May 2, 1967 H. W. SEELER 3,316,905

VARIABLE VOLUME REBREATHING BAG FOR SCUBA SYSTEM

Filed April 24, 1964 4 Sheets-Sheet 1

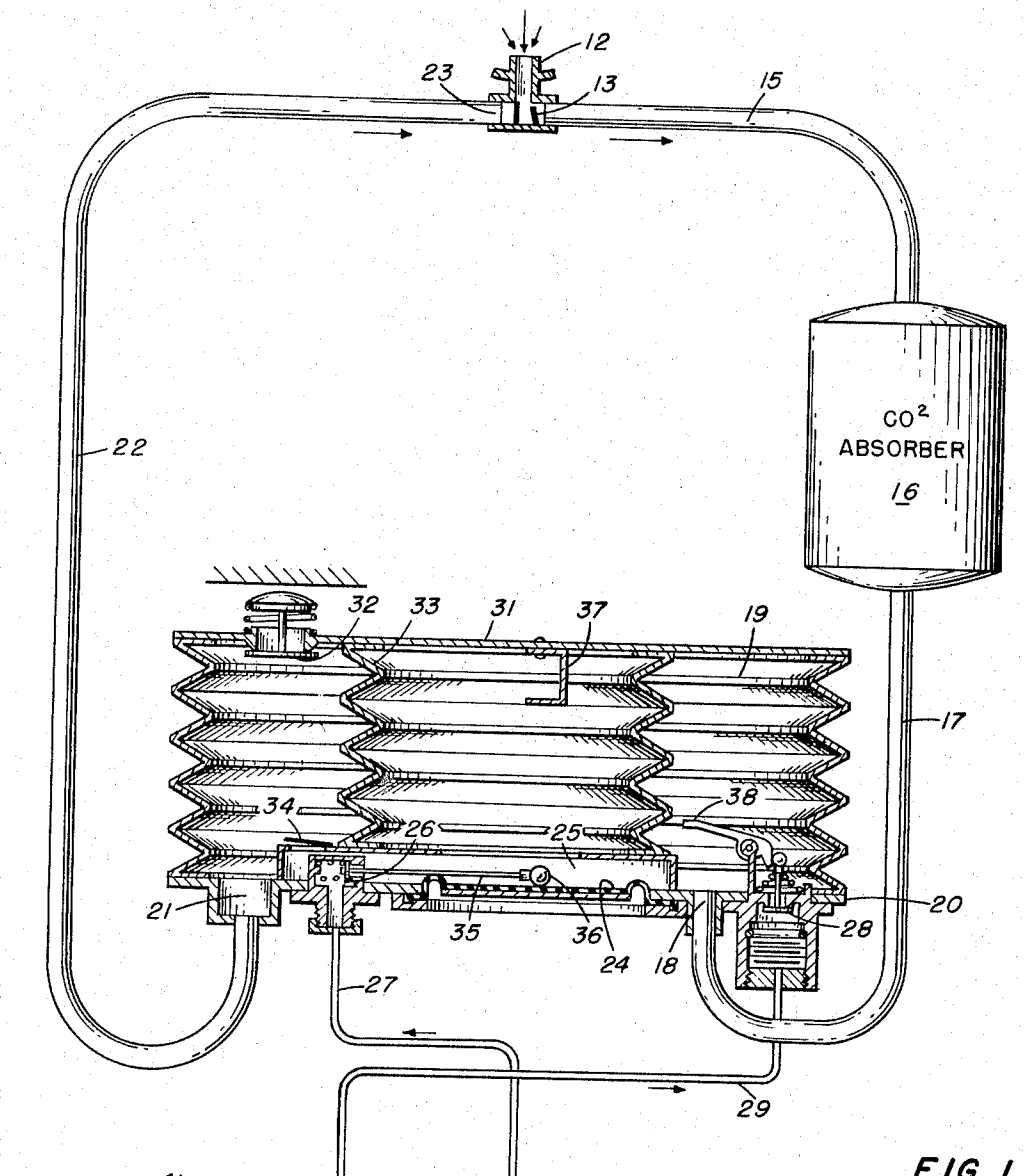


FIG. 1

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May 2, 1967 H. W. SEELER 3,316,905

VARIABLE VOLUME REBREATHING BAG FOR SCUBA SYSTEM

Filed April 24, 1964 4 Sheets-Sheet 2

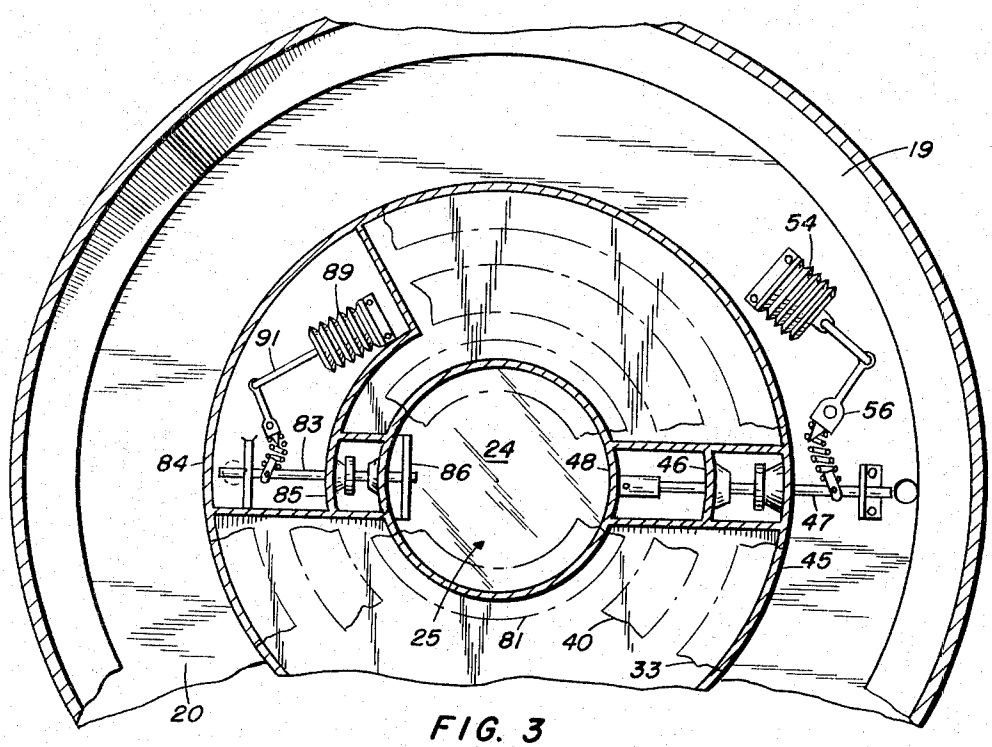


FIG. 3

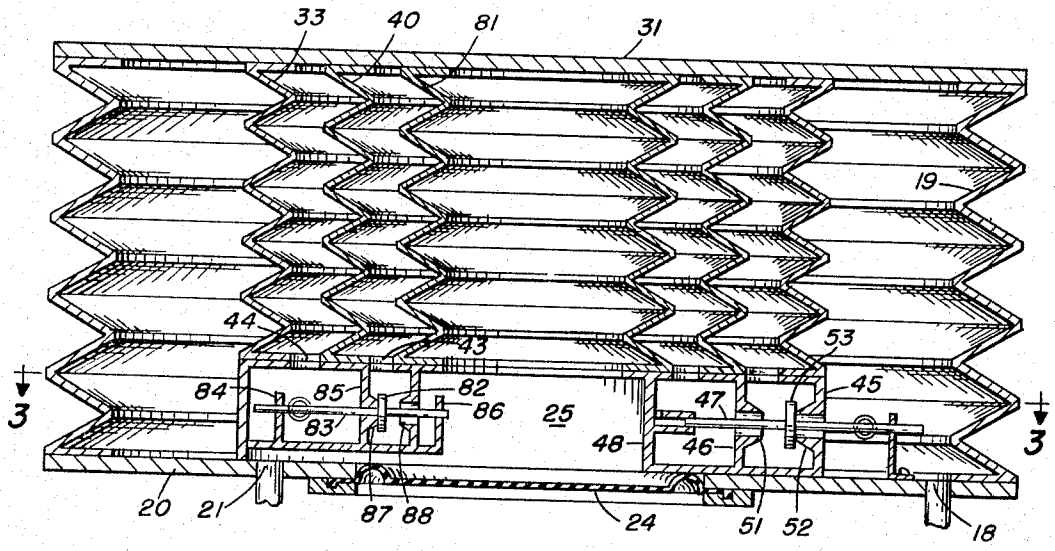


FIG. 2

May 2, 1967 H. W. SEELER 3,316,905

VARIABLE VOLUME REBREATHING BAG FOR SCUBA SYSTEM

Filed April 24, 1964 4 Sheets-Sheet 3

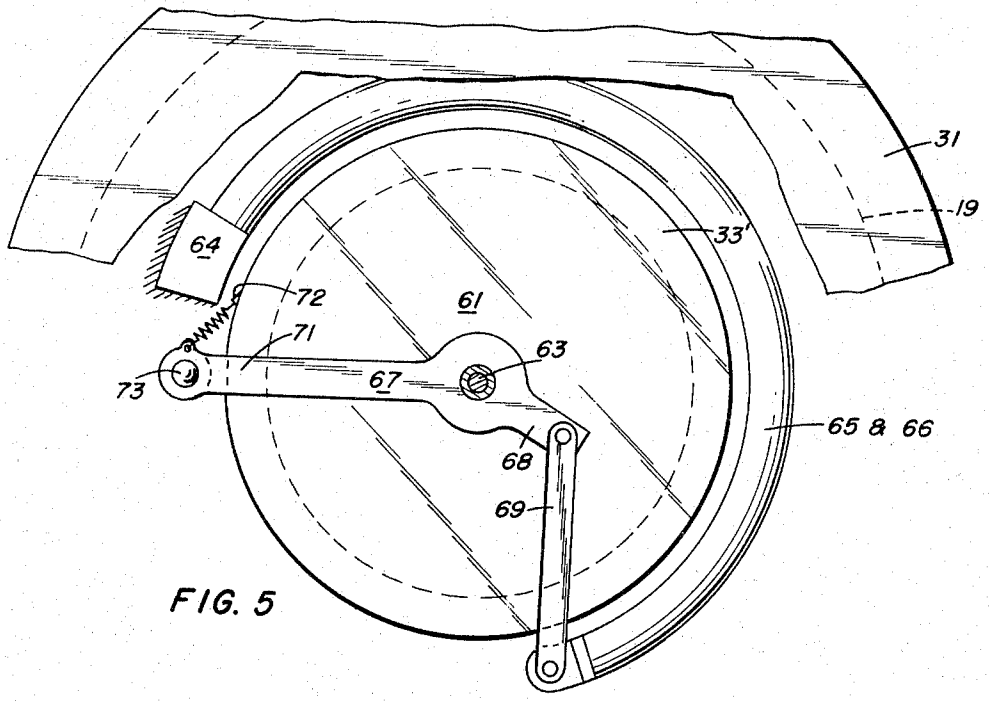


FIG. 5

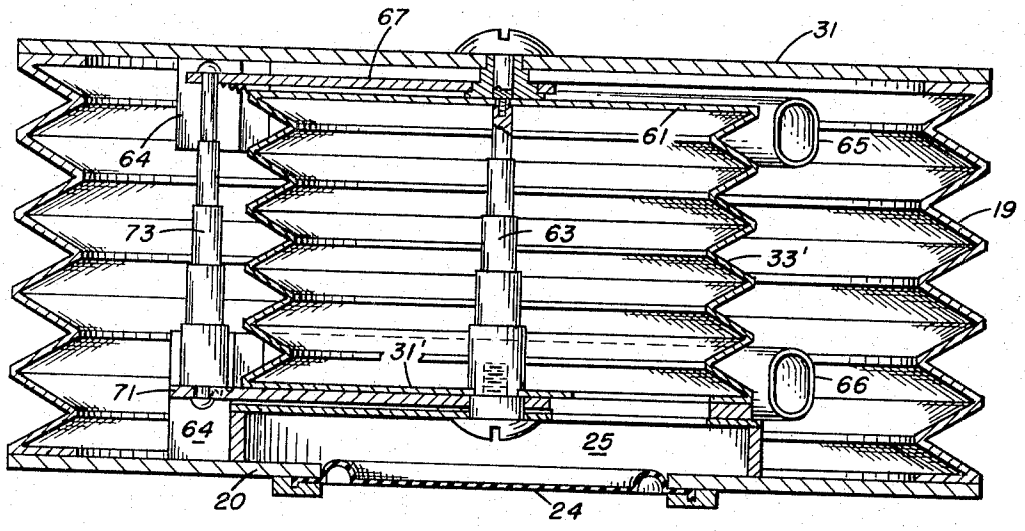


FIG. 4

May 2, 1967 H. W. SEELER 3,316,905

VARIABLE VOLUME REBREATHING BAG FOR SCUBA SYSTEM

Filed April 24, 1964 4 Sheets-Sheet 4

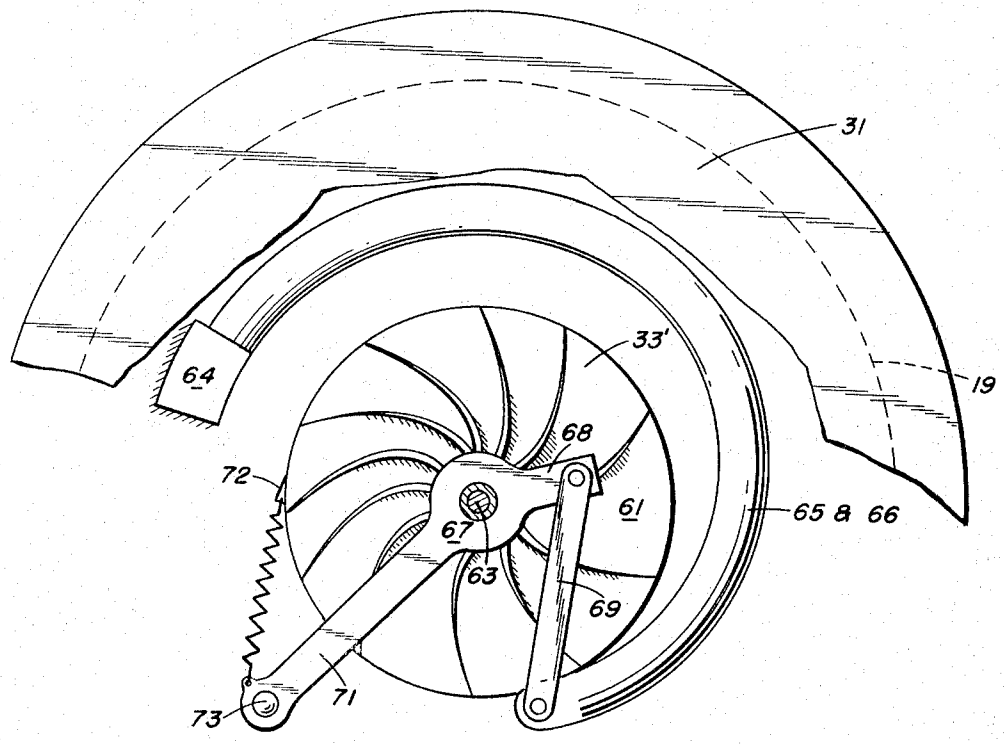


FIG. 6

United States Patent Office 3,316,905
Patented May 2, 1967

3,316,905

VARIABLE VOLUME REBREATHING BAG FOR SCUBA SYSTEM

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Filed Apr. 24, 1964, Ser. No. 362,532
7 Claims. (Cl. 128—147)

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

This invention relates to a closed circuit demand breathing system for divers and, more particularly, to the combination of a novel breathing bag with a canister for purifying exhaled gases and a valve for regulating the kind and amount of gases delivered to the mouthpiece.

The problems of deep sea diving accent the need for a demand breathing system which is self-contained and which will permit the diver to make full use of all of the gases which he is carrying. The exhaled gas contains, when the diver is near the surface, nitrogen and oxygen as well as carbon dioxide. It is only necessary to remove the carbon dioxide from the exhaled gases and to add oxygen to render these gases rebreathable. As certain amounts of the oxygen are used, there must be additional oxygen added to the gases to make them breathable. Also, it is necessary to replace the nitrogen with helium as the diver goes into deeper water. The proportional volume of the mixture of helium and oxygen should be varied with the increasing depth.

In deep sea diving it is necessary to provide the diver with a combination of gases which will supply him with the right amount of oxygen at the right depths. It is necessary to dilute the oxygen with an inert gas as an atmosphere of pure oxygen would be fatal. As the diver descends, the ratio of oxygen to the inert gas must be decreased from approximately 1:4 which is the ratio (approximate) of oxygen to nitrogen in air. In shallow water, oxygen is mixed with nitrogen but as the diver goes deeper it is necessary to change the nitrogen to another inert gas such as helium. As the depth increases, the amount of oxygen is decreased to change the ratio from 1:4 to a possible top of 1:20. Emergency conditions sometimes require a greater amount of gas to be inhaled and these conditions must be satisfied while maintaining the proper proportions.

It is an object of the present invention to provide a system of breathing for a diver in which the breathing gas is delivered in the proper proportions and the required amount without exertion by the diver other than respiration.

Another object of the present invention is the provision of a closed circuit system of underwater breathing apparatus in which the exhaled air is purified by the removal of the carbon dioxide; the remaining gas, together with the addition of oxygen, being rebreathed.

A further object of the present invention is to provide automatic means of interchanging the nitrogen and helium.

It is a further object of the present invention to provide a regulator valve which will automatically apportion nitrogen, helium and oxygen so that in shallow water a mixture of nitrogen and oxygen are so proportioned that the resulting mixture is much the same as air. The nitrogen will gradually be replaced by helium as the diver descends into deeper water and the proportion of helium and oxygen may be varied as the depth increases or decreases.

Another object of the present invention is to provide a breathing bag which will receive the exhaled gases free of carbon dioxide and automatically add oxygen to the exhaled air in the amount approximately used by the diver on the previous breath and hold the mixture for the inhalation of the diver.

It is another object of the present invention to provide means which will receive the exhaled gas from the purifier and which will supply a constantly proportioned amount of oxygen to be mixed with the purified exhaled gas.

It is a further object of the present invention to provide means by which the nature of the gas is regulated by the depth of water, changing from nitrogen to helium or vice versa, as the depth increases or decreases beyond a predetermined depth.

It is a still further object of the present invention to provide a breathing bag in the form of extendable bellows housing a smaller oxygen containing bellows which follows the expansion and contraction of the larger bellows to insure a supply of oxygen which is proportional to the amount of exhaled gas (the exhaled gas is for the most part inert) contained in the larger bellows.

It is a still further object of the present invention to provide means, operated upon demand from the respiration of the diver, to supply additional amounts of both the inert gas and oxygen.

It is a still further object of the present invention to provide a regulator valve which controls the supply of oxygen so that should the supply of inert gas become exhausted while the oxygen remained plentiful the oxygen would be shut-off as an atmosphere of pure oxygen would prove fatal.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing wherein:

FIG. 1 is a vertical cross-sectional view of the breathing bag showing certain cooperating parts in outline;

FIG. 2 is a cross-sectional view of a modified form of breathing bag;

FIG. 3 is a detailed view of the control for the modified form of breathing bag shown in FIG. 2;

FIG. 4 is another modified form of breathing bag shown in cross-section;

FIG. 5 is a top-plan view of the form of breathing bag shown in FIG. 4;

FIG. 6 is a view similar to that of FIG. 5 showing the bag in condition of reduced volume.

Referring particularly to the form of invention shown in FIG. 1 and indicating the parts by numerals, a mouthpiece **12** is formed with exhalation valve **13** which delivers the exhaled gases through the tube **15** to a canister **16** where the carbon dioxide is removed by absorption or other purifying process and passed through the tube **17** to the inlet port **18** of the breathing bag or bellows **19**.

The breathing bag **19** is in the form of an extensible bellows having collapsible sides of cloth or the like. The bottom **20** is stationary and is provided with the inlet **18** for the exhaled gases and an outlet **21** to allow the contained gases to be withdrawn through the tube **22** leading to the inhalation valve **23** at the mouthpiece **12**. The bottom **20** of the bellows further has a central opening covered by a diaphragm **24**.

The diaphragm **24** has its interior face as part of the bottom wall of a compartment **25** which is wholely within the confines of the bellows **19** and the compartment **25**, which houses a tilt oxygen supply valve **26**. The oxygen supply valve **26** extends through the bottom **20** and is attached to the oxygen supply tube **27**. Near the circumference of the bottom **20**, an inlet valve **28** for inert gases communicates with the interior of the bellows **20** and is connected to the inert gas tube **29**.

The top **31** of the bellows is rigid, yet movable, with the bellows during its reciprocal motion and has a relief

valve 32 which is in communication with the interior of the bellows 19. Attached to the top 31 at the center is a depending member 37. This member 37 is located vertically above the diaphragm 24. Housed within and concentric with the bellows 19 is a smaller bellows 33 secured at its top to the top 31 of the bellows 19 and at the bottom is attached to and in communication with the compartment 25. The smaller bellows 33 communicates with the larger bellows through a valve 34 which permits one-way communication from the smaller to the larger bellows. At the bottom the smaller bellows 33 is attached to and in communication with the compartment 25 and receives oxygen from the valve 26 through the compartment 25. The valve 26 has a handle 35 terminating in a head 36 which is in contact with the interior face of the diaphragm 24 and moves to open the valve upon movement of the diaphragm in either direction.

The handle of 35 is located vertically below the depending member 37 of the top 31 and upon collapse of the bellows 19 and its companion bellows 33 the member 37 engages the head 36 depressing the handle 35 to open the valve 26 admitting oxygen to the bellows 33.

The valve 28 is provided with an operating lever 38 carried by the bottom 20 and extending above the bottom to be engaged by the descending top 31 to open the valve 28 and admit helium or any inert gas to the bellows 19.

A regulator valve 39 described in detail in application Ser. No. 362,537, filed Apr. 24, 1964, has a source of nitrogen 41, a source of helium 42 and a source of oxygen 43. The helium could be replaced by any other inert gas without changing the nature of the invention. The regulator valve, when the diver is in shallow water, supplies the diver with a mixture of nitrogen and oxygen. Upon a predetermined depth being reached, the pressure of the water acting on a pressure responsive bellows within the regulator valve shuts off the nitrogen and opens the valve supplying helium to provide a supply of helium and one of oxygen for the diver. The proportioning of the two gases is accomplished by the ratio of the volumes of the two bellows, the larger bellows having approximately four times the ratio of the smaller bellows. As the diver descends, it is necessary to decrease the amount of oxygen available for inhalation. This is accomplished by reducing the volume, automatically, of the smaller bellows as illustrated in FIGS. 2–6.

Referring to the modifications shown in FIGS. 2–6 and, more particularly, to that modification shown in FIGS. 2 and 3, certain details of construction which are shown in FIG. 1 are omitted as unnecessary to show the additions to FIG. 1 which are set forth in FIGS. 2 and 3. The large bellows 19 is illustrated with the rigid top 31 to which the bellows 33 is also attached. The bottom 20 having compartments 25 and diaphragm 24 is likewise shown while details of the valves 26 and 28 and inlets 18 and 21 are omitted. In addition to the details shown in FIG. 1, there is a smaller bellows 40 concentric with each of the other bellows and secured to the top 31. It is attached to and in communication with the compartment 25 through the central opening 43. Also, in communication with the compartment 25 through the hole 44 is the bellows 33. The side wall 45 of the compartment and partitions 46 and 48 within the compartment support a valve stem 47. A valve seat 51 in the partition 46 and a valve seat 52 in the wall 45 are selectively closed by the valve 53 carried on the stem 47.

Mounted within the bellows 19 is a pressure sensitive bellows 54. A lever and spring arrangement 56 provides a flip-flop attachment for moving the valve 53 from the valve seat 52 to the seat 51 or vice versa. This controls the admission of oxygen into the bellows 33 and the bellows 40, that is when the valve seat 52 is closed the bellows 40 and 33 serve as oxygen containing compartments, while with the seat 52 open and the seat 51 closed the bellows 33 is shut-off from the oxygen and open to the exhaled gases normally contained within the bellows 19. This closing of the seat 51 reduces the capacity for oxygen and operates thus to regulate the oxygen as the diver descends and to decrease the oxygen at the same time it increases the proportion of exhaled gases, including an increase of helium to be added to the exhaled gases should the demands of the diver call for more gas than the exhaled gases provide. The pressure sensitive bellows is not sufficiently sensitive to pressure changes so that the small change due to the inhalation of the diver will effect it.

A still smaller bellows 81 concentric with the bellows 19, 33 and 40 is housed within the bellows structure. It is securely attached at its top to the top 31 and is in communication with the compartment 25 at its bottom. This bellows is similar to bellows 40 except that is smaller. It provides for a still smaller volume of oxygen and functions with the bellows 40 as the bellows 40 functions with the bellows 33. A valve 82 carried by a valve stem 83 which is mounted in partition walls 84, 85 and 86, alternately, opens and closes the openings 87 and 88. With the opening 88 closed, only the bellows 81 serves as an oxygen container while the remaining bellows receive the exhaled gases. It will be seen that as the volume of oxygen is reduced, the volume of exhaled gases is increased so that the proportion of the oxygen to the exhaled gases is varied. A pressure actuated bellows 89 is connected to the valve stem 83 by a flip-flop lever and spring arrangement 91 and operates the valve 82 to open or close the bellows 40 to the oxygen chamber 25. The bellows 81 is always open to the oxygen chamber 25 but a still smaller bellows could be mounted within the bellows 81 in a manner similar to the mounting of the bellows 81 to the bellows 40.

The use of a plurality of bellows, concentric with each other may be extended to an indefinite number of bellows. The oxygen delivery must be to the innermost bellows and from the innermost bellows to its adjacent bellows through a selective valve. The operation of each valve stem, controlling the valve openings between adjacent bellows must be by a separate pressure sensitive bellows such as shown. Each bellows must have two openings, one from an inner bellows to itself and another from itself to its adjacent outer bellows. By using a correct number of bellows the oxygen content may be varied as desired.

Referring particularly to FIGS. 4–6, another structure is shown for changing the ratio of oxygen to helium as the diver descends. The bellows 33′ is formed entirely of leakproof cloth including the top 61 and bottom 31′. The bellows is secured to the top 31 of the bellows 19 by a central telescoping bolt 63. The bolt passes through the top of compartment 25 and securely holds the bellows 33′ at a central point permitting extension and retraction of the bellows through the telescoping members.

Attached to the top 31 and the bottom 20 of the bellows 19 are a pair of blocks 64. The blocks 64 support an upper and a lower Bourdon tube 65 and 66, respectively. One end of each of tubes 65 and 66 is secured to one of the blocks and the other end connected to a lever system.

The top lever system comprises a double ended lever 67 pivoted on the telescopic bolt 63. The short end 68 of the lever 67 is connected by the lever 69 to the free end of the tube 65 while the long end 71 is connected to the rim of the bellows 33 at 72. A bottom lever system having similar levers is connected to the bottom rim of the bellows. A second telescopic bolt 73 connects the free ends of the levers 71.

Upon movement of the Bourdon tube due to an increased pressure, the lever system applies a tangential force to the rim of the bellows, both at the top and at the bottom, to wrap the bellows about the center bolt 63 thus reducing the volume of the bellows. The increase in pressure corresponding to depth of water in which the

diver is working will act upon the Bourdon tube and decrease the volume of the bellows **33'** to determine the proportion of oxygen to inert gases.

In use, the breathing demand system functions entirely by the respiration of the diver and the pressure of the depth of water at which the diver is working.

Upon exhalation the gases are purified by the removal of carbon dioxide in the canister **16** and delivered to the bellows **19**. The expansion of the bellows **19** expands the bellows **33** as the two bellows **19** and **33** are concentric and have a common top. Movement of the large bellows **19** also moves the smaller bellows **33** to create a reduced pressure in said small bellows. This reduction of pressure flexes the diaphragm **24** to contact the oxygen admission valve lever means **35** and admit oxygen into the interior of the compartment **25** and to the smaller bellows. Upon inhalation the exhaled purified gases in the larger bellows **19**, together with the oxygen in the smaller bellows **33** which enters the larger bellows through the one-way valve **34**, enters the tube **22** and from there into the mouthpiece **12**.

Provision for an increased amount of both an inert gas and oxygen is made through the valve **28** and the regular oxygen admission valve **26**. Should the diver inhale deeply the bellows will contract and the top descend bringing the member **37** into contact with the lever **35** and the operating member **37** of the valve **28** to admit an additional supply of both gases.

For deep sea diving where the proportion of oxygen to the inert gas must be varied with the depth, the construction shown in FIGS. 2–6 is used. One form shows the reduction of volume of the bellows **33** by reducing the effective size of the bellows, while the other form shows the use of a still smaller concentric bellows with an automatic pressure sensitive means selecting the smaller bellows for the oxygen supply at increased depth to control the proportion of oxygen to helium.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a closed circuit demand rebreathing system for divers, having a mouthpiece and an exhaled gas purifier, the combination of a collapsible bellows receiving the purified exhaled gases, with a variable volume automatically controlled oxygen receiving bellows having deformable top and bottom sections, comprising

a lever system having its pivotal point attached to the center of the deformable top and bottom sections;

a spring connecting one end of the lever to the outer wall of the oxygen receiving bellows; and

pressure actuated means attached to the other end of the lever to rotate said lever about its pivotal point and distort said bellows to reduce the volume of said bellows.

2. In a closed circuit demand rebreathing system for divers, having a mouthpiece and having separate sources of nitrogen, oxygen and helium for inhalation, and a canister for removing carbon dioxide from exhaled gases, the purified exhaled bases being combined with the gases to be inhaled, the combination of a regulator valve for controlling the kind and amount of gases to be inhaled, with a breathing bag, comprising:

a bellows having a secured end and a movable end, said bellows receiving the purified exhaled gases from the canister, the exhalation process extending the bellows;

a second bellows housed within and concentric with said first bellows;

a third bellows housed within and concentric with said second bellows, said second bellows and said third bellows being formed with openings communicating with said first bellows and said second bellows, respectively;

valve means adapted to close either of said openings, the other of said openings remaining open to establish communication between the respective bellows;

means actuated by static water pressure for actuating said valve means;

means establishing connection between the source of oxygen and the third bellows;

whereby under expansion of said first bellows which causes expansion of said second and third bellows, oxygen is delivered to said third bellows and said second bellows when said communication between the third bellows and the second bellows is open and only to said third bellows when the communication between said third bellows and said second bellows is closed to vary the amount of oxygen delivered to said bellows; and

means delivering the contents of all the bellows to a diver upon demand.

3. In a closed circuit demand rebreathing system for divers, having a mouthpiece and having separate sources of nitrogen, oxygen and helium for inhalation, and a canister for removing carbon dioxide from exhaled gases, the purified exhaled bases being combined with the gases to be inhaled, the combination of a regulator valve for controlling the kind and amount of gases to be inhaled, with a breathing bag, comprising:

a plurality of concentric bellows having a common movable top and stationary bottom plates;

a demand mouthpiece attached to the outer of said bellows to deliver to and receive gases from said outer bellows upon exhalation and inhalation of a diver;

means between adjoining bellows for establishing gas passage between adjoining bellows;

valves mounted to cooperate with said gas passage means for controlling the flow of gases through said passages;

means connected to said valves and actuated by the static pressure of the water in which the diver is working, actuating said valves; and

means for delivering oxygen to the innermost of said bellows and from said innermost bellows through any open passage from the innermost of said bellows to its adjacent bellows and continuing to the next adjacent bellows until a closed valve prevents flow of oxygen between adjacent bellows, said remaining bellows receiving purified exhaled gases.

4. In a closed circuit demand rebreathing system for divers according to claim **3** and including:

means establishing one-way communication from a smaller bellows to the larger bellows to discharge the gaseous contents of the smaller bellows to the larger upon partial collapse of the bellows due to inhalation, the oxygen of the smaller bellows becoming mixed with the exhaled gases of the larger bellows before delivery to the mouthpiece.

5. In a closed circuit demand rebreathing system for divers according to claim **3** and including:

means establishing connection between the source of oxygen and the innermost bellows and from said innermost bellows to each of said concentric bellows outward from said innermost bellows according to the setting of the valves in the passages between said plurality of bellows, and means for actuating said setting, said means being dependent on the depth of water, so that as the depth increases the outer bellows will be consecutively shut-off thereby decreasing the oxygen as the depth increases.

6. In a closed circuit demand rebreathing system for divers, having a mouthpiece and an exhaled gas purifier, the combination of a collapsible bellows receiving the purified exhaled gases, with a variable volume automati-

cally controlled oxygen receiving bellows having deformable top and bottom sections, comprising:

a lever system having its pivotal point attached to the center of the deformable top and bottom sections;

means connecting one end of the lever to the outer wall of the oxygen receiving bellows; and

pressure actuated means attached to the other end of the lever to rotate said lever about its pivotal point and distort said bellows to reduce the volume of said bellows.

7. In a closed circuit demand rebreathing system for divers having a mouthpiece and an exhaled gas purifier, the combination of a collapsible bellows receiving purified exhaled gases with a concentric variable volume automatically controlled oxygen receiving bellows comprising:

a substantially cylindrically shaped wall;

deformable top and bottom sections attached to said side wall;

means attached to the center of the top and bottom sections to serve as a center rod on which the top and bottom sections may be wrapped;

means attached to the side wall at the circumference to exert a pull at the circumference and wrap the top and bottom sections about the center means; and

means actuated by change in the static water pressure for actuating said wrapping means.

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