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UNDERWATER BREATHING APPARATUS

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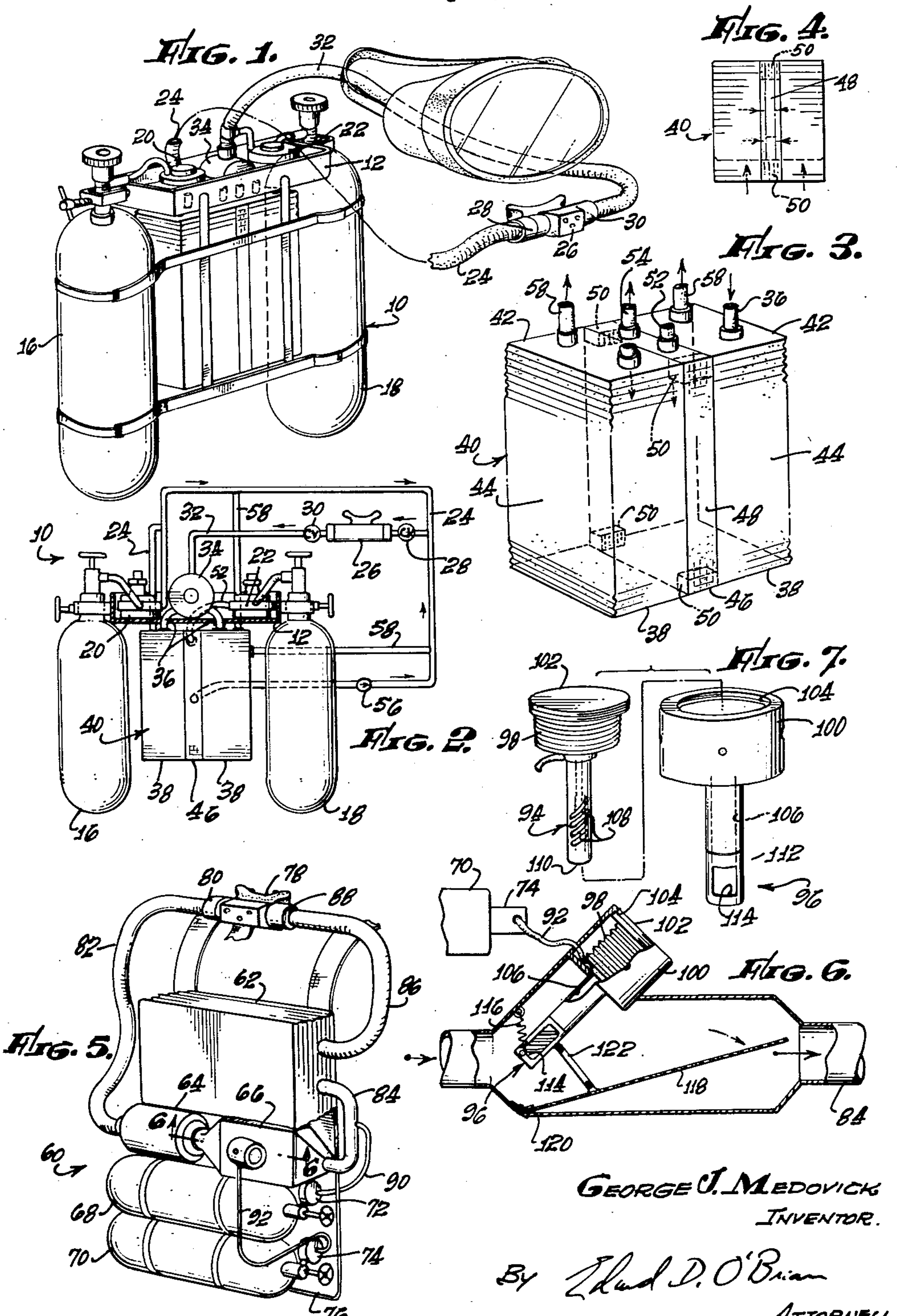

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UNDERWATER BREATHING APPARATUS

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The present invention relates to new and improved underwater breathing apparatus, and, more specifically, to underwater breathing or diving apparatus of the so-called "skin diving" category.

A large number of different types of diving equipment have been developed. Experience has demonstrated that diving equipment incorporating a helmet connected with the water surface by means of air supply lines is not particularly suited for many applications. In order to avoid such cumbersome equipment, several basic types of underwater breathing apparatus have been specifically designed. Perhaps the most common form of such self contained equipment is limited in scope and application by the fact that air from an air supply tank is allowed to escape after having been breathed by an individual. Such escaping air leaves a tell-tale trace of air bubbles; this is undesirable for many purposes. Also, such escaping air constitutes an effectual waste, since not all of the oxygen values are recovered from air during breathing.

For certain sport and military applications, self-contained recirculating diving equipment has been developed. All of the basic types of such self-contained recirculating equipment include a carbon dioxide absorbing canister which is connected to a breathing bag designed primarily to hold exhaled oxygen until it can be inhaled. With this type of equipment a needle valve is connected to an oxygen source so that oxygen can be fed into the inhaled gas. Equipment of this type does not, as a rule, provide for the automatic control of oxygen in accordance with the oxygen needs or requirements of the user of the apparatus. Further, it is undesirable for many applications because of the fact oxygen, such as is recirculated in this type of equipment, acts as a body poison under certain conditions.

The basic object of the present invention is to provide underwater breathing apparatus of essentially a self-contained, recirculating category. More specifically, however, it is an object of this invention to provide equipment of this type which avoids or overcomes substantially all of the limitations and disadvantages of the aforesaid and other related types of diving equipment. A still more specific object of the invention is to provide diving apparatus which is not excessively complicated and, hence, expensive, and which is reliable.

Because of the nature of the invention, it is believed that no further purpose would be served by listing a long series of other objects and advantages of the invention itself. Such other objects and advantages of the invention will be more fully apparent from a consideration of the remainder of this specification, including the appended claims and the accompanying drawing in which:

FIG. 1 is a perspective view of an underwater breathing apparatus of the invention;

FIG. 2 is a diagrammatic side elevational view showing certain constructional details of the apparatus illustrated in FIG. 1;

FIG. 3 is a perspective view of a bellows member employed with the apparatus shown in FIG. 1;

FIG. 4 is a diagrammatic view illustrating the operation of this bellows member;

FIG. 5 is a perspective view similar to FIG. 1 of a modified underwater breathing apparatus of the present invention;

FIG. 6 is a cross sectional view taken at line 6—6 of FIG. 5; and

FIG. 7 is an expanded isometric view showing the construction of several parts employed in this modified apparatus.

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For a complete summary of the essential nature of the invention, reference is made to the appended claims. Further, it may be stated, as an aid to understanding the specification, that the invention involves underwater breathing or diving apparatus, each of which apparatus includes a breathing means; sources of air and oxygen under pressure; demand regulator valves attached to said gas sources; a carbon dioxide absorbent; a pressure control means as will be hereinafter described in more detail; and various hoses for connecting the breathing means so that exhaled air passes through the carbon dioxide absorbent to the pressure control means and thence back to the breathing means. The pressure control means is, with this invention, formed in such a manner as to automatically operate in conjunction with the demand regulator valve attached to the oxygen source so as to cause oxygen to be admixed with the gas flowing to the breathing means. With this structure the demand regulator valve attached to the air source is used to supply air to the entire recirculating system so that the volume of this air is constant, or substantially constant regardless of pressure.

In order to understand the invention in more detail, it is necessary to discuss in general terms air requirements required during diving. At sea level, air contains approximately 80% inert gases and approximately 20% oxygen. When air at sea level is exhaled by an individual it contains approximately 80% inert gases, 16% oxygen and 4% carbon dioxide. Since carbon dioxide is a well known gas poison, it is impossible to re-breathe exhaled air to any material extent without causing undesired effects. The oxygen requirements of an individual under pressure, as an example, underwater, remain substantially constant by mass. However, the volume of oxygen required by an individual under pressure is not constant. In this connection, reference can, of course, be made to the well known gas laws explaining the relationship between pressure and volume with respect to a gas. The pressure responsive control means referred to above are used to maintain a constant percentage of oxygen in the gas breathed by a diver using equipment of the present invention by inter-relating the amount of oxygen obtained from an oxygen source with the volume of gas breathed by an individual and with the ambient pressure surrounding the apparatus.

This is best more fully explained by reference to FIGS. 1, 2 and 3 of the drawing where there is shown an underwater breathing apparatus **10** of this invention which includes a frame **12** to which there are attached by appropriate conventional means a compressed air tank **16** and a compressed oxygen tank **18**. To these two tanks, respectively, there are attached conventional demand regulator valves **20** and **22**, respectively, in an established manner so that the tanks **16** and **18** can be opened and so that gases from within these tanks will flow through the demand regulator valves **20** and **22** in accordance with the requirements of a user of the apparatus **10**.

From the demand regulator valve **20** there leads a flexible hose **24** connecting the air tank **16** with a mouthpiece **26** adapted to be held within the mouth of an individual using the apparatus **10**. If desired, this mouthpiece **26** may be termed a "breathing means"; if desired a conventional type of face mask or the like can be used instead of the specific mouthpiece shown.

The mouthpiece is constructed in such a manner that a common check valve **28** is located at one end of it so that the air flowing into the mouthpiece from the hose **24** passes this check valve. The mouthpiece **26** is also used so as to convey exhaled air through another similar check valve 30 to a further hose 32 leading to a carbon dioxide absorbent canister 34 of conventional design mounted upon the frame 12. This canister may be filled with any conventional material used as an absorbent for carbon dioxide, and is preferably formed in such a manner that it can be taken apart for replacing the material within it. If desired, a conventional water trap (not shown) may be used in conjunction with the canister 34 as part of it. If desired, a separate canister (not shown) may be mounted upon the frame 12 so that any exhalted gas passing into the canister 34 flows through a dehydrating agent such as silica gel held within this other canister.

From the canister 34 exhaled air is conveyed by means of hoses 36 to exterior compartments 38 of a bellows like, pressure responsive control member 40. This control member is quite important with the present invention, and forms a basic part of the apparatus 10. Each of the compartments 38 is formed with a rigid top 42 as shown in FIG. 3 of the drawing, and each of the compartments is formed so that the remaining walls 44 of it are formed out of corrugated flexible materials such as, e.g., rubber. Thus, when this control member is subjected to pressure as by being submerged in a body of water, the compartments 38 tend to be collapsed in a vertical direction as viewed in the drawing, reducing the effective volume of these compartments.

Between the two compartments 38 of the control member 40 there is mounted a further compartment 46 having two side walls contiguous with the adjacent walls of the compartments 38. The remaining four walls of this compartment 36 are preferably formed of rubber or other similar flexible material so as to be capable of expansion or contraction in either a vertical direction as the control member 40 is shown in FIG. 3 or so as to collapse by movement of the compartments 38 towards one another. Preferably, a waffle like configuration is employed for the exposed walls 48 of the compartment 46. Within each of the corners of this compartment 46 there is mounted a small conventional bellows 50 which is capable of expanding or contracting so as to increase or decrease the distance between the compartments 38 in response to ambient pressure applied to the ends of the control member 40. The bellows 50 may be formed of metal, rubber or of any other equivalent material, and are preferably filled with air at about normal atmospheric pressure so that the volume of the compartment 46 is reduced as the control member 40 is submerged.

The compartment 46 is adapted to receive oxygen from the tank 18 through the demand regulator valve 22 by means of a flexible hose 52. This compartment 46 is designed to be exhausted through another hose 54 leading through a check valve 56 to the hose 24. The compartments 38 are also designed to be exhausted through other hoses 58 leading to the hose 24.

The operation of the apparatus 10 is essentially very simple. In use, the frame 12 is strapped upon the back (or front) of an individual, and the tanks 16 and 18 are opened in a conventional manner. Next, the mouthpiece 26 is placed within the mouth of the user of this apparatus, and breathing commences utilizing it. At first the compartments 38 of the control member 40 will be filled with air at normal atmospheric pressure; if they are not so filled, air will be withdrawn by the normal breathing procedure of the individual from the tank 16 through the demand regulator valve 20 so that an adequate supply of air is present in the apparatus.

As an individual wearing this apparatus 10 exhales the exhaled air will pass through the canister 34, and then will be disrtibuted approximately equally into the compartments 38. This exhalation will cause an inflation of these compartments in a vertical direction as indicated in FIGS. 3 and 4 expanding them to approximately the shape shown. As such expansion occurs, the compartment 46 will automatically be elongated. Such elongation of the compartment 46 causes a partial vacuum to form in it, and this partial vacuum will affect the demand regulator valve 22 so that oxygen is drawn into the compartment 46 from the tank 18. When the individual wearing the apparatus inhales, all three of the compartments within the control member 40 will tend to collapse in a vertical direction as gas is displaced from them. The air mixture obtained as a consequence of this, will contain all of the inert gases except carbon dioxide initially exhaled by the user of the apparatus, and will also contain the unconsumed oxygen exhaled by this individual and it will contain sufficient makeup oxygen so as to have the proper air composition normally desired for use with the apparatus 10. This is considered to be the composition of air at atmospheric pressure for most purposes, although, if desired, oxygen rich mixtures can be obtained using this apparatus. This is not normally preferred due to the danger of oxygen poisoning. Any carbon dioxide exhaled by the individual using the apparatus 10 will be removed through the use of the absorbent within the canister 34.

As an individual wearing the apparatus 10 submerges beneath the surface of water, pressure will be exerted upon the opposed ends of the control member 40, so as to tend to compress or flatten the compartment 46 against the pressure of the bellows 50. An important feature of the invention lies in the fact that such compression occurs in accordance with the depth of the apparatus 10, and this, in turn, is related to the quantity of oxygen required by an individual's metabolism. As was explained earlier in this specification, the mass of oxygen required for the normal respiratory processes of an individual remains constant, regardless of the volume of oxygen involved. Thus, the compartment 46 is formed so as to add to the stream of gases being inhaled through the mouthpiece 26 a constant mass of oxygen, this mass corresponding to the oxygen requirment for breathing.

As an example of the above it may be stated that a normal air mixture containing approximately 80% inert gases and approximately 20% oxygen will be exhaled as a gas mixture consisting of approximately 80% inert gases, approximately 16% oxygen and approximately additional 4% carbon dioxide at atmospheric pressure. At a distance of about 33 feet beneath the level of the ocean an individual inhaling a mixture of about 80% inert gases and about 20% oxygen will exhale a gas mixture consisting of about 80% inert gases, 18% oxygen and 2% carbon dioxide. For these proportions to be achieved the compartment 46 should at normal atmospheric pressure have a volume of about 4% of the total volume of the control member 40. The canister 34 is designed so as to remove the exhaled carbon dioxide from such a mixture, and the control member 40 is designed so as to add just sufficient oxygen so as to bring the composition of this mixture back to the initial percentages inhaled.

The effective volume of gas within the apparatus 10 must always remain constant during the use because of the comparatively constant capacity of the human lungs. For this reason, some air will be obtained during the use of the apparatus 10 from the tank 16 through the demand regulator valve 20 as the control member 40 becomes compressed and exhausted as a result of the pressure of water upon this control member tending to compress the gases within it. If desired, various types of control means, shut-off valves, etc. of a conventional category, can be employed with this apparatus 10. Such means are not specifically illustrated inasmuch as they are well within the skill of anyone familiar with designing apparatus in the field to which this invention pertains.

It is possible to form the bottoms of the compartments 38 of a rigid material. Instead of using two compartments 38 as shown only one of these compartments need be employed. An important feature of the particular structure shown lies in the fact that the hoses leading to the compartments **38** are held in a flexible manner so as to accommodate or permit movement of these compartments towards one another. If desired, the entire control member **40** can be disposed within an appropriate protective basketlike housing.

In FIG. 5 of the drawing, there is shown a modified underwater breathing apparatus **60** of this invention which is built so that a large bellows **62**, a canister **64** similar to the canister **34** previously described, a pressure responsive control member **66**, air and oxygen tanks **68** and **70** respectively, and demand regulator valves **72** and **74** connected to the air and oxygen tanks **68** and **70**, respectively, are mounted upon a frame **76** by various conventional means (not shown) such as straps, bolts, etc.

With this apparatus **60** a mouthpiece **78** similar to the mouthpiece **26** is connected through a check valve **80** by means of a hose **82** to the canister **64**, and this canister, in turn, is directly connected with the control member **66**. Gas passing from the canister **64** through the control member **66** is conveyed by means of another hose **84** into the bellows **62**. During use of the apparatus **60** gas from within this bellows is exhausted through another hose **86** through a check valve **88** into the mouthpiece **78**. The air tank **68** is connected by means of a small hose **90** to the hose **84** so as to permit air to be added to the bellows **62** during the use of the apparatus **60** in a similar manner in which air was added from the air tank **16** during the use of the apparatus **10**.

Oxygen is conveyed from the oxygen tank **70** through the oxygen regulator valve **74** through a hose **92** in accordance with the position of two movable valve members **94** and **96** as illustrated in FIGS. 6 and 7 of the drawing. The valve member **94** is mounted so as to project from the end of a conventional bellows **98** mounted within a perforated housing **100**. The method of mounting this bellows should be specifically noted. Attached to the end of it remote from the valve member **94** a disk **102** which is adapted to be threaded within an opening **104** within the housing **100** in such a manner that the valve member **94** projects through a tubular passage **106** extending from the housing **100** into the central portion of the control member **66**. The valve member **94** is hollow and is provided with a plurality of spiral shaped groove-like openings **108** leading through the outside of it. The end **110** of the valve member **94** is preferably solid.

The valve member **96** having the shape of a cup-like sleeve is rotatably mounted upon the end of the passage **106** by being positioned around it; it has the shape of a small sleeve **112** having an opening **114** formed in the side thereof as shown. The end of this sleeve is closed, and the valve member **96** is attached by conventional means (not shown) to a spring **116** which, in turn, is similarly attached to the interior of the control member **66** in such a manner that this spring holds the sleeve **112** in a closed position. Rotation of this sleeve against the pull of the spring results in the sleeve assuming an open position in which the opening **114** and the grooves **108** are aligned with one another so as to permit the passage of oxygen into the control member **66**. A flap **118** is mounted within this control member by means of a hinge **120**, and is connected to the sleeve **112** by means of a small wire **122**.

Gas flow from the canister **64** through the control member **66** tends to rotate this flap **118** about the hinge **120** since the flap **118** fits closely against the sides of the internal portion of the control member **66**. Such rotation is transmitted to the sleeve **112** causing this sleeve to rotate permitting oxygen to pass through the opening **114** in the sleeve. The amount of oxygen drawn into the control member will, of course, depend upon the setting of the demand regulator valve **74**. The amount of oxygen will also depend upon the degree in which the grooves **108** coincide with the openings **114**. As the apparatus **60** is used under water the bellows **98** will be compressed tending to pull the valve member **94** from within the passage **106** permitting smaller and smaller volume of oxygen to pass into the control member **66**.

The operation of the apparatus **60** is essentially extremely similar to the operation of the apparatus **10**. During the use of this apparatus, gas flows substantially as indicated in the preceding discussion, and the bellows **62** serves essentially as a "lung" holding the supply of air inhaled through the mouthpiece **78**.

As air is exhaled the flap **118** is opened or rotated permitting oxygen to flow from the demand regulator valve **74** into the control member **66** in accordance with the requirements of an individual, depending upon ambient pressure. Any surplus air required to operate the apparatus **60** is obtained from the air tank **68** by virtue of the operation of the demand regulator valve **72**. Preferably the same volumetric relationships of quantities of the various gases involved, discussed in conjunction with the apparatus **10**, are employed with this apparatus **60**.

Those skilled in the art to which this invention pertains will realize the invention is capable of extremely wide modification within the scope of this disclosure. Because of this, the invention is not to be considered as being specifically limited to structures formed as illustrated; it is only to be considered as being limited by the appended claims defining the essential features of the invention.

I claim:

1. A diving apparatus of the class described which includes:
  breathing means;
  inhalation and an exhalation check valves connected to said breathing means;
  a carbon dioxide absorbent canister connected to said exhalation check valve;
  an oxygen source;
  a first demand regulator valve attached to said oxygen source;
  an air source;
  a second demand regulator valve connected to said air source and to said inhalation check valve;
  and a pressure responsive control means for adding oxygen to the gas exhaled into said breathing means and passing through said pressure responsive control means during the use of said diving apparatus so as to provide sufficient oxygen to said exhaled gas to bring the composition of said exhaled gas supplied to said breathing means through said inhalation check valve back to its initial percentage composition by volume, said pressure responsive control means having inlet means connected to said canister and to said first demand regulator valve, and said pressure responsive control means also having outlet means connected to said inhalation valve, said pressure responsive control means being responsive to the ambient pressure surrounding said apparatus and the quantity of gas passing through said canister so as to obtain oxygen from said oxygen source in accordance with the mass of carbon dioxide absorbed by said canister so that said oxygen obtained from said oxygen source and said gas passing through said canister may be inhaled through said inhalation check valve from said pressure responsive control means along with air from said air source as required by the user of said apparatus.

2. A breathing apparatus which comprises:
  air source means;
  oxygen source means;
  a first demand regulator valve means attached to said air source means;
  a second demand regulator valve means attached to said oxygen source means;
  breathing means including inlet and outlet check valve means, said inlet check valve means being connected to said first demand regulator valve means;

means for absorbing carbon dioxide connected to said outlet check valve means;

pressure responsive control means for receiving air and oxygen from said means for absorbing carbon dioxide and for supplying air and additional oxygen sufficient to bring the percentage composition of said mixture back to the percentage composition by volume of the gas mixture initially inhaled through said breathing means during the use of said breathing apparatus to said breathing means through said inlet check valve means in accordance with ambient pressure surrounding said apparatus and in accordance with the quantity of air and oxygen passed from said breathing means through said means for absorbing carbon dioxide, said pressure responsive control means being connected to said means for absorbing carbon dioxide, to said second demand regulator valve means and to said inlet check valve means.

3. A breathing apparatus as defined in claim 2 wherein said pressure responsive control means includes a plurality of compartment means connected together so as to be capable of changing volume together in response to gas conveyed to said pressure responsive control means from said means for absorbing carbon dioxide and in accordance with the ambient pressure surrounding said apparatus, one of said compartment means being connected to said second demand regulator valve means and to said inlet check valve means, other of said compartment means being connected to said means for absorbing carbon dioxide and to said inlet check valve means.

4. A breathing apparatus as defined in claim 2 wherein said pressure responsive control means includes means capable of moving in response to gas conveyed to said pressure responsive control means from said means for absorbing carbon dioxide, other valve means actuated by said means capable of moving, said other valve means being connected to said second demand regulator valve means, and means for regulating said other valve means in accordance with ambient pressure surrounding said apparatus.

5. A breathing apparatus which includes:

breathing means including an inlet and outlet check valve means;

means for absorbing carbon dioxide attached to said outlet check valve means;

pressure responsive control means for supplying oxygen to said breathing means in accordance with the quantity of gas passing through said means for absorbing carbon dioxide and in accordance with ambient pressure surrounding said apparatus so as to bring the oxygen content of said gas by volume back to the oxygen content of the gas mixture initially inhaled through said breathing means during the use of said breathing apparatus and for receiving gas from said means for absorbing carbon dioxide and for recirculating the gas so received to said inlet check valve means, said pressure responsive control means being attached to said means for absorbing carbon dioxide so as to receive gases therefrom and being attached to said inlet check valve means so as to be capable of supplying gas thereto;

means for supplying oxygen to said pressure responsive control means, said means for supplying oxygen including demand regulator valve means;

and means for supplying air to said inlet check valve means, said means for supplying air including a demand regulator valve means.

6. A breathing apparatus as defined in claim 5 wherein said pressure responsive control means includes at least two compartments, said compartments being capable of changing volume as gas is supplied to one of said compartments, the other of said compartments also being capable of changing volume in response to ambient pressure surrounding said apparatus, said one of said compartments being connected to said means for absorbing carbon dioxide and to said inlet check valve means, said other of said compartments being connected to said means for supplying oxygen and to said inlet check valve means.

7. A breathing apparatus as defined in claim 5 wherein said pressure responsive control means includes oxygen valve means, said oxygen valve means being connected to said means for supplying oxygen to said pressure responsive control means and being capable of being controlled by ambient pressure surrounding said apparatus, and means for regulating the operation of said oxygen valve means in response to gas conveyed from said means for absorbing carbon dioxide connected to said oxygen valve means, and including bellow means connected to said pressure responsive means and said inlet check valve means, said bellow means being for the storage of a gas mixture until said gas mixture is passed into said breathing means.

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