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(54) Title: MULTI-VALVE DEVICE AND VALVE ARRANGEMENT

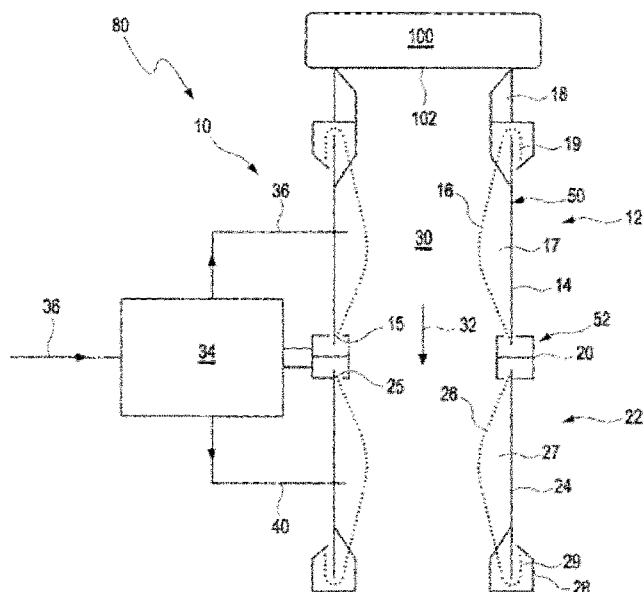


Fig. 1

(57) Abstract: The invention relates to a multi-valve device (10) for scavenging particulate matter (46), in particular dust, from a filter system (100), in particular an air filter system (100), comprising at least a first valve (12) and a second valve (22) arranged in series along a fluid path (32), to establish a collection volume (30) for the particulate matter (46). In each valve (12, 22) a flexible membrane (16, 26) is configured to close or open the fluid path (32) through the valve (12, 22). The first valve (12) and the second valve (22) are configured to be connectable to a valve control unit (34) for activating the flexible membranes (16, 26) independently from each other. The invention further relates to a valve arrangement (80) and a method for scavenging particulate matter (46) from an air filter system (100).

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Description**Multi-Valve Device and Valve Arrangement****Technical Field**

The invention relates to a multi-valve device for scavenging particulate matter, in particular dust, from a filter system, in particular an air filter system and a valve arrangement comprising a multi-valve device as well as a method for scavenging particulate matter, in particular dust, from an air filter system.

Prior Art

US 2010/0229972 A1 discloses an inertially activated ejection valve providing an inertially activated effluent ejector, and particularly an inertially activated dust ejector for an air induction system of an internal combustion engine in a vibratory system generating vibration. The vibration can be that of the engine itself, or a driven component such as an eccentric rotary driven weight. The dust ejection valve can be provided at various places in the air induction system of the internal combustion engine, and is provided between the pre-cleaner and the air filter.

US 2010/0229972 A1 further discloses a method for ejecting dust from an air induction system of an internal combustion engine in a vibratory system generating vibration. The method includes providing a dust ejection valve including an inertial mass, and inertially activating and driving the inertial mass by vibration to discharge dust from the air induction system. The method further includes providing the inertial mass as a plunger, and inertially driving the plunger by the vibration to vibrate and oscillate to an amplitude along an axial oscillation axis. Further it includes translating and oscillating the plunger inertial mass along an axial travel stroke in a channel extending along the oscillation axis, providing the plunger inertial mass with at least one valve face, providing the channel with at least one valve seat, and engaging the valve face and the valve seat at one end of the travel stroke.

Disclosure of the Invention

It is an object of the invention to provide a multi-valve device with a simple and robust operating performance for scavenging particulate matter, in particular dust, from a filter system, in particular an air filter system.

Another object of the invention is to provide a valve arrangement using such a multi-valve device.

A further object of the invention is to provide a method for scavenging particulate matter, in particular dust, from an air filter system with such a valve arrangement.

One object of the invention is achieved by a multi-valve device for scavenging particulate matter, in particular dust, from a filter system, in particular an air filter system, comprising at least a first valve and a second valve arranged in series along a fluid path, to establish a collection volume for the particulate matter, wherein the first valve and the second valve each comprise a housing segment and a flexible membrane arranged inside the housing segment, wherein in each valve the flexible membrane is configured to close or open the fluid path through the valve, wherein the first valve and the second valve are configured to be connectable to a valve control unit for activating the flexible membranes independently from each other.

Another object of the invention is achieved by a valve arrangement comprising a multi-valve device, the multi-valve device having at least a first and a second valve, wherein a valve control unit is provided for activating flexible membranes of valves of the multi-valve device independently from each other, and comprising a two-way valve for supplying the first valve with air and for supplying the second valve with air either, wherein the two-way valve being particularly a solenoid valve.

A further object of the invention is achieved by a method for scavenging particulate matter, in particular dust, from an air filter system, where a valve arrangement is connected to an outlet for particulate matter of the air filter system, the valve arrangement comprising a multi-valve device, the multi-valve device having at least a first and a second valve, wherein a valve control unit is provided for activating flexible membranes of valves of the multi-valve device independently from each other, and comprising a two-way valve for supplying the first valve with air and for supplying the second valve with air either, wherein the two-way valve being particularly a solenoid valve, the method comprising the air filter system operating in a first working phase with the first valve being open and the second valve being closed by the activated second flexible membrane for collecting particulate matter in a collection volume for the particulate matter, and the air filter system operating in a second working phase with the first valve being closed by the activated

second flexible membrane and the second valve being open for scavenging particulate matter from the collection volume for the particulate matter along a fluid path through a second connector.

- 5 The other claims, the description and the drawings describe advantageous embodiments of the invention.

According to a first aspect of the invention, a multi-valve device is proposed for scavenging particulate matter, in particular dust, from a filter system, in particular an air
10 filter system, comprising at least a first valve and a second valve arranged in series along a fluid path, to establish a collection volume for the particulate matter. The first valve and the second valve each comprise a housing segment and a flexible membrane arranged inside the housing segment. In each valve the flexible membrane is configured to close or open the fluid path through the valve. The first valve and the second valve are
15 configured to be connectable to a valve control unit for activating the flexible membranes independently from each other.

The inventive multi-valve device may advantageously be used for flow controlling along the fluid path, in particular for dust collecting and scavenging. According to a favorable
20 embodiment the multi-valve device may comprise three subsystems. Two housing segments as bodies with a flexible membrane forming an inflatable chamber and a central connection component between the two housing segments. The central connection component keeps membranes on both sides in place and allows the fixation of an air admission system. The upper housing segment may comprise an inflatable pinch valve
25 held with a clip connector. The clip connector may include an interface for air filter plugging. The lower housing segment may also comprise an inflatable membrane held by a clip connector. The air admission system may supply air pressure for inflating alternatively chambers of both membranes. When a chamber of a flexible membrane is supplied with air, the corresponding valve pipe is closed. By this way the inventive multi-
30 valve device may advantageously be used to collect dust from an air filter. In a first working phase the first valve adjacent to the air filter system may be open, thus representing in its inner space the collection volume for particulate matter as e.g. dust, whereas the second valve connected in series is closed by inflating the chamber of the flexible membrane. For scavenging the particulate matter from the system, in a second

working phase the first valve adjacent to the air filter system may be closed by inflating the chamber of the corresponding membrane, whereas the second valve may be opened by deflating the chamber of the flexible membrane. Thus the particulate matter from the collection volume of the first valve is transported, e.g. by gravity or by fluid pressure, from the first valve to the second valve and may exit through an outlet of the valve.

Alternatively the flexible membranes may be activated mechanically for closing and opening the corresponding valves.

The flexible membranes may be manufactured from rubber material or other elastomers, which are resistant to dust and/or oil and may work in ambient temperatures from -20°C to 140°C , which are temperatures usually required in the ambience of internal combustion engines. Typical dimensions may be in the range of a length of about 60 mm with an internal free diameter of about 30 to 40 mm. It is to be understood that the dimensions may vary depending on the actual application of the multi-valve device.

The described multi-valve devices may advantageously be used for heavy-duty tractors or construction machines. The device may be integrated at an air filter system in a vertical position or an angled position to a vertical direction. Connection to the air filter system may advantageously be achieved by a quick connector system.

The multi-valve device may advantageously be assembled from existing pinch valves for creating a dust collection volume and may be used for dust pre-separation of an air filter. The flexible membranes of the pinch valves may be activated with pressure from a turbocharger when being integrated in an internal combustion engine.

The inventive multi-valve device reduces the risk of having leakages when dust discharging from an air filter system, which may advantageously improve dust pre-separation efficiency. More over the proposed multi-valve device may be able to work with a two stages turbo-charged engine.

According to an advantageous embodiment of the multi-valve device, the first valve and/or the second valve may be configured as a pinch valve. Pinch valves are commercially available in various dimensions, such that the multi-valve device may be assembled according to the dimensions of the air filter system where the multi-valve

device is intended to collect and scavenge dust during operation of the air filter system. Such pinch valves are advantageously available also for robust working conditions and ambiances.

- 5 According to an advantageous embodiment of the multi-valve device, the flexible membranes of the first valve and the second valve may be formed integrally, in particular wherein each of the flexible membranes may provide a separated inflatable and deflatable chamber between the respective membrane and housing segment. Thus the flexible membrane formed integrally may be manufactured at a lower price. Favorably sealing of
10 the chambers of the flexible membrane to each other and against the ambience may be provided in a reliable way.

According to an advantageous embodiment of the multi-valve device, a separation ring may be arranged in the collection volume for the particulate matter between the two
15 membranes, being configured to secure the flexible membranes to an inner wall of the housing segments. Thus fixation of the flexible membrane in the multi-valve device as well as sealing of the two chambers working independently to each other may be provided in an efficient and reliable way.

- 20 According to an advantageous embodiment of the multi-valve device, the housing segments of the first valve and the second valve may be formed integrally. In such an embodiment connection of the two valves may be facilitated. Further manufacturing of the multi-valve device may be achieved in an efficient and reliable manner. Sealing of the two valves to each other is intrinsically achieved.

25 According to an advantageous embodiment of the multi-valve device, the first housing segment and the second housing segment may be joined by a connection component. Favorably the connection component serves for connecting and sealing the two valves to each other. Thus assembling the multi-valve device may be achieved in a very efficient
30 and flexible way. Further changing one of the valves in case of maintenance may also be facilitated in a favorable manner.

According to an advantageous embodiment of the multi-valve device, the first valve may comprise a first connector arranged opposite to the second valve with respect to the fluid
35 path and/or the second valve may comprise a second connector arranged opposite to the

first valve with respect to the fluid path. The connectors may serve for easy integration of the multi-valve device to an air filter system as well as to a dust collection system. Advantageously quick connectors may be used for easy connection and flexible changing of the multi-valve device in case of maintenance of the system.

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According to an advantageous embodiment of the multi-valve device, the first connector may be configured to secure a section of the first flexible membrane and/or the second connector may be configured to secure a section of the second flexible membrane, and/or wherein an interface region between the first and second housing segments may be configured to secure a section of at least one of the flexible membranes. In such an embodiment the flexible membranes may easily be assembled to the housing segments of the valves. Further sealing of the flexible membranes against the housing segments and the ambience may be facilitated. Thus a robust design of the multi-valve device may be achieved.

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According to another aspect of the invention, a valve arrangement is proposed comprising a multi-valve device. The multi-valve device has at least a first and a second valve. A valve control unit is provided for activating flexible membranes of valves of the multi-valve device independently from each other. The valve arrangement comprises a two-way valve for supplying the first valve with air and for supplying the second valve with air either. The two-way valve may particularly be a solenoid valve. The valve control unit together with the two-way valve may serve for activating the flexible membranes of the multi-valve device, thus controlling the functions of the scavenging an air filter system from particulate matter such as dust. By this way all advantages of the proposed multi-valve device described above may be achieved in a favorable manner.

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According to an advantageous embodiment of the valve arrangement, the flexible membranes may be controlled pneumatically by the valve control unit, in particular by air pressure. Pneumatic control of the flexible membranes is a very efficient and fast reaction means for opening and closing the valves of the multi-valve device. Further air pressure from turbo-chargers may favorably be used, if integrating the valve arrangement in an internal combustion engine, particularly in heavy duty engines of construction machines.

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According to an advantageous embodiment of the valve arrangement, the valve control unit may be fixed to the interface region, in particular wherein the valve control unit may

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be fixed to a connection component located at the interface region. Thus the valve control may easily be fixed to the multi-valve device for efficient assembling of the valve arrangement and easy maintenance. Further short distances between the valve control and the valves is advantageous for connecting air pipes from the valve control to the
5 valves.

According to a further aspect of the invention, a method is proposed for scavenging particulate matter, in particular dust, from an air filter system. A valve arrangement is connected to an outlet for particulate matter of the air filter system. The valve arrangement
10 comprises a multi-valve device, which has at least a first and a second valve. A valve control unit is provided for activating flexible membranes of valves of the multi-valve device independently from each other. The valve arrangement comprises a two-way valve for supplying the first valve with air and for supplying the second valve with air either. The two-way valve may particularly be a solenoid valve. The method comprises operating the
15 air filter system in a first working phase with the first valve being open and the second valve being closed by the activated second flexible membrane for collecting particulate matter in a collection volume for the particulate matter, and operating the air filter system in a second working phase with the first valve being closed by the activated second flexible membrane and the second valve being open for scavenging particulate matter
20 from the collection volume for the particulate matter along a fluid path through a second connector.

The valve arrangement comprises a two-way valve for supplying the first valve with air and for supplying the second valve with air either. The two-way valve may particularly be
25 a solenoid valve. The valve control unit together with the two-way valve may serve for activating the flexible membranes of the multi-valve device, thus controlling the functions of the scavenging an air filter system from particulate matter such as dust.

The multi-valve device is used for flow controlling along the fluid path, in particular for
30 dust collecting and scavenging. According to a favorable embodiment the multi-valve device may comprise three subsystems, i.e. two housing segments as bodies with a flexible membrane forming an inflatable chamber and a central connection component between the two housing segments. The central connection component keeps membranes on both sides in place and allows the fixation of an air admission system. The

upper housing segment may comprise an inflatable pinch valve held with a clip connector. The clip connector may include an interface for air filter plugging. The lower housing segment may also comprise an inflatable membrane held by a clip connector. The air admission system may supply air pressure for inflating alternatively chambers of both
5 membranes. When a chamber of a flexible membrane is supplied with air, the corresponding valve pipe is closed. By this way the inventive multi-valve device may advantageously be used to collect dust from an air filter.

In a first working phase the first valve adjacent to the air filter system may be open, thus
10 representing in its inner space the collection volume for particulate matter as e.g. dust, whereas the second valve connected in series is closed by inflating the chamber of the flexible membrane. For scavenging the particulate matter from the system, in a second working phase the first valve adjacent to the air filter system may be closed by inflating the chamber of the corresponding membrane, whereas the second valve may be opened
15 by deflating the chamber of the flexible membrane. Thus the particulate matter from the collection volume of the first valve is transported, e.g. by gravity or by fluid pressure, from the first valve to the second valve and may exit through an outlet of the valve.

The housing of the multi valve device can be assembled of multiple housing segments.
20 Advantageously the housing of the multi valve device can be assembled of at least two housing segments, in particular cylindrical housing segments, which are connected to each other at an interface region by a connection component, i.e. a ring shaped component. The housing segments could be identically same parts to reduce manufacturing cost. Advantageously the housing segments and/or the connection component can be
25 glued, welded, clipped or screwed to each other.

The housing segments can provide features like protrusions with feedthrough for bolts or screws, possibly with bushes, to secure a strong connection of the parts.

In an alternative embodiment the housing segments and/or the separation ring can be
30 clipped together with lugs on one side and a correspondence snap clip on the adjacent segment.

Advantageously the connection component provides additional functions like mounting devices, i.e. brackets for other components like valve control units or cable clips. The clip

connection can be realized by lugs at the housing parts and clips at the first connector or second connector. Alternatively lugs can be provide by the connectors and the clips by the housing parts.

- 5 For the assembly of the first connector and/or the second connector to the adjacent housing segment a clip connection is realized by at least one lug at the housing segment and at least one clip at the first connector or second connector. Alternatively a least one lug can be provided by the connector and at least one clip by the housing segment.
- 10 The connection component can be composed as a ring with integrated bracket allocated to fix the valve control unit or other engine components.

The housing and the size of the flow cross section are dimensioned to fit with the application the device is used for, depending on working case and requested response
15 time of the multi-valve device. With increase of the flow cross section in relation to the size of the housing and the membrane section, the response time of the multi-valve device for deflating the membrane and release the valve will decrease.

The multi valve device has a connection component, for example a separation ring, which
20 creates an interface to connect the two housing segments of the housing. Additionally a flexible membrane could be fixed and sealed at its end sections with the connection component to create a volume for a collection volume for particulate matter.

The connection component can be formed as a ring with at least one recess to pinch at least one membrane between a housing segment and the connection component.

25 The first housing segment and the second housing segment of the multi-valve device can be joined by a connection component which is formed like a ring with at least one integrated recess to ensure a strong fixation and sealing between the two housing segments. The connector component is ensuring the membrane remains pinched between
30 the connector and the housing segment when the membrane is inflated due to air pressure.

A first connector can ensure the junction between an air filter housing and the multi-valve

device by generating a complementary interface to the air filter housing. The connector can provide a connection between an air filter housing and can hold the membrane in position inside the valve arrangement.

5 Brief Description of the Drawings

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown in:

- Figure 1 schematics of a valve arrangement with a multi-valve device according to
10 an embodiment of the invention, connected to an air filter system;
- Figure 2 schematics of a valve arrangement with a multi-valve device according to a
 further embodiment of the invention, connected to an air filter system;
- Figure 3 schematics of an air filter system with a valve arrangement in a first working
 phase for collecting dust particles according to an embodiment of the
15 invention;
- Figure 4 schematics of an air filter system with a valve arrangement in a second
 working phase for scavenging dust particles from the air filter system
 according to an embodiment of the invention;
- Figure 5 section view of an embodiment of a valve arrangement with a multi-valve
20 device made of separate housing sections;
- Figure 6 perspective view of a valve arrangement with a valve control unit;
- Figure 7 exploded side view of the valve arrangement of Fig. 6 without valve control
 unit;
- Figure 8 perspective view of a valve arrangement with a valve control unit of Fig. 6
25 and
- Figure 9 an additional perspective view of a valve arrangement with a valve control
 unit of Fig. 6.

Detailed Description of the Drawings

- 30 In the drawings, like elements are referred to with equal reference numerals. The
drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

Figure 1 depicts schematics of a valve arrangement 80 with a multi-valve device 10 according to an embodiment of the invention, connected to an air filter system 100 for scavenging particulate matter 46, in particular dust, from the air filter system 100.

5 The valve arrangement 80 comprises the multi-valve device 10, consisting of a first and a second valve 12, 22. A valve control unit 34 as an air distributor system is provided for activating flexible membranes 16, 26 of the valves 12, 22 of the multi-valve device 10 independently from each other. The valve control 34 comprises a two-way valve 44, depicted in the embodiments shown in Figures 3 and 4, for supplying the first valve 12 with
10 air and for supplying the second valve 22 with air either via air pipes 38, 40 respectively, wherein the two-way valve 44 being particularly a solenoid valve.

The first valve 12 and the second valve 22 are configured as a pinch valve each. The first
15 valve 12 and the second valve 22 of the multi-valve device 10 are arranged in series along a fluid path 32, to establish a collection volume 30 for the particulate matter 46. The first valve 12 and the second valve 22 each comprise a housing segment 14, 24 and a flexible membrane 16, 26 arranged inside the housing segment 14, 24, forming a separated inflatable and deflatable chamber 17, 27. In each valve 12, 22 the flexible
20 membrane 16, 26 is configured to close or open the fluid path 32 through the valve 12, 22. The first valve 12 and the second valve 22 are connected to the valve control unit 34 for activating the flexible membranes 16, 26 independently from each other. The flexible membranes 16, 26 are controlled pneumatically by the valve control unit 34, in particular by air pressure, being supplied by an air supply system 36.

25 The first housing segment 14 and the second housing segment 24 are joined by a connection component 20, thus forming a housing of the multi-valve device 10. The valve control unit 34 is fixed to the interface region 52, in particular is the valve control unit 34 fixed to the connection component 20 located at the interface region 52.

30 Alternatively the housing segments 14, 24 of the first valve 12 and the second valve 12, 22 may be formed integrally for easy assembly of the multi-valve device 10.

The first valve 12 comprises a first connector 18 arranged opposite to the second valve
35 22 with respect to the fluid path 32 and the second valve 22 comprises a second

connector 28 arranged opposite to the first valve 12 with respect to the fluid path 32. The multi-valve device 10 is connected to a dust outlet 102 of the air filter system 100 with the first connector 18. The second connector 28 may serve for connecting the multi-valve device 10 to a dust collecting system.

5 The first connector 18 is configured to secure a section 19 of the first flexible membrane 16 and the second connector 28 is configured to secure a section 29 of the second flexible membrane 26. The interface region 52 between the first and second housing segments 14, 24 is configured to secure a section 15, 25 of the flexible membranes 16, 26.

10 Using the valve arrangement 80 with the air filter system 100 depicted in Figure 1 allows to apply a method for scavenging particulate matter 46, in particular dust, from the air filter system 100. In a first working phase the first valve 12 is open and the second valve 22 is closed by the activated second flexible membrane 26 for collecting particulate matter 46 in a collection volume 30 for the particulate matter 46. In a second working phase the first valve 12 is closed by the activated second flexible membrane 26 and the second valve 22 is open for scavenging particulate matter 46 from the collection volume 30 for the particulate matter 46 along a fluid path 32 through a second connector 28.

20 Figure 2 depicts schematics of a valve arrangement 80 with a multi-valve device 10 according to a further embodiment of the invention. The multi-valve device 10 of the embodiment shown in Figure 2 differs from the embodiment shown in Figure 1 by the fact, that the flexible membranes 16, 26 of the first valve 12 and the second valve 12, 22 are formed integrally as a single piece. There still exist two membrane sections 15, 25 of the first and the second valve 12, 22, respectively, wherein each of the flexible membrane sections 15, 25 provide a separated inflatable and deflatable chamber 17, 27 between the respective membrane 16, 26 and housing segment 14, 24. A separation ring 54 is arranged in the collection volume 30 for the particulate matter 46 between the two membranes 16, 26. The separation ring 54 is configured to secure the flexible membranes 16, 26 with its membrane sections 15, 25 to an inner wall of the housing segments 14, 24 by pressing the membranes 16, 26 against the inner wall. Thus the membranes 16, 26 are fixed and two separated inflatable chambers 17, 27 are formed.

35 Figure 3 depicts schematics of an air filter system 100 with a valve arrangement 80 in a first working phase for collecting dust particles 46 according to an embodiment of the

invention, whereas Figure 4 depicts the air filter system 100 in a second working phase for scavenging the dust particles 46 from the air filter system 100.

The embodiment shown in Figure 3 resembles the embodiments shown in Figures 1 and 2, except that there is no connection component 20, because the two valves 12, 22 are directly connected in the interface region 52 without an additional connection component 20. This is due to simplification of the schematics in order to show the main functions of the valve arrangement 80 only. The valve control unit 34 comprises a two-way valve 44 for controlling the air flow 42 from the air supply system 36 to the chambers 17, 27 of the flexible membranes 14, 24 of the valves 12, 22 via air pipes 38, 40 respectively 36.

In the first working phase the first valve 12 adjacent to the air filter system 100 is open, thus representing in its inner space the collection volume 30 for particulate matter 46 as e.g. dust, whereas the second valve 22 connected in series is closed by inflating the chamber 27 of the flexible membrane 24. For scavenging the particulate matter 46 from the air filter system 100, in the second working phase the first valve 12 adjacent to the air filter system 100 is closed by inflating the chamber 17 of the corresponding membrane 14, whereas the second valve 22 is opened by deflating the chamber 27 of the flexible membrane 24. Thus the particulate matter 46 from the collection volume 30 of the first valve 12 is transported, e.g. by gravity or by fluid pressure, from the first valve 12 to the second valve 22 and may exit through an outlet of the valve 22

Figure 5 depicts in a section cut view an example of a specific embodiment of a mainly cylindrical valve arrangement 80 with a multi-valve device 10 similar to the valve arrangement shown in Fig. 1, connected to an air filter system 100 for scavenging particulate matter 46, in particular dust, from the air filter system 100. The valve control unit 34 is not shown.

The valve arrangement 80 comprises the multi-valve device 10, consisting of a first and a second valve 12, 22. Flexible membranes 16, 26 of the valves 12, 22 of the multi-valve device 10 can be activated independently from each other.

The first valve 12 and the second valve 22 are configured as a pinch valve each. The first valve 12 and the second valve 22 of the multi-valve device 10 are arranged in series along a fluid path 32, to establish a collection volume 30 for the particulate matter 46. The first valve 12 and the second valve 22 each comprise a housing segment 14, 24 and a

flexible membrane 16, 26 arranged inside the housing segment 14, 24, forming a separated inflatable and deflatable chamber 17, 27. In each valve 12, 22 the flexible membrane 16, 26 is configured to close or open the fluid path 32 through the valve 12, 22. The first valve 12 and the second valve 22 are connected to a valve control unit (not shown) for activating, in particular for inflating and deflating, the flexible membranes 16, 26 independently from each other. The flexible membranes 16, 26 are controlled pneumatically by the valve control unit, in particular by air pressure, being supplied by an air supply system 36. To connect the deflatable chamber 17, 27 with the valve control unit the housing segment 14, 24 provides a spigots 138, 140, suitable for hoses or air ducts.

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The first housing segment 14 and the second housing segment 24 are joined by a connection component 20, thus forming a housing of the multi-valve device 10.

The first valve 12 comprises a first connector 18 arranged opposite to the second valve 22 with respect to the fluid path 32 and the second valve 22 comprises a second connector 28 arranged opposite to the first valve 12 with respect to the fluid path 32. The multi-valve device 10 is connected to a dust outlet 102 of the air filter system 100 with the first connector 18. The second connector 28 may serve for connecting the multi-valve device 10 to a dust collecting system.

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The first connector 18 is configured to secure a section 19 of the first flexible membrane 16 and the second connector 28 is configured to secure a section 29 of the second flexible membrane 26. The interface region 52 between the first and second housing segments 14, 24, in particular the connection component 20, is configured to secure a section 15, 25 of the flexible membranes 16, 26. A section 15, 25, 19, 29 of the opposite ends of the membranes 16, 26 are clamped and secured over a certain length between a housing segment 14, 24 and the connection component 20 and on the other end between a housing segment 14, 24 and the first connector 18 or second connector 28.

Using the valve arrangement 80 with the air filter system 100 depicted in Figure 5 allows to apply a method for scavenging particulate matter 46, in particular dust, from the air filter system 100. In a first working phase the first valve 12 is open and the second valve 22 is closed by the activated second flexible membrane 26 for collecting particulate matter 46 in a collection volume 30 for the particulate matter 46. In a second working phase the

first valve 12 is closed by the activated second flexible membrane 26 and the second valve 22 is open for scavenging particulate matter 46 from the collection volume 30 for the particulate matter 46 along a fluid path 32 through a second connector 28

5 Figure 6 shows a perspective view of the specific embodiment of the valve arrangement 80 of Fig. 5 with a valve control unit 34 assembled to the multi valve device 10. The valve control unit 34 have connection nozzles 240, 238 to be connected to the air pipes 38, 40 for guiding the air into the chamber 17, 27 of the valve. 12, 22.

For the assembly of the valve arrangement 80 the housing segments 14, 24 can provide
10 features 37, 39, in particular protrusions with feedthrough for bolts or screws, possibly with bushes, to secure a strong connection of the parts.

Figure 7 displays an exploded side view of the separate parts of the valve arrangement 80 of Fig. 5. The connection component 20 provides a device, in particular domes 35, for
15 an assembly of a valve control unit 34.

For the assembly of the first connector 18 and/or the second connector 28 to the adjacent housing segment a clip connection is realized by at least one lug 56, 66 at the housing segment 14, 24 and at least one clip 57, 67 at the first connector 18 or second connector 28. Alternatively a least one lug 56, 66 can be provided by the connector and at least
20 one clip 57, 67 by the housing segment.

Figure 8 shows the specific embodiment of the valve arrangement 80 of Fig. 5 in a perspective view with the assembled valve control unit 34 with connection nozzles 238 for connection of the air pipes 38, 40. The air pipes are not displayed in Fig. 8.

25 Figure 9 shows the specific embodiment of the valve arrangement 80 of Fig. 5 in another perspective view with valve control unit 34 with connection nozzles 236, 238, 240. Nozzle 236 is to connect the valve control unit 34 with an air supply system 36. The air pipes are not displayed in Fig. 9. The valve control unit 34 is fixed to the interface region 52, in particular is the valve control unit 34 fixed to the connection component 20 located at the interface region 52. The valve control unit is fixed on the domes 35 of the connection component 20.
30

Claims

1. A multi-valve device (10) for scavenging particulate matter (46), in particular dust, from a filter system (100), in particular an air filter system (100), comprising at least a first valve (12) and a second valve (22) arranged in series along a fluid path (32), to establish a collection volume (30) for the particulate matter (46), wherein the first valve (12) and the second valve (22) each comprise a housing segment (14, 24) and a flexible membrane (16, 26) arranged inside the housing segment (14, 24), wherein in each valve (12, 22) the flexible membrane (16, 26) is configured to close or open the fluid path (32) through the valve (12, 22), wherein the first valve (12) and the second valve (22) are configured to be connectable to a valve control unit (34) for activating the flexible membranes (16, 26) independently from each other.
2. The multi-valve device according to claim 1, the first valve (12) and/or the second valve (22) being configured as a pinch valve.
3. The multi-valve device according to any one of the preceding claims, wherein the flexible membranes (16, 26) of the first valve (12) and the second valve (12, 22) are formed integrally, in particular wherein each of the flexible membranes (16, 26) provide a separated inflatable and deflatable chamber (17, 27) between the respective membrane (16, 26) and housing segment (14, 24).
4. The multi-valve device according to claim 3, wherein a separation ring (54) is arranged in the collection volume (30) for the particulate matter (46) between the two membranes (16, 26), being configured to secure the flexible membranes (16, 26) to an inner wall of the housing segments (14, 24).
5. The multi-valve device according to any one of the preceding claims, wherein the housing segments (14, 24) of the first valve (12) and the second valve (12, 22) are formed integrally.
6. The multi-valve device according to one of the claims 1 to 5, wherein the first housing segment (14) and the second housing segment (24) are joined by a connection component (20).

7. The multi-valve device according to any one of the preceding claims, wherein the first valve (12) comprises a first connector (18) arranged opposite to the second valve (22) with respect to the fluid path (32) and/or the second valve (22) comprises a second connector (28) arranged opposite to the first valve (12) with respect to the fluid path (32).
8. The multi-valve device according to claim 7, wherein the first connector (18) is configured to secure a section (19) of the first flexible membrane (16) and/or the second connector (28) is configured to secure a section (29) of the second flexible membrane (26), and/or wherein an interface region (52) between the first and second housing segments (14, 24) is configured to secure a section (15, 25) of at least one of the flexible membranes (16, 26).
9. A valve arrangement (80) comprising a multi-valve device (10) according to any one of the preceding claims, the multi-valve device (10) having at least a first and a second valve (12, 22), wherein a valve control unit (34) is provided for activating flexible membranes (16, 26) of valves (12, 22) of the multi-valve device (10) independently from each other, and comprising a two-way valve (44) for supplying the first valve (12) with air and for supplying the second valve (22) with air either, wherein the two-way valve (44) being particularly a solenoid valve.
10. The valve arrangement according to claim 9, wherein the flexible membranes (16, 26) are controlled pneumatically by the valve control unit (34), in particular by air pressure.
11. The valve arrangement according to claim 9 or 10, wherein the valve control unit (34) is fixed to an interface region (52), in particular wherein the valve control unit (34) is fixed to a connection component (20) located at the interface region (52).
12. A method for scavenging particulate matter (46), in particular dust, from an air filter system (100) where a valve arrangement (80) according to any one of the claims 9 to 11 is connected to an outlet (102) for particulate matter (46) of the air filter system (100), the valve arrangement (80) comprising a multi-valve device (10) according to any one of the claims 1 to 8, the multi-valve device (10) having at

least a first and a second valve (12, 22), wherein a valve control unit (34) is provided for activating flexible membranes (16, 26) of valves (12, 22) of the multi-valve device (10) independently from each other, and comprising a two-way valve (44) for supplying the first valve (12) with air and for supplying the second valve (22) with air either, wherein the two-way valve (44) being particularly a solenoid valve,

the method comprising

- operating the air filter system (100) in a first working phase with the first valve (12) being open and the second valve (22) being closed by the activated second flexible membrane (26) for collecting particulate matter (46) in a collection volume (30) for the particulate matter (46),
- operating the air filter system (100) in a second working phase with the first valve (12) being closed by the activated second flexible membrane (26) and the second valve (22) being open for scavenging particulate matter (46) from the collection volume (30) for the particulate matter (46) along a fluid path (32) through a second connector (28).

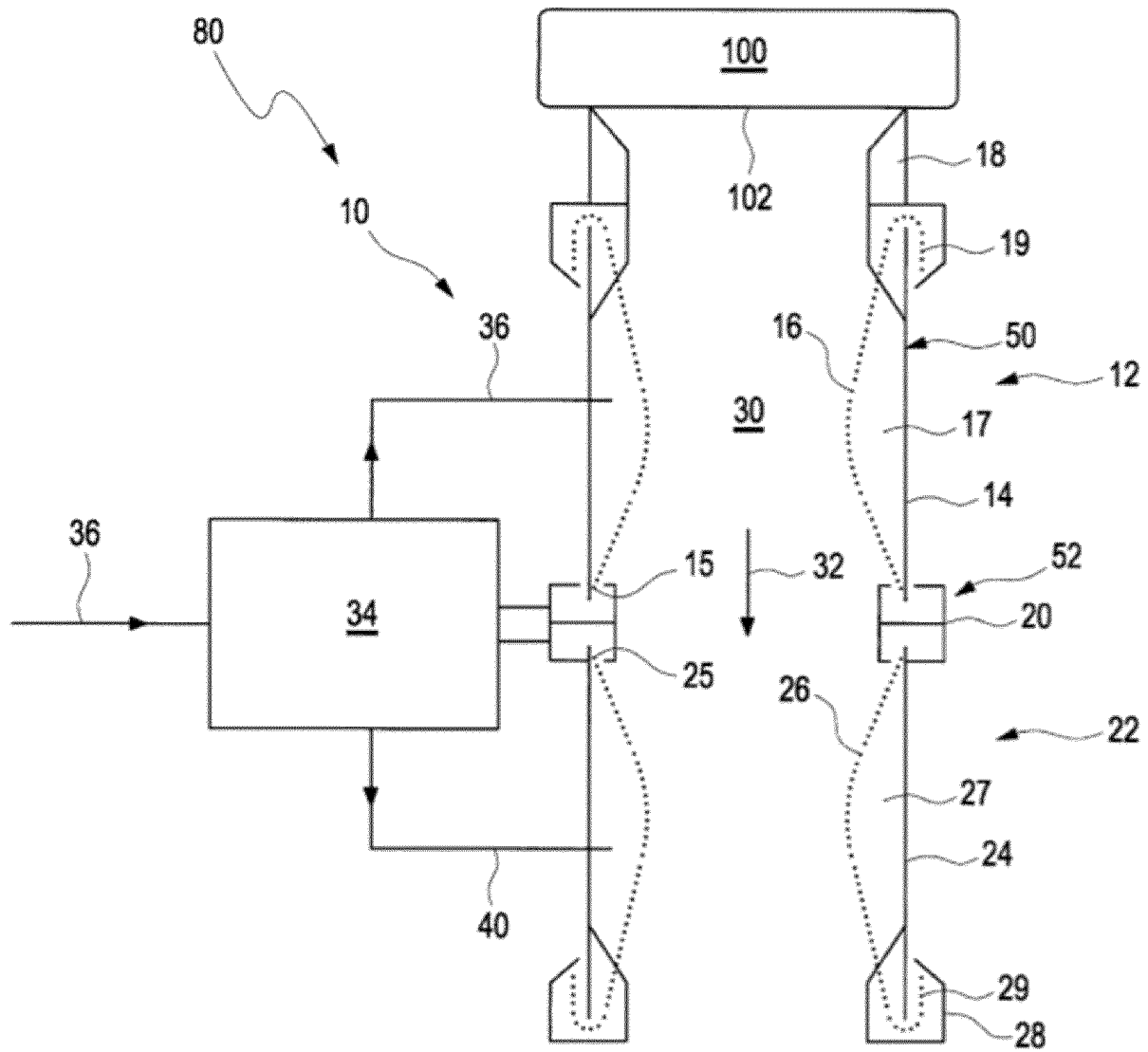


Fig. 1

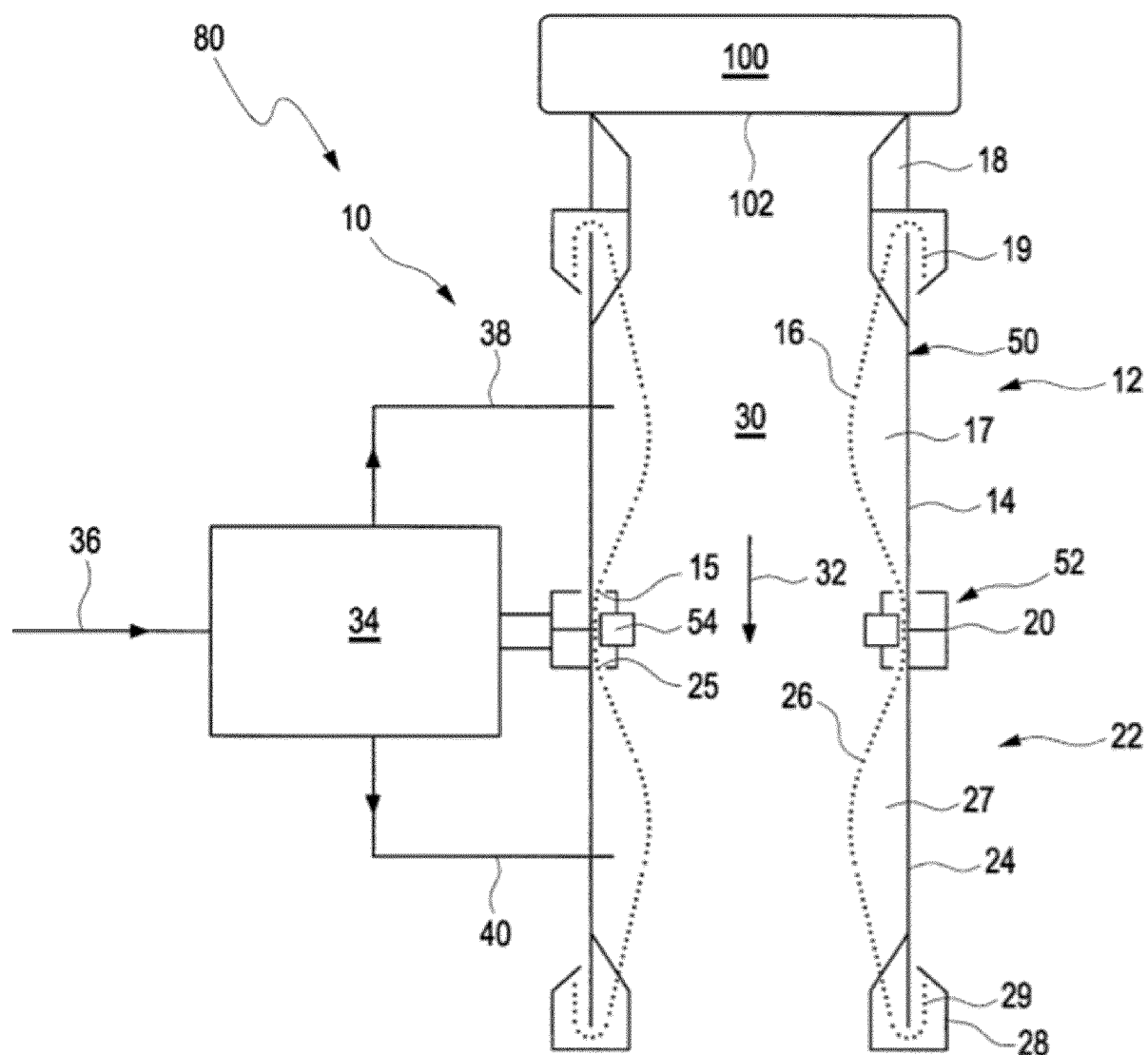


Fig. 2

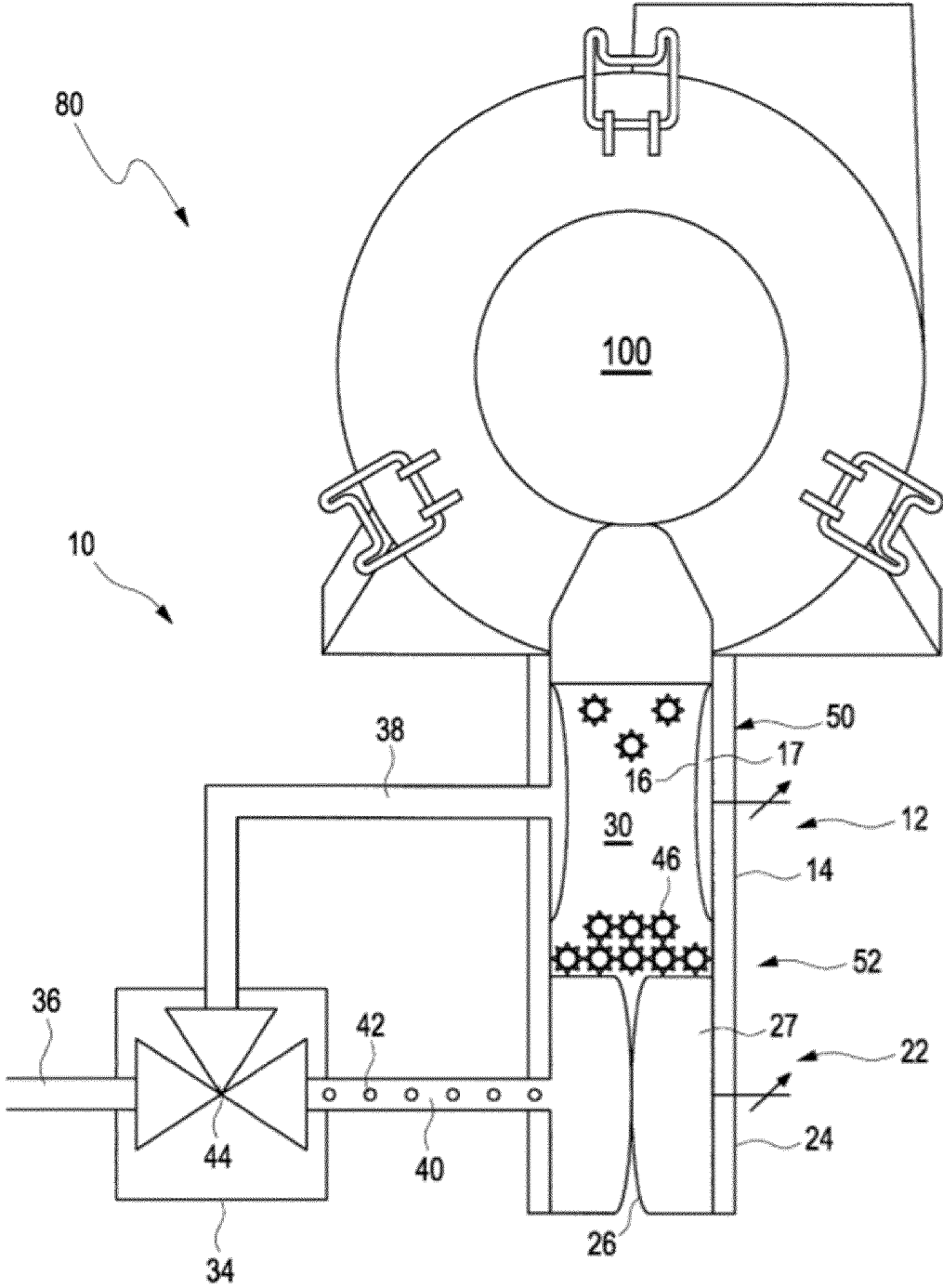


Fig. 3

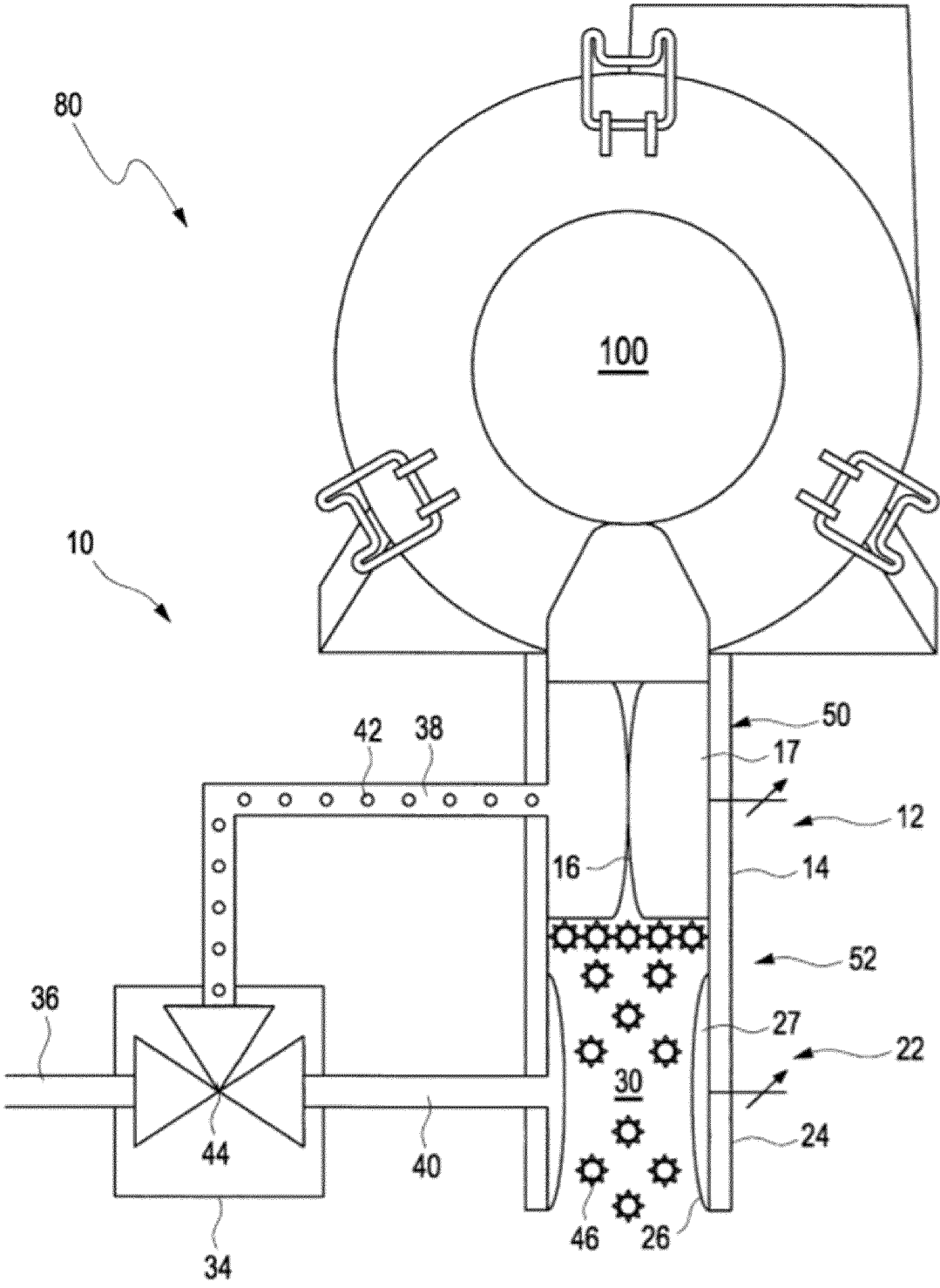


Fig. 4

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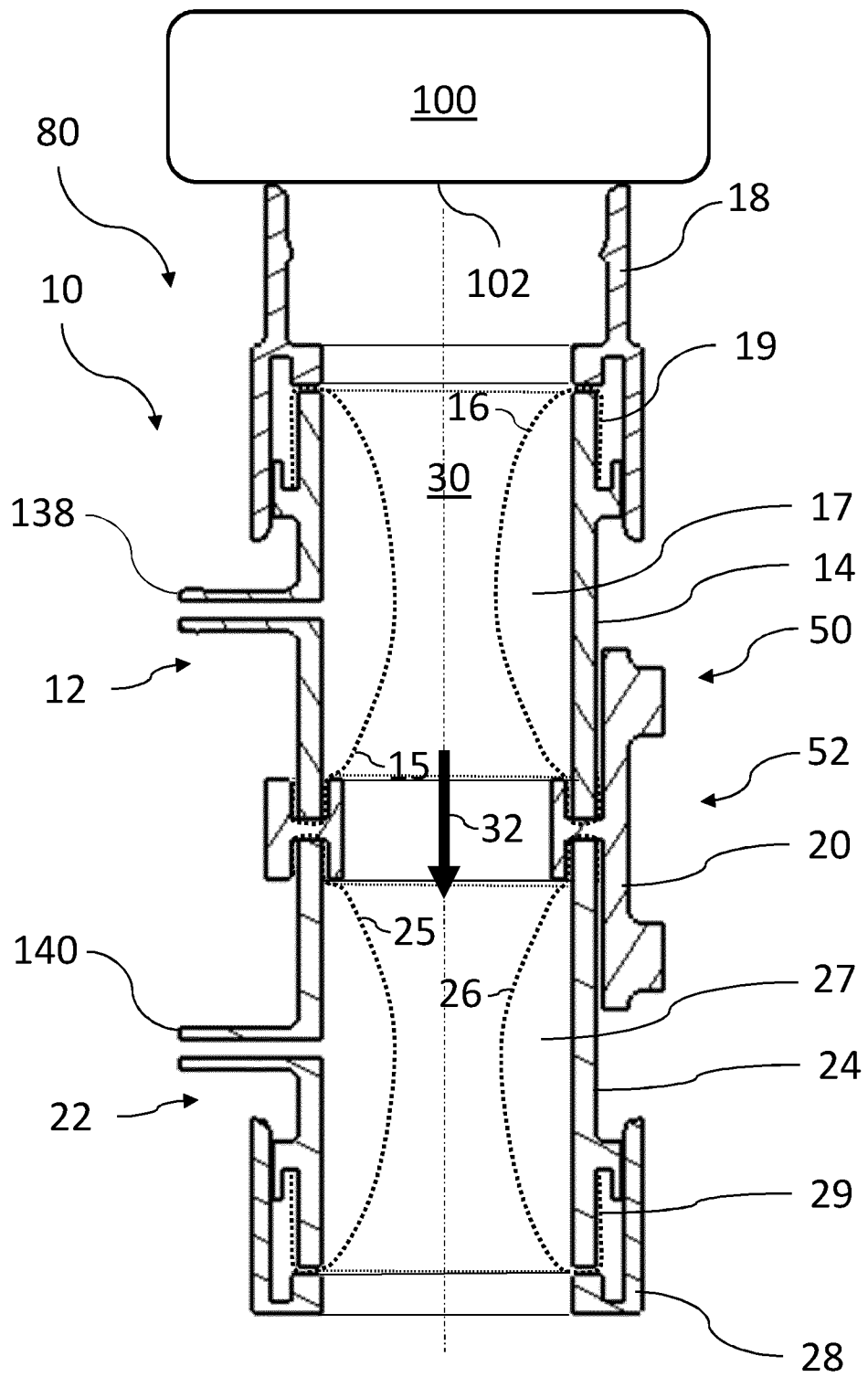


Fig. 5

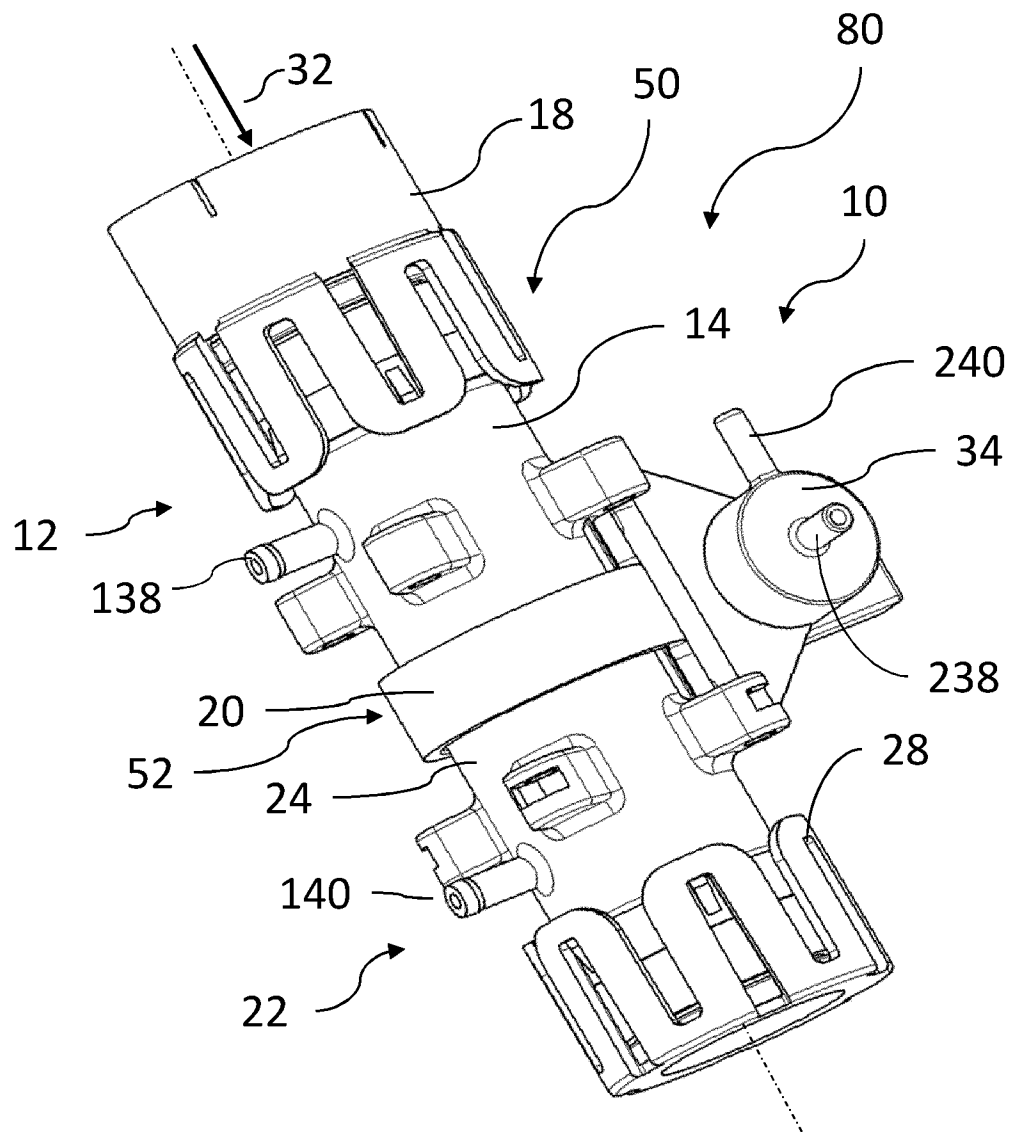


Fig. 6

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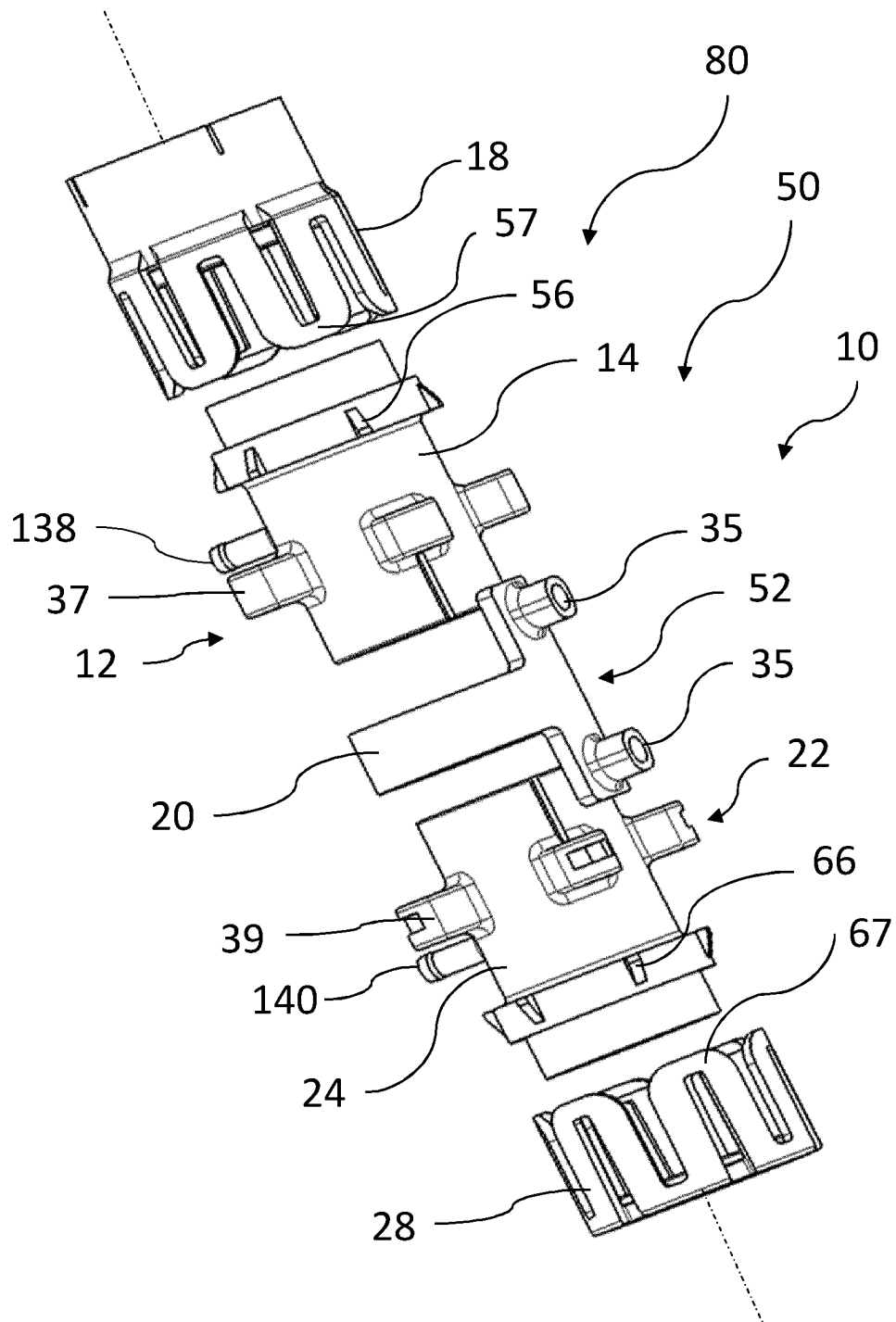


Fig. 7

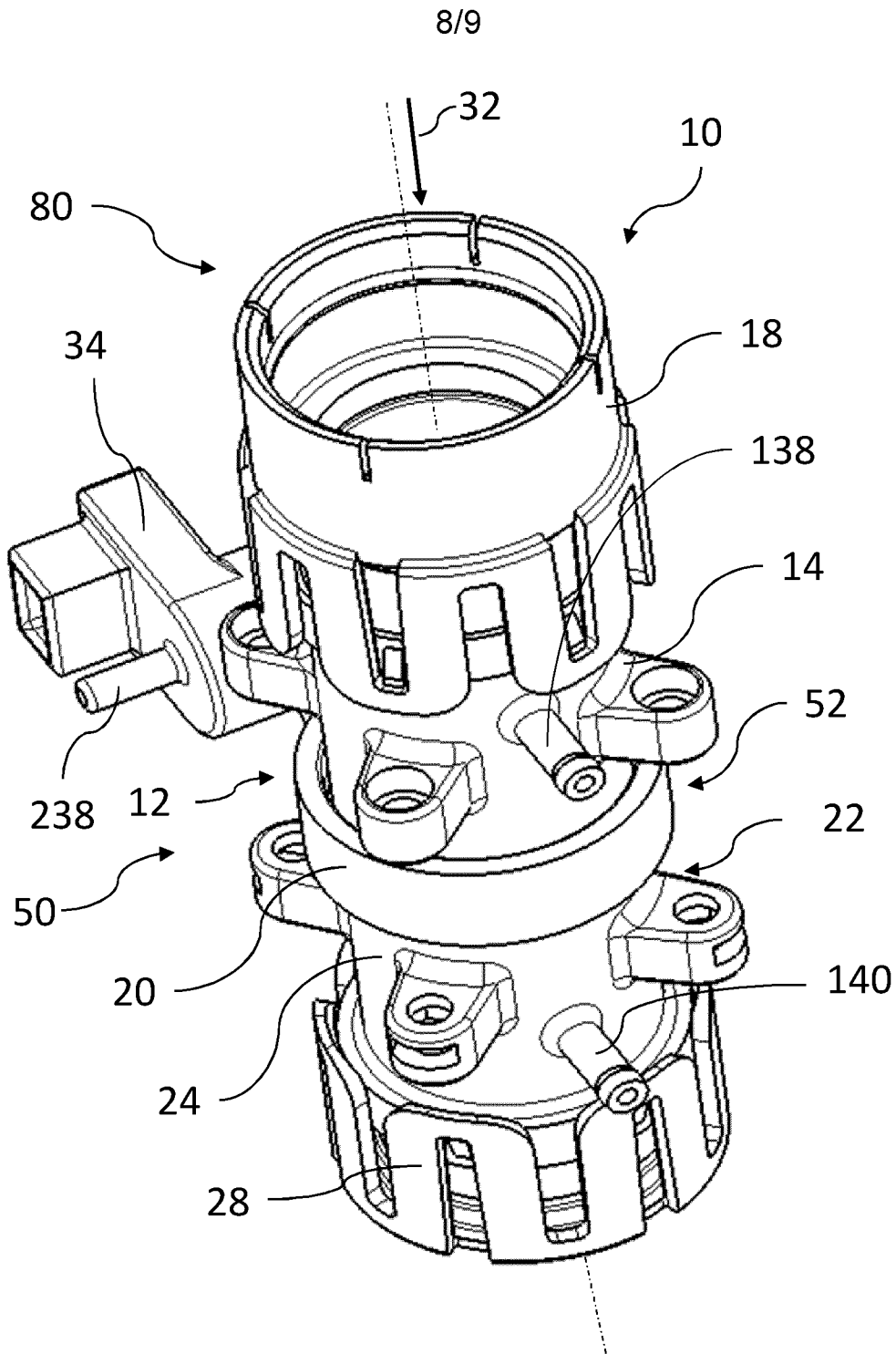


Fig. 8

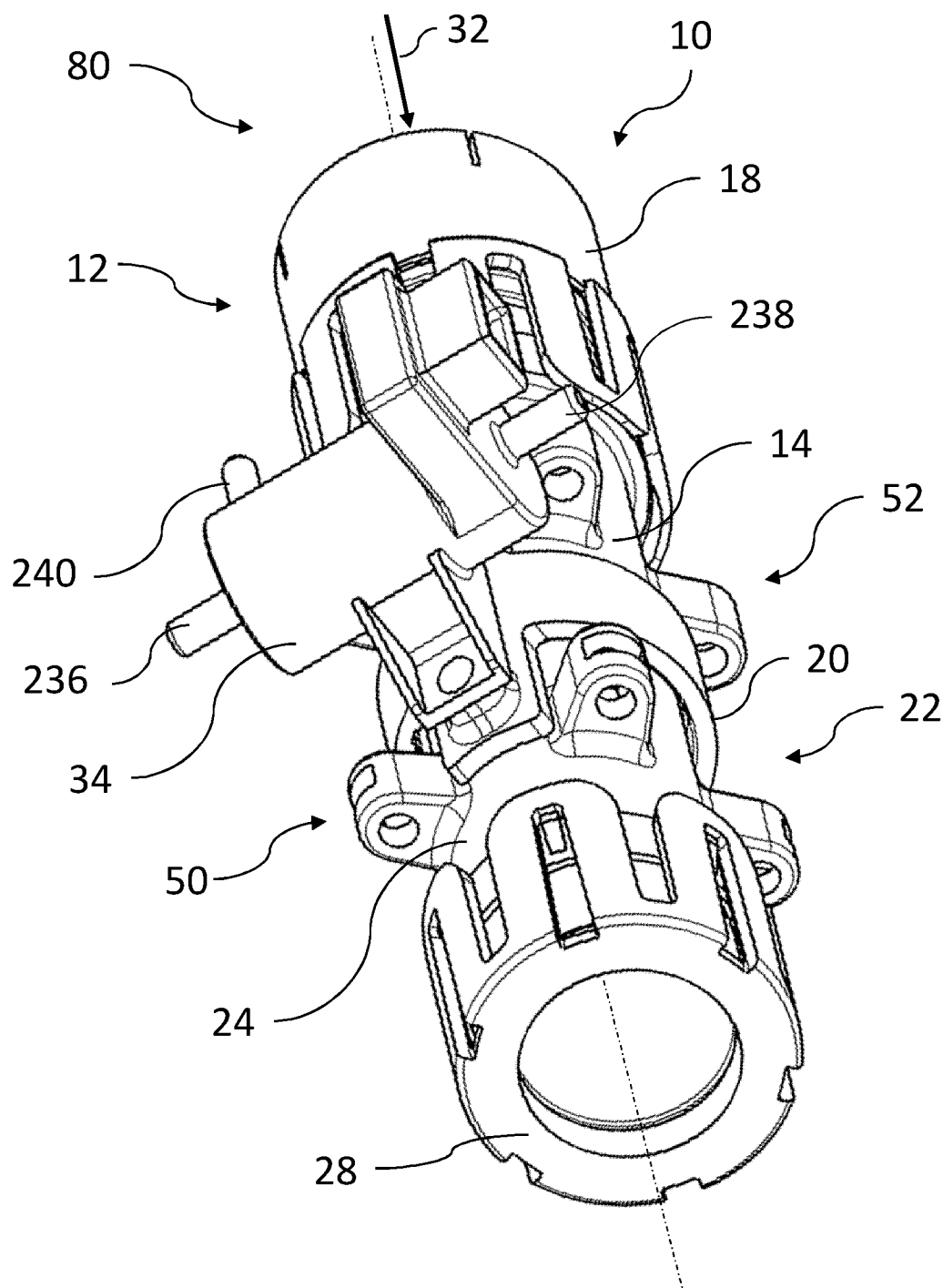


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/057134

A. CLASSIFICATION OF SUBJECT MATTER INV. F02M35/08 B01D45/18 B01D46/42 B01D46/48 F16K7/07 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) F02M B01D F16K A61M		
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.
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X	US 4 820 315 A (DEMARCO THOMAS M [US]) 11 April 1989 (1989-04-11) abstract figure 5 column 5 column 11, line 12 - column 17, line 34 ----- -/--	1,2,6
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 14 April 2020		Date of mailing of the international search report 20/04/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Juvenelle, Cyril

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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