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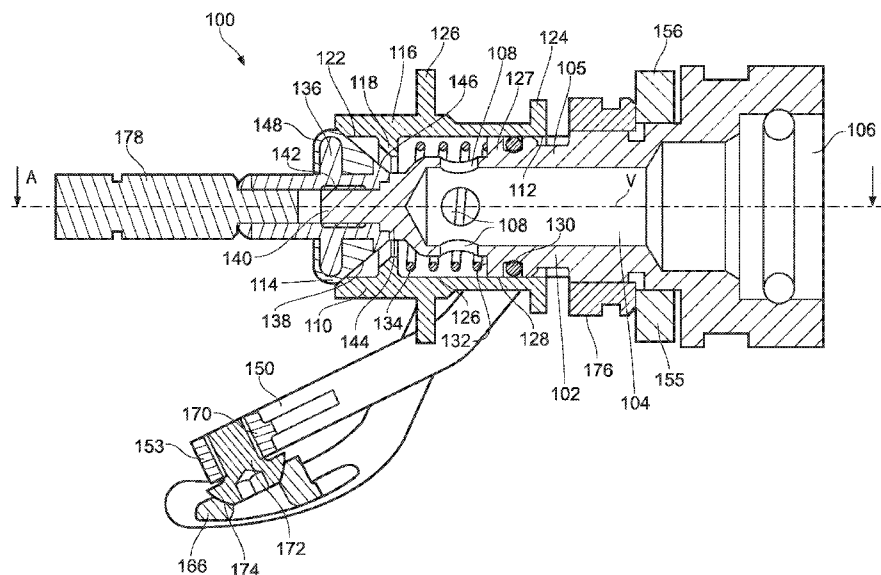


FIG. 1

(57) Abstract: A flow regulation valve for a demand regulator of a breathing apparatus comprising an inlet conduit configured for receiving breathing gas from a breathing gas source; a valve sleeve having an inlet for receiving the inlet conduit and an outlet for expelling breathing gas; and a sealing element configured for sealing the outlet of the valve sleeve; wherein the valve sleeve is moveable between a first position in which the outlet is sealed against the sealing element so as to inhibit breathing gas flow and a second position in which the outlet is not sealed against the sealing element so as to permit gas to permit breathing gas flow; and wherein the valve sleeve is arranged concentrically about the inlet conduit in slidable sealing contact therewith such that the sleeve valve is sealed against the inlet conduit in both of the first and second positions.

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FLOW REGULATION VALVE

The present disclosure concerns flow regulation valves for demand regulators of breathing apparatus.

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In breathing apparatus, a source of pressurised breathing gas, such as a high pressure cylinder, may be provided. However, the breathing gas may not be delivered to a user for breathing at such a high pressure, so various pressure reduction valves may be provided to reduce the pressure of the breathing gas and additionally to regulate and control the flow of breathing gas.

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A known type of breathing apparatus is a self-contained breathing apparatus or SCBA. In an SCBA, a breathing face mask is typically provided, to which a demand regulator (which may also be known as a lung demand valve or a second-stage pressure reduction valve) is connected. The demand regulator may comprise a flow regulation valve for regulating and dosing air to the user via the face mask.

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Some known flow regulation valves are highly complex valve systems, which may include many moving parts and sealing arrangements. Owing to their complexity, these valves may be difficult and expensive to manufacture, may suffer from reliability issues, and may require increased maintenance. Furthermore, a more complex valve arrangement may exhibit increased friction, which may require more user effort to actuate during inhalation, and may provide inefficient gas flow paths, which may inhibit the effective flow of breathing gas to the user.

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Accordingly, it will be understood that improvements are desirable in the field of flow regulation valves for breathing apparatus.

According to a first aspect, there is provided a flow regulation valve for a demand regulator of a breathing apparatus comprising an inlet conduit configured for receiving breathing gas from a breathing gas source; a valve sleeve having an inlet for receiving the inlet conduit and an outlet for expelling breathing gas; and a sealing element configured for sealing the outlet of the valve sleeve; wherein the valve sleeve is moveable between a first position in which the outlet is sealed against the sealing element so as to inhibit breathing gas flow and a second position in which the outlet is not sealed against the sealing element so as to permit gas to permit breathing gas flow;

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and wherein the valve sleeve is arranged concentrically about the inlet conduit in slidable sealing contact therewith such that the sleeve valve is sealed against the inlet conduit in both of the first and second positions.

5 It should be understood that the inner surface (or bore) of the valve sleeve, or the portion thereof which receives the inlet conduit should be arranged concentrically about the outer surface of the inlet conduit, or a portion thereof. For example, the inner bore of the inlet conduit or of the valve sleeve may be arranged eccentrically with respect to the outer surface of the inlet conduit or valve sleeve respectively, but the valve sleeve and inlet
10 conduit will be arranged concentrically provided at least a portion of the bore of the valve sleeve is arranged concentrically with at least a portion of the outer surface of the inlet conduit in a sealing contact therewith.

The valve sleeve may be biased into the first position by a spring and/or by a static
15 pressure applied within the valve sleeve.

The inlet conduit may comprise a substantially cylindrical outer surface and the valve sleeve comprises a substantially cylindrical inner surface, the substantially cylindrical outer surface of the inlet conduit being received within the valve sleeve against the
20 substantially cylindrical inner surface thereof.

One of the inner/outer surfaces may comprise an annular sealing element.

The inlet conduit may be received within the valve sleeve in a piston-like manner.
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The inlet conduit may extend a greater distance into the valve sleeve in the second position than in the first position.

The inlet conduit and the sealing element may be connected so as to form a valve shaft
30 about which the valve sleeve is arranged. The valve sleeve may be configured so as to be axially moveable relative to the valve shaft, which comprises the sealing element for sealing the outlet of the sleeve and the inlet conduit which is for slidably sealing the inlet of the sleeve and delivering breathing gas to the interior of the sleeve.

The inlet conduit, the valve sleeve, and the sealing element may arranged substantially coaxially so as to define a valve axis. The valve sleeve may be arranged to move between the first and second positions in a direction parallel to the valve axis.

- 5 The inlet conduit may comprise an inlet channel extending along the valve axis and bounded by a conduit wall.

The inlet conduit may comprise one or more inlet apertures arranged in the conduit wall so as to expel air from the inlet channel into the valve sleeve in a lateral or oblique
10 direction with respect to the valve axis.

Two or more inlet apertures may be provided. The inlet apertures may be evenly spaced about the valve axis.

- 15 In the second position, the valve sleeve may abut a stop element which is configured to prevent further movement of the valve sleeve away from the first position.

The stop element may be adjustable so as to adjust the second position of the valve sleeve and thereby adjust a maximum breathing gas flow provided by the flow regulation
20 valve.

The valve sleeve may be continuously moveable between the first and second positions so as to vary a breathing gas flow rate through the valve.

- 25 The sealing element may comprise a substantially conical or frustoconical sealing surface for sealing the outlet of the sleeve valve.

The outlet of the sleeve valve may comprise a frustoconical surface for sealing against the sealing element.

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In the first position, the sleeve valve may be configured so as to be internally statically pressurised by breathing gas provided by the inlet conduit. The valve sleeve may be configured such that an applied internal static pressure biases the outlet of valve sleeve against the sealing element.

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The flow regulation valve may further comprise an actuation mechanism configured to move the valve sleeve away from the first position towards the second position in response to a force applied to the actuation mechanism.

- 5 According to a second aspect, there is provided a demand regulator for a breathing apparatus comprising a flow regulation valve according to the first aspect above.

The demand regulator may comprise a diaphragm configured to be deflected by a decrease in pressure within the demand regulator during a user inhalation. The actuation
10 mechanism may be configured such that deflection of the diaphragm applies a force to the actuation mechanism.

The actuation mechanism may comprise a pivotable first lever configured to contact the diaphragm, and a pivotable second lever configured to contact the first lever and to move
15 the sleeve valve towards the second position in response to pivoting of the first lever. The actuation mechanism may further comprise an adjustment mechanism for adjusting the relative positions of the first and second levers when in contact.

According to a third aspect, there is provided a breathing apparatus comprising a flow
20 regulation valve according to the first aspect above or a demand regulator according to the second aspect above.

A demand regulator may also be known as a lung demand valve or a second stage pressure reduction valve. The breathing apparatus may be a self-contained breathing
25 apparatus or SCBA.

The skilled person will appreciate that except where mutually exclusive, a feature described in relation to any one of the above aspects may be applied mutatis mutandis to any other aspect. Furthermore except where mutually exclusive any feature described
30 herein may be applied to any aspect and/or combined with any other feature described herein.

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

Figure 1 shows a cross-sectional view of an exemplary flow regulation valve in a first, closed position;

5 **Figure 2** shows a further cross-sectional view of the exemplary flow regulation valve of Figure 1 in the first, closed position;

Figure 3 shows an a cross-sectional view of the exemplary flow regulation valve of Figures 1 and 2 in a second, open position;

10 **Figure 4** shows a further cross-sectional view of the exemplary flow regulation valve of Figures 1, 2 and 3 in the second, open position;

Figure 5A shows a detailed cross-sectional view of a portion of the exemplary flow regulation valve of Figures 1 and 2 in the first, closed position;

15 **Figure 5B** shows a detailed cross-sectional view of a portion of the exemplary flow regulation valve of Figures 3 and 4 in the second, open position;

20 **Figure 6** shows a cross sectional view of an exemplary demand regulator for a breathing apparatus; and

Figure 7 shows a detailed cross-sectional view of a portion of the exemplary demand regulator of Figure 6.

25 **Figures 1 and 2** show an example of a flow regulator valve 100, in particular for a demand regulator of a breathing apparatus, which may also be referred to herein as “valve 100” for brevity. Figure 1 shows the valve 100 in a first cross-sectional view viewed along the section plane BB of Figure 2 in the direction of the arrows. Figure 2 shows a second cross-sectional view of the valve 100 viewed along the section plane
30 AA of Figure 1 in the direction of the arrows. Accordingly, from the Figures 1 and 2, a full understanding of the arrangement of the valve 100 may be gained.

Generally, the valve 100 is configured so as to regulate a flow of breathing gas. The valve 100 is operable to prevent breathing gas flow or permit breathing gas flow. The
35 valve 100 in this example is also operable to finely adjust or regulate a flow rate of breathing gas.

As will be explained in more detail below, Figures 1 and 2 show the valve 100 in a first, closed position. In this closed position, flow of breathing gas through the valve 100 is substantially prevented. In contrast, **Figures 3 and 4** show the same exemplary flow regulator valve 100 along the same cross sections as Figures 1 and 2 respectively. However, unlike Figures 1 and 2, the valve 100 is shown in a second, open position in Figures 3 and 4. In this open position, the valve 100 is fully open, meaning that it will provide a maximum flow rate of breathing gas. It should be understood that the valve 100 may take intermediate positions between the closed position of Figures 1 and 2 and the fully open position of Figures 3 and 4. Any position between the open and closed positions of the valve 100 may be referred to herein as an intermediate position.

Referring first to Figures 1 and 2, the flow regulation valve 100 comprises an inlet conduit 102. The inlet conduit 102 comprises a main inlet channel 104 which extends generally axially therethrough and enclosed by a generally annular conduit wall 105. At a first end, the main inlet channel 104 has a gas delivery opening 106 to which a breathing gas source of a breathing apparatus (not shown), such as a self-contained breathing apparatus or SCBA, can be connected so as to deliver breathing gas to the valve 100. At a second end, the main inlet channel 104 comprises a plurality of inlet apertures 108 are formed in the conduit wall 105 such that breathing gas delivered at the gas delivery opening 106 can travel through the inlet conduit 102 in the main inlet channel 104 and be exhausted from the inlet conduit 102. The inlet conduit 102 is generally annular and tubular in shape and is centred about an axis formed at the intersection of planes AA and BB in Figures 1 and 2. This axis will be referred to as the “valve axis V” herein and the terms “axially” and “axial” should be interpreted herein as denoting directions parallel to the valve axis V, unless otherwise specified. The diameter of the main inlet channel 104 and the conduit wall 105 varies along the axial length of the inlet conduit 102, but in other examples, the dimensions of the inlet conduit may be constant or have differing sizes than those shown.

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The flow regulation valve 100 also comprises a valve sleeve 110 (or “sleeve 110” for brevity), which is the major moveable valve element of the valve 100 operable to adjust the gas flow rate through the valve. The sleeve 110 is generally tubular in shape having an inlet 112 at a first end thereof, and an outlet 114 at a second end thereof. The sleeve 110 comprises a main annular wall 116 from which there extends a first radially-inwardly extending flange 118, which will be referred to as the “inner flange 118” for brevity. The

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inner flange 118 generally divides the sleeve 110 into two interior axial sections, an inlet section 120 proximate the inlet 112 and an outlet section 122 proximate the outlet 114. The outer surface of the wall 116 of the valve comprises two radially-outwardly extending flanges, an abutment flange 124 and a sleeve flange 126. The abutment flange 124 is
5 formed at the inlet end of the sleeve 110 and provides an increased annular surface on the inlet end of the sleeve 110. The sleeve flange 126 may be used to abut a duct for transporting breathing gas from the outlet of the valve to thereby prevent entrainment of air. The sleeve flange 126 may also provide an abutment edge for an actuator for opening the valve 100, for example to provide bypass flow.

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The sleeve 110 is arranged concentrically about the inlet conduit 102. The inlet conduit extends into the inlet 112 of the sleeve 110 such that the inlet apertures 108 are arranged internally within the sleeve 110 to deliver breathing gas directly to the interior of the sleeve 110. The inlet conduit 102 has a radially-extending sealing flange 127 which
15 provides a cylindrical outer sealing surface 128. The sealing surface 128 has an outer diameter which is slightly smaller than an inner diameter of the inlet section 120 of the sleeve 110 such that the inlet conduit 102 is slidably received within the sleeve 110. In this example, a sealing O-ring 130 is provided on the sealing surface 128 to seal against the sleeve 110 but, in other examples, a sliding seal may be provided by other means.
20 Accordingly, the inlet conduit 102 is received within the sleeve 110 in a piston-like manner, such that gas within the sleeve 110 cannot escape from the sleeve 110 via the inlet 112 of the sleeve. Accordingly, the sleeve valve 110 is sealed against the inlet conduit 102 in both of the first, closed and second, open positions. Generally, it should be understood that in order for the sleeve 110 and inlet conduit 102 to be arranged
25 concentrically, it is required that a portion of the inner surface of the sleeve 110 should be concentric with a portion of the outer surface of the inlet conduit. Other parts of the sleeve or the inlet conduit may be non-concentrically or eccentrically arranged (for example, the channel 104 may be an eccentric bore with respect to the sealing surface 128, and/or the inlet section 120 of the sleeve may be eccentrically bored with respect
30 to the outer surface of the sleeve) and the sleeve and inlet conduit may still be considered to be concentric with the inlet conduit and in sealing contact therewith within the meaning of the present disclosure.

As will be described more with respect to Figures 3 and 4, the sleeve 110 is moveable
35 with respect to the inlet conduit 102 such that the extent to which the inlet conduit 102 extends into the sleeve 110 can be varied. However, in all positions of the sleeve 110,

a seal is maintained with the inlet conduit 102 such that gas cannot escape the sleeve 110 via its inlet 112. Accordingly, the sleeve 110 and inlet conduit 102 are configured such that the inlet conduit 102 delivers breathing gas directly to the interior of the sleeve 110. Additionally, the inlet apertures 108 are arranged to deliver breathing gas from the
5 channel 104 to the interior sleeve in a lateral or radial direction with respect to the valve axis V. The inlet apertures 108, of which there are four in this example, are evenly spaced about the valve axis V such that the breathing gas expelled therefrom impinges on the annular wall 116 of the sleeve 110 in a balanced manner, applying a balanced force on the sleeve about the axis V. Accordingly, the breathing gas entering the sleeve 110 from
10 the inlet conduit 104 may assist in centring the sleeve 110, which may permit smoother movement of the sleeve 110 by reduced friction. Importantly, reducing the friction of the sleeve 110 may thereby improve the operation of the valve 100 and a breathing apparatus more generally, as it may reduce the effort required by a user to actuate the valve 100 when breathing.

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The sealing flange 127 of the conduit 102 forms an annular surface 132 on the conduit 102. A spring 134 is arranged between the inner flange 118 of the sleeve 110 and the sealing flange 127 in a compressed state so as to bias the sleeve 110 axially away from the inlet conduit 102. Accordingly, the spring 134 will act to urge the inlet conduit 102
20 out of the sleeve 110 and, more generally, to urge the valve 100 into the closed position against the sealing element 136.

The valve 100 further comprises a sealing element 136. The sealing element 136 is configured to seal the outlet 114 of the sleeve 110 to thereby prevent gas flow through
25 the valve. In this example, the sealing element is if structurally connected to the inlet conduit 102 such that there is a fixed spatial relationship therebetween. Of course, in other examples, the sealing element may be not connected to the inlet conduit, and may be fixed in some other way. In the example of Figure 1, the sealing element 136 comprises a generally frustoconical sealing face 138 which is formed from a resiliently
30 deformable material, such as silicone rubber. The sleeve 110 is concentric with the sealing element 136 and, by virtue of the spring 134, is urged axially towards the sealing element 136. The diameter of the sealing element 136 increases from its first end 146, which extends axially into the outlet portion 122 of the sleeve 110, to its second end 148. At its first end 146, the outer diameter of the element 136 is smaller than the inner
35 diameter of the outlet portion 122 and at its second end 148, its outer diameter is larger than that of the outlet portion 122. Accordingly, as the sleeve 110 is urged axially towards

the second end 148 of the sealing element 136, the outlet 114 annulus comes into abutment with the sealing face 138 and is thereby sealed to prevent the flow of gas from the outlet 114. In this example, the outlet 114 comprises a chamfered or correspondingly frustoconical face which may provide a more reliable or improved seal with the sealing
5 element 136.

In addition to the spring 134, the example valve 100 provides a further feature which may assist in providing a reliable seal of the outlet 114. As shown in Figure 1, the inner diameter of the inlet portion 120, and thus the surface area of the annular surface 132 of
10 the inlet conduit 102, is slightly larger than the inner diameter of the outlet portion 122. Accordingly, when the valve 100 is pressurised with a source of breathing gas, the static pressure of the gas within the sleeve 110 will act to bias the valve 100 towards the closed position (i.e. bias the sleeve 110 against the sealing element 136). Of course, when the valve 100 is not pressurised, such as during cleaning or maintenance, the spring 134 will
15 bias the valve 100 closed to thereby inhibit the ingress of any undesirable substances which might damage or degrade the operation of the valve 100.

The inlet conduit 102 comprises an axially extending male coupling 140 which is received in a corresponding axially extending female coupling formed in the sealing element 136.
20 Accordingly, when connected, the sealing element 136 and the inlet conduit 102 form a valve shaft 144 which is encircled by the valve sleeve 110. As the sealing element 136 and the inlet coupling 102 are in a fixed positional relationship, when the sleeve 110 moves axially with respect to the inlet conduit 102, it also moves axially with respect to the sealing element 136. More generally, it should be understood that the valve sleeve
25 110 is configured so as to be axially moveable relative to the valve shaft 144, which comprises the sealing element 136 for sealing the outlet 114 of the sleeve 110 and the inlet conduit 102 which is for slidably sealing the inlet 112 of the sleeve 110 and delivering breathing gas to the interior of the sleeve 110.

Referring additionally to Figure 2, the actuation mechanism 149 of the valve 100 can be clearly seen. The actuation mechanism 149 comprises a first actuating lever 150 and a second contact lever 152. The two levers 150, 152 are pivotable about a common pivot axis PP. The actuating lever 150 comprises first and second arms 151 which are spaced apart either side of the main valve body by a crossbar 153 at a distal end of each of the
30 arms 151. A fixed axle 154 is provided at the proximal end of each arm 151. A lever support 155 is provided comprising a threaded annular ring 156 arranged concentrically
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about the inlet conduit 102. The lever support 155 has first and second frame arms 158 extending axially from the ring 156 comprising respective bushings 159 in which the axles 154 of the actuating lever 150 are received so as to permit pivoting of the actuating lever 150. The lever support 155 may be axially adjustable with respect to the valve 100, and in particular the inlet conduit 104, so as to adjust the location of the pivot axis P, and thereby the resting position of the levers 150, 152 and the sleeve 110. It should be understood that moving the lever support 155 axially away from the sealing element 136 will likewise move the resting position of the sleeve 110 away from the seating element 136. Accordingly, by adjusting the position of the lever support 155, the sleeve 110 can be finely tuned to provide an appropriate sealing contact of the outlet 114 with the sealing element 136 in the first, closed (i.e. resting) position.

The actuating lever 150 also comprises a supplementary axle 162 formed coaxially with the axles 154 and extending in the opposite axial direction (i.e. radially outwardly from the valve axis V). The contact lever 152 has a similar construction to that of the actuating lever 150, comprising first and second arms 164 spaced apart at their distal ends by a crossbar 166. At the proximal ends of the arms 164, a respective bushing 168 is provided. Each bushing 168 receives a respective one of the supplementary axles 162. Accordingly, the contact lever 152 may pivot relative to both the valve 100 and the actuating lever 150.

As shown in Figure 1, the crossbar 153 of the actuating lever 150 comprises a threaded hole 170 which receives a bolt 172. The crossbar 166 of the contact lever 152 comprises a relief 174 for contacting the head of the bolt 172. By adjusting the depth of the bolt 172 in the hole 170, a relative minimum spacing between the distal parts of the levers 150, 152 can be adjusted to thereby adjust the actuation of the valve by a diaphragm of a demand regulator, as will be discussed below.

The valve 100 further comprises a stop element 176 in the form of a threaded ring which engages a corresponding thread on the outer surface of the inlet conduit 102. The stop element 176 is arranged on the inlet conduit 102 axially spaced apart from the abutment flange 124 at the outlet 112 of the sleeve 110. Accordingly, the stop element 176 is configured so as to prevent axial movement of the valve sleeve 110 along the valve 100 beyond the stop element 176.

The valve 100 further comprises an axially-extending valve support element 178 connected to the sealing element 136. This support element 178 may be utilised to support and connect the valve 100 in position in use as will be described further below.

5 **Figures 5A and 5B** show a cross-sectional view of the valve sleeve 110, the actuating lever 150, and the stop element 176. As can be seen most clearly here and in Figure 2, the radially-innermost (relative to the valve axis V) portion 160 of each axle 154, which will be referred to as the actuating portion 160, has a generally semi-circular cross-section. The flat surface of each actuating portion 160 is arranged to abut the abutment
10 flange 124 of the sleeve 110 in the closed position, which is depicted in Figure 5A, which corresponds to the configuration of the valve 100 in Figures 1 and 2. As the pivot axis P is fixed relative to the inlet conduit 102 due to the lever support 154, as the actuating lever 150 is pivoted (arrow R), the eccentricity of the actuating portion 160 applies a force to the abutment flange 124 of the sleeve 110 causing the sleeve 110 to move axially (in
15 direction x) with respect to the inlet conduit 102. Accordingly, the axial movement of the sleeve 110 is generally proportional to the rotation of the actuating lever 150. As shown in Figure 5B, the axial movement of the sleeve 110 is limited by the stop element 176. Once the sleeve 110 has moved a sufficient distance so as to contact the stop element 176, it cannot move any further. As the stop element 176 is threadedly attached to the
20 inlet conduit 102, its axial position can be adjusted so as to adjust the extent of axial movement possible by the sleeve 110.

Turning now to Figures 3 and 4, the valve 100 is now shown in the configuration depicted in Figure 5B, whereby the actuating lever 150 has been depressed sufficiently that the
25 sleeve 110 has axially moved into abutment with the stop element 176. This position will be referred to as the second 'fully' open position. As the stop element 176 is adjustable, it should be understood that the position in which the sleeve 110 abuts the stop element 176 is the 'fully' open position, regardless of the adjustment of the stop element 176.

30 As can be seen in Figures 3 and 4, the valve sleeve 110 has been axially moved to the right by the pivoting movement of the actuating lever 150 as described above. Accordingly, the outlet 114 of the sleeve 110 has been unseated from the sealing element such that an open annulus is formed between the sleeve outlet 114 and the sealing element 136. Consequently, breathing gas may now flow through the valve 100
35 and out of the outlet 114 of the sleeve 110 as shown by the arrows in Figure 3.

As should be understood, dependent upon the amount of rotation of the actuating lever 150, the valve sleeve may take any intermediate position between the closed position shown in Figures 1 and 2, and the 'fully' open position shown in Figures 3 and 4. It should likewise be understood that the flow rate of breathing gas possible through the valve will be proportional to the size of the annular gap formed between the sealing element 136 and the outlet 114 of the sleeve 110. Accordingly, the flow rate through the valve may be regulated and adjusted in proportion with the rotation of the actuating lever 150.

10 A flow regulation valve according to the invention, for example valve 150, may provide more accurate and reliable valve than has been previously achievable. In particular, the main valve element, the valve sleeve is a single moving part which can be actuated in a simple and compact manner. Accordingly, a valve according to the invention may be less complex and require less maintenance, thereby having an improved working life and
15 reduced cost.

The valve of the invention may enable the input and output of breathing gas to be configured coaxially in-line, which can in turn enable a less complex valve and reduce the pressure drop of breathing gas through the valve

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Furthermore, the particular configuration of the valve of the invention may provide more accurate control and dosing of breathing gas flow. In particular, the movement of the valve sleeve may be more finely controlled such that and the initial flow of air after unseating the sleeve from the sealing element may self-centralise the valve sleeve, thereby improving the quality and smoothness of gas flow through and from the valve. The 'piston-like' arrangement of the inlet conduit in the sleeve may also improve centralisation and stability of the valve, thereby improving flow control. The invention may also provide a valve with reduced friction between moving components, thereby improving the ease of actuation of the valve and thereby reducing the user effort required
25 during breathing.
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Turning now to **Figure 6**, a cross sectional view through an exemplary demand regulator 300 comprising a flow regulation valve 200 is shown. The flow regulation valve 200 may be substantially similar in construction to the flow regulation valve 100 described above. Like features between the valve 100 and the valve 200 are indicated with reference numerals differing by 100. **Figure 7** shows a cross-sectional view of the valve 200 and

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a portion of the demand regulator 300 shown on the section plane DD in the direction of the arrows.

The demand regulator 300 comprises a main housing 302 defining an outer port 304 for
5 connection to a breathing face mask or similar (not shown). The housing comprises a removable access portion 306 which may be removably attached to the main housing 302 to provide internal access to the regulator 300 if required. The access portion 306 comprises one or more openings (not shown) which permit pressure equalisation with an ambient environment. The main housing 302 additionally supports a diaphragm 308
10 which is sealed about its peripheral edge to the housing 302 and is impermeable to gas. The diaphragm 308 has an ambient side 310 which is exposed to ambient pressure via the access portion 306, and a breathing side 312 which is exposed to the pressure within the regulator housing 302. Accordingly, when the outer port 304 is connected to a face mask and a user breathes in, the reduction in pressure within the housing 302 compared
15 to the ambient pressure will cause the diaphragm 308 to move inwardly. The diaphragm 308 comprises a rigid contact plate 314 arranged generally centrally, which is bounded by a resiliently deformable skirt 316, which permits the diaphragm 308 to move inwardly and outwardly in response to a pressure differential across the diaphragm 308.

20 The main housing 302 additionally comprises an inner port 318 additional supports the valve 200 within its interior. The inner port 318 comprises a mask connecting portion 320 which is generally concentric with the outer port 304. The inner port 318 also comprises a valve connecting portion 322 which is generally concentric with the valve 200, and in particular with the outlet section 222 and sealing element 236 of the valve 200. The
25 inner port 318 forms a generally elbow shaped duct 324 for transporting breathing gas from the outlet of the valve 200 to a breathing face mask.

The main housing 302 also supports and houses the flow regulation valve 200. The inlet conduit, at its gas delivery opening 206 end, is connected and statically secured to the
30 housing 302. At the opposing axial end of the valve 200, the valve support element 278 is received with and secured to a valve support recess 326 formed in the inlet port 318. Accordingly, the main valve shaft 244, comprising the inlet conduit 202, the sealing element 236 is statically secured within the housing 302 of the regulator 300. The valve 200 is arranged such that the contact lever 252 rests against the contact plate 314 of the
35 diaphragm 308 in the valve's 200 and the diaphragm's 308 resting position, in other words the closed position of the valve 200 as shown in Figure 6. In order to ensure

contact between the contact lever 252 and the plate 314 in the closed position of the valve 200 (i.e. neutral position of the actuating lever 250), the spacing between the levers 250,252 can be adjusted using the bolt 272.

5 The gas delivery opening 206 of the inlet conduit 202 is connected to a breathing gas supply hose 328. The breathing gas supply hose comprises a flexible hose 330, having a swivel connector 329 formed at the end thereof. The swivel connector 329 is connected to a hose elbow coupling 332 such that the coupling 332 and the connector 329 (and therefore the hose 330) can swivel relative to one another. The hose coupling
10 332 is sealingly received within the gas delivery opening 206 with an O-ring seal 334 and releasably secured using a locking pin 336. The elbow coupling 332 may itself be swivelled within the opening 206 to thereby provide a further degree of freedom between the hose 328 and the valve 200. The breathing gas supply hose 328 is connected to a source of pressurised breathing gas of a breathing apparatus, such as a high pressure
15 breathing gas cylinder via a first-stage pressure reduction valve. It is however possible that the hose 328 may connect the valve 200 directly to a source of breathing gas. Accordingly, the breathing gas supply hose 328 delivers breathing gas to the inlet conduit 202 of the valve 200. When connected to the breathing gas supply hose 328, the interior of the valve sleeve 210 is statically pressurised such that the valve 200 is biased into the
20 close position as discussed in detail above.

Accordingly, it will be understood that, as the diaphragm 308 moves inwardly in response to the reduced pressure in the housing 302 during a user inhalation, the plate 314 will depress the levers 250,252, thereby axially moving the valve sleeve 210 and opening
25 the valve 200 to permit the flow of breathing gas during a user inhalation. Once a user stops inhaling, the pressure in the housing 302 will equalise with ambient pressure, and therefore, the diaphragm 308 will return to a rest position and the biasing of the valve 200 will force the levers 250,252 back to the rest position, thereby closing the valve 200 to prevent the unnecessary supply of breathing gas when the user is not inhaling.

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Accordingly, use of the flow regulation valve of the invention with a demand regulator for a breathing apparatus may provide a particularly simple and user-friendly demand regulator which has a simpler construction, requires reduced maintenance, and may require less user effort to actuate.

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It will be understood that the invention is not limited to the embodiments above-described and various modifications and improvements can be made without departing from the concepts described herein. Except where mutually exclusive, any of the features may be employed separately or in combination with any other features and the disclosure
5 extends to and includes all combinations and sub-combinations of one or more features described herein.

CLAIMS

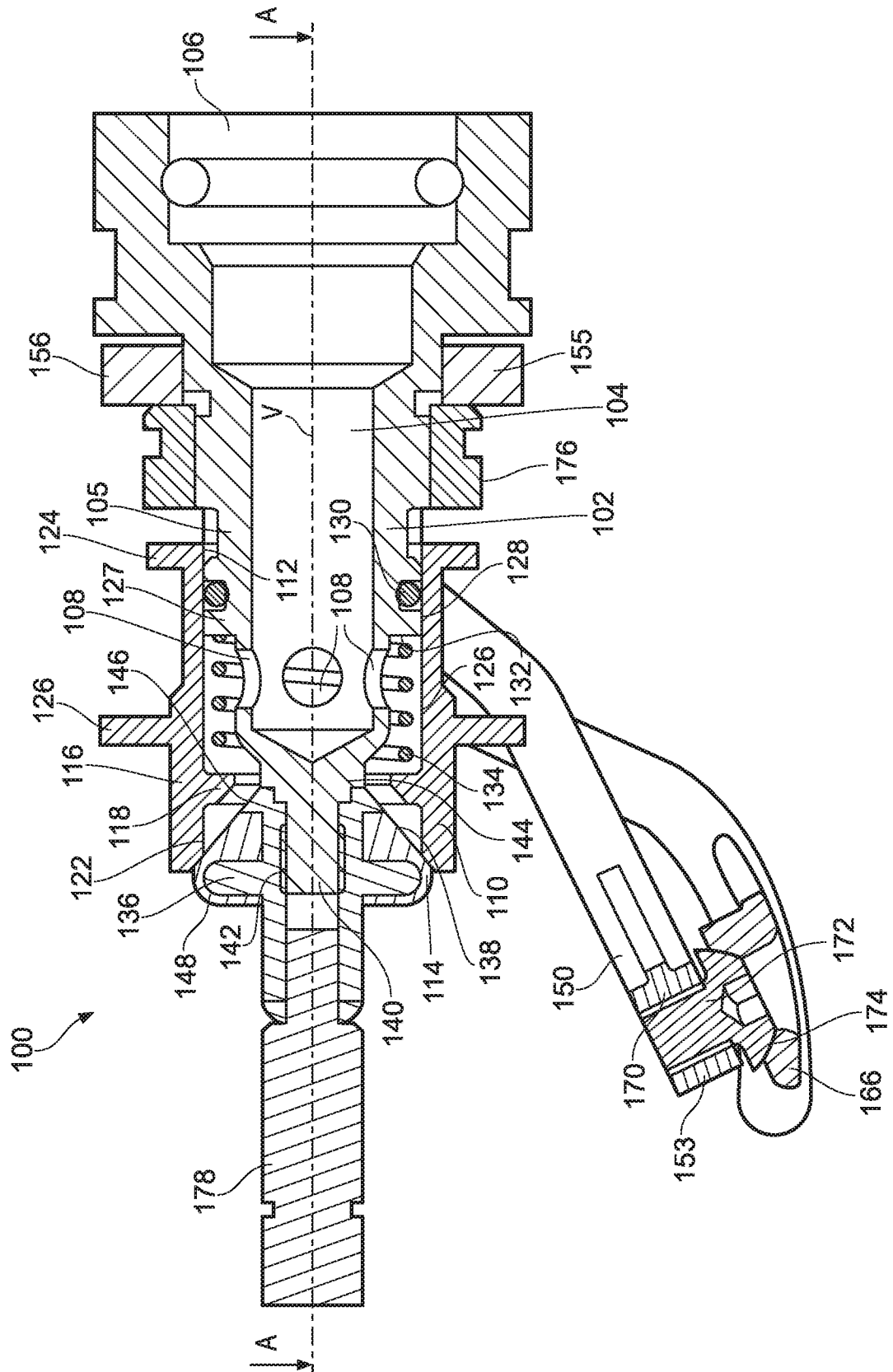
1. A flow regulation valve for a demand regulator of a breathing apparatus comprising:
 - 5 an inlet conduit configured for receiving breathing gas from a breathing gas source;
 - a valve sleeve having an inlet for receiving the inlet conduit and an outlet for expelling breathing gas; and
 - a sealing element configured for sealing the outlet of the valve sleeve;
- 10 wherein the valve sleeve is moveable between a first position in which the outlet is sealed against the sealing element so as to inhibit breathing gas flow and a second position in which the outlet is not sealed against the sealing element so as to permit gas to permit breathing gas flow; and
- wherein the valve sleeve is arranged concentrically about the inlet conduit in
- 15 slidable sealing contact therewith such that the sleeve valve is sealed against the inlet conduit in both of the first and second positions.
2. A flow regulation valve for a demand regulator as claimed in claim 1, wherein the inlet conduit comprises a substantially cylindrical outer surface and the valve
- 20 sleeve comprises a substantially cylindrical inner surface, the substantially cylindrical outer surface of the inlet conduit being received within the valve sleeve against the substantially inner surface thereof.
3. A flow regulation valve for a demand regulator as claimed in claim 1 or 2, wherein
- 25 the inlet conduit is received within the valve sleeve in a piston-like manner.
4. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the inlet conduit extends a greater distance into the valve sleeve in the second position than in the first position.
- 30 5. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the inlet conduit and the sealing element are connected so as to form a valve shaft about which the valve sleeve is arranged.
- 35 6. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the inlet conduit, the valve sleeve, and the sealing element are arranged

substantially coaxially so as to define a valve axis, and wherein the valve sleeve is arranged to move between the first and second positions in a direction parallel to the valve axis.

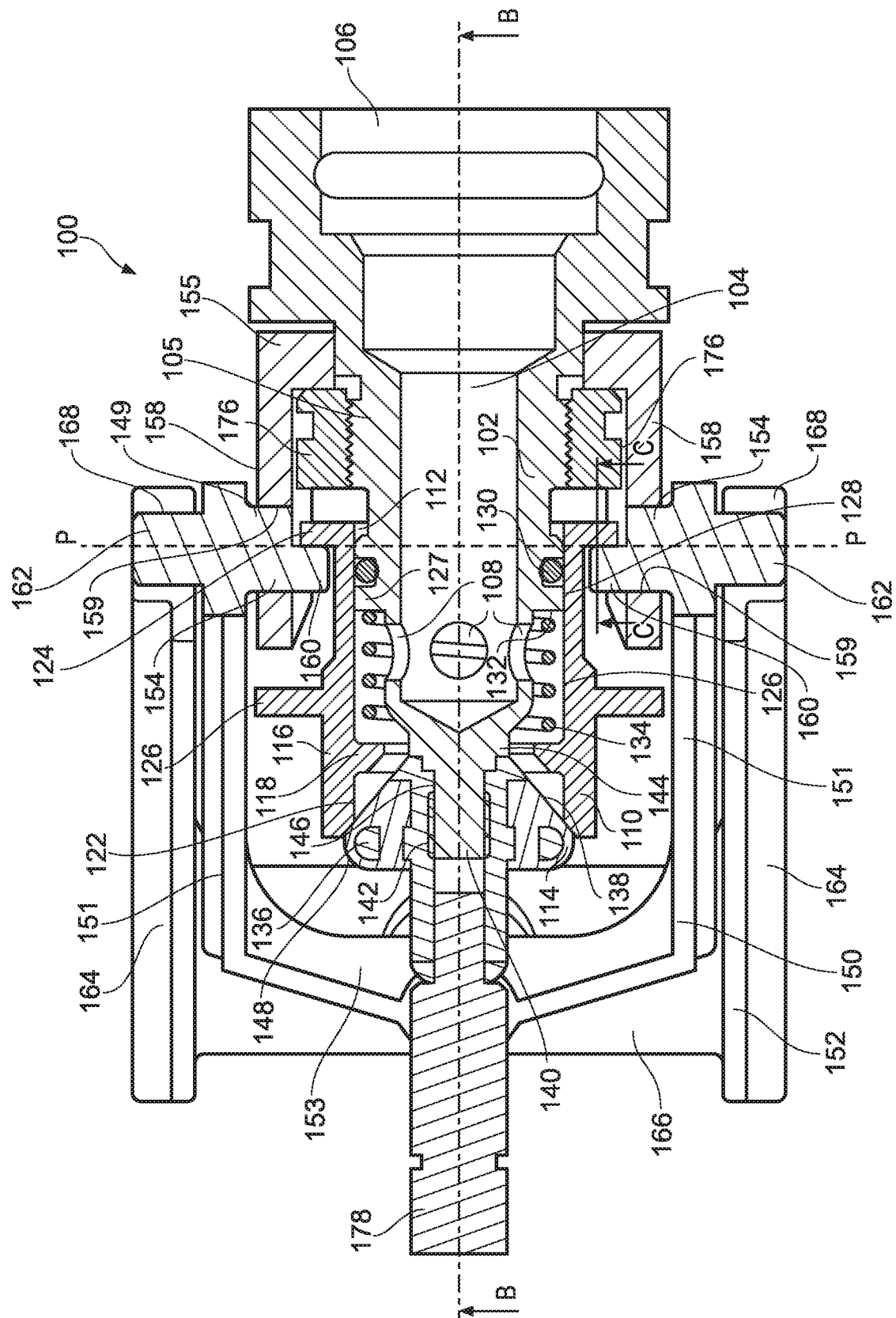
- 5 7. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the inlet conduit comprises an inlet channel extending along the valve axis and bounded by a conduit wall.
- 10 8. A flow regulation valve for a demand regulator as claimed in claim 7, wherein the inlet conduit comprises one or more inlet apertures arranged in the conduit wall so as to expel air from the inlet channel into the valve sleeve in a lateral or oblique direction with respect to the valve axis.
- 15 9. A flow regulation valve for a demand regulator as claimed in claim 8, wherein two or more inlet apertures are provided, and wherein the inlet apertures are evenly spaced about the valve axis.
- 20 10. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein, in the second position, the valve sleeve abuts a stop element configured to prevent further movement of the valve sleeve away from the first position.
- 25 11. A flow regulation valve for a demand regulator as claimed in claim 10, wherein the stop element is adjustable so as to adjust the second position of the valve sleeve and thereby adjust a maximum breathing gas flow provided by the flow regulation valve.
- 30 12. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the valve sleeve is continuously moveable between the first and second positions so as to vary a breathing gas flow rate through the valve.
- 35 13. A flow regulation valve for a demand regulator as claimed in any preceding claim, wherein the sealing element comprises a substantially conical or frustoconical sealing surface for sealing the outlet of the sleeve valve.

14. A flow regulation valve as claimed in any preceding claim, wherein the outlet of the sleeve valve comprises a frustoconical surface for sealing against the sealing element.
- 5 15. A flow regulation valve as claimed in any preceding claim, wherein, in the first position, the sleeve valve is configured so as to be internally statically pressurised by breathing gas provided by the inlet conduit and wherein the valve sleeve is configured such that an applied internal static pressure biases the outlet of valve sleeve against the sealing element.
- 10 16. A flow regulation valve for a demand regulator as claimed in any preceding claim, further comprising an actuation mechanism configured to move the valve sleeve away from the first position towards the second position in response to a force applied to the actuation mechanism.
- 15 17. A demand regulator for a breathing apparatus comprising a flow regulation valve as claimed in claim 16.
- 20 18. A demand regulator as claimed in claim 17, wherein the demand regulator comprises a diaphragm configured to be deflected by a decrease in pressure within the demand regulator during a user inhalation, and wherein the actuation mechanism is configured such that deflection of the diaphragm applies a force to the actuation mechanism.
- 25 19. A demand regulator as claimed in claim 18, wherein the actuation mechanism comprises a pivotable first lever configured to contact the diaphragm, and a pivotable second lever configured to contact the first lever and to move the sleeve valve towards the second position in response to pivoting of the first lever, wherein the actuation mechanism further comprises an adjustment mechanism for
- 30 adjusting the relative positions of the first and second levers when in contact.
20. A breathing apparatus comprising a flow regulation valve according to any of claims 1-16 or a demand regulator according to any of claims 17-19.

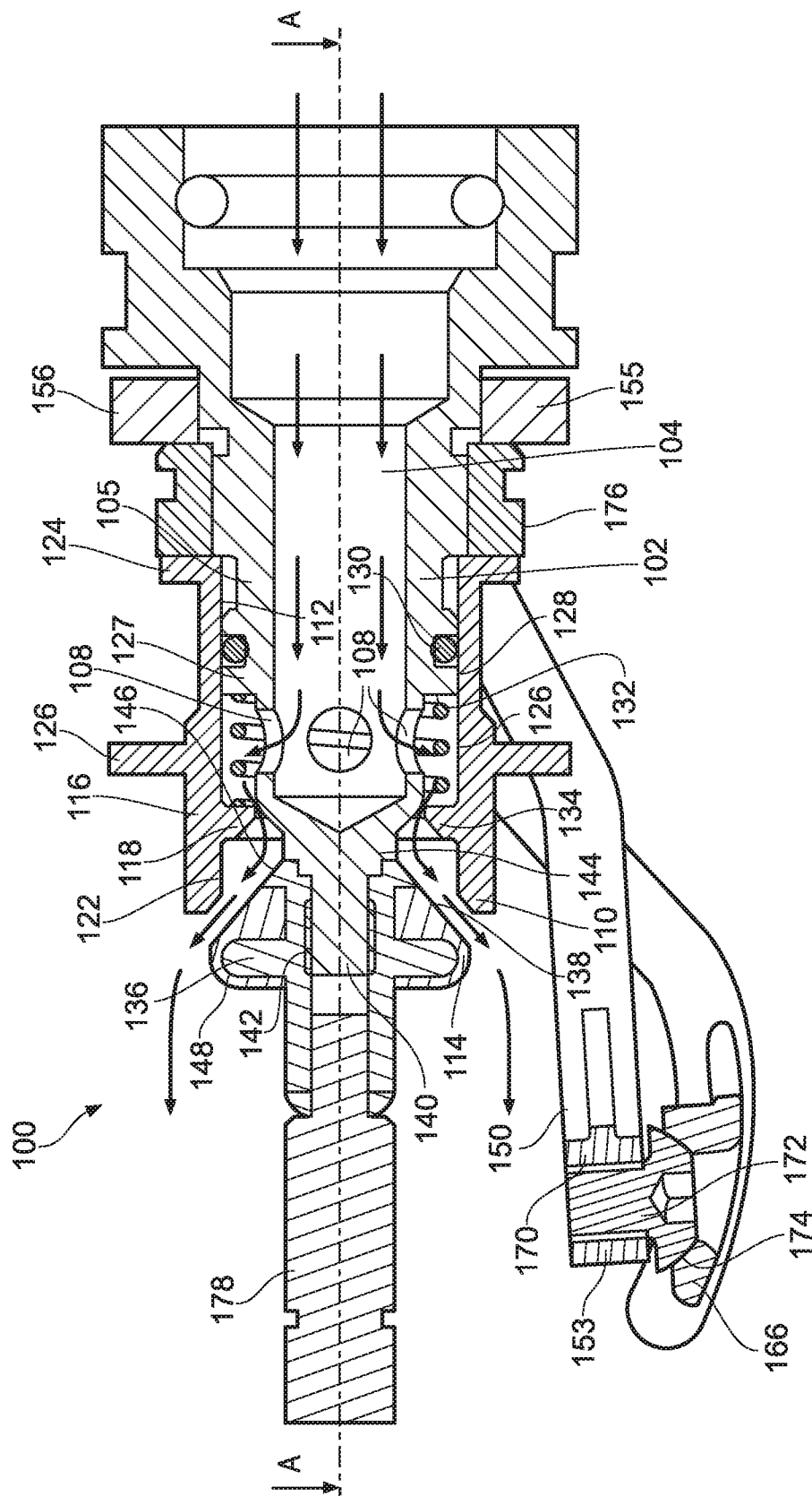
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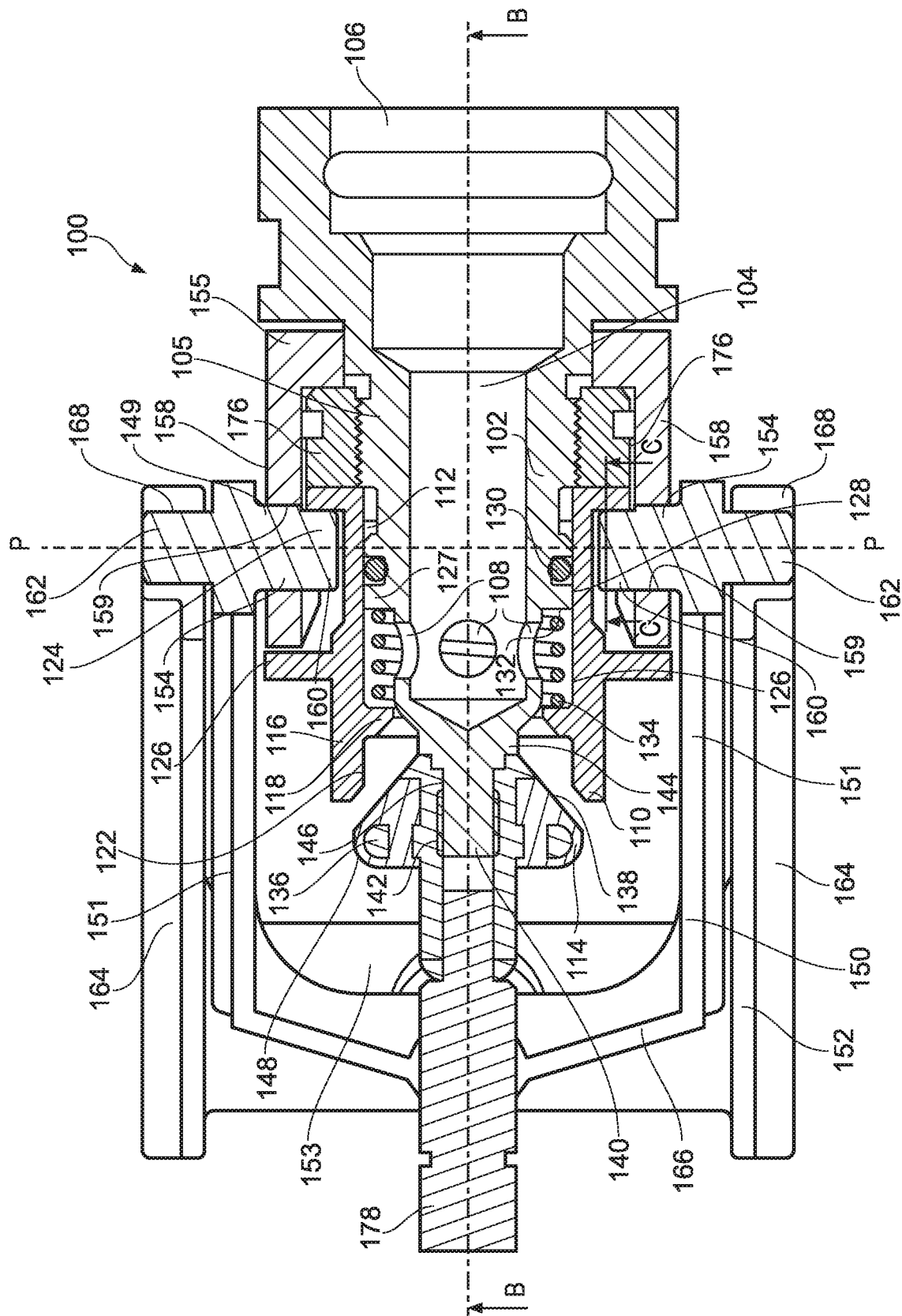
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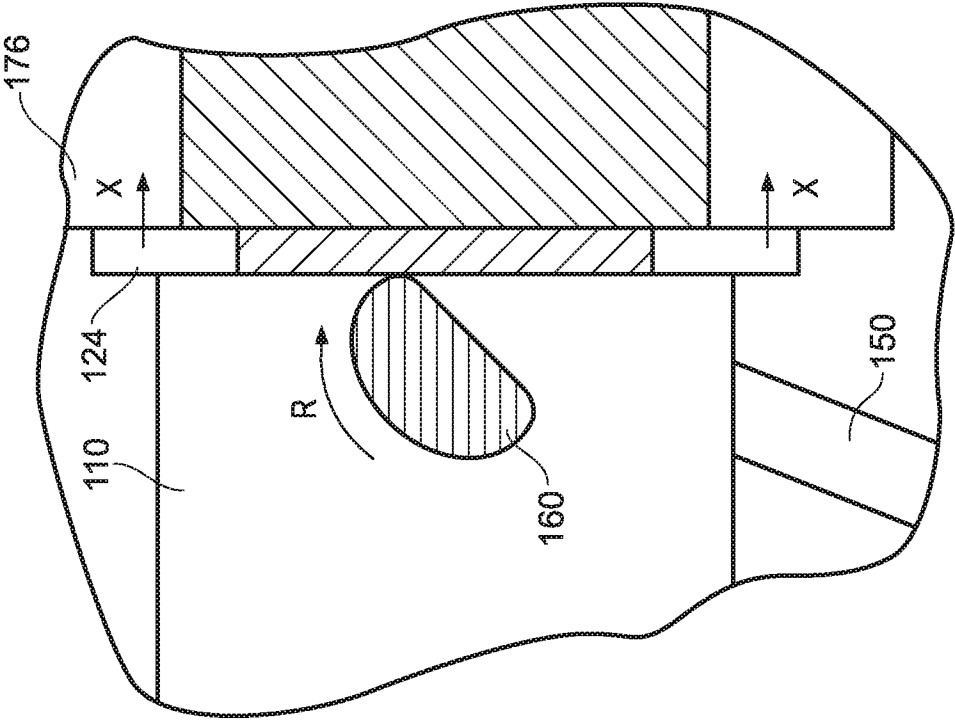


FIG. 5B

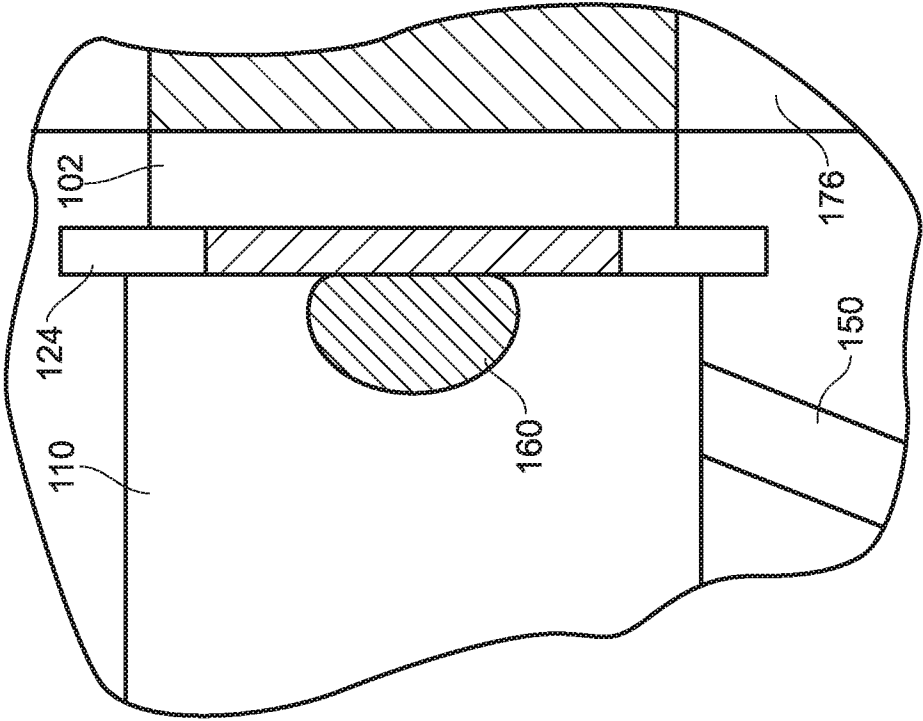


FIG. 5A

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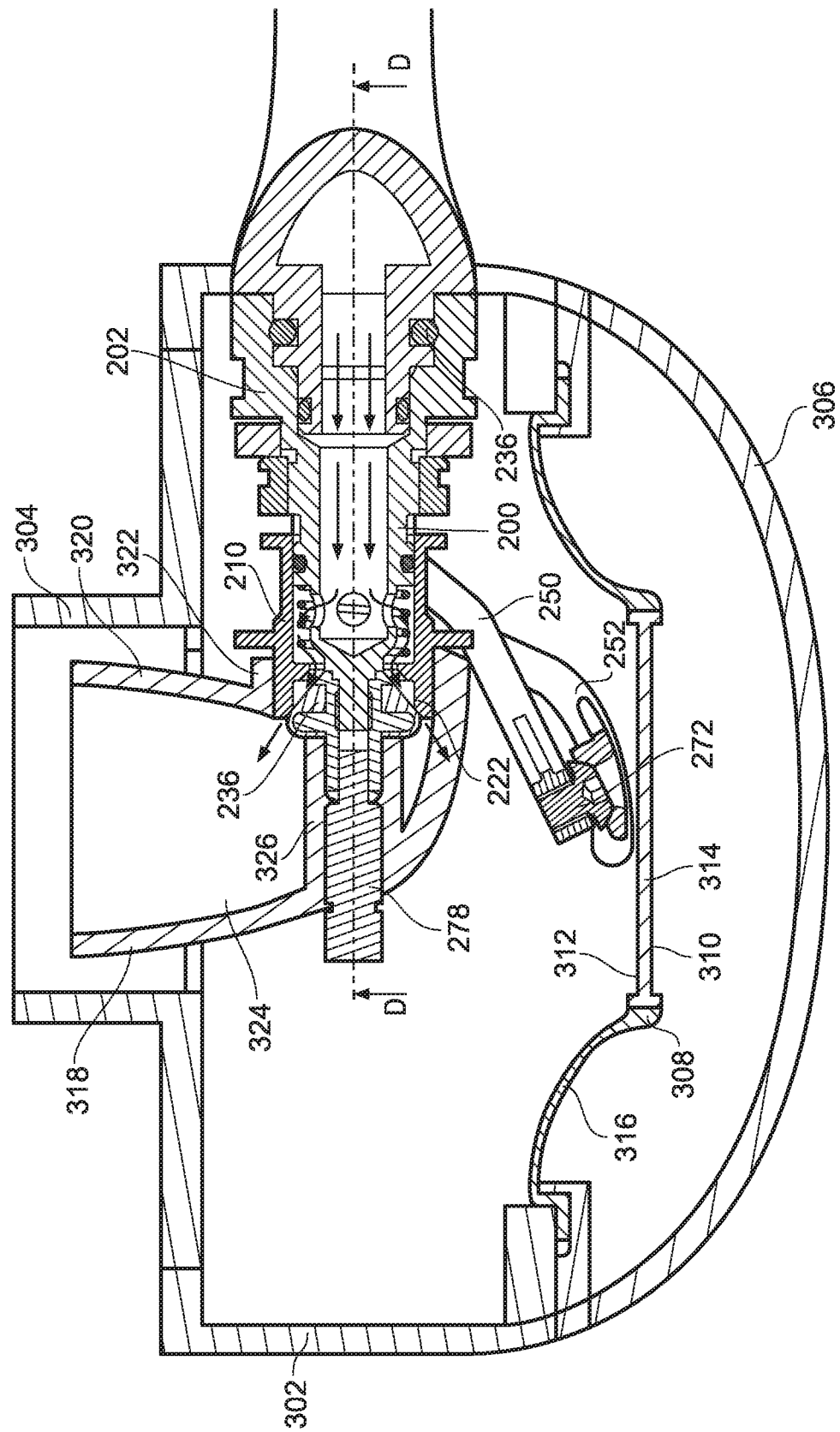
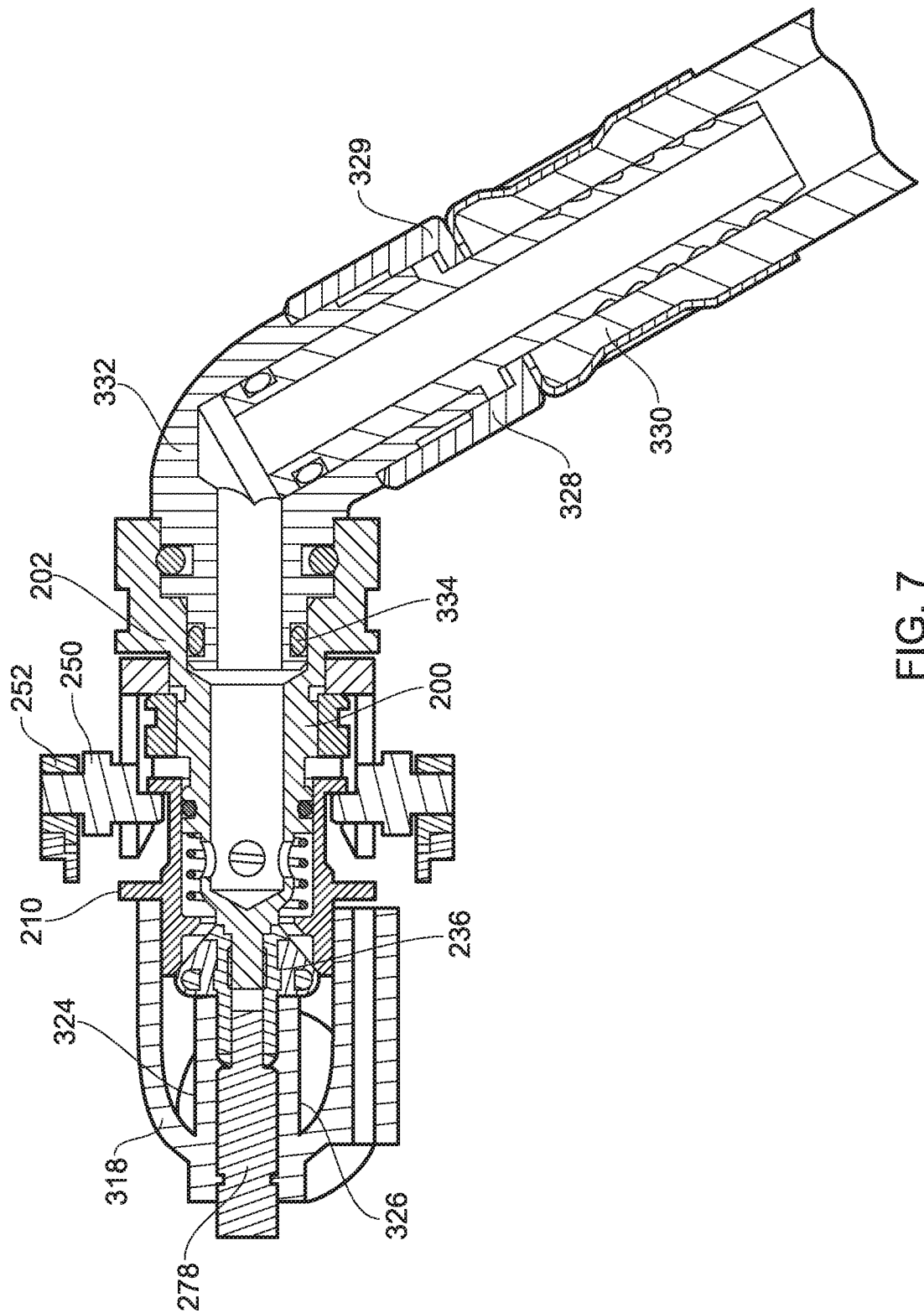


FIG. 6

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2019/051782

A. CLASSIFICATION OF SUBJECT MATTER
INV. A62B9/02
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)
A62B

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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A	EP 2 514 484 A2 (DRAEGER SAFETY UK LTD [GB]) 24 October 2012 (2012-10-24) paragraph [0010]; figures -----	1-20
A	US 5 803 073 A (TOTH DOUGLAS J [US]) 8 September 1998 (1998-09-08) column 2, line 61 - column 3, line 45; figures -----	1-20
A	US 5 259 375 A (SCHULER MANFRED [US]) 9 November 1993 (1993-11-09) column 2, line 17 - column 3, line 54; figures -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 September 2019

Date of mailing of the international search report

10/10/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2019/051782

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