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[54] **OPEN CIRCUIT BREATHING APPARATUS**

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[51] **Int. Cl.** **A62b 7/04,** A61m 16/00, F16k 7/00

[58] **Field of Search** ..... 137/63 R, 102, 505.25, 137/505.28; 128/142.2, 145.5, 145.6, 145.8, 146.4, 146.5

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Attorney, Agent, or Firm—A. Yates Dowell, Jr.

[57] **ABSTRACT**

An open circuit breathing apparatus having demand and exhaust valves and including structure for directing the flow of fresh air, oxygen, or other gases discharged by the demand valve in such a manner as to promote easier respiration while simultaneously increasing the effective sealing capacity of the exhaust valve.

4 Claims, 7 Drawing Figures

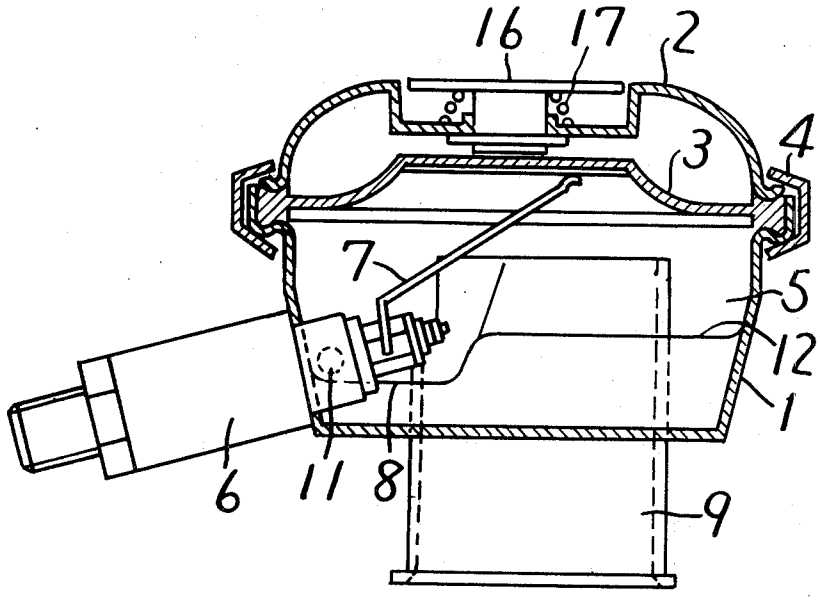


Fig. 2

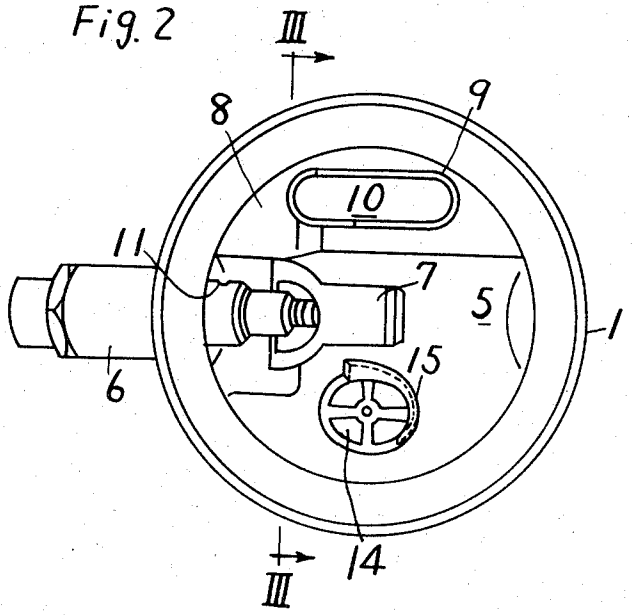


Fig. 1

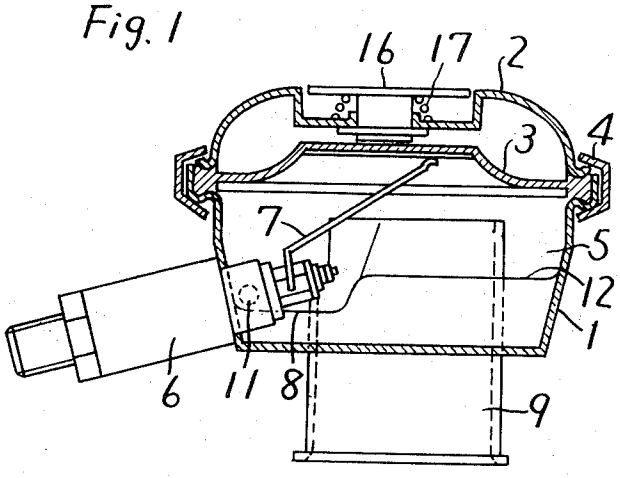


Fig. 3

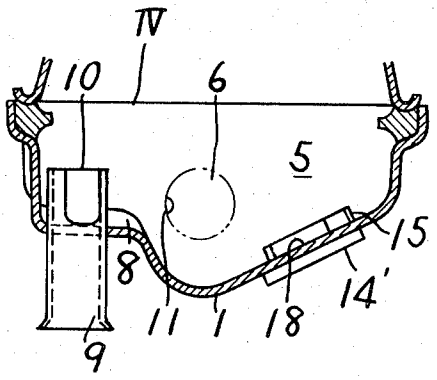


Fig. 5

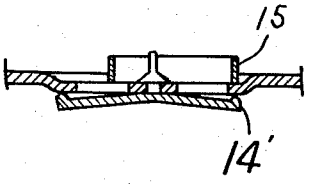


Fig. 4

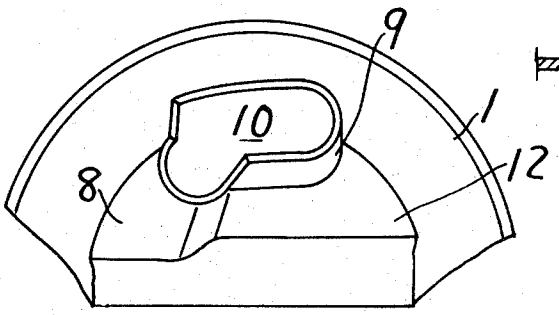


Fig. 6

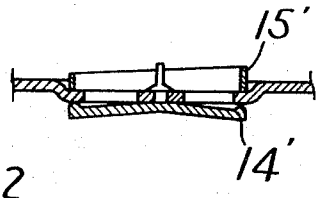
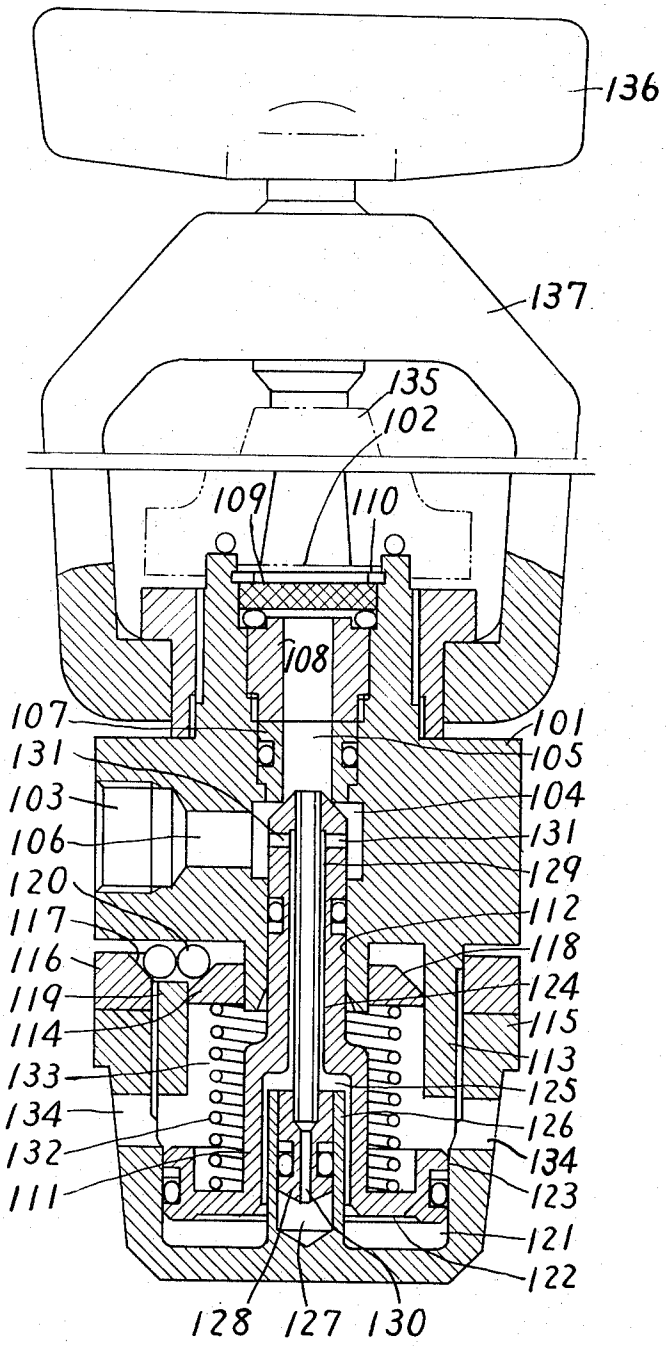


Fig. 7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OPEN CIRCUIT BREATHING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an open circuit breathing apparatus having a primary pressure reducing valve and a demand valve assembly. More particularly the invention relates to an open circuit breathing apparatus which is activated in response to the normal respiration of a person using the apparatus and includes a demand valve assembly having an air inlet for discharging air into a chamber in response to the negative pressure within the chamber created during inhalation, a breathing tube extended from the chamber, and an exhaust valve assembly for discharging air out of the chamber according to the positive pressure created during exhalation.

2. Description of the Prior Art

Open circuit breathing apparatus are commonly used to provide a regulated oxygen supply to persons under water and in thin, poisonous or other noxious atmospheres. Such apparatus supply air which is regulated to approximately standard atmospheric or other desired pressure by means of a primary pressure-reducing valve.

Many demand valve apparatus incorporate a flexible diaphragm to actuate the demand or air intake valve. The flexible diaphragm is connected to a valve actuating member and forces the actuating member to open the demand valve in response to the decreased pressure within the valve chamber caused as a person using the apparatus inhales and thereby allows fresh air or oxygen to flow into the valve chamber and be inhaled to the use's respiration system. When the pressure in the valve chamber is increased as the user stops inhaling and begins exhaling, the flexible diaphragm returns to its balanced or closed position. As the pressure in the valve chamber increased above the pressure surrounding the apparatus, an exhaust valve assembly is opened permitting the air exhaled by the user to be discharged from the valve chamber to the environment.

It is of primary importance that the demand valve apparatus permit easy breathing, that is, that fresh air or oxygen flow out through the demand valve into the valve chamber and be inhaled by the user with ease. Generally speaking, with the demand valve apparatus, a higher pressure is established within the valve chamber as the air enters from the demand valve, or air inlet valve, in response to the lower pressure within the valve chamber caused by inhalation. Subsequently, as a result of the movement of the flexible diaphragm toward a closed position by the increased pressure in the valve chamber, the demand valve is urged to a closed position and thereby a greater resistance to respiration is created. These defects are apt to become greater as the respiration volume per unit time is increased.

One example of various apparatus which have been designed to alter these shortcomings in the demand valve apparatus of the prior art is characterized by having a baffle board installed within the valve chamber of the demand valve apparatus and thereby directs as much air as possible from the outlet of the demand valve to an opening in the breathing tube. However, there remain several problems associated with a demand valve apparatus of this type, including the high cost owing to the increased time for assembly of the baffle board and also the air flow fluctuation caused by the baffle board unless it is suitably mounted.

Further, with demand valve apparatus of the prior art, more consideration has been given to directing the air stream created by inhalation than that created during exhalation. Generally speaking, an air discharging outlet is provided on a side of the valve chamber and includes an exhaust valve disposed on the outer surface of the valve chamber which operates to form an effective seal with a valve seat associated therewith when the pressure of the valve chamber is less than that of the surrounding environment. When this difference in pressure is negligible, which often occurs between inhalation and exhalation, an exhaust valve lip is provided to press against the valve seat. However, when this valve is aged or when fine particles or other obstacles are deposited between the lip and the valve seat, the sealing effect is decreased making possible the danger that water or poisonous or other noxious gases may flow into the valve chamber. If a hardener or less resilient material is used for the lip to overcome these defects, the resistance to exhaled air increases and thereby creates yet another problem.

Further, with the structures of pressure reducing valves of the prior art which are used to supply air from an oxygen tank or similar container to a demand valve apparatus, the pressure of the supplied air has a tendency to vary as the pressure of the air source or tank is decreased. With some pressure reducing valves, the pressure of air supplied to a person using the open circuit breathing apparatus is caused to be lowered, and with others, is caused to be raised.

OBJECTS OF THE INVENTION

1. It is an object of this invention to provide an improved open circuit breathing apparatus which creates less resistance to inhalation, is simply constructed, and can be assembled easily.

2. It is an object of this invention to provide an improved open circuit breathing apparatus which creates less variation in the resistance to inhalation even during changes in the breathing volume.

3. It is an object of this invention to provide an improved open circuit breathing apparatus which has an exhaust valve assembly having less resistance to exhalation and offering an effectively tight seal.

4. It is another object of this invention to provide an open circuit breathing apparatus comprising an improved primary pressure reducing valve which enables air pressure to be maintained constant regardless of the pressure variation within the air supply tank.

5. It is another objectof this invention to provide an open circuit breathing apparatus comprising an improved pressure reducing valve which enables one to adjust the air pressure with ease.

SUMMARY OF THE INVENTION

The above mentioned objects of this invention are attained by the provisions and considerations as follows:

With the present invention, the low resistance to inhalation is attained by providing a channel in the valve chamber of the demand valve apparatus which is disposed between the outlet of the demand valve and an opening to a breathing hose. In this case, a portion of the fresh air entering the valve chamber from the discharging outlet of the demand valve is directed to the

opening of the breathing hose through the channel, while the remaining fresh air bypasses the opening of the breathing tube and is whirled along the wall of the valve chamber and directed back to the opening after passing through the under part of the demand valve and the channel. The two fresh air streams as mentioned above create an ejective effect by which the air existing in the upper part of the valve chamber or near the flexible diaphragm is partially sucked or evacuated therefrom, thereby enabling the resistance to inhalation to be maintained at a low level even if the breathing volume is increased. At the same time, the demand valve apparatus can be constructed cheaply because it is not a necessity that it be formed of a specific material nor does it require any extra time to assemble.

Furthermore, a receiving wall is installed in the valve chamber to guide the air blowing out from the discharging outlet of the demand valve block into the opening of the breathing hose and is also effective in decreasing the resistance to inhalation. The receiving wall can easily be provided by extending a portion of the breathing tube into the valve chamber. The function of the receiving wall is to guide not only a portion of the air entering the valve chamber from the demand valve to the opening of the breathing hose, but also to guide the remaining air introduced during inhalation around the valve chamber without any complicated turbulent flow. Therefore, with this invention, the shape of the receiving wall surface and the inside surface of the case or valve chamber are such that the remaining portion of the air flow is caused to whirl around the valve chamber helping to create a negative pressure adjacent the flexible diaphragm while being guided smoothly to the opening.

With the exhaust valve of this invention, a portion of the air blowing out of being whirled around the valve chamber from the discharging outlet helps to create a negative or lower pressure adjacent a wall-like portion of the exhaust valve. This decreased pressure is created along the inner surface of the exhaust valve thereby creating a pressure that is lower than the pressure against the outer surface thereof. As the result of this, a valve lip of the exhaust valve is pressed against an associated valve seat, thereby preventing fluid from entering the valve chamber.

With the primary pressure reducing valve of this invention, the valve body is provided with a cap by which the pressure of the reduced air flow can easily be adjusted to maintain a balanced pressure controlled only by the response to the change of the air pressure of the reduced air flow through the valve. In greater detail, a mechanism is provided to adjust the stiffness of a pressure reducing ratio setting spring associated with the cap and thereby change the pressure setting point to reduce air flow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of the demand valve apparatus of this invention.

FIG. 2 is a top view of the demand valve apparatus of this invention with the lid and the flexible diaphragm removed.

FIG. 3 is a cross-sectional view taken along line III — III of FIG. 2.

FIG. 4 is a partial view looking from point IV of FIG. 3.

FIG. 5 is a longitudinal cross-sectional view of an embodiment of the exhaust valve assembly of this invention.

FIG. 6 is a view similar to FIG. 5 showing another embodiment of the exhaust valve assembly of this invention.

FIG. 7 is a longitudinal cross-sectional view of an embodiment of the primary pressure reducing valve used for the demand valve apparatus of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With detailed reference to FIGS. **1**, **2**, **3** and **4**, the demand valve apparatus includes a cylinder-like case **1** and lid **2**. A flexible diaphragm **3** is located between case **1** and lid **2**, and includes a brim or enlarged peripheral portion which is secured or clamped between the case **1** and the lid **2**. The case **1** and lid **2** are connected by a clamp, clip ring or other such device **4**, as shown in FIG. **1**.

A sealed valve chamber **5** is formed between the case **1** and the flexible diaphragm **3**. A conventional demand valve apparatus **6** is provided having its inner end extending through the side wall of the case **1** adjacent the lower portion thereof and the outer end connected to a source of compressed air or other fluid (not shown). A valve actuating lever **7** is connected at one end to the inner end of the demand valve apparatus **6**. The other or free end of the valve actuating lever **7** is normally disposed adjacent to, or in contact with, the flexible diaphragm **3**. The bottom surface of the case **1** is stepped and includes an intermediate portion or channel **8** and a raised portion **12**. A breathing tube **9** is inserted through and fixed to the raised portion **12** adjacent to the intermediate portion **8**. The breathing tube **9** projects outwardly from the case **1** and is used to guide air to a face mask or directly to the mouth of a person using the apparatus.

A discharge outlet **11** of demand valve assembly **6** directs compressed air along the intermediate portion **8** toward an opening **10** in one end of the breathing tube **9** when the lever **7** is operated. The remaining portion of the breathing tube **9**, which is remote from demand valve assembly **6**, extends into the valve chamber **5** above the raised portion **12** of the case and forms a receiving wall which directs a portion of the air entering the valve chamber into the breathing tube **9** after the air has flowed through recess **8**. However, all of the air discharged from demand valve assembly **6** is not guided into breathing tube **9**. Rather, a portion of the air is guided or whirled past the breathing tube along the casing wall of the valve chamber and under the demand valve assembly **6**.

On another portion of the bottom surface, indicated at **18** and located generally opposite to opening **10**, an exhaust opening is provided which normally is closed by a conventional exhaust valve **14** having a lip **14'**. A wall-like member **15** is disposed around all or a portion of the opening for the valve **14**. The height of the wall-like member **15** is such that the air stream flowing along the wall of case **1** creates a negative or decreased pressure along the reverse or inner side of the wall-like member **15** and therefore the decreased pressure is created adjacent to the exhaust valve **14**. With an underwater breathing apparatus, the wall-like member **15** is of substantially constant height and is disposed along a portion of the exhaust valve opening, as shown in FIG.

5, so that water which has seeped into the apparatus by some reason may be discharged with ease. However, when used on land, an exhaust valve wall 15' may be provided, as shown in FIG. 6, which extends entirely around the exhaust valve opening and is tapered from one side to the other.

The form and size of channel 8 is such that the air or other fluid entering from the discharge outlet 11 of the demand valve assembly 6 into the apparatus, is guided to the opening 10 directly. However, the shape of the bottom and side walls of the case 1 is designed so that a portion of the air entering the apparatus in response to the demand or decreased pressure as the user inhales, flows along and around the valve chamber. Furthermore, the shape of channel 8 and the raised bottom portion 12 are designed so that they may be formed simultaneously by press work or the like.

When the device is to be used on land, an opening (not shown) may be provided in the lid 2 to allow the surrounding or environmental air pressure to act directly on the flexible diaphragm 3. An actuating button 16 also is provided so that the flexible diaphragm may be manipulated manually. The actuating button 16 is mounted in such a manner that it normally is urged away from the flexible diaphragm by means of a spring 17. If the actuating button 16 is pushed against the tension of the spring, the flexible diaphragm 3 is urged downwardly into the valve chamber causing the demand valve assembly 6 to be opened by the lever 7 regardless of the pressure within the valve chamber 5.

As a person using the apparatus inhales, the pressure within the valve chamber 5 is lower than that of the environmental or surrounding pressure and thus the force of pressure is directed inwardly and urges the flexible diaphragm 3 into the valve chamber thereby forcing lever 7 to open the demand valve assembly 6 allowing fresh air or other gas to enter the chamber 5 from discharging outlet 11. Most of the fresh air is guided through channel 8 toward opening 10 of the breathing tube 9, however, a portion of the fresh air is directed along and around the inner periphery of the valve chamber 5 causing the upper part of the valve chamber to be under reduced pressure and, as a result, resistance to inhalation is very slight.

When a person using the apparatus begins to inhale, the air in the chamber 5 is withdrawn through the breathing tube 9 to create a reduced pressure in the chamber which causes the diaphragm 3 to collapse which in turn causes the lever 7 to open the demand valve assembly 6 and introduce additional air into the chamber 5. Most of the air being discharged through the demand valve discharge outlet 11 passes directly into the breathing tube 9; however, a portion of such air passes the breathing tube, impinges on the wall 15 and flows over the top of such wall. The flow of air across the wall 15 creates a venturi effect in the area behind the wall and thereby reduces the pressure adjacent to the exhaust valve 14. At this time the pressure acting on the exhaust valve within the valve chamber is less than the pressure within the main portion of the valve chamber and therefore the surrounding environmental air or water pressure maintains the exhaust valve lip 14' seated agains the casing 1. When the inhalation of air from the valve chamber 5 is substantially completed, air from the demand valve assembly 6 fills the chamber 5 and causes the diaphragm 3 to return its normal expanded condition and the lever 7 closes the demand valve assembly 6.

When the pressure within the valve chamber increases during exhalation above that of the environmental or surrounding pressure, the valve lip 14' on valve 14 is forced open allowing air within the valve chamber to be discharged. When the pressure within and surrounding the valve chamber are substantially the same or equal, as normally occurs with decreased exhalation, the exhaust valve is caused to be closed, and an inhalation is initiated the exhaust valve is firmly seated and thereby establishes an effective seal between the valve chamber and the surrounding environment.

With detailed reference to FIG. 7, the primary pressure reducing valve 101 of this invention is shown therein to include an inlet 102 and an outlet 103. The inlet 102 and outlet 103 are interconnected by air inlet and outlet passages 105 and 106, respectively, and a valve chamber 104. Within the passage 105, a ring-like valve seat 107, constructed of flexible material such as teflon, is fixed by ring-like valve seat holder or retainer 108. A snap-ring 110 is used to fix an O-ring and filter 109 to valve seat holder 108. One end of a valve body 111 is slidably disposed through a guide bore or hole 112 into valve chamber 104 which communicates with air passages 105 and 106. Further, the primary pressure reducing valve 101 is provided with ring-like foot or flange member 113 which extends parallel to the guide hole 112.

An inner ring 114 is slidably disposed along the inner surface of the flange 113. The outer girth or portion of flange 113 is threadedly received within a cap 115. An outer ring 116 is also provided along the outer girth of flange 113 between the valve body 101 and cap 115. Although the outer ring 116 and cap 115 are shown as being separate members, it is possible that they may be constructed in a single body.

The outer ring 116 and the inner ring 114 are provide with beveled portions 117 and 118, respectively. Each of the beveled portions 117 and 118 form a portion of a bearing seat which is interconnected or completed through a plurality of holes 119 disposed through the flange 113 and thereby form a plurality of bearing seats. Two ball elements 120 are carried by each of the bearing seats.

A ring shaped recess or opening 121 is provided in the head portion of cap 115 and receives a piston member 122 of the valve body 111. When the piston member is so disposed, the outer surface 123 of piston member 122 is in slidable engagement with the inside surface of the cap head. A hole or bore 124 is provided in the center of the valve body 111, the diameter of which is enlarged near the piston member 122 thereby forming a recess 125. An upstanding or flanged center portion 126 of the head portion of the cap is inserted into the recess in such a manner that a gap is formed between the recess 125 and the flanged portion 126 and thereby serves as an air passage. An inner piston 128 is slidably mounted within a chamber 127 of the flanged portion 126. A small tube 129 is connected to the top of inner piston 128 and is coextensive with a bore 130 through the inner piston 128. The small tube 129 extends through bore 124 of valve body 111 and is fixed to the upper end thereof. The gap formed between bore 124 and small tube 129 also serves as an air passageway which cooperates with the outer valve

chamber **104** of the valve body **111** by way of a bore **131** formed through the upper end of valve body **111** and which extends generally perpendicular to the tube **129.**

A spring element **132** is supported within a chamber **133** and is engageable with the piston **122** and inner ring **114.** A bore **134** in cap **115** is provided to allow air to enter the chamber **133.**

When the reducing valve is in use, the outlet valve of the air tank or container (not shown) is retained in cooperative alignment with air inlet passage **102** by a handle mechanism **136** which is mounted on the valve body **101** by a connecting frame **137.** The outlet **103** of the valve body **101** is connected to the demand valve block of the demand valve apparatus through a hose (not shown). When the reducing valve is not in use, an inlet cap or cover **135,** indicated by the dotted line in FIG. **7,** is retained by the handle **136.**

Under normal operating conditions, the piston **122** of the valve body **111** is forced downwardly by the spring **132** opening the valve head of the valve body **111** from the valve seat **107.** When this valve is opened, gas such as oxygen or air supplied from a tank or suitable container is allowed to flow into the demand valve apparatus after passing through inlet **102,** filter **109,** inlet passageway **105,** valve chamber **104,** outlet passageway **106,** and outlet **103.** At the same time, a portion of the gas flows through the bores **131** and **124** into the gap **125** formed between the piston **122** and the cap **115** and thereby acts as a thrusting force urging the piston **122** against the spring **132.** A further portion of the gas flows through the small tube **129** and bore **130** through the inner piston **128** into the chamber **127** of the flanged portion **126** and inner piston **128** and urges the inner piston **128** upwardly.

Therefore, the forces acting on the valve body **111** are directed both upwardly and downwardly. The upwardly directed force is created by the pressure of the gas acting on piston **122** and the inner piston **128.** The downwardly directed force is created by the pressure of the gas acting on the valve head in combination with the spring force. When the upwardly directed force is greater, the valve body **111** is urged upwardly and the valve body **111** is seated against the valve seat **107** thereby prohibiting the flow of gas into the valve chamber **104.** When the valve head is thusly seated, the pressure of outlet **103** acts through bore **129** and gap **125** to urge the piston **122** upwardly as the spring **132** acts on the piston **122** downwardly. As the area of inner piston **128** acted upon by the pressure through bore **130** and tube **129** is substantially the same as that of the area of the valve head acted upon by pressure within bore **105,** the forces directed against these members will be substantially balanced.

From the above description, valve body **111** is constructed so that it will move in pursuit of a balanced condition between the force of the spring and the force of the gas pressure within outlet **103** which acts on piston **122.** As the area of the piston, on which air acts, is constant, the force of spring **132** can be chosen according to the pressure desired within outlet **103.** When the pressure within outlet **103** decreases, the spring force causes the valve body **111** to be urged downwardly, and as a result, air from an air tank or container enters the pressure reducing valve. When the pressure of outlet **103** increases, the valve body is urged upwardly causing the valve head to engage the valve seat.

Thus, valve body **111** is moved accordingly to the pressure within outlet **103.** In order to establish a proper air pressure within the pressure reducing valve, the cap **115** is adjustable. If higher air pressure at the outlet **103** is desired, cap **115** is screwed-in, forcing a ball **120** inwardly by the action of the leveled portions **117** thereby causing the inner ring **114** to be urged downwardly compressing the spring. Consequently, the pressure within outlet **103** is increased. When cap **115** is unscrewed, the pressure within the outlet **103** is decreased.

Therefore, the primary reducing valve of this invention can be easily adjusted for proper air pressure regardless of the pressure within the air tank or container.

We claim:

1. An open circuit breathing apparatus comprising a case, demand valve assembly means mounted on said case and including a demand valve outlet means disposed in said case, demand valve control means within said case responsive to decreases in pressure within said case to open said demand valve outlet means and responsive to increases in pressure within said case to close said demand valve outlet means, a breathing tube mounted on said case and having an opening disposed generally toward said demand valve outlet means, channel means extending from adjacent said demand valve outlet means toward said opening to said breathing tube whereby a first substantial portion of a stream of gas entering said case from said demand valve outlet means flows directly into said opening to said breathing tube and a second portion of the gas bypasses said opening to said breathing tube and flows around the inside of said case, exhaust valve means disposed through said case, a rim of limited height extending into said case and disposed along at least a portion of said exhaust valve means, said rim directing the flow of the second portion of the stream of gas which is flowing around the inside of said case over at least a portion of said exhaust valve means whereby the passage of gas directed by said rim over said portion of said exhaust valve causes a decrease in pressure adjacent said portion of said exhaust valve.

2. The invention according to claim **1** in which said demand valve control means includes a flexible diaphragm sealing said case and responsive to pressures both interior and exterior of said case, and actuating means extending from adjacent said flexible diaphragm to said demand valve outlet means.

3. The invention of claim **1** in which said rim of limited height is disposed around said exhaust valve and includes a first portion adjacent one side of said exhaust valve and a second portion adjacent a second side of said exhaust valve, and said first portion of said exhaust valve is greater in height than said second portion.

4. An open circuit breathing apparatus comprising a case having inner and outer surfaces, demand valve assembly means mounted on said case and including a demand valve outlet means disposed in said case, demand valve control means within said case, said demand valve control means including a diaphragm means responsive to pressures inside and outside of said case and actuating means extending from said diaphragm means to said demand valve outlet means, said demand valve control means being responsive to decreases in pressure within said case to open said demand valve

outlet means and responsive to increases in pressure within said case to close said demand valve outlet means, a breathing tube mounted on said case and having a portion thereof extending into said case, an opening in said portion of said breathing tube disposed generally toward said demand valve outlet means, channel means extendng from adjacent said demand valve outlet means toward said opening to said breathing tube whereby a first substantial portion of a stream of gas entering said case from said demand valve outlet means flows directly into said opening to said breathing tube and a second portion of the gas bypasses said opening to said breathing tube and flows around the inside of said case, exhaust valve means disposed through said case and having means for forming a seal along a portion of said outer surface of said case, a rim of limited height extending into said case and disposed adjacent at least a portion of said exhaust valve means, said rim directing the flow of the second portion of the stream of gas which is flowing around the inside of said case over at least a portion of said exhaust valve means whereby the passage of gas directed by said rim over said portion of said exhaust valve causes a decrease in pressure adjacent said portion of said exhaust valve.

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