

(19)



(11)

EP 3 608 535 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.02.2020 Bulletin 2020/07

(51) Int Cl.:
F03C 1/247 ^(2006.01) **F03C 1/00** ^(2006.01)
F03C 1/04 ^(2006.01) **F04B 1/113** ^(2020.01)
F04B 1/04 ^(2020.01) **F04B 1/06** ^(2020.01)
F04B 49/03 ^(2006.01)

(21) Application number: **18188151.7**

(22) Date of filing: **09.08.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
KH MA MD TN

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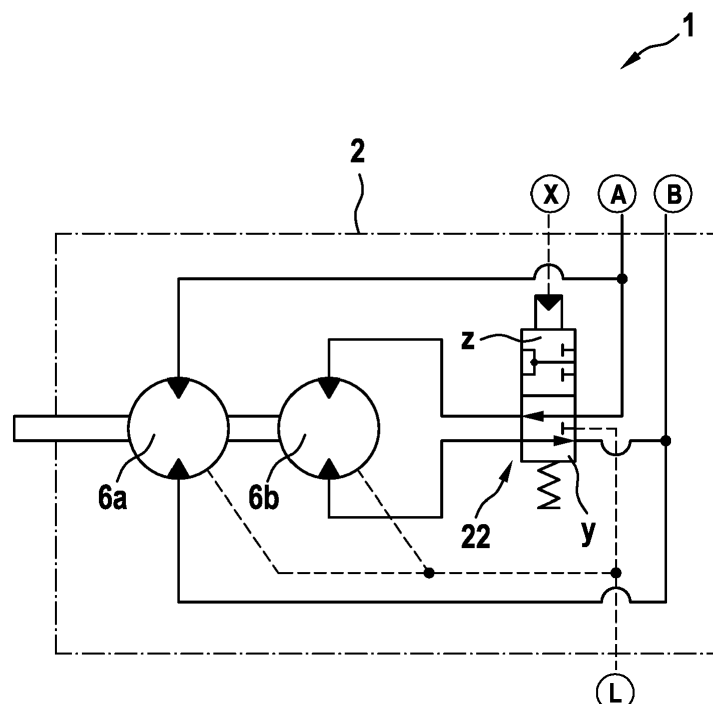
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(54) **HYDROSTATIC RADIAL PISTON MACHINE**

(57) Disclosed is a hydrostatic radial piston machine which may be a motor and/or a pump. The machine is configured to operate in the full displacement mode and additionally in one or more reduced-displacement modes.

To optimize the efficiency of the machine in the reduced-displacement modes the pistons can be retained in their cylinder holes when they pass one of the deactivated lobes.

Fig. 2

Description

[0001] The present invention relates to a hydrostatic radial piston machine.

[0002] Hydrostatic radial piston machines ("machines") typically comprise a plurality of pistons pressed against a cam body via rollers, wherein the cam body has a plurality of lobes on its periphery.

[0003] The pistons are accommodated in cylinder holes of an internal cylinder block and thus enclose working spaces. During a turn of a piston along the cam body, the piston performs working strokes, whose number corresponds to the number of lobes of the cam body. The cylinder block can rotate relative to the cam body, or the cam body rotates relative to the cylinder block.

[0004] When the radial piston machine is used as a motor, to which, e.g., a wheel of a mobile working machine is coupled in a rotationally-fixed manner, the motor is towed along in an overrun operation, e.g., when the mobile working machine rolls downhill.

[0005] In order to prevent the pistons from performing braking and wear-inducing idle strokes, US 3,999,465 discloses a radial piston motor with magnets on the pistons, via which all pistons can be retracted radially inwards into the associated cylinder holes and can be held there. With this, the rollers of the pistons are lifted from the lobes of the cam body. Then, the cam body of the motor of US 3,999,465 can rotate freely in a towing operation.

[0006] In addition, radial piston machines are known that can operate in different displacement modes, e.g. a motor with two different speeds. This can be achieved by turning off the pressure supply to the pistons related to only some of the lobes. These lobes are allocated in a so called switchable group. A reduced displacement mode is achieved by interrupting the pressure to each piston in turn as it passes through the angular extent of the lobes of the switchable group. Such a motor is disclosed by the applicant in RE 15199: "Radial piston motor for integrated drives MCR-H" Edition 03.2017. For the reduced displacement mode, both flanks of the lobes of the switchable group are connected via a valve with control pressure. The corresponding pistons are towed along, so that under control pressure they carry out braking and wear-inducing idle strokes in a disadvantageous manner.

Summary of the Invention

[0007] It is an object of the invention to provide a hydrostatic radial piston machine comprising one group of lobes which is always active and comprising at least a further group of lobes, which can be activated and deactivated in order to realize at least two different displacement modes of the radial piston machine. The first group is called active group and the second group is called switchable group. In the reduced displacement mode the machine shall have higher efficiency than current state

of the art.

[0008] This object is achieved by the subject-matter of claim 1. Advantageous further developments are subject-matter of the dependent claims.

[0009] The hydrostatic radial piston machine comprises lobes arranged in a circumferential direction on a cam body, each lobe comprising a lobe portion or flank of rising type and a lobe portion or flank of falling type. Pistons are movable relative to the cam and guided in cylinder holes or cylinder bores which are arranged in a cylinder block radially or in a star-shaped manner. The lobes are divided into an active group and at least one switchable group in order to realize at least two displacement modes of the radial piston machine. In more detail, the lobes of the switchable group are switched on and activated in the full displacement mode and switched off and deactivated in the reduced displacement mode. The lobes of the active group are active in each displacement mode. According to the invention, each piston is individually pullable into the cylinder block by magnetic force and can be kept there in a retained position when the assigned cylinder hole is in operative connection with a lobe of the switchable group. Operative connection means that the cylinder hole is arranged in an angular range or passes through an angular range assigned to a lobe of the switchable group.

[0010] With this, all pistons are retracted into the cylinder hole or cylinder block when passing over the deactivated lobes. In this way, these pistons or their rollers have only minimal or no contact with the deactivated lobes. Therefore, the machine has higher efficiency in the reduced displacement mode.

[0011] The pistons may have a radial distance or gap even to the innermost portions of the lobes in the retained positions of the pistons. In this way, the deactivated lobes are not contacted in any way by the pistons or their rollers in the retained positions of the pistons, thus the efficiency of the machine is optimized. The gap can be provided to account for manufacturing tolerances.

[0012] In a particularly preferred alternative there will be no gap between the roller and the innermost point of the piston lobe. This means that the roller will not have any free stroke before it strikes the cam again. This will keep noise down and reduce damage to the cam.

[0013] Preferably, a main valve is used to select the displacement mode whose valve body is adjustable to a full displacement position and a reduced displacement position.

[0014] Preferably, the main valve is continuously adjustable between the two displacement positions to allow a smooth transition between the two displacement modes.

[0015] The main valve is preferably a 5/2-way valve, which in the full displacement position connects the cylinder holes being in operative connection with the lobes of the switchable group with the working ports of the radial piston machine, while in the reduced displacement position it connects the cylinder holes being in operative con-

nection with lobes of the switchable group with an interior of a case or with a tank connection or with a leakage connection.

[0016] In a preferred case of application, the radial piston machine is a motor, wherein the main valve is a speed valve, since it serves for selecting a speed of the motor.

[0017] The pistons preferably are stepped pistons which have a portion of larger diameter and a portion of smaller diameter.

[0018] Preferably, the magnetic force is applied by magnets.

[0019] Standard magnets can be active all the time as the motor runs. This does not have a detrimental effect on the efficiency of the motor - as well as resisting the outgoing stroke, the magnets aid the return stroke of the pistons, so the effect of having the magnets on all the time as the motor runs is cancelled out over a full stroke of each piston.

[0020] Preferably the magnet only has enough pulling force to hold the piston in when it is very near.

[0021] According to a first embodiment, the magnets are fixed to the respective piston.

[0022] In a further development of the first embodiment with the stepped piston, the magnets are concentrically accommodated in a blind hole or through hole of the portion of smaller diameter.

[0023] Thereby, a diameter of the magnets should be smaller than a diameter of the portions of smaller diameter of the pistons.

[0024] A length of the magnets may correspond to approximately a length of the portion of smaller diameter.

[0025] The pistons also can be non stepped pistons.

[0026] In this case the magnets preferably have smaller diameter than the non stepped pistons.

[0027] According to a second embodiment, the magnets are fixed in the respective cylinder hole at the cylinder block.

[0028] In a further development of the second embodiment, the magnets are concentrically accommodated in a blind hole or through hole on one end face of the cylinder hole and/or of the cylinder block.

[0029] Thereby, a diameter of the magnets should be smaller than a diameter of the front end of the cylinder hole and/or of the cylinder block.

Description of Figures

[0030] Two preferable exemplary embodiments of the invention are explained in more detail in the following with the help of schematic drawings, wherein the same numerals are used to represent the same elements and wherein:

Fig. 1 shows a hydrostatic radial piston machine according to two embodiments of the invention;

Fig. 2 shows a schematic according to both embodiments of the invention;

Fig. 3 shows a section of a hydrostatic radial piston machine according to the first embodiment; and

Fig. 4 shows a section of a hydrostatic radial piston machine according to the second embodiment.

Detailed Description of Embodiments

[0031] Fig. 1 shows a hydrostatic radial piston machine 1 according to both embodiments of the invention. It has a case 2 formed in sections by a cam body 4. The cam body 4 is circumferentially circular and has six lobes 6a, 6b on its inner side, which are seen here as reductions in the thickness of the cam body 4, i.e. as "valleys". Alternatively, lobes 6a, 6b could also be regarded as mountains. Thus, each lobe 6a, 6b has an angle range 8a, 8b of 60°.

[0032] The radial piston machine 1 of the two embodiments described here is designed as a motor and has a circumferential or rotating case 2 or cam body 4.

[0033] Accordingly, a stationary cylinder block 10 is arranged in the interior of case 2, in which a number of stepped cylinder holes 12 deviating from the number of lobes 6a, 6b is formed. In the stepped cylinder holes 12, the respective stepped pistons 14, 14a, 14b are radially guided.

[0034] Fig. 3 shows a piston from Fig. 1, on which a roller 16 is rotatably mounted. By applying pressure to the two-part cylinder hole 12, the piston 14 is pressed radially outwards, wherein its roller 16 rolls off the cam body 4 and sets it in rotation.

[0035] Via an opening 20 of the cylinder hole 12, it is alternately (in the way known from the prior art) connected to distributor holes 21 distributed around the circumference and thus alternately to two working ports A, B formed at the case 2.

[0036] Fig. 2 shows a schematic according to both embodiments of the radial piston machine 1 according to the invention. The group of permanently activated lobes 6a and the group of switchable lobes 6b are shown separately, each with the symbol of a hydraulic motor. The group of permanently activated lobes 6a is always connected via the distributor holes 21 to the two working ports A, B of the machine, while the group of switchable lobes 6b can be activated and deactivated via the distributor holes 21 and via a main valve 22.

[0037] The main valve 22 is designed as a 5/2-way valve. Its valve body can have a full displacement position y (shown in Fig. 2) and a reduced displacement position z. The valve body is preloaded via a spring into the full displacement position y (shown in Fig. 2). In this position, the group of switchable lobes 6b is also connected to the working ports A, B. In the reduced displacement position z, which can be switched by a control pressure x, the group of switchable lobes 6b is "short-circuited" and connected to a leakage connection L or to the interior of the case 2a (see Fig. 1). More precisely, the openings 20 (cf. Fig. 1, Fig. 3 and Fig. 4) of all those cylinder holes 12

which pass over an angle range 8b of a deactivated lobe 6b are connected to the leakage connection L or to the interior (cf. Fig. 1). This applies to the lobe portions or flanks of the rising type and to the lobe portions or flanks of the falling type.

[0038] Fig. 3 shows a piston 14 passing over an innermost portion 24 of the cam body 4. Thus, the rotational position of the cam body 4 shown in Fig. 3 is exactly the transition between two lobes 6a, 6b. In the two embodiments shown in Fig. 1, each transition between two lobes 6a, 6b always also means switching of the relevant cylinder hole 12 or respectively of the relevant piston 14.

[0039] Piston 14 is designed as a stepped piston 14 and has a circular cylindrical portion of larger diameter 26 on the outer circumference, in which the rotating roller 16 is accommodated. Furthermore, the piston 14 has a circular cylindrical portion of smaller diameter 28, which is also on the outer circumference. A hole 29 is concentrically drilled into this portion 28, the diameter of which corresponds to about half of the diameter of the portion of smaller diameter 28 in the embodiment shown. A magnet 30 is inserted to fit precisely into this bore 29, which is switched by a control unit (not shown) of the radial piston machine 1 at each transition from a lobe 6a, 6b to an adjacent lobe 6a, 6b. More precisely, each time the piston 14 enters an angle range of a deactivated lobe 8b, the magnet 30 draws the piston 14 radially inwards into the cylinder block 10. This means that the piston 14 does not carry out any wear-inducing and loss energy-generating idle strokes in the corresponding angle ranges 8b.

[0040] Fig. 4 shows a section of a cylinder block 10 according to the second embodiment of the radial piston machine 1 according to the invention, in which a cylinder hole 12 is shown without piston. It can be seen that a hole 129 is drilled into an inner end face of the cylinder hole 12, so that a portion of larger diameter of cylinder hole 12 and a portion of smaller diameter of cylinder hole 12 and the hole 129 are formed to be circular-cylindrical and are arranged concentrically to each other. A respective radial step is provided in between.

[0041] A magnet 130 is inserted to fit precisely into hole 129, via which the piston 14 (not shown in Fig. 4) can be retracted in principally the same way as in the first embodiment. Since the cylinder block 10 of the two embodiments shown is at rest, the magnet 130 of the second embodiment of Fig. 4 also rests.

[0042] A lobe according to the invention is not necessarily understood to be only a radially rising portion or flank followed by a radially falling portion or flank of the cam body in the direction of rotation. A lobe may also be understood to be a radially falling portion or flank followed by a radially rising portion or flank of the cam body in either circumferential direction.

[0043] Further optionally, the pistons, cylinder holes and rollers may be provided radially outside of a cam body whose cam surface is on its outer periphery. Further optionally, the cylinder holes may be provided as individual elements rather than in an integral cylinder body. Fur-

ther optionally, the pistons may bear directly on the cam surface, rather than via rollers.

[0044] The machine of the invention may be a motor and/or a pump. The machine is configured to operate in the full displacement mode and additionally in one or more reduced-displacement modes.

[0045] To optimize the efficiency of the machine in the reduced-displacement modes, the pistons can be retained in their cylinder holes when they pass one of the deactivated lobes.

Reference Signs

[0046]

1	radial piston machine
2	case
4	cam body
6a	activated lobe
6b	switchable / deactivated lobe
8a	angle range of an activated lobe
8b	angle range of a deactivated lobe
10	cylinder block
12	cylinder hole
14	piston
14a	activated piston
14b	deactivated piston
16	roller
20	opening
21	distributor hole
22	main valve
24	innermost portion
26	portion of larger diameter
28	portion of smaller diameter
29	hole
30	magnet
129	hole
130	magnet
A	working port
B	working port
L	leakage connection
x	control pressure
y	full displacement position
z	reduced displacement position

Claims

1. Hydrostatic radial piston machine, comprising lobes (6a, 6b) arranged in a circumferential direction on a cam body (4), wherein pistons (14, 14a, 14b) are movable relative to the cam body (4) and are guided in cylinder holes (12), which are arranged in a cylinder block (10) radially or in a star-shaped manner, wherein the lobes (6a, 6b) are divided into an active group (6a) and at least one switchable group (6b) in order to realize at least two displacement modes of the radial piston machine, **characterized in that**

each piston (14, 14a, 14b) is individually pullable into the cylinder block (10) by magnetic force and can be kept there in a retained position when the assigned cylinder hole (12) is in operative connection with a lobe (6b) of the switchable group.

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2. Hydrostatic radial piston machine according to claim 1 having a main valve (22) for selecting the displacement mode, comprising a full displacement position (y) and a reduced displacement position (z). 10
3. Hydrostatic radial piston machine according to claim 2, wherein in the full displacement position (y) the cylinder holes (12) in operative connection with lobes (6b) of the switchable group are connected with working ports (A, B) of the radial piston machine, while in the reduced displacement position (z) the cylinder holes (12) in operative connection with lobes (6b) of the switchable group are connected with an interior of a case (2) or with a tank connection or with a leakage connection (L). 15 20
4. Hydrostatic radial piston machine according to claim 2 or 3, which is a motor, wherein the main valve (22) is a speed valve. 25
5. Hydrostatic radial piston machine according to one of the preceding claims, wherein the pistons (14, 14a, 14b) are stepped pistons which have a portion of larger diameter (26) and a portion of smaller diameter (28). 30
6. Hydrostatic radial piston machine according to one of the preceding claims, wherein the magnetic force is applied by magnets (30), which are fixed to the respective piston (14, 14a, 14b). 35
7. Hydrostatic radial piston machine according to claims 5 and 6, wherein each magnet (30) is accommodated in a hole (29) of the portion of smaller diameter (28). 40
8. Hydrostatic radial piston machine according to claim 5 or 7, wherein a diameter of the magnets (30) is smaller than a diameter of the portions of smaller diameter (28). 45
9. Hydrostatic radial piston machine according to one of claims 1 to 5, wherein the magnetic force is applied by magnets (130), which are fixed in the respective cylinder hole (12) at the cylinder block (10). 50
10. Hydrostatic radial piston machine according to claim 9, wherein each magnet (130) is accommodated in a hole (129) of the cylinder hole (12) and/or of the cylinder block (10). 55

Fig. 1

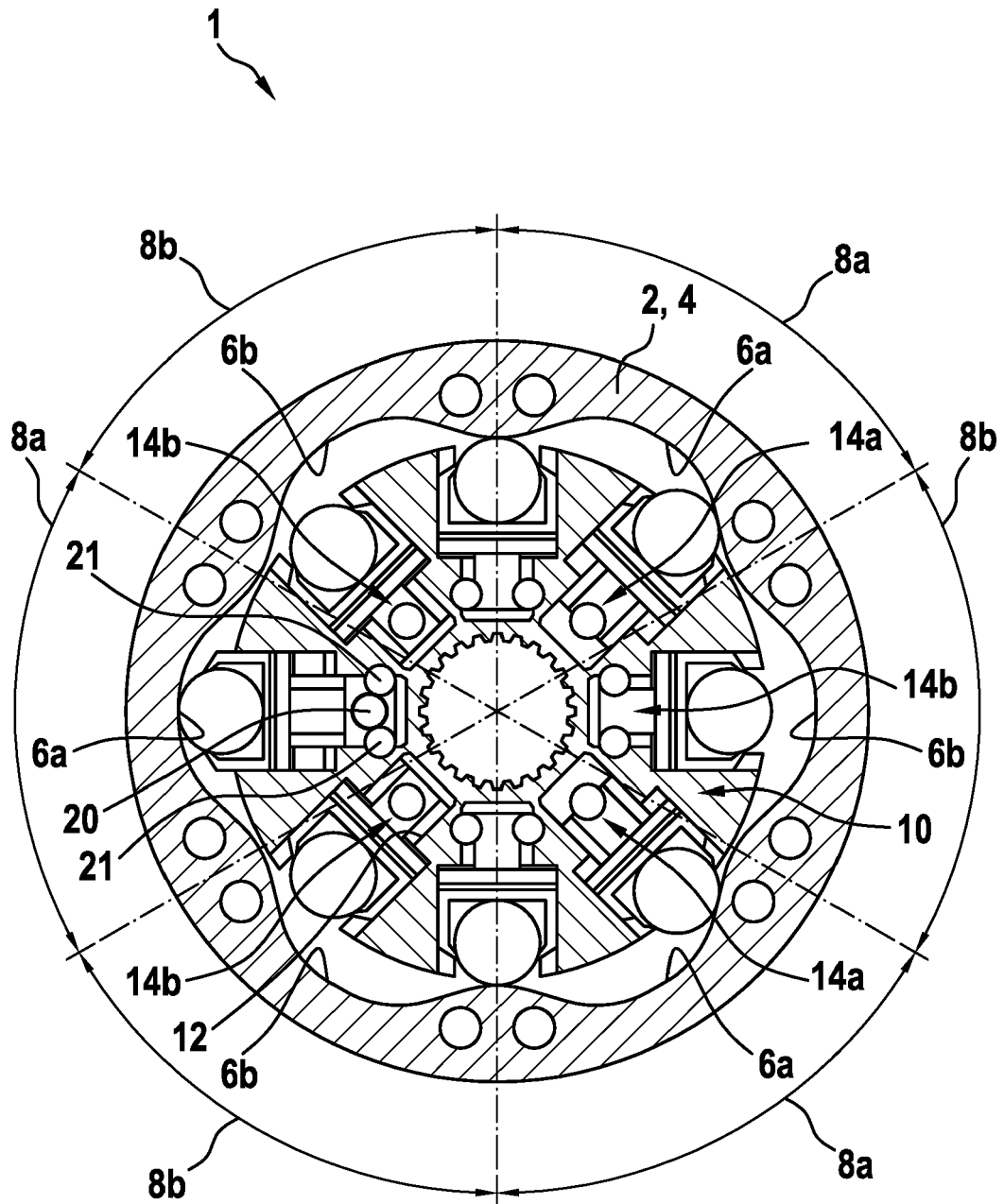


Fig. 2

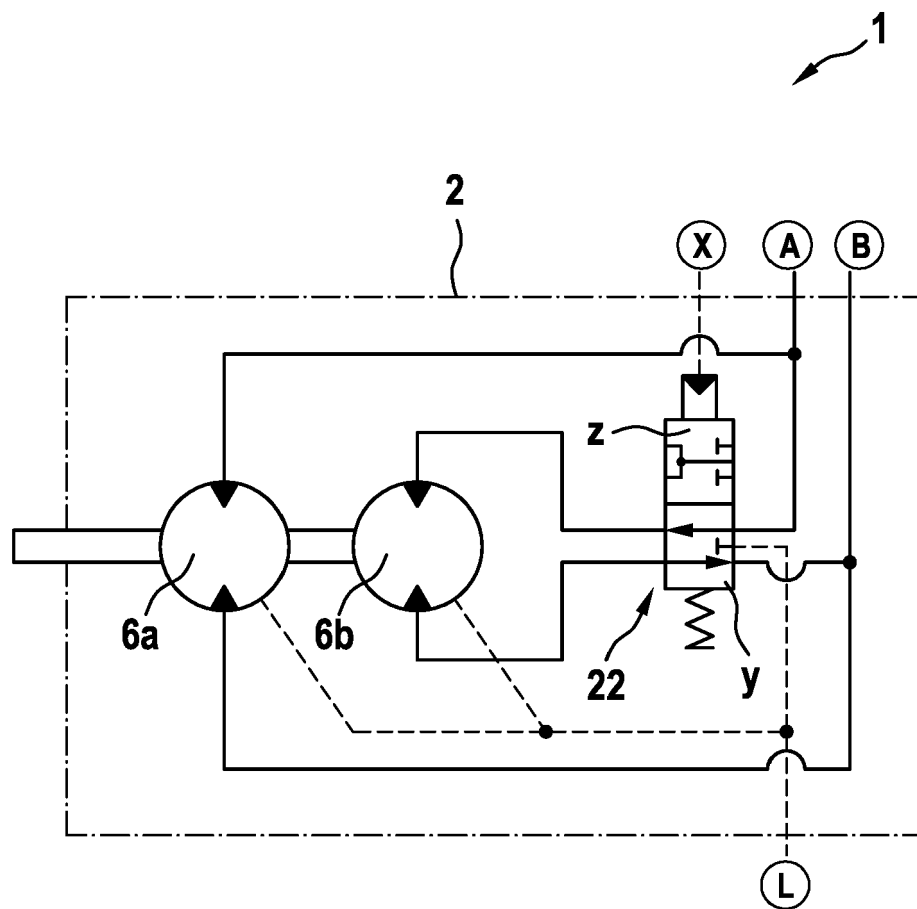


Fig. 3

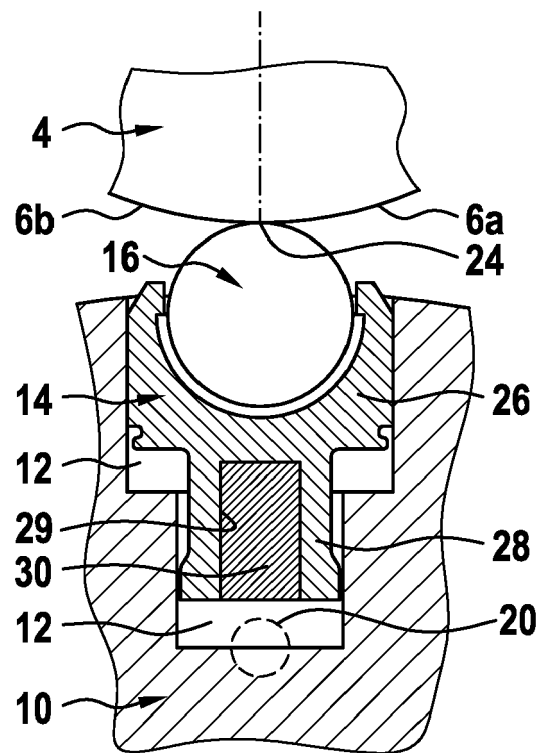
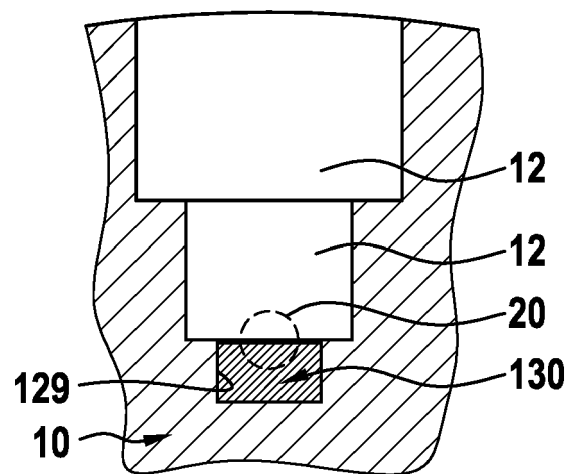


Fig. 4





EUROPEAN SEARCH REPORT

Application Number
EP 18 18 8151

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2014 212206 A1 (BOSCH GMBH ROBERT [DE]) 31 December 2015 (2015-12-31) * paragraphs [0023], [0027], [0028]; figure 1 *	1-10	INV. F03C1/247 F03C1/00 F03C1/04 F04B1/113 F04B1/04 F04B1/06 F04B49/03
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 January 2019	Examiner Homan, Peter
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 18 18 8151

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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