing surface, the improvement in the bearing between the slipper and its bore including means defining an annular working space between each slipper and its bore in the drive member, a passage to deliver pressure fluid within such working space, the working space being so arranged that the delivered pressure fluid opposes the piston's thrust, the working space being so proportioned, in relation to the pressure developed therein, that its opposing force cannot exceed the piston's thrust urging the slipper against the cam surface, but resists at least an appreciable portion thereof.

2. A slipper bearing as in claim 1, wherein the slipper's face that bears upon the cam's surface is recessed, the recess being also accessible to pressure fluid from the passage, to resist thrust urging the slipper against the cam surface, the recess and the annular working space being so proportioned that the sum of the resisting forces within the recess and within the working space cannot exceed the thrust urging the slipper against the cam surface.

3. A slipper bearing as claimed in claim 1, wherein the slipper extends completely through the drive member to engage the cam surface and the slipper is formed with two exterior cylindrical surfaces joined by a shoulder located at its end adjacent the cam surface to fit within two bores of similar diameters also joined by a shoulder in the drive members, distant from the cam surface, thereby to define the working space between the shoulders, the smaller diameter cylindrical surface of the slipper, and the larger diameter cylindrical bore.

4. A slipper bearing as claimed in claim 1 wherein the conjoint rotational connection between the slipper and its piston includes a connecting rod extending from the slipper to the piston, the piston being reciprocable by the slipper, and wherein a passage is formed through the piston, the connecting rod, and the slipper to admit fluid pressure from the cylinder to act within the working space.

5. A slipper bearing as in claim 2, the passage including a restrictor in advance of the slipper's recess, whereby the force reaction between the slipper and the cam's bearing surface is automatically adjusted by the clearance between the slipper and the cam to balance exactly the force acting to urge the slipper into the cam.

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