BREATHING OXYGEN MASK INHALATION AND EXHALATION DIAPHRAGM VALVE UNIT

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The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to automatic pressure control valve assemblies for handling and control of gaseous and liquid media and more particularly to inhalation and exhalation valve assemblies for supplying oxygen to high altitude face or breathing masks and has for an object a valve structure which is simple in construction, more positively actuated than other existing valves, and is controlled by the differential pressures across diaphragm means therein between a positively supplied predetermined low oxygen pressure and the relative inhalation and exhalation breathing pressures supplied to the valve assembly structure from a high altitude oxygen face mask by an occupant or wearer thereof.

A further object of the invention is the provision of a pressure compensated valve structure including diaphragm means therein for supplying oxygen under predetermined low pressure to a high altitude face mask during the inhalation cycle and operating during the exhalation cycle to exhaust the exhalation air mixture from the mask through the valve structure to the exterior thereof under control of the diaphragm means therein.

A further object is the provision of an inhalation and exhalation valve structure or casing for high altitude gas masks comprising a casing having two spaced parallel diaphragms therein constituting diaphragm valve means dividing the interior of the casing into a central exhalation chamber and spaced outer pressure compensating and inhalation chambers in which the central chamber includes a diaphragm controlled outlet passage therein in communication with the exterior of the casing formed with a valve seat cooperating with a first one of the diaphragms to close the outlet passage, and an inhalation and exhalation port in communication with the central chamber, adapted to be connected to an inhalation and exhalation conduit from a high altitude oxygen mask, including a branch inhalation conduit therefore connected in communication with the second outer inhalation chamber having a valve seat therein adapted to be closed by the other or second one of the diaphragms, and provided with an oxygen inlet port in communication with both of the outer pressure compensating and inhalation chambers at opposite sides of the central exhalation chamber, which port is adapted to be connected to a predetermined pressure controlled low pressure oxygen supply means, whereby oxygen is supplied to the spaced outer chambers at a predetermined low pressure to pressurize the two diaphragms toward each other, in which the inhalation conduit and said exhaust passage to the exterior of the assembly are in communication with the central chamber.

A further object is the provision of an exterior pressure operated compensating means in the other casing which is open to the exterior and connected to the exhalation control diaphragm to compensate for differences in pressure on opposite sides of the exhalation control diaphragm between oxygen pressure and exterior ambient air pressures at different altitudes.

A further object is the provision of a simplified two-piece diaphragm therein dividing the interior of the casing into an exhalation chamber in communication with an inhalation and exhalation conduit for a high altitude oxygen face mask and the exhalation chamber includes an exhalation conduit opening outwardly from the casing having an exhalation port in the form of a diaphragm valve seat concentrically disposed to be opened and closed by the diaphragm and an oxygen inlet chamber at the opposite side of the diaphragm having an oxygen inlet port adapted to be connected to a low predetermined pressure oxygen supply, and including an oxygen delivery conduit in said inhalation chamber formed with a diaphragm valve seat adapted to be closed by said diaphragm which is located in spaced concentric relation to the exhalation conduit at the opposite side of the diaphragm, including a branch conduit therefrom communicating through the casing to the exhalation and inhalation conduit, in which displacement of the diaphragm by the incoming oxygen opens the oxygen delivery conduit to supply oxygen into the inhalation and exhalation conduit during the inhalation cycle, and exhalation pressure, during the exhalation cycle, in the inhalation and exhalation conduit and branch conduit displaces the diaphragm in the opposite direction to close the oxygen delivery conduit and open the exhalation conduit in the casing to the exterior thereof.

These and other objects of the invention will become more apparent from the following description and accompanying drawings in which like reference characters refer to like parts in the several figures.

**Drawings**

FIG. 1 is a transverse selection view through an inhalation and exhalation valve structure for high altitude oxygen face or gas masks, illustrating one form of the invention to show the position of the diaphragm valve structure during the oxygen inhalation cycle.

FIG. 2 is a similar sectional view showing the position of the diaphragm valve structure during the exhalation cycle, dotted lines showing the diaphragms in the positions occupied during the inhalation cycle.

FIG. 3 is a transverse sectional view of a second or modified form of inhalation and exhalation valve structure showing the position of the control diaphragm means during the oxygen inhalation cycle.

FIG. 4 is a view similar to FIG. 3, but illustrating the position of the control diaphragm valve during the exhalation cycle.

FIG. 5 is a top plan view of the valve assembly shown in FIGS. 3 and 4.

Referring to FIGS. 1 and 2 and the reference numeral 1 denotes the inhalation and exhalation valve assembly generally, which comprises a three piece or sectional housing, preferably of cylindrical configuration which may easily be made of light metal or molded plastic and comprises a central section 2 and outer or upper and lower sections 3 and 4, the edges of the sections being preferably flanged or indicated at 5 and 6 and secured together in any suitable or desirable manner such as by threaded fasteners (somewhat like that shown in FIG. 4), or by split clamping rings (not shown).

A first or exhalation diaphragm 7 is clamped between the flanges 5 while a second or inhalation diaphragm 8 is clamped between the flanges 6, dividing the casing 1 into a central or exhalation chamber 9 and spaced upward and lower, or outer chambers 10 and 11. The upper chamber 10 comprises a pressure equalizing or compensating chamber while the lower chamber 11, as indicated, constitutes an inhalation chamber. The diaphragms 7 and 8 constitute valve means and therefore should be reinforced to some extent across their central portions, and flexible adjacent their peripheries as indicated at 7a and 8a to permit substantially free deflection between their full and dotted line positions, as shown in FIGS. 1 and 2. However, a pressure compensating bellows 13
is connected at 14 to the center of the diaphragm 7 for controlling the deflection of this diaphragm 7 in a predetermined ratio to the pressure differential between the upper and central chambers 10 and 9. The bellows 13 is open to the exterior of the casing 1 as indicated at 13a. In other words the bellows 13 is open to ambient atmosphere.

The chambers 10 and 11 are in communication with each other and with a low predetermined pressure controlled oxygen supply means indicated in dotted lines by the reference numeral 15, being of any conventional type such as a high pressure oxygen supply tank 16, with a pressure regulator 16a for reducing the pressure supplied to the casing to a predetermined conventional low breathing pressure.

A suitable and preferably flexible, oxygen supply conduit 17 is connected to the bifurcated oxygen supply pipe at 18, having one branch 19 disposed in communication with the upper or pressure compensating chamber 10 while the other branch 20 is on communication with the lower or inhalation chamber 11, substantially as shown.

An exhalation or exhaust tube or conduit 21 extends inwardly from the wall of the exhalation chamber 9 having an upturned extremity 21a constituting a valve seat for the diaphragm valve member 7 when it is deflected downwardly into contact with this seat to close the conduit to the exterior (or ambient atmosphere) during the inhalation cycle, as seen in FIG. 1. The other end of the conduit 21 is open to the exterior, or atmosphere, at all times, indicated at 21b.

The inhalation chamber 11 is formed with an oxygen outlet or delivery conduit 22 extending inwardly from the wall thereof, having an upturned portion formed with an oxygen delivery valve seat 22a disposed in concentrically aligned relation to the seat 21a and disposed to be closed by the diaphragm valve 7 when the same is deflected downwardly or away from the other diaphragm 8, as shown in full lines in FIG. 2 (during the exhalation cycle).

An inhalation and exhalation pipe or conduit 23 is fixed to wall of the central chamber 9 with an exhalation portion 23a in communication through the wall with the exhalation chamber 9 while the opposite end 23b is connected by a flexible inhalation and exhalation conduit or hose 24 to a high altitude oxygen face mask or other breathing enclosure, as indicated diagrammatically at 25.

The inhalation and exhalation conduit or pipe 23 is formed with an inhalation branch portion 26 in communication at one end with the oxygen delivery conduit 22 and at its other end with the inhalation and exhalation pipe 23.

It will be observed that the effective diameters or areas of the seat 21a, and the bellows 13 are the same, also that the bellows 13 and the exhalation or exhaust conduit 21 are both open to the exterior, or atmosphere, whereby the effective (ambient atmospheric) pressure effective on both sides of the diaphragm 7 due to the positive connection 14 is substantially balanced, except possibly for the very light resiliency of the bellows 13 (leading to seat the diaphragm valve member 7 on the exhalation pipe 21).

As oxygen flows through the regulator 16a, conduit 17, and branches 19 and 20 into the respective chambers 10 and 11, as seen in FIG. 1, the diaphragm 7 is disposed downwardly on its seat 21a, maintaining the central chamber 9 closed while the low oxygen pressure entering the inhalation chamber 11 through the branch 20 raises or deflects the other diaphragm valve 8 upwardly off its seat 22a, as seen in FIG. 1, and oxygen flows into the mask 25 through the pipe 22, branch 26, and conduits 23 and 24. The diaphragms 7 and 8 are now in the positions shown in full lines in FIG. 1, and the low oxygen pressure also, finally, at the end of inhalation by the wearer builds up through the conduit portion 23a in the central chamber 9 to equalize the pressure in the chambers 10 and 11, relieving the deflection pressure in the chamber on the diaphragms 7 and 8.

Upon exhalation by the wearer the mask pressure in the central chamber 9 increases to cause the upper diaphragm 7 to raise off its seat 21a as seen in FIG. 2, and opens the exhaust conduit 21, allowing exhalation through the conduit 21 to the exterior of the casing 1, or to atmosphere.

It should be noted that the areas of the diaphragms 7 and 8 are very large compared to the areas of the seats 21a and 22a, also that the diaphragms are resilient in operation and constructed so that with zero differential pressure on the opposite surface areas of each diaphragm, the diaphragms rest against their seats 21a and 22a. Thus the valves are closed unless positively actuated. The inner or central chamber 9 is connected directly to the mask and its pressure varies between that of the inhaled and exhaled breath, which would be respectively less, then greater, etc. than the supplied oxygen mixture, and the differential pressures acting across the diaphragms actuate the valves in proper sequence. The actuating force is directly proportional to the areas of the diaphragms. The desired multiplied effect is thus determined.

During inhalation, the inner chamber is under reduced pressure and both valves (diaphragms 7 and 8) move inward, opening the inlet diaphragm valve 8 and closing the outlet diaphragm valve 7, while during exhalation the pressure in chamber 9 exceeds the pressure in the outer chambers 10 and 11 and both diaphragm valves 7 and 8 move outwardly, or away from each other, and the outlet to ambient atmosphere opens and the oxygen supply diaphragm valve 8 closes. The ambient compensating bellows 13 is provided to give the exact equivalent working area on both sides of the outlet diaphragm 7, since without it the working area above the diaphragm 7 would exceed that below the area of the outlet to ambient seat 21a.

The compensating bellows disk 13 is equivalent in operative area to the seat area 21a and is attached to the diaphragm 7 by the connector or stem 14 already mentioned. Thus the seat area is null and the actuating forces are dependent only on the differential pressures resulting from the exhalation breath and the supply oxygen mixture.

Referring to the modified form shown in FIGS. 3, 4 and 5, the reference numeral 30 denotes the oxygen breathing valve assembly generally, which comprises an upper or exhalation chamber 31 and a lower or inhalation chamber 32 composed of the individual parts 31a and 32a flanged at 31b and 32b respectively with a flexible diaphragm 33 sandwiched therebetween, dividing the casing 30 into the exhalation and inhalation chambers 31 and 32 just mentioned. The casing is secured together at the flanged portions 31b and 32b, seen in FIG. 4, by fastening means such as screws or bolts 33a.

An inhalation-exhalation conduit 34 is connected in communication with the upper or exhalation chamber 31, the exhalation-inhalation conduit 34 having a lateral oxygen inlet or intake conduit 35 which extends into the oxygen inhalation chamber 32, having a laterally bent concentric oxygen inlet and 35a forming a valve seat for closing engagement by the diaphragm 33 when it is deflected downwardly, as seen in FIG. 4.

Oxygen is supplied to the inhalation chamber 32 through an oxygen (mixture) supply tube or conduit 36 in the side of the chamber 32, oxygen or an oxygen mixture being supplied from a conventional oxygen supply 37 through a conventional pressure regulator 38 and/or mixing device for supplying oxygen into the inhalation chamber 32 at the usual conventional pressure or pressures.

An exhalation tube 39 extends concentrically into the exhalation chamber 31, having a diaphragm valve seat 39a adapted to be closed by the diaphragm 33 when the
same is deflected upwardly during the inhalation cycle as seen in FIG. 3. The diaphragm 33 is preferably stiff across its center with a flexure portion 33c adjacent its periphery to permit substantially free movement thereof between the inhalation cycle as shown in FIG. 3 and the exhalation cycle as seen in FIG. 4.

In the operation of this form of the device oxygen (or oxygen and air mixture) from regulator 38 enters the inhalation chamber 32 through the conduit 36 under slight pressure deflecting the diaphragm 33 upwardly to seat on the exhalation port valve seat 39a and close the exhalation port or tube 39. The oxygen enters through the inhalation conduit 35 and valve seat 35a into the inhalation-exhalation passage 34 and through the flexible conduit 40 (diagonmatically shown) into the conventional oxygen or gas mask 41.

Pressure during the inhalation cycle being greater in the inhalation chamber 32 than in the exhalation chamber 31 holds the diaphragm 33 raised to close the exhalation port 39a.

During the exhalation cycle the exhalation pressure from the mask 41 becomes greater than the predetermined controlled oxygen pressures, and the exhalation pressure from the mask 41 in the conduit 40 and in the inhalation and exhalation conduit 34 flips the diaphragm 33 down, as seen in FIG. 4, to close the inhalation seat 35a and tube 35, and open the exhalation seat 39a and port 39, allowing exhalation through the seat 39a and passage 39 to the exterior or to ambient atmosphere.

At the end of the exhalation, and inhalation begins, pressure in the chamber 31 is caused to drop below the predetermined oxygen delivery pressure in the chamber 32 and the diaphragm 33 is thus deflected upwardly as depicted in FIG. 3, closing the exhalation passage 39 and opening the inhalation branch passage 35 to the mask to connect the mask 41 to the oxygen supply chamber 32 again.

For purposes of exemplification, a particular embodiment of the invention has been shown and described to the best understanding thereof. However, it will be apparent that changes and modifications in the arrangement and construction of the parts thereof may be used without departing from the true spirit and scope of the invention as defined in the following claims.

Although this description pertains to oxygen breathing equipment it is intended to apply also to handling and control applications of other fluid media.

I claim:

1. A breathing oxygen gas mask inhalation and exhalation valve structure comprising a casing, flexible diaphragm valve means defining said casing into an inhalation chamber and an exhalation chamber, an inhalation and exhalation conduit disposed in open communication at one end with said exhalation chamber, adapted to be connected at its opposite end with the interior of an oxygen gas mask, an inhalation conduit connected at one end in communication with said inhalation and exhalation conduit and extending into said inhalation chamber having a diaphragm valve seat concentrically disposed to be closed by deflection of said diaphragm valve means toward said inhalation chamber and opened by deflection of said diaphragm valve means in the opposite direction toward said inhalation chamber, whereby said inhalation and exhalation conduit is in communication with both of said inhalation and exhalation chambers, an exhalation tube extending into said exhalation chamber having a central valve seat inlet at its inner end to be closed by deflection of said diaphragm valve means toward said inhalation chamber, disposed in open communication at its other end with ambient exterior of said casing, an oxygen supply conduit adapted to be connected at one end to a predetermined low pressure oxygen supply means connected at its opposite end with the inhalation valve at one side of the diaphragm valve means for supplying oxygen into said inhalation chamber from the oxygen supply means.

2. An oxygen breathing mask inhalation and exhalation valve structure comprising a cylindrical closed casing, flexible diaphragm valve means intermediate the ends of the casing dividing the casing into an inhalation chamber and an exhalation chamber, said diaphragm being deflectable in one direction toward said inhalation chamber and in the opposite direction toward said exhalation chamber, an inhalation and exhalation conduit disposed in open communication at one end through the wall of the casing with said exhalation chamber, adapted to be connected at its opposite end with a conventional oxygen breathing mask, a branch inhalation conduit connected in open communication with said inhalation and exhalation conduit at one end and extending through said wall into said inhalation chamber, formed with laterally extending concentric diaphragm valve seat inlet opening disposed to be closed by said diaphragm valve means by deflection of said diaphragm valve means toward said inhalation chamber, an oxygen supply conduit in communication at one end through said wall with said inhalation chamber, adapted to be connected at its opposite end with a conventional low pressure oxygen supply, an exhalation conduit disposed in communication with the interior of said exhalation chamber having a concentric diaphragm valve seat adapted to be closed by said diaphragm valve means, by deflection of said diaphragm valve means toward said inhalation chamber.

3. Apparatus as set forth in claim 2 in which the operative area of said diaphragm valve means exceeds the area of said diaphragm valve seat.

4. Apparatus as set forth in claim 3 in which said diaphragm valve means comprises spaced parallel flexible diaphragms, in which one of said diaphragm valves is disposed to open or close said inhalation conduit and the other diaphragm is disposed to open or close said exhalation conduit, and includes a pressure equalization chamber in the casing above the said other diaphragm disposed in communication with said oxygen supply conduit, and an exterior pressure compensating bellows concentrically disposed in open communication to the exterior of the casing having an operating connection therefrom connected to the said other diaphragm valve means, for adjusting the closing action thereof on said exhalation conduit in predetermined relation to the exterior ambient air outside the casing.

5. Apparatus as set forth in claim 4 in which the operative area of said bellows is equal to the operative area of said exhaled conduit diaphragm valve seat.

6. A pressure operated inhalation and exhalation device for high altitude oxygen gas masks comprising, a closed casing, diaphragm valve means therein comprising a pair of parallel spaced flexible diaphragm valve disposed across said casing dividing the same into spaced inhalation and pressure equalizing chambers and an intermediate exhalation chamber, an oxygen supply conduit adapted to be connected at one end to a predetermined low pressure oxygen supply means, said conduit having branch conduits therefrom disposed in open communication with said inhalation chamber and said pressure equalization chamber respectively, an inhalation and exhalation conduit connected at one end to said casing in open communication with the interior of said exhalation chamber having an opposite end adapted to be connected to a high altitude gas mask, a branch conduit connected in open communication with said inhalation and exhalation conduit intermediate the ends thereof, said branch conduit extending through said inhalation chamber having a concentric valve seat inlet port facing said diaphragm means and opened or closed by opposite deflection of the diaphragm valve between said inhalation and exhalation chambers, toward or away from said inhalation chamber, an exhalation tube open to ambient atmosphere at one end, extending into said exhalation.
chamber having an outlet valve seat concentrically facing the other diaphragm valve, and opened or closed thereby incident to deflection of that diaphragm valve away from or toward the other diaphragm valve, extensible resilient bellows means concentrically fixed in said casing in said equalizing chamber having an inner closed end and an outer end open to the ambient atmosphere exterior of said casing, and a positive actuating connection between the closed inner end of said bellows means and the diaphragm valve located between the exhalation chamber and the equalization chamber for tensioning the latter diaphragm in predetermined relation to the pressure differential between the ambient air exterior of said casing and the oxygen pressure in the equalization chamber from the oxygen supply means to control the opening and closing deflections of said latter diaphragm valve means on said exhalation tube outlet valve seat in predetermined ratio to said pressure differential.

7. A pressure operated inhalation and exhalation device as set forth in claim 6 in which the operative areas of said diaphragm valves are substantially equal and exceed the operative areas of the cooperating valve seats thereof and the operative area of the bellows means equals the operative area of the exhalation tube outlet diaphragm valve seat.

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