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(54) **Valve assembly and breathing apparatus incorporating this valve assembly.**

(57) A valve assembly especially for a breathing apparatus comprises a housing 14, an inlet for admitting gas into the housing from a source of gas at a superatmospheric pressure, a movable valve member 21 which is capable of closing the gas inlet and which, in operation, is acted upon, at least when ist is closed or nearly closed, by a force resulting from the pressure difference between the higher pressure gas upstream of the inlet and the lower pressure gas in the housing 14, the effect of which force is to tend to move the valve member 21 to open the gas inlet, and means 16 responsive to the difference between the pressure in the housing 14 and the ambient pressure, the pressure-responsive means 16 being so connected to the valve member 21 that, if the pressure in the housing 14 exceeds the ambient pressure, at least by a certain amount, the pressure-responsive means 16 exerts a force on the valve member 21 which tends to cause the valve member to move to close the inlet.

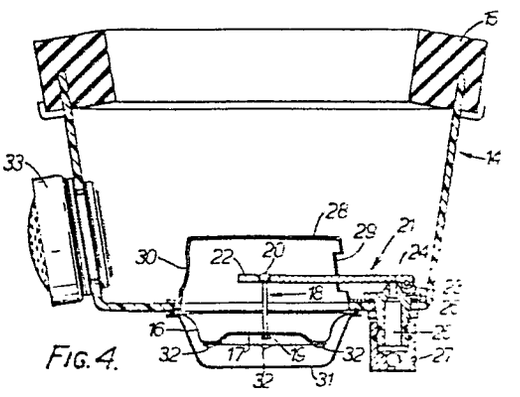

FIG. 4.

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TITLE MODIFIED
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Improvements in and relating to valves

The present invention relates to valve assemblies, and especially to demand valves for controlling the flow of pressurised respirable gas to breathing apparatus.

The present invention provides a valve assembly which comprises a housing, an inlet for admitting gas into the housing from a source of gas at a superatmospheric pressure, a movable valve member which is capable of closing the gas inlet and which, in operation, is acted upon, at least when it is closed or nearly closed, by a force resulting from the pressure difference between the higher pressure gas upstream of the inlet and the lower pressure gas in the housing, the effect of which force is to tend to move the valve member to open the gas inlet, and means responsive to the difference between the pressure in the housing and the ambient pressure, the pressure-responsive means being so connected to the valve member that, if the pressure in the housing exceeds the ambient pressure, at least by a certain amount, the pressure-responsive means exerts a force on the valve member which tends to cause the valve member to move to close the inlet.-

The valve assembly may form part of a breathing apparatus, that is to say, the valve assembly may be a so called "demand valve". It may be fixed directly to a face mask or it may be connected to a mouth piece, for example, in an aqualung.

The pressure-responsive means advantageously comprises a

diaphragm of which one face is exposed to the ambient pressure and of which the other face is exposed to the pressure in the housing. Preferably, the movable valve member is so connected to the pressure-responsive means that the pressure-responsive means acts only to tend to move the valve member to close the inlet. When the pressure-responsive means comprises a flexible diaphragm as referred to above, the valve member is preferably connected to the diaphragm by means of a rigid member which is fixed to, and extends from, the centre of the diaphragm in a direction substantially normal to the plane of the central part of the diaphragm and into the interior of the housing. It will be appreciated that, as a result of that arrangement, the diaphragm experiences a restoring couple if it tends to turn or rock rather than execute a purely translational movement.

Advantageously, the movable valve member comprises a lever which is so mounted as to be pivotable about an axis, of which one part is arranged to open and close the inlet and which is connected to the pressure-responsive means at a point spaced apart from the inlet along the length of the lever. The use of a pivotally mounted lever as the movable valve member has the advantage that, as is explained in greater detail hereinafter, it facilitates the achieving of the desired balance of forces. Preferably, the part of the movable valve member and the point at which the movable member is connected

to the pressure-responsive means are situated on the same side of the axis about which the lever is pivotable. That arrangement makes it possible to provide, for a given length of lever, a greater degree of leverage than can be provided if the part of the lever that is arranged to open and close the inlet and the point at which the lever is connected to the pressure-responsive means are situated on opposite sides of the axis of pivot.

When the valve assembly is to serve as a demand valve for breathing apparatus, the arrangement and dimensions of the valve assembly are preferably such that, in operation, the valve assembly maintains the gas in the housing at a super-atmospheric pressure. Such a "positive pressure" demand valve has a number of advantages over a demand valve in which the inlet to the housing is opened only when the gas in the housing is at a subatmospheric pressure. Thus, any leakage that occurs downstream of the gas inlet will be primarily a leakage of gas out of the breathing apparatus, rather than a leakage of, for example, noxious gas or water, into the apparatus which would be the case if the pressure downstream of the inlet ever fell below the ambient pressure.

Advantageously, there is provided means tending to impede the flow of gas within the housing from the inlet to the immediate vicinity of the pressure-responsive means. The provision of such impedance means has the advantage that the pressure-responsive means is subjected primarily to the static pressure within the housing and not to dynamic forces such as might result if a stream of gas entering the housing through the inlet were to impinge directly on the pressure-responsive means. Preferably, the impedance means comprises a cover member formed with an aperture through which the valve member extends and also with one or more apertures situated remote from the inlet, which apertures form the only means of communication for the flow of gas within the housing between the region of the housing that is immediately adjacent to the pressure-responsive means and regions of the housing remote from the pressure-responsive means.

Advantageously, there is provided external cover means arranged to protect the pressure-responsive means and the pressure-responsive means is exposed to ambient pressure only through one or more apertures in the external cover means, the aperture or apertures being so dimensioned as to tend to prevent unstable operation of the movable valve member. Satisfactory dimensions for the aperture or apertures can readily be ascertained by trial and error, the objective being to make them small enough to eliminate "flutter" of the

movable valve member, or to reduce such flutter to an acceptable level, while at the same time not making the dimensions of the aperture or apertures so small that the response of the valve to a change in the pressure within the housing is unduly retarded.

The invention also provides a breathing apparatus, which includes a face mask and a demand valve, wherein the demand valve is a valve assembly in accordance with the invention.

Advantageously, the housing of the valve assembly is formed by a part of the face mask.

The breathing apparatus may be provided with an ori-nasal mask and then, when the valve assembly is provided with impedance means comprising a cover member as referred to hereinbefore, the aperture or apertures in the cover member, other than the aperture through which the movable valve member extends, preferably communicate directly with the interior of the ori-nasal mask.

Two forms of valve assembly constructed in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a vertical cross-section taken through the first form of valve assembly with the valve in a first position;

Fig. 2 is a cross-section corresponding to that of Fig. 1, but with the valve in a second position;

Fig. 3 is a front view of a face mask incorporating the second form of valve assembly; and

Fig. 4 is a cross-section taken on the line IV-IV in Fig. 3.

Referring to Figs. 1 and 2 of the accompanying drawings, the first form of valve assembly, which is designed for use as a demand valve in breathing apparatus, comprises a housing which is indicated generally by the reference numeral 1, a diaphragm 2 located at one end of the housing, a tubular member 3 having, at its end remote from the housing, a bead 4 for attaching the demand valve directly to a breathing mask (not shown). A member 5, formed with a bore which terminates at one end in an inlet 6, is connected to a conduit (not shown) that can itself be connected to a source of pressurized respirable gas. As seen in Fig. 1, the inlet 6 is closed by a lever 7 that is attached to the inside of the housing 1 by a pivot 8. One end of the lever 7 is linked, by means of a pin 9 having a head 10, to a rigid plate 11 that is attached to the diaphragm 2. The pin 9 passes through a hole at one end of the lever 7, and the head 10 engages the side of the lever that is remote from the diaphragm 2.

One side of the diaphragm and plate assembly 2 and 11 faces the interior of the housing 1, while the other side of the assembly is open to ambient pressure by way of an aperture 12 in a protective cover 13. The housing 1, the diaphragm 2 and the cover 13 are all sealed around their outer edges by a clamping bead.

It will be noted that the pin 9 and head 10 act on the lever 7 at a distance a from the pivot 8 that is greater than the distance b between the inlet 6 and the pivot. It will also be noted that the effective area of the diaphragm 2 is much greater than the area of the inlet 6. Consequently, the lever 7 moves to open or close the inlet 6 in response to changes in the pressure within the housing 1 of the order of 1 inch water gauge (250 Pa) when the gas supply pressure is about 95 pounds per square inch gauge (650 kPa).

Fig. 1 shows the demand valve in a first position in which the lever 7 closes the gas inlet 6. The valve assumes the first position when the pressure in the housing 1 is greater than a predetermined value. In the first position, the moment applied to the lever 7 about the pivot 8 as a result of the force generated by the pressure difference across the diaphragm 2 (the first moment) is greater than the moment of the force applied to the lever as a result of the difference between the pressure in the conduit 5 and the pressure in the housing 1 (the second moment). If the pressure in the housing falls to a value below the predetermined value, for example, by inhalation by the wearer of the mask, the second moment becomes greater than the first moment and the valve assumes a second position, which is shown in Fig. 2, in which the gas inlet 6 is open. If the pressure in the housing 1 again rises to a value above the predetermined level, for example, as a

result of exhalation by the wearer of the mask, the valve returns to the first position.

Referring to Figs. 3 and 4 of the accompanying drawings, the second form of valve assembly is also designed for use as a demand valve in breathing apparatus, and comprises a housing, which is indicated generally by the reference numeral 14 and which forms part of a face mask of a breathing apparatus.

The housing 14 is slightly tapered outwardly and is open at its larger, inner side where it is in air-tight engagement with the face seal 15 of the face mask. At its smaller, outer side, the housing 14 is formed with a central aperture which is closed by a flexible diaphragm 16. Fixed to the outer surface of the diaphragm 16 is a rigid circular plate 17 of dished form.

The diaphragm 16 and the plate 17 are formed with central apertures through which there passes one end portion, which is screw-threaded and of reduced diameter, of a pin which is indicated generally by the reference numeral 18. The diaphragm 16 and the plate 17 are clamped between the shoulder on the pin 18, formed where the screw-threaded end portion of the pin meets the main body of the pin, and a nut 19 on the screw-threaded portion of the pin.

The pin 18 terminates, at the end remote from the screw-threaded portion, in a ball 20, which is of larger diameter than the main body of the pin and which can seat in a recess formed towards the free end of a lever, which is indicated generally by the

reference numeral 21. The portion 22 of the lever between the recess in which the ball 20 can seat and the free end of the lever is bifurcated to form a slot extending longitudinally with respect to the lever and through which the pin 18 can be inserted during assembly.

The lever 21 is pivotally mounted at 23 adjacent to the end of the lever that is remote from its free end. Secured to one side of the lever 21 close to the point 23 is a resilient pad 24 which, when the lever is in the position shown in Fig. 4, serves to close an air inlet formed by the open end of a supply conduit 25, which is formed in a member 26 which is sealed in an aperture in the housing 14.

The supply conduit 25 communicates via the hollow interior of an air inlet swivel elbow member 26 to an air supply tube 27.

Between the air inlet and the immediate vicinity of the diaphragm 16 there is interposed impedance means in the form of a plastics cover member 28, which is formed on the side nearest the air inlet with a slit 29 which is just wide enough to allow the lever 21 to pass through it without actually touching the cover member 28 and is long enough to ensure that the lever is free to turn far enough about the pivot 23 to open and close the air inlet. On the side remote from the air inlet, the cover member 28 is formed with a relatively large aperture 30 through which air can flow freely between the region bounded by the diaphragm 16 and the cover member 28, and the remainder of the interior of the housing 14.

The diaphragm 16 is protected against external damage by a cover 31, which may be formed of stainless steel, which is sealed to the housing 14 and which is formed, in its underside, with three apertures 32. As is explained hereinbefore, the dimensions of the apertures 32 are chosen to reduce or eliminate any tendency the lever 21 may have to flutter while at the same time not unduly retarding the response of the diaphragm 16 to pressure changes within the interior of the housing 14. The location of the apertures 32 in the underside of the cover 31 reduces the risk that any one of them will become blocked by dirt and the provision of more than one such aperture renders the consequence of blockage of an aperture less serious. Further, the apertures 32 are so located that they cannot be closed by the diaphragm 16.

Finally, the housing 14 is provided in one of its side walls with a conventional exhalation valve 33.

The breathing apparatus operates in the following way. The air supply tube 27 is supplied with air at a pressure of, say, 95 pounds per square inch gauge (650 kPa) and it is desired to maintain the pressure within the interior of the housing 14 within, say, the range of from 0.5 inch to 2.5 inches water gauge (125 to 625 Pa).

It will be appreciated that, as in the case of the corresponding parts of the valve assembly described with reference to Figs. 1 and 2, the high pressure air at the air

inlet always exerts a force on the lever 21 that tends to open the inlet. When the lever 21 is in the position shown in Fig. 4, the inlet is closed by the resilient pad 24 on the lever and the pressure is a static pressure. When the lever 21 pivots clockwise as seen in Fig. 4 to open the inlet, the force exerted on the lever by the high pressure air flowing into the housing 14 is, at least in part, a kinetic reaction on the lever caused by the air impinging on it.

On the other hand, given that the air pressure within the housing 14 is always above ambient pressure, the pressure difference across the diaphragm 16 itself tends to move the diaphragm outwards with the result that the effect of the pressure difference is to tend to move the lever 21 to close the air inlet. The force exerted on the pin 18, which is clamped to the diaphragm 16, does not, however, result solely from the pressure difference, but includes a component arising from the tension in the skirt portion of the diaphragm, that is to say, the portion of the diaphragm that lies radially outwards of the plate 17. With the configuration of the skirt portion of the diaphragm 16 shown in Fig. 4, that tension will tend to exert an inwards force (upwards as seen in Fig. 4) on the pin 18. As in the case of the corresponding parts of the valve assembly described with reference to Figs. 1 and 2, however, the connection between the pin 18 and the lever 21 is such that the pin never exerts a force on the lever which would tend to cause the lever to move to open the air inlet.

The desired balance of forces on the lever 21 is obtain despite the great disparity between the pressure of the air supplied to the air inlet and the pressure that obtains in the housing 14, partly because of the leverage afforded by the lever 21 and partly because the effective area of the diaphragm 16 is much larger than the area of the air inlet.

The maximum pressure reached within the housing 14 is determined by the setting of the exhalation valve 33, which should normally be such (in order to avoid the wastage of air or other respirable gas) that the air inlet and the exh tion valve are not open at the same time.

The construction of the valve assembly and the associa breathing apparatus can of course be varied in many respect without departing from the scope of the invention. In particular, the aperture 30 in the cover member 28 may be replaced by an aperture or apertures in the inner face (th upper face as seen in Fig. 4) leading directly to the inte of an ori-nasal mask, which, may itself be secured to, or integral with, the cover member 28.

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Claims:

1. A valve assembly which comprises a housing, an inlet for admitting gas into the housing from a source of gas at a superatmospheric pressure, a movable valve member which is capable of closing the gas inlet and which, in operation, is acted upon, at least when it is closed or nearly closed, by a force resulting from the pressure difference between the higher pressure gas upstream of the inlet and the lower pressure gas in the housing, the effect of which force is to tend to move the valve member to open the gas inlet, and means responsive to the difference between the pressure in the housing and the ambient pressure, the pressure-responsive means being so connected to the valve member that, if the pressure in the housing exceeds the ambient pressure, at least by a certain amount, the pressure-responsive means exerts a force on the valve member which tends to cause the valve member to move to close the inlet.

2. A valve assembly as claimed in claim 1, wherein the pressure-responsive means comprises a flexible diaphragm of which one face is exposed to the ambient pressure and of which the other face is exposed to the pressure in the housing.

3. A valve assembly as claimed in claim 1 or claim 2, wherein the movable valve member is so connected to the pressure-responsive means that the pressure-responsive means acts only to tend to move the valve member to close the inlet.

4. A valve assembly as claimed in claim 3 when dependent on claim 2, wherein the valve member is connected to the diaphragm by means of a rigid member which is fixed to, and extends from, the centre of the diaphragm in a direction substantially normal to the plane of the central part of the diaphragm and into the interior of the housing.

5. A valve assembly as claimed in any one of claims 1 to 4, wherein the movable valve member comprises a lever which is so mounted as to be pivotable about an axis, of which one part is arranged to open and close the inlet and which is connected to the pressure-responsive means at a point spaced apart from the inlet along the length of the lever.

6. A valve assembly as claimed in claim 5, wherein the part of the movable valve member and the point at which the movable member is connected to the pressure-responsive means are situated on the same side of the axis about which the lever is pivotable.

7. A valve assembly as claimed in any one of claims 1 to 6, wherein the arrangement and dimensions are such that, in operation, the valve assembly maintains the gas in the housing at a superatmospheric pressure.

8. A valve assembly as claimed in any one of claims 1 to 7, when dependent on claim 2, wherein there is provided means tending to impede the flow of gas within the housing

from the inlet to the immediate vicinity of the pressure-responsive means.

9. A valve assembly as claimed in claim 8, wherein the impedance means comprises a cover member formed with an aperture through which the valve member extends and also with one or more apertures situated remote from the inlet, which apertures form the only means of communication for the flow of gas within the housing between the region of the housing that is immediately adjacent to the pressure-responsive means and regions of the housing remote from the pressure-responsive means.

10. A valve assembly as claimed in any one of claims 1 to 9, wherein there is provided external cover means arranged to protect the pressure-responsive means and the pressure-responsive means is exposed to ambient pressure only through one or more apertures in the external cover means, the aperture or apertures being so dimensioned as to tend to prevent unstable operation of the movable valve member.

11. A valve assembly as claimed in claim 1 and substantially as hereinbefore described with reference to, and as shown in, Figs. 1 and 2 of the accompanying drawings.

12. A valve assembly as claimed in claim 1 and substantially as hereinbefore described with reference to, and as shown in, Figs. 3 and 4 of the accompanying drawings.

13. A breathing apparatus, which includes a face mask and a demand valve, wherein the demand valve is a valve assembly as claimed in any one of claims 1 to 12.

14. A breathing apparatus as claimed in claim 13, wherein the valve assembly is as claimed in any one of claims 1 to 10 and 12 and the housing of the valve assembly is formed by a part of the face mask.

15. A breathing apparatus as claimed in claim 13, which is provided with an ori-nasal mask and wherein the valve assembly is provided with impedance means as claimed in claim 9 and the aperture or apertures in the cover member, other than the aperture through which the movable valve member extends, communicate directly with the interior of the ori-nasal mask.

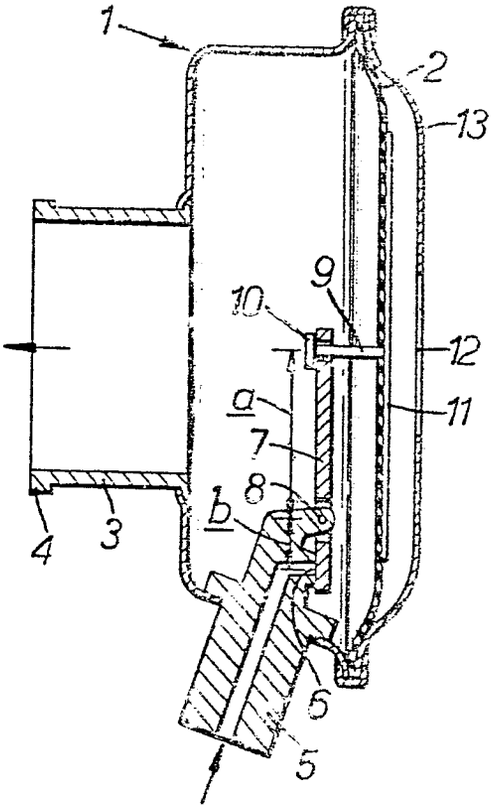

FIG.1.

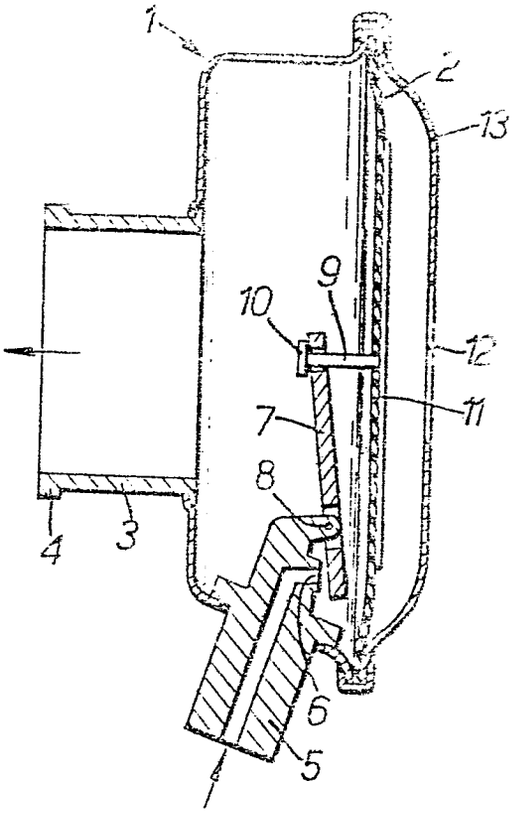

FIG.2.

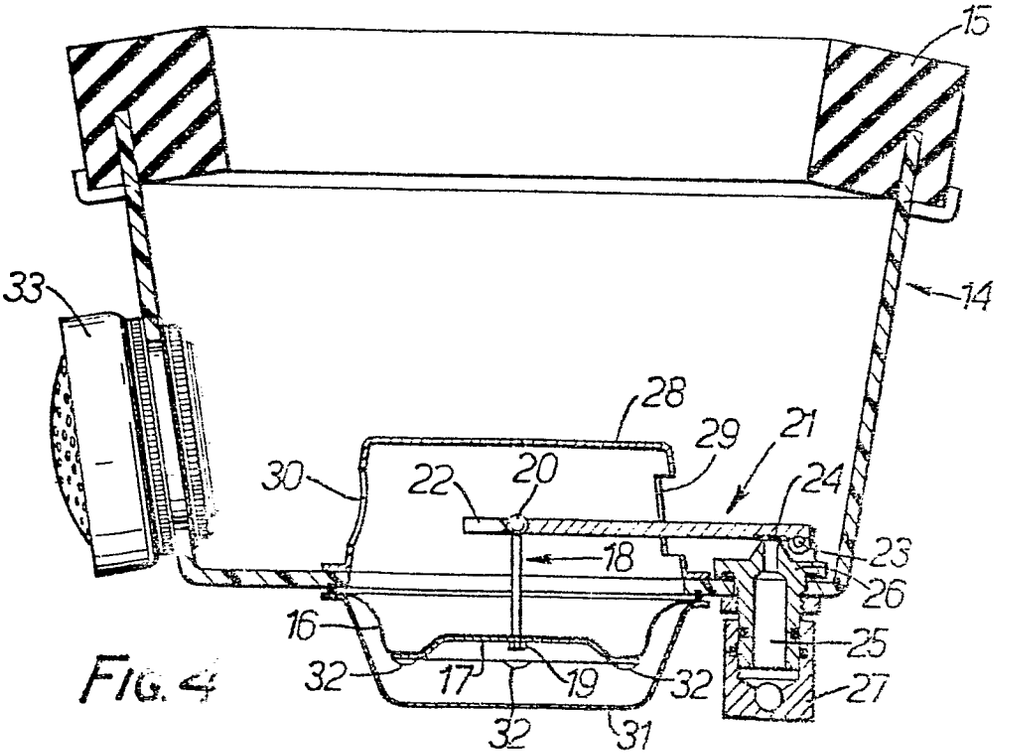

FIG. 4

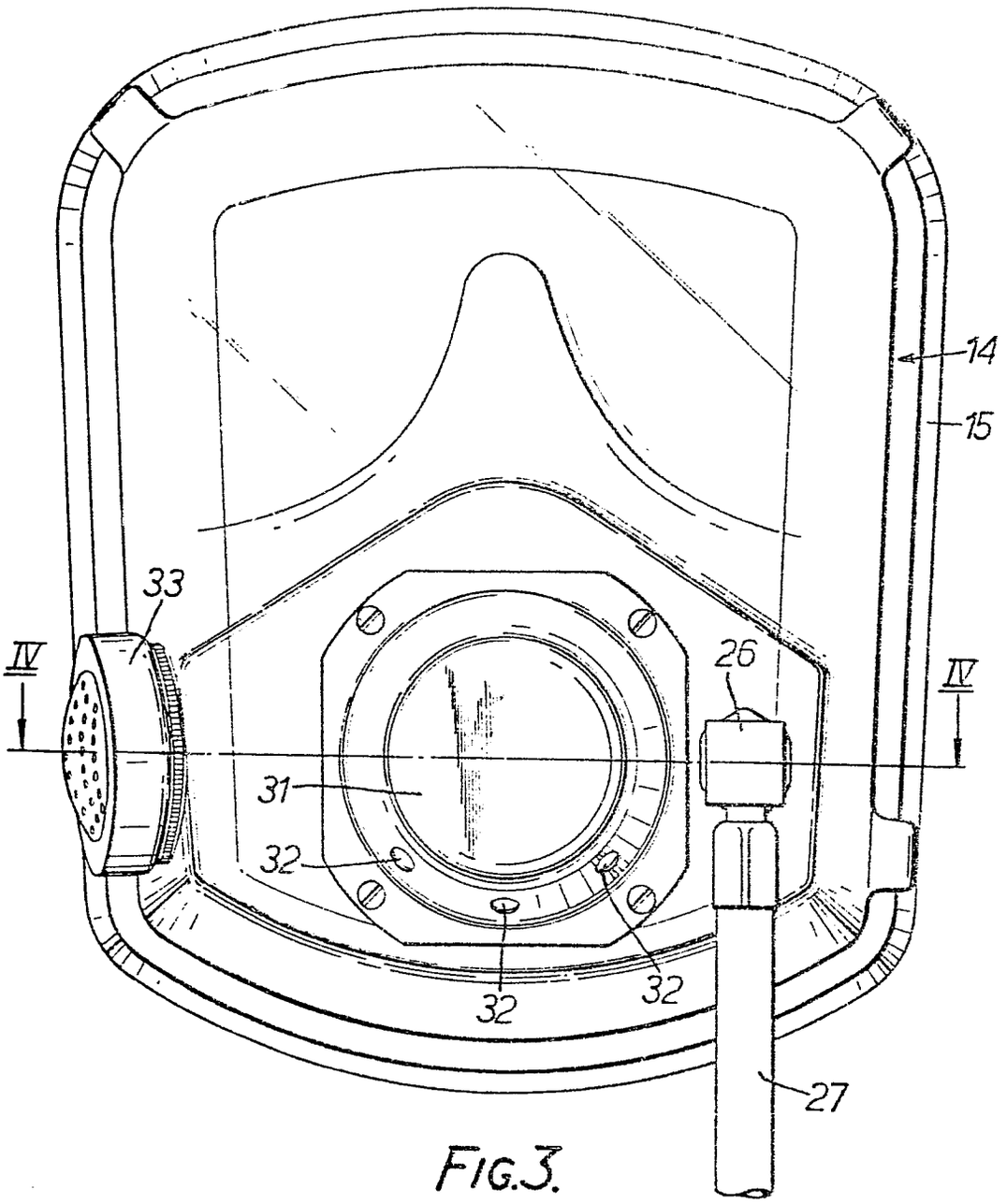

FIG.3.

European Patent Office

EUROPEAN SEARCH REPORT

0014290
Application number
EP 79302867.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	GB - A - 1 050 715 (BRISKIN) + Page 1, line 90 + --	1-3, 11-15
	GB - A - 764 111 (S.A. GASACCHUMULATOR) + Page 3, lines 12-17,70 + --	1-3, 11-15,7
	GB - A - 757 652 (SCOTT A.C.) + Fig. 6,13; page 4, lines 70-80; page 5, lines 74-84 + --	1-3,7, 11-15
A	US - A - 2 303 155 (BERGE) + Page 2, right column, lines 1-8 + --	1-3
	GB - A - 1 457 284 (CALOR E.L.) + Fig. 1 + --	4,5,8
	GB - A - 775 611 (R.E. PAGE) + Fig. 9 + --	4,5,8
	FR - E - 70 219 (REBIKOFF u.a.) + Fig. 3 + --	6
	US - A - 3 433 222 (BIOENGIONICS INC.) + Fig. 3 + ----	9,10

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

B 63 C 11/14
F 16 K 31/126
G 05 D 16/06

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

B 63 C 11/00
F 16 K 31/00
G 05 D 16/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

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

Place of search	Date of completion of the search	Examiner
VIENNA	20-02-1980	WASSERMANN

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