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(54) **HYDRAULIC PISTON PUMP AND METHOD FOR AFFECTING THE SOUND CHARACTER OF THE PISTON PUMP**

(57) Hydraulic piston pump (1) comprising a plurality of pistons (8), where each piston is arranged in a cylinder barrel (10), where at least one piston (8) is arranged to deliver a specific pressure or output flow that differs from the pressure or output flow delivered by the other pistons (8).

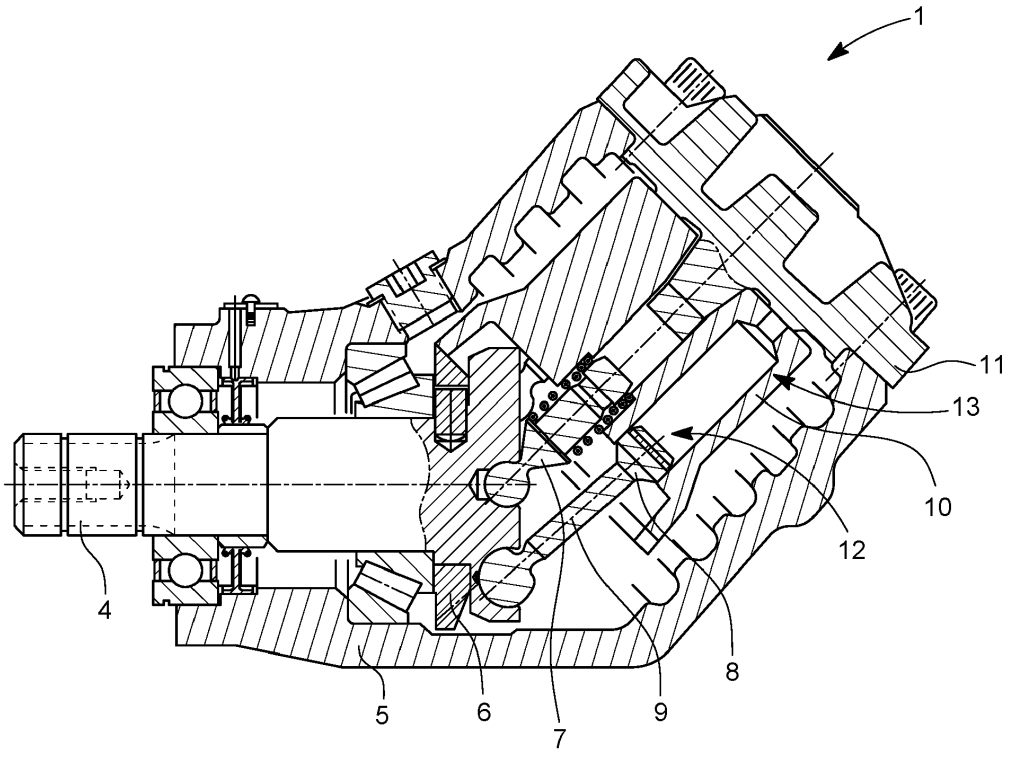

FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic piston pump and a method for affecting the sound character of the piston pump. The hydraulic piston pump is primarily intended to be used in an electric vehicle, where an internal combustion engine does not hide the sound emitted from the piston pump.

BACKGROUND ART

[0002] Heavy machines, such as trucks of different types, construction equipment machines and the likes are often provided with additional hydraulic equipment powered by a hydraulic pump. The hydraulic pump is often referred to as a power take-off (PTO) and is often mounted to an engine or a transmission of the vehicle or machine. The interface for the power take-off is normally standardized such that an additional power take-off can be mounted when required. An engine and/or a transmission may be provided with one or more locations where a PTO can be mounted.

[0003] The hydraulic pump will emit a specific noise that is dependent e.g. on the number of pistons, the size of the hydraulic pump and the actual delivered pressure or flow from the hydraulic pump. The noise emitted from the hydraulic pump is normally partly masked by the noise emitted from the internal combustion engine of the vehicle or machine, especially since a higher power output from the hydraulic pump is obtained by a higher engine speed, and thus a higher engine noise, and the sound character of the hydraulic pump follows the sound and rotational speed of the internal combustion engine.

[0004] In vehicles powered without combustion engines, the sound masking property of the combustion is removed, and other sound sources become more pronounced. The substitution sound with electric motors is more silent and has much weaker sound masking properties. In such vehicles, the noise emitted from the hydraulic pump becomes more noticeable. Further, depending on the type of hydraulic pump, the noise emitted from the hydraulic pump have some prominent frequencies linked to the number of pistons of the pump and the rotational speed of the pump. These specific frequencies with overtones may become more annoying or disturbing than the well-known sound from a combustion engine. At the same time, some noise is desirable in order for a user to receive feedback from the operation in question. This feedback is essential for the operator when performing work tasks.

[0005] Different measures for reducing the noise from a hydraulic pump are known. These methods often aim at reducing the hydraulic ripple or pulsations emitted at the orifice of the pump. Others can include sound isolation in different ways, such that the level of noise is reduced. Measures that address the character of the sound that can make the sound both pleasant and audible are less common.

[0006] There is thus a need for an improved hydraulic piston pump.

DISCLOSURE OF INVENTION

[0007] An object of the invention is therefore to provide an improved hydraulic piston pump. A further object of the invention is to provide a method for affecting the emitted sound character from a hydraulic piston pump. A further object of the invention is to provide a vehicle comprising such a hydraulic piston pump.

[0008] The solution to the problem according to the invention is defined by the claims directed to a hydraulic piston pump, a method and a vehicle. The claims also contain advantageous further developments of the inventive hydraulic piston pump and method.

[0009] In the inventive hydraulic piston pump comprising a plurality of pistons, where each piston is arranged in a cylinder barrel, the object of the invention is achieved in that at least one piston is arranged to deliver a specific pressure or output flow that differs from the pressure or output flow delivered by the other pistons.

[0010] With the inventive hydraulic piston pump, it is possible to change the frequency distribution of the emitted sound from the hydraulic piston pump. This will alter the sound character of the hydraulic piston pump and will give a hydraulic piston pump that gives a more pleasant audible operation feedback. By changing the delivered pressure or output flow from a piston of the hydraulic piston pump, the character of the sound emitted from the pump changes. By designing the pistons, it will thus be possible to provide a more attractive sound from the hydraulic piston pump.

[0011] The sound emitted from a hydraulic piston pump is provided with a base frequency that is dependent on the rotational speed of the hydraulic piston pump. The pistons will emit a base tone having a specific amplitude and harmonic overtones. The shape of the emitted sound will depend on e.g. the delivered pressure and the shape of the piston/cylinder cavity. When all pistons are identical, the impulses from the pistons repeat the same number of times per rotation as the number of pistons in the hydraulic piston pump. This cause there to be a clear, well separated, tone at the frequency of the impulses and harmonic overtones will appear at multiples of this frequency. The frequency distance between these multiple harmonic tones is the same as the frequency of the fundamental tone of the impulses. When all pistons have different output pressure or output flow, the amplitude and shape of the impulses will differ, so that the fundamental tone become equal to the rotation speed of the hydraulic piston pump. This tone will have a frequency that is lower in frequency and the harmonic overtones will become less pronounced as they are denser in frequency. This means that the sound will be less sharp when compared to a similar hydraulic piston pump with

identical pistons.

[0012] In one example, the output pressure from all the pistons differs from each other. For a hydraulic piston pump having seven pistons, this will give seven different pressure impulses that will superimpose. The time signal from one rotation become unique, but repeat itself for the coming rounds, and cause a fundamental frequency equal to the rotation speed.

[0013] In another example, the output pressure from three of the pistons differs from the other. For a hydraulic piston pump having seven pistons, three pistons may have one size and four may have another size. The emitted pressure impulses from the pistons will superimpose and will give a different sound than from a hydraulic piston pump where all pistons are identical.

[0014] The output pressure or output flow from a piston can be altered in different ways. In all cases, the size of the compressed volume by the piston and/or the pressure in the compression by the piston is altered. In one example, the length of the piston is changed. In another example, the length of the piston rod is changed. In another example, the shape of the upper surface of the piston is changed. In another example, the stiffness of the piston rod is changed. All these changes can be made using a conventional hydraulic piston pump using an existing cylinder barrel. It would also be possible to change the diameter of the piston. This will require a special cylinder barrel.

[0015] In a method for affecting the emitted sound character from a hydraulic piston pump comprising a plurality of pistons arranged in a cylinder barrel, where the cylinder barrel is rotated by an input shaft such that the pistons move back and forth in the cylinder barrel, thereby creating an output pressure and output flow, the step of; providing a specific output pressure or output flow from at least one piston, and providing a specific output pressure or output flow from at least one piston that differs from the output pressure or output flow from the other pistons is comprised.

[0016] By this first embodiment of the method, a hydraulic piston pump that emits a sound where the amplitude of the base frequency is lower and where the distribution of frequencies is narrower is obtained, when compared to a regular hydraulic piston pump.

BRIEF DESCRIPTION OF DRAWINGS

[0017] The invention will be described in greater detail in the following, with reference to the attached drawings, in which

Fig. 1 shows a schematic vehicle provided with a hydraulic piston pump,

Fig. 2 shows a schematic hydraulic piston pump, and

Fig. 3 shows a schematic flow chart of the inventive method.

MODES FOR CARRYING OUT THE INVENTION

[0018] The embodiments of the invention with further developments described in the following are to be regarded only as examples and are in no way to limit the scope of the protection provided by the patent claims.

[0019] Fig. 1 shows a schematic vehicle 20 provided with an inventive hydraulic piston pump 1, adapted to power an auxiliary hydraulic component (not shown) of some type. The vehicle 20 is in the shown example provided with an electric machine 2 and a transmission 3. In some vehicles, the transmission may not be required. The auxiliary hydraulic component may e.g. be a crane, a hoist, a water pump, a lift cylinder, a winch, a compactor or the like. The hydraulic piston pump may be mounted to the transmission, as shown in Fig. 1, or to the electric machine. The hydraulic piston pump may be mounted before or after the gearbox of the transmission, depending on the requirements and the intended use of the hydraulic piston pump. It is also possible to provide the hydraulic piston pump with a separate, integrated electric motor such that a freestanding hydraulic piston pump unit is provided.

[0020] Fig. 2 shows a schematic hydraulic piston pump 1. The hydraulic piston pump can be used to power any auxiliary hydraulic equipment and can be powered in different ways. In the shown example, the hydraulic piston pump is provided with an input shaft 4 suspended on roller bearings and adapted to be connected to a PTO of an electric machine or a transmission, but the hydraulic piston pump may also be provided with an integrated electric motor such that a freestanding hydraulic piston pump unit is provided. The hydraulic piston pump 1 comprises a housing 5 that encloses all the components and that is provided with a fastening interface such that the hydraulic piston pump can be attached to e.g. a transmission. The input shaft drives a timing gear 6 that intermeshes with the cylinder barrel 10 in a rotary fashion. A barrel support 7 supports and guides the cylinder barrel during the rotation of the cylinder barrel.

[0021] The hydraulic piston pump is provided with a number of pistons 8 that are connected to the input shaft 4 through piston shafts 9. A piston may be attached to a piston shaft with e.g. a pin or may be integrated with the piston shaft as a single part. The rotational axle of the input shaft and the rotational axle of the cylinder barrel are offset with an angle, e.g. between 30 to 45 degrees, such that the pistons will move in and out of a cylinder 13 of the cylinder barrel when the cylinder barrel rotates. The hydraulic piston pump is also provided with an end cap 11 that is provided with an input for hydraulic oil and an output for pressurized hydraulic oil.

[0022] In a regular hydraulic piston pump, all pistons and cylinders are identical. This means that the output pressure and output flow from each piston is the same. The emitted sound from the hydraulic piston pump will result from a superposition of all impulses from each piston. Since all pistons are identical, the repetitive pattern

of impulses will occur as many times as there are number of pistons and the resulting spectrum have spars tonal components with a distance between the frequency harmonics equal to the number of pistons times the rotations speed of the hydraulic piston pump. At e.g. 600 rpm, the hydraulic piston pump will emit a ground tone of 70 Hz, with overtones at 140 Hz, 210 Hz, etc. with lower amplitudes.

[0023] In order to affect the emitted sound character from the hydraulic piston pump, one or more pistons are changed, such that the output pressure and/or output flow from that piston differs from the output pressure and/or output flow of the other pistons. The number of pistons that are changed can be varied depending on the desired end result. In one example, all pistons are different from each other. In another example, some of the pistons are changed. For a hydraulic piston pump comprising nine pistons, it is e.g. possible to use two types of pistons, with five pistons of one type and four pistons of another type. It is also possible to use three pistons of a first type, three pistons of a second type and three pistons of a third type.

[0024] With different types of pistons, the hydraulic piston pump will emit more different ground tones, depending on the number of pistons of the hydraulic piston pump and the difference of the pistons. The spread of the frequency of the emitted sound will be smaller with more different pistons. In a hydraulic piston pump having nine pistons, and where one piston is changed, a ground tone of eight times the rotational speed will be dominant. The single different piston will emit a ground tone with a frequency corresponding to the rotational speed of the hydraulic piston pump. The hydraulic piston pump will further emit overtones with a multiple of eight having a relatively high amplitude, and overtones corresponding to a multiple of the rotational speed having a low amplitude.

[0025] With two types of pistons, e.g. five pistons of one type and four pistons of another type, one ground tone of five times the rotational speed and one ground tone of four times the rotational speed will be dominant, but the amplitude of each ground tone will be lower than the amplitude of the ground tone of a hydraulic piston pump having identical pistons. The hydraulic piston pump will further emit overtones having frequencies of multiples of five and multiples of four times the rotational speed. Thus, by varying the types of pistons, and the number of each type, the tonal components in each emitted sound can be altered. By using more different pistons, more different ground tones will be emitted, and the amplitude of each ground tone may be lower than compared to a hydraulic piston pump having identical pistons. The amplitude of the emitted tones may also be changed by changing the displacement of the pump.

[0026] The use of different pistons must of course be related to the total output pressure of the hydraulic piston pump, since each change of the output pressure and/or output flow of a piston may be a degradation of the output pressure and/or output flow from that piston.

[0027] In one example, the length of a piston is changed. In this case, the piston will be shorter than a regular piston, since the original piston length is the maximal length for a piston. By using pistons that are slightly shorter than a regular piston, and by using pistons with different lengths, the tonal character of the emitted sound character can be affected. It is also possible to use piston rods with different length in order to affect the emitted sound character. In some piston pumps, the piston and piston rod are produced as one piece. In this case, the total length of the combination is changed. By using a shorter piston or piston rod, the output pressure and/or the output flow produced by that piston is reduced slightly. At the same time, the emitted sound character will be affected.

[0028] Another way of altering the output pressure and/or output flow is to change the shape of the upper surface of a piston. This will also introduce a somewhat reduced output pressure and/or output flow from that piston. In one example, the upper surface may be provided with differently shaped cavities.

[0029] In another example, the output pressure and/or output flow is altered by using pistons having different diameters. A piston having a diameter that is e.g. larger than the diameter of a regular piston will produce a larger output flow from that piston. At the same time, the emitted sound character from that piston will be affected.

[0030] In another example, the stiffness of the piston shaft differs from the stiffness of a regular piston shaft. By using a piston rod that is not as stiff as a regular piston shaft, the pressure impulse produced by that piston will change, which will also affect the emitted sound character. A less stiff piston rod will flex more, and will thus produce a slightly lower pressure.

[0031] The hydraulic piston pump may be any type of piston pump, such as a bent axis piston pump or a swashplate piston pump.

[0032] Fig. 3 shows a schematic flow chart of the method for modifying emitted sound from a hydraulic piston pump.

[0033] In step 100, a specific output pressure or output flow is provided from at least one piston. The output pressure or output flow is in one example the normal pressure or flow produced by a regular piston.

[0034] In step 110, a specific output pressure or output flow is provided from at least one piston that differs from the output pressure or output flow from the other pistons. By producing different output pressure or output flow from different pistons, the impulses from the different pistons will vary, which may give a more pleasant sound character of the hydraulic pump. The hydraulic pump will contain at least two different pistons. More different pistons will give a different tonal character of the emitted sound, and will contain frequency components that become lower and closer in frequency.

[0035] The invention is not to be regarded as being limited to the embodiments described above, a number of additional variants and modifications being possible

within the scope of the subsequent patent claims.

REFERENCE SIGNS

[0036]

1: Hydraulic piston pump
2: Electric machine
3: Transmission
4: Input shaft
5: Housing
6: Timing gear
7: Barrel support
8: Piston
9: Piston shaft
10: Cylinder barrel
11: End cap
12: Upper surface of piston
13: Cylinder

20: Vehicle

Claims

1. Hydraulic piston pump (1) comprising a plurality of pistons (8), where each piston is arranged in a cylinder barrel (10), **characterized in that** at least one piston (8) is arranged to deliver a specific pressure or output flow that differs from the pressure or output flow delivered by the other pistons (8).

2. Hydraulic piston pump according claim 1, wherein the length of at least one piston (8) differs from the length of the other pistons (8).

3. Hydraulic piston pump according to claim 1, wherein the length of at least one piston shaft (9) differs from the length of the other piston shafts (9).

4. Hydraulic piston pump according to claim 1, wherein the upper surface (12) of at least one piston (8) differs from the upper surface (12) of the other pistons (8).

5. Hydraulic piston pump according to claim 1, wherein the stiffness of at least one piston shaft (9) differs from the stiffness of the other piston shafts (9).

6. Hydraulic piston pump according to claim 1, wherein the diameter of at least one piston (8) differs from the diameter of the other pistons (8).

7. Hydraulic piston pump according to any of claims 1 to 6, wherein the hydraulic piston pump (1) is a bent axis piston pump.

8. Hydraulic piston pump according to any of claims 1 to 6, wherein the hydraulic piston pump (1) is a swashplate piston pump.

9. A vehicle (20) comprising a hydraulic piston pump (1) according to any of claims 1 to 8.

10. Method for affecting the emitted sound character from a hydraulic piston pump comprising a plurality of pistons arranged in a cylinder barrel, where the cylinder barrel is rotated by an input shaft such that the pistons move back and forth in the cylinder barrel, thereby creating an output pressure and output flow, comprising the step of:

    - providing a specific output pressure or output flow from at least one piston, and
    - providing a specific output pressure or output flow from at least one piston that differs from the output pressure or output flow from the other pistons.

11. Method according to claim 10, wherein the different output pressure from at least one piston is obtained by using a piston with a length that differs from the other piston lengths.

12. Method according to claim 10, wherein the different output pressure from at least one piston is obtained by using a piston shaft with a length that differs from the other piston shaft lengths.

13. Method according to claim 10, wherein the different output pressure from at least one piston is obtained by using a piston with an upper shape that differs from the upper shape of the other pistons.

14. Method according to claim 10, wherein the different output pressure from at least one piston is obtained by using a piston shaft with a stiffness that differs from the stiffness of the other piston shafts.

15. Method according to claim 10, wherein the different output flow from at least one piston is obtained by using a piston having a diameter that differs from the diameter of the other pistons.

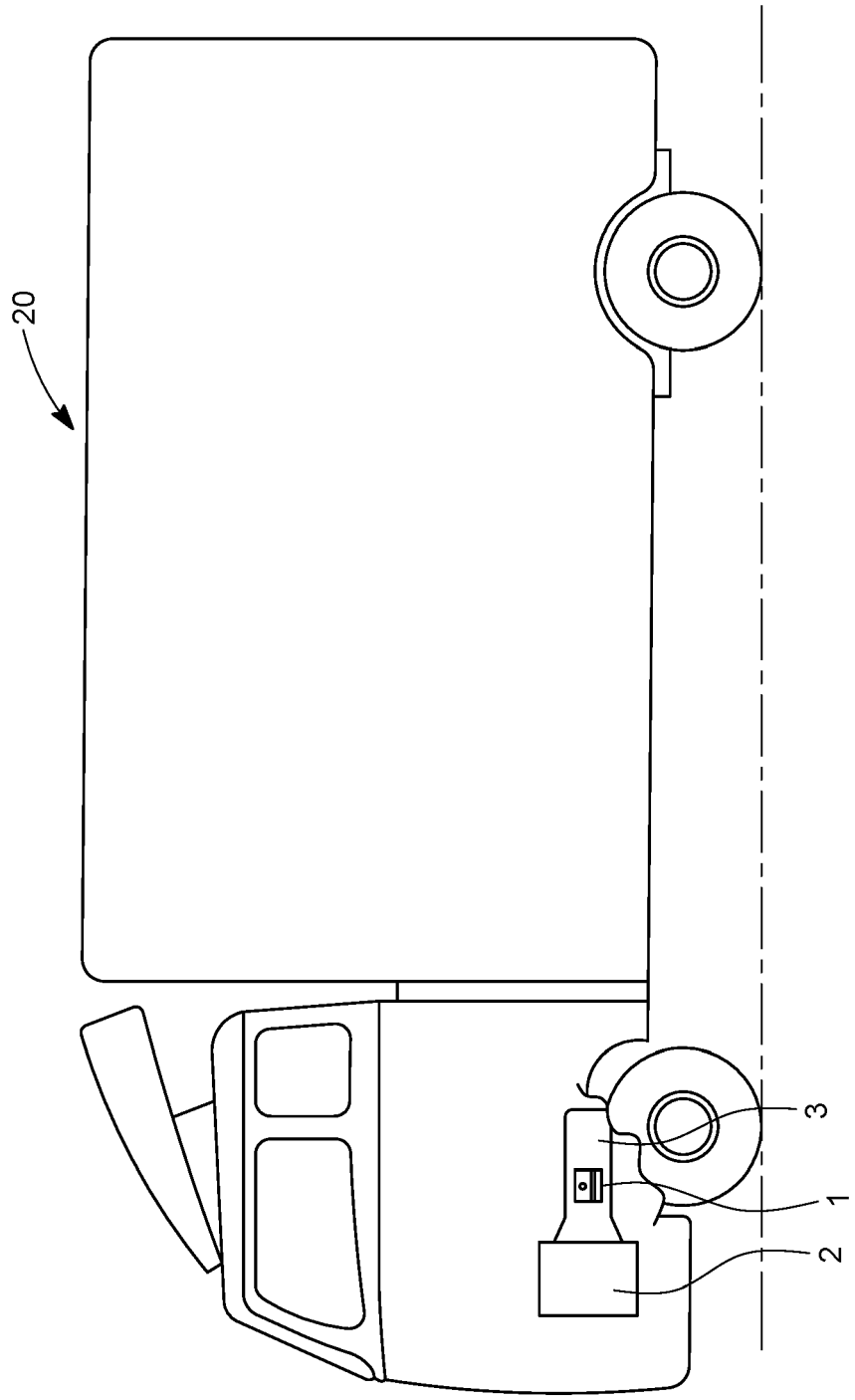

FIG. 1

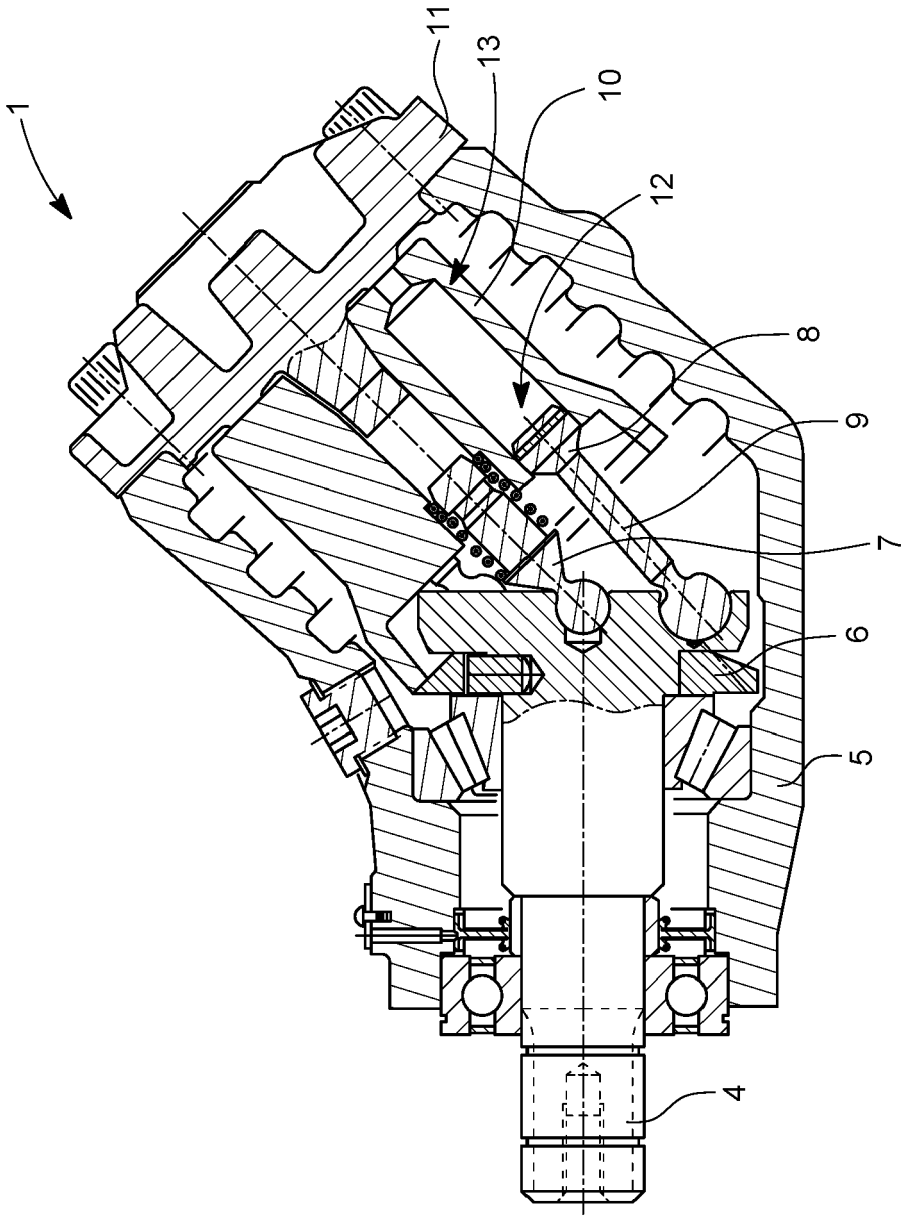

FIG. 2

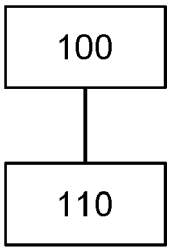

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 0010

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 March 2023	Lange, Christian

CATEGORY OF CITED DOCUMENTS

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