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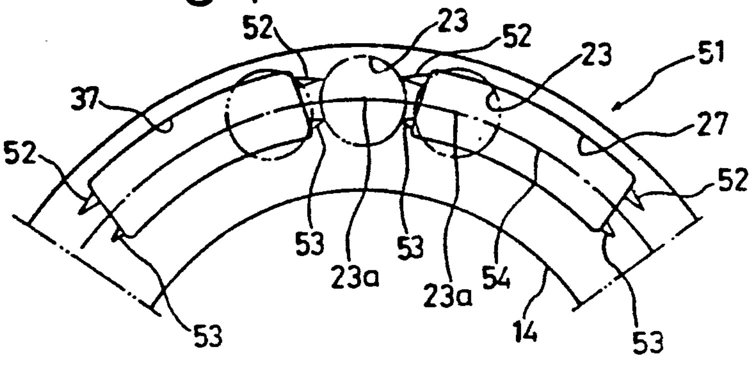
(54) Rotary fluid switching device.

(57) A rotary fluid switching device mounted between the pintle (14) and the cylinder barrel of a rotary fluid energy converter has first and second valve surfaces which are in sliding contact with each other. The first surface has openings (27, 37) for supply and discharge of fluid. Cylinder ports (23) are circumferentially spaced from one another on the second surface. As the two surfaces are rotated relatively to each other, the openings (27, 37) periodically establish and interrupt communication with the cylinder ports (23). Two notches (52, 53) extend from each end of the openings (27, 37) and are located off the line (23a) along which each center of the cylinder ports travels in operation.

fig.4



EP 0 234 134 A1

"ROTARY FLUID SWITCHING DEVICE"

The present invention relates to a rotary fluid switching device adapted for use, for example, in a fluid passage in a rotary fluid energy converter, such as a hydraulic pump or motor.

Rotary fluid switching devices has been mounted in fluid passages in hydraulic pumps or motors of the radial piston type, bent axis type, or swash plate type to cause a working fluid to be continuously distributed to, and discharged from, cylinders.

A rotary fluid switching device of this kind is shown in Fig. 5 and presents a block d with its valve surface a provided with a port b for high pressure and a port c for low pressure, for supplying and discharging fluid. The switching device further presents a cylinder block g provided with ports f circumferentially spaced apart from each other in its valve surface e that comes into sliding contact with the port block d. As the blocks d and g rotate relatively to each other, the ports f periodically establish and interrupt communication with the ports b and c. Devices of this type often have notches h and i (see also Fig. 6) extending away from ends of the ports b and c in order to reduce the shock occurring when the system is switched from high pressure to low pressure or vice versa, and to cut down on noise and vibration.

In the conventional device shown in Figs. 5 and 6, the notches h and i are located on the median circle line k of the ports b and c, which means that the center j of each port f travels over the notches h and i. This tends to reduce the volumetric efficiency for the following reason. The formation of the notches h and i generally tends to produce erosion at those locations on the valve surface e of the cylinder block g over which travel the notches h and i. Therefore, the erosion progressively extends along the line k connecting each center j of the ports f on the valve surface e of the cylinder block g. If the ports f are circular in shape, the line k connecting each center j of the ports f provides the shortest distance between any two circumferentially adjacent ports f. Accordingly, such an extension of the erosion results in that the adjacent ports f rapidly establish communication with each other via the eroded portion, frequently leading to a decrease in the volumetric efficiency. For this reason, one is dissuaded to arrange the ports f in close adjacent position.

It is an object of the present invention to provide a rotary fluid switching device having a simple structure that effectively circumvents disadvantages which would otherwise be introduced by the presence of notches as mentioned above.

The above object is achieved by a rotary fluid switching device having a first valve surface provided with fluid supply and discharge openings and a second valve surface being in sliding contact with said first valve surface and provided with circular or elliptic cylinder ports that are spaced from one another in the direction of rotation, said two valve surfaces being rotated relative to each other so that the cylinder ports alternately establish and interrupt communication with the openings, characterized in that at least one notch extends at least one end of said openings, said notch being located off the line along which each center of the cylinder ports travels.

According to one preferred embodiment of the invention, a pair of notches extend each end of said openings, both notches being located off the line along which each center of the cylinder ports travels.

According to another embodiment of the invention, the two notches of each said pair are different in length, so that the fluid communication simultaneously occurs and interrupts for both notches and the width in cross section of each notch gradually decreases away from its corresponding opening end.

In one feature of the invention, even if an erosion occurs on the valve surface having cylinder ports because of the presence of the notches, the erosion develops along locations lying off the median line connecting each center of the cylinder ports. Since said median line provides the shortest distance between adjacent cylinder ports, the risk of fluid leaking from one cylinder port to the adjacent one is thus effectively prevented. Hence, the volumetric efficiency does not deteriorate.

Other objects and features of the invention will appear in the course of the description that follows, and of the drawings in which :

Fig. 1 is a front elevation view in cross section of a rotary fluid energy converter incorporating a rotary fluid switching device according to the invention.

Fig. 2 is a cross-sectional view taken along line II-II of Fig. 1.

Fig. 3 is a cross-sectional view taken along line III-III of Fig. 1.

Fig. 4 is an enlarged view of a valve surface formed on the outer periphery of the pintle shown in Figs. 1-3.

Fig. 5 is a view in perspective of a conventional device in a disassembled condition ; and

Fig. 6 is a view of the device shown in Fig. 5 as seen from the direction indicated by arrow VI.

Referring to Figs. 1-4, there is shown a rotary fluid energy converter incorporating a rotary fluid switching device according to the invention as described later. This energy converter comprises a torque ring 2 that is rotatably and closely held against the inner surface of a housing 1 via first static pressure bearings 3. The housing 1 is shaped as a cone with a bottom portion, and is provided at one end with an opening 1a. A tapering surface 4 that tapers off toward the opening 1a is formed in the portion of the inner surface of the housing 1 supporting the ring 2. The ring 2 is shaped like a cup, and has an outer peripheral wall 2a presenting the same apical angle as the tapering surface 4. A rotating shaft 6 protrudes away from one end of the axially central portion of the ring 2. The front end of the shaft 6 extends outwardly from the housing 1 through the opening 1a. Flat surfaces 2c are formed on the portions of the inner surface of the ring 2 which are opposite to the first surface pressure bearings 3.

The first static pressure bearings 3 have shoes 5 rigidly secured to the outer periphery of the ring 2 at required positions. The shoes 5 are attached to the tapering surface 4 of the housing 1. Each shoe 5 is provided with pressure pockets 7 into which fluid pressure is introduced. An odd number of pressure bearings 3 are circumferentially regularly spaced from one another. Pistons 8 are disposed at locations corresponding to the flat surfaces 2c of the inner surface of the ring 2. The front ends 8a of the pistons 8 are connected to their respective inner surfaces 2c via second static pressure bearings 9 whose active surfaces are made flat so that the front ends 8a of the pistons 8 are in intimate contact with the inner surfaces 2c. Pressure pockets 11 are formed in the front ends 8a, and fed with pressure fluid.

A pintle 14 and an annular cylinder barrel 15 rotatably fitted over the outer periphery of the pintle 14 are mounted inside the torque ring 2. The axis n of the pintle 14 is parallel to the axis m of the housing 1. The pintle 14 has a sliding portion 14a guided by the housing 1. The barrel 15 is equipped with cylinders 16 which are circumferentially regularly spaced from one another. The axes of the cylinders 16 are substantially perpendicular to the outer periphery of the pintle 14. The pistons 8 are fitted in the respective cylinders 16 so as to be slidable. The bottom end surfaces 8b of the pistons 8 cooperate with the inner surfaces of the cylinders 16 to delimit chambers 13 for introduction and discharge of fluid. The cylinder barrel 15 is connected to the torque ring 2 by means of an Oldham coupling 20 or similar means, and rotates at the same angular velocity as the ring 2.

The contour of the pintle 14 takes the form of a truncated cone presenting substantially the same apical angle as the peripheral wall 2a of the ring 2. The pistons 8 are held in such a way that they can move back and forth perpendicularly to said peripheral wall 2a of the ring 2. The sliding portion 14a of the pintle 14 is shaped into a vertically elongated block of trapezoidal cross section. The housing 1 is formed with a trapezoidal groove 19 in which the sliding portion 14a is fitted so as to be slidable. In other words, the pintle 14 is so held as to be slidable in a direction perpendicular to the axis m of the housing 1. This makes it possible to adjust the distance D between the axis n of the pintle 14 and the axis m of the housing 1 to any desired value, including zero.

As shown in Fig. 2, the inside of the housing 1 is divided into a first region A and a second region B by an imaginary line P drawn in the direction in which the pintle 14 slides. Any chamber 13 moving across the first region A communicates with a first fluid communication passage 21. Any chamber 13 passing across the second region B communicates with a second communication passage 22.

The first fluid communication passage 21 comprises cylinder ports 23, a port 24 extending through the pintle 14, and a fluid inlet/outlet port 25 formed in the housing 1. The ports 23 permit the chambers 13 to communicate with the inner surface 15v, or valve surface, of the cylinder barrel 15. One end of the port 24 extends to the outer periphery 14v, or valve surface, of the pintle 14 in the first region A, while the other end extends to an inclined surface 14b of the sliding portion 14a of the pintle 14 in the second region B. The port 25 extends to the other end of the port 24. Formed at said one end of port 24 is a pressure pocket 27 for supply and discharge of fluid. This pocket 27 is used to form a third static pressure bearing 26 between the outer periphery (valve surface) 14v of the pintle 14 and the inner surface (valve surface) 15v of the cylinder barrel 15. Formed at the other end of the port 24 is a pressure pocket 29 forming a fourth static pressure bearing 28 between the inclined surface 14b of the pintle 14 and the inner surface of the housing 1. The pocket 27 is elongated circumferentially, and acts to place all the chambers 13 present in the first region A in communication with the port 24 extending through the pintle. The pocket 29 is elongated in the direction in which the pintle 14 slides, and serves to prevent the inlet/outlet port 25 from being disconnected from the port 24 when the pintle 14 is sliding.

The second fluid communication passage 22 comprises the aforementioned cylinder ports 23, a port 34 extending through the pintle 14, and a fluid inlet/outlet port 35 formed in the housing 1. One end of the port 34 extends to the outer periphery -

(valve surface) 14v of the pintle 14 in the second region B, while the other end extends to an inclined surface 14c of the sliding portion 14a of the pintle in the first region A. The inlet/outlet port 35 corresponds in position to the other end of the port 34. A pressure pocket 37 for supply and discharge of fluid is formed at one end of the port 34. This pocket 37 is also used to form a third static pressure bearing 36 between the pintle 14 and the cylinder barrel 15. Formed at the other end of the port 34 is a pressure pocket 39 that is employed to form a fourth static prssure bearing 38 between the inclined surface 14c of the pintle 14 and the inner surface of the housing 1. These pressure pockets 37 and 39 are similar in structure to the pressure pockets 27 and 29.

In the construction as described above, the fluid pressure within the chambers 13 corresponding to the pistons 8 is guided into the pressure pockets 11 of the corresponding second static pressure bearing 9 via a pressure inlet passage 41 formed along the axis of each piston 8. Then, the fluid pressure inside the pockets 11 is directed to the pressure pockets 7 of the corresponding first static pressure bearing 3 via a fluid passage 42 formed in the torque ring 2. The directions and areas of the bearings 3 and 9 are so set that the force acting on the ring 2 due to the static pressure of the fluid introduced into the first bearings 3 is equal in magnitude but opposite in direction to the force acting on the ring 2 due to the static pressure of the fluid introduced into the second bearings 9. The area of the second bearings 9 is set to such a value that the force acting on the pistons 8 due to the static pressure of the fluid introduced into the second bearings 9 is cancelled by the force acting on the pistons 8 due to the static pressure of the fluid inside the chambers 13. Also, the area of the third static pressure bearings 26 and 36 is set to such a value that the force acting on the cylinder barrel 15 due to the static pressure introduced into the bearings 26 and 36 is cancelled by the force acting on the barrel 15 due to the static pressure of the fluid within the chambers 13 extending in the repective regions A and B. Further, the angle at which the surfaces 14b and 14c having the fourth bearings 28 and 38 are inclined is set to such a value that the force acting on the pintle 14 due to the static pressure of the fluid introduced into the fourth bearings 28 and 38 is cancelled by the force acting on the static pressure of the fluid introduced into the third bearings 26 and 36 existing in the respective regions A and B corresponding to the inclined surfaces 14b and 14c.

The sliding portion 14a of the pintle 14 is biased in one direction by a spring 45, and can be moved in the opposite direction against the action of the spring 45 by a hydraulic actuator 46. When the fluid pressure inside a high-pressure passage 48 exceeds a predetermined value, a pressure-compensation valve 47 is switched to its other state whereby to supply working high-pressure fluid to the actuator 46.

The fundamental operation of the fluid energy converter is described in Japanese laid-open patent specification n ° 77179/1983. Specifically, when a high-pressure fluid is supplied into the chambers 13 existing in the first region A via the first fluid communication passage 21, a couple is produced which induces rotation of the torque ring 2 in the direction indicated by the arrow S. Thus, the converter acts as a motor. When the ring 2 is rotated by an external force in the direction indicated by the arrow R, the high-pressure fluid is discharged from the first passage 21. Accordingly, the converter acts as a pump. When the eccentricity of the axis n of the pintle 14 from the axis m of the housing 1 is changed by moving the pintle 14 back and forth along the trapezoidal groove 19, the displacement is varied.

A rotary fluid switching converter 51 embodying the concept of the invention is mounted between the pintle 14 and the cylinder barrel 15. The converter 51 comprises the valve surface 14v of the pintle 14 and the valve surface 15v of the cylinder barrel 15, and these surfaces 14v and 15v are in sliding contact with each other. The openings 27 and 37 for supply and discharge of fluid extend up to the valve surface 14v. The circular cylinder ports 23 are circumferentially spaced from one another on the valve surface 15v. As the valve surfaces 14v and 15v are rotated relative to each other, the cylinder ports 23 periodically establish and interrupt communication with the openings 27 and 37. A pair of small notches 52 and 53, is formed at ends of the openings 27 and 37. The cross-sectional area of these notches 52 and 53 varies gradually circumferentially, i.e. in the direction of rotation. As can be seen from the expanded view of Fig. 4, the notches 52 and 53 are located off the line 54 connecting each center 23a of the cylinder ports 23. In other words, each center 23a of the ports 23 does not travel over the notches 52 or 53.

Since the fluid switching device 51 is constructed as described hereabove, even if an erosion occurs on the valve surface 15v of the barrel 15 because of the presence of the notches 52 and 53, the erosion will develop off the line 54 connecting each center of the cylinder ports 23, being noted that the line 54 provides the shortest distance between adjacent ports 23. Therefore, it is unlikely that fluid leaks from one port 23 to an adjacent one 23, so that the volumetric efficiency is also unlikely to be reduced. Hence, it is possible to arrange the ports 23 closer to each other than in conventional devices.

In the illustrated embodiment, two notches are formed at each end of the openings for supply and discharge of fluid. Of course, the invention is not limited to this arrangement. For example, only one notch may be formed off the center line 54 of the cylinder ports for each end. However, formation of a pair of notches at each end of the openings as in the illustrated embodiment reduces still more effectively occurrence of erosion. Whether an erosion occurs easily or not depends on the fluid velocity, or the kinetic energy of the fluid. The fluid velocity obtained when two notches are formed at each end as in the illustrated embodiment is half of the fluid velocity obtained when only one notch is formed at each end. For this reason, with the former arrangement, erosion is less likely to occur. Obviously, it is not necessary that all the ends of openings for supply and discharge of fluid have notches.

In the above-described embodiment, the fluid switching device is mounted between the pintle and the cylinder barrel fitted over the pintle. The present invention is not necessarily limited to such an arrangement. For example, it can be similarly applied to an arrangement where the fluid switching device is mounted between a port block or plate having a flat valve surface and a cylinder block as shown in Fig. 5. Furthermore, the invention is applicable to fluid switching sections in pumps and motors of the ordinary radial piston type, bent axis type, or swash plate type. In addition, the shape of the notches is not limited to the shape used in the illustrated embodiment. Various changes and modifications may be made thereto without departing from the scope of the invention. In addition, in the above embodiment openings for supply and discharge of fluid also serve as pressure pockets for balancing the static pressure, but the invention is not limited to such a scheme.

Since the novel rotary fluid switching device is constructed as described hereabove, the simple structure effectively prevents deterioration in the volumetric efficiency, in spite of the existence of notches. The intended performance can be maintained over a long working life. Moreover, it allows cylinder ports to be arranged closely without secondary drawback.

Claims

1. A rotary fluid switching device having a first valve surface (14v) provided with fluid supply and discharge openings (27, 37) and a second valve surface (15v) being in sliding contact with said first valve surface (14v) and provided with circular or elliptical cylinder ports (23) that are spaced from one another in the direction of rotation, said two valve surfaces (14v, 15v) being rotated relatively to each other so that the cylinder ports (23) alternately establish and interrupt communication with the openings (27, 37), characterized in that at least one notch (52, 53) extends at least one end of said openings, said notch (52, 53) being located off the line along which each center of the cylinder ports travels.

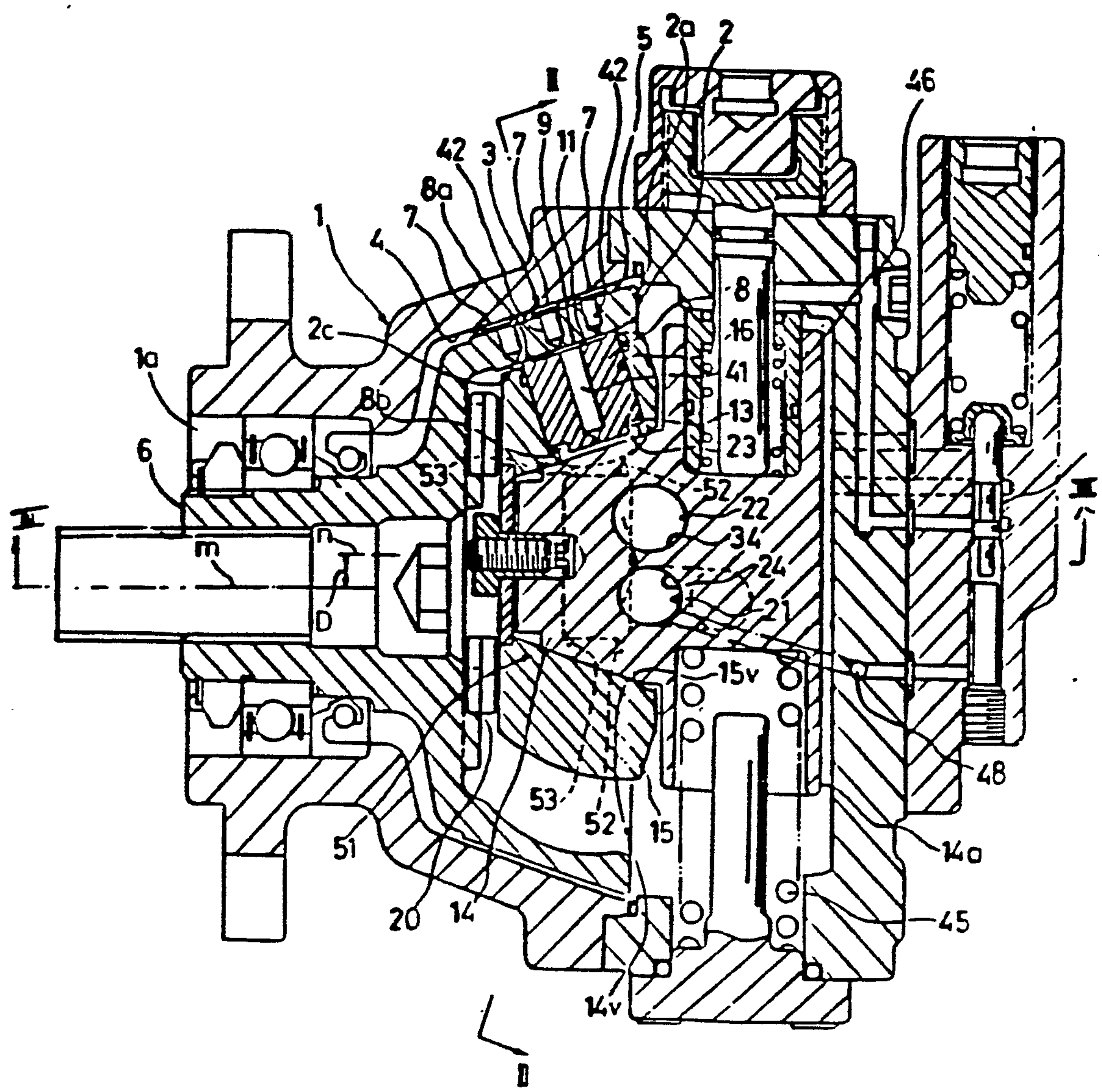
2. A rotary fluid switching device as set forth in claim 1, characterized in that a pair of notches (52, 53) extend each end of said openings (27, 37) both notches (52, 53) being located off the line (23a) along which each center of the cylinder ports travels.

3. A rotary fluid switching device according to claim 2, characterized in that said two notches (52, 53) extending said opening ends are formed on different sides with respect to said median line - (23a) travelled by each center of the cylinder ports.

4. A rotary fluid switching device according to claim 2, characterized in that the two notches (52, 53) of each said pair are different in length, so that the fluid communication simultaneously occurs and interrupts for both notches.

5. A rotary fluid switching device as set forth in any claims 1 to 4, characterized in that the width in cross section of each notch (52, 53) gradually decreases away from its corresponding opening end.

fig.1



2a
2
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II
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11
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8a
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4
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2c
1a
8b
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8
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41
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fig. 2

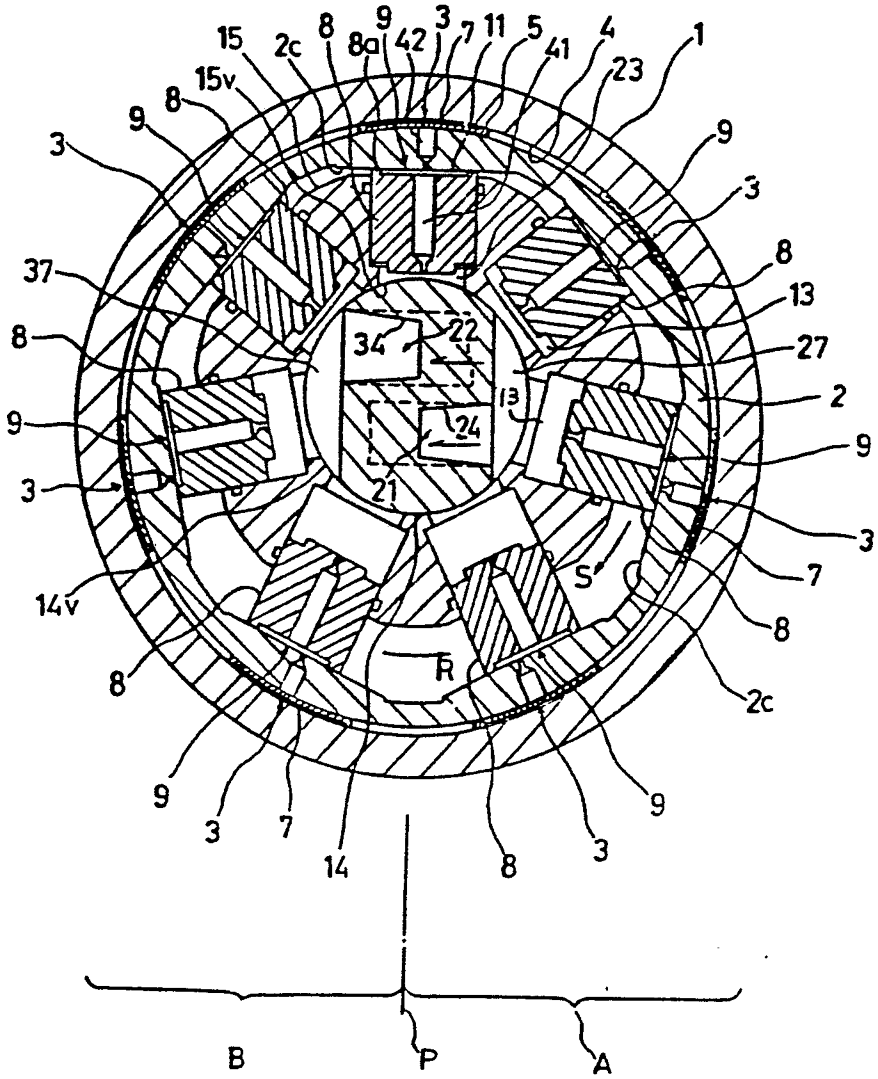
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fig.3

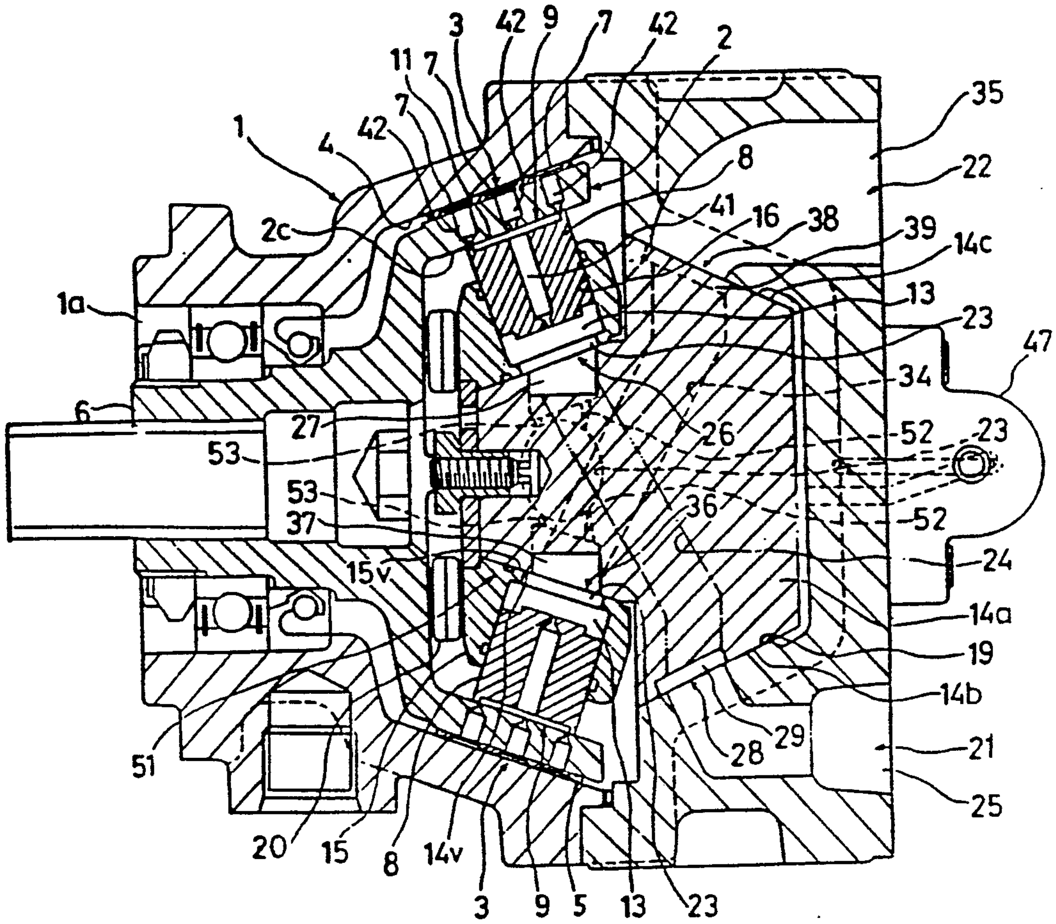

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fig.4

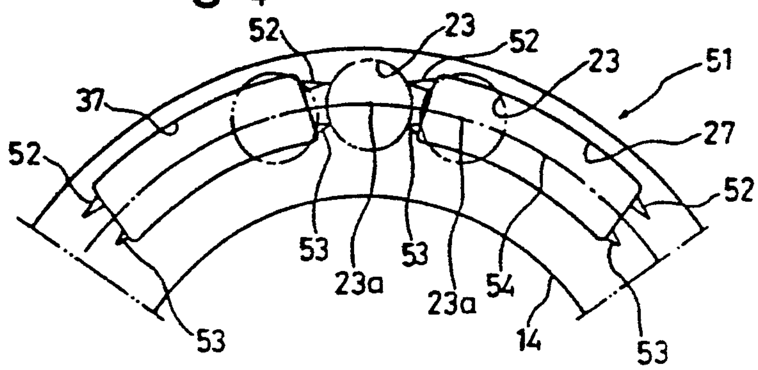


fig.5

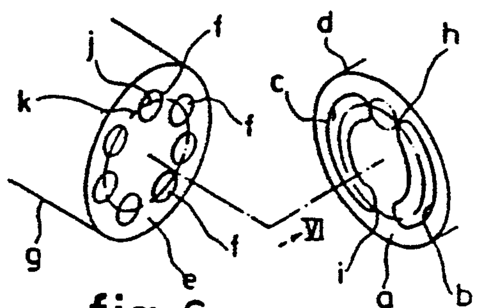
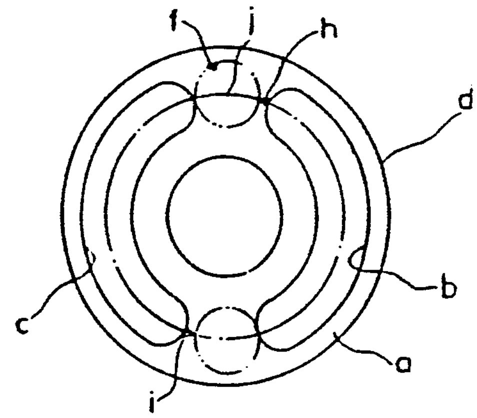


fig.6



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EUROPEAN SEARCH REPORT

Application number

EP 86 40 0387

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DE-A-2 047 557 (VEB KOMBINAT) * Whole document * -----	1-5	F 04 B 1/10 F 04 B 1/04 F 04 B 1/20
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			F 04 B F 03 C F 01 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21-10-1986	VON ARX H.P.

CATEGORY OF CITED DOCUMENTS

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