BREATHING APPARATUS WITH BREATHING BAG-OPERATED VALVES

Filed Feb. 25, 1965 5 Sheets-Sheet 1

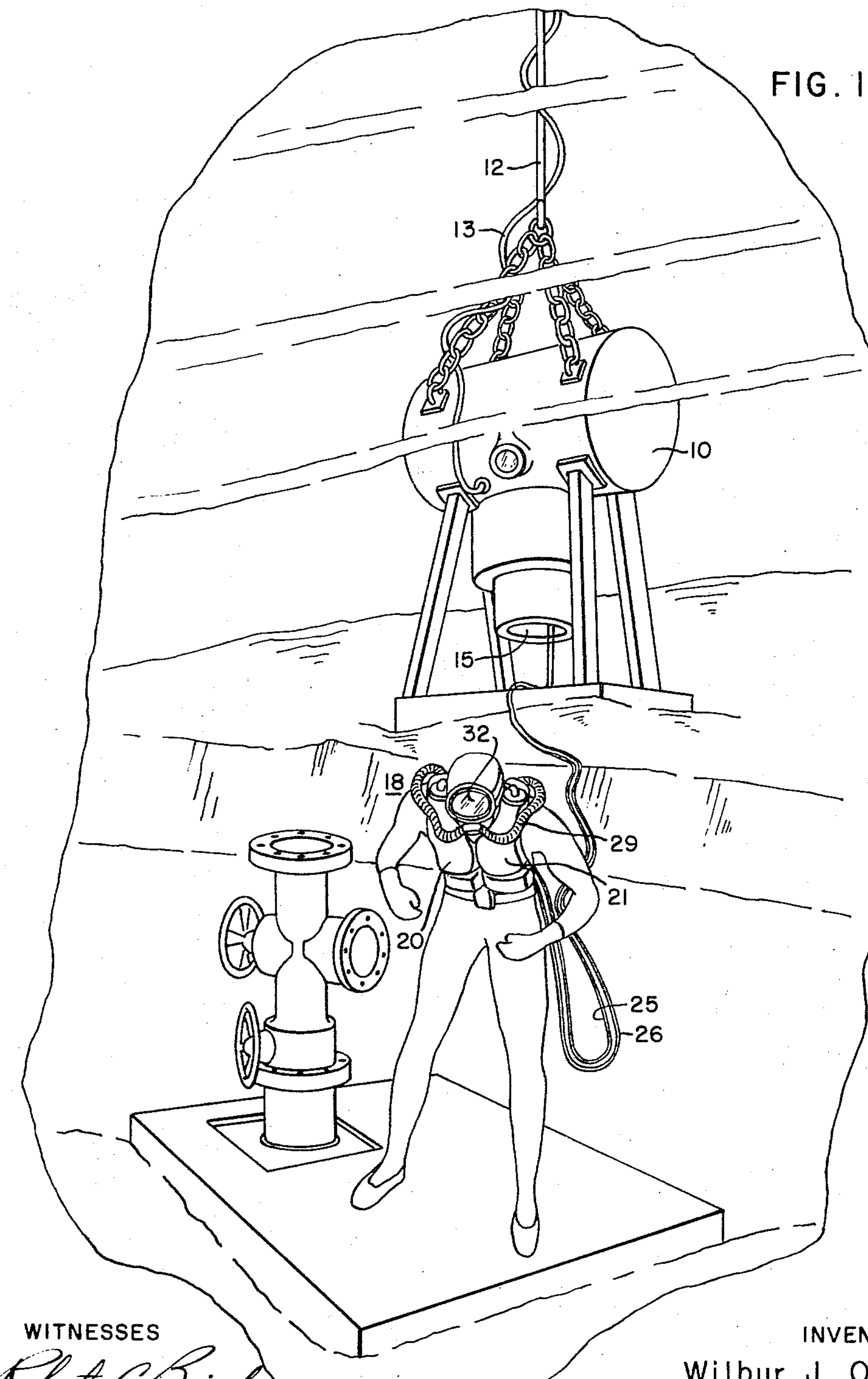

FIG. I.

WITNESSES
Robert C. Baird
James F. Young

INVENTOR
Wilbur J. O'Neill.
BY Dean Schron
ATTORNEY

BREATHING APPARATUS WITH BREATHING BAG-OPERATED VALVES

Filed Feb. 25, 1965 5 Sheets-Sheet 2

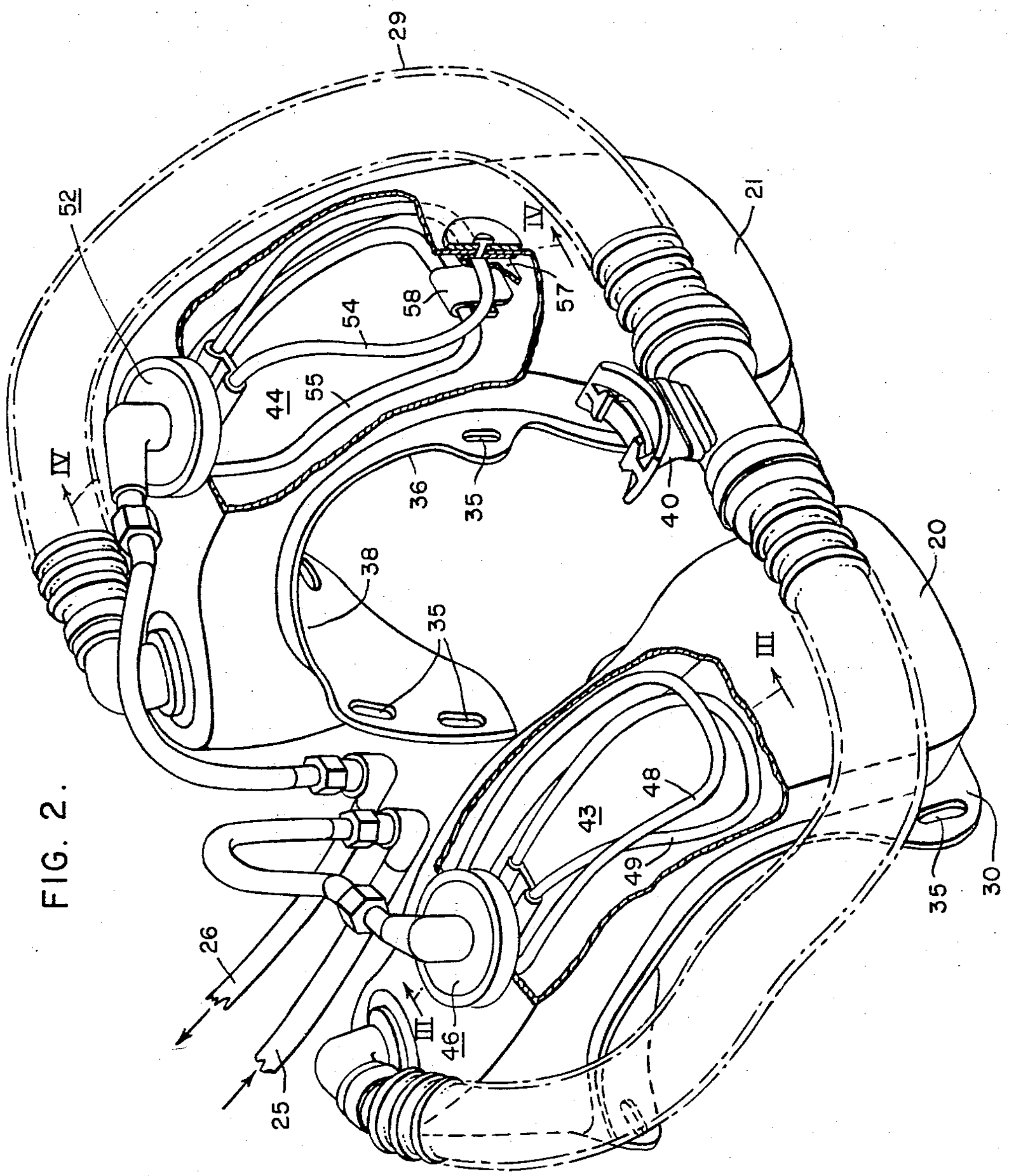

FIG. 2.

BREATHING APPARATUS WITH BREATHING BAG-OPERATED VALVES

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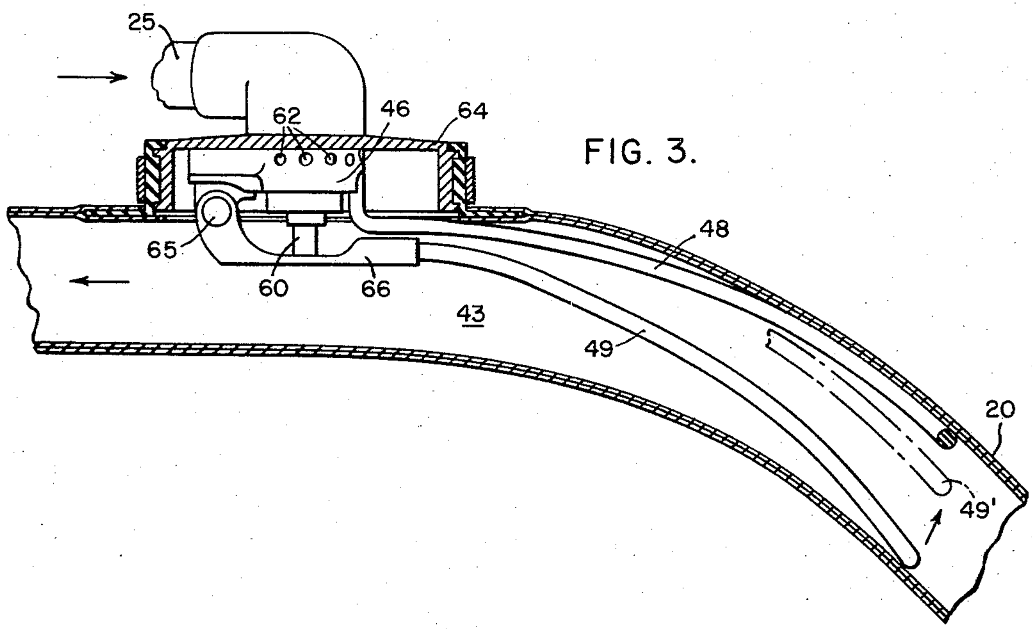

FIG. 3.

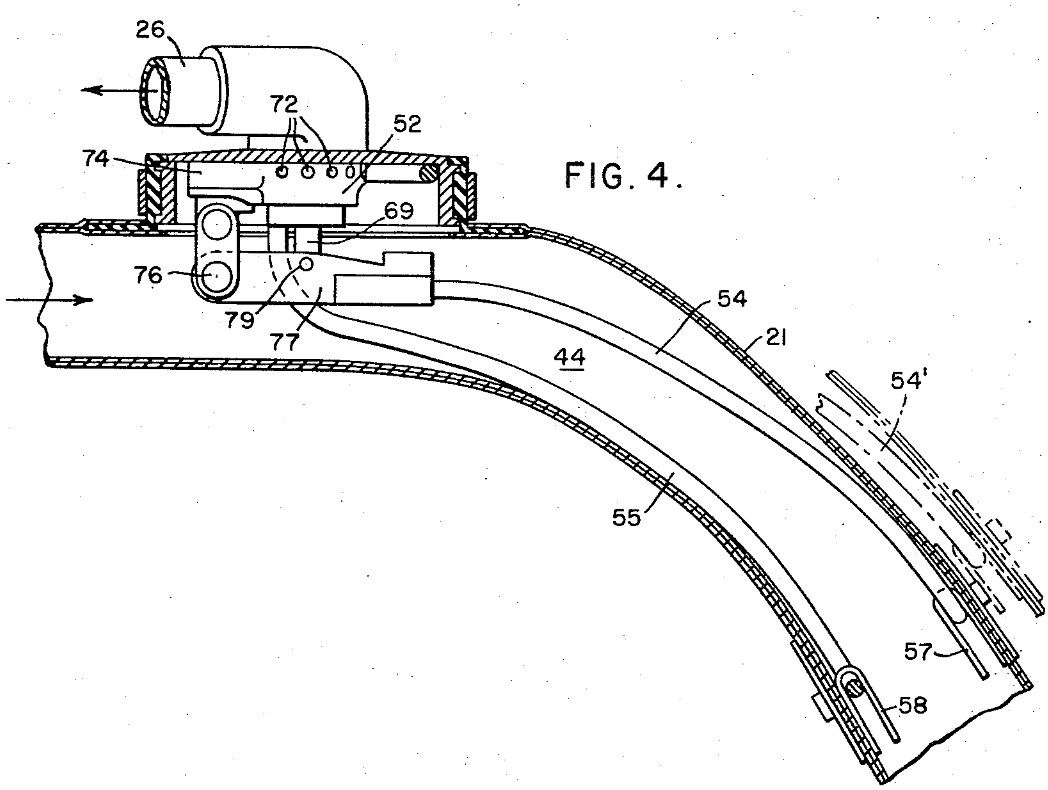

FIG. 4.

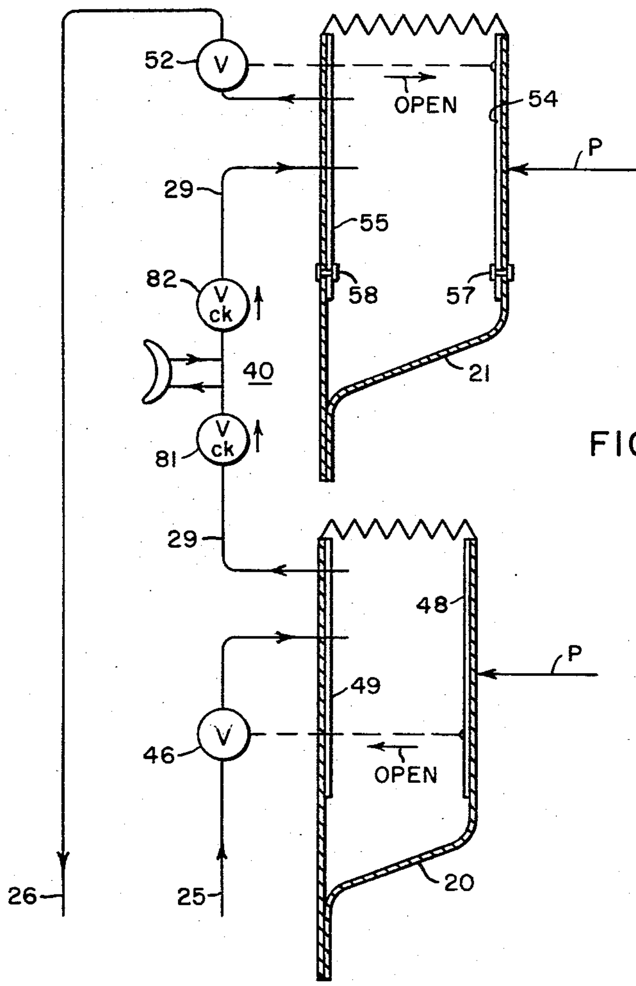
52
V
OPEN
54
P
29
55
82
V ck
58
57
40
21
81
V ck
29
48
P
49
46
V
OPEN
20
26
25

FIG. 5.

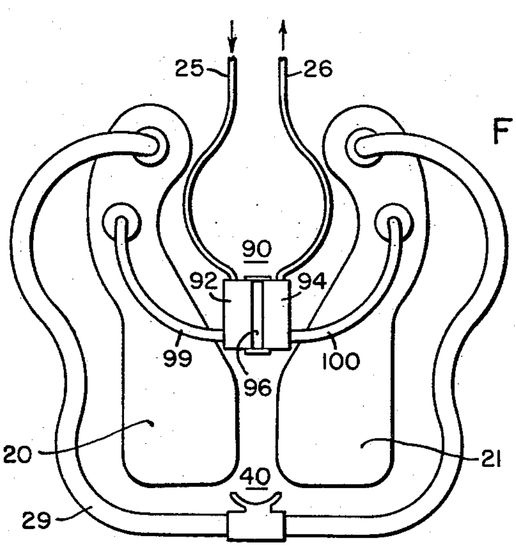
25
26
90
92
94
99
96
100
20
40
21
29

FIG. 6.

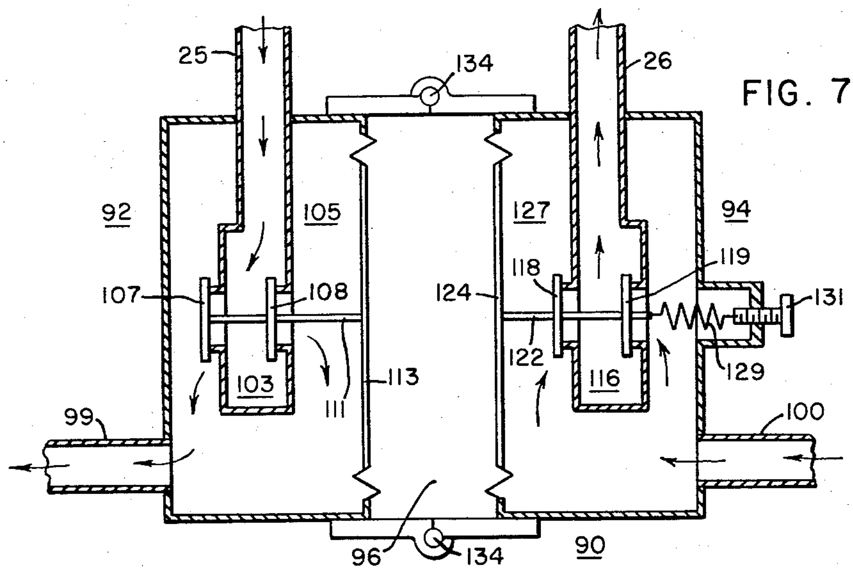
25
134
26
92
105
127
94
107
108
124
118
119
131
122
129
103
111
113
116
99
100
96
134
90

FIG. 7.

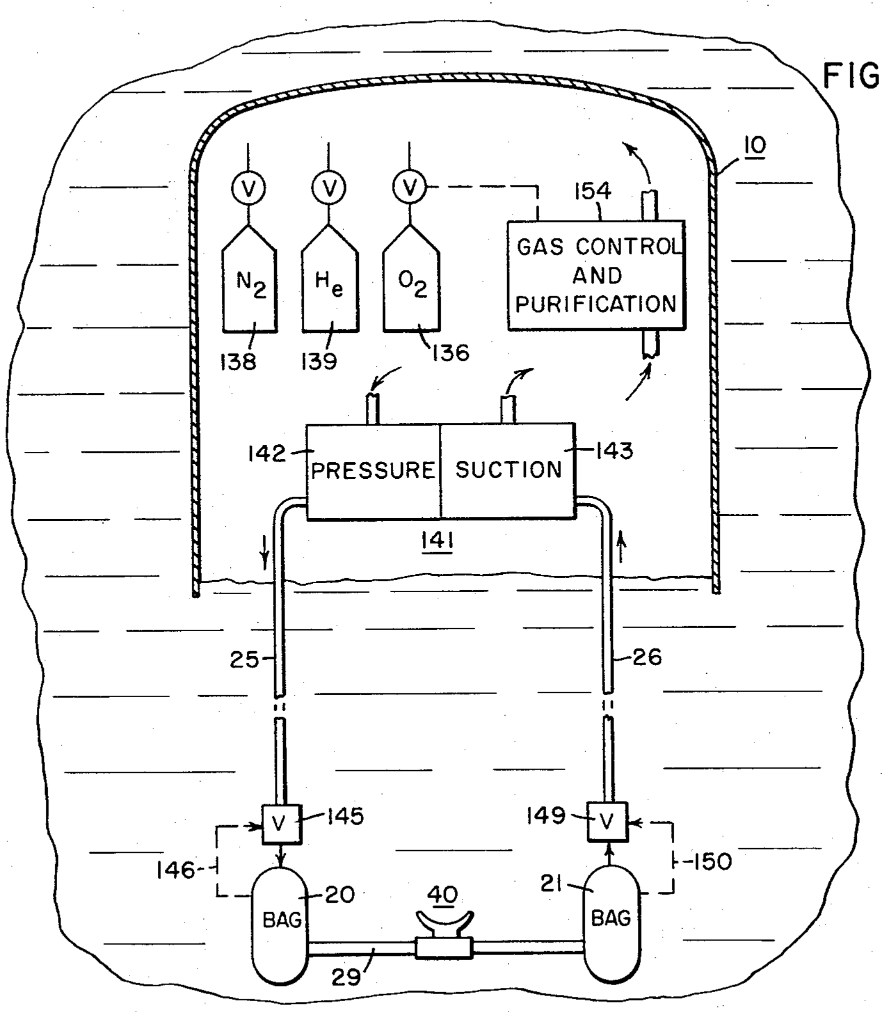
10
V
V
V
154
N_2
H_e
O_2
GAS CONTROL AND PURIFICATION
138
139
136
142
PRESSURE
SUCTION
143
141
25
26
145
149
V
V
146
150
21
20
40
BAG
BAG
29

FIG. 8.

United States Patent Office 3,370,585
Patented Feb. 27, 1968

3,370,585
BREATHING APPARATUS WITH BREATHING BAG-OPERATED VALVES

Wilbur J. O'Neill, Chelmsford, Mass., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania
Filed Feb. 25, 1965, Ser. No. 435,258
13 Claims. (Cl. 128—142.2)

ABSTRACT OF THE DISCLOSURE

Diver apparatus includes an inhalation breathing bag and an exhalation breathing bag with a breathble gas mixture being supplied by pressure source to the inhalation bag through an inlet valve. The exhalation bag is connected to a suction source through an outlet valve with the apparatus including a flexible hose connected between the breathing bags and having a suitable mouthpiece and valving arrangement for diver breathing. The inlet valve opens up to supply the gas mixture when the inhalation breathing bag collapses due to a diver inhalation or a descent, and the outlet valve opens to allow removal of the exhaled breath when the exhalation breathing bag expands due to an exhalation or an ascent. One valving arrangement utilizes wire bales extending within the respective breathing bags an another arrangement utilizes valve chambers with diaphragms having on one side the water pressure and on the other side either the inhalation breathing bag pressure or the exhalation breathing bag pressure. The valves are biased to insure that they are not simultaneously opened.

This invention in general relates to underwater breathing apparatus, and in particular to underwater breathing apparatus of the closed circuit type wherein a diver may be supplied with a breathable gas mixture from a source not carried by the diver.

A common type of underwater breathing apparatus is one wherein a diver carries one or more tanks of compressed air, with suitable pressure reducing and demand valves so that upon inspiration the diver receives a proper amount of air in accordance with his needs. Air is then exhaled to the surrounding medium. Since the exhaled breath contains an amount of usable oxygen, this exhalation to the surrounding water medium represents a waste and reduces the time that a diver may remain underwater. To this end there has been developed closed circuit types of underwater breathing apparatus wherein the diver carries a tank of oxygen and an inert gas such as nitrogen and/or helium, in addition to a purification system for absorbing carbon dioxide. With the closed circuit type of system the carbon dioxide in the exhaled breath of the diver is removed, oxygen is added and the mixture is recirculated thereby effecting a more useful utilization of the gases of the tanks which he carries.

With advances in underseas technology and the increasing interests in underwater exploration, there has been proposed underwater living quarters where divers may live and work for extended periods of time. The atmosphere within the living quarters may be supplied by suitable tanks within the living quarters together with suitable purification equipment, and for extended stays may be replenished through hoses connected to a surface vessel. Since the atmosphere within the living quarters is accurately maintained at proper breathing conditions, it has been suggested that divers on working or exploration missions within a selected range of the living quarters be supplied with the atmosphere within the living quarters, thus eliminating the need for extra breathable gas tanks and purification equipment for each diver.

The proposed method for supplying a diver in such a situation includes a pump for supplying the atmosphere within the living quarters through a hose connected to a diving mask of the driver. A second hose connected to the mask leads back to the quarters for purification in a closed system. This type of apparatus will work satisfactorily as long as the diver maintains a substantially equal level with the exit of the quarters, which is generally at the lowermost portion. If the diver descended to any depth beyond the lower level of the quarters he would be subjected to dangerous eye, face and thoracic squeeze due to the suction pressure caused by the differential in height between the diver and the quarters. At depths below the living quarters, the air supplied to the driving mask would quickly bypass the diver and be returned to the living quarters, thus presenting a dangerous situation.

In such an environment it would sometimes be necessary to either check the structure of the living quarters above the lower entrance or to check various connections to the living quarters. With the diving mask apparatus this would be an impossibility since the diver's exhalation at a point more than a few inches above the bottom of the living quarters would be at a lesser pressure than that in the living quarters and consequently would not be returned.

It is, therefore, a primary object of the present invention to provide a closed circuit type of breathing apparatus wherein a diver may be supplied with a breathable gas mixture from a source not carried by the diver.

Another object is to provide a breathing apparatus wherein the diver is supplied from an atmosphere within an underwater living quarters and in which the diver may descend to depths below the living quarters.

Another object is to provide a breathing apparatus wherein the diver is supplied from an atmosphere within an underwater living quarters and in which the diver may ascend to heights above the living quarters.

Another object is to provide a breathing apparatus of the type described wherein a diver is not subject to dangerous eye, face and thoracic squeeze.

Yet another object is to provide a breathing apparatus of the type described wherein a breathable gas supplied to the diver does not bypass the diver.

Briefly, in accordance with the above objects, there is provided first and second flexible breathing bags with the first constituting an inhalation bag and the second constituting an exhalation bag. Associated with the inhalation and exhalation bags are inlet and outlet valve means. The inlet valve means is connected by means of a conduit to a source of a breathable gas mixture, which gas may be pumped under pressure to the diver from an underwater living quarters. A suction line connects the outlet valve means to a suction source also within the living quarters so that the diver's exhaled breath may be purified, conditioned, and recirculated. The diver communicates with the inlet and outlet bags by means of, for example, a corrugated flexible hose having one-way check valves and a mouth piece.

Upon inspiration, or upon a descent, the inhalation bag tends to reduce in volume. The inlet valve means is made responsive to this volumetric contraction for allowing the breathable gas mixture to be supplied to the inlet breathing bag. Upon an exhalation, or upon an ascent, the outlet breathing bag tends to increase in volume. The outlet valve means is made responsive to this volumetric expansion for connecting the suction line with the outlet breathing bag to allow excess gas in the exhalation bag to be exited.

The inlet and outlet valve means are constructed and arranged, as will be described in more detail, so that during the normal course of operation of the breathing apparatus, the outlet valve means remains in a closed position when the inlet valve means is in an open position and vice versa, to insure that the gas supplied to the inhalation bag does not bypass the diver.

The above stated as well as further objects and advantages will become more apparent upon a reading of the following detailed specification taken in conjunction with the drawings, in which:

FIGURE 1 illustrates the utilization of the present invention in a typical environment;

FIG. 2 illustrates one embodiment of the present invention;

FIG. 3 is a view taken along line III—III of FIG. 2 illustrating the inlet valve in somewhat more detail;

FIG. 4 is a view taken along line IV—IV of FIG. 2 illustrating the outlet valve in more detail;

FIG. 5 illustrates a schematic flow diagram of the apparatus of FIG. 2;

FIG. 6 illustrates another embodiment of the present invention;

FIG. 7 illustrates the valve means of FIG. 6 in somewhat more detail; and

FIG. 8 illustrates a typical supply and drain of a breathable gas atmosphere from an underwater living quarters.

Referring now to FIG. 1, there is shown a typical environment in which the present invention may be used. An underwater living and/or working quarters in the form of chamber **10** is lowered by means of cables **12** to a position on the ocean bottom. Equalization of the ambient water pressure is achieved by supplying the chamber **10** with a breathable atmosphere either by means of hose **13** which is supplied from an attending surface vessel, or for relatively short periods of underwater living or exploration, the chamber **10** may carry tanks to supply a breathable atmosphere. Divers may enter and exit from the chamber **10** from the lowermost and open portion **15**.

The apparatus of the present invention is shown on a diver **18** working on a construction or drilling project. The apparatus includes first and second flexible breathing bags **20** and **21** constituting inhalation and exhalation bags respectively, which are worn on the upper part of the diver's torso starting at, for example, the shoulders and extending down the diver's chest. An inlet conduit **25** provides a breathable gas mixture under pressure from the chamber **10** to the inhalation bag **20** through suitable valve means. The diver's exhaled breath is communicated through suitable valving means to outlet conduit **26** back to a suction source in chamber **10** where it is conditioned for reuse. Passageway means in the form of a corrugated flexible hose **29** including familiar one-way check valves is connected between the breathing bags and is communicative with the diver. The diver **18** is illustrated as wearing a mask **32**, however, in other embodiments the passageway means **29** and mask **32** would be incorporated as a single unit. For a more detailed illustration of the diver's breathing apparatus reference should now be made to FIG. 2.

In FIG. 2 the first and second flexible breathing bags **20** and **21** are seen to include a plurality of apertures **35** in lip portions **36** for connection to suitable fastening means which may be carried on a vest worn by the diver. Obviously, the breathing bags **20** and **21** could be incorporated as an integral part of a vest or other type of wearing apparel. The curved portions **38** of the breathing bags is adapted to fit on the diver's shoulders so that the remainder of the breathing bags extends downwardly on the diver's chest. The diver then inhales from and exhales to a pressure equal to that surrounding his lungs. The corrugated flexible hose member **29** extends from the inhalation bag **20** over to the exhalation bag **21** and includes a familiar mouthpiece **40** for communication with the diver. The mouthpiece unit **40** has the usual one-way check valve means so that upon inhalation the breathable

gas mixture will be withdrawn from the inhalation bag **20** and upon exhalation the exhaled breath will be directed toward the exhalation bag **21**.

The breathing bags **20** and **21** have been cut away to show the inlet valve means **43** and the outlet valve means **44** in greater detail. The valve means **43** includes a valve section **46** which is operated by relative movement of first and second elongated spaced-apart actuators **48** and **49**. The spaced-apart actuators **48** and **49** of FIG. 2 are in the form of wires which when pressed towards one another from a rest position will cause the valve **46** to open and allow a breathable gas atmosphere suplied by conduit **25** to enter the inhalation bag **20**. The outlet valve means **44** includes an outlet valve section **52** which is operable to open by relative movement of third and fourth elongated spaced-apart actuators **54** and **55**. An important difference between the valve means **44** and **43** is that in valve means **44** movement of spaced-apart actuators **54** and **55** away from one another tends to open the outlet valve **52**, whereas in valve means **43** movement of actuators **48** and **49** toward one another tends to open the inlet valve **46**. In order that the actuators **54** and **55** be responsive to a volumetric expansion of the exhalation bag **21** there is provided first and second clip means **57** and **58** which are connected to the rear and front surfaces respectively of the exhalation bag **21** and grip the actuators **54** and **55** respectively. A better understanding of the valve means **43** and **44** may be had by referring to FIGS. 3 and 4 which illustrate side views of the inlet and outlet valve means respectively.

In FIG. 3 the inlet valve **46** is spring biased to a normally closed position and will open upon depression of the valve stem **60** (movement upwards in FIG. 3) to allow the breathable gas mixture in conduit **25** to enter the inhalation bag **20** through ports **62**. The first actuator means **48** may be rigidly secured to the valve covering or housing **64**, which is attached to the flexible bag **20**, and the second actuator **49** may be movably mounted by means of hinge member **65**, a flat portion **66** of which contacts the valve stem **60**. When the actuators **48** and **49** are squeezed towards one another the flat portion **66** forces the valve stem **60** upwardly against its spring bias thereby opening the inlet valve. The actuators **48** and **49** will be squeezed together and the breathable gas mixture will enter the inhalation bag **20** upon the occurrence of either an inhalation by the diver, increased water pressure on the bags during a descent, or when manually depressed by the diver. In FIG. 3, the actuator **49** is shown to be in its rest position relative to actuator **48** and when moved from this position towards its maximum closed position **49'** will cause actuation of the valve section **46**.

In FIG. 4 the outlet valve section **52** includes a valve stem **69**, which need not be spring biased, and when moved upwardly causes the outlet valve section **52** to open thereby allowing the gas in exhalation bag **21** to be withdrawn via port **72** back to the underwater chamber through the outlet conduits **26**. In the inlet valve means of FIG. 3, relative movement of the actuators **48** and **49** towards one another cause the valve section **46** to open. In FIG. 4, relative movement of the actuators **54** and **55** away from one another will cause the outlet valve section **52** to open. This is accomplished in FIG. 4 by rigidly securing the lower actuator **55** to the valve covering or housing **74** and movable securing actuator **54** by means of hinge member **76** having a portion **77** secured to the valve stem **69** by means of pin **79**. The movable actuator **54** connected to the valve stem **69** is located above the fixed actuator **55** and in order to effect relative movement of the two actuators, actuator **54** is secured to the front surface of the exhalation bag **21** by clip means **57** and the actuator **55** is connected to the rear of the exhalation bag by clip means **58** so that upon a volumetric expansion of the exhalation bag **21** the actuators **54** and **55** will move apart to open the outlet valve section **52**. The actuators **54** and **55** are shown in their rest position with actuator **54** movable to a maximum position **54'**.

The valve means **43** and **44** are constructed and arranged so that the outlet valve section **52** remains in a deactuated or closed position when the inlet valve section **46** is in an actuated or open position and the inlet valve section **46** is in a closed position when the outlet valve section **52** is in an open position. If this were not true and both valves were opened simultaneously the breathable gas mixture supplied to the inhalation bag **20** would bypass the diver through the corrugated flexible hose **29**, enter the exhalation bag **21**, and would be drawn back to the suction source via the outlet conduit **26**. One method of insuring proper operation is to make the mean distance between actuators **54** and **55** of outlet valve means **44** somewhat greater than the mean distance between the actuators **48** and **49** of the inlet valve means **43**. This particular feature in addition to the operation of the breathing device of FIG. 2 is further illustrated in FIG. 5.

FIG. 5 schematically illustrates the apparatus illustrated in FIG. 2 and the same reference numerals are given to those members in FIG. 5 which appear in FIG. 2. For ease of explanation in FIG. 5 some of the parts have been rearranged and greatly exaggerated. The breathing bags **20** and **21** are shown one above the other with actuators **49** and **55** in the same line. Since the actuators for each valve means moves relative to one another it will be assumed that actuator **48** will move relative to actuator **49** to open the inlet valve **46**, and actuator **54** will move relative to actuator **55** to open valve **52**. It is seen that the distance between actuators **54** and **55** is greater than the distance between actuators **48** and **49**. This distance might be in the order of a quarter inch or greater depending upon design considerations. Assuming for the moment that both breathing bags **20** and **21** are filled with the breathable gas mixture, it is seen that water pressure represented by arrow P is tending to collapse the breathing bags. However, since both breathing bags have a gas mixture within them, there is an equalizing pressure force from within and the bags take on a certain shape. Since the same pressure is acting upon both breathing bags (assuming both bags are on the same horizontal axis), the volume of gas within the inhalation bag **20** is the same as the volume of gas within the exhalation bag **21**. The flexible inhalation bag **20** will be somewhat wider (facing the diver) than the flexible exhalation bag **21** due to the fact that actuators **54** and **55** are spaced a greater distance apart than actuators **48** and **49**, with the volumes in both bags being the same. Since there is a pressure differential from the top of the breathing bag to the bottom of the breathing bag (approximately .445 p.s.i. per foot) the lowermost portion of the breathing bags will have a greater pressure on them and if there is a change in volume within the breathing bag it is reflected in this lowermost portion. In other words, in actuality the front and rear surfaces of the breathing bags do not move parallel to one another.

Referring again to the operation of the apparatus, a point in time is considered wherein both bags take on a respective volume to equalize the effective water pressure P. Both inlet valve **46** and outlet valve **52** are in a closed position. Upon inhalation by the diver the breathable gas mixture is withdrawn from inhalation bag **20** through the flexible hose **29**, passes through one-way check valve **81**, into the mouthpiece **40**. No gas will be withdrawn from the exhalation bag **21** due to the provision of one-way check valve **82**. The inhalation causes a removal of the gas from inhalation bag **20** which tends to reduce its volume due to the effective water pressure. Otherwise stated, there is a momentary pressure reduction within the inhalation bag **20** causing the greater effective water pressure P to cause relative movement of the actuators **48** and **49** towards one another. Practically, this is accomplished by the front and rear surfaces of the inhalation bag **20** being squeezed towards one another (starting from the lower portion and progressing upwards). The relative movement of the actuators **48** and **49** towards one another causes activation of the inlet valve section **46** to allow the pressurized breathable gas mixture to enter the inhalation bag **20** to again bring it back to its rest volume, that is, to equalize the effective water pressure, which action thereby closes the inlet valve **46**. Upon the diver's exhalation the exhaled breath will pass through one-way check valve **82** and into the exhalation bag **21** tending to increase its volume, that is, the pressure within the exhalation bag **21** becomes greater than the effective water pressure P. The volumetric expansion of the exhalation bag **21** causes the actuators **54** and **55** to move apart from one another since they are connected to the front and rear surfaces of the bag by clip means **57** and **58**. This relative movement causes the outlet valve **52** to open thereby connecting the suction line **26** to the inside of the exhalation bag **21** to withdraw the excess amount of gas within the bag until a point is equalized to again bring the actuators **54** and **55** to their identical rest position thereby closing the outlet valve **52**.

If the mean distance between actuators **54** and **55** was less than the mean distance between the actuators **48** and **49**, the breathable gas mixture under pressure entering the inhalation bag **20** would flow through the corrugated flexible hose **29** into the exhalation bag **21** tending to expand it, thereby causing relative movement of actuators **54** and **55**. This movement would open the outlet valve **52** and a continuous gas flowing circuit would be set up since gas would continuously be withdrawn from the exhalation bag (in addition to the inhalation bag) thus causing the inlet valve **46** to be open all the time. On the other hand, with the actuators **54** and **55** spaced as shown in FIG. 5 the opening of inlet valve **46** allows a flow of breathable gas mixture into inhalation bag **20** in addition to exhalation bag **21**; however, when the volumes and pressures are equalized the spaced-apart actuators **54** and **55** are not being forced apart to open outlet valve **52**.

Different mean distances between actuators of the inlet and outlet valve means is one way of insuring that the outlet valve means remains in a closed position when the inlet valve means is in an open position. Obviously, other types of valves with other types of arrangements may be made in accordance with the invention herein. One such other embodiment is shown in more detail in FIGS. 6 and 7.

FIG. 6 diagrammatically illustrates the inhalation and exhalation breathing bags **20** and **21** with the corrugated flexible hose **29** connected between the bags. In order to insure the diver of a proper respiratory cycle, there is provided the valve structure **90** which includes an inlet valve means **92** and an outlet valve means **94** with the space **96** therebetween being opened to the surrounding water. The breathable gas mixture is supplied to the inlet valve means **92** by the inlet conduit **25** and the outlet conduit **26** is connected to the outlet valve means **94**. Passageways **99** and **100**, in effect, extensions of the inhalation and exhalation bags **20** and **21**, respectively, are additionally connected to the inlet and outlet valve means **92** and **94**, respectively.

FIG. 7 illustrates in somewhat more detail the valve structure **90** of FIG. 6. The inlet valve means **92** includes a valve **103** of the balanced type located in a chamber **105** which is, in essence, an extension of the inhalation bag **20** by virtue of the connection through passageway **99**.

The balanced inlet valve **103** includes first and second valve heads **107** and **108** both connected by means of a rod **111** to the first diaphragm **113**. The balanced valve **103** will remain closed even though there is supplied to it a breathable gas mixture under pressure. Basically, this is due to the fact that the pressurized gas tending to unseat the valve head **107** is equal to the gas pressure which tends to seat the valve head **108** thereby maintaining a balanced condition. Movement of the diaphragm **113** inwardly towards the chamber **105** activates the valve to an open condition by virtue of the connecting rod **111**.

The outlet valve means 94 includes a balanced valve 116 having valve heads 118 and 119 connected by means of rod 122 to the second diaphragm 124. A chamber 127 forms an extension of the exhalation bag 21 by virtue of the connection through passageway 100. The suction pressure in outlet conduits 26 tends to unseat the valve head 119. However, this same suction pressure tends to increase the seating of valve head 118 thereby maintaining a balanced condition. In the case of the outlet valve means 94, water pressure on the diaphragm 124 tends to seat the valve 116. The valve 116 may be slightly biased to a closed position by means of spring 129 connected to rod 122, the biasing being adjustable by means of knob 131, or the like.

The water pressure within the space 96 tends to push in diaphragms 113 and 124 into chambers 105 and 127 respectively with the same force since they are facing and substantially parallel to one another with the center of each diaphragm being on the same axis normal to the general plane of both diaphragms. In order not to have the inlet and outlet valve means 92 and 94 be moved out of a predetermined orientation, they may be connected by adjustable fastening means 134.

Since the chamber 105 is an extension of the inhalation bag 20, a diver's inhalation, or an increase in depth, causes a volumetric contraction of the inhalation bag 20, and a reduction in volume of chamber 105, The water pressure acting on diaphragm 113 causes rod 111 to move, thereby opening the inlet valve 103 allowing the breathable gas mixture in inlet conduit 25 to equalize pressures and to bring back to conditions previous to inhalation. Otherwise stated, an inhalation by the diver causes a momentary reduction in pressure within the chamber 105. Whereas before the inhalation pressure within the chamber 105 equaled the effective water pressure, that is the pressure on diaphragm 113, the reduction in pressure after the inhalation caused a pressure differential whereby the water pressure was greater than the pressure in chamber 105 thereby effecting an opening of valve 103.

Pressure in chamber 127 on the outlet side before an exhalation is equal to the effective water pressure on the diaphragm 124, the net result being a seating of the valve heads 118 and 119. With equal pressures in both the inhalation and exhalation bags the spring means 129 assures that the outlet of valve 116 remains in a closed position. The spring bias 129 in effect performs a function similar to the difference in spacing between the actuators 54 and 55 relative to actuators 48 and 49 illustrated in FIG. 5. Upon an exhalation by the diver, there is a volumetric expansion of the exhalation bag, and consequently a volumetric expansion of the chamber 127 causing the diaphragm 124 to pull the valve heads 118 and 119, thereby unseating them to connect the chamber 127 to the suction line 26. After the gas mixture has been withdrawn from the chamber 127 there is a reduced pressure within the chamber tending once more to close the valve 116. That is, before the exhalation the effective water pressure on diaphragm 124 was substantially equal to the pressure within the chamber 127. An exhalation increased the pressure within the chamber 127 causing a pressure differential to cause opening of a valve 116.

The spring means 129 is just one method which insures that the outlet valve means remains in a closed position when the inlet valve means is in an open position. Obviously, other means or arrangements could be utilized to achieve this end. One type of construction and arrangement which would eliminate the need for a physical biasing means such as spring 129 would be to mount the outlet valve means 94 at a lower position in the water than inlet valve means 92. In this latter arrangement, the effective water pressure on the diaphragm 124 would be greater than the effective water pressure on diaphragm 113 due to the differential in water depth.

FIG. 8 schematically illustrates the breathing apparatus of the present invention in a closed circuit. The under-

water living quarters 10 includes an oxygen tank 136 which together with, for example, nitrogen tank 138 and helium tank 139 supplies a breathable gas mixture to the interior of the quarters 10. A pump means 141 includes a pressure side 142 and a suction side 143 connected to inlet and outlet conduits 25 and 26 respectively. The atmosphere within the quarters 10 is pumped under sufficient pressure through the inlet conduit 25 to the inlet valve means 145. The inlet valve means 145 is responsive to a volumetric contraction of the inhalation breathing bag (the coaction being shown by dotted line 146) for supplying the breathable gas mixture to the inhalation bag 20 and to the user, or diver, by means of the passageway 29. The exhalation by the diver causes a volumetric expansion of exhalation bag 21 which opens the outlet valve means 149 (the coaction being illustrated by dotted line 150) to connect the exhalation bag 21 to the suction side 143 via the outlet conduit 26. The exhaled breath therefore leaves the suction side and may enter into the atmosphere within the living quarters 10. A gas control and purification system 154 operates to scrub the exhaled breath of carbon dioxide and may sense the presence of oxygen in the exhaled breath for controlling the admission of more oxygen to the system.

Both in FIGS. 1 and 8 there has been illustrated a typical environment in which the present invention may be used. Obviously, the apparatus may be used in other types of environments where it is desired to provide a closed breathing circuit for consummation or conservation of a breathable gas mixture and wherein the user does not have to carry his own supply with him.

Although the invention has been described with a certain degree of particularity, it is to be understood that various other modifications and changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the scope and spirit of the invention.

What is claimed is:

1. Breathing apparatus comprising:
(a) first and second flexible breathing bags;
(b) inlet and outlet valve means communicative with said first and said second flexible breathing bags respectively;
(c) inlet and outlet conduits for connection to a source of a breathable gas mixture and a suction source, respectively;
(d) said inlet valve means being responsive to a volumetric contraction of said first breathing bag for connecting said first breathing bag with said inlet conduit to allow said gas mixture to enter said first bag;
(e) said outlet valve means of said second breathing bag for connecting said second breathing bag with said outlet conduit to allow said gas mixture to exit from said second breathing bag;
(f) passageway means including check valve means connected between said bags and adapted to be communicative with a user of said gas mixture; and
(g) said inlet and outlet valve means being constructed and arranged to insure that said outlet valve means remains in a closed position when said inlet valve means is in an open position, and that said inlet valve means remains closed when said outlet valve means is in an open position.

2. Breathing apparatus comprising:
(a) first and second flexible breathing bags;
(b) an inlet valve having first and second spaced-apart actuators located in said first breathing bag;
(c) an outlet valve having third and fourth spaced-apart actuators located in said second breathing bag and connected to opposite surfaces thereof;
(d) an inlet conduit connected to said inlet valve for supplying a breathable gas mixture;
(e) an outlet conduit connected to said outlet valve;
(f) passageway means including check valve means connecting said first and second flexible breathing

bags and adapted to be communicative with a user of said gas mixture;

(g) said inlet valve being operable to connect said inlet conduit with said first breathing bag for supplying said gas to said breathing bag upon a relative movement of said first and second actuators towards one another;

(h) said outlet valve being operable to connect said outlet conduit with said second breathing bag for allowing said gas to exit from said second breathing bag upon a relative movement of said third and fourth actuators away from one another.

3. Breathing apparatus comprising:

(a) first and second flexible breathing bags;

(b) an inlet valve having first and second spaced-apart actuators located in said first breathing bag;

(c) an outlet valve having third and fourth spaced-apart actuators located in said second breathing bag and connected to opposite surfaces thereof;

(d) an inlet conduit connected to said inlet valve for supplying a breathable gas mixture;

(e) an outlet conduit connected to said outlet valve;

(f) passageway means including check valve means connecting said first and second flexible breathing bags and adapted to be communicative with a user of said gas mixture;

(g) said inlet valve being operable to connect said inlet conduit with said first breathing bag for supplying said gas to said breathing bag upon a relative movement of said first and second actuators toward one another;

(h) said outlet valve being operable to connect said outlet conduit with said second breathing bag for allowing said gas to exit from said second breathing bag upon a relative movement of said third and fourth actuators away from one another;

(i) the mean distance between said third and fourth spaced-apart actuators being normally greater than the mean distance between said first and second actuators.

4. Breathing apparatus comprising:

(a) first and second flexible breathing bags;

(b) inlet and outlet conduits for connection to a source of a breathable gas mixture and a suction source, respectively;

(c) inlet and outlet valve means connected with said inlet and outlet conduits respectively;

(d) said inlet valve means including

(1) an inlet valve,

(2) a first chamber surrounding said inlet valve and being communicative with said first breathing bag,

(3) a first diaphragm forming a portion of said second chamber and being communicative with an external medium and being operable to open said inlet valve upon a reduction of pressure within said first chamber; and

(e) said outlet valve means including:

(1) an outlet valve,

(2) a second chamber surrounding said outlet valve and being communicative with said second breathing bag,

(3) a second diaphragm forming portion of said second chamber and being communicative with said external medium and being operable to open said outlet valve upon an increase of pressure within said second chamber; and

(f) passageway means including check valve means connected between said bag and adapted to be communicative with a user of said gas mixture.

5. Apparatus according to claim **4** wherein the first and second diaphragms face each other.

6. Apparatus according to claim **4** wherein the first and second diaphragms are substantially parallel to one another.

7. Apparatus according to claim **4** wherein the centers of the first and second diaphragms are on the same axis normal to the general plane of both the first and second diaphragms.

8. Breathing apparatus according to claim **4** wherein said inlet and outlet valves are of the balanced valve type.

9. Breathing apparatus according to claim **4** wherein the outlet valve is slightly biased to a closed condition to insure that the outlet valve remains in a closed position when the inlet valve is in an open position.

10. A breathing system comprising:

(a) a source of a breathable gas mixture;

(b) a pressure source;

(c) a suction source;

(d) first and second flexible breathing bags;

(e) inlet and outlet valve means;

(f) said pressure source being operable to supply said gas mixture to said first breathing bag through said inlet valve means upon a predetermined volumetric contraction of said first breathing bag;

(g) said suction source being operable to remove gas from said second breathing bag through said outlet valve means upon a predetermined volumetric expansion of said second breathing bag; and

(h) passageway means connected to both said breathing bags and adapted to be communicative with a user of said gas mixture.

11. A breathing system according to claim **10** wherein the source of the breathable gas mixture is an underwater chamber and the pressure and suction sources are located within the chamber.

12. Breathing apparatus comprising:

(a) first and second flexible breathing bags each having an upper portion adapted to fit over a wearer's shoulders and a remaining portion adapted to extend down the wearer's chest;

(b) inlet and outlet conduits adapted to be connected to a source of a breathable gas mixture and a suction source respectively;

(c) an inlet valve having first and second elongated spaced-apart actuators extending within said first breathing bag for opening said inlet valve upon a predetermined volumetric contraction of said first breathing bag;

(d) an outlet valve having third and fourth elongated spaced-apart actuators extending within, and connected to opposed surfaces of, said second breathing bag for opening said outlet valve upon a predetermined volumetric expansion of said second breathing bag;

(e) said inlet and outlet valves being connected with said inlet and outlet conduits respectively;

(f) passageway means connected between said first and second breathing bags and adapted to be communicative with a user of said gas mixture;

(g) said inlet and outlet valves being constructed and arranged so that they are not open simultaneously during the normal course of operation of said apparatus.

13. In combination:

(a) first and second independent flexible breathing bags;

(b) inlet and outlet valve means;

(c) said inlet valve means being communicative with said first breathing bag for opening upon a predetermined volumetric contraction of said first breathing bag;

(d) said outlet valve means being communicative with said second breathing bag for opening upon a predetermined volumetric expansion of said second breathing bag; and

(e) passageway means communicative with both said first and second breathing bags and adapted to be communicative with user.

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RICHARD A. GAUDET, *Primary Examiner.*

W. E. KAMM, *Examiner.*