(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 489 587 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.08.2012 Bulletin 2012/34

(51) Int Cl.:
B63C 11/22 *(2006.01)*

(21) Application number: **12154395.3**

(22) Date of filing: **08.02.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **17.02.2011 IT GE20110018**

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(54) **Regulator for underwater breathing apparatus**

(57) Regulator for underwater breathing apparatus, comprising a box-like body (1) in which is formed a chamber (6) having a first tubular element (8) for connection to a mouthpiece, a second tubular element (9) provided with a regulating valve (14) for supplying air to the inside of the regulator chamber (6), a conduit (11) for discharging expired air and any residual water, and an aperture (7) on which is positioned a flexible diaphragm (2) surmounted by a cover (3, 3') provided with a set of holes (5) or apertures (5') adapted to allow water to come into contact with the outer surface of the flexible diaphragm (2); the flexible diaphragm (2) interacts by suitable means (13, 13') with the regulating valve (14); the diaphragm (2) and the cover (3, 3') lie on, or are parallel to, a plane (M') facing upwards and inclined forwards relative to a generally upright position of the diver; a plurality of water inlet apertures (5') is formed behind the cover (3').

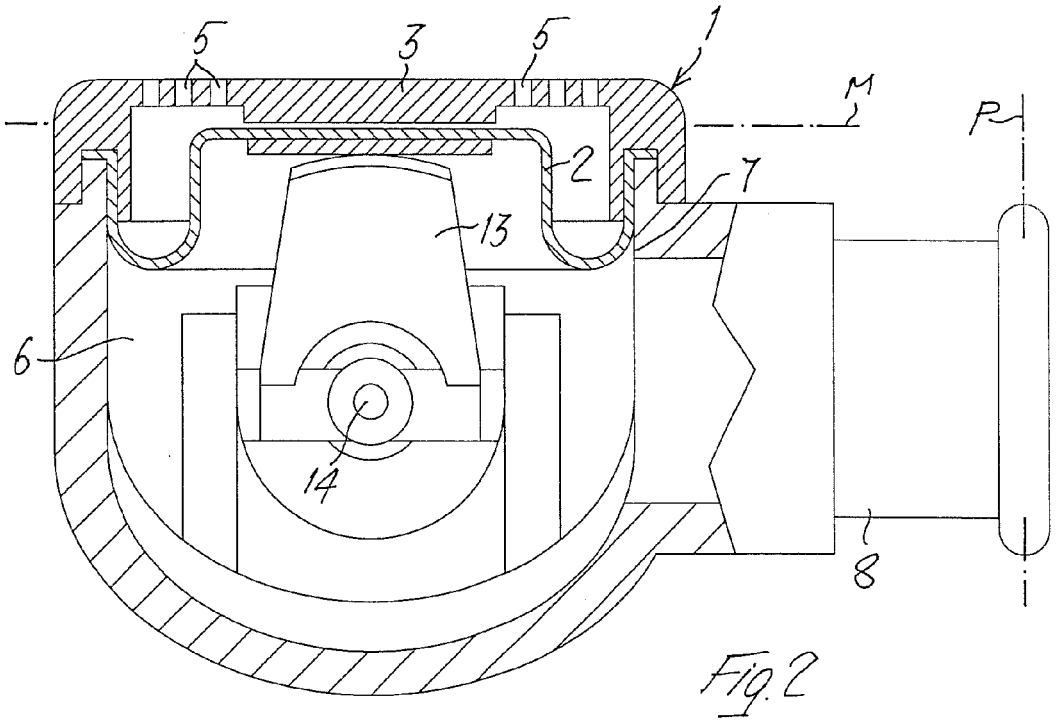

Fig. 2

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Description

[0001] The present invention relates to regulators for underwater breathing apparatus.

[0002] As is known, an underwater breathing regulator, or more specifically the second stage thereof, comprises a box-like body in which is formed a chamber having a first tubular element for sealed connection to a mouthpiece, a second tubular element provided with a regulating valve and adapted to be connected to a hose for supplying air to the inside of the regulator chamber, a conduit for the discharge of expired air and any residual water, and a front aperture closed by a flexible diaphragm on which is positioned a cover having a set of holes or apertures adapted to allow the water to come into contact with the outer surface of this flexible diaphragm. This flexible diaphragm interacts, by means of a suitable lever positioned in the regulator chamber, with the regulating valve which is placed in the tubular element for supplying air to the regulator.

[0003] Known regulators of this type have a number of drawbacks, primarily the fact that the flexible diaphragm and its cover with the holes or apertures for the passage of water is positioned on the front of the regulator; this diaphragm and cover are normally substantially parallel to the plane in which the aperture of the tubular element for connection to the mouthpiece lies. This positioning may cause excessive force to be imparted to the diaphragm by the water, especially in the presence of strong underwater currents or when the diver swims at a certain speed, and this can result in undesired phenomena of free flow, because the flexible diaphragm can act spontaneously on the lever interacting with the regulating valve of the tubular element for admitting air into the regulator.

[0004] This problem has been partially resolved by means of regulators in which the flexible membrane and the cover face upwards relative to a generally upright position of the diver. However, the presence of the holes and apertures on the surface of the cover, particularly on the front or anterior part thereof, can cause the operating efficiency of the regulator to be less than perfect.

[0005] Another negative aspect of conventional regulators is the positioning of the hose which is connected downstream to the tubular air supply element and upstream to the first regulator stage located at the outlet of the cylinder or cylinders. The tubular air supply element in a conventional regulator is positioned laterally relative to the regulator and emerges perpendicularly therefrom, and consequently the hose connected to this regulator also emerges from the tubular connecting element in the same lateral and perpendicular direction, and must therefore be curved through a large angle in order to be connected to the first stage at the outlet of the cylinders. This positioning of the hose gives rise to numerous problems, including excessive overall dimensions which cause a considerable degree of friction with the water, and the risk that the hose may be entangled in obstacles in the course of the diver's underwater movements. The inconvenient shape assumed by the hose because of this positioning also gives rise to excessive muscle fatigue in the diver, who has to keep the regulator firmly held in his mouth, since the centre of gravity of the regulator lies in the chamber at the outlet of the mouthpiece, thus forming an over-long lever arm which creates excessive forces for the diver. As a general rule, therefore, conventional regulators with these perpendicular lateral hoses are found to be bulky and heavy, and create considerable friction with the water.

[0006] A further disadvantage of known regulators is that the elimination of any residual water from the regulator chamber and towards the discharge conduit can take place conveniently only when the diver is in an upright position or is looking up towards the surface of the water, whereas in other cases, for example in the swimming position, the water accumulates near the front diaphragm, creating considerable difficulties for its elimination. The difficulty in expelling residual water from the inside of the regulator may give rise to the constant presence of water droplets in the regulator, which cause problems during respiration and, if diving takes place in cold water, can even cause the formation of ice crystals in the regulator, with obvious risks for the diver.

[0007] The object of the present invention is therefore to provide a regulator for underwater breathing apparatus which overcomes the drawbacks and disadvantages of the aforementioned known regulators.

[0008] This object is achieved by the present invention by means of a regulator for underwater breathing apparatus, comprising a box-like body in which is formed a chamber having a first tubular element for connection to a mouthpiece, a second tubular element provided with a regulating valve for supplying air to the inside of the regulator chamber, a conduit for discharging expired air and any residual water, and an aperture on which is positioned a flexible diaphragm surmounted by a cover provided with a set of holes or apertures adapted to allow water to come into contact with the outer surface of the flexible diaphragm, this flexible diaphragm interacting by suitable means with the regulating valve, **characterized in that** the diaphragm and the cover lie on, or are parallel to, a plane facing upwards and inclined forwards relative to a generally upright position of the diver; a plurality of water inlet apertures is formed behind the cover.

[0009] A second aspect of the present invention is a regulator for underwater breathing apparatus in which the tubular element for connection to the air supply hose is inclined to the rear, in other words towards the tubular element for connection to the mouthpiece.

[0010] A further aspect of the present invention is a regulator in which the chamber inside the box-like body is of truncated conical shape with an increasing cross section, inclined towards the conduit for discharging expired air and any residual water.

[0011] Other features and advantages of the present invention will be made clear in the course of the following

description, to be considered as a nonlimiting example, which refers to the attached drawings, in which:

- Fig. 1 is a view from above of a regulator for underwater breathing apparatus according to the present invention;
- Fig. 2 is a view in partial section of the present regulator, taken along the line II-II of Fig. 1;
- Fig. 3 is a further view in partial section of the present regulator, taken along the line III-III of Fig. 1;
- Fig. 4 is a view from above of a first variant embodiment of the present regulator; and
- Fig. 5 is a view in lateral elevation and in partial section of a further variant embodiment of the present regulator.

[0012] With reference to the attached drawings and with particular reference to Figures 1, 2 and 3, the number 1 indicates the box-like body of a regulator for underwater breathing apparatus according to the present invention. This box-like body 1 comprises an internal chamber 6, on one side of which is formed an aperture 7 closed by a flexible diaphragm 2. This diaphragm 2 is fixed to the annular edge of the box-like body 1 by means of a removable cover 3. The cover 3 is fixed to the box-like body 1, by means of pins 4 for example, and comprises a set of holes 5 which are suitably designed to allow water to enter the chamber 6 of the regulator and create the correct pressure difference between the surfaces of the diaphragm 2. The annular edge of this diaphragm 2 is held between the cover 3 and the box-like body 1, thus providing an excellent seal for the regulator. A first tubular element 8 is formed on one side of the box-like body 1 and in one piece with the latter, and can be connected in a sealed way to the mouthpiece which is not shown in the drawings. A second tubular element 9 for admitting air into the chamber 6 of the regulator is formed on another side of the box-like body 1 and in one piece with the latter. This tubular element 9 is adapted to be connected, by means of its threaded terminal part 10, to a hose, not shown in the drawings, which is connected upstream to the first stage of the regulator and then to the air supply cylinder or cylinders. A conduit 11, for discharging expired air and any residual water, is formed on the side opposite the side on which the tubular element 9 for admitting air into the regulator is formed. This conduit 11 is closed by a check valve 12 in the chamber 6 of the regulator. In a known way, the flexible diaphragm 2 interacts with a lever 13 connected to the plug of an air flow regulating valve 14 located in the tubular air inlet element 9.

[0013] During the operation of the present regulator, when the diver breathes in from the mouthpiece 8, the diaphragm 2 bends resiliently towards the inside of the chamber 6 so as to lower the lever 13, with respect to the rest position of Fig. 3 for example, and the plug of the regulating valve 14 opens to allow the air drawn from the first stage located at the outlet of the cylinders to pass through the hose and enter the chamber 6 through the tubular element 9. When the diver breathes out, the flexible diaphragm 2 is returned to the position of Fig. 3, the plug of the valve 14, being provided with suitable resilient return means, is closed, and the lever 13 also moves to the position of Fig. 3. The air breathed out by the diver and any residual air flow out of the check valve 12 towards the discharge conduit 11.

[0014] As can be seen in the drawings described above, the flexible diaphragm 2 and the cover 3 face upwards relative to a generally upright position of the diver wearing the present regulator, and are parallel to a plane M (see Fig. 2) which is substantially orthogonal to a plane P in which the aperture of the tubular element 8 for connection to the mouthpiece lies. By this positioning of the flexible diaphragm 2 and the cover with its holes 5 facing upwards, the risks of undesired forces imparted by the water to the diaphragm are partially eliminated in the regulator, as are the risks of free flow when the diver encounters strong underwater currents or when he is swimming at a certain speed.

[0015] In order to overcome, in an optimal way, the undesired phenomena of free flow in the regulator according to the present invention, the cover 3' and the flexible diaphragm 2 are parallel to a plane M' (see Fig. 5) which is inclined forwards relative to the plane M of the embodiment of Fig. 2. The cover 3' advantageously has a front or anterior surface without water inlet holes, to avoid undesired forces of the water on the diaphragm and the consequent risks of free flow. However, this cover 3' is provided with a set of water inlet apertures 5' which are located on the rear part of the box-like body 1 of the regulator. Consequently, these apertures face the tubular element 8 for connection to the mouthpiece, and are therefore shielded from any underwater currents. Advantageously, the optimal angle of inclination A of this plane M' relative to the plane M is approximately 35°.

[0016] In order to optimize the present regulator and make its operation more efficient than that of other regulators, the discharge conduit 11 is positioned on one side of the body 1 of the regulator, in particular on the side opposite that on which the tubular hose connection element 9 is formed. This positioning of the discharge conduit 11 facilitates the operation of expiration by the diver. Additionally, this discharge conduit 11 is inclined downwards at an angle B relative to the plane M, as shown in Fig. 3, and faces to the rear, in other words towards the back of the diver's neck, as shown in Fig. 5. The angle B of inclination of the conduit 11 relative to the plane M is approximately 35°.

[0017] Fig. 3 also shows another important characteristic of the present regulator, namely the double-taper truncated conical shape of the inside chamber 6 of the body of the regulator. The inner cross section of the chamber 6 increases towards the discharge valve 12 located upstream of the discharge conduit, and has a first portion 6' having a certain degree of taper and inclination towards the conduit 11 and a second portion 6", located

in the proximity of the discharge valve 12 and having a greater inclination than the first portion 6'. This shape of the inside chamber 6 of the box-like body 1 of the regulator facilitates the elimination of any residual water from the regulator even when the diver is not in an upright position, and therefore even when the diver is, for example, in a swimming position. Thus the water is conveyed towards the discharge valve 12 regardless of the position of the diver, and any water droplets, which often cause problems during breathing and which can cause the formation of ice crystals in the regulation during dives in cold water, are advantageously discharged from the conduit 11.

[0018] Fig. 4 shows a further important characteristic of the present regulator, in which the tubular hose connection element 9 is inclined to the rear, in other words towards the tubular mouthpiece connection element 8, relative to the lateral perpendicular direction D of known tubular connecting elements. The angle C of inclination of this tubular element 9 is preferably variable between 30° and 60°. This tubular element 9 can also be slightly inclined upwards when the diver is in an upright position.

[0019] Because of this inclination of the tubular element 9 which houses the regulating valve 14, the lever 13' must be made with a certain amount of single or double curvature, so as to follow the shape of the box-like body 1 of the present regulator, which has an optimum degree of compactness.

[0020] Numerous benefits are obtained by making the tubular element 9 inclined to the rear at a certain angle C. In the first place, the hose connected to this tubular element 9 has much smaller overall dimensions than the hose of a conventional regulator, in which, as mentioned above, the hose runs in a lateral and perpendicular outward direction D. The smaller overall dimensions of the rearwardly inclined hose according to the present invention decrease the friction in water and reduce the possibility of the diver's becoming entangled in any obstacles. The inclined hose is much more convenient in use and forms a smaller lever arm than the perpendicular hose of a conventional regulator, and therefore the diver can hold the regulator firmly in his mouth without excessive muscle fatigue. The rearward inclination of the hose also reduces the risks of contact between the hose and the diver's shoulder, the regulator is more balanced overall than conventional regulators, and its weight is advantageously reduced.

[0021] As the preceding description makes clear, many benefits can be obtained from the use of a regulator for underwater breathing apparatus according to the present invention, and many other variants of this regulator can be produced within the scope of the attached claims.

Claims

1. Regulator for underwater breathing apparatus, comprising a box-like body (1) in which is formed a chamber (6) having a first tubular element (8) for connection to a mouthpiece, a second tubular element (9) provided with a regulating valve (14) for supplying air to the inside of the regulator chamber (6), a conduit (11) for discharging expired air and any residual water, and an aperture (7) on which is positioned a flexible diaphragm (2) surmounted by a cover (3, 3') provided with a set of holes (5) or apertures (5') adapted to allow water to come into contact with the outer surface of the flexible diaphragm (2), the flexible diaphragm (2) interacting by suitable means (13, 13') with the regulating valve (14), **characterized in that** the diaphragm (2) and the cover (3, 3') lie on, or are parallel to, a plane (M') facing upwards and inclined forwards relative to a generally upright position of the diver, a plurality of water inlet apertures (5') being formed behind the cover (3').

2. Regulator according to Claim 1, in which the discharge conduit (11) is formed in the box-like body (1) of the regulator in a lateral position relative to the tubular mouthpiece connection element (8).

3. Regulator according to Claim 1, in which the discharge conduit (11) is inclined downwards relative to a generally upright position of the diver.

4. Regulator according to Claim 1, in which the discharge conduit (11) is positioned on the side opposite the side of the box-like body (1) in which is formed the tubular element (9) for connection to the air supply hose.

5. Regulator for underwater breathing apparatus, comprising a box-like body (1) in which is formed a chamber (6) having a first tubular element (8) for connection to a mouthpiece, a second tubular element (9) provided with a regulating valve (14) and adapted to be connected to a hose for supplying air to the inside of the regulator chamber (6), a conduit (11) for discharging expired air and any residual water, and an aperture (7) in which is positioned a flexible diaphragm (2) surmounted by a cover (3, 3') provided with a set of holes (5) or apertures (5') adapted to allow water to come into contact with the outer surface of the flexible diaphragm (2), the flexible diaphragm (2) interacting by suitable means (13, 13') with the regulating valve (14), **characterized in that** the tubular element (9) for connection to the air supply hose is inclined to the rear, in other words towards the tubular mouthpiece connection element (8).

6. Regulator according to Claim 5, in which the angle (C) of inclination of the tubular hose connection element (9) is variable between 30° and 60°.

7. Regulator according to Claim 5, in which the tubular

connecting element (9) is additionally inclined upwards relative to a generally upright position of the diver.

8. Regulator according to Claim 5, in which said means comprise at least one lever (13') interacting with the regulating valve (14) and with the flexible membrane (2) is made with a degree of single or double curvature so as to follow the shape of the box-like body (1).

9. Regulator for underwater breathing apparatus, comprising a box-like body (1) in which is formed a chamber (6) having a first tubular element (8) for connection to a mouthpiece, a second tubular element (9) provided with a regulating valve (14) for supplying air to the inside of the regulator chamber (6), a conduit (11) for discharging expired air and any residual water, and an aperture (7) on which is positioned a flexible diaphragm (2) surmounted by a cover (3, 3') provided with a set of holes (5) or apertures (5') adapted to allow water to come into contact with the outer surface of the flexible diaphragm (2), the flexible diaphragm (2) interacting by suitable means (13, 13') with the regulating valve (14), **characterized in that** the chamber (6) inside the box-like body has a truncated conical shape with an increasing cross section inclined towards the conduit (11) for discharging expired air and any residual water.

10. Regulator according to Claim 9, in which the chamber (6) comprises two truncated conical surfaces (6', 6") having different inclinations, the surface with the greater inclination being positioned directly upstream of the discharge conduit (11).

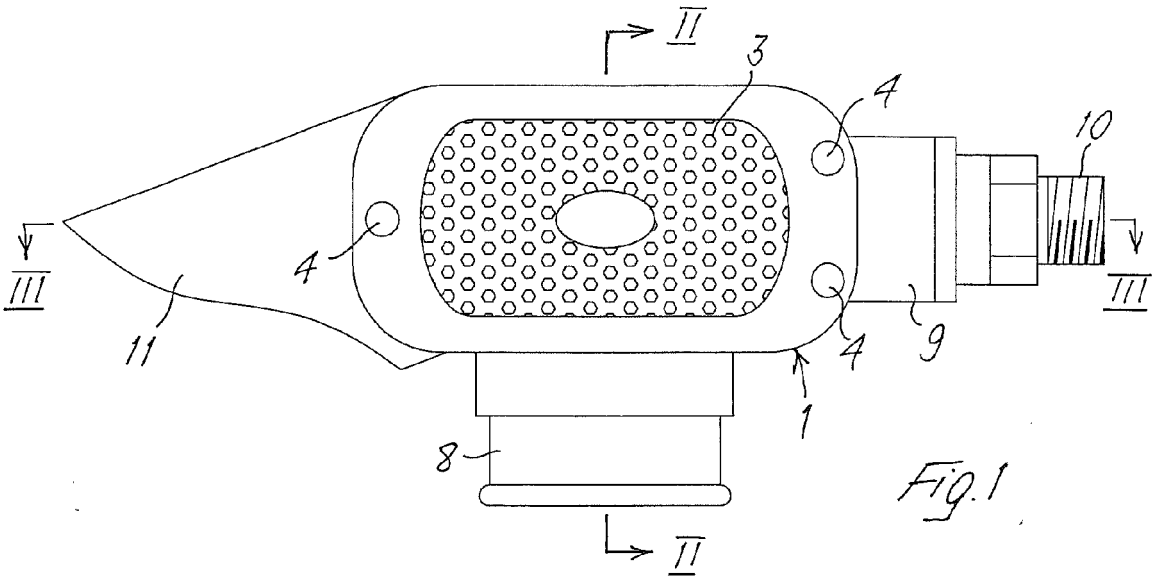

Fig. 1

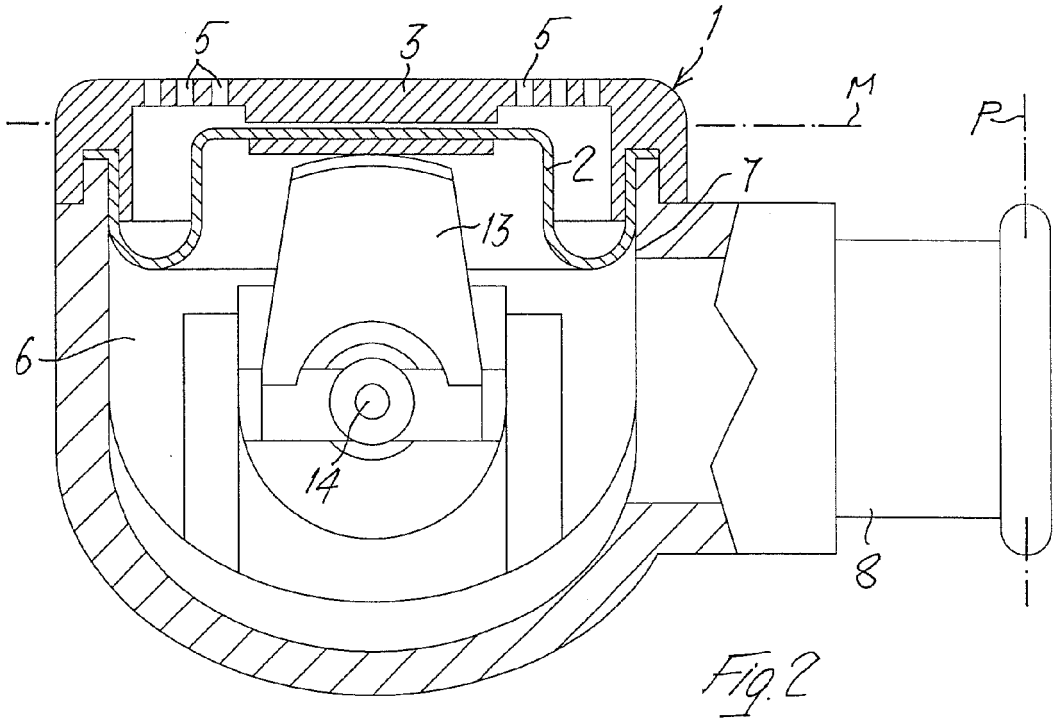

Fig. 2

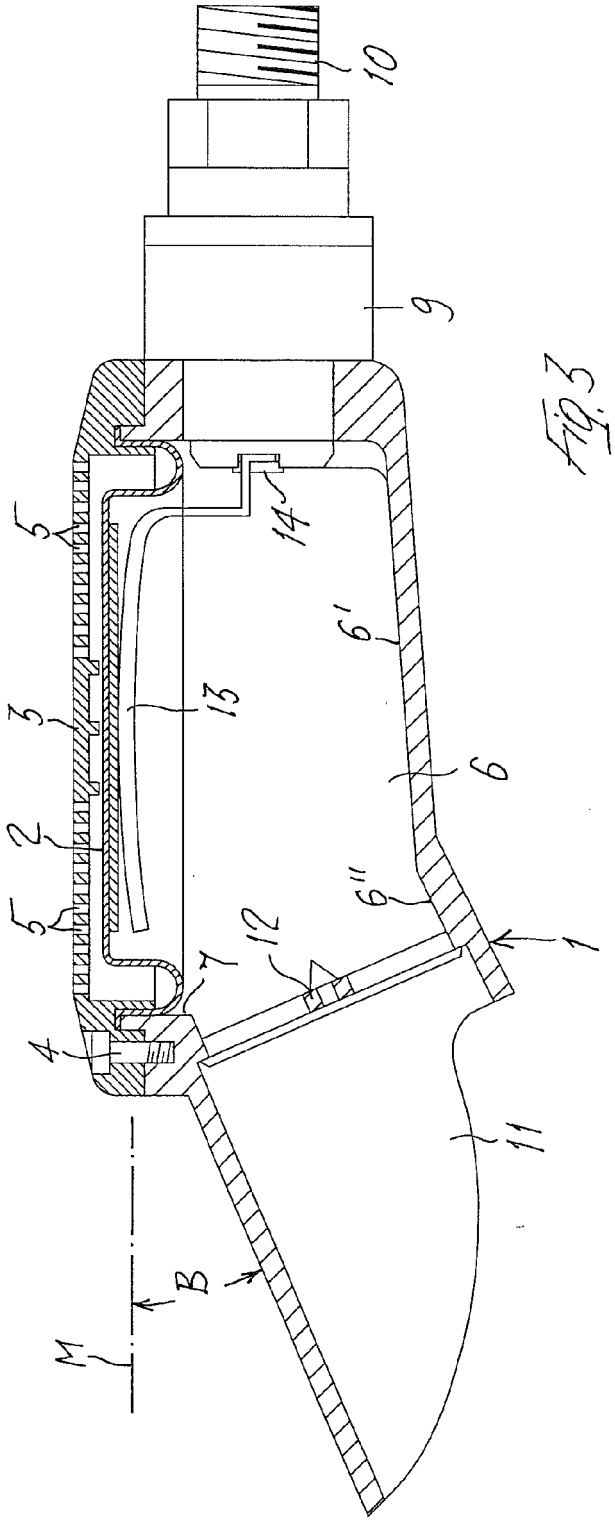

Fig. 3

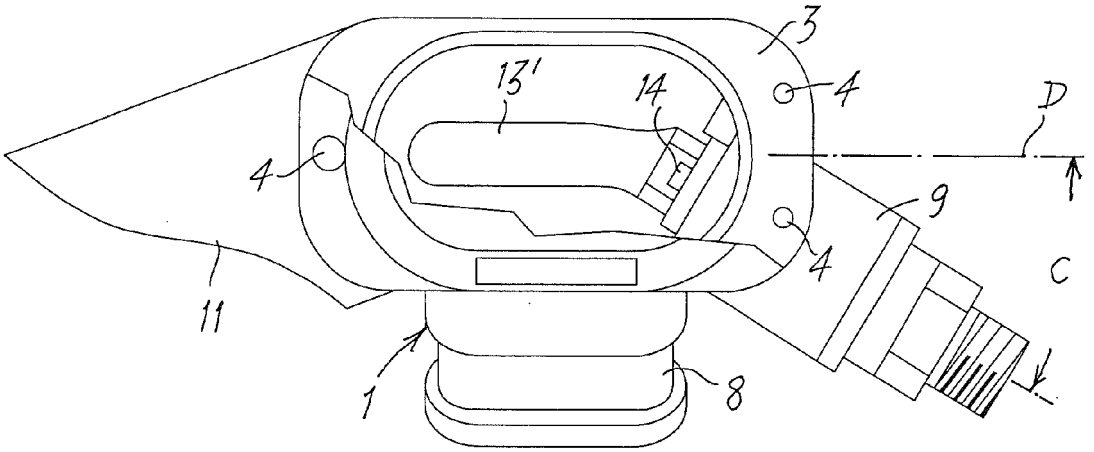

Fig. 4

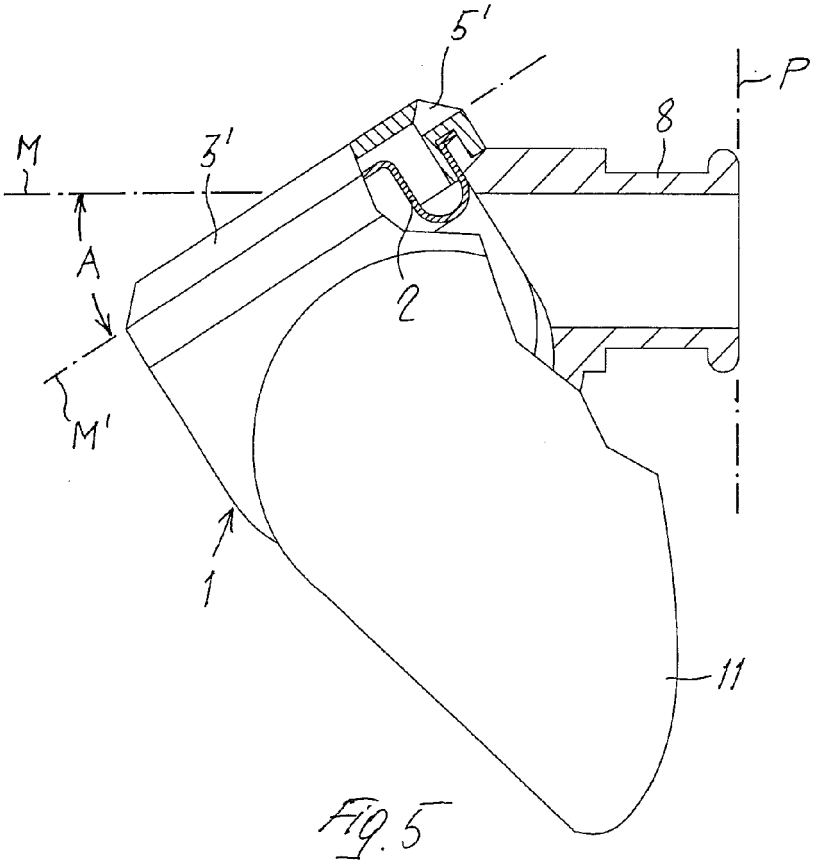

Fig. 5