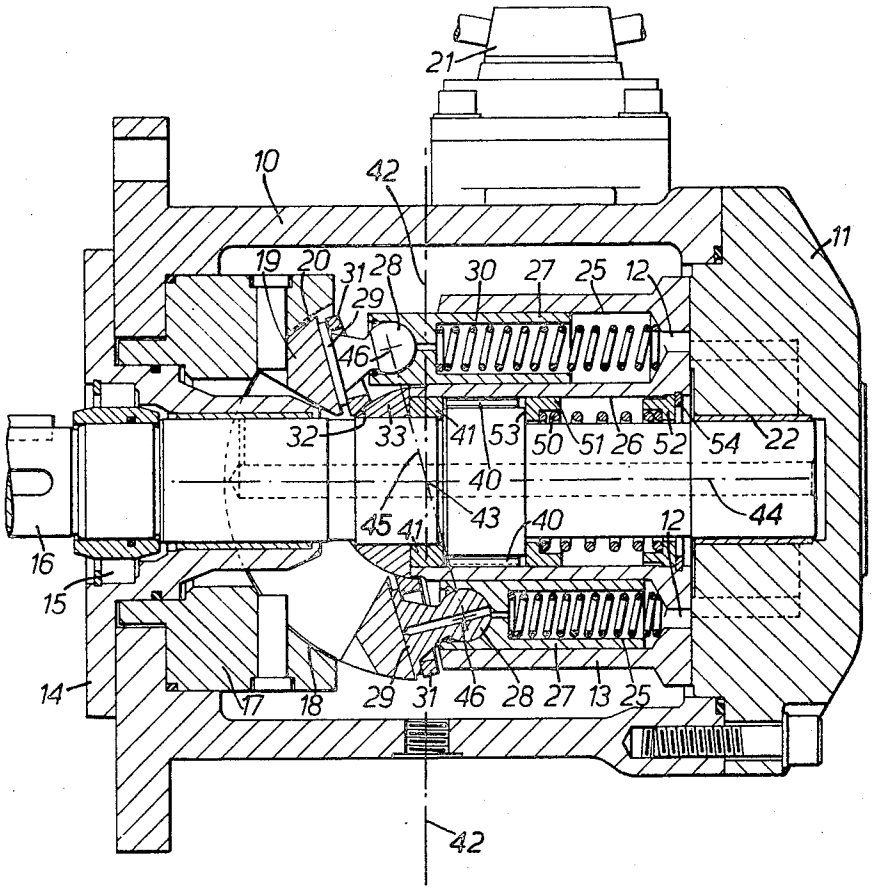
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HYDRAULIC PUMPS OR MOTORS

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HYDRAULIC PUMPS OR MOTORS

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ABSTRACT OF THE DISCLOSURE

An axial piston hydraulic pump or motor including a rotary cylinder block mounted on a rotary shaft and having a number of pistons connected through ball joints to slippers sliding on an inclined cam, the cylinder block being connected to the shaft by means of a soft bronze ring mounted at the position where the plane through the centers of the ball joints intersects the shafts, and a direct spline coupling between the cylinder block and shaft, immediately adjacent the bronze ring, and the spline teeth lying wholly within the axial projection of the ring.

This invention relates to an axial piston fluid displacement machine such as a pump or motor, having a rotary cylinder block connected to a drive shaft, the block being formed with a number of parallel or substantially parallel cylinder bores whose pistons co-act through ball joints and sliding slippers with a non-rotating cam to cause reciprocation of the pistons in their cylinder bores. The cam may be fixed at an angle inclined to the rotary axis of the machine or its inclination may be adjustable. The opposite end of the cylinder block remote from the cam engages a stationary valve body having ports which cooperate with passages in the cylinder block to control the admission and discharge of fluid from the cylinder bores.

In such machines it is important that the cylinder block should be maintained in close contact with the adjacent surface of the valve body and in view of the difficulties of machining the adjacent surfaces to the necessary accuracy it is also important that the cylinder block should be given limited freedom of angular deflection.

It is known that the reaction forces created by the engagement of the slippers on the cam surface create side loads. Various methods have been proposed for resisting these loads and in some machines of this general type the loads are resisted particularly by the side thrust being absorbed by the engagement of the pistons in their cylinder bores. The individual piston side loads together create a cumulative radial side load, which can be treated as acting approximately at the point of intersection of the main rotary axis with the plane containing the centres of the ball joints which connect the pistons to the slippers. It is, therefore, desirable that the cylinder block should be located at this point of intersection but allowed limited angular deflection about this point, this point of intersection of the plane containing the centres of the balls with the main rotary axis of the machine, being referred to for convenience herein as the main centre.

In order to avoid application of tilting moments to the cylinder block the block should be located radially at or near this main centre. A number of possible methods can be employed, for example the cylinder block can be supported in a surrounding bearing. However, this raises a number of constructional problems and is expensive and conflicts with some of the requirements mentioned above, in particular the need to allow angular deflection of the cylinder block. Furthermore it is necessary to provide means for transmitting drive torque between the cylinder block and the shaft, or vice versa.

According to the invention an axial piston hydraulic pump or motor comprises a rotary cylinder block formed with generally axially extending cylinder bores each containing a reciprocating piston which is connected through a ball joint to a slipper engaging an inclined or inclinable cam plate, and a non-rotary valve member engaging a ported end face of the cylinder block to control the admission and discharge of fluid to and from the cylinder bores, the shaft being located transversely by two spaced bearings and the cylinder block being located transversely relative to the shaft in a plane passing through the point of intersection between the main rotary axis and a plane parallel to the surface of the cam plate and passing through the centres of the ball joints, by means of a wear ring interposed between the shaft and the cylinder block in way of the said transverse plane, the wear ring being formed of a material softer than the shaft or cylinder block such that the cylinder block can become inclined relative to the shaft about the said point of intersection, and including a toothed driving connection between the shaft and the cylinder block axially adjacent to the wear ring.

Thus the invention provides means for supporting the cylinder block radially in a transverse plane passing through the main centre in such a way that the cylinder block can undergo small pivotal movements about this main centre. The support of the cylinder block from the shaft by means of the wear ring is a particularly convenient construction since the manufacturing operations are extremely simple. Moreover since the ring is a separate component it has two surfaces, its internal and external surfaces, each of which can contribute to the necessary small pivotal movements of the cylinder block. Furthermore being of a softer material the wear ring will tend to wear or otherwise deform into an approximately spherical shape, and since the ring can be formed of an anti-friction material such as bronze the possibility of fretting corrosion will be greatly reduced and the construction will maintain accurate radial location of the cylinder block in the transverse plane passing through the main centre. This construction also avoids the imposition of any radial loads on the teeth of the driving connection which would be most undesirable.

Preferably the toothed connection acts directly between the shaft and the cylinder block and according to a preferred feature of the invention the ratio of the effective axial length of the wear ring to its overall diameter is less than one third.

In one embodiment the internal and external surfaces of the wear ring are initially cylindrical, in which case the internal and/or external surfaces of the ring will in use become slightly worn as the cylinder block pivots about the main centre. Alternatively the internal and/or external surfaces of the wear ring may be initially part-spherical, tapered or chamfered.

In a preferred construction the external and internal diameters of the wear ring are respectively greater and smaller than the root circle diameter and the tip circle diameter of the teeth on one of the respective toothed parts. This is particularly convenient since the splines or teeth on the shaft and on the cylinder block can then be broached or machined by a tool moving parallel to the rotary axis, there being no radial projection on either part obstructing such movement of the tool.

The invention also permits the wear ring to be mounted in a rigid robust part of the cylinder block so as to limit radial deformation which would otherwise disturb the accurate positioning of the cylinder block. Thus preferably at least part of the wear ring is situated at an axial

position within the axial length of the solid part of the cylinder block which accommodates the cylinders.

The wear ring preferably acts solely as a radial location between the shaft and the cylinder block.

Of course it is necessary to urge the cylinder block axially against the non-rotary valve member and this is preferably performed by thrust means separate from the wear ring. In some cases adequate axial thrust can be transmitted by the reaction of the pressure within the cylinder bores in the application, this pressure reacting through the pistons and sliding slippers on the non-rotary cam plate. Alternatively or in addition an axial thrust may be exerted on the cylinder block in a direction towards the valve member by a spring or a hydraulic thrust generator acting between the cylinder block and the valve member.

In any case the toothed connection should be located axially closely adjacent to the wear ring since the main centre about which the cylinder block pivots is positioned in a transverse plane passing through the wear ring. Since the shaft and the cylinder block are located radially by the wear ring the splines or teeth can be formed to provide small clearances sufficient to allow the necessary small pivotal movements.

The invention may be performed in various ways and one specific embodiment will now be described by way of example with reference to the accompanying drawing which represents a sectional side elevation through a pump according to the invention.

In this example the invention is applied to a variable displacement pump comprising a cylindrical casing **10** having at one end an end wall **11** rigidly secured thereto, this end wall also constituting the non-rotary valve member of the pump, and having inlet and discharge passages (not shown) connected to the usual kidney-shaped ports, which cooperate with ports **12** formed in the adjacent end of the cylinder block **13**. At the opposite end of the casing an apertured plate **14** is secured in position to support a bearing **15** for the drive shaft **16** of the pump, and also a mounting block **17** within the casing having a part cylindrical abutment surface **18** centred on a transverse axis and facing towards the valve member **11**. An annular tilting cam plate **19** having a corresponding part-cylindrical rear surface **20** is mounted in the casing between transversely extending stub shafts (not shown) and means are provided, including an operating shaft **21**, for rocking this cam plate **19** about the transverse axis to vary the displacement of the pump.

The drive shaft **11** extends through the end plate **14**, being supported by the bearing **15** therein, and its opposite end is received in a plain bearing **22** positioned in a central recess in the valve member **11**. The shaft is thus capable of small axial movements.

The cylinder block **13** contains, for example, nine parallel axial cylinder bores **25** and is formed with a central bore or passage **26** surrounding the drive shaft. Each of the cylinder bores **25** contains a piston **27** which is connected by a ball joint **28** to a sliding slipper **29** engaging the adjacent flat annular face of the cam plate **19**. The cylinder bores **25** also contain compression springs **30** urging the pistons towards the cam plate **19** and the slippers are maintained at all times in contact with the cam plate by an annular pressure plate **31** overlying the pads of the slippers, this pressure plate having an internal part-spherical surface **32** which engages a corresponding part-spherical abutment ring **33** mounted on the drive shaft **16**. The combination of the springs with these abutment surfaces act to hold the cylinders at all times in engagement with the cam surface. The opposite ends of the cylinder bores **25** communicate with the fluid passages **12** designed to cooperate with the kidney ports in the valve member as the cylinder block rotates.

At the mid-point in the length of the drive shaft teeth **40** are formed integrally thereon and corresponding internal teeth are formed in the central bore **26** of the cylinder block. These teeth on both parts project from the respective surfaces and can therefore be formed simply by a gear milling or broaching operation. The teeth are specifically designed in such a way as to permit limited angular deflection of the two parts. Immediately adjacent to this toothed connection a wear ring **41** of bronze is positioned between the shaft **16** and the cylinder block **13** and situated in transverse alignment with the transverse plane **42** passing through the main centre **43** where the axis of rotation **44** of the shaft **16** intersects a plane **45** passing through the centres **46** of the ball joints **28**. In this particular example the axial length of the wear ring **41** is 0.5", its external diameter is 2.5", and its internal diameter is 2.25". Thus the ratio of the effective axial length of the wear ring to its external diameter is 0.5/2.5=1/5. The internal and external surfaces of the wear ring are in this example initialy cylindrical with slightly bevelled edges but the fact that the ring is formed of bronze combined with its relatively small axial length is sufficient to ensure that the cylinder block has adequate freedom for pivotal movement about the main centre **43**. The wear ring **41** is situated at least partly within the main body portion of the cylinder block **13** and a generally rigid support is therefore provided for the cylinder block which will not distort appreciably under the radial loads applied.

In this example the cylinder block **13** is urged axially against the valve member **11** by the reaction of the hydraulic pressure within those of the cylinder bores **25** which are at any time subject to pressure, and in addition a compression spring **50** is provided surrounding the drive shaft **16** and situated within the internal central bore **26** in the cylinder block, the opposite ends of the spring abutting against rings **51**, **52** located respectively by a shoulder **53** on the shaft and a spring ring **54** fitted in the cylinder block. The axial reaction thrust of the spring **50** on the drive shaft is transferred from the spherical abutment ring **33** through the slipper pads **29** to the stationary cam plate **19** and thus exerts a corresponding axial thrust on the cylinder block **13** towards the valve member **11**.

I claim:

1. An axial piston hydraulic pump or motor comprising a casing, a drive shaft within the casing, a rotary cylinder block connected to the shaft and formed with generally axially extending cylinder bores each containing a reciprocating piston which is connected through a ball joint to a slipper engaging an inclined or inclinable cam plate, and a non-rotary valve member engaging a ported end face of the cylinder block to control the admission and discharge of fluid to and from the cylinder bores, the shaft being located transversely relative to the casing by two spaced bearings and the cylinder block being located transversely relative to the shaft in a plane passing through the point of intersection between the main rotary axis and a plane parallel to the surface of the cam plate and passing through the centers of the ball joints, by means of a wear ring interposed between the shaft and the cylinder block in way of the said transverse plane, the wear ring being formed of an anti-friction material softer than the shaft or cylinder block such that the cylinder block can become inclined relative to the shaft about the said point of intersection, and including a direct straight-toothed driving connection between the shaft and the cylinder block axially adjacent to the wear ring, the shaft and the cylinder block each being formed with integral toothed formations, and in which the external diameter of the wear ring is not less than the root circle diameter of the teeth on the cylinder block, and the internal diameter of the wear ring is not greater than the tip circle diameter of the said teeth.

2. An axial piston hydraulic pump or motor as claimed in claim **1**, in which the ratio of the effective axial length

of the wear ring to its overall diameter is less than one third.

3. An axial piston hydraulic pump or motor as claimed in claim 1, in which an internal surface and an external surface are formed on the wear ring, at least one of said surfaces initially providing a cylindrical surface and a linear surface skewed with respect to said cylindrical surface.

4. An axial piston hydraulic pump or motor as claimed in claim 1, in which an internal surface and an external surface are formed on the wear ring, at least one of the surfaces being initially part-spherical.

5. An axial piston hydraulic pump or motor as claimed in claim 1, in which at least part of the wear ring is situated at an axial position within the axial length of the solid part of the cylinder block which accommodates the cylinders.

6. An axial piston hydraulic pump or motor as claimed in claim 1, in which the wear ring is formed of bronze and the shaft and the cylinder block are formed of steel.

7. An axial piston hydraulic pump or motor as claimed in claim 1, in which the wear ring acts solely as a radial location between the shaft and the cylinder block.

8. An axial piston hydraulic pump or motor as claimed in claim 7, including additional thrust means acting between the cam plate and the pistons to provide an effective force urging the cylinder block against the non-rotary distributor plate.

9. An axial piston hydraulic pump or motor as claimed in claim 1, in which the toother connection is displaced axially from the wear ring by a distance less than the axial length of the wear ring.

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