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(54) **SECOND STAGE PRESSURE REDUCTION DEVICE FOR UNDERWATER USE**

(57) Second stage pressure reduction device of a breathable gas mixture for a dispenser of an underwater self-breathing system, comprising an inlet chamber (1) of the gas mixture and a breathing chamber (2), which chambers (1, 2) are connected to each other by means of a valve (3). The valve (3) is provided with a valve seat (35) and a movable shutter (30) and elastic stressing means (31) of the shutter (30) towards the closing condition of the valve (3). The breathing chamber (2) is delimited in part by a flexible membrane (4) connected to the shutter (30) by an actuating lever (43) so that a displacement of the flexible membrane (4) towards the interior of the breathing chamber (2) causes a displacement of the shutter (30) in the opening direction of the valve (3). A balancing chamber (5) is included and the shutter (30) is hollow and provided with an insertion shaft (32) at a mouth of the balancing chamber (5) opposite the valve seat (35). The device comprises a barrier element (8) adapted to separate the mouth of the balancing chamber (5) from the breathing chamber (2).

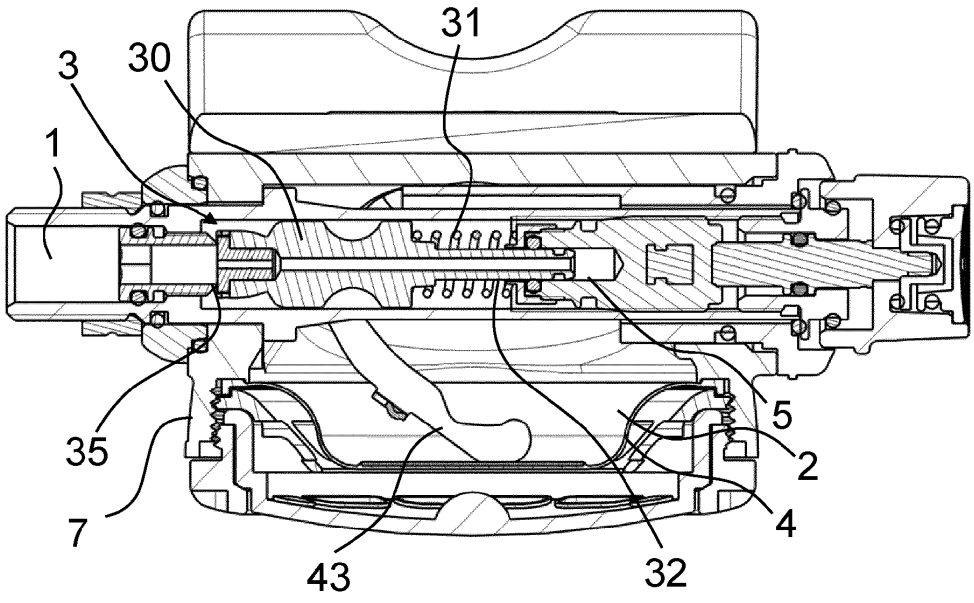

Fig. 2

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Description

[0001] The present invention relates to a balanced second stage pressure reduction for diving.

[0002] The technical area of reference is that of breathing systems used in diving equipment.

[0003] Such systems utilize one or more reduction stages, the object of which is to provide the user with an accurate, constant and linear output pressure, reducing the input pressure from a higher value to a breathable output value. These reducers generally consist of two chambers communicating with each other, the first chamber is in contact with the pressure to be reduced, called the source, the second is the chamber adapted to reduce the pressure where the gas generally expands and therefore reduces its pressure.

[0004] Two reduction stages are generally included in the breathing systems currently used. A first reduction stage is configured to reduce the pressure of the cylinders, typically around 300 bar, to an intermediate pressure of about 9 bar. At the dispenser, the intermediate pressure is further reduced from a second reduction stage to an outlet pressure of about 3 mbar, i.e., a breathable pressure. The second stage is the most important and conspicuous part of the dispenser and provides the air at the user's request.

[0005] The second stage typically incorporates a valve mechanism which uses a pressure differential on opposite sides of a flexible membrane to actuate an air valve. Opening the valve allows air to be supplied to a breathing chamber from which the user inhales. The flexible membrane separates the breathing chamber with the external water, so that when the user breathes in, a pressure differential is created between the breathing chamber and the water which causes the membrane to deflect and consequently the air inlet valve to open. The air inlet in the breathing chamber returns the valve to the closing condition, by virtue of the presence of a spring which stresses the valve in the closing condition. Thereby, upon exhalation by the user, the exhaled air in the breathing chamber is discharged to the outside through a one-way discharge valve.

[0006] The diving equipment market requires a series of products with similar function but differentiated according to whether they are intended for amateur athletes, advanced athletes or professional athletes. In particular, the second stage exists in many versions known in the state of the art, grouped into three different technical levels:

- Basic second stage, suitable for normal sports diving;
- Second stage with sensitivity regulator device, suitable for more experienced divers and more technical dives;
- Second stage with sensitivity regulator and internal balancing system, suitable for diving at deeper altitudes, for experienced and professional divers.

[0007] The sensitivity regulator device allows the user to set the inhalation resistance necessary to move the membrane for opening and closing the air valve, in particular by acting on the tension of the spring acting on the valve to push it or keep it towards the closing condition. Thereby, the user has the freedom to adjust, based on personal preferences, the inhalation resistance, thus making inhaling air from the dispenser more or less easy or sensitive.

[0008] These state-of-the-art devices aim to customize the equipment according to the breathing needs of each user, in particular according to the diving depth. This is particularly important for a user who wants to operate at various depths and under different physical exertion conditions, changing the parameters for the type of breathing required.

[0009] The second stage type with internal balancing system mentioned above allows for further improved performance. Such second stages have a pneumatically balanced valve system: the pressure on the valve of the second stage is balanced by virtue of the presence of a balancing chamber located so as to allow the medium-pressure air to promote the force of the spring, which can therefore be expected to be weaker, i.e., more sensitive. This reduces the inhalation effort required to open the second stage valve, balancing the pressure differences between the inside and the outside of the dispenser and thereby improves the overall ease of breathing in all diving conditions for a more comfortable breathing experience.

[0010] An example of a balanced second stage known in the state of the art is illustrated in figure 1.

[0011] The second stage device comprises an input chamber 1 connected to the output of the first stage and separated from the breathing chamber 2 by a movable shutter 30. As previously mentioned, the breathing chamber 2 is connected to the mouthpiece for the user and is separated from the water placed outside by means of an elastic membrane 4. The elastic membrane 4 is connected to the shutter 30 by means of a lever 43, so that a displacement of the membrane 4 inwards of the breathing chamber 2 causes a displacement of the shutter 30 from a closing condition of the valve, in which the shutter 30 makes a seal on a valve seat, to an opening condition, in which the shutter 30 is in a position away from the valve seat and one or more air passageways are freed from the inlet chamber 1 to the breathing chamber 2.

[0012] The shutter 30 is stably stressed by a spring 31 towards the closing condition.

[0013] The shutter 30 is hollow and is provided with an end shaft 32 for insertion into a balancing chamber 5. Thereby, the medium-pressure air of the inlet chamber 1 enters inside the shutter 30 from a first end and passes to the opposite end of the shutter 30, from which it enters the balancing chamber 5. The shaft 32 is slidably placed inside the balancing chamber 5 and is provided with one or more guide o-rings 33. The action of the intermediate-pressure air pressure on both sides of the shutter 30 al-

lows a balanced system to be obtained.

[0014] However, this type of device has some drawbacks, mainly due to the fact that a greater mechanical complexity to obtain higher performance corresponds to the need for more frequent maintenance in order to maintain optimal operation.

[0015] In particular, when the breathing system is used, the breathing chamber may be flooded by water for various reasons or needs. Inside the breathing chamber the water, especially sea water but not only, can carry impurities of various nature into suspension, such as saline concretions or sand dust, which can settle in the confined spaces of the sliding area between the shaft and the balancing chamber. Such deposits, if not properly removed by a subsequent rinse, may lead to the deterioration of the guide o-rings of the shaft. Over time, such deterioration can cause defects in the balancing mechanism or, in the worst cases, a closing condition locking of the valve, resulting in high danger to the user.

[0016] The present invention aims to overcome these drawbacks with simple and inexpensive measures to drastically reduce the risk of malfunction and the consequent need for frequent maintenance.

[0017] The invention achieves the aforesaid objects with a second stage pressure reduction device of a breathable gas mixture for a dispenser of an underwater self-breathing system comprising a gas mixture inlet chamber and a breathing chamber, which chambers are connected to each other by a valve. Such a valve is provided with a valve seat and a movable shutter and with elastic stressing means of the shutter towards the closing condition of the valve. The breathing chamber is delimited in part by a flexible membrane connected to the shutter by an actuating lever so that a displacement of the flexible membrane towards the interior of the breathing chamber causes a displacement of the shutter in the valve opening direction. The device includes a balancing chamber and the shutter is hollow and provided with an insertion shaft in a mouth of the balancing chamber in the position opposite the valve seat. The device further comprises a barrier element adapted to separate the mouth of the balancing chamber from the breathing chamber.

[0018] The presence of the barrier element prevents the water impurities from reaching and obstructing the air passages, in particular preserving the sliding of the shutter shaft inside the balancing chamber from any impediment and blockage.

[0019] In an exemplary embodiment, the barrier element has a wall separating the balancing chamber from the breathing chamber, which wall is provided with a through hole for the sliding housing of the shaft. The separation wall thereby isolates the balancing chamber from the breathing chamber without preventing the sliding of the shaft by virtue of the presence of said hole.

[0020] In a further exemplary embodiment, the barrier element comprises a gasket ring adapted to make a hydraulic seal on the mantle surface of the shaft, which gasket ring is interposed between the separation wall and the mouth of the balancing chamber. The gasket ring prevents any water leakage in the direction of the balancing chamber through the hole.

[0021] In an embodiment, the mouth of the balancing chamber is shaped so as to form a bushing end, the cup-shaped barrier element comprising a side wall and a bottom wall, which bottom wall is formed by the separation wall, and the barrier element being coupled to the bushing end.

[0022] Thereby, the coupling of the barrier element with the bushing end of the mouth of the balancing chamber completely seals such a mouth with the exception of the sliding hole of the shutter shaft.

[0023] In an improvement, the barrier element is screwed onto the bushing end, the barrier element and the bushing end being provided with complementary threads.

[0024] The coupling by screwing ensures stability and tightness and at the same time ease of assembly.

[0025] According to an embodiment the gasket ring is in contact with the barrier element separation wall and the head surface of the bushing end.

[0026] This means that the barrier element is sized such that, in the coupled condition with the bushing end, the distance between the separation wall and the bushing end is exactly the same as the thickness of the gasket ring, allowing the overall dimensions to be minimized.

[0027] According to an exemplary embodiment, the elastic means for stressing the shutter consist of a spring, the barrier element being provided with a tubular extension extending from the separation wall in the opposite direction with respect to the side wall, which tubular extension is shaped so as to form a spring engagement seat in combination with the separation wall.

[0028] In a further example, the through hole is sized so as to form with the shaft a cavity of greater thickness than the cavity between the shaft and the mouth of the balancing chamber.

[0029] The hole of the barrier element is therefore sized to have more slack with respect to the shaft sliding seat in the balancing chamber, so as to form a coarser first barrier with respect to the shaft gasket elements. Thereby, a sort of pre-filtration is carried out, by which the most dangerous impurities are prevented from reaching the heart of the balancing mechanism.

[0030] The device described above and subsequently claimed has the great advantage that the balancing chamber, which forms the heart of the internal balancing second stage mechanism, remains isolated from the external environment by means of a fixed gasket ring in place of the traditional one or two o-rings mounted on the movable shaft.

[0031] This allows for improved cleaning, reduced friction and therefore greater ease of breathing and greater reliability over time without maintenance.

[0032] These and other features and advantages of the present invention will become clearer from the fol-

lowing description of some non-limiting exemplary embodiments illustrated in the attached drawings in which:

fig. 1 illustrates a balanced second stage device known in the state of the art;
fig. 2, 4 and 5 illustrate different sections of the second stage object of the present invention;
fig. 3 illustrates a detailed view of the barrier element;
fig. 6 illustrates an exploded view of the device;
fig. 7 illustrates an assembled view of the dispenser;

[0033] The second stage device for reducing the pressure of a breathable gas mixture for a dispenser of a self-breathing system for underwater use object of the present invention includes an inlet chamber 1 connected to the outlet of a first supply stage of a breathable gas mixture and a breathing chamber 2 formed by a casing 7. The inlet chamber 1 is separated from the breathing chamber 2 by a valve 3 provided with a movable shutter 300. The breathing chamber 2 is connected to the mouthpiece 6 and is delimited in part by a flexible membrane 4, which separates it from the water placed outside. In fact, the casing 7 is provided with water inlet openings 70 from the outside, so that the water is in contact with the elastic membrane 4 in the diving condition.

[0034] The valve 3 is comprised inside a hollow cylindrical case 34 provided with air passage openings.

[0035] The elastic membrane 4 is connected to the shutter 30 by an actuating lever 43 movably hinged on the special openings of the cylindrical housing 34 so that a displacement of the membrane 4 towards the interior of the breathing chamber 2 causes a displacement of the shutter 30 from a valve closing condition, in which the shutter 30 makes a seal on a valve seat 35, to an opening condition, in which the shutter 30 is in a position away from the valve seat 35 and one or more air passageways are freed from the inlet chamber 1 to the breathing chamber 2.

[0036] The valve seat 35 consists of an abutment edge on which a head surface of the shutter 30 contacts. The shutter 30 is permanently stressed by elastic means towards the closing condition, in particular by a spring 31. Alternatively, the elastic means may be of any type currently known and adapted to be used in a second stage device.

[0037] The shutter 30 is hollow and is provided with a terminal shaft 32 extending in the direction opposite the valve seat 35 and adapted to be inserted in the mouth of a balancing chamber 5. Thereby, the medium-pressure air of the inlet chamber 1 enters inside the shutter 30 from a first end and passes to the opposite end of the shutter 30, from which it enters the balancing chamber 5.

[0038] The balancing chamber 5 is formed by a hollow balancing element 50, in particular consisting of a substantially cylindrical element with a coaxial cylindrical cavity open only in the direction of the shaft 32 to form said mouth.

[0039] The shaft 32 is slidably placed inside the balancing chamber 5 and is provided with an o-ring 33 placed in a special cavity obtained in the mantle surface of the shaft 32. The o-ring 33 slides on the inner surface of the balancing chamber 5 and has the function of guiding the shaft 32 in the axial direction inside the balancing chamber 5. This guiding function is however accessory and the o-ring 33 could not be provided. The balancing chamber 5 may be of constant section as in the figures or it may be provided with a radial enlargement. In the latter case, the shaft 32 is shaped so that, during the excursion inside the balancing chamber, the o-ring 33 slides on the inner surface of a constant-section stretch of the mouth of the balancing chamber 5.

[0040] The device comprises a barrier element 8 adapted to separate the mouth of the balancing chamber 5 from the breathing chamber 2. The mouth of the balancing chamber 5 is shaped so as to form a bushing end 51 and the barrier element 8 is cup-shaped and thus comprises a bottom wall 80 and a side wall 81. The barrier element 8 is coupled to the bushing end 51 by means of screwing, the barrier element 8 and the bushing end 51 being provided with complementary threads. Alternative coupling modes such as welding, gluing, interlocking, or the like, may be envisaged. Therefore, the bottom wall 80 forms a separation wall between the breathing chamber 2 and the balancing chamber 5 and prevents impurities suspended in the water, when it enters the breathing chamber 2, from accessing the balancing chamber 5, in particular causing wear or blockage to the o-ring 33 of the shaft 32.

[0041] The bottom wall 80 is provided with a through hole for the sliding housing of the shaft 32. The bottom wall 80 thereby isolates the balancing chamber 5 from the breathing chamber 2 without preventing the sliding of the shaft 32 by virtue of the presence of the hole. The through hole is sized so as to form with the shaft 32 a cavity of greater thickness than the cavity present between the shaft 32 and the mouth of the balancing chamber 5.

[0042] The barrier element 8 further comprises a gasket ring 82 adapted to make a hydraulic seal on the mantle surface of the shaft 32. The gasket ring 82 is interposed between the bottom wall 80 and the mouth of the balancing chamber 5, in particular it is in contact with the bottom wall 80 and with the head surface of the bushing end 51.

[0043] The barrier element 8 is further provided with a tubular extension 83 extending from the bottom wall 80 in the opposite direction with respect to the side wall 81. Such a tubular extension 83 is shaped so as to form, in combination with the bottom wall 80, an engagement seat of the spring 31.

[0044] Figures 6 and 7 illustrate exploded and assembled views of the entire second stage, respectively, also comprising a tension adjusting mechanism 9 of the spring 31, known in the state of the art.

[0045] From the foregoing, it is evident that the invention is not limited to the embodiment described above and illustrated merely by way of non-limiting example,

but also comprises other models which achieve equal utility by using the same inventive concept.

[0046] Therefore, it is understood that the present invention may be varied and modified, as a whole and in its individual details, according to the specific needs and conveniences of manufacture and use, especially constructively and within the context of the technical and functional equivalents, all without abandoning the inventive concept set forth above and claimed below.

Claims

1. Second stage device for reducing the pressure of a breathable gas mixture for a dispenser of a self-breathing system for underwater use, comprising an inlet chamber (1) of the gas mixture and a breathing chamber (2), which chambers (1, 2) are connected to each other by means of a valve (3), which valve (3) is provided with a valve seat (35) and a movable shutter (30) and elastic stressing means (31) of the shutter (30) towards the closing condition of the valve (3), the breathing chamber (2) being delimited in part by a flexible membrane (4) connected to the shutter (30) by an actuating lever (43) so that a displacement of the flexible membrane (4) towards the interior of the breathing chamber (2) causes a displacement of the shutter (30) in the opening direction of the valve (3), a balancing chamber (5) being provided and the shutter (30) being hollow and provided with an insertion shaft (32) in a mouth of the chamber (5) in the position opposite the valve (35),
characterized in that
it comprises a barrier element (8) adapted to separate the mouth of the balancing chamber (5) from the breathing chamber (2).

2. Device according to claim 1, wherein the barrier element (8) has a separation wall (80) of the balancing chamber (5) from the breathing chamber (2), which wall (80) is provided with a through hole for the sliding housing of the shaft (32).

3. Device according to claim 2, wherein the barrier element (8) comprises a gasket ring (82) adapted to make a hydraulic seal on the mantle surface of the shaft (32), which gasket ring (82) is interposed between the separation wall (80) and the mouth of the balancing chamber (50).

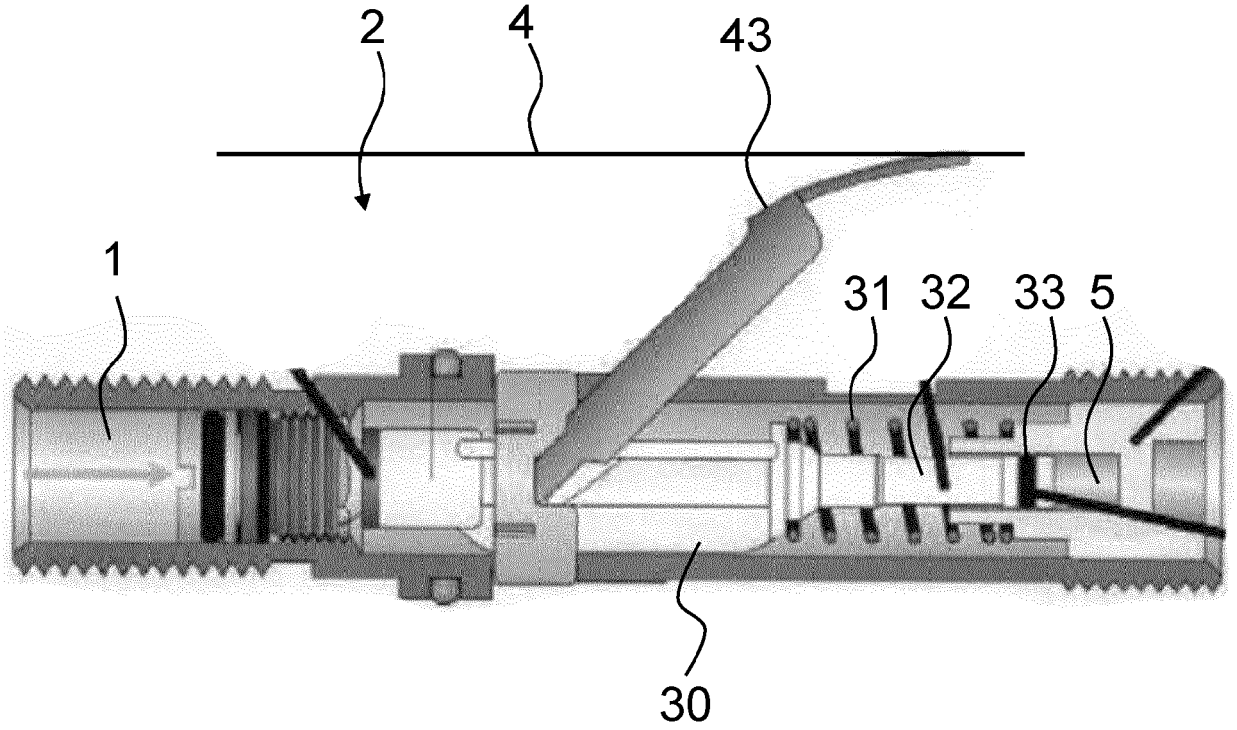
4. Device according to one or more of the preceding claims, wherein the mouth of the balancing chamber (5) is shaped so as to form a bushing end (51), the barrier element (8) being cup-shaped comprising a side wall (81) and a bottom wall (80), which bottom wall is formed by the separation wall, and the barrier element (8) being coupled to the bushing end (51).

5. Device according to claim 4, wherein the barrier element (8) is screwed onto the bushing end (51), the barrier element (8) and the bushing end (51) being provided with complementary threads.

6. Device according to claim 4 or 5, wherein the gasket ring (82) is in contact with the separation wall (80) of the barrier element (8) and with the head surface of the bushing end (51).

7. Device according to one or more of the preceding claims, wherein said elastic stressing means of the shutter consist of a spring (31), the barrier element (8) being provided with a tubular extension (83) extending from the separation wall (80) in the opposite direction with respect to the side wall (81), which tubular extension (83) is shaped so as to form an engagement seat of the spring (31) in combination with the separation wall (80).

8. Device according to one or more of the preceding claims, wherein the through hole is sized so as to form with the shaft (32) a cavity of greater thickness than the cavity between the shaft (32) and the mouth of the balancing chamber (5).



PRIOR ART

Fig. 1

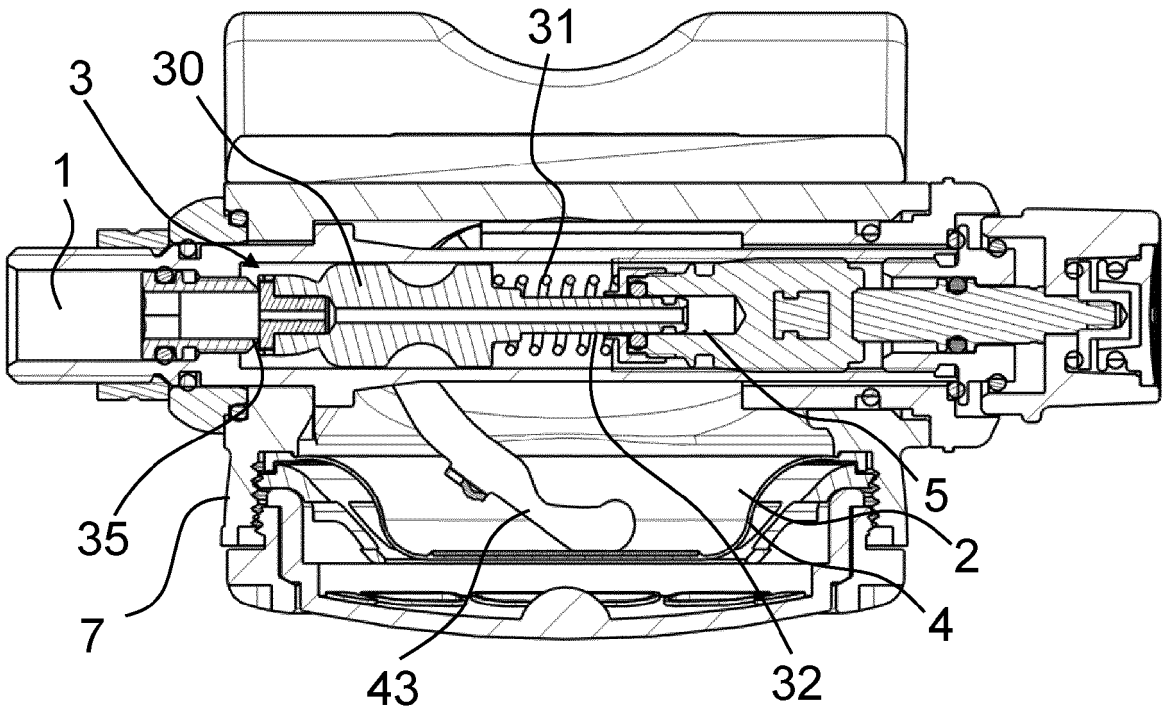


Fig. 2

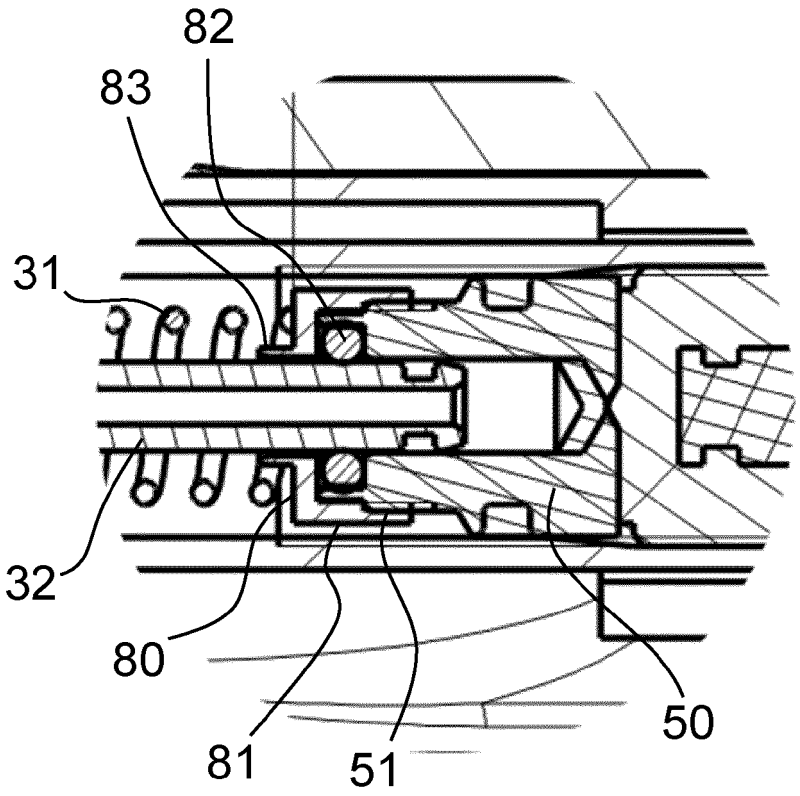


Fig. 3

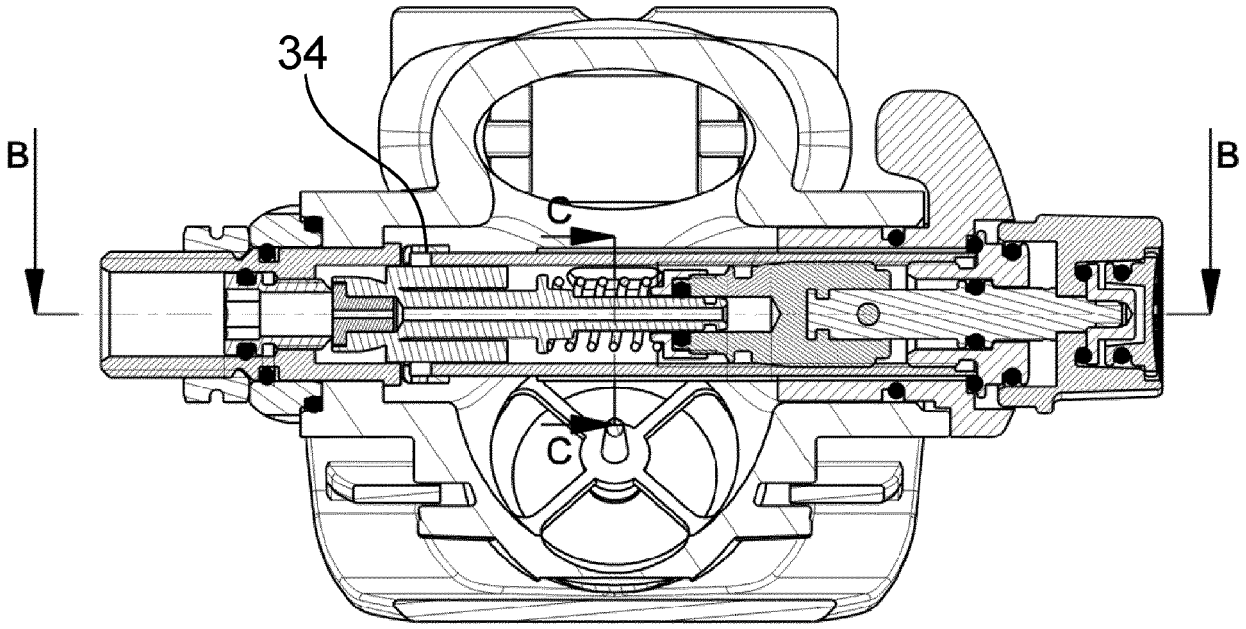


Fig. 4

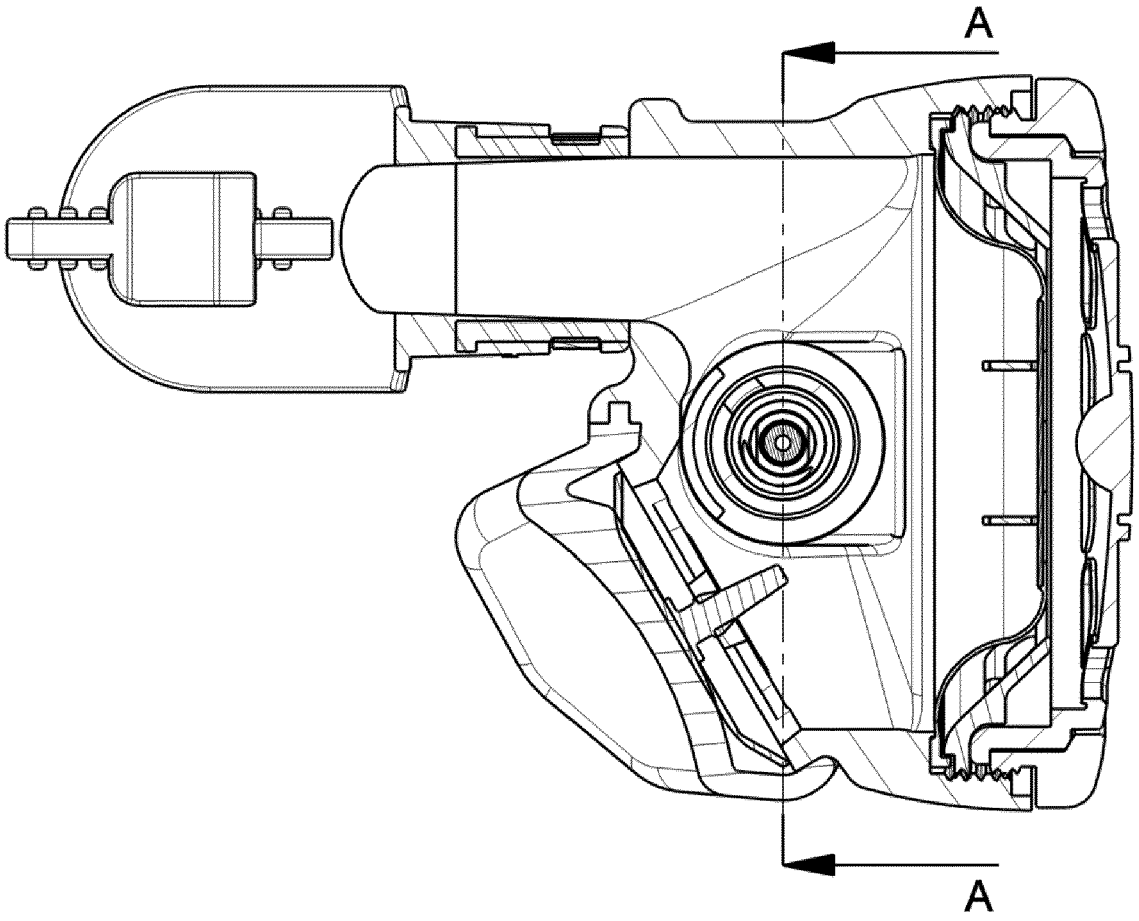


Fig. 5

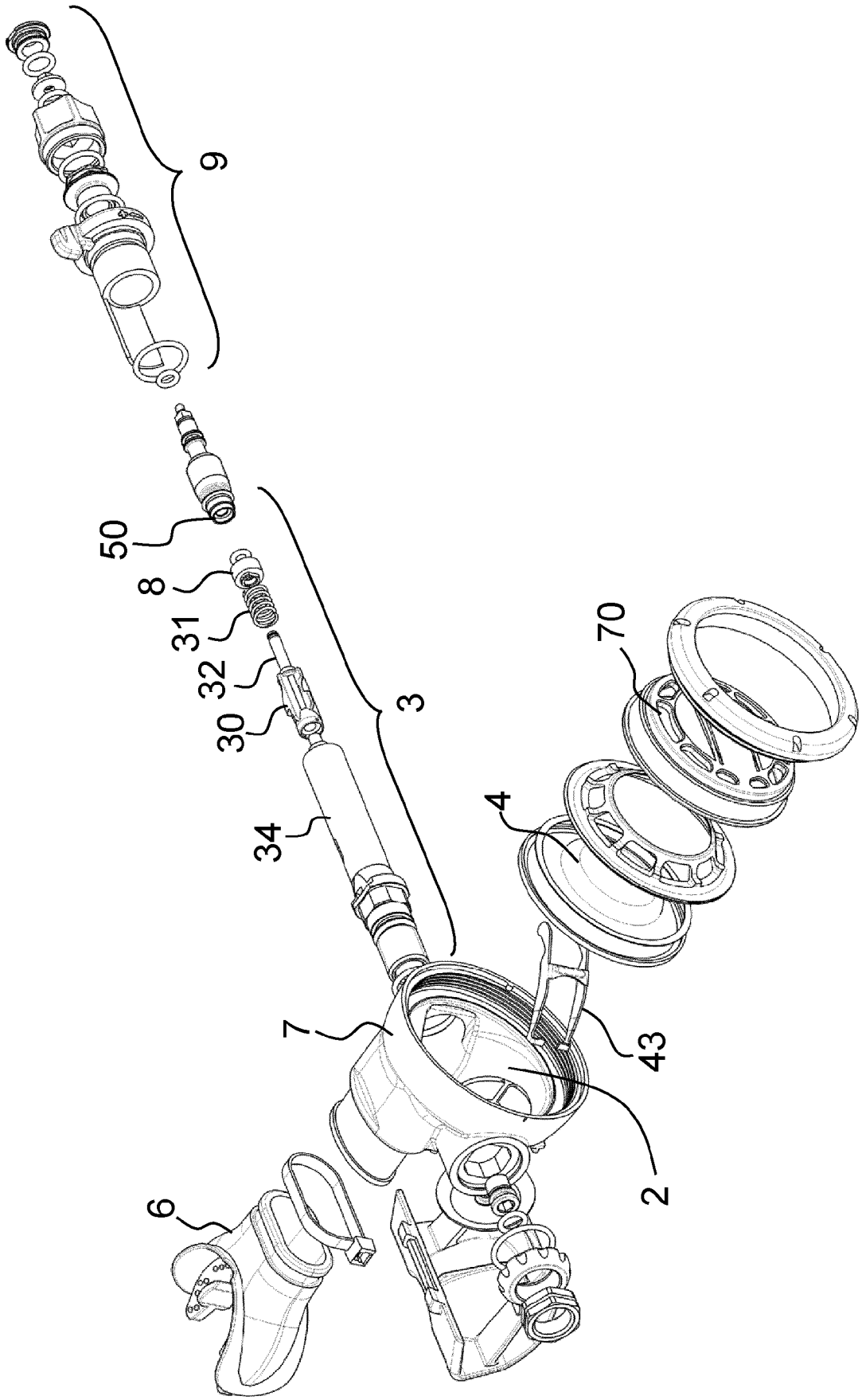


Fig. 6

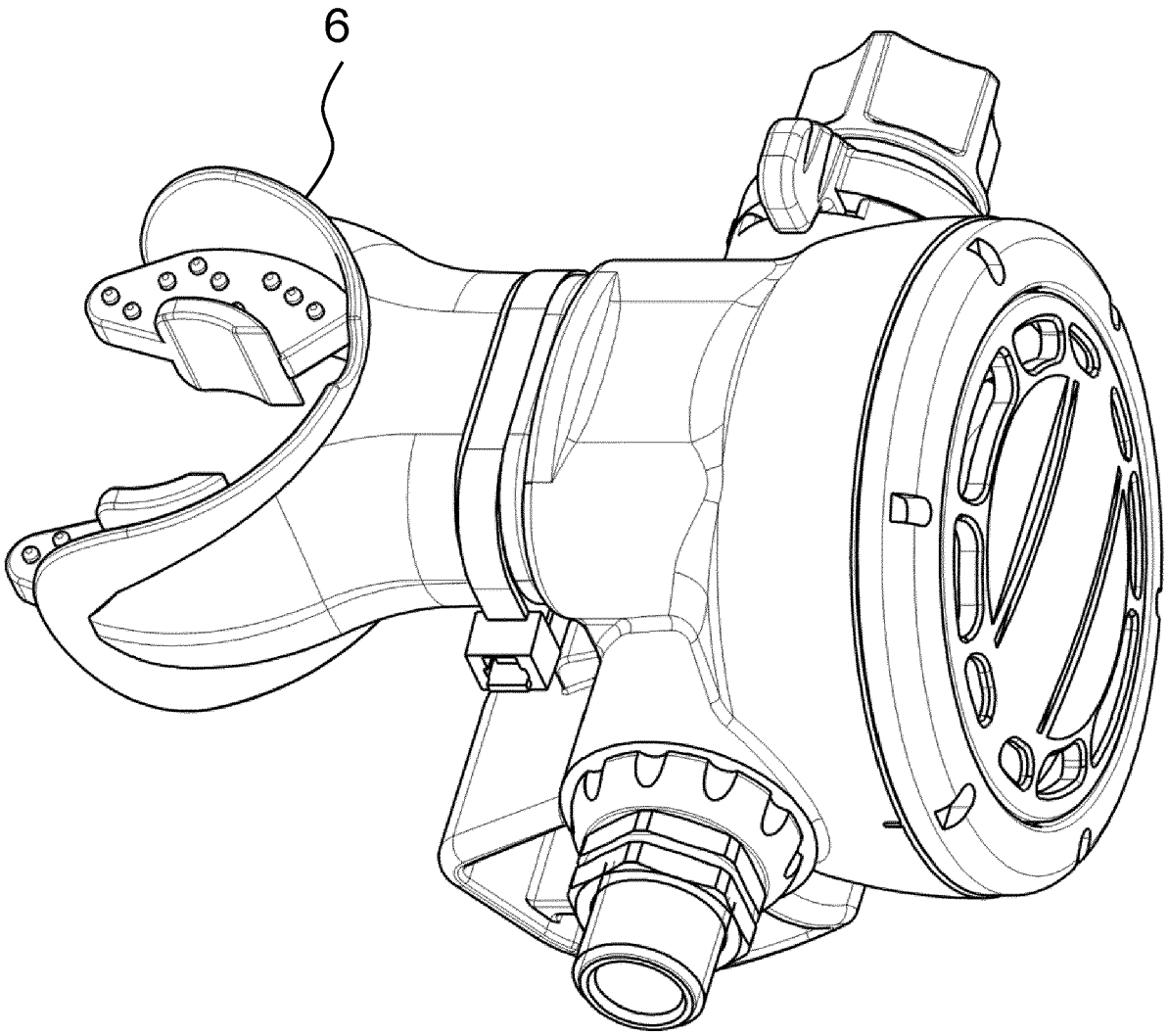


Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 0199

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 5 549 107 A (GARRAFFE DEAN R [US] ET AL) 27 August 1996 (1996-08-27) * column 4, lines 29 - 64 * * figure 1 * -----	1-3,8 4-7	INV. B63C11/22
A	US 2005/279410 A1 (ANGELINI SERGIO A [CH] ET AL) 22 December 2005 (2005-12-22) * paragraphs [0025] - [0030] * * figures 2, 3 * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)
B63C

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31 January 2022	Gatti, Davide

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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31-01-2022

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