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(54) Rotary hydraulic pump.

(57) A rotary hydraulic machine usable as a pump for marine auto-pilot installations includes a rotor block - (15) rotatable in a stator (1), the rotor block having a cylinder (14) within which slides a piston (13) on an axis perpendicular to the axis of rotation of the rotor block in the stator. Ports (25, 26) communicate with the cylinder on opposite sides of the piston. The axis of rotation of the rotor block in the stator is eccentric relative to the axis of the drive shaft (6) which drives the rotor block, a lost motion connection (10,12) being provided between the drive shaft and the piston, so that rotation of the rotor block in the stator is accompanied by reciprocation of the piston in the cylinder and hydraulic fluid flow in the ports.

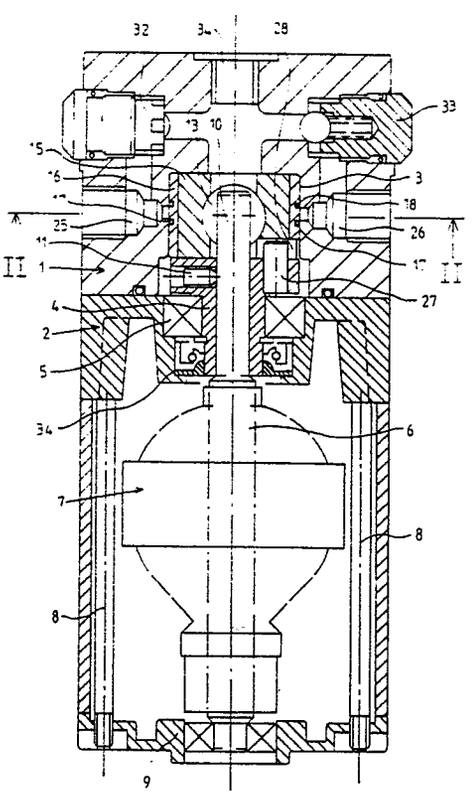

FIG 1

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Rotary Hydraulic Machine

This invention relates to rotary hydraulic machines.

More particularly, but not exclusively, the invention is concerned with a rotary hydraulic pump suitable for low capacity applications such as, for example, the provision of hydraulic power for marine auto-pilot installations. The invention is particularly suited for low pressure applications, in which the pressure typically does not exceed approximately 2750kPa or, for continuous running, approximately 1750kPa.

A known type of hydraulic pump has one or more pistons slidable radially in a cylinder of cylinders formed in a block, the pistons being spring-loaded radially outwardly or inwardly into sliding engagement with an eccentric cam surface formed on a rotor or rotor housing. Upon rotation of the rotor the eccentric cam surface cause the or each piston to reciprocate in its cylinder, with consequent hydraulic flow into and out of the cylinder through suitable valving communicating with the cylinder.

An object of the present invention is to provide an improved rotary hydraulic machine having a double-acting piston and cylinder arrangement which is both simpler to manufacture and involves less wear on mechanical moving parts compared with machines having one or more single-acting spring-loaded pistons.

According to the present invention there is provided a rotary hydraulic machine comprising a rotor block which is rotatable in a stator and which is provided with a cylinder the axis of which is perpendicular to the axis of rotation of the rotor block in the stator, a piston slidable within the cylinder, ports communicating with the cylinder on opposite sides of the piston, and a drive shaft coupled to the rotor block to impart rotation to the latter, the axis of rotation of the rotor block in the stator being eccentric relative to the axis of the drive shaft, and a lost motion connection between the drive shaft and the piston, so that rotation of the rotor block in the stator is accompanied by reciprocation of the piston in the cylinder and hydraulic fluid flow in the ports.

Preferably the lost motion connection between the drive shaft and the piston comprises a support pin connected to or formed in the drive shaft and engaging a slot in the piston.

In one embodiment, drive is imparted to the rotor block through an eccentric crank pin driven by the drive shaft and engaging with clearance in a slot in the rotor block. However, drive may equally be imparted by engaging a crank pin on the rotor block with a clearance slot formed eccentrically in association with the drive shaft. To reduce wear between the pin and the slot, the pin may be located in a slider mechanism which slides within the slot, thereby increasing bearing surface area, or the slot bearing surfaces and/or the pin may be hardened.

To counter the tendency of tangential drive forces, arising from a single eccentric crank pin arrangement, to twist the rotor block in the stator, thereby slightly offsetting the axis of rotation of the rotor block and reducing the drive efficiency, it is preferred to impart drive to the rotor block through an Oldham type coupling, comprising two eccentric crank pins driven by the drive shaft and engaging clearance slots in an intermediate floating drive disk. Two further clearance slots in this intermediate disk engage with two eccentric pins projecting from the rotor block.

When the machine is used as a pump, the rotor block is driven to cause reciprocation of the piston in the cylinder by virtue of the eccentricity of the stator relative to the axis of the drive shaft.

In a preferred embodiment of the invention, the ports are formed in a cylinder sleeve which surrounds the rotor block and which is fluid-tightly sealed in a cylindrical bore in the stator, the sleeve defining with the piston respective chambers in the cylinder, whereby the volume of hydraulic fluid in the chambers varies cyclically upon rotation of the rotor block. In use of the machine as a pump, the piston is reciprocated in the cylinder and is in effect double-acting, with hydraulic fluid being delivered to and from each of the two chambers at opposite ends of the cylinder.

The ports in the sleeve preferably communicate with respective circumferentially extending grooves, sealed from each other, in the external surface of the sleeve, the surface area of the sleeve between the grooves being such that in operation of the machine the radially inwardly directed force on the sleeve due to the pressure in the groove substantially counterbalances the radially outwardly directed force on the sleeve due to the pressure in the chamber with which the said groove communicates. This pressure-balanced embodiment results in considerably reduced wear of the rotor in the stator block.

For a machine of the present invention having a low fluid throughput, for example in a low capacity pump, it is a simple matter to arrange for the eccentricity of the stator relative to the axis of the drive shaft to be adjustable, to enable the stroke of the piston, and therefore the fluid displacement of the machine, to be adjusted. For example, the stator may be angularly adjustable about a pivot

pin or axis which is eccentric relative to the axis of the drive shaft, means being provided for clamping the stator in any position of angular adjustment. Preferably the drive shaft is journalled in upper and lower bearings respectively on either side of the rotor block and the stator is adjustably located between the upper and lower bearings and contained within a housing that locates one of the said bearings, such that adjustment of the stator to alter the direction of flow or the stroke of the piston may be effected without either leakage of hydraulic fluid or ingress of air or foreign matter. Furthermore, the use of upper and lower bearings increases the resistance of the drive shaft to lateral flexing, thus increasing the accuracy and precision of the machine.

Embodiments of the invention are described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic axial section of a rotary hydraulic pump in accordance with one embodiment of the invention;

Figure 2 is a diagrammatic transverse cross section through the pump of Figure 1, taken on line II-II in Figure 1;

Figure 3 is a diagrammatic 90° axial section of a rotary hydraulic pump in accordance with another embodiment of the invention; and

Figure 4 is an exploded perspective view of an Oldham type coupling for use in the pump depicted in Figures 1 to 3.

The rotary hydraulic pump illustrated in the drawings is a low capacity hydraulic oil pump designed for use with a marine auto-pilot.

Referring firstly to Figure 1, the pump has a stator block 1 and cover plate 2. A cylindrical axial bore 3 is formed in the block 1. A rotor 4 is located within the bore 3 and is supported from the cover plate 2 by a roller or needle bearing 5. The rotor 4 is driven by a drive shaft 6 of an electric motor 7 supported from the cover plate 2 by tie rods 8 and an end bearing plate 9. Thus the motor shaft 6 has an axial extension in the form of a support pin 10 coaxial with the drive shaft 6, the rotor 4 being keyed to the support pin 10 by means of a socket grub screw 11 or by other means such as a splined coupling.

For a marine auto-pilot application the motor 7 would typically be a 10 volt 30 watt motor having a rotational speed of 2600 rpm.

The support pin 10 projects into the cylindrical bore 3 coaxially with the axis of the drive shaft 6 and engages in an elongate slot 12 in a piston 13. The pin 10 and slot 12 constitute a lost motion connection between the drive shaft 6 and the piston 13. The piston 13 is slidable in a cylinder 14 formed in a rotor block 15, the axis of the cylinder 14 being perpendicular to the common axis of the drive shaft 6 and the cylindrical bore 3.

The rotor block 15 is essentially cylindrical - (Figure 2) and is mounted within a cylindrical sleeve 16 which surrounds the rotor block 15 and is formed with piston ring or composite seals 17, 18 which make sealing contact with the cylindrical bore 3. The sleeve 16, together with the piston 13, defines respective chambers 19, 20 within the cylinder 14. The sleeve 16 is formed with diametrically opposed apertures 21, 22 through which the chambers 19, 20 are placed in communication with respective circumferentially extending grooves 23, 24 in the outer surface of the sleeve 16.

Respective inlet and outlet ports 25, 26 are arranged diametrally opposite each other in the stator block 1 and communicate with the bore 3 of the stator block 1.

The rotor block 15 and the sleeve 16 are fixed to each other and are rotatable freely within the cylindrical bore 3 of the stator block 1. The rotor block 15 is coupled to the rotor 4 for rotation therewith by a crank pin 27 projecting from the rotor 4 and engaging with play in a slot 28 in the rotor block 15.

The stator block 1 is adjustable angularly relative to the cover plate 2 about the axis of the motor shaft 6 so that the position of the axis of the bore 2 in the block 1 can be adjusted laterally relative to the axis of the shaft 6 and the support pin 10. In the illustrated embodiment, such adjustment is effected by angular displacement of the block 1 relative to the cover plate 2 about a pivot axis 29 spaced from the axis of the block 1. Clamping screws 30 attached to the cover plate 2 and engaging in respective slots 31 in the stator block 1 limit the range of angular adjustment of the block 1 relative to the cover plate 2. The slots 31 are such that the stator block 1 has a central position of coaxial alignment between the axis of the bore 3 and the axis of the support pin 10 and a range of eccentric positions between two extreme positions in which the axis of the bore 3 is displaceable from the axis of the support pin 10 on opposite sides thereof.

The pump is operated by the drive imparted to the rotor block 15 from the motor 7 through the motor shaft 6, the rotor 4 and the crank pin 27. The axis of rotation of the rotor block 15 will be spaced from the axis of rotation of the drive shaft 6 by an amount equal to the eccentricity of the stator block 1 relative to the cover plate 2, such eccentricity being accommodated by movement of the support pin 10 in the slot 12 and by the play between the crank pin 27 and the slot 28. By virtue of this

eccentricity, the rotation of the rotor block 15 will be accompanied by displacement of the piston 13 within the cylinder 14, with a stroke determined by the eccentricity of the stator block 1.

In one complete rotation of the rotor block 15 about the axis of the support pin 10, the piston 13 will perform one complete cycle of reciprocation within the cylinder 14. Thus the volume of hydraulic fluid in the chamber 19 will increase and decrease cyclically in exact antiphase to the change of volume of the hydraulic fluid in chamber 20, so that the piston 13 is double-acting.

The arrangement of the circumferential grooves 23 and 24 communicating with the two chambers 19 and 20 is such that, for a clockwise direction of rotation of the rotor (as seen in Figure 2) that port 25 is always in communication with that chamber which at any given time is decreasing in volume, so that the port 25 acts as a fluid outlet port, while the opposite port 26 is always in communication with tha chamber which at any given time is increasing in volume, so that the port 26 acts as an inlet port of the pump.

In order to vary the delivery of fluid displacement of the pump, the eccentricity of the stator block 1 is adjusted relative to the axis of the support pin 10, using the adjustable clamping screws 20 as previously described. In the central position in which the eccentricity is zero, the bore 3 of the stator block 1 is coaxial with the axis of the support pin 10 and the piston 13 is not displaced in the cylinder 14. This is a neutral or zero delivery setting of the pump. The flow direction of the pump delivery will, of course, depend upon the sense in which the axis of the stator block 1 is displaced relative to the axis of the support pin 10.

Since the pump is reversible, the stator block 1 also includes two spring-loaded non-return ball valves 32, 33 communicating with a central oil return duct 34 in the stator block 1. The valves 32, 33 allow any oil which leaks from the pressurised side of the pump to be returned to the non-pressurised port.

A shaft seal 34 is provided around the lower end of the rotor 4 to contain any leakage.

The rotor block 15 can be effectively pressure-balanced by arranging that the surface area between the grooves 23, 24 in the outer surface of the sleeve 16 is equal to the surface area of the sleeve in each respective chamber 19, 20 upon which a radially outward pressure acts. This in turn reduces the friction wear between the rotor block 15 and the stator block 1 in which it rotates.

Referring to Figure 3 a modified form of the pump illustrated in Figures 1 and 2 is illustrated by way of a 90° axial section. The modified pump includes a motor 35 which drives a drive shaft 36 which is journalled betwen upper and lower bearings 37 and 38 respectively. The lower bearings 38 are located in the cover plate 39 and the upper bearings 37 are located in a housing 40 which is clamped to cover plate 39 by bolts 41. Keyed to the drive shaft 36 is rotor 42 which imparts drive to the rotor block 43 via a crank pin/slot arrangement (not shown), similar to that illustrated at 27 and 28 in Figure 1. The rotor block rotates in stator block 44 which is angularly adjustable relative to the cover plate/housing 39/40 combination on slackening of the bolts 41, the extent of angular adjustment being regulated by pins 45 in the cover plate and which engage in respective slots in the stator block. Inlet and outlet ports 46 are arranged diametrally opposite each other in the stator block and communicate at one end with the bore in the stator block and at the other in sealing engagement with slotted ducts 47 in the housing, the slots being adapted to accommodate angular adjustment of the stator block while remaining in communication with the ports. The slotted ducts terminate in tapped recesses 48 via valves 49 for returning any leaked oil from the pressurised to the non-pressurised side of the pump.

The rotor block 43 includes a cylinder in which is slidable a piston having a slot in which the drive shaft 36 rotates to constitute a lost motion connection, as in Figures 1 and 2. Furthermore, the rotor block 43 is rotatable with a cylindrical sleeve which is formed with seals, the sleeve and piston defining chambers within the cylinder which are in communication with circumferentially extending grooves in the outer surface of the sleeve, again as in Figures 1 and 2, the chambers alternately communicating with respective ports 46 on rotation of the rotor block about the drive shaft.

The housing 40 is formed with a skirt 49 which is sealingly engaged via "O" ring seal 50 the cover plate 39. On slackening the bolts 41 to effect angular adjustment of the stator block, the seals prevent leakage of oil or ingress of air or foreign matter. Furthermore, since the housing 40 remains in fixed position relative to the remainder of the exterior of the pump, irrespective of the extent of angular adjustment of the stator block, hydraulic lines connected to the recesses 48 do not suffer any movement or other disturbance on effecting adjustment of the stator block.

Referring to Figure 4, an Oldham type coupling is shown for use in place of the crank pin/slot 27-28 arrangement of Figure 1 or the corresponding arrangement described with reference to Figure 3. The coupling consists of (with particular reference to the pump described with reference to Figure 3) a floating intermediate drive disk 51 containing four radial slots 52 located at 90° to one another. The rotor block 43 carries eccentric crank pins 53 lo-

cated at 180° to one another and which engage in an opposed pair of slots 52. The rotor 42 carries eccentric crank pins 54 which engage in the other pair of slots 52.

Claims

1. A rotary hydraulic machine comprising a rotor block which is rotatable in a stator and which is provided with a cylinder the axis of which is perpendicular to the axis of rotation of the rotor block in the stator, a piston slidable within the cylinder, ports communicating with the cylinder on opposite sides of the piston, and a drive shaft coupled to the rotor block to impart rotation to the latter, the axis of rotation of the rotor block in the stator being eccentric relative to the axis of the drive shaft, and a lost motion connection between the drive shaft and the piston, so that rotation of the rotor block in the stator is accompanied by reciprocation of the piston in the cylinder and hydraulic fluid flow in the ports.

2. A machine according to Claim 1, in which the lost motion connection between the drive shaft and the piston comprises a support pin connected to or formed with the drive shaft and engaging in a slot in the piston.

3. A machine according to Claim 1 or Claim 2, in which drive is imparted from the drive shaft to the rotor block via the combination of an eccentric crank pin on either the drive shaft or the rotor block, which engages with a clearance slot formed in the other of the drive shaft or rotor block.

4. A machine according to Claim 3, in which drive is imparted to the rotor block via an intermediate floating disk containing four radial slots placed at 90° to one another, two of said slots engaging with pins mounted in the rotor block, and the other two engaging with pins driven by the drive shaft.

5. A machine according to Claim 3 or Claim 4, in which the pin locates within a slider mechanism which slides within the slot.

6. A machine according to any one of Claims 1 to 5, in which the ports are formed in a cylindrical sleeve which surrounds the rotor block and which is fluid-tightly sealed in a cylindrical bore in the stator, the sleeve defining with the piston respective chambers in the cylinder, whereby the volume of hydraulic fluid in the chambers varies cyclically upon rotation of the rotor block.

7. A machine according to Claim 6, in which the ports in the sleeve communicate with respective circumferentially extending grooves, sealed from each other, in the external surface of the sleeve, the surface area of the sleeve between the grooves being such that in operation of the machine the radially inwardly directed force on the sleeve due to the pressure in the groove substantially counterbalances the radially outwardly directed force on the sleeve due to the pressure in the chamber with which the said groove communicates.

8. A machine according to any one of the preceding claims, in which the eccentricity of the stator relative to the axis of the drive shaft is adjustable.

9. A machine according to Claim 8, in which the drive shaft is journalled between upper and lower bearings respectively on either side of the rotor block, the stator being adjustably located between the said upper and lower bearings.

10. A machine according to Claim 9, in which one of the said bearings is located within a housing which resists leakage of hydraulic fluid or ingress of air or foreign matter on angular adjustment of the stator.

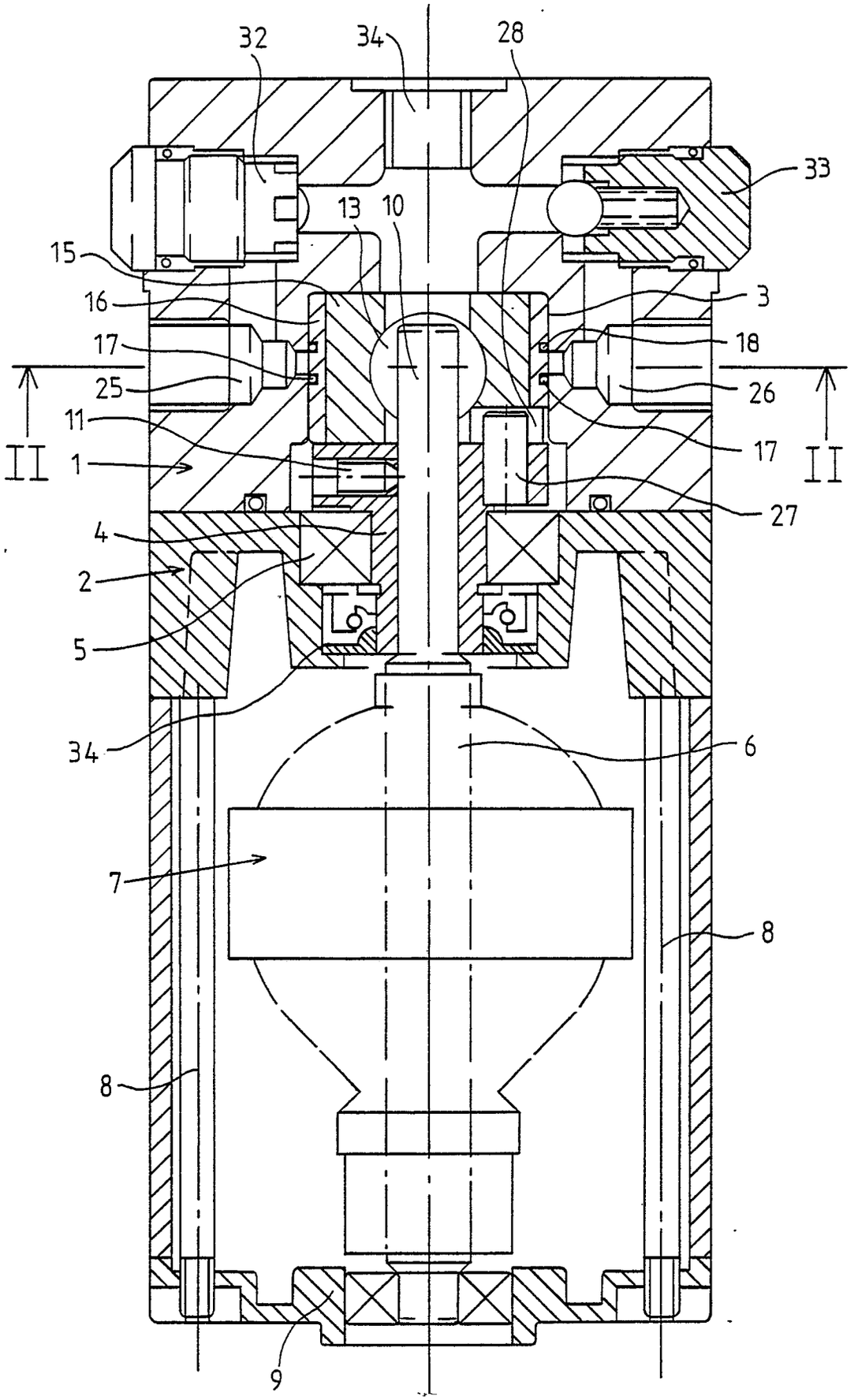

FIG.1.

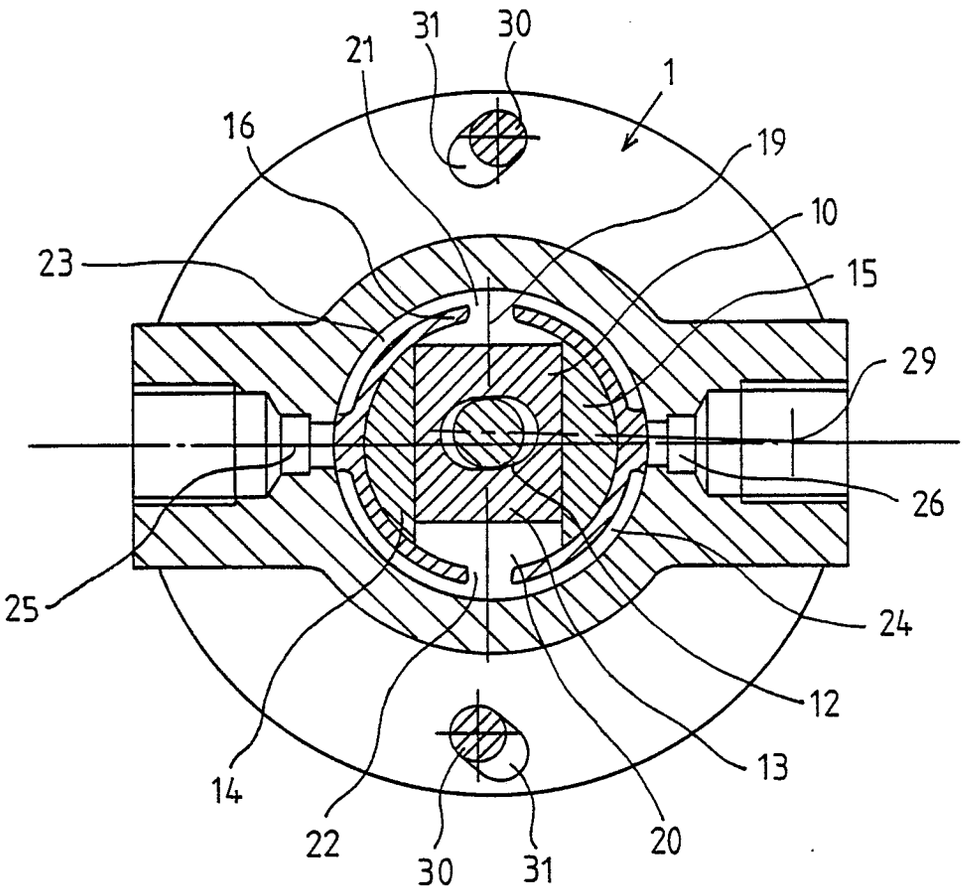

FIG.2.

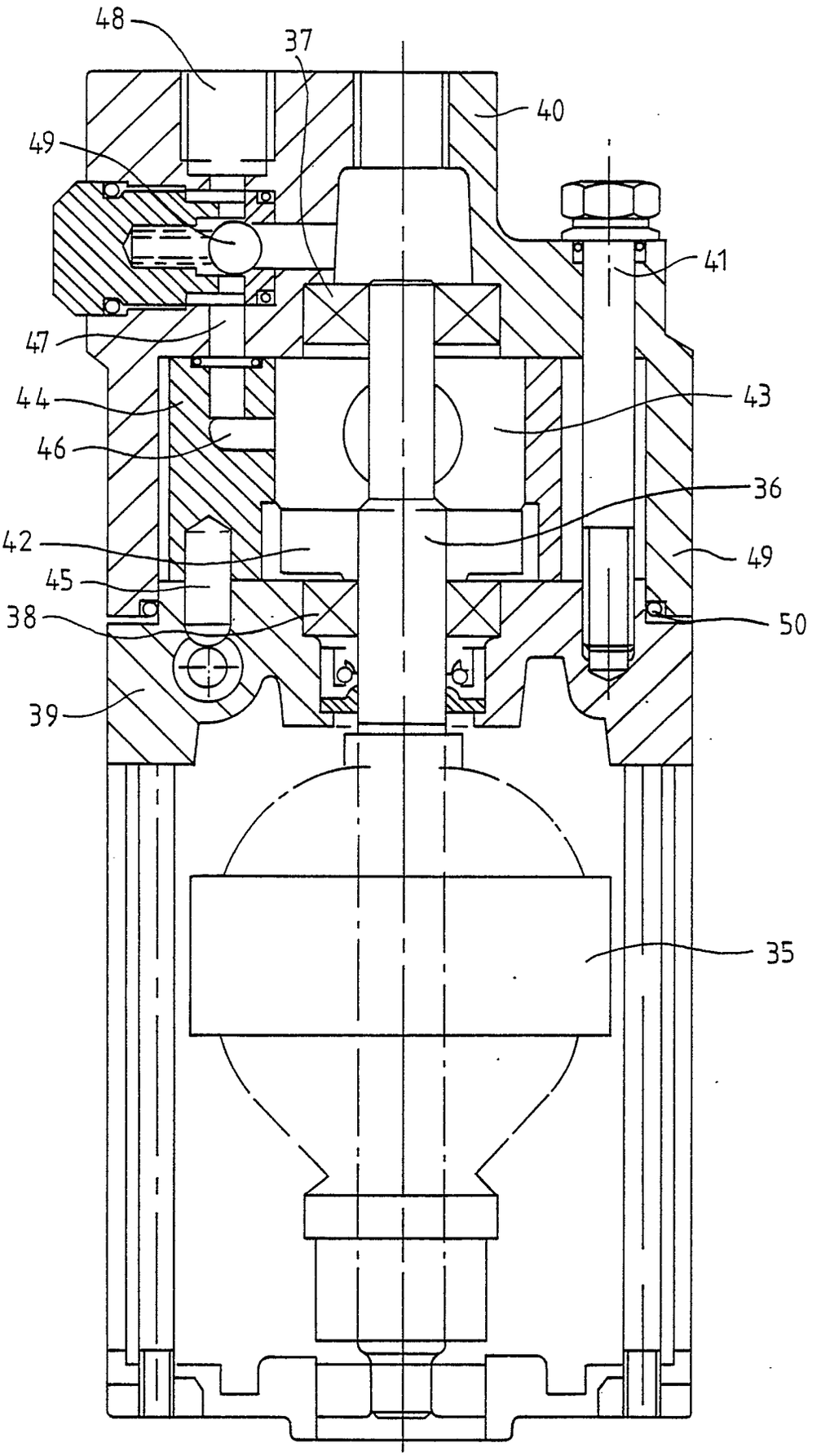

FIG.3.

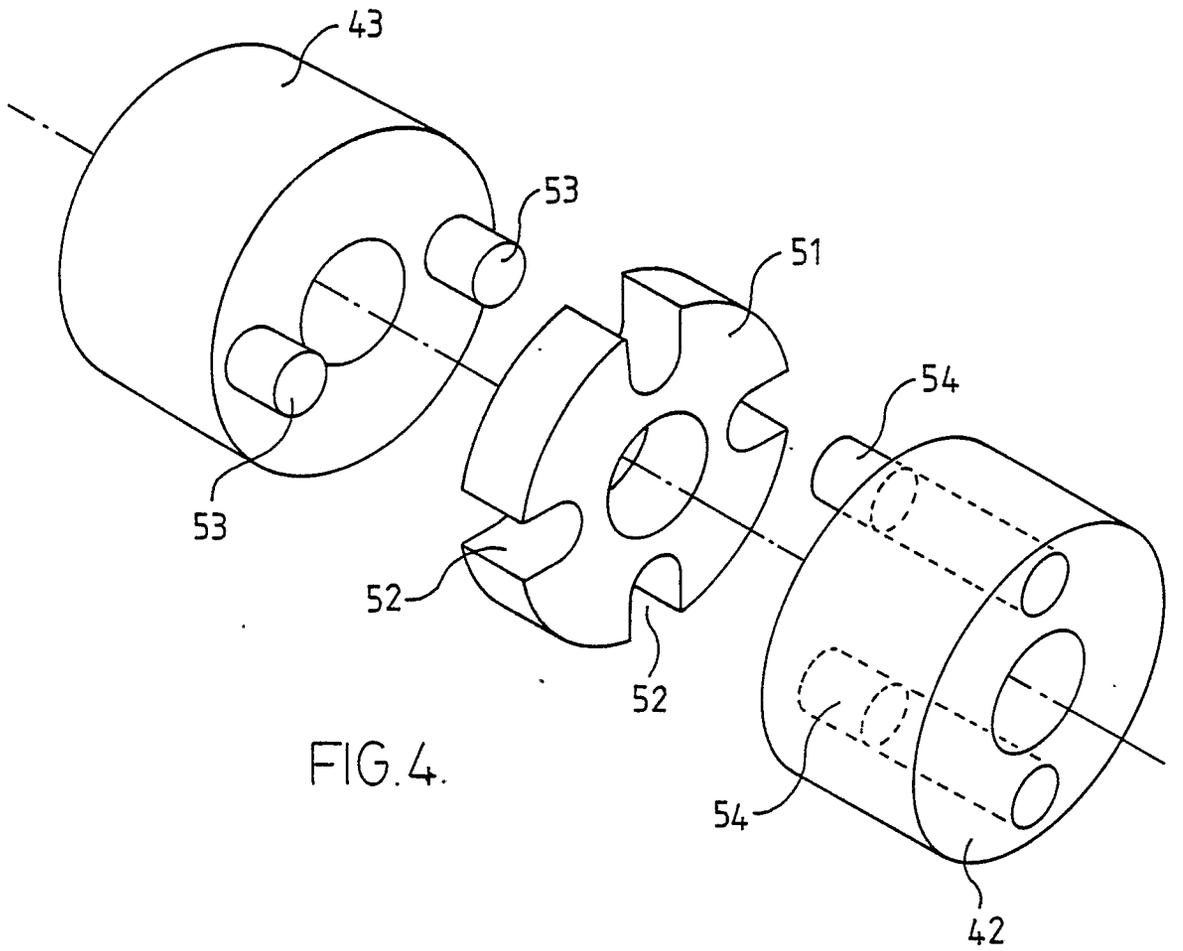

FIG.4.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT

EP 86306782.3

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	FR - A3 - 2 323 870 (CAMERON) * Totality; especially page 4, line 7 - page 5, line 8; fig. 1 *	1	F 04 B 1/10 F 04 C 2/00
A	AU - B - 469 828 (KELVIN) * Totality; especially page 5, line 9 - page 6, line 22; fig. 2,3,4,5,6 *	1	
A	GB - A - 1 183 624 (MATTI) * Totality; especially page 1, line 50 - page 2, line 88; fig. *	1	
A	AT - B - 106 898 (MÜSER) * Totality *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 04 B 1/00 F 04 B 9/00 F 04 C 2/00 F 04 C 18/00
A	DE - A1 - 2 905 940 (LUCAS) * Totality; especially claim 1; fig. 8 *	1	
A	FR - A - 2 133 189 (REBER) * Totality; especially fig. 2,3*	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	13-02-1987	WERDECKER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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