April 2, 1968 W. F. CRENSHAW 3,375,839

BREATHING OXYGEN MASK INHALATION AND EXHALATION DIAPHRAGM VALVE UNIT

Filed Nov. 12, 1965 2 Sheets-Sheet 1

Fig-1

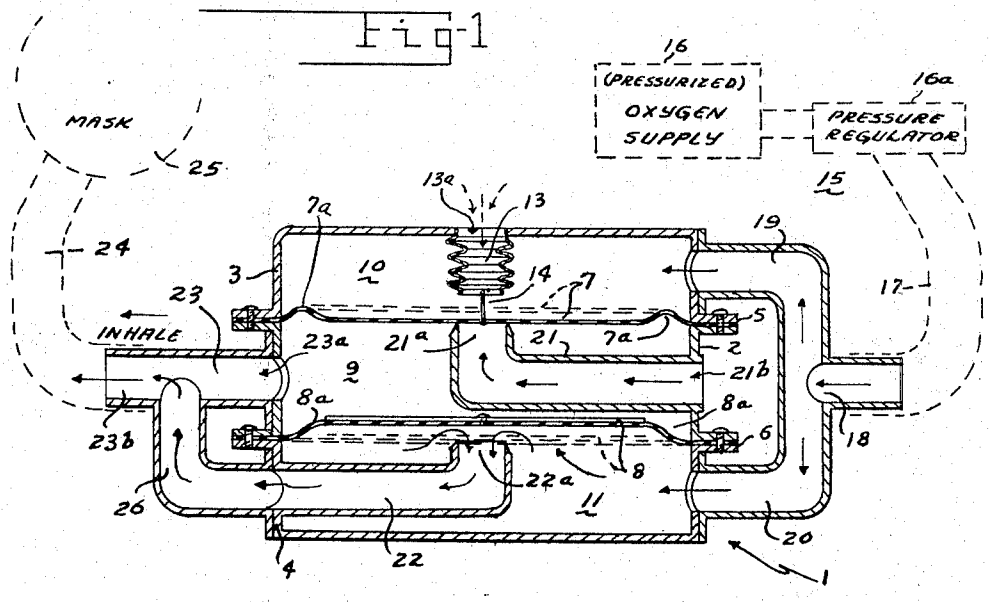
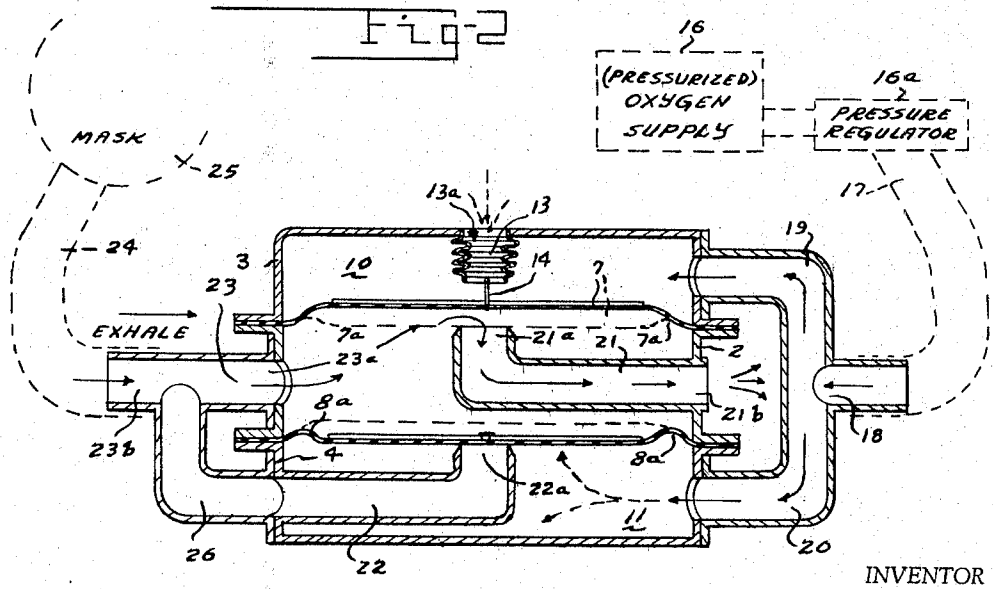


Fig-2



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2 Sheets-Sheet 2

Fig-3

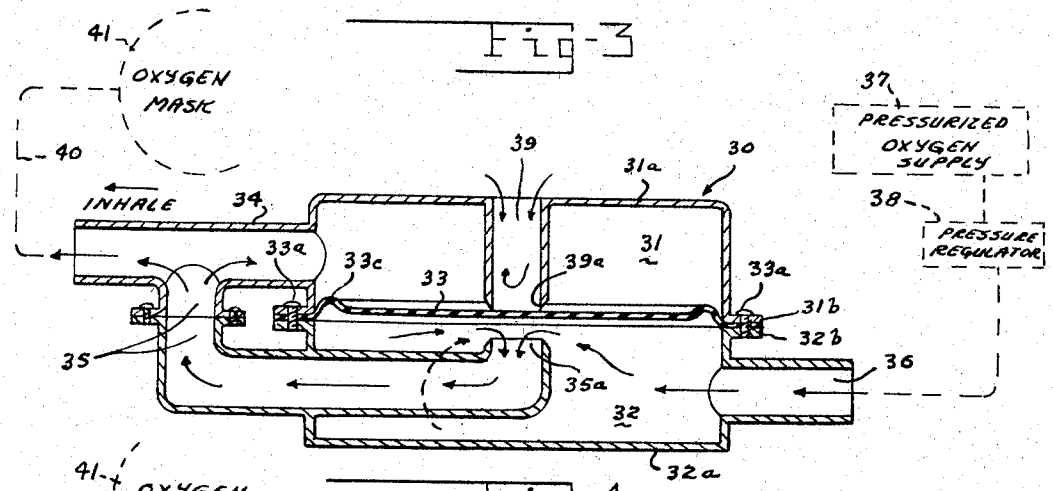


Fig-4

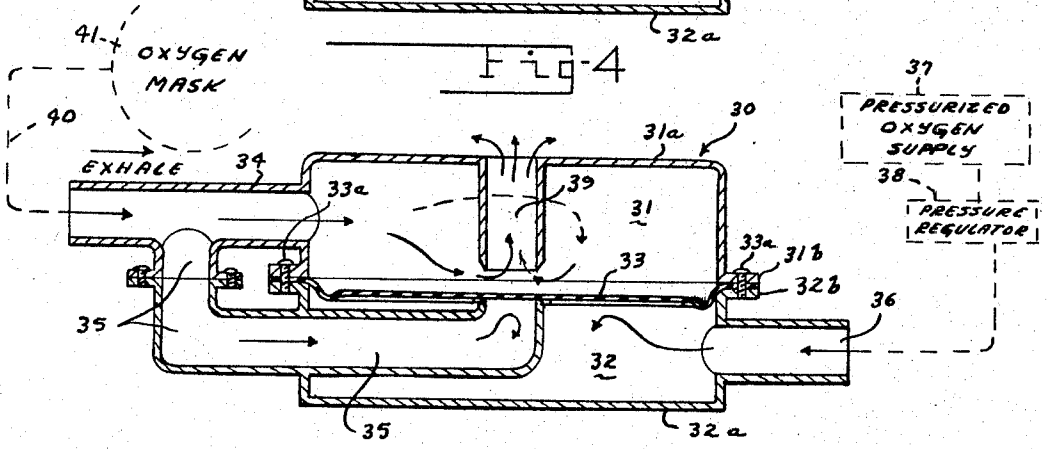
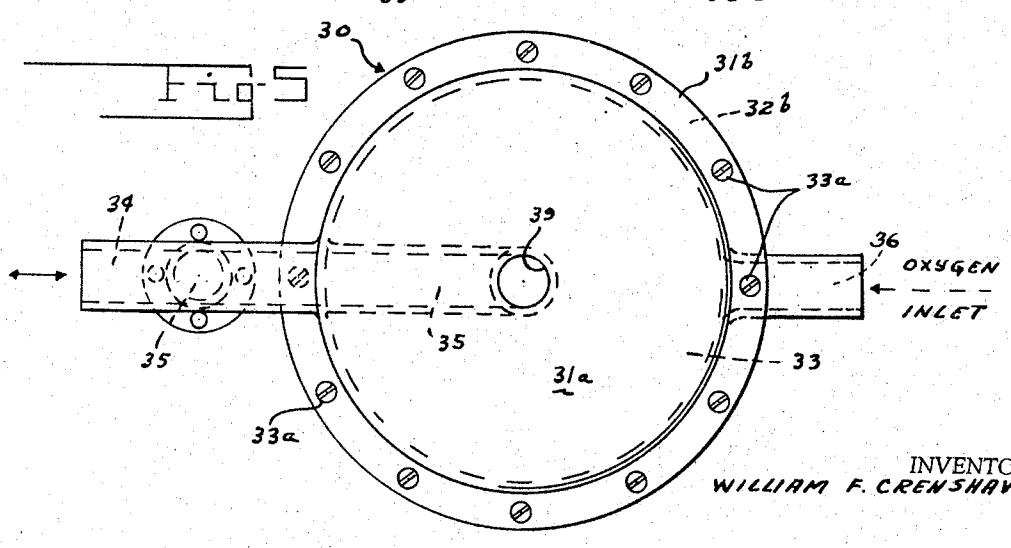


Fig-5



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United States Patent Office 3,375,839 Patented Apr. 2, 1968

3,375,839

BREATHING OXYGEN MASK INHALATION AND EXHALATION DIAPHRAGM VALVE UNIT

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Filed Nov. 12, 1965, Ser. No. 507,593
7 Claims. (Cl. 137—81)

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 gas mask, including a branch inhalation conduit therefor 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 exhalation 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 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 pressures 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 casing having a single 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 selectional 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 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 as 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 upper 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 **7***a* and **8***a* 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 **13***a*. 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 **16***a* 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 **21***a* constituting a valve seat for the diaphragm valve member **7** when it is deflected downwardly into contact with this seat to close the conduit **21** 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 **21***b*.

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 **22***a* disposed in concentrically aligned relation to the seat **21***a* and disposed to be closed by the diaphragm valve **8** when the same is deflected downwardly or away from the other diaphragm **7**, 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 **23***a* in communication through the wall with the exhalation chamber **9** while the opposite end **23***b* 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** (located within the casing **1**) 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 **21***a*, 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 exterior (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** (tending to seat the diaphragm valve member **7** on the exhalation pipe **21**).

As oxygen flows through the regulator **16***a*, conduit **17**, and branches **19** and **20** into the respective chambers **10** and **11**, as seen in FIG. 1, the diaphragm **7** is disposed down on its seat **21***a*, 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 **22***a*, 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 **23***a* in the central chamber **9** to equalize the pressure in the chambers **10** and **11**, relieving the deflecting pressure in the chamber on the diaphragms **7** and **8**.

Upon exhalation by the wearer of the mask pressure in the central chamber **9** increases to cause the upper diaphragm **7** to raise off its seat **21***a* 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 **21***a* and **22***a*, 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 **21***a* and **22***a*. 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 **21***a*.

The compensating bellows disk **13** is equivalent in operative area to the seat area **21***a* and is attached to the diaphragm **7** by the connector or stem **14** already mentioned. Thus the seat area is nulled 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 cylindrical casings **31***a* and **32***a* flanged at **31***b* and **32***b* 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 **31***b* and **32***b*, seen in FIG. 4, by fastening means such as screws or bolts **33***a*.

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 end **35***a* 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 **39***a* 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 **33***c* 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 **39***a* and close the exhalation port or tube **39**. The oxygen enters through the inhalation conduit **35** and valve seat **35***a* into the inhalation-exhalation passage **34** and through the flexible conduit **40** (diagrammatically 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 **39***a*.

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 **35***a* and tube **35**, and open the exhalation seat **39***a* and port **39**, allowing exhalation through the seat **39***a* 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 low predetermined oxygen delivery pressure in the chamber **32** and the diaphragm **33** is thus deflected upwardly as depicted in FIG. 3, closing the exhaust 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 resorted to 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 dividing 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 air 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 chamber 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 exhaust 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 seats.

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 exhaust 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 valves 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 with 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 seating inlet port facing said diaphragm means and opened or closed by opposite deflections of the diaphragm valve between said inhalation and exhalation chambers, toward or away from said exhalation 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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