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(54) Title: VEHICLE SUSPENSION APPARATUS

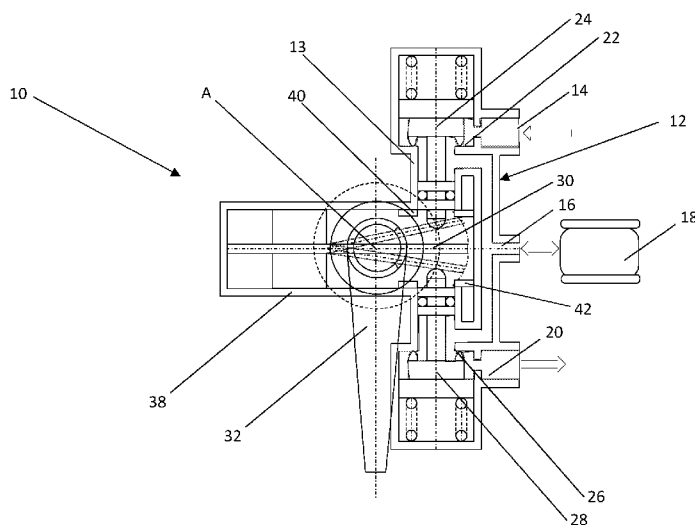


Fig. 1

(57) Abstract: A vehicle suspension apparatus (10, 110) including a valve (12, 112) having an inlet port (14, 114) which is fluidly communicable with a supply of pressurised fluid, an outlet port (16, 116) which is fluidly communicable with a suspension actuator (18, 118), and an exhaust port (20, 120) which is fluidly communicable with a low-pressure area, the valve (12, 112) also including a valve actuation member (30, 130) which is moveable between a first position to enable the flow of fluid from the supply of pressurised fluid to the suspension actuator (18, 118) and a second position to enable the flow of fluid from the suspension actuator (18, 118) to the exhaust port (20, 120), wherein the valve actuation member (30, 130) is electronically and manually controllable, the suspension apparatus (10, 110) including a manual adjustment device (32, 132) which is moveable between a disengaged position in which the flow of fluid to and/or from the suspension actuator (18, 118) is not controlled by the manual adjustment device (32, 132), and an engaged position in

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Title: Vehicle Suspension Apparatus

5 Description of Invention

This invention relates to a vehicle suspension apparatus.

10 It is known in the art of vehicles including a tractor and one or more trailers, to provide a suspension apparatus which enables levelling of the or each trailer. The suspension apparatus includes a raise/lower valve for controlling the height of the suspension. The valve includes an inlet, which is in fluid communication with a supply of pressurised fluid, for example a suspension reservoir, an outlet, which is in fluid communication with a suspension
15 actuator, for example suspension bellows, and an exhaust port, which is capable of venting to atmosphere or another low pressure area. The valve is typically manually operable via a handle which is located on the exterior of the vehicle. Electronically operable raise/lower valves are also known.

20 A disadvantage of known suspension apparatus is that it may be possible to electronically set a ride height of the vehicle, for example, but if electrical power is lost or disconnected, it is not possible to adjust the suspension height electronically, for example if a trailer is disconnected from a tractor of a heavy goods vehicle, the power supply to the trailer is likely to be lost. It is then not
25 possible to adjust the suspension height, for example to adjust a loading height of the trailer. Furthermore, suspension apparatus may lose height over time, for example as a trailer is loaded, or due to leakage of pneumatic fluid from the suspension apparatus.

30 An aim of the invention is to provide an improved suspension apparatus.

In accordance with embodiments of the invention, there is provided:

a vehicle suspension apparatus including a valve having an inlet port which is fluidly communicable with a supply of pressurised fluid, an outlet port which is fluidly communicable with a suspension actuator, and an exhaust port which is fluidly communicable with a low-pressure area, the valve also including a valve actuation member which is moveable between a first position to enable the flow of fluid from the supply of pressurised fluid to the suspension actuator and a second position to enable the flow of fluid from the suspension actuator to the exhaust port, wherein the valve actuation member is electronically and manually controllable, the suspension apparatus including a manual adjustment device which is moveable between a disengaged position in which the flow of fluid to and/or from the suspension actuator is not controlled by the manual adjustment device, and an engaged position in which the flow of fluid to and/or from the suspension actuator is controlled by the manual adjustment device.

The manual adjustment device may be biased towards its disengaged position.

The vehicle suspension apparatus may include a levelling portion, which includes a first inlet which is fluidly communicable with the outlet port of the valve, a second inlet which is fluidly communicable with a levelling device, and an outlet which is fluidly communicable with the suspension actuator.

The levelling device may be a levelling valve.

The levelling portion may be directly fluidly connected to the outlet port of the valve.

The levelling portion may include a closure member which is moveable between a first position in which the closure member closes the first inlet of the

levelling portion and a second position in which the closure member closes the second inlet of the levelling portion.

The position of the closure member may be electronically controllable.

5

The position of the closure member may be manually controllable.

The position of the closure member may be controllable by the manual adjustment device.

10

The closure member may be biased towards its first position, enabling fluid communication between the levelling device and the suspension actuator.

The manual adjustment device may include a first engagement formation which is operable to engage the valve actuation member and a second engagement formation which is operable to engage the closure member of the levelling portion.

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The suspension actuator may include one or more suspension bellows.

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The valve actuation member may be a flexure.

The closure member may be a flexure.

The suspension actuator may be fluidly communicable with at least one of the valve and the levelling device at all times, even in the event of a loss of electrical power.

25

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

30

FIGURE 1 shows a side cross-sectional view of a suspension apparatus;
Figures 2A and 2B are front cross-sectional views of the suspension apparatus
of Figure 1, showing a manual adjustment device of the suspension apparatus
in a disengaged and engaged position, respectively;

5 FIGURES 3A and 3B are side cross-sectional views of the suspension
apparatus showing the suspension apparatus in a raise and lower
configuration, respectively, a valve actuation member being electronically
controlled;

FIGURES 4A and 4B are side cross-sectional views of the suspension
10 apparatus in a raise and lower configuration, respectively, with the valve
actuation member being manually controlled;

FIGURE 5 is a front cross-sectional view of a further suspension apparatus;

FIGURES 6A-C are front cross-sectional views of the suspension apparatus of
Figure 5, in an electronically adjustable configuration; and

15 FIGURES 7A-C are front cross-sectional views of the suspension apparatus of
Figure 5, in a manually adjustable configuration.

Referring to Figures 1 to 4B, there is shown a suspension apparatus 10 for a
vehicle. The suspension apparatus 10 includes a valve 12 which is operable
20 to control the height of a vehicle suspension actuator, e.g. suspension bellows
18. The valve 12 includes a valve body 13, an inlet port 14, which is in fluid
communication with a supply of pressurised fluid, for example a suspension
reservoir; an outlet port 16, which is in fluid communication with the
suspension actuator 18; and an exhaust port 20, which is capable of venting to
25 atmosphere or another low pressure area. The valve 12 also includes a first
valve seat 22 and a first valve member 24 which is moveable between a
closed position against the first valve seat 22 to close the inlet port 14, and an
open position in which the first valve member 24 is spaced from the first valve
seat 22, to open the inlet 14, to permit fluid flow from the source of pressurised
30 fluid into the valve body 13. The valve 12 also includes a second valve seat
26 and a second valve member 28 which is moveable between a closed

position against the second valve seat 26 to close the exhaust port 20, and an open position in which the second valve member 28 is spaced from the second valve seat 26 to open the exhaust port 20, to permit the flow of fluid from the valve body 13 to atmosphere or other low pressure region. The first and second valve members 24, 28 may be formed as separate members, or may be formed as a single member.

The valve 12 also includes a valve actuation member 30, which is operable to move the first and second valve members 24, 28 between their respective open and closed positions. The valve actuation member 30 may be manufactured from or include a resilient material, and may be in the form of a flexure. The valve actuation member 30 is moveable between a first position and a second position. The default position of the valve actuation member is an intermediate position between the first and second positions. In its first position, the valve actuation member 30 engages with the first valve member 24, and positions the first valve member 24 in its open position, thus opening the inlet port 14. In its second position, the valve actuation member 30 engages with the second valve member 28, and positions the second valve member 28 in its open position, thus opening the exhaust port 20. The valve actuation member 30 may also occupy an intermediate position, between its first and second positions. When the valve actuation member 30 is in its intermediate position, the valve actuation member 30 engages neither the first valve member 24 nor the second valve member 28, such that both the first valve member 24 and the second valve member 28 occupy their closed positions.

The suspension apparatus 10 is electronically operable. The valve 12 includes a first electromagnet 40, which is associated with the first valve seat 22 and a second electromagnet 42, which is associated with the second valve seat 26. The valve actuation member 30 may include a ferromagnetic material, such that energisation of the first electromagnet 40 attracts the valve

actuation member 30 towards its first position, and energisation of the second electromagnet 42 attracts the valve actuation member 30 towards its second position.

- 5 The valve actuation member 30 is connected to a manual adjustment device, which in embodiments may be a handle 32. The handle 32 is manually operable to move the valve actuation member 30 between its first, intermediate and second positions. The handle 32 may be rotatable to move the valve actuation member 30. The handle 32 may be rotatable about a first
10 axis A. The handle 32 may also be moveable between an engaged position, wherein the handle 32 is engaged with the valve actuation member 30, and is operable to move the valve actuation member 30 (as shown in Fig 2B), and a disengaged position wherein the handle is disengaged from the valve actuation member 30, and movement of the handle 32 does not cause
15 movement of the valve actuation member 30 (as shown in Fig. 2A). The handle 32 may be linearly moveable between the disengaged position and engaged position. The linear movement of the handle 32 between the engaged and disengaged positions may be along, or substantially parallel with the first axis A. The handle 32 may include an engagement formation 34 for
20 engaging a part of the valve actuation member 30. The engagement formation 34 may include a first engagement portion 34a and a second engagement portion 34b. When the handle 32 is in its disengaged position, the valve actuation member 30 may be located in the first engagement or "clearance" portion 34a, wherein the handle 32 does not engage with the valve actuation
25 member 30, and rotation of the handle 32 about the first axis A does not effect movement of the valve actuation member 30. When the handle 32 is in its engaged position, at least a part of the valve actuation member 30 may be located in the second engagement portion 34b, such that the handle 32 engages with the valve actuation member 30, and rotation of the handle 32
30 about the first axis A effects movement of the valve actuation member 30 between its first, second and intermediate positions. The suspension

apparatus 10 may include a biasing member 36 to bias the handle 32 into one of the engaged position or disengaged position. The biasing member 36 may be a resilient biasing member, for example a spring. The biasing member 36 may bias the handle 32 towards the disengaged position. The biasing member 36 may be positioned between a part of the handle 32 and a housing 38 of the suspension apparatus 10. Part of the handle 32 may be accessible from the exterior of the vehicle.

In use, in order to increase the height of the suspension, first electromagnet 40 is energised, whilst the second electromagnet 42 is not energised, such that the valve actuation member 30 is attracted towards its first position, thus opening the inlet port 14. The pressurised fluid source is thus fluidly communicable with the outlet port 16, to increase the volume of the suspension actuator 18, and hence to increase the vehicle height. In order to decrease the height of the suspension, and hence the height of the vehicle, the second electromagnet 42 is energised, whilst the first electromagnet 40 is not energised. The valve actuation member 30 is attracted towards its second position, to open the exhaust port 20, such that fluid may flow through the valve body 13 from the suspension actuator 18 to atmosphere or other low pressure area, to reduce the volume of the suspension actuator 18.

The suspension apparatus 10 may include or be communicable with a control unit, which may provide signals to control the valve 12. The control unit may be a part of the vehicle braking system. The control unit may provide signals to energise the first and second electromagnets 40, 42 appropriately, to provide a desired suspension height. One or more sensors may be provided in communication with the control unit in order to provide an indication of suspension height. The controller may determine whether adjustment of the suspension height is required, for example from signals provided by one or more of the or each of the sensors, and control the electromagnets 40, 42 accordingly.

The ability to adjust the suspension height electronically is advantageous in that it may be possible to set different heights for different situations, for example different loading conditions, and/or it may be possible to adjust the suspension height automatically, for example in response to a signal from a sensor. A disadvantage of a solely electrically operated suspension apparatus 10 is that if there is a lack of or loss of electrical power, for example if a trailer is disconnected from its associated tractor, the controller and/or the electromagnets 40, 42 may not be operable.

10

The suspension apparatus 10 is also manually adjustable. It is possible to adjust the height of the suspension apparatus 10 without a power supply being connected with such an arrangement. Such manual adjustment may be advantageous in situations where a suspension height other than "ride height" is required, for example to adjust the height of the vehicle to match another body, for example a vehicle dock (e.g. a loading bay) or another vehicle, but the vehicle, e.g. a trailer, is disconnected from a power supply.

To manually adjust the suspension height, an operator moves (in the example shown, pushes) the handle 32 into its engaged position relative to the valve actuation member 30. Rotation of the handle 32 in a first, for example anti-clockwise, direction causes movement of the valve actuation member 30 into its first position, such that the inlet port 14 is open, as shown, for example in Figure 4A. Pressurised fluid is able to enter the valve body 13 via the inlet port 14, and be transferred to the suspension actuator 18 via the outlet port 16. Supply of fluid to the suspension actuator 18 increases the volume of the suspension actuator 18, which, in turn, increases the height of the vehicle body.

In order to lower the suspension manually, the user rotates the handle 32 in the opposite direction (for example clockwise) to cause the valve actuation

member 30 to occupy its second position such that the exhaust port 20 is open, as shown, for example, in Figure 4B. The inlet port 14 is closed such that there is no fluid communication between the supply of pressurised fluid and the suspension actuator 18. Fluid is able to enter the valve body 13 from the suspension actuator 18 via the outlet port 16, and to be vented via the exhaust port 20.

When the handle 32 is released, the biasing member 36 moves the handle 32 into its disengaged position, and the valve actuation member 30 moves into its intermediate position such that both the inlet port 14 and the outlet port 16 are closed. The resilience of the valve actuation member 30 means that the valve actuation member 30 returns to its default, intermediate position automatically when neither of the electromagnets 40, 42 is energised. This effectively sets the suspension height, and the inlet port 14 and the outlet port 16 are closed unless and until further adjustment of the suspension actuator 18 is required.

An embodiment of a suspension apparatus 110 is shown in Figures 5 – 7C.

Features of the suspension apparatus 110 which are the same as those shown in Figures 1 to 4B have the same reference numerals with a '1' prefix. The suspension apparatus 110 has a valve 112, having a valve body 113, an inlet port 114, an outlet port 116 and an exhaust port 120. The outlet port 116 is fluidly communicable with a suspension actuator 118, for example suspension bellows. The suspension apparatus 110 includes a first valve seat 122, a first valve member 124, a second valve seat 126 and a second valve member 128. A valve actuation member 130 is operable to move the first and second valve members 124, 128. A manual adjustment device, for example a handle, 132 is operable to control the position of the valve actuation member 130. First and second electromagnets 140, 142 are provided to enable electronic control of the valve actuation member 130, and hence electronic control of the suspension height.

The suspension apparatus 110 also includes a levelling portion 150. The levelling portion 150 includes a body 152 which is fluidly communicable with the output port 116. The levelling portion 150 includes a first inlet 154 which is fluidly communicable with the outlet 116 of the valve 112, and a second inlet 156 which is fluidly communicable with a levelling device, for example a levelling valve. The levelling valve may be a pneumatic levelling valve. The levelling device may be manually operable. The levelling portion 150 includes an outlet 157 which is fluidly communicable with a suspension actuator 118 of the vehicle. It will be understood that more than one suspension actuator 118 may be provided, as required, and that the outlet 157 may be fluidly communicable with each suspension actuator 118. The levelling portion 150 includes a closure member 158 which is moveable between a first position in which the closure member 158 closes the first inlet 154, and prevents fluid communication between the valve 12 and the levelling portion 150, and a second position in which the closure member 158 closes the second inlet 156, thus preventing fluid communication between the levelling valve and the levelling portion 150. The closure member 158 may be a flexure.

The levelling portion 150 includes a first levelling portion magnet 160 and a second levelling portion magnet 162. The first levelling portion magnet 160 may be a permanent magnet and the second levelling portion magnet 162 may be an electromagnet which is energisable by a controller. The closure member 158 may include a ferromagnetic material. The closure member 158 is biased towards its first position, and energisation of the second electromagnet 162 causes the closure member 158 to be attracted to its second position.

In use, when the closure member 158 is attracted to its first position, the first inlet 154 of the levelling portion is closed, and the suspension actuator 118 is in fluid communication with the levelling valve via the second inlet 156. This

may cause the suspension actuator 118 to occupy a normal height or “ride height” as shown in Figure 6A. The normal height may be predetermined and/or preset.

5 It is possible to override this configuration, by energising the second levelling portion electromagnet 162, which attracts the closure member 158 to its second position in which the second inlet 156 is closed, and the suspension actuator 118 is in fluid communication with the valve 112 as shown in Figures 6B, 6C. This allows the valve actuation member 130 to control the flow of fluid
10 to and/or from the suspension actuator 118. In this situation, the valve 112 may be operated electronically as described above in relation to the valve 12, i.e. the position of the valve actuation member 130, and hence the flow of fluid through the valve 112 to the suspension actuator 118 is controlled by the energisation of the first and second electromagnets 140, 142.

15

In the event of a lack or loss of electrical power to the suspension apparatus 110, for example if the vehicle stops and electrical power is switched off and/or disconnected, the closure member 158 is attracted towards its first position by the permanent magnet 160. In addition to a first engagement formation 134
20 which enables engagement and disengagement of the handle 132, the handle 132 may include a second engagement formation 166, which may be engageable with a part of the closure member 158. In embodiments, the second engagement formation 166 may include a protrusion which may extend through the outlet 116 of the valve 112, and into the first inlet 154 of the
25 levelling portion 150. Moving the handle 132 to its engaged position, causes the second engagement formation 166 to urge the closure member 158 towards its second position, such that the suspension actuator 118 is in fluid communication with the valve 112, and not in fluid communication with the levelling valve. Therefore it is possible to manually control the suspension
30 height in the event of loss of electrical power. i.e. a user may move the handle 132 into its engaged position, and then move the handle 132 into the

appropriate position to increase (as in Figure 7B) or decrease (as in Figure 7C) the height of the suspension actuator 118, by controlling the position of the valve actuation member 130 and hence the opening and/or closing of the first and second valve members 124, 128 to control the flow of fluid through the valve 112 to the suspension actuator 118.

When the handle 132 is in its disengaged position, the second engagement formation 166 does not engage the closure member 158, and has no effect on the position of the closure member 158. In this condition, the closure member 158 is attracted towards its first position (levelling valve in fluid communication with the suspension actuator 118).

To reset the suspension height to the "ride height", the second levelling portion electromagnet 162 is de-energised and the closure member 158 is attracted to its first position, enabling fluid communication between the levelling valve and the suspension actuator 118.

The present invention is advantageous since the suspension actuator 118 may be controlled whether there is electrical power or not. Biasing the closure member 158 to its first position wherein the levelling valve is in fluid communication with the suspension actuator 118 means that the levelling valve continues to be in fluid communication with the suspension actuator even when there is no electrical power supplied to the suspension apparatus. Thus the height of the suspension actuator 118 may be maintained (for example at a predetermined and/or set "normal" or "ride" height) via the levelling valve, without the need for electrical power, even if fluid is lost from the suspension actuator 118, for example through leakage. The option to manually adjust the suspension height whether or not electrical power is supplied is a further advantage. The biasing of the manual adjustment device to its disengaged position means that electronic control of the suspension apparatus 10, 110 is the dominant control mode, and a user cannot

inadvertently forget to revert to electronic control in the event of regaining electrical power, for example by reconnection to a power supply.

5 The arrangement of the suspension apparatus 10, 110 described herein, enables a simple arrangement of pneumatic pipes and connections.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the
10 presence of other features, steps or components.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for
15 attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Although certain example embodiments of the invention have been described,
20 the scope of the appended claims is not intended to be limited solely to these embodiments. The claims are to be construed literally, purposively, and/or to encompass equivalents.

CLAIMS

1. A vehicle suspension apparatus including a valve having an inlet port
5 which is fluidly communicable with a supply of pressurised fluid, an outlet port
which is fluidly communicable with a suspension actuator, and an exhaust port
which is fluidly communicable with a low-pressure area, the valve also
including a valve actuation member which is moveable between a first position
to enable the flow of fluid from the supply of pressurised fluid to the
10 suspension actuator and a second position to enable the flow of fluid from the
suspension actuator to the exhaust port, wherein the valve actuation member
is electronically and manually controllable, the suspension apparatus including
a manual adjustment device which is moveable between a disengaged
position in which the flow of fluid to and/or from the suspension actuator is not
15 controlled by the manual adjustment device, and an engaged position in which
the flow of fluid to and/or from the suspension actuator is controlled by the
manual adjustment device.
2. A vehicle suspension apparatus according to claim 1 wherein the
20 manual adjustment device is biased towards its disengaged position.
3. A vehicle suspension apparatus according to claim 1 or claim 2
including a levelling portion, which includes a first inlet which is fluidly
communicable with the outlet port of the valve, a second inlet which is fluidly
25 communicable with a levelling device, and an outlet which is fluidly
communicable with the suspension actuator.
4. A vehicle suspension apparatus according to claim 3 wherein the
levelling device is a levelling valve.

5. A vehicle suspension apparatus according to claim 3 or claim 4 wherein the levelling portion is directly fluidly connected to the outlet port of the valve.
6. A vehicle suspension apparatus according to any of claims 3 to 5 wherein the levelling portion includes a closure member which is moveable between a first position in which the closure member closes the first inlet of the levelling portion and a second position in which the closure member closes the second inlet of the levelling portion.
7. A vehicle suspension apparatus according to claim 6 wherein the position of the closure member is electronically controllable.
8. A vehicle suspension apparatus according to claim 6 or 7 wherein the position of the closure member is manually controllable.
9. A vehicle suspension apparatus according to claim 8 wherein the position of the closure member is controllable by the manual adjustment device.
10. A vehicle suspension apparatus according to any of claims 6 to 9 wherein the closure member is biased towards its first position, enabling fluid communication between the levelling device and the suspension actuator.
11. A vehicle suspension apparatus according to any of claims 6 to 10 wherein the manual adjustment device includes a first engagement formation which is operable to engage the valve actuation member and a second engagement formation which is operable to engage the closure member of the levelling portion.
12. A vehicle suspension apparatus according to any preceding claim wherein the suspension actuator includes one or more suspension bellows.

13. A vehicle suspension apparatus according to any of the preceding claims wherein the valve actuation member is a flexure.
- 5 14. A vehicle suspension apparatus according to any of claims 6 to 12 wherein the closure member is a flexure.
- 10 15. A vehicle suspension apparatus according to any of the preceding claims wherein the suspension actuator is fluidly communicable with at least one of the valve and the levelling device at all times, even in the event of a loss of electrical power.

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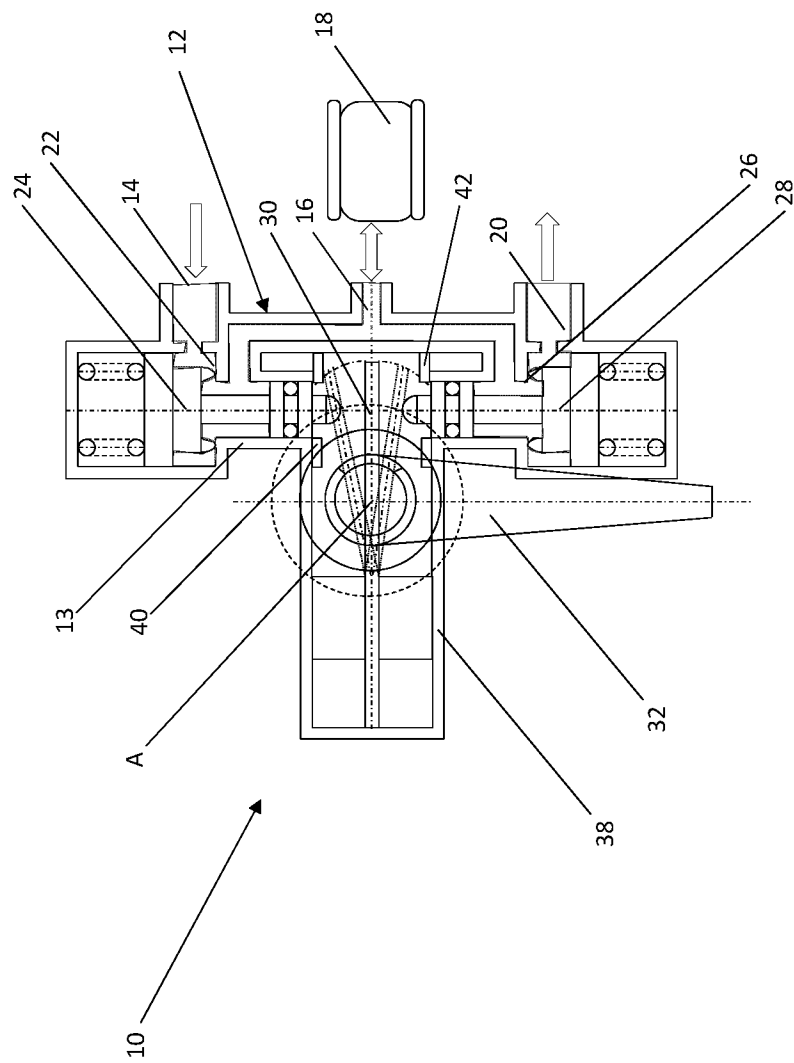


Fig. 1

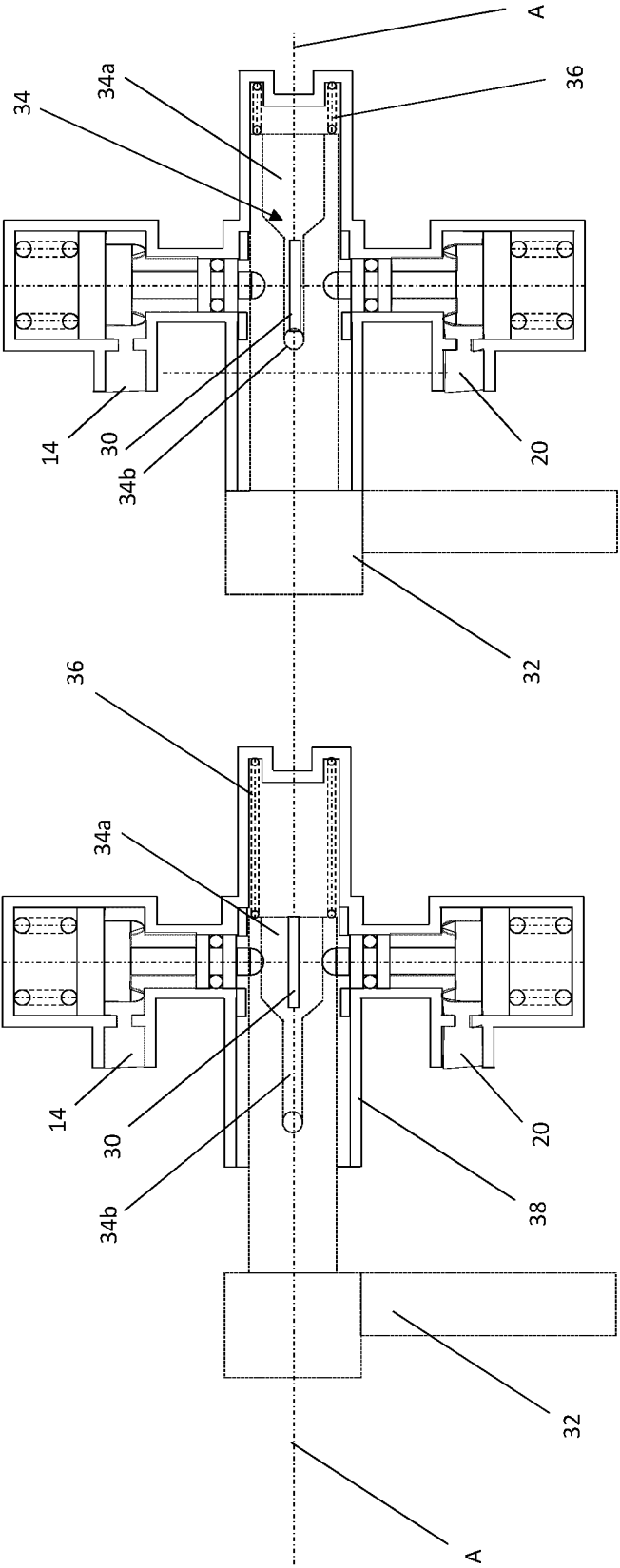


Fig. 2B

Fig. 2A

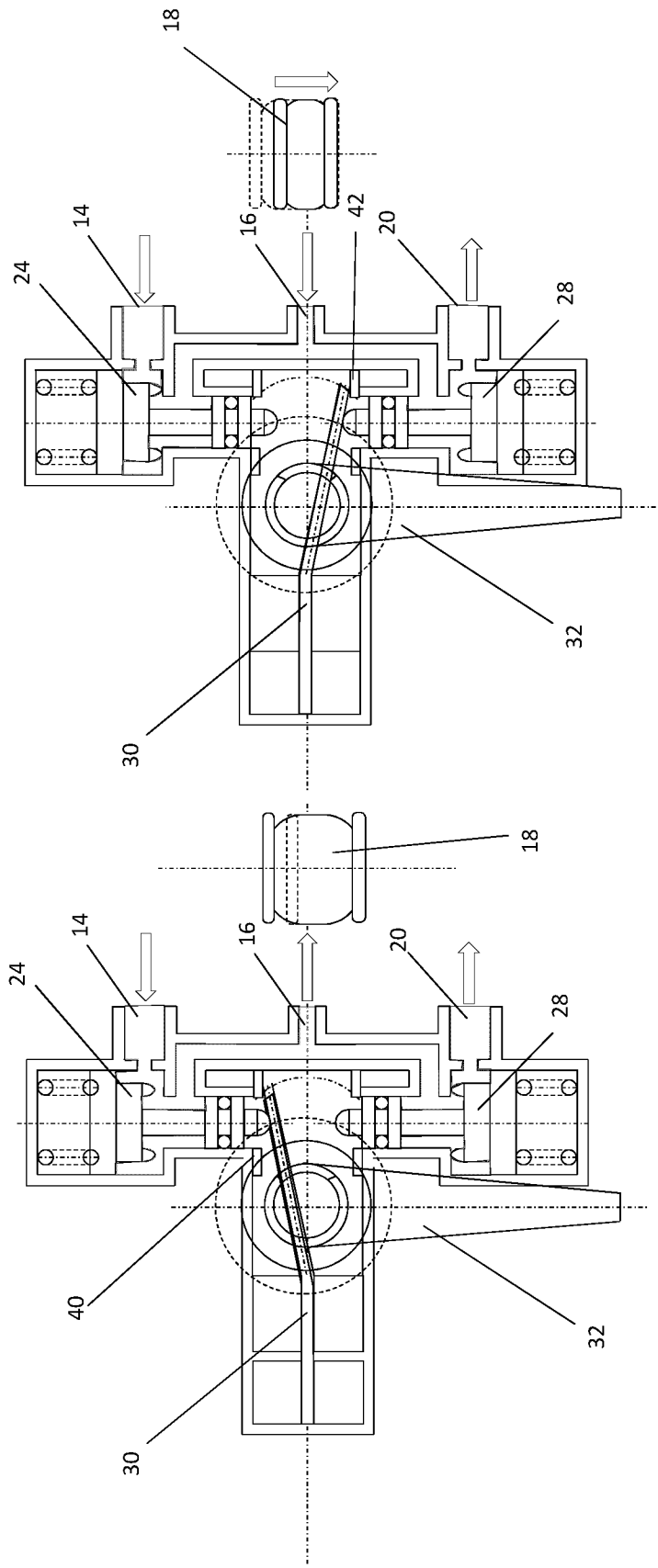


Fig. 3B

Fig. 3A

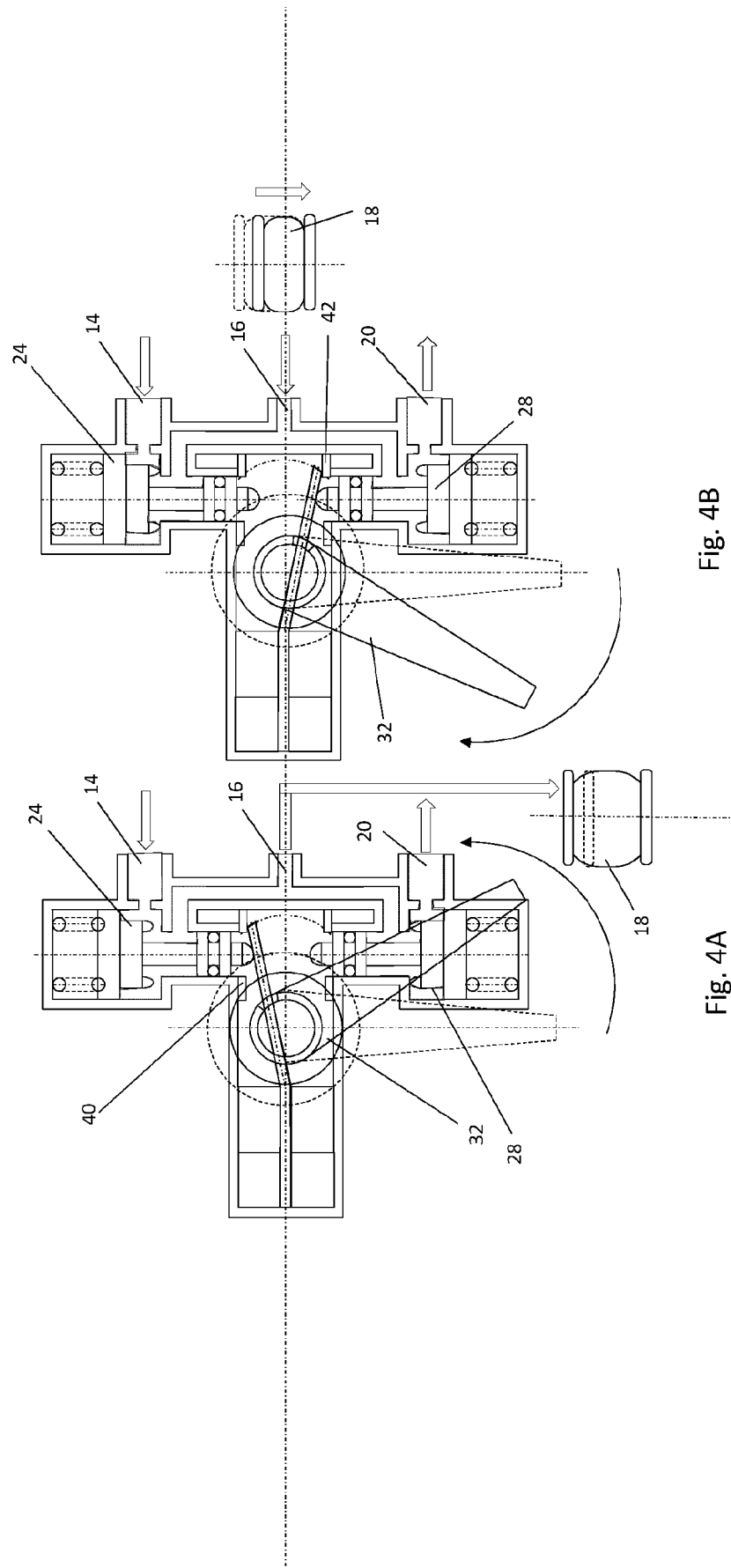


Fig. 4B

Fig. 4A

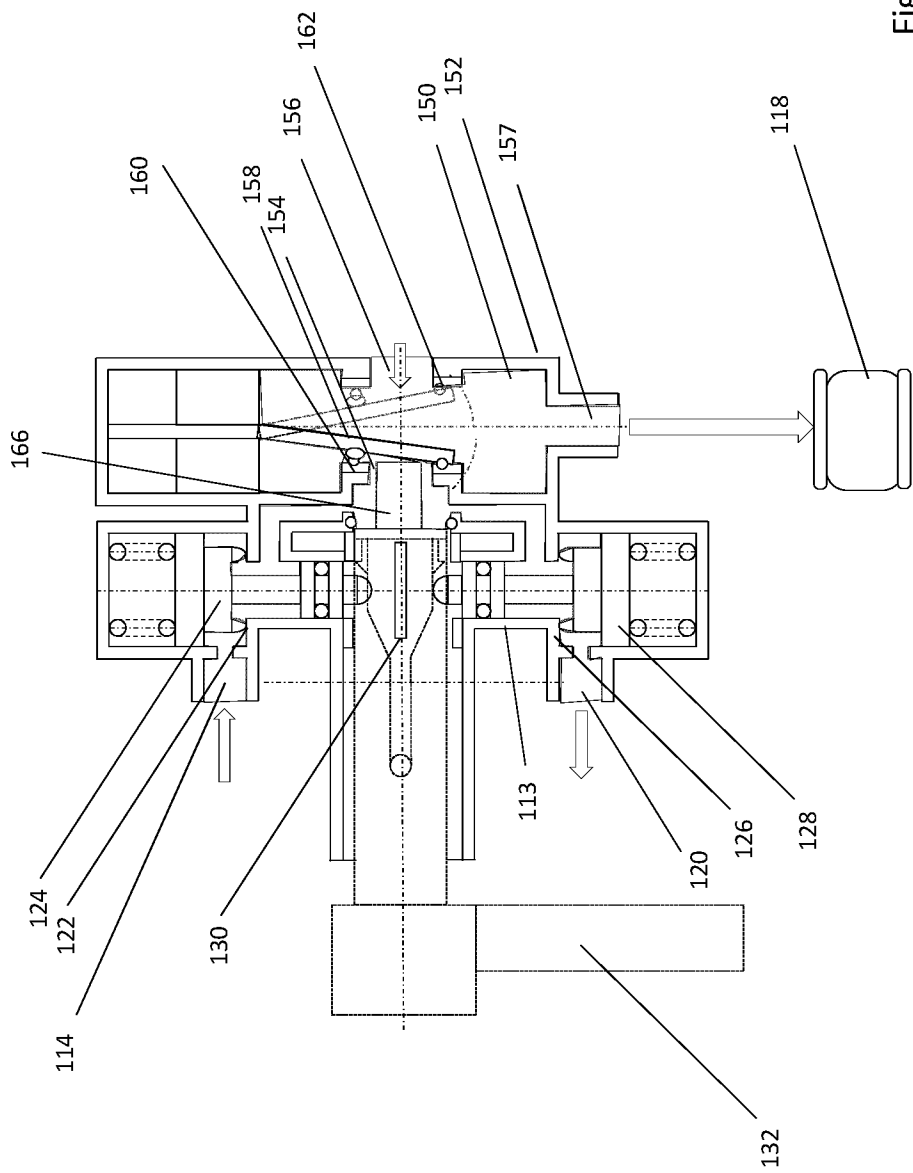


Fig. 5

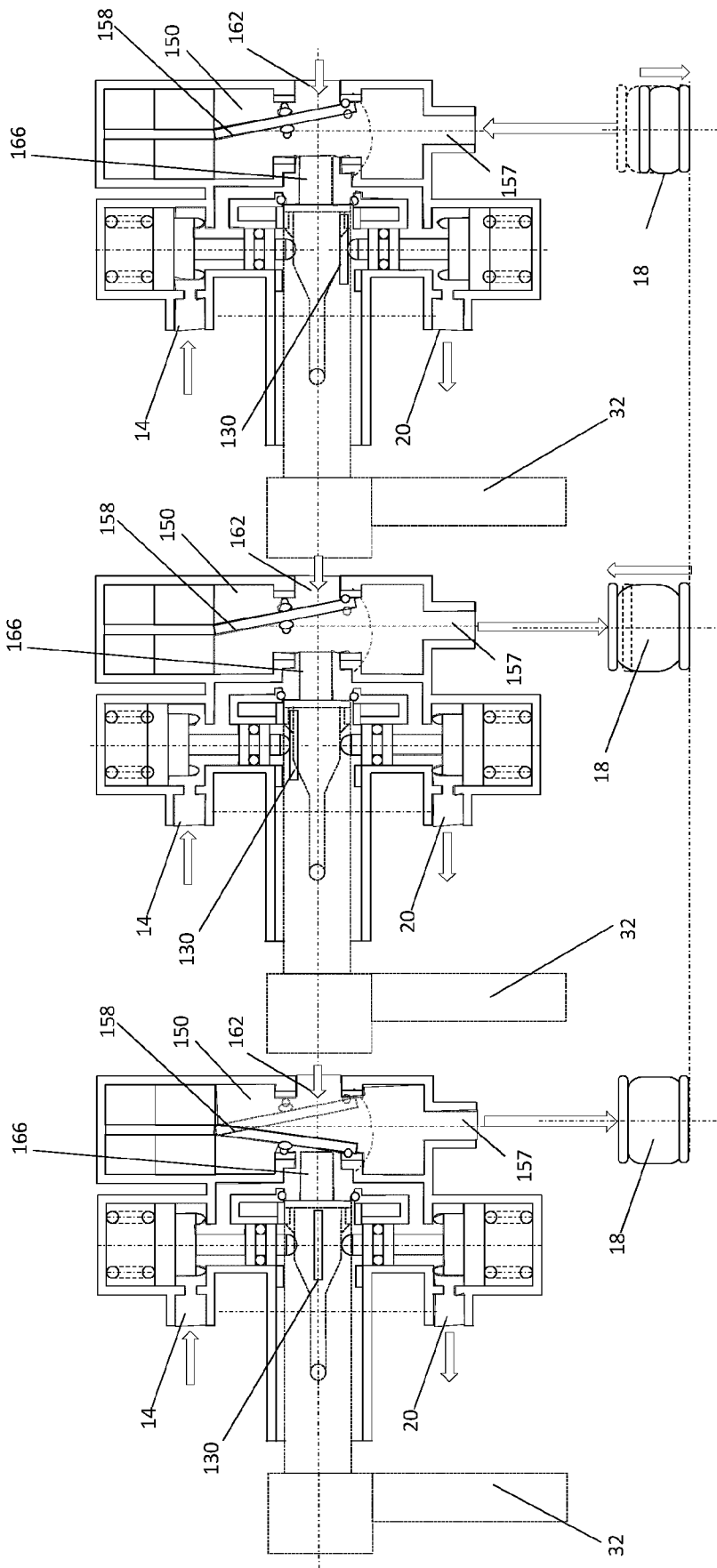


Fig. 6C

Fig. 6B

Fig. 6A

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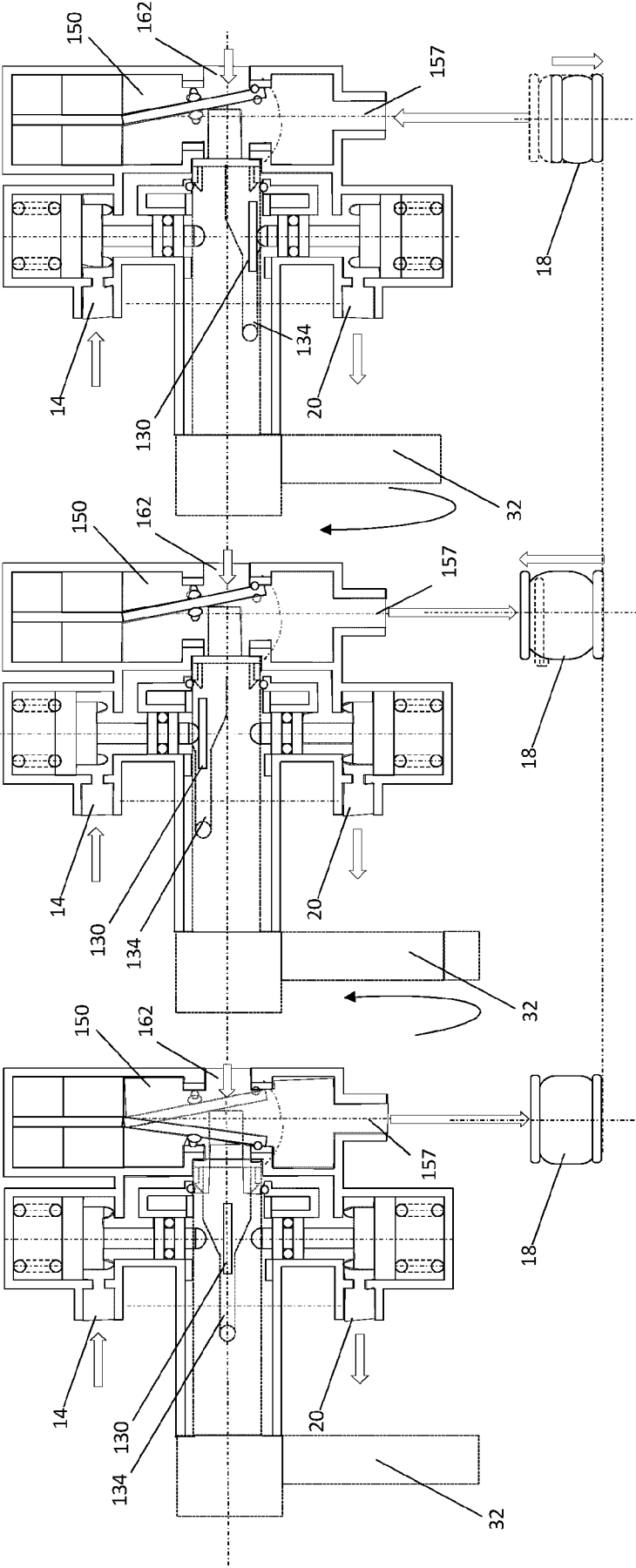


Fig. 7C

Fig. 7B

Fig. 7A

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/084745

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G11/27 B60G17/052 F16K31/06 F16K31/08 F16K31/60
ADD.

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)
B60G F16K

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

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

EPO-Internal, 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 A	EP 2 177 383 A1 (WABCO GMBH [DE]) 21 April 2010 (2010-04-21) the whole document paragraphs [0015], [0016], [0022]; figure 1 paragraphs [0025], [0029], [0030], [0031]; figure 2 paragraphs [0019], [0021]	1,2,12, 15 3
A	WO 02/04851 A1 (CAMCON LTD [GB]; WYGNANSKI WLADYSLAW [GB]) 17 January 2002 (2002-01-17) abstract; figures 1-3 second paragraph; page 22 ----- -/-	13,14



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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