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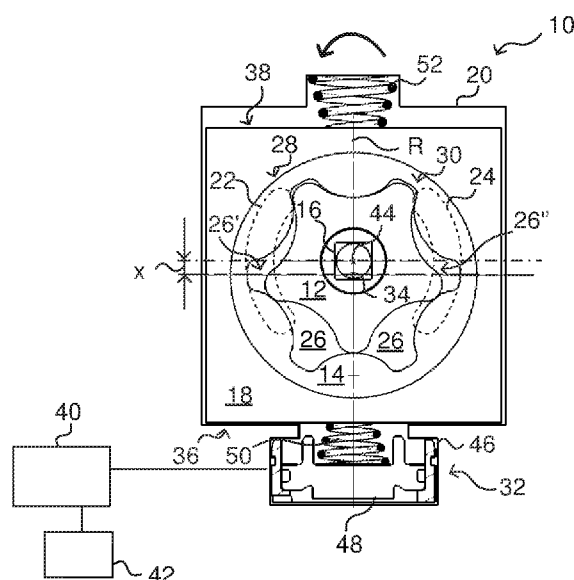
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(54) Title: A REVERSIBLE PUMP AND A METHOD TO CONTROL A REVERSIBLE PUMP**Fig. 3a**

(57) Abstract: The invention relates to a reversible pump (10) for a fluid, comprising an externally toothed inner rotor (12); an internally toothed outer rotor (14) with a circular periphery surrounding the inner rotor (12); a drive shaft (16) concentrically connected to the inner rotor (12), an inner housing (18) surrounding the outer rotor (14); an outer housing (20); an inlet (22) and an outlet (24) for the fluid arranged mirror symmetric on opposing sides of the drive shaft (16) and of a reference line (R) extending perpendicularly to the longitudinal extension of the drive shaft (16), wherein the inner rotor (12) has 10 one less tooth than the outer rotor (14) and wherein the outer rotor (14) is eccentrically arranged in meshing engagement with the inner rotor (12), such that variable cavities (26, 26', 26'') are formed between the inner rotor (12) and the outer rotor (14), wherein the inlet (22) and the outlet (24) are each arranged in fluid communication with a cavity (26', 26''). A positioning device 15 (32) is arranged in connection with the inner housing (18), wherein the positioning device (32) is adapted to be actively controlled to displace the inner housing (18) and the outer rotor (14) based on the rotational direction of the drive shaft (16), such that the centre of rotation of the outer rotor (34) is displaced along the reference line (R). 20 The invention also relates to a method to control such a reversible pump (10), a gearbox (4), a vehicle (1), a computer program (P) and a computer program product. 25

A reversible pump and a method to control a reversible pump

TECHNICAL FIELD

- 5 The present invention relates to a reversible pump according to the preamble of claim 1 and a method to control a reversible pump according to claim 9. The invention also relates to a gearbox comprising such a reversible pump according to claim 14 and a vehicle comprising such a reversible pump according to claim 15. The invention further relates to a computer program according to claim 16 and a computer program product comprising program code according to claim 17.
- 10

BACKGROUND

- 15 Positive displacement pumps are widely used in various applications and typically have an expanding cavity on a suction side and a decreasing cavity on a discharge side. A fluid flows into the pump as the cavity on the suction side expands and the fluid flows out of the pump when the cavity decreases on the discharge side. The flow through the pump is constant for each cycle of operation. Gerotor pumps (Generated Rotor pumps) are a type of positive displacement pump which is specifically suitable for low pressure applications. Gerotor pumps may thus be suitable for example for light fuel oils, lube oils, cooking oils and hydraulic fluids. A gerotor pump comprises an inner and an outer rotor, wherein the inner rotor is externally toothed and the outer rotor is internally toothed. The outer rotor is eccentrically arranged surrounding the inner rotor. The inner rotor has one less tooth than the outer rotor and is fixedly connected to a drive element. When the drive element is rotating, the inner rotor rotates in the same direction and meshes with the outer rotor and causes the outer rotor to rotate as well. During rotation of the two rotors cavities are created between the inner rotor and the outer rotor, which cavities changes continuously. On the suction side a cavity expands, negative pressure is created and the fluid may thereby flow through an inlet into the cavity. On the
- 20
- 25
- 30

discharge side a cavity decreases, compression occurs and the fluid is pumped out from the cavity through an outlet. The displacement of a gerotor pump is thus a function of the dimensions of the two rotors and the amount of eccentricity between them.

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Document US20140023539 A1 describes an oil pump comprising an inner and an outer rotor, wherein the discharge volume is varied between low-speed rotation and high-speed rotation due to rotation of a reference line linking a centre of rotation of the inner rotor and the outer rotor. The rotors are rotated
10 by a surrounding guide mechanism which can be manoeuvred to different positions by an adjustment mechanism.

Typically, the inner rotor of a gerotor pump is driven in one specific direction. In some applications however, it would be advantageous if the pump could be
15 driven both clockwise and counter-clockwise. If the rotation of the inner rotor changes direction in a non-reversible gerotor pump, the flow through the pump would be inverted and the fluid would be discharged through the inlet and vice versa. This could obviously cause various problems and it is therefore desirable to maintain the flow direction through the pump independent of the
20 direction of rotation of the rotors. Such reversibility of a gerotor pump is typically obtained by one or multiple friction elements arranged between the outer rotor and a housing surrounding the outer rotor, wherein the friction elements are used to rotate the outer rotor for example 180 degrees.

25 SUMMARY OF THE INVENTION

Despite known solutions in the field, there is still a need to develop a positive displacement pump which is reversible and thus delivers a fluid in a predetermined manner regardless of direction of rotation of the rotors.

30

An object of the present invention is to achieve a positive displacement pump which is reversible.

Another object of the invention is to achieve a reversible positive displacement pump, which minimizes drag losses and wear.

- 5 A further object of the invention is to achieve a reversible positive displacement pump with optimized efficiency.

Another object of the invention is to achieve a method to control a reversible positive displacement pump.

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Another object of the present invention is to achieve a new and advantageous computer program for controlling a reversible positive displacement pump.

- 15 The herein mentioned objects are achieved by a vehicle system characterized by the features in the characterizing part of claim 1.

The herein mentioned objects are achieved by a method characterized by the features in the characterizing part of claim 9.

- 20 The herein mentioned objects are also achieved by a gearbox characterized by the features in the characterizing part of claim 14.

The herein mentioned objects are also achieved by a vehicle characterized by the features in the characterizing part of claim 15.

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The herein mentioned objects are also achieved by a computer program for controlling a reversible pump characterized by the features in the characterizing part of claim 16.

- 30 The herein mentioned objects are also achieved by a computer program product for controlling a reversible pump characterized by the features in the characterizing part of claim 17.

According to an aspect of the present invention a reversible pump for a fluid is provided. The pump comprises an externally toothed inner rotor; an internally toothed outer rotor with a circular periphery, wherein the outer rotor surrounds
5 the inner rotor; a drive shaft concentrically connected to the inner rotor, an inner housing surrounding the outer rotor; an outer housing; an inlet and an outlet for the fluid arranged mirror symmetric on opposing sides of the drive shaft and of a reference line extending perpendicularly to the longitudinal extension of the drive shaft, wherein the inner rotor has one less tooth than the
10 outer rotor and wherein the outer rotor is eccentrically arranged in meshing engagement with the inner rotor, such that variable cavities are formed between the inner rotor and the outer rotor, wherein the inlet and the outlet are each arranged in fluid communication with a cavity. A positioning device is arranged in connection with the inner housing, wherein the positioning device
15 is adapted to be actively controlled to displace the inner housing and the outer rotor based on the rotational direction of the drive shaft, such that the centre of rotation of the outer rotor is displaced along the reference line.

The inner housing is suitably arranged in direct contact with the outer rotor.
20 This means that if the positioning device is actively controlled to displace the inner housing, the outer rotor is similarly displaced.

The reversible pump according to the invention is a positive displacement pump and more specifically a gerotor pump. The inner rotor and the outer rotor
25 are thus eccentrically arranged whereby the cavities formed between the inner and the outer rotor continuously changes in size/volume during rotation of the inner and the outer rotor. When the drive shaft rotates the inner rotor rotates in the same direction. The inner rotor meshes with the outer rotor which rotates in the same direction as well. The pump has a suction side where the cavities
30 expand and a discharge side where the cavities decrease. The inlet is thus suitably arranged on the suction side in fluid communication with a cavity which expands and the outlet is suitably arranged on the discharge side in fluid

communication with a cavity which decreases. When the cavity in fluid communication with the inlet is expanding, negative pressure or vacuum is created and the fluid is sucked in through the inlet to the cavity. The fluid may thereafter flow between the inner rotor and the outer rotor until it reaches the

5 cavity in fluid communication with the outlet. This cavity decreases and compression is created such that the fluid is pushed/pumped out through the outlet. By configuring the reversible pump with a positioning device adapted to be actively controlled to displace the inner housing and the outer rotor based on the direction of rotation of the drive shaft, it is ensured that the cavity in fluid

10 communication with the inlet always expands and that the cavity in fluid communication with the outlet always decreases. This way, the fluid is always entering through the inlet by suction and is always pumped out through the outlet by compression. The flow direction through the pump is thus maintained regardless of the direction of rotation of the drive shaft and the two rotors, and

15 the pump is thereby reversible. This may be specifically advantageous for example when the pump constitutes an oil pump providing lubrication to a gearbox. A non-reversible pump driven by a drive shaft which can rotate in two different directions would start sucking oil from the gearbox and discharge it in the oil sump when the drive shaft rotates in the wrong direction. In commonly

20 known reversible pumps friction elements are arranged between the outer rotor and what herein is called the inner housing. The friction elements rotate the inner housing and the outer rotor when the drive shaft changes direction. The displacement of the inner housing and the outer rotor is thus a direct result of the rotational direction of the drive shaft, due to the friction elements. The

25 friction elements are constantly abutting the outer rotor and the housing and thus cause friction losses and abrasion. According to the present invention the positioning device is actively controlled to displace the inner housing and the outer rotor only when it is needed, that is, only when the direction of rotation changes. This way, no additional friction elements between the outer rotor and

30 the inner housing are needed in order to render the pump reversible. The reversible pump according to the present invention thus enables a substantially frictionless displacement of the outer rotor and the inner housing.

Drag losses and unnecessary wear on the pump is thereby avoided and a reversible positive displacement pump is achieved, which has an optimized efficiency.

- 5 The inner rotor suitably has a trochoidal shape. The inner rotor may have n teeth and the outer rotor thus has $n+1$ teeth, where n could be any number, preferably a number between 4-20. The inner rotor may be referred to as an inner gear and the outer rotor may be referred to as an outer gear.
- 10 The inlet and the outlet, the inner rotor and the outer housing are arranged in fixed positions in relation to each other. The inner housing and the outer rotor are movably arranged. It is thus only the outer rotor and the inner housing that may be laterally displaced in relation to the other components. The inlet and the outlet are suitably configured as channels in the outer housing. The inlet is
- 15 preferably configured such that it is in fluid communication with an expanding cavity both when the drive shaft rotates clockwise and when it rotates counter-clockwise. The outlet is preferably configured such that it is in fluid communication with a decreasing cavity both when the drive shaft rotates clockwise and when it rotates counter-clockwise. The inlet and the outlet are
- 20 preferably shaped with an arc-shaped inlet area and outlet area respectively. The inlet area and the outlet area may extend substantially in the same direction as the reference line.

- The outer housing is surrounding the inner housing, the outer rotor and the
- 25 inner rotor. The outer housing suitably also surrounds the positioning device or at least partly surrounds the positioning device. The outer housing may be the housing of a machine to which the reversible pump is connected. The outer housing may be a housing of for example a gearbox. The outer housing and the inner housing may have any shape. According to an aspect of the present
- 30 invention the inner rotor and the outer rotor has substantially the same peripheral shape.

The drive shaft may be a shaft of a machine to which the reversible pump is connected. In the case where the pump is connected to a gearbox in order to provide a lubricant to the gearbox, the drive shaft may be a shaft of the gearbox. The drive shaft may thus be a lay shaft, an input shaft or an output shaft of a gearbox.

The reference line is a line linking the centre of rotation of the inner rotor and the centre of rotation of the outer rotor. The reference line is a centre line extending symmetrically through the cross-section of the outer housing and the inner housing. The reference line is suitably extending along the diameter of the circular periphery of the outer rotor.

According to an embodiment of the invention, when the drive shaft rotates counter-clockwise, the positioning device is adapted to displace the inner housing and the outer rotor, such that the centre of rotation of the outer rotor is on a predetermined distance x from the centre of rotation of the inner rotor on a first side of the centre of rotation of the inner rotor. The positioning device is likewise adapted to displace the inner housing and the outer rotor, such that the centre of rotation of the outer rotor is a predetermined distance x from the centre of rotation of the inner rotor on a second side of the centre of rotation of the inner rotor, when the drive shaft rotates clockwise. The second side is opposite the first side. The first side is suitably closer to the positioning device than the second side. The centre of rotation of the outer rotor is thus always the same predetermined distance x from the centre of rotation of the inner rotor, but on opposite sides of the centre of rotation of the inner rotor along the reference line. Suitably, the centre of rotation of the inner rotor is referred to as the zero level, whereby the centre of rotation of the outer rotor is a positive distance $+x$ from the centre of rotation of the inner rotor when the drive shaft rotates clockwise and a negative distance $-x$ when the drive shaft rotates counter-clockwise. This way, the inlet is always in fluid communication with an expanding cavity and the outlet is always in fluid communication with a

decreasing cavity and the flow direction through the pump is maintained regardless of direction of rotation of the drive shaft.

The predetermined distance x may be a distance between 1-10 mm. The
5 predetermined distance x is preferably a distance between 1-5 mm.

According to an embodiment of the invention the positioning device is adapted to linearly displace the inner housing and the outer rotor. The positioning device is suitably adapted to displace the inner housing and the outer rotor in a
10 direction parallel with the reference line. The positioning device is thus adapted to be actively controlled to displace the inner housing and the outer rotor along a straight line. The positioning device is thus adapted to be controlled to displace the inner housing and the outer rotor the distance $2 \cdot x$, such that the centre of rotation of the outer rotor is a predetermined distance x from the
15 centre of rotation of the inner rotor on either the first or the second side of the centre of rotation of the inner rotor. This way, an easy way of substantially frictionless displacement of the outer rotor is achieved.

According to an embodiment of the invention the positioning device is adapted
20 to displace the inner housing and the outer rotor through a rotational movement. In this case, the inner housing is in the shape of an eccentric ring surrounding the outer rotor. The positioning device is thus adapted to act on the inner housing such that it rotates inside the outer housing. When the inner housing rotates, the outer rotor rotates and due to the eccentricity of the inner
25 housing the centre of rotation of the outer rotor is displaced along the reference line. The inner housing is preferably rotated such that the outer rotor is rotated 180 degrees. This way, an alternative way of substantially frictionless displacement of the outer rotor is achieved.

30 According to an aspect of the invention the positioning device is arranged on a first side of the inner housing. When the drive shaft is rotating clockwise, the positioning device is controlled to displace the inner housing and the outer

rotor, such that the centre of rotation of the outer rotor is displaced in a direction away from the positioning device to the second side of the centre of rotation of the inner rotor. When the drive shaft is rotating counter-clockwise, the positioning device is controlled to displace the inner housing and the outer
5 rotor, such that the centre of rotation of the outer rotor is displaced in a direction towards the positioning device to the first side of the centre of rotation of the inner rotor.

The positioning device preferably has an idle state and an active state. In the
10 idle state the inner housing and the outer rotor are displaced such that the centre of rotation of the outer rotor is on the first side of the centre of rotation of the inner rotor. The positioning device is thus in its idle state when the drive shaft rotates counter-clockwise. In the active state the inner housing and the outer rotor are displaced such that the centre of rotation of the outer rotor is on
15 the second side of the centre of rotation of the inner rotor. The positioning device is thus in its active state when the drive shaft rotates clockwise.

According to an embodiment of the invention the positioning device comprises a pneumatic cylinder. The pneumatic cylinder suitably comprises a cylinder
20 pipe and piston means arranged inside the cylinder. An arrangement for supply of compressed air is arranged in connection to the cylinder. Compressed air may thus be provided inside the cylinder, wherein the compressed air acts on the piston means such that the piston means moves in a desired direction. The idle state of the positioning device constituting a
25 pneumatic cylinder suitably means that the piston means is in a retracted position. The active state of the pneumatic cylinder suitably means that the piston means is in an extracted position. According to an embodiment the positioning device comprises a first spring element. The first spring element is thus preferably arranged inside the cylinder pipe for resilient return of the
30 piston means. The spring may be arranged outside the cylinder pipe. Alternatively the positioning device comprises a pneumatic device or any

device which can be controlled to displace the inner housing and the outer rotor.

In the case where the positioning device is adapted to displace the inner housing and the outer rotor linearly, the positioning device is preferably arranged symmetrically relative to the reference line on the first side of the inner housing. When the positioning device comprises a pneumatic cylinder, the positioning device is arranged such that the piston means moves in the direction of the reference line. The first spring element may be arranged such that it abuts the inner housing. The piston means is suitably arranged such that compressed air may be provided between the piston means and the cylinder. When compressed air is provided inside the cylinder it acts on the piston means, wherein the piston means is pushed in direction towards the inner housing to its extracted state. The first spring element is thereby compressed between the inner housing and the piston means. The inner housing and the outer rotor are thus linearly displaced in the direction of the reference line away from the positioning device. When the air pressure is removed, no load is applied on the first spring element and the spring element thus automatically returns to its neutral state and the piston means is moved in the direction away from the inner housing to its retracted position. This way, the inner housing and the outer rotor are linearly displaced in the direction towards the positioning device.

A second spring element may be arranged symmetrically relative to the reference line on a second side of the inner housing. The second spring element is suitably arranged between the outer housing and the inner housing. The second side of the inner housing is suitably opposite the first side of the inner housing and thus opposite the positioning device. When the positioning device is controlled to displace the centre of rotation of the outer rotor in the direction away from the positioning device, the second spring element is compressed. When the positioning device is controlled to displace the centre of rotation of the outer rotor in the direction towards the positioning device, the

load on the second spring is decreased whereby the second spring element returns to its neutral state and thereby acts on the inner housing and facilitates the displacement.

- 5 In the case where the positioning device is adapted to displace the inner housing and the outer rotor through a rotational movement, the positioning device is suitably arranged on the first side of the inner housing. When the positioning device comprises a pneumatic cylinder, the positioning device is preferably arranged such that the piston means moves in a direction
- 10 perpendicular to the reference line. A second spring element is suitably arranged symmetrically relative to the reference line on a second side of the inner housing. The positioning device suitably further comprises a displacement device connected to the first spring element of the pneumatic cylinder. The displacement device is arranged in contact with the outer
- 15 periphery of the inner housing. The displacement device may be a toothed rack, a belt or similar. When the air pressure inside the cylinder changes, the piston means and thus the displacement device moves and the inner housing, being an eccentric ring, rotates. Preferably, when the drive shaft rotates clockwise, compressed air is provided to act on the piston means. The piston
- 20 means moves to its extracted position and the inner housing is rotated clockwise. Due to the eccentricity of the inner housing, the second spring element is compressed by the load and the centre of rotation of the outer rotor is displaced along the reference line to the second side of the centre of rotation of the inner rotor, away from the positioning device. When the drive shaft
- 25 rotates counter-clockwise, the air pressure is removed and the load applied on the second spring is lower than its spring force. The second spring element thus returns to its neutral state, whereby the displacement device and the piston means are moved to the retracted position and the inner housing rotates counter-clockwise. This way, the centre of rotation of the outer rotor is
- 30 displaced along the reference line to the first side of the centre of rotation of the inner rotor, towards the positioning device.

- According to an embodiment of the invention a method to control a reversible pump for a fluid is provided. The reversible pump comprises an externally toothed inner rotor; an internally toothed outer rotor with a circular periphery, wherein the outer rotor surrounds the inner rotor; a drive shaft concentrically connected to the inner rotor; an inner housing surrounding the outer rotor; an outer housing; an inlet and an outlet for the fluid arranged mirror symmetric on opposing sides of the drive shaft and of a reference line extending perpendicularly to the longitudinal extension of the drive shaft, wherein the inner rotor has one less tooth than the outer rotor and wherein the outer rotor is eccentrically arranged in meshing engagement with the inner rotor, such that variable cavities are formed between the inner rotor and the outer rotor, wherein the inlet and the outlet are each arranged in fluid communication with a cavity. The method comprises the steps to:
- a) identify the direction of rotation of the drive shaft;
 - b) control a positioning device arranged in connection with the inner housing, to displace the inner housing and the outer rotor based on the rotational direction of the drive shaft, such that the centre of rotation of the outer rotor is displaced along the reference line.
- The direction of rotation of the drive shaft may be determined in step a) by a sensor. The sensor is suitably arranged in communication with a control unit. The control unit is further arranged in communication with the positioning device. The control unit thus controls the positioning device in step b) based on the rotational direction of the drive shaft, such that the centre of rotation of the outer rotor is displaced along the reference line. In the case where the positioning device is a pneumatic cylinder, the control unit controls the supply of compressed air into the cylinder and thus controls the movement of the piston means.
- In the case where it is identified that the drive shaft rotates counter-clockwise in step a), the positioning device is controlled to displace the inner housing and the outer rotor in step b), such that the centre of rotation of the outer rotor is on

a predetermined distance x from the centre of rotation of the inner rotor on a first side of the centre of rotation of the inner rotor. In the case where it is identified that the drive shaft rotates clockwise in step a), the positioning device is controlled to displace the inner housing and the outer rotor in step b),
5 such that the centre of rotation of the outer rotor is a predetermined distance x from the centre of rotation of the inner rotor on a second side of the centre of rotation of the inner rotor. The second side is suitably opposite the first side. The centre of rotation of the outer rotor is thus always the same predetermined distance x from the centre of rotation of the inner rotor, but on opposite sides
10 of the centre of rotation of the inner rotor, along the reference line. This way, the inlet is in fluid communication with an expanding cavity and the outlet is in fluid communication with a decreasing cavity independently of the rotational direction of the drive shaft. The flow direction through the pump is thereby maintained regardless of direction of rotation of the drive shaft. The
15 predetermined distance x is preferably a distance between 1-5 mm.

According to an aspect of the invention the positioning device is arranged on a first side of the inner housing. When it is identified that the drive shaft is rotating clockwise in step a), the positioning device is controlled in step b) to
20 displace the inner housing and the outer rotor, such that the centre of rotation of the outer rotor is displaced in a direction away from the positioning device to the second side of the centre of rotation of the inner rotor. When it is identified that the drive shaft is rotating counter-clockwise in step a), the positioning device is controlled in step b) to displace the inner housing and the outer rotor,
25 such that the centre of rotation of the outer rotor is displaced in a direction towards the positioning device to the first side of the centre of rotation of the inner rotor.

According to an embodiment of the invention the inner housing and the outer
30 rotor are linearly displaced in step b). The inner housing and the outer rotor are preferably linearly displaced in a direction parallel with the reference line. The positioning device is thus controlled in step b) to displace the inner housing

and the outer rotor the distance $2 \cdot x$, such that the centre of rotation of the outer rotor is a distance x from the centre of rotation of the inner rotor on either the first or the second side of the centre of rotation of the inner rotor. This way, an easy way of substantially frictionless displacement of the outer rotor is achieved.

According to an embodiment of the invention the positioning device is controlled to displace the inner housing and the outer rotor through a rotational movement in step b). In this case, the inner housing is in the shape of an eccentric ring surrounding the outer rotor. The positioning device is thus controlled to act on the inner housing such that it rotates inside the outer housing. When the inner housing rotates, the outer rotor rotates and due to the eccentricity of the inner housing the centre of rotation of the outer rotor is displaced along the reference line. The positioning device is preferably controlled to displace the inner housing in step b) such that the outer rotor is rotated 180 degrees.

Actions and features described herein as being associated with a counter-clockwise rotational direction of the drive shaft may alternatively be associated with a clockwise rotational direction of the drive shaft and vice versa.

According to an aspect of the invention, a computer program is provided, wherein said computer program comprises programme code for causing an electronic control unit or a computer connected to the electronic control unit to perform the steps according to the herein mentioned method.

According to an aspect of the invention a computer programme product is provided, comprising a programme code stored on a computer-readable medium for performing the method steps according to the herein mentioned method, when said computer programme is run on an electronic control unit or a computer connected to the electronic control unit.

Further objects, advantages and novel features of the present invention will become apparent to one skilled in the art from the following details, and also by putting the invention into practice. Whereas the invention is described below, it should be noted that it is not restricted to the specific details
5 described. Specialists having access to the teachings herein will recognise further applications, modifications and incorporations within other fields, which are within the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

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For fuller understanding of the present invention and further objects and advantages of it, the detailed description set out below should be read together with the accompanying drawings, in which the same reference notations denote similar items in the various diagrams, and in which:

15

- Figure 1 schematically illustrates a vehicle according to an embodiment of the invention;
- Figure 2a schematically illustrates a reversible pump according to an embodiment of the invention;
- 20 Figure 2b schematically illustrates a reversible pump according to an embodiment of the invention;
- Figure 3a schematically illustrates a reversible pump according to an embodiment of the invention;
- Figure 3b schematically illustrates a reversible pump according to an
25 embodiment of the invention;
- Figure 4a schematically illustrates a reversible pump according to an embodiment of the invention;
- Figure 4b schematically illustrates a reversible pump according to an embodiment of the invention;
- 30 Figure 5 illustrates a flow chart for a method according to an embodiment of the invention; and

Figure 6 schematically illustrates a control unit or computer according to an embodiment of the invention.

5 DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 schematically shows a side view of a vehicle 1 according to an embodiment of the invention. The vehicle 1 comprises an internal combustion engine 2 and a gearbox 4. The gearbox 4 is also connected to the driving
10 wheels 8 of the vehicle 1 through an output shaft of the gearbox (not shown). A reversible pump 10 according to the invention is connected to the gearbox 4 in order to provide a fluid such as a lubricant to the gearbox 4. The vehicle 1 may be a heavy vehicle, e.g. a truck or a bus. The vehicle 1 may alternatively be a passenger car.

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Figures 2a and 2b schematically shows a reversible pump 10 for a fluid according to an embodiment of the invention. The pump 10 is a gerotor. The pump 10 thus comprises an externally toothed inner rotor 12; an internally toothed outer rotor 14 with a circular periphery surrounding the inner rotor 12;
20 a drive shaft 16 concentrically connected to the inner rotor 12; an inner housing 18 surrounding the outer rotor 14; an outer housing 20; an inlet 22 and an outlet 24 for the fluid, arranged mirror symmetric on opposing sides of the drive shaft 16 and of a reference line R extending perpendicularly to the longitudinal extension of the drive shaft 16, wherein the inner rotor 12 has one
25 less tooth than the outer rotor 14 and wherein the outer rotor 14 is eccentrically arranged in meshing engagement with the inner rotor 12, such that variable cavities 26 are formed between the inner rotor 12 and the outer rotor 14, wherein the inlet 22 and the outlet 24 are each arranged in fluid communication with a cavity 26. The inlet 22 is in fluid communication with an
30 expanding cavity 26' and the outlet 24 is in fluid communication with a decreasing cavity 26''.

The pump 10 may be connected to a gearbox 4 of a vehicle 1 (see Fig. 1). The fluid is thus a lubricant such as oil. The outer housing 20 surrounds the inner housing 18, the outer rotor 14 and the inner rotor 12. The outer housing 20 may be the housing of the gearbox 4. The drive shaft 16 may be a shaft of the gearbox 4 which can rotate in two directions. The inner housing 18 is arranged in contact with the outer rotor 14. The outer housing 20, the inlet 22, the outlet 24 and the inner rotor 12 are fixedly arranged relative each other. The inner housing 18 and the outer rotor 14 are movably arranged. The inlet 22 and the outlet 24 are channels in the outer housing 20 and the inlet area and the outlet area are arc-shaped. The inlet 22 is suitably connected to a container with the fluid (not shown) and the outlet 24 is suitably connected to the components of the gearbox 4. The inlet 22 is arranged on a suction side 28 of the pump 10 and the outlet 24 is arranged on a discharge side 30 of the pump 10. The inner rotor 12 has five teeth and the outer rotor 14 has six teeth, however, the inner rotor 12 may have any number of teeth as long as the outer rotor 14 has one tooth more. The reference line R extends symmetrically through the cross-section of the inner housing 18 and the outer housing 20. The reference line R also extends along the diameter of the circular periphery of the outer rotor 14, between the inlet 22 and the outlet 24.

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A positioning device 32 is arranged in connection with the inner housing 18. The positioning device 32 is adapted to be actively controlled to displace the inner housing 18 and the outer rotor 14 based on the rotational direction of the drive shaft 16, such that the centre of rotation of the outer rotor 34 is displaced along the reference line R. In this embodiment the positioning device 32 is adapted to be controlled to linearly displace the inner housing 18 and the outer rotor 14 in a direction parallel to the reference line R. The positioning device 32 is symmetrically arranged at a first side of the inner housing 36 and has an idle state and an active state. The positioning device 32 is adapted to displace the inner housing 18 and the outer rotor 14 inside the outer housing 20, along a straight line. The inner housing 18 and the outer rotor 14 may thus be moved away from and towards the positioning device 32. The positioning device 32

may be a pneumatic cylinder, a hydraulic device or any form of device which can be controlled to displace the inner housing 18 and the outer rotor 14 linearly.

- 5 An electronic control unit 40 is arranged in communication with the positioning device 32. The control unit 40 is adapted to control the positioning device 32 such that it displaces the inner housing 18 and the outer rotor 14 based on the direction of rotation of the drive shaft 16. A computer 42 may be connected to the control unit 40.

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Figure 2a shows an embodiment of the invention where the drive shaft 16 rotates counter-clockwise as indicated by an arrow above the pump 10. The positioning device 32 has been controlled to the idle state and the centre of rotation of the outer rotor 34 is a distance x from the centre of rotation of the inner rotor 44, on a first side of the centre of rotation of the inner rotor 44. The centre of rotation of the outer rotor 34 is thus closer to the positioning device 32 than the centre of rotation of the inner rotor 44. As the drive shaft 16 rotates the inner rotor 12 and the outer rotor 14 rotates in the same direction as the drive shaft 16. The cavities 26 between the inner rotor 12 and the outer rotor 14 continuously vary in volume. The cavity 26' in fluid communication with the inlet 22 is expanding as the rotors 12, 14 rotate whereby a negative pressure is created and fluid is sucked through the inlet 22 into the cavity 26'. The fluid flows between the inner rotor 12 and the outer rotor 14 and on the discharge side 30 the cavity 26'' in fluid communication with the outlet 24 decreases in size. Compression of the fluid occurs and the fluid is pumped out through the outlet 24.

Figure 2b shows an embodiment of the invention where the drive shaft 16 rotates clockwise as indicated by an arrow above the pump 10. The positioning device 32 has been controlled to the active state and the centre of rotation of the outer rotor 34 is a distance x from the centre of rotation of the inner rotor 44, on a second side of the centre of rotation of the inner rotor 44. The centre

of rotation of the outer rotor 34 is thus further away from the positioning device 32 than the centre of rotation of the inner rotor 44. Due to the displacement of the outer rotor 14 the cavity 26' in fluid communication with the inlet 22 is still expanding when the drive shaft 16 rotates clockwise and the cavity 26'' in fluid communication with the outlet 24 decreases. This way, the flow through the pump 10 is maintained regardless of the direction of rotation of the drive shaft 16 and a reversible pump 10 without the disadvantages of friction elements is achieved.

Figure 3a and 3b schematically shows a reversible pump 10 for a fluid according to an embodiment of the invention. The pump 10 is configured as described in Figure 2a and 2b and the positioning device 32 comprises a pneumatic cylinder 32. The positioning device 32 thus comprises a cylinder pipe 46, a piston means 48 and a first spring element 50. The positioning device 32 is arranged such that the piston means 48 moves in a direction parallel with the reference line R. The first spring element 50 is connected to the piston means 48 and abuts the inner housing 18. Alternatively, the first spring element 50 is surrounding the piston means 48, wherein the piston means 48 abuts the inner housing 18. As the piston means 48 moves due to the air pressure inside the cylinder 46, the inner housing 18 and the outer rotor 14 are linearly displaced. An arrangement for supply of compressed air (not shown) is arranged in connection to the positioning device 32. The control unit 40 is thus adapted to control the supply of compressed air to the cylinder 46 and thereby control the position of the piston means 48 and thus the displacement of the inner housing 18 and the outer rotor 14. A second spring element 52 is arranged on a second side of the inner housing 38, opposite the first side 36. The second spring element 52 is thus arranged opposite the positioning device 32. The second spring element 52 abuts the inner housing 18 and is arranged inside the outer housing 20.

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Figure 3a shows an embodiment of the invention where the drive shaft 16 rotates counter-clockwise and the positioning device 32 is controlled to the idle

state where there is no air pressure inside the cylinder 46. Since there is no air pressure acting on the piston means 48, no load is applied on the first spring element 50 and the first spring element 50 is thus in a neutral state. The second spring element 52 is likewise in its neutral state. The piston means 48 is in a retracted position. The inner housing 18 and the outer rotor 14 have thus been displaced such that the centre of rotation of the outer rotor 34 is a distance x from the centre of rotation of the inner rotor 44, on the first side of the centre of rotation of the inner rotor 44. The centre of rotation of the outer rotor 34 is thereby closer to the positioning device 32 than the centre of rotation of the inner rotor 44.

Figure 3b shows an embodiment of the invention where the drive shaft 16 rotates clockwise and the positioning device 32 is controlled to the active state where compressed air is provided inside the cylinder 46. The control unit 40 has controlled the supply of compressed air into the cylinder 46 such that the piston means 48 is moved by the compressed air to a retracted position. The piston means 48 thus linearly displaces the inner housing 18 and the outer rotor 14 away from the positioning device 32. The first spring element 50 is thereby compressed between the piston means 48 and the inner housing 18. The second spring element 52 is in a compressed state as the inner housing 18 is pressed against it. The centre of rotation of the outer rotor 34 is thus a distance x from the centre of rotation of the inner rotor 44, on the second side of the centre of rotation of the inner rotor 44. The centre of rotation of the outer rotor 34 is thereby further away from the positioning device 32 than the centre of rotation of the inner rotor 12. Should the drive shaft 16 start rotating counter-clockwise again, the control unit 40 controls the positioning device 32 such that the air pressure is removed. With no air pressure acting on the piston means 48, there is no load applied on the first spring element 50 and the first spring element 50 thus returns to its neutral state. The piston means 48 is thereby moved to the retracted position, and the inner housing 18 and the outer rotor 14 are thereby linearly displaced in the direction towards the positioning device 32. With no air pressure in the cylinder 46, there is no longer any load applied

to the second spring element 52. The second spring element 52 thus returns to its neutral state and thereby facilitates the displacement of the inner housing 18.

5 Figures 4a and 4b schematically shows a reversible pump 10 for a fluid according to an embodiment of the invention. The pump 10 is a gerotor. The pump 10 thus comprises an externally toothed inner rotor 12; an internally toothed outer rotor 14 with a circular periphery surrounding the inner rotor 12; a drive shaft 16 concentrically connected to the inner rotor 12, an inner
10 housing 18 surrounding the outer rotor 14; an outer housing 20; an inlet 22 and an outlet 24 for the fluid arranged mirror symmetric on opposing sides of the drive shaft 16 and of a reference line R extending perpendicularly to the longitudinal extension of the drive shaft 16, wherein the inner rotor 12 has one less tooth than the outer rotor 14 and wherein the outer rotor 14 is eccentrically
15 arranged in meshing engagement with the inner rotor 12, such that variable cavities 26 are formed between the inner rotor 12 and the outer rotor 14, wherein the inlet 22 and the outlet 24 are each arranged in fluid communication with a cavity 26. The inlet 22 is in fluid communication with an expanding cavity 26' and the outlet 24 is in fluid communication with a
20 decreasing cavity 26''.

The pump 10 may be connected to a gearbox 4 of a vehicle 1 (see Fig. 1). The fluid is thus a lubricant such as oil. The outer housing 20 surrounds the inner housing 18, the outer rotor 14 and the inner rotor 12. The outer housing 20
25 may be the housing of the gearbox 4. The drive shaft may be a shaft of the gearbox 4 which can rotate in two directions. The inner housing 18 is an eccentric ring and is arranged in contact with the outer rotor 14. The outer housing 20, the inlet 22, the outlet 24 and the inner rotor 12 are laterally fixedly arranged relative each other. The inner housing 18 and the outer rotor 14 are
30 movably arranged. The inlet 22 and the outlet 24 are channels in the outer housing 20 and the inlet area and the outlet area are arc-shaped. The inlet 22 is suitably connected to a container containing the fluid (not shown) and the

outlet 24 is suitably connected to the components of the gearbox 4. The inlet 22 is arranged on a suction side 28 of the pump 10 and the outlet 24 is arranged on a discharge side 30 of the pump 10. The inner rotor 12 has five teeth and the outer rotor 14 has six teeth, however, the inner rotor 12 may have any
5 number of teeth as long as the outer rotor 14 has one tooth more. The reference line R extends along the diameter of the circular periphery of the outer rotor 14 between the inlet 22 and the outlet 24.

A positioning device 32 is arranged in connection with the inner housing 18 on
10 a first side of the inner housing 36. The positioning device 32 is adapted to be actively controlled to displace the inner housing 18 and the outer rotor 14 based on the rotational direction of the drive shaft 16, such that the centre of rotation of the outer rotor 34 is displaced along the reference line R. An electronic control unit 40 is arranged in communication with the positioning
15 device 32. The control unit 40 is adapted to control the positioning device 32 such that it displaces the inner housing 18 and the outer rotor 14 based on the direction of rotation of the drive shaft 16. A computer 42 may be connected to the control unit 40.

20 In this embodiment the positioning device 32 is adapted to be controlled to displace the inner housing 18 and the outer rotor 14 through a rotational movement. The positioning device 32 comprises a pneumatic cylinder and thus comprises a cylinder pipe 46, a piston means 48 and a first spring
25 element 50. The positioning device 32 is arranged such that the piston means 48 moves in a direction perpendicular to the reference line R. The first spring element 50 is connected to the piston means 48. A displacement device 54 is connected to the first spring element 50 and/or the piston means 48. The displacement device 54 is arranged in contact with the outer periphery of the inner housing 18. The displacement device 54 may be a toothed rack or a belt
30 or similar. As the piston means 48 moves due to the air pressure in the cylinder 46, the displacement device 54 moves and forces the inner housing 18 to rotate. The inner housing 18 makes the outer rotor 14 rotate and due to

the eccentricity of the inner housing 18, the centre of rotation of the outer rotor 34 is displaced along the reference line R. A second spring element 52 is arranged on a second side of the inner housing 38, opposite the first side 36. The second spring element 52 is typically arranged such that the reference line
5 R extends through the second spring element 52. The second spring element 52 abuts the inner housing 18 and is arranged inside the outer housing 20.

An arrangement for supply of compressed air (not shown) is arranged in connection to the positioning device 32. The control unit 40 is thus adapted to
10 control the supply of compressed air to the cylinder 46 and thereby control the position of the piston means 48 and thus the displacement of the inner housing 18 and the outer rotor 14.

Figure 4a shows an embodiment of the invention where the drive shaft 16
15 rotates counter-clockwise as indicated by an arrow above the pump 10. The positioning device 32 has been controlled to an idle state where there is no air pressure inside the cylinder 46. The piston means 48 and the displacement device 54 are thus in a retracted position. The first spring element 50 is in a neutral state where substantially no load is applied to it, and also the second
20 spring element 52 is in a neutral state with substantially no load applied to it. The centre of rotation of the outer rotor 34 is a distance x from the centre of rotation of the inner rotor 44, on a first side of the centre of rotation of the inner rotor 44. The centre of rotation of the outer rotor 34 is thus closer to the positioning device 32 than the centre of rotation of the inner rotor 44. As the
25 drive shaft 16 rotates the inner rotor 12 and the outer rotor 14 rotates in the same direction as the drive shaft 16. The cavities 26 between the inner rotor 12 and the outer rotor 14 continuously vary in volume. The cavity 26' in fluid communication with the inlet 22 is expanding as the rotors 12, 14 rotate whereby a negative pressure is created and fluid is sucked through the inlet 22
30 into the cavity 26'. The fluid flows between the inner rotor 12 and the outer rotor 14 and on the discharge side 30 the cavity 26'' in fluid communication

with the outlet 24 decreases in size. The fluid is compressed and is pumped out through the outlet 24.

Figure 4b shows an embodiment of the invention where the drive shaft 16 rotates clockwise as indicated by an arrow above the pump 10. The positioning device 32 has been controlled to an active state where compressed air is provided in the cylinder 46. The compressed air acts on the piston means 48 such that the piston means 48 and the displacement device 54 are in an extracted position. The inner housing 18 has thus been rotated by the displacement device 54 and the centre of rotation of the outer rotor 34 has been displaced along the reference line R. The first spring element 50 is compressed between the piston means 48 and the displacement device 54 and the second spring element 52 is compressed between the inner housing 18 and the outer housing 20. The centre of rotation of the outer rotor 34 is now a distance x from the centre of rotation of the inner rotor 44, on a second side of the centre of rotation of the inner rotor 44. The centre of rotation of the outer rotor 34 is thus further away from the positioning device 32 than the centre of rotation of the inner rotor 44. Due to the displacement of the outer rotor 14 the cavity 26' in fluid communication with the inlet 22 is still expanding when the drive shaft 16 rotates clockwise and the cavity 26'' in fluid communication with the outlet 24 decreases. This way, the flow through the pump 10 is maintained regardless of the direction of rotation of the drive shaft 16 and a reversible pump 10 without the disadvantages of friction elements is achieved. Should the drive shaft 16 start rotating counter-clockwise again, the control unit 40 actively controls the positioning device 32 such that the air pressure is removed. With no air pressure acting on the piston means 48, there is no load applied on the first spring element 50 and the first spring element 50 thus returns to its neutral state. The piston means 48 and the displacement device 54 are thereby moved to the retracted position, and the inner housing 18 and the outer rotor 14 are thereby rotated. As the inner housing 18 rotates, due to the eccentricity, the load applied to the second

spring element 52 is removed. The second spring element 52 thus returns to its neutral state.

Figure 5 shows a flowchart for a method to control a reversible pump 10 for a fluid according to an embodiment of the invention. The reversible pump 10 is preferably configured as described in Figure 2a, 2b, 3a, 3b, 4a or 4b and comprises an externally toothed inner rotor 12; an internally toothed outer rotor 14 with a circular periphery, wherein the outer rotor 14 surrounds the inner rotor 12; a drive shaft 16 concentrically connected to the inner rotor 12, an inner housing 18 surrounding the outer rotor 14; an outer housing 20; an inlet 22 and an outlet 24 for the fluid arranged mirror symmetric on opposing sides of the drive shaft 16 and of a reference line R extending perpendicularly to the longitudinal extension of the drive shaft 16, wherein the inner rotor 12 has one less tooth than the outer rotor 14 and wherein the outer rotor 14 is eccentrically arranged in meshing engagement with the inner rotor 12, such that variable cavities 26 are formed between the inner rotor 12 and the outer rotor 14, wherein the inlet 22 and the outlet 24 are each arranged in fluid communication with a cavity 26. The method comprises the steps to: a) identify the direction of rotation of the drive shaft 16; b) control a positioning device 32 arranged in connection with the inner housing 18, to displace the inner housing 18 and the outer rotor 14 based on the rotational direction of the drive shaft 16, such that the centre of rotation of the outer rotor 34 is displaced along the reference line R.

The direction of rotation of the drive shaft 16 may be determined in step a) by a sensor (not shown). The sensor is suitably arranged in communication with a control unit 40. The control unit 40 is further arranged in communication with the positioning device 32. The control unit 40 thus controls the positioning device 32 in step b) based on the rotational direction of the drive shaft 16, such that the centre of rotation of the outer rotor 34 is displaced along the reference line R.

If it is identified that the drive shaft 16 rotates counter-clockwise in step a), the positioning device 32 is controlled to displace the inner housing 18 and the outer rotor 14 in step b), such that the centre of rotation of the outer rotor 34 is on a predetermined distance x from the centre of rotation of the inner rotor 44 on a first side of the centre of rotation of the inner rotor 44. If it is identified that the drive shaft 16 rotates clockwise in step a), the positioning device 32 is controlled to displace the inner housing 18 and the outer rotor 14 in step b), such that the centre of rotation of the outer rotor 34 is a predetermined distance x from the centre of rotation of the inner rotor 44 on a second side of the centre of rotation of the inner rotor 44. The second side is opposite the first side. The centre of rotation of the outer rotor 34 is thus always the same predetermined distance x from the centre of rotation of the inner rotor 44, but on opposite sides of the centre of rotation of the inner rotor 44, along the reference line R . This way, the inlet 22 is always in fluid communication with an expanding cavity 26 and the outlet 24 is always in fluid communication with a decreasing cavity 26 and the flow through the pump 10 is maintained regardless of direction of rotation of the drive shaft 16. The predetermined distance x is preferably a distance between 1-5 mm.

According to an aspect of the invention the positioning device 32 is arranged on a first side of the inner housing 36. If it is identified that the drive shaft 16 is rotating clockwise in step a), the positioning device 32 is controlled in step b) to displace the inner housing 18 and the outer rotor 14, such that the centre of rotation of the outer rotor 34 is displaced in a direction away from the positioning device 32 to the second side of the centre of rotation of the inner rotor. If it is identified that the drive shaft 16 is rotating counter-clockwise in step a), the positioning device 32 is controlled in step b) to displace the inner housing 18 and the outer rotor 14, such that the centre of rotation of the outer rotor 34 is displaced in a direction towards the positioning device 32 to the first side of the centre of rotation of the inner rotor 44.

According to an embodiment of the invention the inner housing 18 and the outer rotor 14 are linearly displaced in step b). The inner housing 18 and the outer rotor 14 are preferably linearly displaced in a direction parallel with the reference line R. The positioning device 32 is thus controlled in step b) to

5 displace the inner housing 18 and the outer rotor 14 the distance $2 \cdot x$, such that the centre of rotation of the outer rotor 34 is a distance x from the centre of rotation of the inner rotor 44 on either the first or the second side of the centre of rotation of the inner rotor 44. This way, an easy way of substantially frictionless displacement of the outer rotor 14 is achieved. In the case where

10 the positioning device 32 is a pneumatic cylinder, the control unit 40 controls the supply of compressed air into the cylinder 46 in step b). This is further described with regard to Figure 3a and 3b.

According to an embodiment of the invention the positioning device 32 is

15 controlled to displace the inner housing 18 and the outer rotor 14 through a rotational movement in step b). In this case, the inner housing 18 is in the shape of an eccentric ring surrounding the outer rotor 14 (see Figure 4a and 4b). The positioning device 32 is thus controlled to act on the inner housing 18 such that it rotates inside the outer housing 20. When the inner housing 18

20 rotates, the outer rotor 14 rotates and due to the eccentricity of the inner housing 18 the centre of rotation of the outer rotor 34 is displaced along the reference line R. The positioning device 32 is preferably controlled to displace the inner housing 18 in step b) such that the outer rotor 14 is rotated 180 degrees. In the case where the positioning device 32 is a pneumatic cylinder,

25 the control unit 40 controls the supply of compressed air into the cylinder 46 and thus controls the movement of the piston means 48. This is further described with regard to Figure 4a and 4b.

Figure 6 schematically illustrates a device 500. The control unit 40 and/or

30 computer 42 described with reference to Fig. 2-Fig. 4 may in a version comprise the device 500. The term "link" refers herein to a communication link which may be a physical connection such as an optoelectronic communication

line, or a non-physical connection such as a wireless connection, e.g. a radio link or microwave link. The device 500 comprises a non-volatile memory 520, a data processing unit 510 and a read/write memory 550. The non-volatile memory 520 has a first memory element 530 in which a computer programme, e.g. an operating system, is stored for controlling the function of the device 500. The device 500 further comprises a bus controller, a serial communication port, I/O means, an A/D converter, a time and date input and transfer unit, an event counter and an interruption controller (not depicted). The non-volatile memory 520 has also a second memory element 540.

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There is provided a computer programme P which comprises routines for a method to control a reversible pump 10 according to the invention. The computer programme P comprises routines for identifying the direction of rotation of the drive shaft 16. The computer programme P comprises routines for controlling the positioning device 32 to displace the inner housing 18 and the outer rotor 14 based on the direction of rotation of the drive shaft 16, such that the centre of rotation of the outer rotor 34 is displaced along the reference line R. The computer programme P comprises routines for controlling the supply of compressed air into a pneumatic cylinder 32. The programme P may be stored in an executable form or in a compressed form in a memory 560 and/or in a read/write memory 550.

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Where the data processing unit 510 is described as performing a certain function, it means that the data processing unit 510 effects a certain part of the programme stored in the memory 560 or a certain part of the programme stored in the read/write memory 550.

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The data processing device 510 can communicate with a data port 599 via a data bus 515. The non-volatile memory 520 is intended for communication with the data processing unit 510 via a data bus 512. The separate memory 560 is intended to communicate with the data processing unit 510 via a data bus 511.

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The read/write memory 550 is adapted to communicating with the data processing unit 510 via a data bus 514.

5 When data are received on the data port 599, they are stored temporarily in the second memory element 540. When input data received have been temporarily stored, the data processing unit 510 is prepared to effect code execution as described above.

10 Parts of the methods herein described may be effected by the device 500 by means of the data processing unit 510 which runs the programme stored in the memory 560 or the read/write memory 550. When the device 500 runs the programme, methods herein described are executed.

15 The foregoing description of the preferred embodiments of the present invention is provided for illustrative and descriptive purposes. It is not intended to be exhaustive or to restrict the invention to the variants described. Many modifications and variations will obviously be apparent to one skilled in the art. The embodiments have been chosen and described in order best to explain the principles of the invention and its practical applications and hence make it
20 possible for specialists to understand the invention for various embodiments and with the various modifications appropriate to the intended use.

Claims

1. A reversible pump (10) for a fluid, comprising an externally toothed inner rotor (12); an internally toothed outer rotor (14) with a circular periphery, wherein the outer rotor (14) surrounds the inner rotor (12); a drive shaft (16) concentrically connected to the inner rotor (12); an inner housing (18) surrounding the outer rotor (14); an outer housing (20); an inlet (22) and an outlet (24) for the fluid, arranged mirror symmetric on opposing sides of the drive shaft (16) and of a reference line (R) extending perpendicularly to the longitudinal extension of the drive shaft (16), wherein the inner rotor (12) has one less tooth than the outer rotor (14) and wherein the outer rotor (14) is eccentrically arranged in meshing engagement with the inner rotor (12), such that variable cavities (26, 26', 26'') are formed between the inner rotor (12) and the outer rotor (14), wherein the inlet (22) and the outlet (24) are each arranged in fluid communication with a cavity (26', 26''), **characterized in that** a positioning device (32) is arranged in connection with the inner housing (18), wherein the positioning device (32) is adapted to be actively controlled to displace the inner housing (18) and the outer rotor (14) based on the rotational direction of the drive shaft (16), such that the centre of rotation of the outer rotor (34) is displaced along the reference line (R).
2. A pump according to claim 1, **characterized in that** when the drive shaft (16) rotates clockwise, the positioning device (32) is adapted to displace the inner housing (18) and the outer rotor (14), such that the centre of rotation of the outer rotor (34) is on a predetermined distance (x) from the centre of rotation of the inner rotor (44) on a first side of the centre of rotation of the inner rotor (44).
3. A pump according to claim 1 or 2, **characterized in that** when the drive shaft (16) rotates counter-clockwise, the positioning device (32) is adapted to displace the inner housing (18) and the outer rotor (14), such that the centre of rotation of the outer rotor (34) is a predetermined distance (x) from the centre

of rotation of the inner rotor (44) on a second side of the centre of rotation of the inner rotor (44).

4. A pump according to claim 2 or 3, **characterized in that** the predetermined distance (x) is between 1-5 mm.

5. A pump according to any of the preceding claims, **characterized in that** the positioning device (32) is adapted to linearly displace the inner housing (18) and the outer rotor (14).

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6. A pump according to any of claims 1-4, **characterized in that** the positioning device (32) is adapted to displace the inner housing (18) and the outer rotor (14) through a rotational movement.

15 7. A pump according to any of the preceding claims, **characterized in that** the positioning device (32) comprises a pneumatic cylinder.

20 8. A pump according to any of the preceding claims, **characterized in that** a second spring element (52) is arranged between the outer housing (20) and the inner housing (18).

9. A method to control a reversible pump (10) for a fluid comprising an externally toothed inner rotor (12); an internally toothed outer rotor (14) with a circular periphery, wherein the outer rotor (14) surrounds the inner rotor (12); a drive shaft (16) concentrically connected to the inner rotor (12); an inner housing (18) surrounding the outer rotor (14); an outer housing (20); an inlet (22) and an outlet (24) for the fluid arranged mirror symmetric on opposing sides of the drive shaft (16) and of a reference line (R) extending perpendicularly to the longitudinal extension of the drive shaft (16), wherein the inner rotor (12) has one less tooth than the outer rotor (14) and wherein the outer rotor (14) is eccentrically arranged in meshing engagement with the inner rotor (12), such that variable cavities (26, 26', 26'') are formed between the

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inner rotor (12) and the outer rotor (14), wherein the inlet (22) and the outlet (24) are each arranged in fluid communication with a cavity (26', 26''),

characterized by the steps to:

a) identify the direction of rotation of the drive shaft (16);

- 5 b) control a positioning device (32) arranged in connection with the inner housing (18), to displace the inner housing (18) and the outer rotor (14) based on the rotational direction of the drive shaft (16), such that the centre of rotation of the outer rotor (34) is displaced along the reference line (R).

- 10 10. A method according to claim 9, **characterized in that** if the drive shaft (16) rotates clockwise in step a), the positioning device (32) is controlled to displace the inner housing (18) and the outer rotor (14) in step b), such that the centre of rotation of the outer rotor (34) is on a predetermined distance (x) from the centre of rotation of the inner rotor (44) on a first side of the centre of rotation
15 of the inner rotor (44).

11. A method according to any of claims 9-10, **characterized in that** if the drive shaft (16) rotates counter-clockwise in step a), the positioning device (32) is controlled to displace the inner housing (18) and the outer rotor (14) in step
20 b), such that the centre of rotation of the outer rotor (34) is a predetermined distance (x) from the centre of rotation of the inner rotor (44) on a second side of the centre of rotation of the inner rotor (44).

12. A method according to any of claims 9-11, **characterized in that** the inner
25 housing (18) and the outer rotor (14) are linearly displaced in step b).

13. A method according to any of claims 9-11, **characterized in that** the inner housing (18) and the outer rotor (14) are displaced through a rotational movement in step b).

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14. A gearbox (4), **characterized by** a reversible pump (10) according to any of the claims 1-8.

15. A vehicle (1), **characterized by** a reversible pump (10) according to any of the claims 1-8.

5 16. A computer program (P), wherein said computer program comprises programme code for causing an electronic control unit (40; 500) or a computer (42; 500) connected to the electronic control unit (40; 500) to perform the steps according to any of the claims 9-13.

10 17. A computer programme product comprising a programme code stored on a computer-readable medium for performing the method steps according to any of claims 9-13, when said computer programme is run on an electronic control unit (40; 500) or a computer (42; 500) connected to the electronic control unit (40; 500).

15

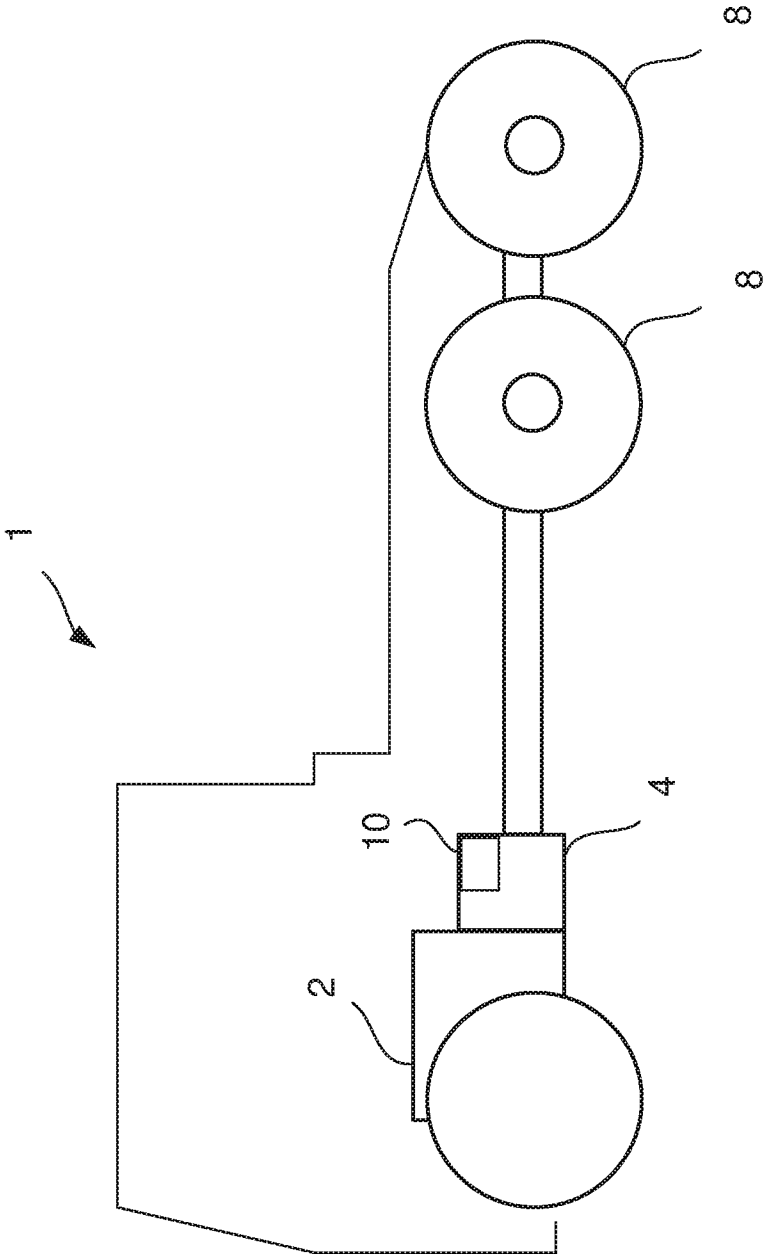


Fig. 1

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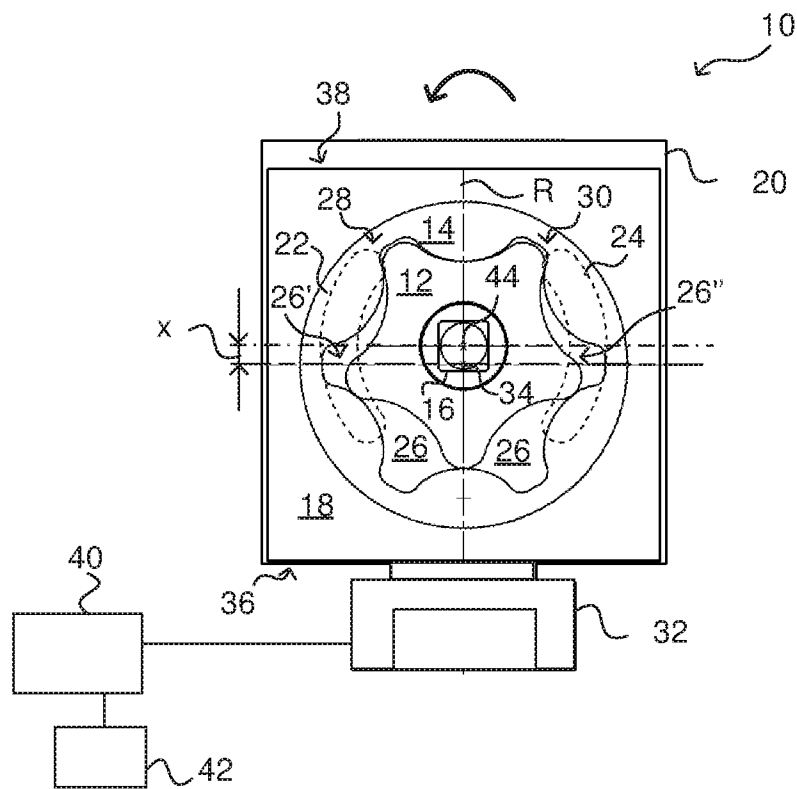


Fig. 2a

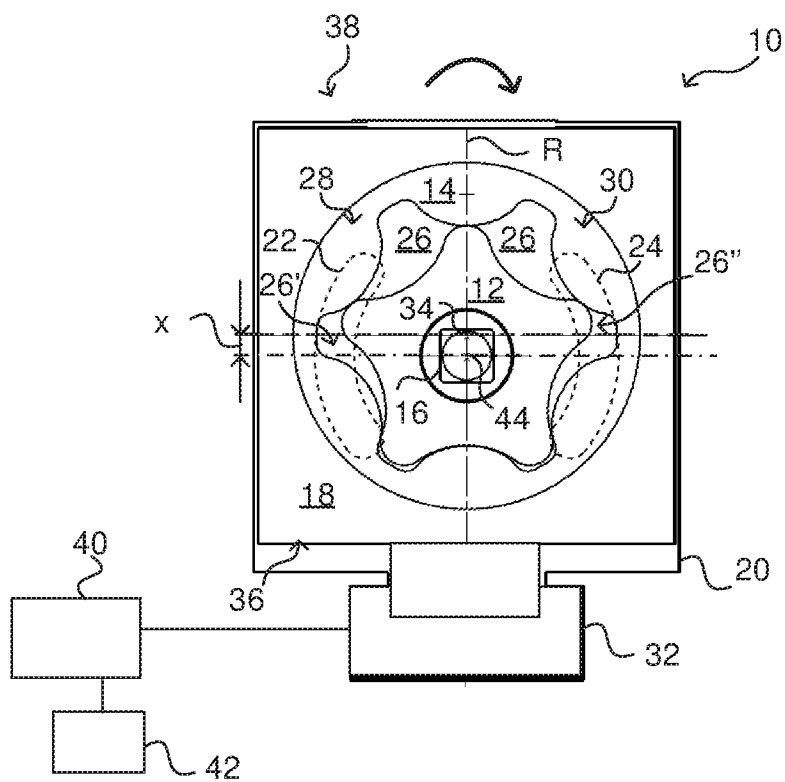


Fig. 2b

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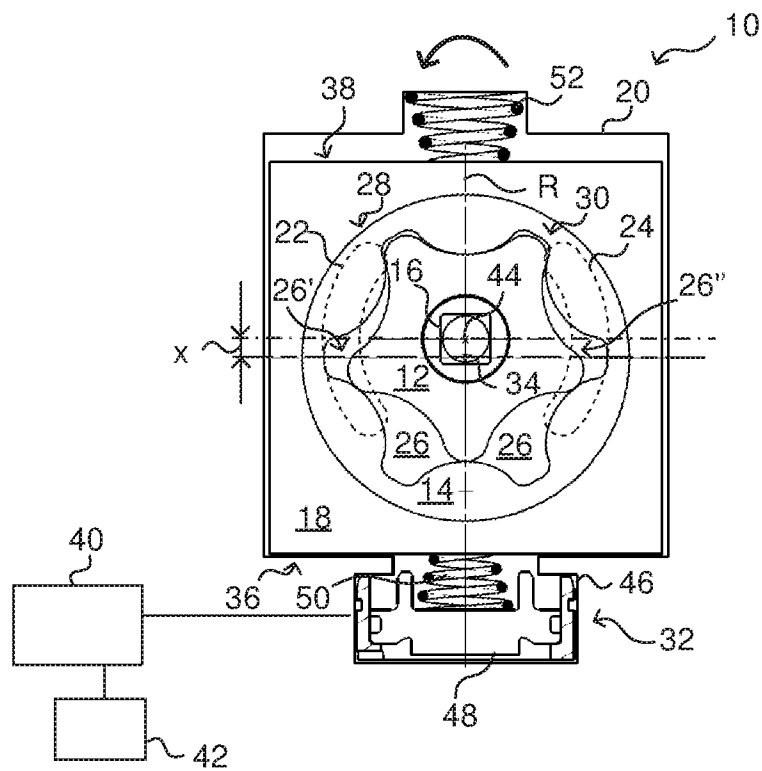


Fig. 3a

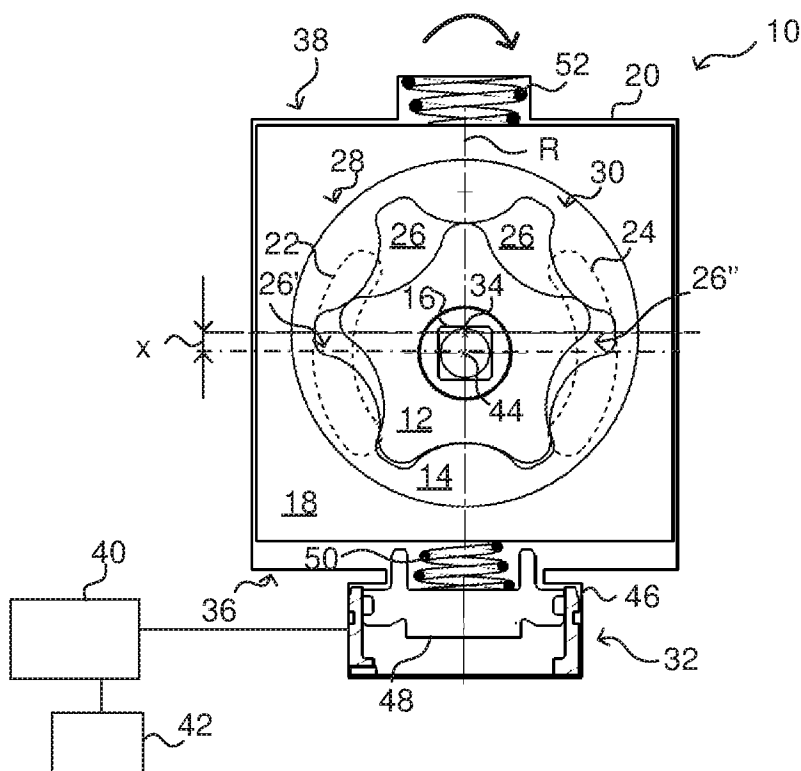


Fig. 3b

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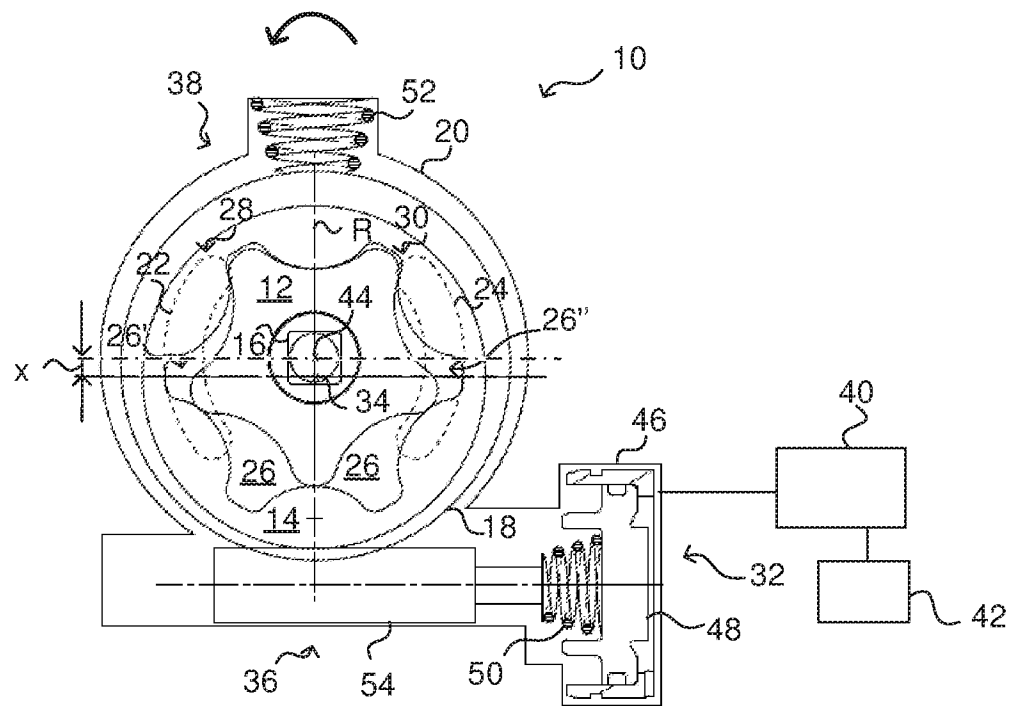


Fig. 4a

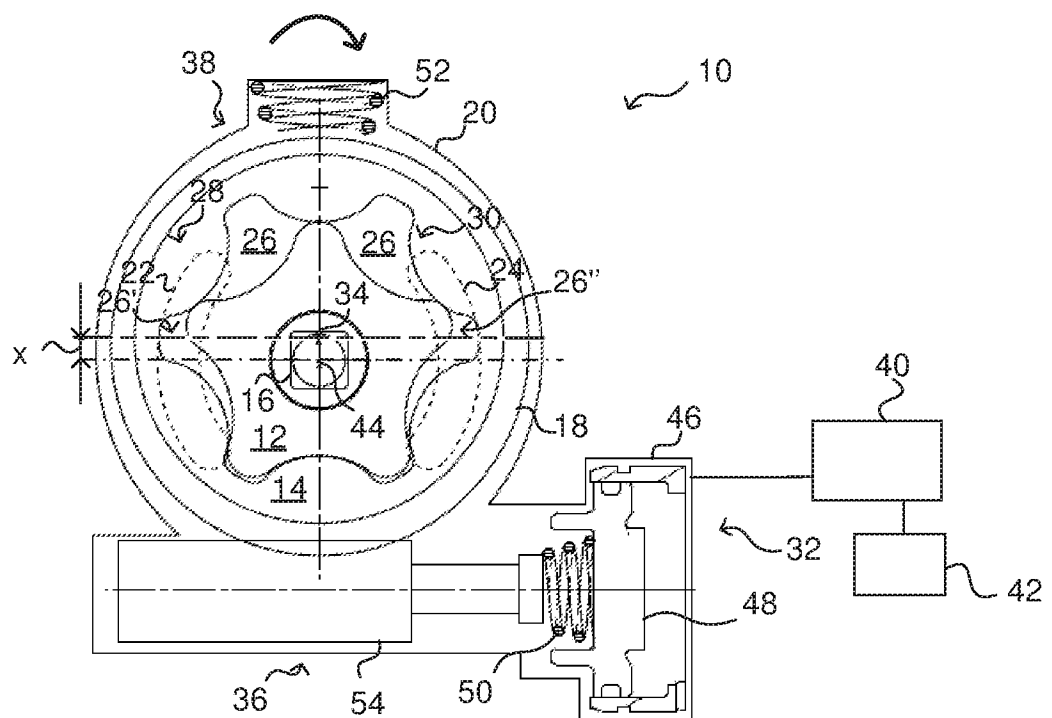


Fig. 4b

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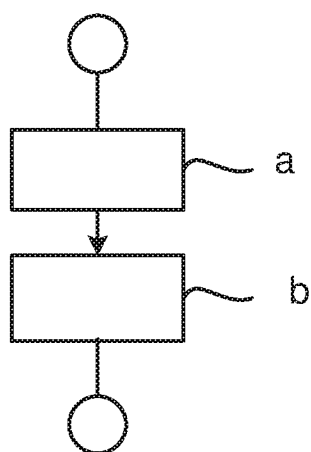


Fig. 5

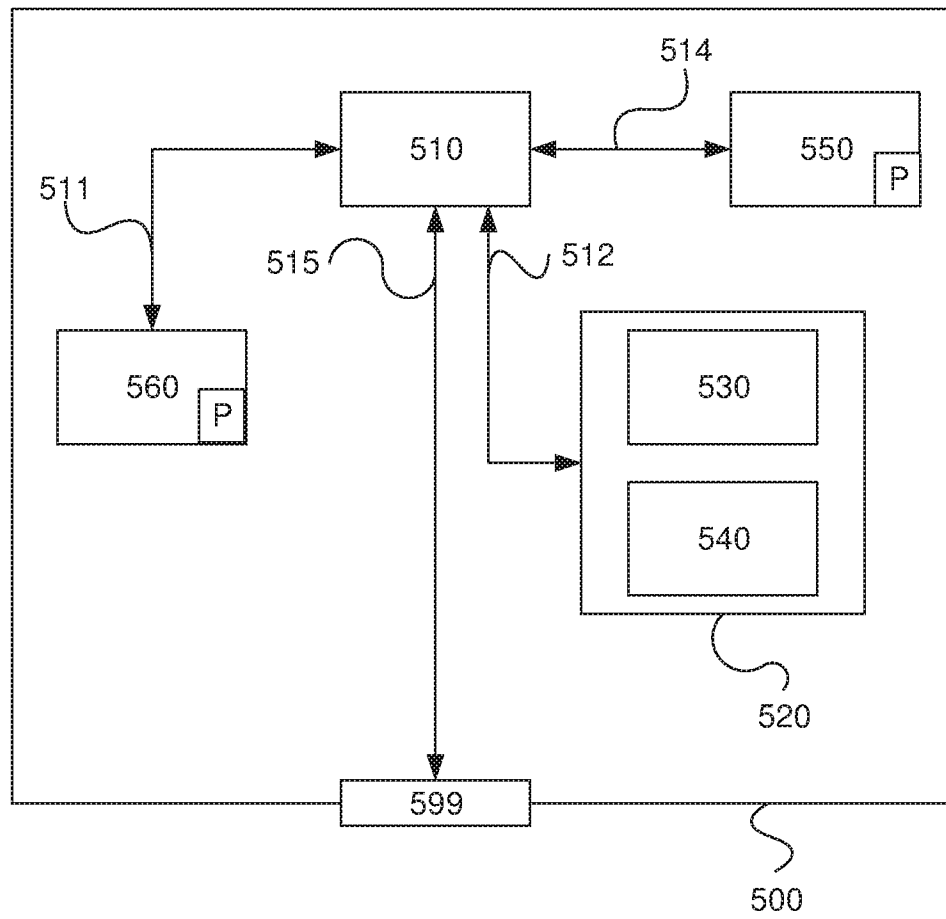


Fig. 6

INTERNATIONAL SEARCH REPORT

 International application No.
PCT/SE2016/050386

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F03C, F04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 282707 A (JAMES BUTLER TUTHILL), 26 July 1928 (1928-07-26); page 3, line 3 - line 35; figures 1-3 --	1-17
A	US 4944662 A1 (CHILD ROBIN E), 31 July 1990 (1990-07-31); abstract; figures 1-3; claim 1 --	1-17
A	DE 2055883 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN AG), 18 May 1972 (1972-05-18); figures 1,2; claims 1-4 --	1-17
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 20040184942 A1 (PHILLIPS EDWARD H), 23 September 2004 (2004-09-23); paragraphs [0093]-[0114] --	1-17
A	US 3536426 A1 (ALBRECHT CLIFFORD C ET AL), 27 October 1970 (1970-10-27); figures 1-6; claim 3 -- -----	1-17

Continuation of: second sheet**International Patent Classification (IPC)****F04C 14/04** (2006.01)**F04C 2/10** (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

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