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(54) A reciprocating positive-displacement diaphragm pump for liquids

(57) The pump comprises at least a piston-cylinder group, having a liquid pump chamber (30), and a piston-cylinder pair. A flexible diaphragm (35) separates the pump chamber (30) from the cylinder mouth (31), which is connected to the front thrust surface of the piston (32); a thrust chamber (37), external of the pump chamber (30), is delimited between the diaphragm (35), the thrust surface of the piston (32) and the guide surface (31 b) of the cylinder, and is sealedly closed and filled with non-compressible thrust oil. The rear tank is delimited on the front transversal side by the piston and on the lateral side by a tubular lateral wall (41), comprising a front portion having an internal surface which defines the cylindrical guide surface (31 b) for the piston (32) and a rear portion (41 a) joined to the front portion. To restore the thrust oil level, lost by leakage from the thrust chamber to the rear tank, the tubular wall 41 comprises at least an open-topped groove (31 b), and facing the lateral surface (32b) of the piston, which develops substantially axially, having a rear end connected to the rear tank (40) and a front end that when the piston (32) is in the environs of the bottom dead centre, opens frontally of the front seal edge (33a) and communicates with the thrust chamber (37).

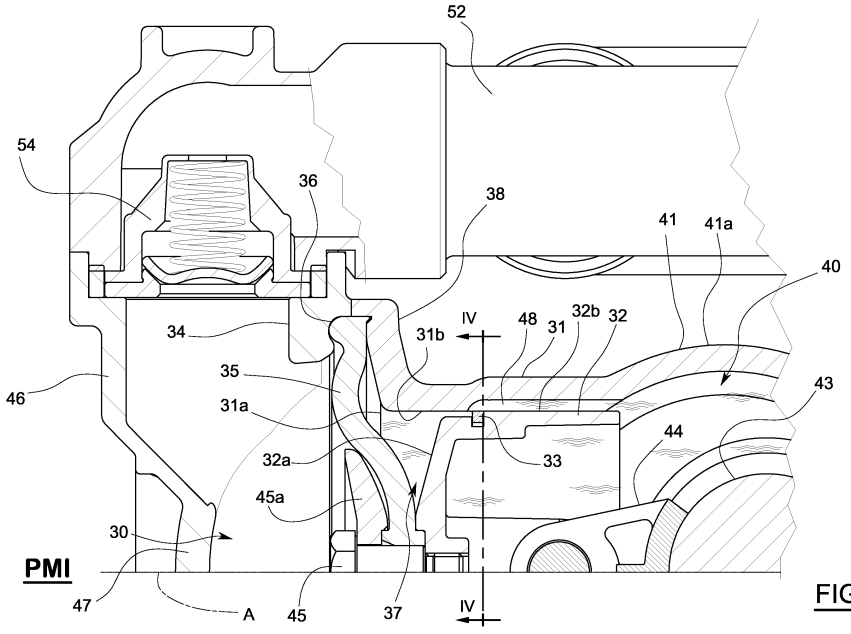

FIG. 2A

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Description

[0001] The present invention relates to a reciprocating positive-displacement diaphragm pump for liquids, operating with flow rates from 5 to 500 litres/min and with pressures of from 0 to 100 Bar.

[0002] The typical sector of application is agriculture, with particular reference to the treatment and protection of crops; however it can be applied in other fields besides.

[0003] Figure 1 is an axial section of an example of a reciprocating positive-displacement diaphragm pump for liquids, made by the same Applicant, of a type that has been known for years.

[0004] The pump illustrated in figure 1 has two piston-cylinder groups axially opposite one another, each of which comprises:

- a liquid pump chamber 10, for example water;
- a piston-cylinder pair, the cylinder 11 of which has a front mouth intersecting the pump chamber 10 and exhibits a cylindrical internal surface 11 b which functions as a guide for the piston 12,
- the piston 12 has a cylindrical lateral surface 12b coupled, in axial sliding and with an oil seal, with the guide surface 11 b of the cylinder,
- a flexible diaphragm 15, which separates the chamber 10 from the cylinder mouth 11 a, having a perimeter edge 16 fixed to the periphery of the pump chamber 10; the diaphragm 15 is connected to the front surface 12a of the piston 12 (for example by means of a screw 25 and fastening washer 25a).

[0005] The pump further comprises a thrust chamber 17, separated from the pump chamber 10, delimited between the diaphragm 15, the thrust surface 12a of the piston and the guide surface 11 b of the cylinder; the chamber 17 is sealedly closed and is filled with non-compressible thrust oil.

[0006] The piston 12 comprises an elastic wiper ring 13, which realizes the seal by acting against the guide surface 11 b of the cylinder 11. The pump comprises a substantially cylindrical wall 21 which defines a rear tank 20 filled with thrust oil, which closes both the cylinder 11 and the piston 12, and is separated from and non-communicating with the thrust chamber 17.

[0007] A mechanism is comprised for actuating a reciprocating axial motion of the piston 12 in the cylinder 11, between a bottom dead centre (PMI) and a top dead centre (PMS) and vice versa; for example a drive shaft with a cam 23 is included, which acts on each piston 12 by means of a respective connecting rod 24.

[0008] The thrust needed for the pumping of the pressurised liquid (water) is exerted by the diaphragm (15) which is made of elastic material (typically rubber) and is subject to a reciprocating movement (typically induced by the crank mechanism driven by the shaft 22), which, together with a cylinder head 26 (cap-shaped) circumscribes a volume variable between a maximum value and a minimum value (capacity) into which the fluid enters and exits in a reciprocating motion, the flow being regulated by valves 27a and 27b of the unidirectional type, respectively aspirating and delivery, with automatic opening.

[0009] The pressure energy is transferred to the liquid (water) to be pumped directly from the diaphragm 15 which is pushed, during this phase, by the piston 12, in part by direct action, and in part by the mass of thrust oil enclosed in the thrust chamber 17.

[0010] During the delivery phase, corresponding to the stroke of the piston from bottom dead centre to top dead centre, this mass of oil subjected to thrust undergoes a loss of oil, by effect of "leakage" on the wiper ring 13 or in any case along the play provided by the coupling tolerance between piston and cylinder.

[0011] This reduction of the mass of oil is readily compensated in the subsequent return step of the piston from TDC to BDC; particularly at the moment in which the piston 12 moves into the environs of bottom dead centre, the elastically-bound front sealing edge of the ring 13 (or the piston itself) uncovers an opening 28 (typically in the form of a cylindrical through-hole) formed transversally on the wall of the guide cylinder 11, which places the thrust chamber 17 in communication with the rear tank 20, filled with the same thrust oil.

[0012] By effect of the depression induced in the thrust chamber 17 by the return of the piston 12 opposed by the resistance offered by the entrance of liquid (water) to be pumped internally of the pumping chamber 10, the thrust oil in the tank 20 is aspirated into the chamber 17 through the transversal holes 28 placed on the cylinder 11, thus restoring the quantity of oil necessary for supporting the diaphragm 15 for the next phase of pumping.

[0013] This cycle is repeated in the same way at each turn of the drive shaft 22.

[0014] An aim of the present invention is to reduce the manufacturing costs of the pumps having the characteristics described above.

[0015] Thanks to the invention, the wall which delimits the rear of the pump tank 12, in addition to fulfilling the function of oil containment also has the function of guiding the piston, thus rendering the guide cylinder unnecessary.

[0016] The advantages stemming from the invention are:

- the elimination of the guide cylinder, resulting in an important economic saving both in production and, indirectly, of management (fewer specifications, fewer codes, etc..), and of assembly;
- the elimination of the cylinder enables a more compact and lighter tank to be built, with a consequently lower production cost;
- a more compact casing enables reducing the amount of oil contained therein with a consequent reduction of the cost of the complete pump;
- a smaller amount of oil in the pump leads to lower

environmental impact. These and other aims are attained by the invention as characterized in the claims.

[0017] The invention is described in detail in the following with the aid of the accompanying figures, which illustrate, by way of example, an embodiment thereof.

Figure 2 shows, in axial section, a pump according to the invention, of the type having two axially opposite piston-cylinder groups, in which the group on the left side is in the bottom dead center position (PMI), and consequently the group on the right side is in the top dead center position (TDC).

Figure 2A is an enlarged detail of the piston-cylinder group on the left side of figure 2.

Figure 2B is a detail in larger scale of figure 2A.

Figure 3 shows the pump of figure 2, the piston-cylinder group of which on the left side is in axial section and is in the TDC position.

Figure 4 is a section along plane IV-IV of figure 2.

[0018] The invention relates to pumps with any number of piston-cylinder groups; only by way of example, the pump shown in figures 2-4 (and also the one shown in figure 1) comprises two piston-cylinder groups, arranged on the same axis; however the following description of the figures is focused on one only of these groups, the one placed on the left side in the figures, since the one on the right side exhibits the same characteristics. Identical components of the piston-cylinder groups on the left side and right side are denoted using the same reference numeral.

[0019] The pump illustrated in figures 2-4 comprises, as mentioned above, two piston-cylinder groups.

[0020] Each of them comprises:

- a liquid pump chamber 30, for example water;
- a piston-cylinder pair, the cylinder 31 of which has a front mouth intersecting the pump chamber 30 and exhibits a cylindrical internal surface 31 b which functions as a guide for the piston 32,
- the piston 32 having a cylindrical lateral surface 32b coupled in axial sliding and with an oil seal, with the guide surface 31 b of the cylinder 31,
- a flexible diaphragm 35, which separates the chamber 30 from the cylinder 31 mouth 31 a, the perimeter edge 36 of which is fixed at the periphery of the pump chamber 30, in particular is located, with an axial pressure, between an annular relief 34 of the head 46, located at the periphery of the chamber 30, and a front appendage 38 of the cylinder 31 which is prolonged forwards and radially towards the outside. The diaphragm 35 is further connected to the front thrust surface 32a of the piston (32 (for example by means of a screw 45 and fastening washer 45a located in a central position of both the diaphragm and the piston).

[0021] The piston-cylinder group further comprises a thrust chamber 37, separate from the pump chamber 30, delimited between the diaphragm 35, the thrust surface 32a of the piston and the guide surface 31 b of the cylinder; the chamber 37 is sealedly closed and is filled with non-compressible thrust oil.

[0022] The piston 32 comprises a front edge seal 33a, defined by the front edge of an elastic wiper ring 33, borne by the piston 32, which realizes the oil seal between the piston and the cylinder by acting against the guide surface 31 b of the cylinder 31, the edge 33a of which defines the boundary of the thrust chamber 37 between the cylinder 31 and the piston 32.

[0023] The pump comprises an oil-filled rear reservoir 40 enclosing both the cylinder 31 and the piston 12, and is separate and not communicating with the thrust chamber 37. The oil contained in the tank 40 serves both to lubricate the moving parts of the piston, also contained within the reservoir 40, and to provide return oil for the thrust chamber 37.

[0024] The rear tank 40 is delimited on the transversal section by at least one piston and on the lateral part by a tubular lateral wall 41 (wherein the term "tubular" means that every transversal section of the wall defines a circular closed loop), a front portion of which defines the guide cylinder 31; in particular, this front portion comprises an internal surface which defines the cylindrical guide surface 31 b of the piston 32 and a rear portion 41 a joined, preferably in a single body, to the front portion.

[0025] In the case illustrated in the figures, where the pump comprises two piston-cylinder groups, axially opposite along the axis A, the tank 40 is delimited on both opposite front sides by the two pistons 32 and laterally by the tubular wall 41.

[0026] If there is a second piston 32 present, which closes the reservoir 40, this can be posteriorly closed by any transversal wall.

[0027] The pump comprises a mechanism, housed in the rear reservoir 40, for actuating a reciprocating axial movement of the piston 32 in the cylinder 31 thereof, between a bottom dead center (PMI) and a top dead center (TDC, and vice versa; in particular a drive shaft 42 with a cam 43 is provided, which acts on both the pistons 32 by means of respective connecting rods 44. Each connecting rod 44 is connected by a pin 49 to the respective piston 32.

[0028] The volume of the pump chamber 30 is delimited on one side by an internal cap 47 (forming part of a cylinder head 46) and on the other side by the diaphragm 35. In operation, the thrust necessary for the pumping of the liquid (water) pressure is exerted by the diaphragm 35, which is preferably made of an elastic material (typically rubber, and is subject to a reciprocating movement (typically induced by the crank mechanism activated by the drive shaft 42 so that the volume of the pump chamber 30 assumes a size variable between a maximum and a minimum (the difference of which defines the displacement); the liquid enters and leaves in a reciprocating mo-

tion, the flow in the chamber 30 being controlled by automatically-opening single-acting valves 53 and 54, respectively aspiration and delivery.

[0029] The pressure energy is transferred to the liquid to be pumped into the chamber 30 directly by the diaphragm 35, which is pushed by the piston 32, in part by direct action, and in part by the mass of thrust oil enclosed in the thrust chamber 37.

[0030] Each of the two pump chambers 30 communicates with an aspirating conduit 51 and with a delivery conduit 52, with the intake valve 53 and outlet 54 valve being interposed. According to the embodiment illustrated in the figures, the aspirating conduit 51 is common to both chambers 30, as is the delivery conduit 52.

[0031] During the delivery step, corresponding to the stroke of the piston from bottom dead centre (PMI) to top dead centre (PMS), this mass of thrust oil undergoes, due to the "leakage" on the wiper ring 33 or in any case along the play provided by the coupling tolerance between the piston 32 and the cylinder 31, a reduction in the mass of oil.

[0032] To restore the thrust oil level lost due to leakage from the thrust chamber to the rear tank between the piston and the cylinder, the lateral wall comprises one or more open-top grooves 48 (two in the figures) formed on the guide surface 31 b, and facing the lateral surface 32b of the piston, which develops substantially axially. Each groove 48 has a rear end 48b connected with the rear tank 40 and a front end 48a which, when the piston 32 is located in the neighborhood of the piston-cylinder, exceeds, by a short stretch B, the sealing edge of the front 33a and communicates with the thrust chamber 37.

[0033] During the delivery phase (from BDC to TDC) of the piston 32, as soon as the front edge 33a of the elastic-equipped ring 33 (or the piston itself) has passed beyond the end 48a of the groove 48, the chamber 37 is isolated from the tank 40, and the delivery stroke develops, as the chamber is hermetically closed, apart from, as mentioned, the leakage towards the tank 40.

[0034] In the following return of the piston from TDC to BDC, by effect of the depression induced in the pump chamber 30 by the resistance to the liquid (water) entrance into the chamber, a resistance to the return of the diaphragm 35 to the bottom dead centre position is induced, which accordingly also produces a depression in the thrust chamber 37. At the moment when the piston 32 enters the environs of bottom dead centre (this position is illustrated in detail and in enlarged scale in figure 2B), the sharp edge of the front seal 33a communicates, along this short section B, with the groove 48, which in turn communicates with the tank 40; during this step, due to the depression in the chamber 37, the thrust oil pressure contained in the tank 40 is aspirated through the slots 48, thereby restoring the quantity of oil in the chamber 37 previously lost to leakage. This cycle is repeated in the same way at every turn of the drive shaft 42.

Claims

1. A reciprocating positive-displacement diaphragm pump for liquids, comprising:

at least a piston-cylinder group, having:

- a liquid pump chamber (30),
- a piston-cylinder pair, the cylinder (31) of which has a front mouth intersecting the pump chamber (30) and exhibits a cylindrical internal surface (31 b) for guiding the piston (32),
- the piston (32) having a cylindrical lateral surface (32b) coupled in axial sliding and with an oil seal with the guide surface (31 b) of the cylinder (31),
- a flexible diaphragm (35), a perimeter (36) of which is fixed to the internal surface of the pump chamber (30), which separates the chamber (30) from the cylinder (31) mouth, the diaphragm (35) being connected to the front thrust surface of the piston (32),
- a thrust chamber (37), external of the pump chamber (30), delimited between the diaphragm (35), the thrust surface of the piston (32) and the guide surface (31 b) of the cylinder,
- the chamber (37) being sealedly closed and being filled with non-compressible thrust oil,
- the piston (32) comprising a front seal edge (33a), which realizes the seal by acting against the guide surface (31 b) of the cylinder, which defines a mobile confine of the thrust chamber (37),

the pump further comprising:

- a mechanism for actuating a reciprocating axial movement of the piston (32) in the cylinder (31), between a bottom dead centre and an upper dead centre, and vice versa,
- a rear tank (40), closed and filled with thrust oil, which closes the rear portion of the piston, separate and not communicating with the thrust chamber (37),

characterised in that the rear tank is delimited, on the front transversal side, by the piston and on the lateral side by a tubular lateral wall (41), comprising a front portion having an internal surface defining the cylindrical guide surface (31 b) for the piston (32) and a rear portion (41 a) joined to the front portion;
and further **characterised in that** in order to restore the thrust oil level, lost by leaking from the thrust chamber to the rear tank, the tubular wall

41 comprises at least an open groove (48) fashioned on the guide surface (31 b), and facing the lateral surface (32b) of the piston, which develops substantially axially, having a rear end connected to the rear tank (40) and a front end which, when the piston (32) is in the environs of the lower dead centre, opens frontally of the front seal edge (33a) and communicates with the thrust chamber (37).

2. The pump of claim 1, wherein the front portion of the tubular wall (41), which defines the cylindrical guide surface (31 b), is in a single body with a rear portion (41 a) of the wall.

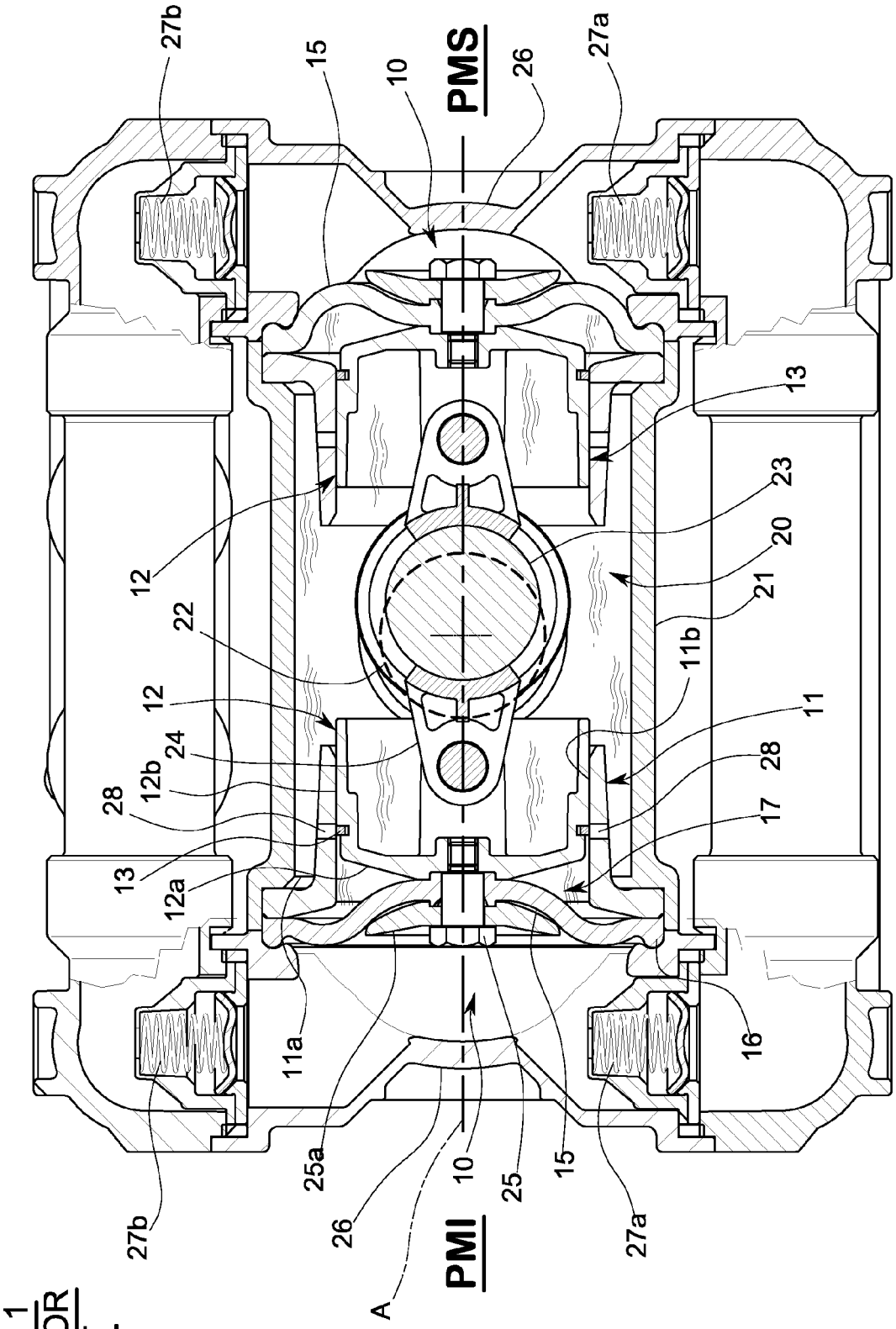
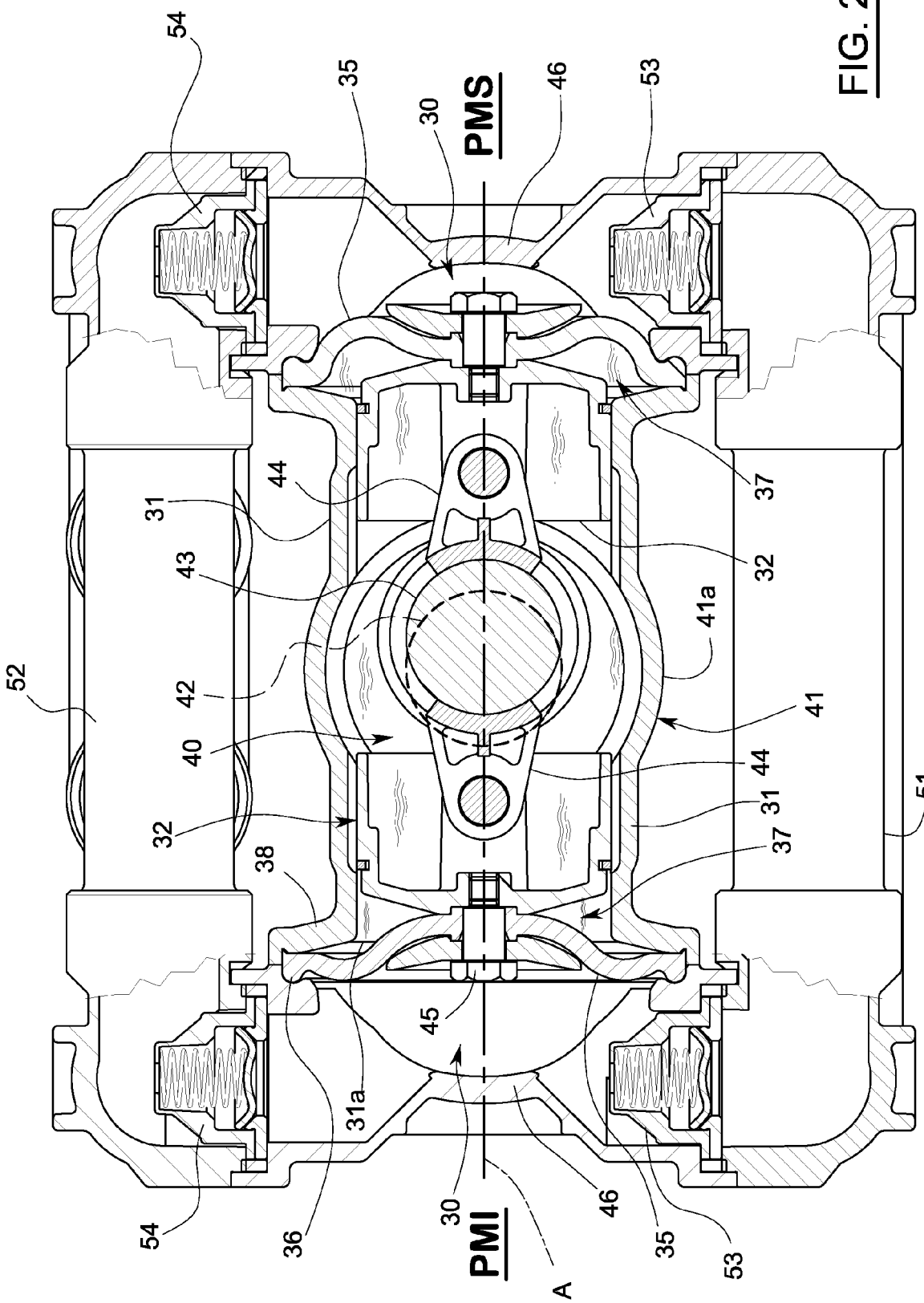


FIG. 1
PRIOR
ART


54
35
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PMS
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41a
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31a
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PMI
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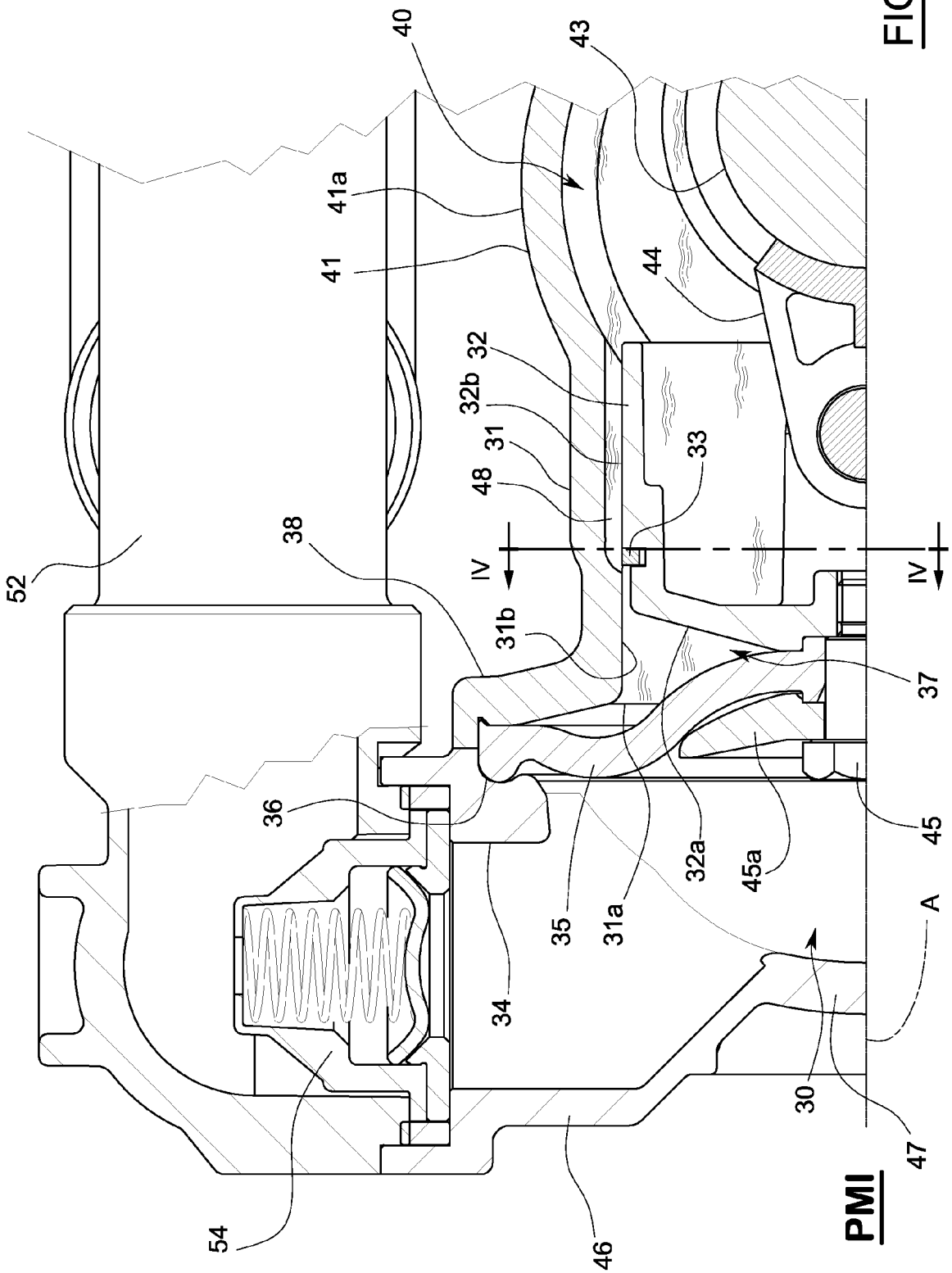
A

FIG. 2


40
43
41a
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44
32
32b
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48
33
IV
IV
52
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31b
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36
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32a
45a
35
31a
A
34
30
47
54
46
PMI

FIG. 2A

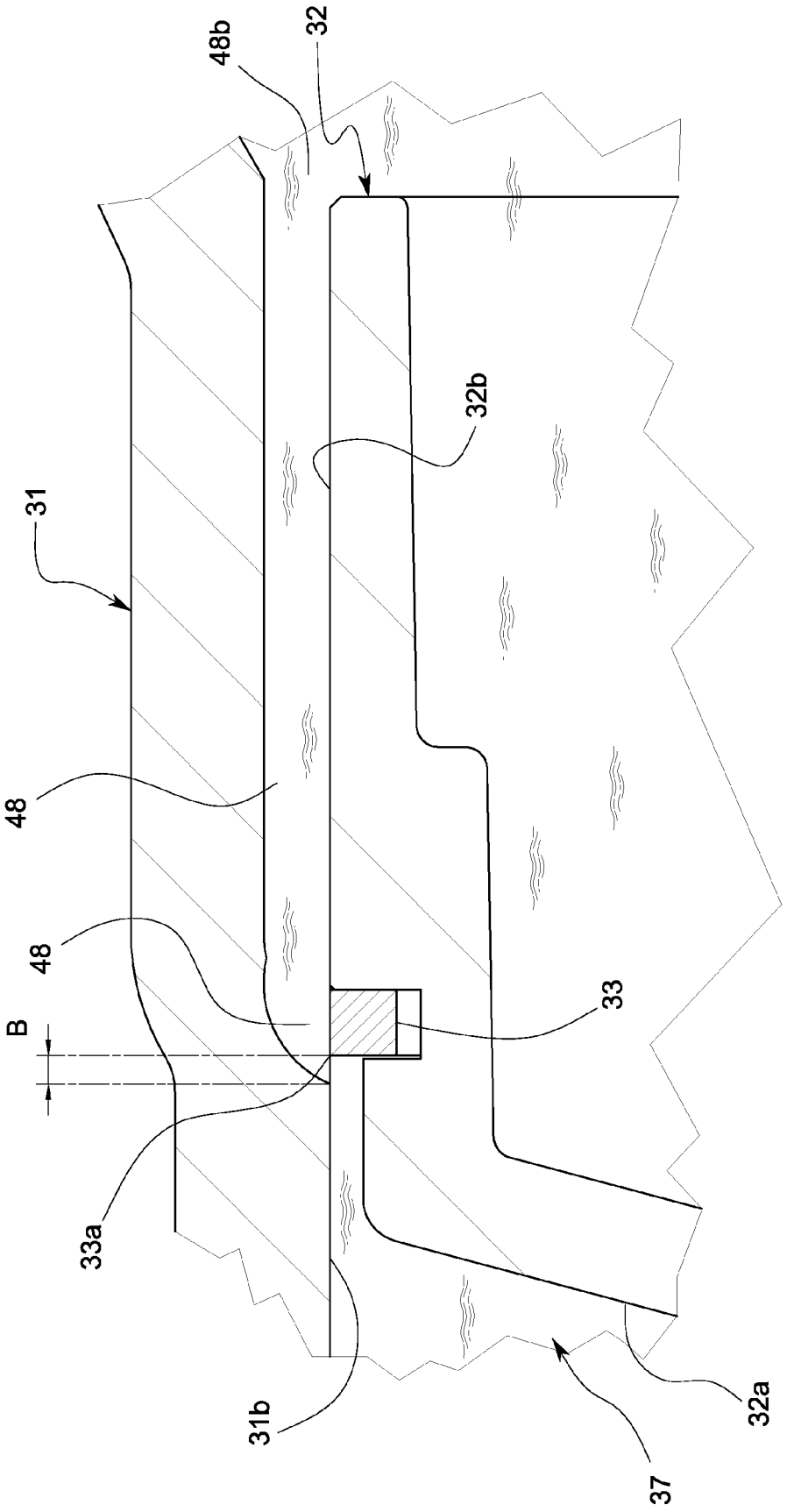

FIG. 2B

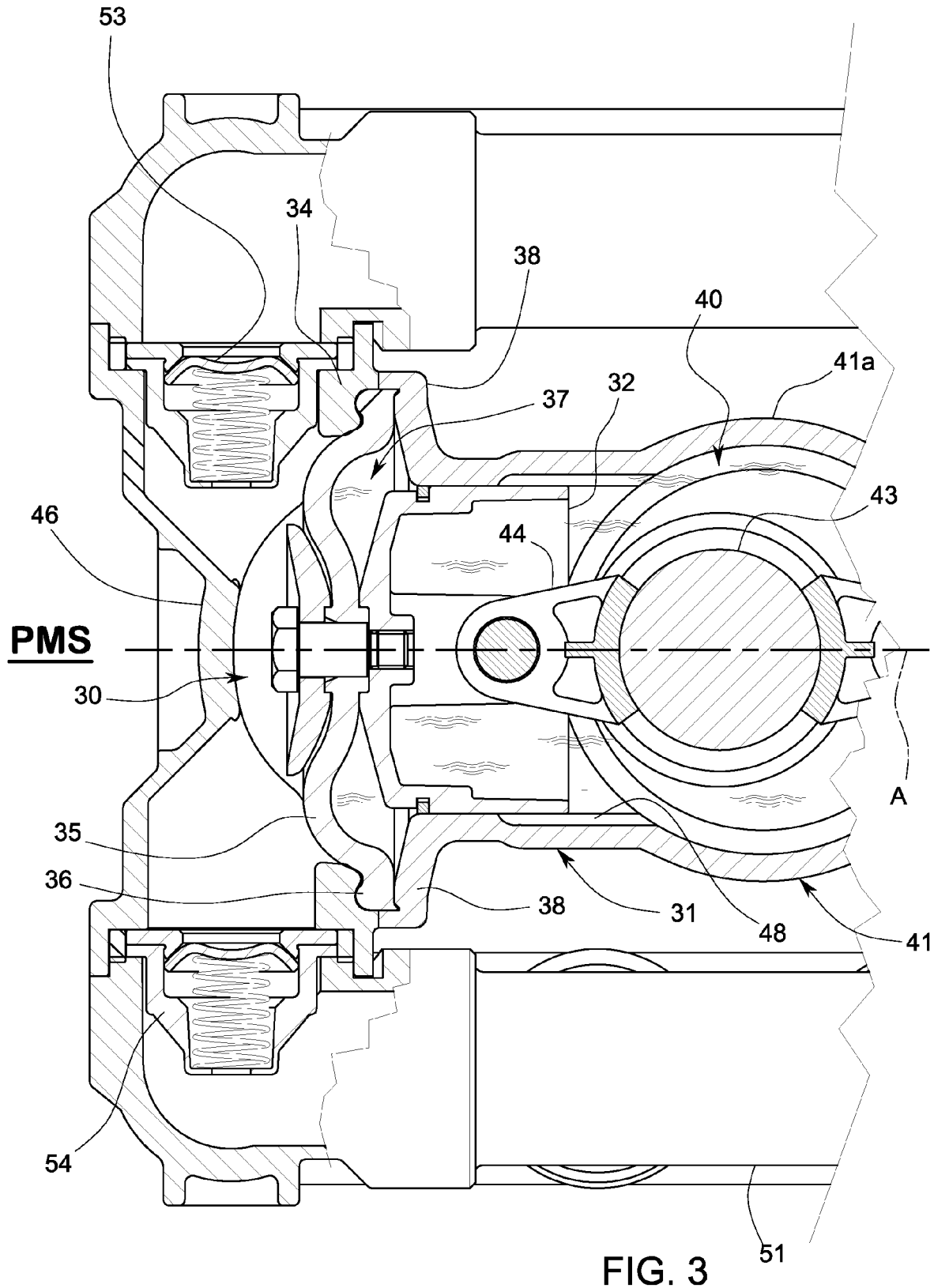

FIG. 3

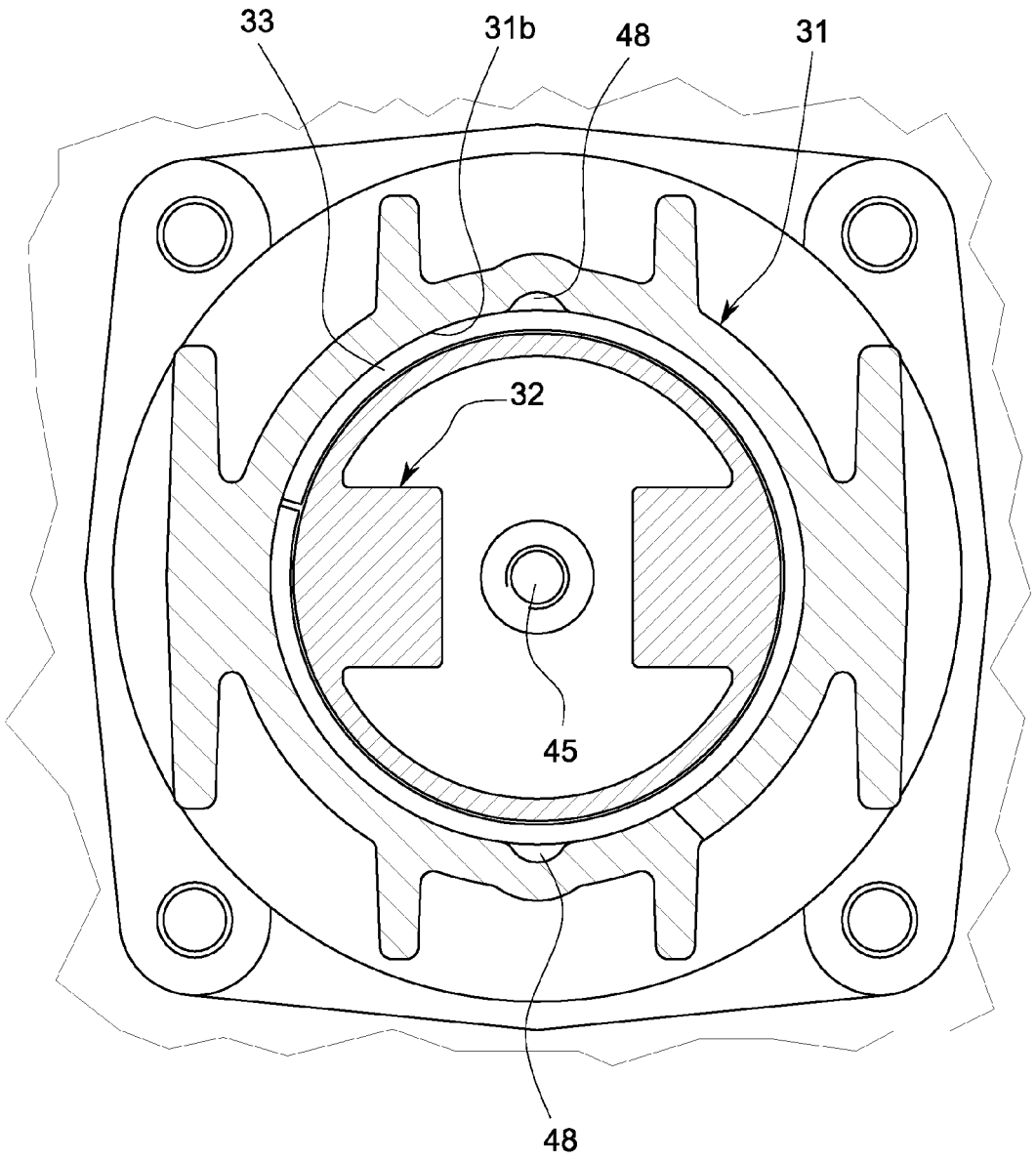

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 7054

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	12 March 2015	Pinna, Stefano

CATEGORY OF CITED DOCUMENTS

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