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An automatic delivery valve.

A valve assembly suitable for self-contained underwater breathing apparatus used in conjunction with an adjustable buoyancy life jacket has two inlets (30, 62), one outlet (26) and first and second valves (40, 67) which control the flow of air from a respective inlet to the outlet, each valve (40, 67) being controlled to open or close by a respective first and second diaphragm (36, 71) which both experience substantially the same pressure differential but which have a different mechanical resistance from one another so that the assembly automatically directs air to the outlet from one inlet or the other depending on the depression in a diaphragm chamber.

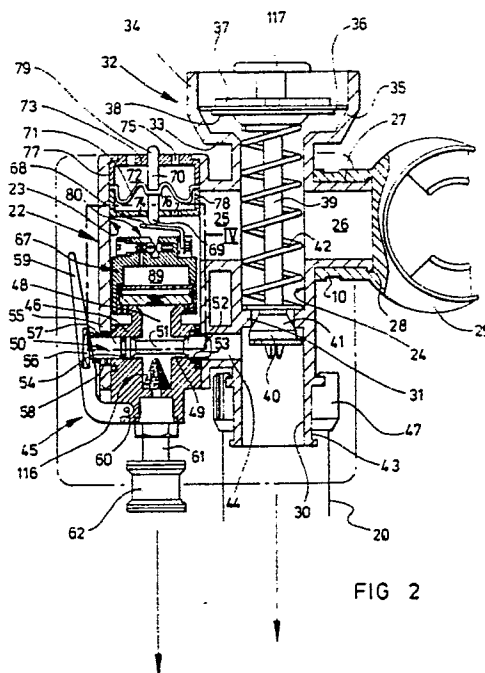


FIG 2

EP 0 318 157 A1

AN AUTOMATIC DELIVERY VALVE

The present invention relates generally to an automatic delivery valve, and particularly to a delivery valve adapted for use with a life jacket.

Technological background:

Adjustable buoyancy life jackets (ABLJs) have found increasing popularity with both sport and professional divers. Such life jackets can be used to control buoyancy by the selective introduction of air from an air bottle, and this air is not lost when introduced into the life jacket in the sense that it can be withdrawn for emergency breathing if the main breathing air bottle should become exhausted. Such life jackets have a small auxiliary or emergency air bottle, into which air from the main bottle is decanted before a dive, which can be used to inflate the lifejacket from time to time as necessary, and although it contains only a relative small amount of air compared with the main air bottle, this can be critical in determining whether the diver can safely reach the surface in an emergency. In order to make the air from the life jacket available a secondary hose leads from the interior of the life jacket to a secondary mouthpiece held in a clip from which it can be removed to be placed in the diver's mouth when necessary.

Technical problem:

The majority of divers dive in pairs for safety reasons. If one diver has difficulty with his air supply it is then possible for the two divers to share the functioning air supply of the other diver whilst ascending to the surface. Conventional techniques for sharing a single mouthpiece have been established, with each diver taking two inhalations and then passing the mouthpiece to the other diver whilst holding his breath for the process to be repeated. This conventional technique has a number of disadvantages; it requires skill and practice to execute, but if the air supply to a diver fails this is very often associated with other problems, and in any case causes stress, a rising pulse and breathing rate and an increased demand for air, which makes sharing a single mouthpiece extremely difficult.

To overcome this some divers have a secondary mouthpiece connected to a reduction valve on the air bottle for use by their partner in emergencies. This, means that if they also have the above-mentioned subsidiary mouthpiece for an adjustable buoyancy lifejacket, there may be three

mouthpieces and hoses on the breathing equipment, and this may be not only cumbersome but also confusing. The present invention seeks therefore to provide a novel valve for breathing apparatus of the like having a single mouthpiece and two inlets, which valve will automatically supply air from one inlet (for example the air bottle) for as long as this is available and then change over to supply air from the other inlet (for example the life jacket) without requiring any action by the user.

The Prior Art:

Prior attempts to form such a valve have involved the incorporation of a manually operable control member such as a push button or a lever which had to be operated in synchronism with the breathing. The present invention, on the other hand, provides an entirely automatic breathing valve which requires the diver only to inhale through the mouthpiece in a conventional manner.

The invention:

According to the present invention, therefore, there is provided a valve assembly having two inlets, a single outlet and first and second valves controlling the flow of fluid from a respective inlet to the outlet, characterised in that each valve is controlled to open or close by a respective first and second diaphragm, the said first and second diaphragms experiencing substantially the same pressure differential but having a different mechanical resistance from one another so that the first valve opens to allow fluid flow from one inlet to the outlet when the pressure differential reaches a first critical value and the second valve opens to allow fluid flow from the other inlet to the outlet at a second critical value which is higher than the first.

Preferably the outlet communicates with a common internal chamber to the pressure within which both the first and second diaphragms are exposed on one face.

In the application specifically described herein the outlet is a mouthpiece for breathing and the first and second inlets are adapted to be connected to primary and secondary sources of breathable gas respectively, although in other embodiments the inlets and outlet may be connected to other sources and destinations and the fluid the flow of which is controlled by the valve, may be a liquid rather than a gas.

The present invention also comprehends a life

jacket fitted with such a valve assembly. This valve assembly may be used as a secondary mouthpiece for the diver's partner if the partner's air supply should fail, and also may be used as an emergency supply of air from the life jacket if the diver's own air supply should fail. The only difference between inhalation through the secondary mouthpiece when drawing air from the air bottle or the life jacket is the slightly greater force of suction required to create the higher pressure differential between the interior of the valve chamber and the external environment to open the said other valve which is connected to the life jacket interior.

By utilising two diaphragms having different mechanical resistance values the necessity for any manual controls for breathing is avoided, although a separate manual control lever or button may be provided to allow air to be introduced into the life jacket from the primary air source through the two hoses leading to the mouthpiece, this manual control operating a third valve positioned in the valve housing on the other side of the main valve chamber from the first and second valves so that no air is lost through the mouthpiece when inflating the life jacket.

Because the secondary mouthpiece will for the majority of the time be clipped to a mount on the life jacket and not be placed in the user's mouth it will itself fill with water and in order to clear it before use the said first valve is preferably provided with a manually operable control member operable to open the first valve to allow air to pass through and clear water from the valve chamber after having been introduced into the user's mouth and prior to inhalation.

One embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a life jacket incorporating an automatic delivery valve formed in accordance with the principles of the present invention;

Figure 2 is a sectional view of a valve formed as an embodiment of the invention;

Figure 3 is a perspective view of a first detail of the valve shown in Figure 2; and

Figure 4 is a sectional view of a second detail of the valve shown in Figure 2.

Referring now to the drawings, the life jacket illustrated in Figure 1, and generally indicated with the reference numeral 11 comprises two main lateral buoyancy chambers 12, 13 communicating with generally tubular buoyancy chambers 14, 15 which are positioned behind the diver when the life jacket is fitted. The life jacket illustrated in Figure 1 also serves as a harness, for mounting a gas bottle

16 (usually air) for which purpose the lifejacket incorporates a main substantially rigid dorsal member 17 which forms a rigid base on which the fabric panels defining the chambers referred to above are held. Attached to this dorsal member 17, and to the buoyancy chambers are attachment straps 18, 19 of a fixing harness, by which the life jacket can be fitted to a wearer. This life jacket is shown and described purely as an example of the application of the valve of the present invention, however, and it will be appreciated that other forms of lifejacket, particularly conventional collar-type jackets, may be equally well used.

Attached to the upper part of one of the tubular chambers 15, and in communication with the interior thereof, is a flexible hose 20 which carries at its free end, a valve assembly 21 having a mouthpiece 29, formed as an emergency demand valve, as will be described in more detail in relation to Figure 2, and by means of which it is possible for a second diver to breathe air from the bottle 16 or for either diver to breathe the air contained within the life jacket in an emergency. Air can be introduced into the life jacket from an emergency air bottle contained in a pocket 90 or from the main air bottle as will be described below.

The main lateral buoyancy chambers 12, 13 have a rather elongate flattened configuration and are prevented from adopting a spherical or near spherical shape upon inflation by the use of retainers 26 which act to "quilt" the chambers 12, 13 retaining them in the desired approximately planar shape so that they do not restrict the arms of a wearer as is described in our co-pending British Patent application published under Serial No 2,197,627A.

Referring now to Figure 2 the valve 21 illustrated is a development of the valve for underwater breathing apparatus described and claimed in our British Patent No 1,339,898, and comprises a valve casing 22, preferably made of injection moulded plastics (although other techniques may be used) in a shape forming two main cylindrical chambers 23, 24 joined by a transverse passage 25. The casing 22 may be enclosed within an outer cover shown in broken outline in Figure 2, which provides a shaped exterior surface convenient to grip when handling the valve with gloves. In alignment with the transverse passage 25 is a mouthpiece passage 26 defined by a tubular spigot 27 having a perimetral annular ridge 28 for retaining a mouthpiece 29 of conventional form having a cooperating internal annular groove for receiving the ridge 28 and an external annular groove 10. The mouthpiece 29 is made of a soft elastomeric material sufficiently resilient to be fitted over the spigot 27 and annular ridge 28 and to retain itself thereon with the aid of a retainer band (not shown) fitted into the

groove 10.

The cylindrical chamber 24 is terminated at one end by an inwardly directed annular projection 31 and at the other end by a cup-shape enlargement 32 comprising a disc-like flat radial wall 33, a cylindrical wall 34 and a conically tapered intermediate wall 35 joining the flat radial wall 33 at the base of the cup with the cylindrical wall 34. The cup-shape enlargement 32 houses a resilient diaphragm 36 reinforced on opposite faces by a rigid disc 37, on one side and a relatively hard rubber disc 38 on the other, which also mount the diaphragm 36 to a central valve shaft 39 which extends from the diaphragm 36 through the cylindrical bore 24 and is connected at its other end to a valve shutter 40 having a conical face 41 which cooperates with the radially inwardly projecting annular ridge 31. The ridge 31 also acts as an abutment for one end of a compression coil spring 42 the other end of which engages against an enlarged end of the central valve shaft 39, thereby urging the valve stem 39 and consequently the valve 40 axially towards the cup-shape enlargement 32 thereby holding the valve 40 closed with its conical face 41 pressed firmly against the annular inward projection 31.

Axially aligned with the cylindrical bore 24 is a cylindrical spigot 30 of similar diameter which is shaped to receive a connector 47 to the hose 20 leading to the lifejacket 11.

The interior bore of the spigot 30 communicates via a transverse passageway 44 with a manually controllable valve generally indicated with the reference numeral 45 housed in one end of the bore 23 which extends parallel to the bore 24 in the valve casing 22. The valve 45 comprises a valve body 46 of generally cylindrical form the diameter of which closely matches that of the bore 23 so that it is a sealed fit within it. The valve body 46 has an axial passage 48 and a transverse passage 49 intersecting the axial passage 48 and aligned with the transverse passage 44 in the valve body 22 leading to the interior of the spigot 30.

Within the transverse passage 49 is housed a slide valve member 50 having a narrow central stem 51 and an enlarged head end 52 which seals within an annular seal 53 housed in an annular groove in the transverse passage 49. A similar annular seal 54 housed in an annular groove in an enlarged foot end 55 of the valve slide 50 seals the opposite end thereof in the passage 49. The foot end 55 has an enlarged cap 56 against which abuts a compression coil spring 57 which surrounds the foot end 55 and passes through an aperture 58 to contact the valve body 46 at its other end urging the valve slide member 50 towards the left as viewed in Figure 2 maintaining the large head end 52 in contact with the sealing ring 53 and thereby

closing communication between the axial passage 48 and the transverse passage 44. A lever 59 pivotally mounted at 60 to the valve body 46 engages the cap 56. On depression of the lever 59 the valve slide 50 is displaced towards the right as viewed in Figure 2, against the action of the biasing spring 57, to a position where the enlarged head end 52 is displaced from the sealing ring 53 to allow communication between the axial passage 48 and the transverse passage 44 via the transverse passage 49 and the narrow stem 51 of the valve member 50. It will be appreciated that the transverse passage 44 in the valve casing 22 is of slightly greater diameter than the transverse passage 49 in the valve body 46 so that the enlarged head end 52 of the valve member 50 is received in the former with a sufficient clearance to allow the ready transfer of air.

The axial passage 48 communicates, via a filter 116, with a stem 61 having a connector 62 to which is connected an air line 63 (Figure 1) leading from a control regulator valve 64 of the main air bottle 16. The regulator valve 64 also supplies an air line 65 to a main mouthpiece 66 for normal use and the mouthpiece 21 is provided with a clip or other appropriate housing by which it can be secured against unwanted movement when not in use.

The inner end of the axial passage 48 in the valve body 46, that is the end facing inwardly of the axial bore 23 in the casing 22 is closed by a servo valve 67 having a pilot valve 80 with a control lever 68 the end of which is engaged against the inner end 69 of a stem 70 carried by a rolling diaphragm 71 within a diaphragm chamber generally indicated 72 having opposite radial walls 73, 74 with respective apertures 75, 76. Each of the radial walls 73, 74 has a respective peripheral axial flange 77, 78 defining cylindrical walls the ends of which trap the diaphragm 71 between them. The stem 70 is guided in respective central apertures in the radial walls 73, 74 and a free end 79 thereof projects from the diaphragm chamber 72 in order to act as a push button which can be pressed to cause axial displacement of the stem 70, guided by the central apertures in the radial walls 73, 74 causing the lever 68 to depress and open the pilot valve 80 of the servo valve 67 as will be described below. Axial displacement of the stem 70 may also be caused by a pressure differential across the diaphragm 71.

The servo valve 67 comprises an inverted cup-shape body 81 (Figure 4) fitted over the upper end of the cylindrical valve body 46 housing the manually operable valve 45. The cup-shape body 81 has an outer diameter which is less than the inner diameter of the bore 23 so as to leave an annular passage way 82 between them, and the open end of the inverted cup-shape body 81 fits over a radial

flange 83 having axial apertures 84 the upper ends of which are closed by the periphery of a resilient disc 85 clamped between the flange 83 and an apertured spacer disc 86 lodged between the perimeter of the disc 85 and a shoulder on the inner wall of the inverted cup-shape valve body 81. The resilient disc 85 has a calibrated central aperture 87 whilst the spacer 86 has a plurality of apertures 88 allowing communication between an upper chamber 89 within the inverted cup-shape valve body 81 and an intermediate chamber 90 between the spacer disc 86 and the resilient valve disc 85.

The pilot valve 80 is shown in more detail in Figure 3 and comprises two aligned semi-cylindrical bodies 91, 92 separated by a gap 93. The first body 91 houses a nozzle member 94 having a central body portion 95 the diameter of which is less than that of the bore 96 (Figure 4) in the body 91 in which it is housed. The central body 95 has apertures 97 communicating from its exterior surface to an interior axial passage 98 leading to an orifice 99 at an exposed nozzle end 100 projecting into the gap 93. At the opposite end the body 95 has an enlarged threaded head 101 with a slot 102 by means of which the axial position of the nozzle member 94 in the housing 91, and therefore to adjust its position within the gap 93.

Within the axially aligned housing 92 there is a slidable stem 104 with an enlarged head 105 forming a valve shutter pad engageable against the orifice 99 in the nozzle end 100 of the nozzle member 94. The stem 104 is slidable axially of the housing 92 under the action of the lever 68 which, as can be seen in Figure 3, has a bifocated stirrup portion 106 at its pivot end, having two inwardly directed flat fingers 107, 108 which are held against an end face 109 of the housing 92 with the interposition of a washer 110. A second washer 111 is held in place on a threaded end 112 of the stem 104 by a pair of lock nuts 113, 114 and the stem 104 is resiliently biased to the left as viewed in Figure 2 by a coil spring 115 which draws the threaded end 112 and, with it, the washer 111 and the lock nuts 113, 114 against the fingers 107, 108 to hold them flat against the washer 110 and to determine the pressure exerted on the nozzle end 100 of the nozzle member 94. By suitably adjusting the head end 103 of the nozzle member by engaging a suitable tool in the slot 102, and by correspondingly adjusting the lock nuts 113, 114 it is possible to vary the positions of the orifice 99 and the pressure exerted on it by the shutter head 105 for purposes which will be described in more detail hereinbelow.

In use, the valve of the invention is fitted to the ends of the hose 20 leading to the life jacket 11 and the line 63 leading to the valve 64 on the air bottle 16. Normally, the valve defined by the valve

body 40 and the radial projection 31 is closed by the spring 42, the valve defined by the enlarged end 52 of the valve member 50 is closed by its engagement with the seal 53 and the servo valve 67 is closed to prevent the flow of air from the axial passage 48. The mouthpiece 21 is secured on a suitable mount (not shown) where it is available for use but not in the way of the diver utilising the main mouthpiece 61. A first function of the valve of the present invention is to make available the option of a second diver utilising the air supply of the air bottle 16 should any fault in his own air supply develop. For this purpose it is simply necessary to take the mouthpiece 21, clear the water from it as will be described, insert the tooth grip 29 in the conventional manner and inhale. Such inhalation will cause a vacuum in the transverse passage 25 and therefore a pressure differential across both the diaphragm 36 in the cup-shape enlargement 32 and the diaphragm 71 in the diaphragm chamber 72. The spring 42 initially resists displacement of the diaphragm 36 up to and above a pressure differential which causes the diaphragm 71 to flex, thereby displacing the pin 70 to depress the lever 68 which results in the flat fingers 107, 108 turning about their common longitudinal axis to draw the stem 104 and thus the shutterhead 105 away from the nozzle orifice 99. This opens communication between the chamber 25 and the chamber 48 through a pathway comprising the nozzle orifice 99, the interior of the nozzle body, the radial passages 97, the communicating passage 83, the chamber 89, the passages 88 in the spacer 86, the gap 90 and the calibrated orifice 87 in the flexible diaphragm 85. Because, during inhalation, the pressure in the chamber 25 is maintained low this depression is transferred to the upper side of the flexible diaphragm 85 which thus flexes upwardly in the middle, being trapped around the periphery by the spacer 86, to lift its surface from the annular array of passages 84 thereby creating a route for air from the chamber 48 between the now upwardly flexed diaphragm 85 and its seat, through the passages 84, along the narrow annular space 82 between the valve body 81 and the cylindrical bore 23, and so through the chamber 25 into the passage 26 of the mouthpiece. The calibrated aperture 87 in the flexible diaphragm 85 allows a slow leakage of air from the chamber 48 into the upper chambers 89 and 90 so that this flexible diaphragm 85 will close as the pressure in the chamber 25 rises at the end of inhalation.

Upon exhalation the increase in pressure causes the servo valve 67 to close and, because it is restrained by the valve stem 39, the diaphragm 36 in the cup-shape body 32 allows the escape of air around its periphery.

Whether or not the mouthpiece 21 is being

used for breathing by the second diver, the lever 59 may be depressed to allow air from the gas bottle 16 to be introduced into the lifejacket 11. This causes axial displacement of the end cap 56 and, consequently, the valve stem 51 and enlarged end 52 until the latter is no longer in register with the annular seal 53 in the groove in the valve body 46, whereupon air can communicate through the stem 61 and the axial passage 48, via the transverse passage 44 in the valve casing 22 and into the interior chamber 30 of the spigot 43 which is connected to the hose 20. Any air so transferred into the lifejacket is not lost for breathing, however, since should the gas bottle 16 become exhausted before the diver has reached the surface, it is nevertheless possible to breathe the gas in the life jacket, again by inhaling through the mouthpiece 21 after the teeth grip 29 has been placed in the mouth. Additional air can be introduced directly into the life jacket from the small emergency cylinder to replace that withdrawn if necessary to maintain buoyancy. In these circumstances, since a reduction in the pressure within the chamber 25 cannot cause opening of the valve 67 (since the gas bottle 16) is assumed to be completely exhausted) and consequently even though the diaphragm 71 may be displaced by the pressure differential between the interior of the chamber 25 and the surrounding environment, the servo valve 67 will not open because there is inadequate pressure differential across the flexible diaphragm 85.

This results in a further fall in the pressure in the chamber 25 sufficient to overcome the resistance of the spring 42 by the force exerted by the pressure differential across the diaphragm 36 and this therefore urges the valve stem 39 downwardly as viewed in Figure 2 opening the valve 40 and allowing air to enter the mouthpiece from the lifejacket 11. Displacement of the valve stem 39 causes the diaphragm 36 to move into the region of the cup-shape enlargement 34 constituted by the conically tapered walls 35 thereby increasing the security of the seal and ensuring no water enters through this valve. Upon exhalation the stem 39 moves axially until the valve 40 closes and expired air again passes around the perimeter of the diaphragm 36.

In an emergency, therefore, the mouthpiece 21 may be used either by a second diver or by the diver wearing the life jacket 11, either to breathe air from the bottle 16, in parallel with the main mouthpiece 66, or alternatively to breathe air from the life jacket 11 (in which latter case, if there are two divers, the mouthpiece 21 may have to be shared for alternate breaths).

During an ascent the air in the life jacket expands and, because of the reduction in pressure, increased buoyancy may lead to a too-rapid rise.

Buoyancy can be reduced by manual depression of the stem 39, acting on a button 117 at the free end thereof, to open the valve 40 and allow air to pass out through the mouthpiece 29 or, if the diver has the mouthpiece in his mouth, around the edges of the resilient diaphragm 36, thereby controlling the rate of ascent and avoiding the risk of the bends by partially deflating the life jacket.

The valve also allows the life jacket to be inflated, for example, on the surface, if there is no supply of compressed air available, simply by pressing button 117 on the free end of the shaft 39 hard until the rubber reinforcing disc 38 closes against the shoulder 33 and then blowing into the mouthpiece 29.

Claims

1. A valve assembly having two inlets (30, 62), a single outlet (26) and first and second valves (40, 67) controlling the flow of fluid from a respective inlet to the outlet, characterised in that each valve (40, 67) is controlled to open or close by a respective first and second diaphragm (36, 71), the said first and second diaphragms experiencing substantially the same pressure differential but having a different mechanical resistance from one another so that the first valve (67) opens to allow fluid flow from one inlet (62) to the outlet (26) when the pressure differential reaches a first critical value and the second valve (40) opens to allow fluid flow from the other inlet (30) to the outlet (26) at a second critical value which is higher than the first.

2. A valve assembly according to Claim 1, characterised in that the outlet (26) communicates with a common internal chamber (25) to the pressure within which both the first and second diaphragms (36, 71) are exposed on one face.

3. A valve assembly according to Claim 1 or Claim 2, characterised in that the outlet (26) is provided with a mouthpiece (29) for breathing and the two inlets (30, 62) are adapted to be connected to primary (16) and secondary (11) sources of breathable gas respectively.

4. A valve assembly according to any preceding Claim, characterised in that the said first valve (67) is manually operable to allow gas to flow through the valve assembly from the said one inlet (62) to the outlet whereby to exhaust liquid from the interior of the assembly.

5. A valve assembly according to Claim 3 or Claim 4, characterised in that there is further provided a unidirectional exhaust valve (32) whereby to allow exhalation through the mouthpiece (29) of the valve assembly.

6. A valve assembly according to Claim 5, characterised in that the unidirectional exhalation valve (32) is constituted by the said second diaphragm (36) linked to the said second valve (40) for opening the said second valve (40) at the said second, higher, critical pressure differential value. 5

7. A valve assembly according to any preceding Claim, characterised in that the said one valve (67) includes a diaphragm (85) secured at its periphery in a mount (46, 83) having openings (84) which are closed by the diaphragm (85) in its relaxed state and opened upon flexure of the diaphragm in a first direction to open communication between the said one inlet (62) and the outlet (26). 10

8. A valve assembly according to Claim 7, characterised in that the pressure differential across the said diaphragm (85) of the said one valve (67), and therefore its flexure, is controlled with a pilot valve (80) by displacement of the said first diaphragm (71). 15 20

9. A valve assembly according to Claim 7 or Claim 8, characterised in that the said diaphragm (85) of the said first valve has a central calibrated aperture (87) allowing controlled escape of gas towards a control chamber of the said first valve. 25

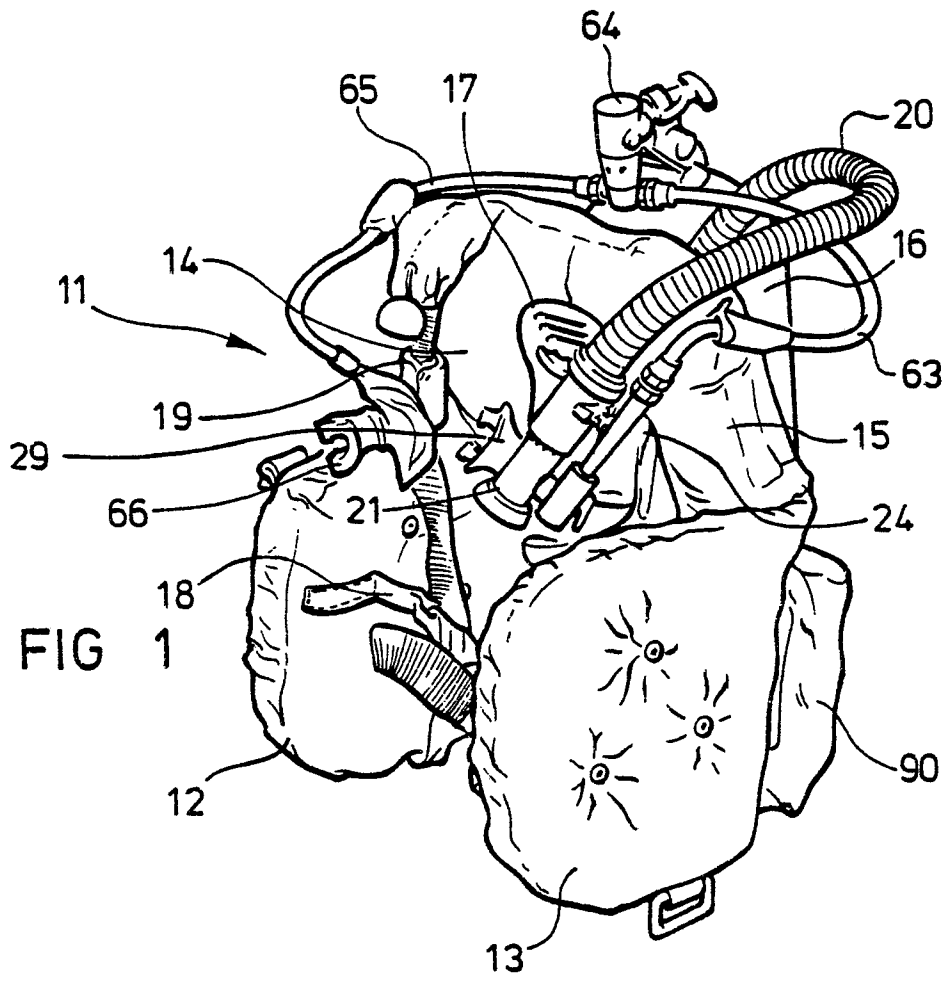
10. A valve assembly according to any of claims 7 to 9, characterised in that the said pilot valve (80) comprises a nozzle member (94) adjustable longitudinally in a nozzle housing (91) and a nozzle closure member (105) displaceable axially with respect to the nozzle member (94) whereby to open or close the nozzle orifice (99) thereof, said nozzle closure member (105) being controlled by a lever (68) one end of which is displaced by displacement of the said first diaphragm (71). 30 35

11. A life jacket incorporating a valve assembly having a first inlet connectable to an air bottle, a second inlet connected to a hose leading to the interior of the life jacket, and an outlet formed with a mouthpiece, the said valve assembly operating automatically upon inhalation through the mouthpiece to draw air through the first inlet when it is available and to draw air from the second inlet when there is no air available from the first. 40 45

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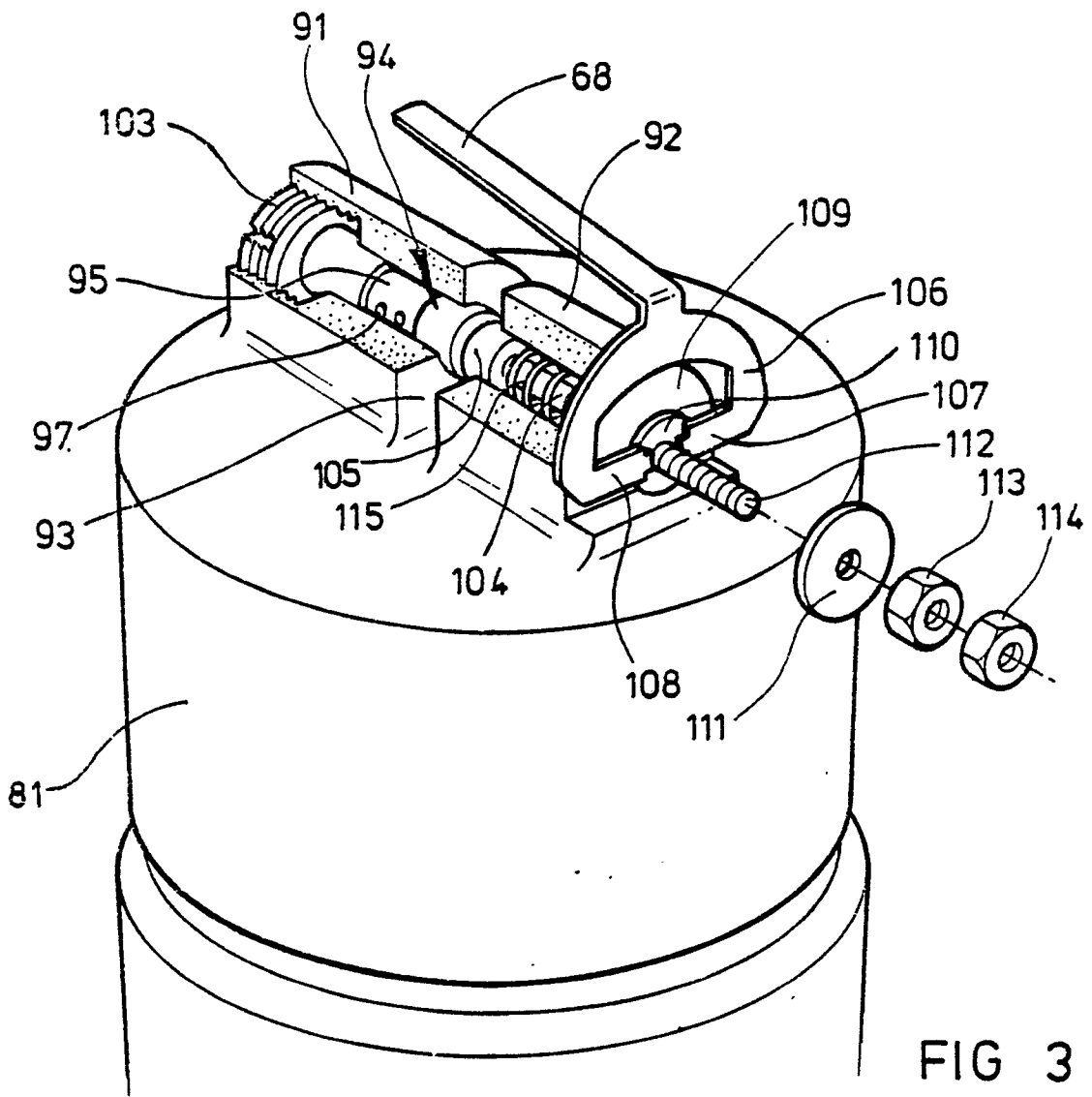


FIG 3

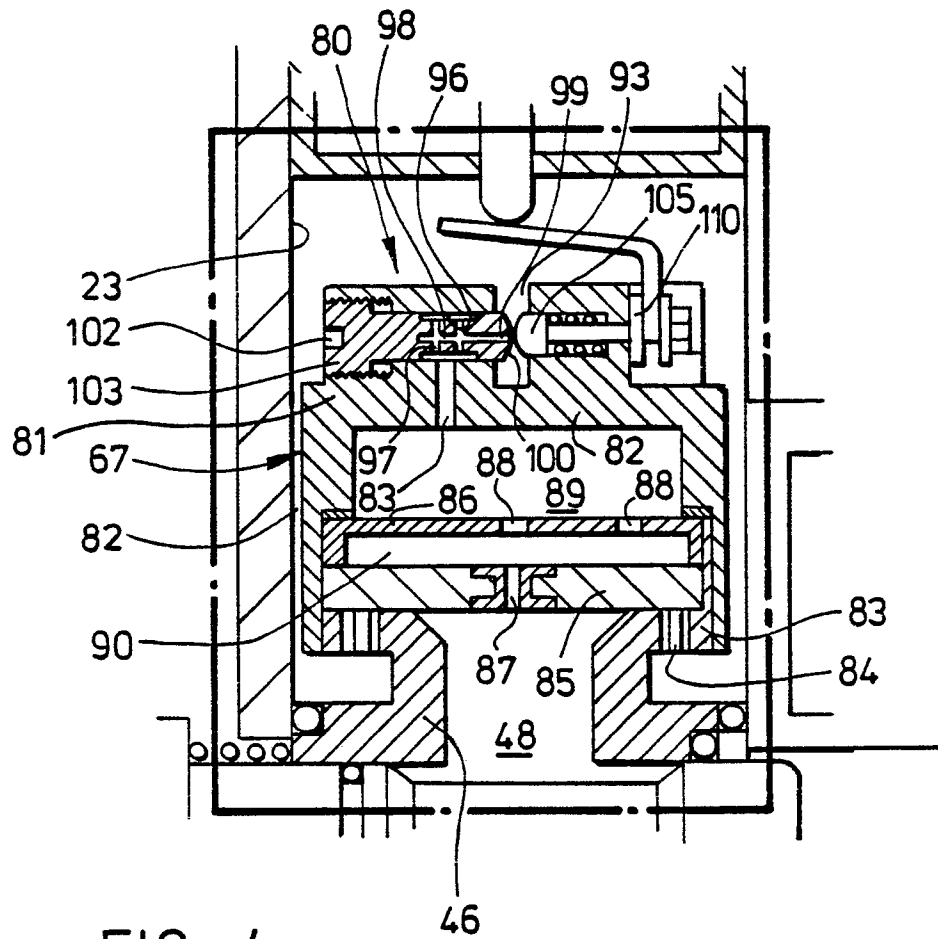


FIG 4



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	US-A-3 219 034 (KALENIK) * Whole document * ---	1	B 63 C 11/08 B 63 C 11/22
A	GB-A-2 084 881 (PEAKMAN) * ABSTRACT; figure * ---	1	
A	WO-A-8 706 557 (BUCKLE) * Abstract; figure * ---	1	
A	US-A-3 898 705 (SCHULER) * Abstract; figures * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			B 63 C A 62 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 28-02-1989	Examiner VISENTIN, M.
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