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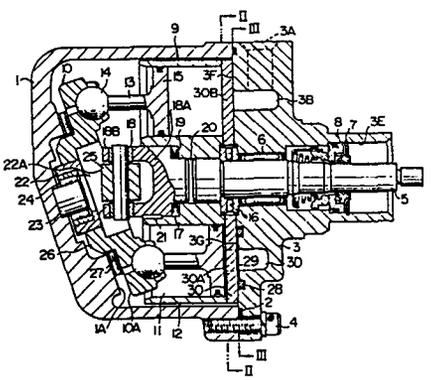
(54) Fluid machine.

(57) A fluid machine has a rotary shaft (5) carried rotatably, a cylinder block (12) provided in fixed relation to the rotary shaft and having through bores (11), and pistons (15) received in the through bores (11). A float valve is disposed between the cylinder block and an end plate (3) in which is formed a high-pressure chamber (3D), the float valve being operative in response to the discharge pressure. A seal ring (28) is disposed between the float valve and the end plate (3) such as to surround the high-pressure chamber (3D) thereby forming a high-pressure area between the float valve and the end plate (3). The float valve is pressed onto the end surface of the cylinder block (12) by the discharge pressure existing in the high pressure area.



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FLUID MACHINE

BACKGROUND OF THE INVENTION

The present invention relates to a fluid machine and, more particularly, to a fluid machine having a valve mechanism which is effective particularly when the fluid machine is used as a compressor or a pump for pressurizing and delivering a fluid such as air, hydraulic oil and so forth.

Liquid pumps for pressurizing and delivering a working fluid such as oil and liquid motors for obtaining torque by making use of head energy of working fluid are known as fluid machines.

This kind of fluid machine are generally sorted into two types: namely, a rotary swash plate type machine in which, as shown in Fig. 1 attached to Japanese Patent Application Laid-open No. 91383/1983, an oscillation disk on a driven shaft is oscillatorily driven by a swash plate fixed to a drive shaft such that the rotary motion of the drive shaft is changed into a reciprocatory motion, and rotary slant shaft type in which eccentric motion of a slant shaft formed integrally on the output end of a drive shaft is transmitted to an oscillation disk which is mounted through a rotation prevention means on the outer periphery of the slant shaft, thereby converting a rotary motion into reciprocatory motion.

The rotary swash plate type machine, however,

requires a complicated construction due to necessity of the bearing means such as needle bearing between the swash plate and the oscillation disk for converting the rotary motion of the swash plate into reciprocatory motion of the oscillation disk. In addition, a large friction resistance is produced in a central ball bearing which supports the oscillation disk and bears all part of the thrust load, resulting in a low mechanical efficiency.

The oscillation disk is not allowed to rotate about its axis because the peripheral portion of the oscillation disk carries a plurality of piston rods which in turn are connected to pistons slidably received by respective cylinders. The prevention of rotation of the oscillation disk is achieved through a so-called slide gear type mechanism which employs a meshing engagement between a stationary bevel gear and a spur gear formed on the side surface of the oscillation disk. This mechanism is inherently not durable.

Referring now to the rotary slant shaft type machine, the oscillation disk is mounted through a thrust bearing on the outer periphery of the slant shaft which is integral with the drive shaft, so that an axial thrust is generated as in the case of the rotary swash plate type machine. In consequence, this type of machine also suffers from a problem concerning durability of the mechanism for preventing the rotation of the oscillation disk, as well as the requirement for

the thrust bearing to perform various functions, with a result that the construction is too complicated.

Furthermore, in this type of fluid machine, the long and heavy slant shaft causes an unbalance of rotation mass, resulting in large vibration and noise. The unbalance of rotation mass is encountered also in the rotary swash plate type machine. Although a balance weight is used for the purpose of eliminating the mass unbalance, vibration cannot be suppressed satisfactorily because it is not allowed to obtain a geometrical balance.

The vibration acts as an eccentric load on the drive shaft such as to increase the friction loss of power. The mechanical vibration shortens the life of the machine and impairs the quality of the product as commercial goods because it imparts unpleasant feel to the user.

Thus, both typical examples of the fluid machine of the kind mentioned before suffer from heavy axial thrust load and eccentric load on the drive shaft. Although various countermeasures are taken, problems such as friction loss due to axial thrust load and eccentric load due to vibration are not eliminated appreciably, and the mechanical efficiency is impractically low from synthetic point of view.

On the other hand, another type of fluid machine used as a hydraulic pump has been known in which a cylinder block is rotated, as disclosed in the

specifications of United States Patent Nos. 3,479,963 and 3,818,803. More specifically, in this type of fluid machine, the cylinder block is arranged such that it makes a sliding contact at its end surface with a sheet valve member which in turn is fixed to the high-pressure side of a end plate of a machine housing. Therefore, the attainable discharge pressure is ruled by the machining and assembly precision of these two members. It is quite difficult to attain a hermetic sliding contact between these two members, so that the discharge pressure is inevitably low to seriously affect the pump efficiency.

SUMMARY OF THE INVENTION

Accordingly, an object of the invention is to provide a fluid machine having a valve mechanism which is simple in construction and high in precision, thereby overcoming the above-described problems of the prior art.

To this end, according to the invention, there is provided a fluid machine in which through bores formed in a cylinder block which is fixed to a rotary shaft are adapted to be closed by float valves which are disposed between the high-pressure chamber and the end surface of the cylinder block and adapted to be pressed onto the end surfaces of the cylinder block by pressure which exists in the high-pressure chamber.

In this fluid machine, since the cylinder block and the motion converting mechanism rotate in synchronism with each other, the cylinder block and the motion converting mechanism are apparently not moved in relation to each other, while the pistons move reciprocatingly such as to perform a pumping or compressing function. In addition, the valve mechanism exhibits a high sealing effect because the float valves are pressed against the end surface of the cylinder block at high pressure which is generated in the machine.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show embodiments of a fluid machine in accordance with the invention in which:

Fig. 1 is a vertical sectional view of an essential portion of an air compressor as an embodiment of the invention;

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

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

Fig. 4 is a vertical sectional view of an essential portion of another embodiment of the compressor;

Fig. 5 is a sectional view of an essential portion of a hydraulic pump as another embodiment of the invention; and

Fig. 6 is a sectional view taken along the line VI-VI of Fig. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the invention will be described hereinunder with reference to the drawings.

Fig. 1 is a vertical sectional view of an air compressor which is a first embodiment of the invention, while Figs. 2 and 3 are sectional views taken along the lines II-II and III-III of Fig. 1, respectively.

Referring to these Figures, an end plate 3 is attached to open end of a substantially bowl-shaped casing 1 through an "O" ring 2 by means of a plurality of mounting screws 4. A radial bearing 6 mounted on the center of the end plate 3 rotatably carries a rotary shaft 5. A mechanical seal 8 is disposed between the rotary shaft 5 and the inner peripheral wall 3E of the end plate 3 defining the bore receiving the shaft 5, and is prevented from coming off by means of a clip 7. In order to reduce the weight of the air compressor, the casing 1 and the end plate 3 are made of aluminum material. The casing 1 accommodates a working chamber assembly 9 and a motion converting mechanism 10. The working chamber assembly 9 is composed of an aluminum cylinder block 12 having a plurality of through bores 11 arranged at a constant circumferential pitch, and pistons 15 received in the through bores 11 and having respective rod portions 13 and ball

portions 14. The cylinder block 12 has a central bore into which is pressed and fixed one end of the rotary shaft 5. The fixing of the rotary shaft 5 to the cylinder block 12 may be made by any known mechanical fixing means, as well as press-fit employed in the illustrated embodiment.

A reference numeral 16 denotes a thrust bearing arranged coaxially with the rotary shaft 5 and in contact at its one side with the end plate such as to bear the axial thrust load on the rotary shaft 5 and the cylinder block 12. The central bore in the cylinder block 12 is stepped such as to form an enlarged portion 17 which receives, through a buffer spring 19, the drive shaft 18A of a cross-spider type universal joint 18. The end of the drive shaft 18A opposes the end of the rotary shaft 5 through a spacer 20. The drive shaft 18A is secured to the cylinder block 12 by means of a key 21.

The universal joint 18 has a driven shaft 22 which is supported, through a radial bearing 24, by the outer periphery of an oblique stationary shaft 23 which is provided on the bottom of the casing 1. A fork-shaped arm 22A integral with the drive shaft 22 is connected through a cross-spider 25 to another fork-shaped arm 18B which in turn is integral with the drive shaft 18A. From the view point of easiness of assembly, the inclination of the oblique stationary shaft 23 is attained by forming beforehand a tapered

surface on the inner bottom 1A of the casing 1 and providing the shaft 23 perpendicularly to the tapered surface.

To explain in more detail about the motion converting mechanism 10, this mechanism has a rotary disk 26 which is fixed at its central portion to the outer periphery of the driven shaft 22 and provided at its peripheral portion with a plurality of ball-receiving recesses which rotatably receive the ball portions 14 of the pistons 15. The motion converting mechanism further has a thrust bearing 27 disposed between the inner bottom surface 1A of the casing 1 and the rear surface of the rotary disk 26 and intended for receiving the load produced by the pistons 15.

The valve mechanism will be explained in detail with reference to Fig. 3. As will be seen from this Figure, the end plate is provided in the inner surface 3F thereof with an arcuate low-pressure chamber 3B communicating with a suction port 3A and an arcuate high-pressure chamber 3D which opposes the low-pressure chamber 3B and communicated with a discharge port 3C. A seal ring 28 such as a rubber ring is provided such as to surround the high-pressure chamber 3D thereby defining a high-pressure area 29. This high-pressure area 29 can be formed easily by forming a step in the inner surface of the end plate 3 such that the surface in the high-pressure area 29 is slightly recessed from other portion of the surface, as shown in sectional

view in Fig. 1, although such a height difference is not necessary because the high-pressure area can be formed simply by partly embedding the seal ring 29 in the inner surface of the end plate. An equal effect will be produced when a step is formed in the end surface of a float valve which will be mentioned later. The float valve 30 constituting the cylinder head is composed of a dough-nut shaped iron plate which is disposed between the end plate 3 and the cylinder block 12 concentrically with the latter. As shown in Fig. 2, the float valve is provided with a high-pressure passage 30A and a low-pressure passage 30B which are arranged to oppose the chambers 3B and 3D formed in the end plate 3. A small annular gap is formed between the outer peripheral surface of the float valve 30 and the inner peripheral surface of the casing 1. Since the only requirement is such that the float valve itself is located substantially in the high-pressure side, so that the arrangement may be such that an iron sheet is cut out in an arcuate form in a size slightly greater than the size of the seal ring 2, while other iron plate is fixed to the casing 1.

In the arrangement described above, as the rotary shaft 5 is rotated by, for example, an internal combustion engine, the cylinder block 12 is rotated in synchronism with the rotary shaft 5, followed by rotation of the driving side, cross-spider 25 and the driven side of the universal joint 18. Consequently

the rotary disk 26 is rotated simultaneously.

It is assumed here that the cylinder block 12 and the rotary disk 26 rotate in synchronism in, for example, counter-clockwise direction as shown in Fig. 3. In this state, the piston 15 near the leading end of the low-pressure chamber 3B has been slightly displaced from the top dead center towards the bottom dead center thereof. As the cylinder block 12 further rotates counter-clockwise, the piston 15 moved towards the bottom dead center. When the cylinder block has been rotated to a position where the trailing end of the low-pressure chamber is located near the piston 15, the piston 15 has been moved almost to the bottom dead center thereof but not reached yet the bottom dead center. When the piston 15 is at the bottom dead center in its stroke, the through bore 11 receiving this piston 15 communicates neither with the low-pressure passage 30B nor with the high-pressure passage 30A. As the cylinder block 11 further rotates, the piston 15 comes to confront the leading end of the high-pressure passage 30A and starts to move towards its top dead center. When the cylinder block 12 has been rotated to a position where the piston 15 confronts the trailing end of the high-pressure passage 30A, the piston 15 has been brought almost to the top dead center but has not reached the same yet. Needless to say, when the piston 15 is in its top dead center, the through bore 11 receiving this piston 15 communicates neither with the

low-pressure passage 30B nor the high-pressure passage 30A. As a result, a high pressure is established in the high-pressure chamber 3D and, hence, in the high-pressure area defined by the seal ring 28 between the inner surface of the cylinder block 3 and the float valve 30, so that the float valve 30 is pressed onto the end surface of the cylinder block 12 thereby sealingly close the through bore 11. Thus, when the high pressure is maintained in the high-pressure chamber 3D, the float valve 30 is pressed onto the cylinder block, so that a highly precise valve mechanism is attained to stably seal the through bores 11 in the cylinder block. Since the float valve is pressed by the force of pressure, the valve mechanism can have quite a simple construction due to elimination of any specific pressing means, which in turn ensures high reliability and productivity.

The invention does not exclude a modification in which the float valve is provided only at the high-pressure side. In such a modification, the cylinder head can be formed from a material different from the material of the cylinder head. This is quite advantageous from the view point of reduction in the weight of the machine.

Fig. 4 shows another modification which is distinguished from the embodiment shown in Fig. 1 in that a bevel gear is used in place of the universal joint shown in Fig. 1. More specifically, in this

modification, a tubular member 40 is fixed by press fit to the end of the rotary shaft 5. The tubular member 40 is press-fitted in the cylinder block 12 and is provided at its end with a bevel gear 40A. The tubular member 40 receives a ball holder 42 which is urged by a buffer spring 41 also received by the tubular member 40. A tubular member 43 is provided with a bevel gear 43A meshing with the bevel gear 40A and a ball holder 44. The ball holders 42 and 44 are provided in the center thereof with spherical recesses which receive a common ball 45. For obtaining a high bearing effect, the ball holders are made of an aluminum-silicon alloy. Thus, in this modification, the driving coupling is achieved by means of bevel gears such that the pistons 15 are reciprocatingly driven in accordance with the rotation of the rotary disk 26. Other portions of the mechanical construction and the operation are the same as those in the embodiment described before, so that detailed description thereof is omitted in this specification.

Figs. 5 and 6 show a hydraulic pump which is another embodiment of the fluid machine in accordance with the invention. The basic construction of this embodiment is materially identical to that of the first embodiment shown in Fig. 1, except the construction of the float valve mechanism. The following description, therefore, will be concentrated to the float valve mechanism.

In this embodiment, a stepped groove 53 is formed around the high-pressure passage 52 formed in the end plate 50 in communication with the discharge port 51. The bottom surface of the stepped groove 53 is greater than the width of cross-section of the seal ring 54 for example.

On the other hand, the float valve 55 contacting the cylinder block 12 has an arcuate form with a convexed cross-sectional shape such as to fit in the stepped groove 53. The width of the end of cross-section of the float chamber 55 is determined to be greater than the width of section of the seal ring 54. According to this arrangement, a high-pressure area is formed on the end of the float valve. When the liquid pressure in the high-pressure passage becomes high, the float valve 55 is pressed towards the cylinder block 12 such as to form a tight seal between itself and the cylinder block 12. As shown in Fig. 6, a thrust plate 56 is positioned such as to oppose the float valve 55. This thrust place 56, intended for attaining a balanced rotation of the cylinder block 12, is provided in the surface thereof with a channel 57 and is fixed to the front cover 50 by means of fixing screws 58.

With this arrangement, it is possible to attain a high fluid-tightness of the seal in the valve mechanism by quite a simple construction, which in turn makes it possible to produce a hydraulic pump having a high performance and high output.

The described constructions of the float valve are only illustrative and can have various other forms because the self-closing nature of the float valve can be attained by suitably selecting the area ratio.

It will be seen also that an appreciable improvement in the life of the machine can be attained by providing a layer of a lubricant material such as a fluororesin by coating or by means of an adhesive on at least one of the mutually contacting surfaces of the cylinder block and the float valve.

As will be seen from the foregoing description, according to the invention, it is possible to obtain a fluid machine incorporating a valve mechanism which is simple in construction and capable of attaining a high sealing effect.

WHAT IS CLAIMED IS

1. A fluid machine having a rotary shaft 5 carried rotatably, a cylinder block 12 in fixed relation to said rotary shaft and having through bores 11, and pistons 15 received in said through bores 11, said fluid machine comprising:

a float valve disposed between said cylinder block 12 and an end plate in which is formed a high-pressure chamber 3D, said float valve being operative in response to the discharge pressure; and

a seal ring 28 disposed between said float valve 30 and said end plate 3 such as to surround said high-pressure chamber 3D thereby forming a high-pressure area 29 between said float valve 30 and said end plate 3;

whereby said float valve 30 is pressed onto the end surface of said cylinder block by the discharge pressure existing in said high-pressure area.

2. A fluid machine according to claim 1, wherein said high-pressure area is constituted by a space which is surrounded at least by said seal ring 28 and defined between said end plate 3 and said float valve 30.

3. A fluid machine according to claim 1, wherein said float valve 35 has a convexed sectional shape and is disposed, through an intermediary of a searling 54, in a stepped groove 53 formed in the inner periphery of said high-pressure chamber.

4. A fluid machine according to claim 2, wherein

said float valve 30 has a disk-like form and is held in contact with the end surface of said cylinder block 12.

5. A fluid machine according to either one of claims 1 and 4, wherein said float valve is coated with a fluororesin on the surface thereof facing said cylinder block.

6. A fluid machine according to either one of claims 1 and 4, wherein said cylinder block is coated with a fluororesin at its side facing said float valve.

7. A fluid machine having a rotary shaft 5 carried rotatably, a cylinder block 12 in fixed relation to said rotary shaft and having through bores 11, and pistons 15 received in said through bores 11, said fluid machine comprising: a float valve disposed between said cylinder block 12 and an end plate in which is formed a high-pressure chamber 3D, said float valve being operative in response to the discharge pressure.

FIG. 1

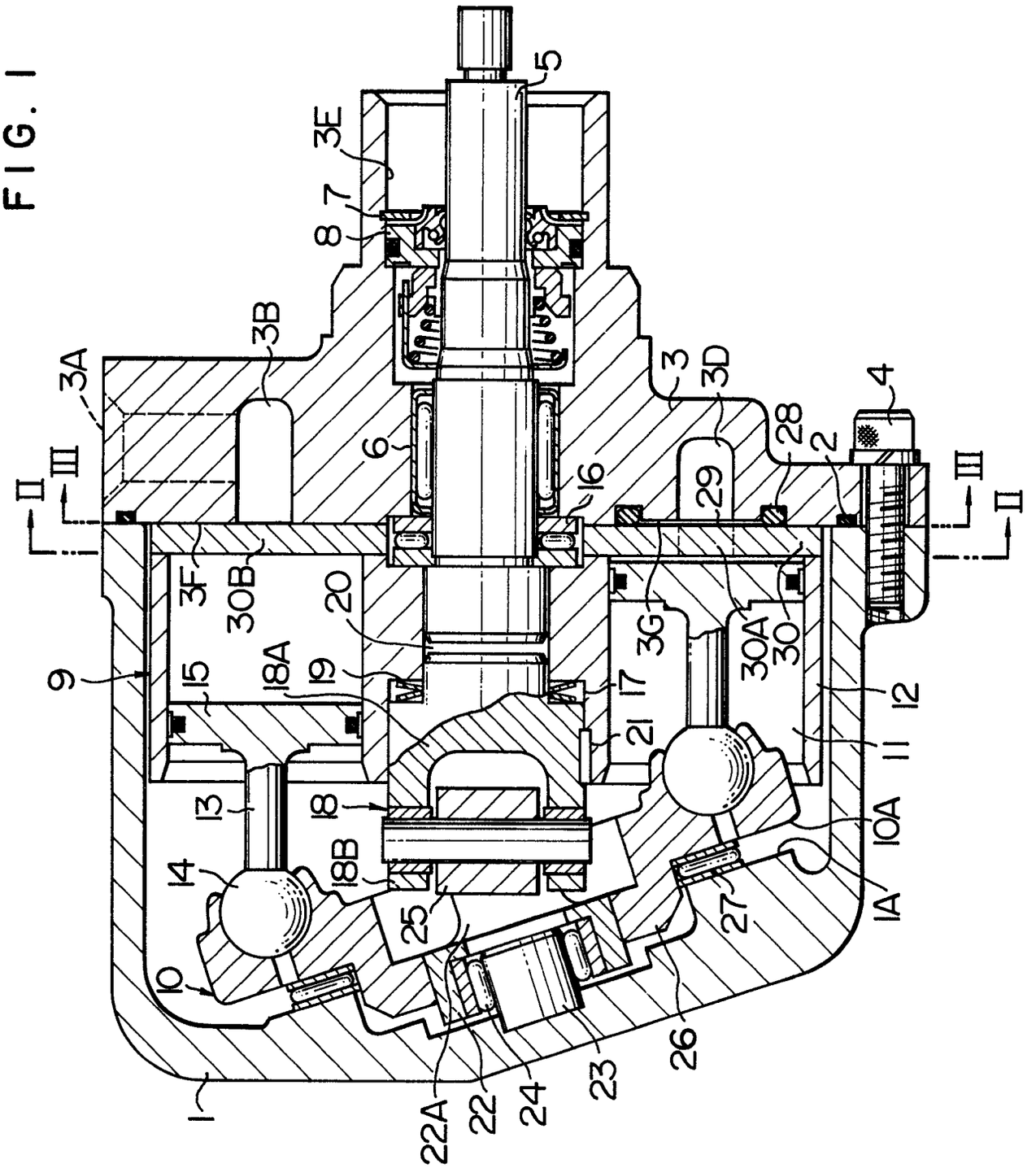
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FIG. 2

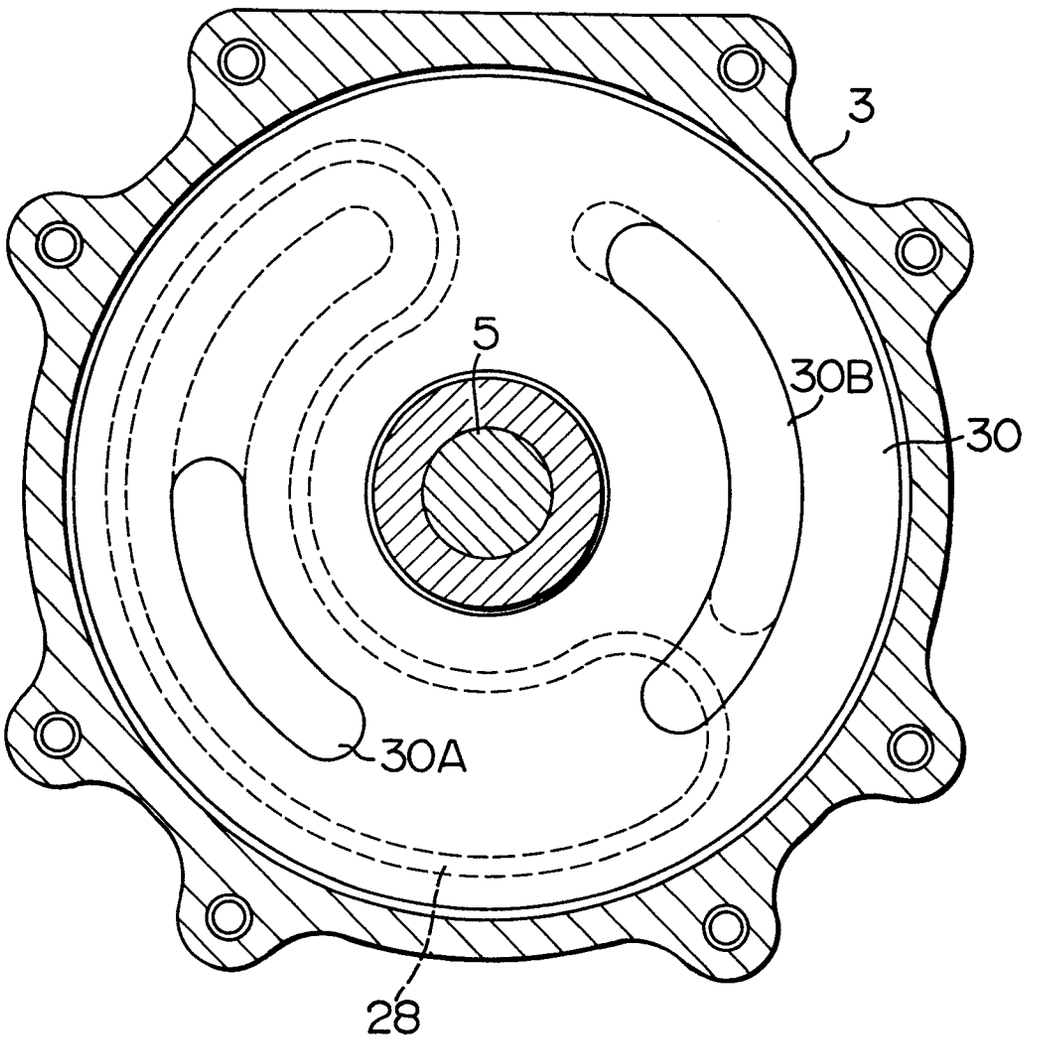

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FIG. 3

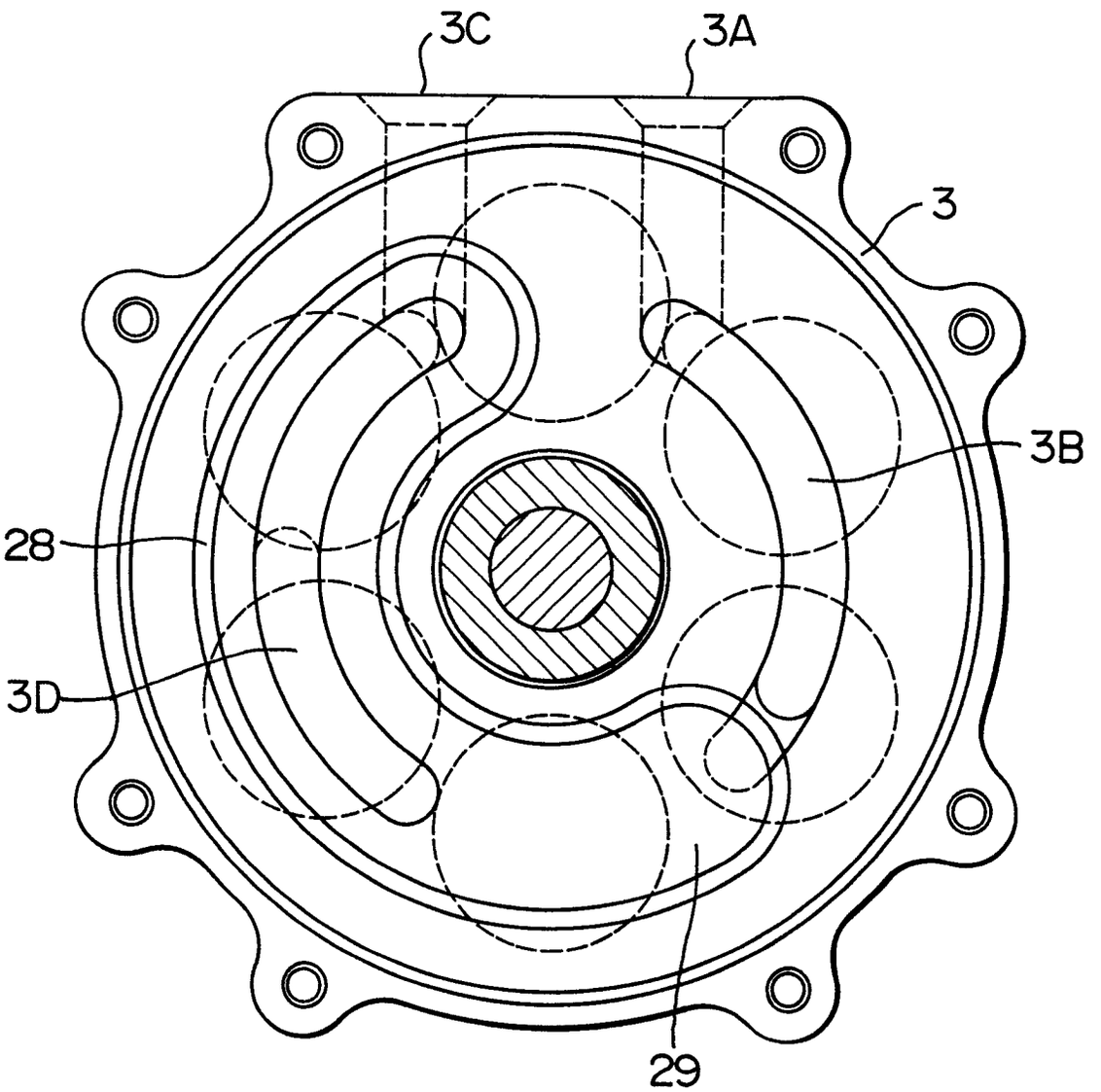

FIG. 4

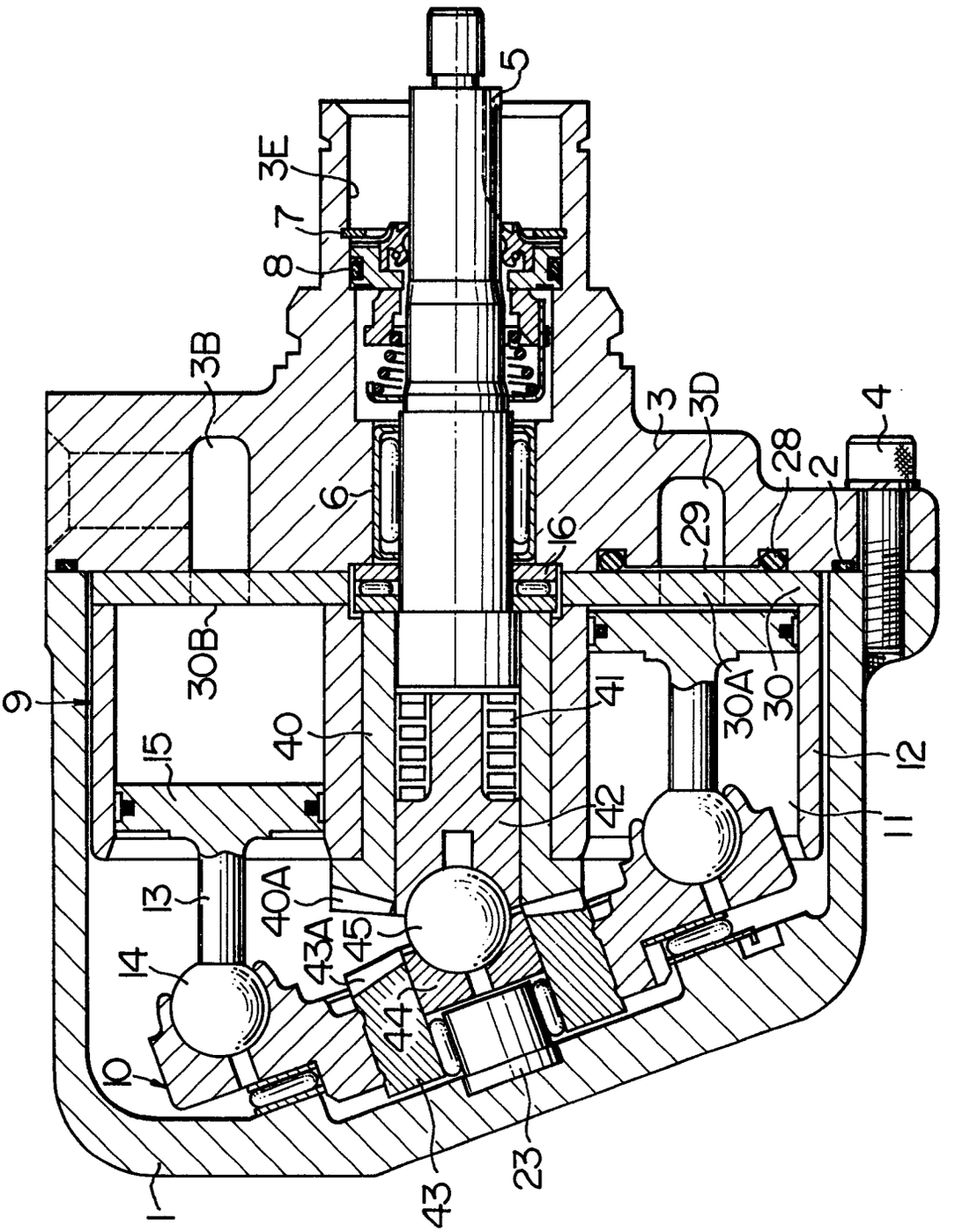
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FIG. 5

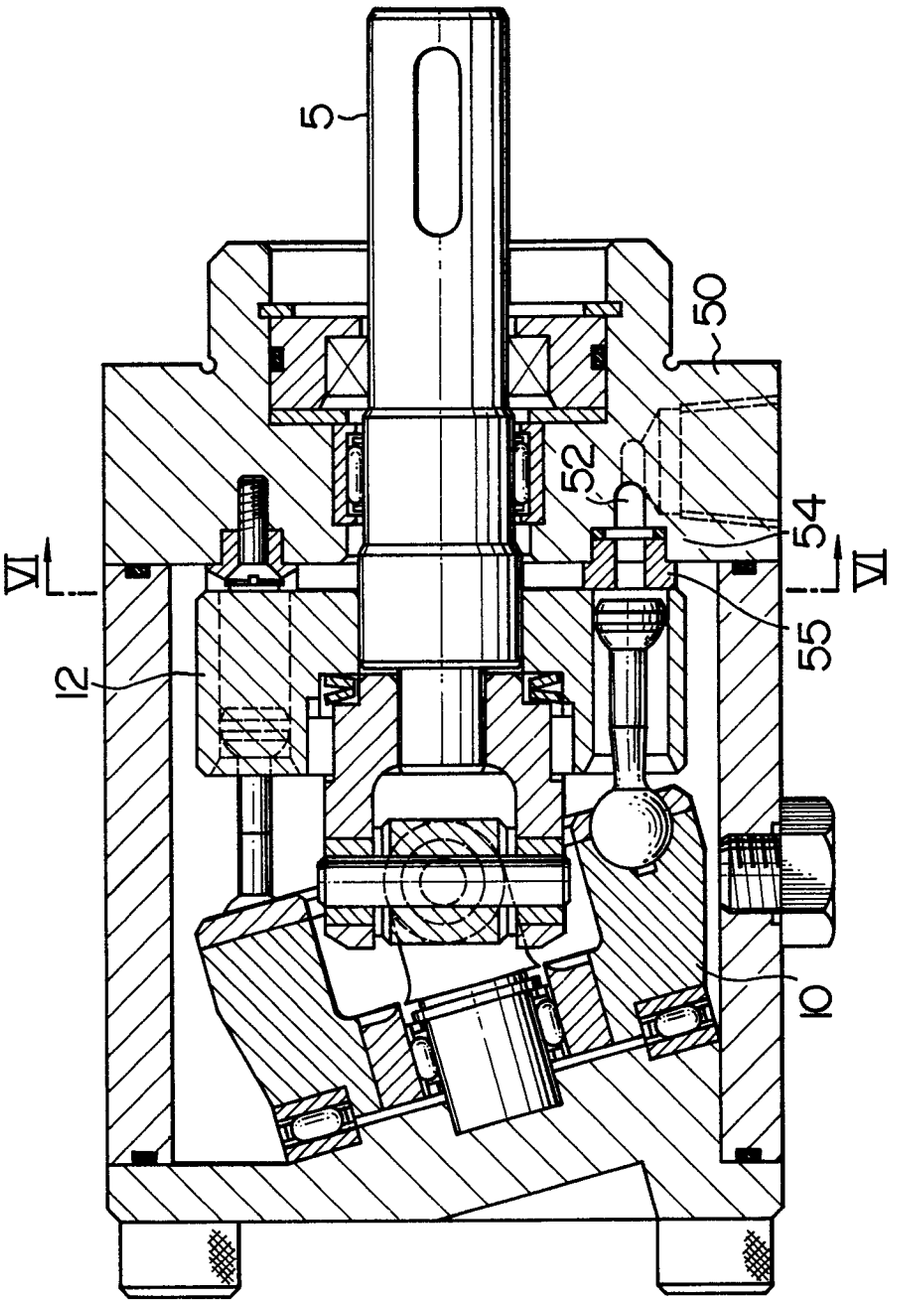
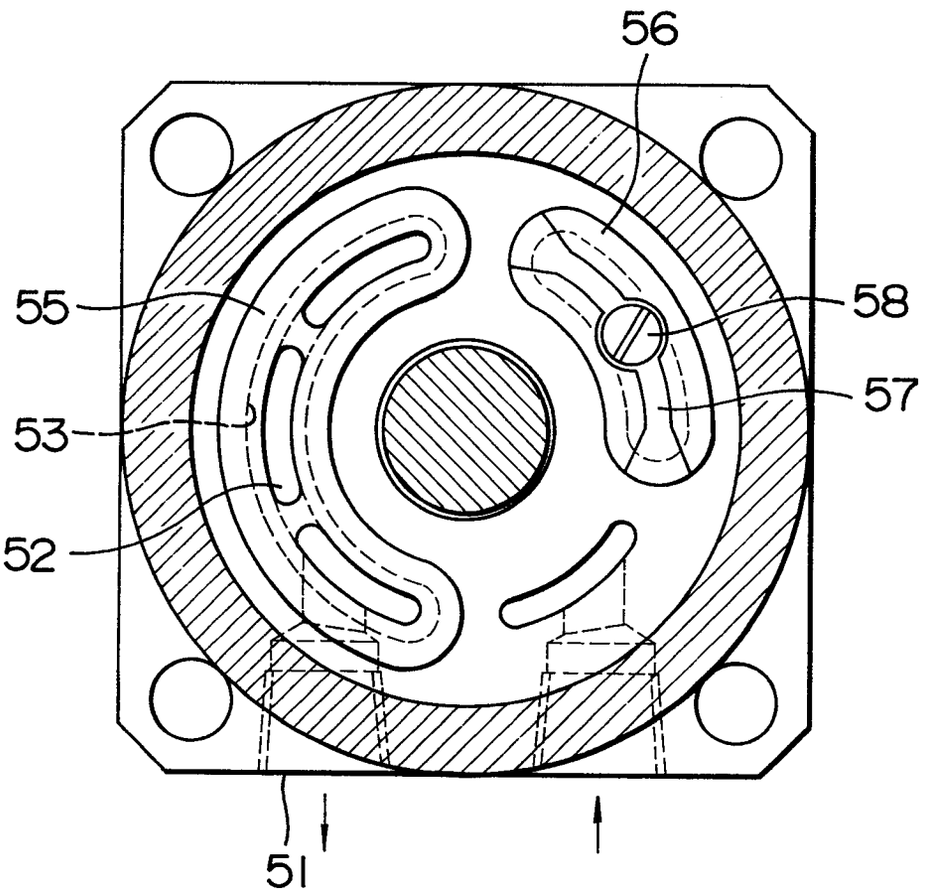


FIG. 6



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EUROPEAN SEARCH REPORT

0175206
Application number

EP 85 11 1087

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	US-A-3 910 587 (LOEFFLER) * Abstract; column 1, lines 32-40; column 6, line 43 - column 24, line 11; figures 1-18 *	1,2,4, 7	F 01 B 3/00
Y		5,6	

Y	US-A-3 124 079 (BOYER) * Column 5, lines 18-26; column 6, lines 19-59; column 7, lines 55-71 *	5,6	
A		1,3,7	

A	DE-A-1 810 778 (HASHEMI) * Page 7, paragraphs 2,3 *	1,3-7	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
	-----		F 04 B 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	12-12-1985	VON ARX H.P.

CATEGORY OF CITED DOCUMENTS

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