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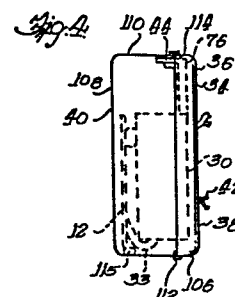
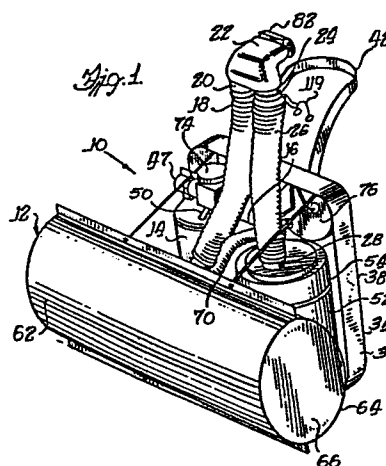
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(54) Emergency breathing apparatus.

(57) A lightweight, self contained breathing apparatus is provided for supplying breathable gas continuously or on demand to a user such as a miner in an emergency situation or to a person suffering from emphysema or asthma who needs oxygen enriched air. The apparatus includes a pressurized oxygen container (14) and conduits (16) for delivering oxygen to a flexible breathing bag (12) from which the user draws breathable gas. Gas exhaled by the user is reused after it flows through a scrubber (30) which removes carbon dioxide and other respiratory impurities from exhaled gas. A mouthpiece (22) is connected by an inhalation conduit (18) directly to the air bag to receive air without its being reheated in a return flow through the scrubber. Within the scrubber, the exhaled air passes through molecular sieve material before and after passing through a layer of carbon dioxide reactive material. The apparatus is hermetically sealed in a transparent plastic case (34) which provides for visual inspection of the integrity of the hermetic seal as well as the condition of the apparatus contained therein. Both the case and the oxygen container are constructed of light weight materials to reduce the weight of the apparatus. A second air bag may be provided between the mouthpiece and scrubber to increase the exposure time of the exhaled air to the scrubber's chemical bed so that the carbon dioxide level may be kept low even though the user is exerting considerable energy for a prolonged period of time.



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EMERGENCY BREATHING APPARATUS

This invention relates to self-contained portable breathing apparatus for self rescue use in emergency situations and for periodic use by a patient
5 with respiratory illnesses.

Portable breathing units which provide a user with a short term supply of breathable gas without relying on the potentially contaminated or rarified available atmosphere are becoming standard safety
10 equipment for miners. Portable air supplies have application in other industries where high levels of air contamination may be present, in fire fighting, at high altitudes, or for patients who may periodically experience breathing difficulties such as those with
15 asthma or emphysema.

Portable breathing units are generally designed to provide the user with a constant short term supply of oxygen while permitting the user free use of his hands, a feature essential, for example, in a mine escape unit
20 where the user may need to climb or dig his way to freedom. Such a portable breathing unit is contained in a case which is portable and which may be strapped to the user at the time of use. The apparatus within the case includes an inhalation device, e.g., a mouthpiece,
25 a bladder reservoir of breathable air, a supply of oxygen, either in pressurized or chemical form, to replenish the oxygen which is used, and a scrubber to remove waste products of respiration from exhaled gas.

The scrubber generally contains a bed of
30 chemicals reactive with carbon dioxide, the primary by-product of animal respiration. An efficient and commonly used chemical for removing carbon dioxide from the air is lithium hydroxide which is lightweight and reacts readily with carbon dioxide. In addition, other
35 material such as molecular sieves may be used in conjunction with the carbon dioxide reactive material for removing excess water and hydrocarbons. An example of an air purification unit which utilizes lithium

hydroxide in conjunction with a molecular sieve, i.e., zeolite material, is described in U.S. Patent No. 4,005,708.

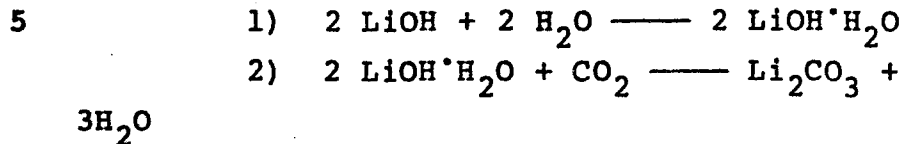
Emergency portable breathing apparatus are
5 commonly sealed in a container or case preventing atmosphere entering the breathing apparatus from depleting the scrubbing material. Sealed cases further avoid exposure of the apparatus to air-carried particles and corrosive chemicals which could lead to malfunction
10 of the apparatus. The maintenance of the hermetic seal is relied upon by high risk workers such as miners to assure the integrity of their emergency equipment.

As a means of determining whether the hermetic seal has been broken, windows, such as are described in
15 U.S. Patent No. 4,019,509, provide a view of hygroscopic material, within the case, that changes color as it collects moisture. A color change, of course, indicates the introduction of moisture and the breaking of the hermetic seal. Another commonly used examination
20 procedure is to submerge the case in water whereby a broken seal may be detected by the presence of air bubbles. Neither of these tests, of course, provides for examination of the equipment within the case. It is desirable to have breathing apparatus and cases
25 therefore which permit the immediate inspection, not only of the hermetic seal, but of the apparatus within the case.

It is desirable that portable breathing equipment be as lightweight as possible. Each pound
30 which can be removed from a miner's heavy load makes his work that much easier. Weight becomes an especially critical factor in emergency situations where a miner has to climb or otherwise maneuver to safety under adverse circumstances. Also, elderly persons or persons
35 weak from emphysema do not want to be burdened with heavy units.

Among the discomforts of breathing through portable breathing apparatus of the above-described kind

is the elevated temperature of the breathable air which generally results from the scrubbing of the carbon dioxide. Two reactions occur when carbon dioxide passes through a lithium bed:



Reaction (1) is endothermic and removes a mole of carbon dioxide for each mole of lithium hydroxide.

10 Reaction (2) is exothermic and only removes one half mole of carbon dioxide for each mole of lithium hydroxide. Unfortunately, the reaction produces heat, and hence, the scrubbing of carbon dioxide produces considerable amounts of heat. The temperature in a
15 typical lithium hydroxide scrubber may reach 275°F whereas it is uncomfortable to inhale air above 115°F.

Accordingly, it is desirable to minimize the heating effects of the scrubber as much as possible and to provide breathable gas to the user at close to
20 ambient temperatures. This is accomplished in the breathing loop in the breathing bag.

In order to be used in mine applications, the portable emergency breathing apparatus must meet various standards. To meet one of these standards, the
25 apparatus is operated as though a man were using it while doing heavy work for about one and a half hours. In such a test, it has been found that carbon dioxide level may reach the level of 1-1/2 percent by volume of the air being inhaled and this level is too high.
30 Although the scrubber has enough lithium hydroxide to last one and a half hours, the scrubber wasn't performing adequately until means were provided to increase the transit time of the air through the scrubber so that the carbon dioxide level could be
35 maintained below 1.5 percent.

In emergency escape equipment, which will hopefully never be used and used on rare occasions if at all, reusability of the equipment and oxygen cannister

is desirable but of secondary concern. While portable breathing apparatus is intended to provide a continuous short term supply of breathable air, there are applications, both in emergency situations and in
5 medical applications, where it is desirable that the breathing apparatus be used intermittently to supplement the user's available air supply over an extended period of time. It may, for example, be sufficient for a patient who experiences chronic breathing difficulties,
10 to rejuvenate himself with an occasional breath of oxygen-enriched air from a portable unit. If, as is generally true in the case of units from which oxygen is produced by a chemical reaction, the oxygen supply cannot be turned off once activated, the oxygen supply
15 is quickly depleted irrespective of the patient's needs. Thus, it is desirable that the apparatus may be shut off and turned on at will.

In addition to removing carbon dioxide from the exhaled air, scrubbers commonly include material, e.g.
20 molecular sieve material, which removes water vapor and other impurities from the exhaled air for recycling. Users of emergency portable air supplies are encouraged to hold their breath or breathe as little as possible prior to donning the emergency equipment, a measure
25 intended to protect the person from inhaling poisonous gasses. Unfortunately, in an emergency situation, this advice may go unheeded as a result of user uncertainty or as a result of unavoidable time delay in donning the apparatus, and, consequently, the first breath, which
30 the user exhales, may contain significant amounts of impurities. Desirably, portable oxygen equipment anticipates the immediate exhalation of foul air into the mouthpiece.

Accordingly, a general object of the invention
35 is to provide a new and improved portable breathing apparatus.

Another object of the invention is to minimize the effects to the user of the exothermic carbon dioxide

removing reactions in the scrubber.

A still further object of the invention is to provide a breathing apparatus which is reusable and inexpensively refurbished after use.

5 Another object of the invention is to provide lighter weight emergency breathing apparatus.

These and other objects and advantages of the invention will become more apparent from the following detailed description of the apparatus in reference to
10 the accompanying drawings in which:

FIGURE 1 is a perspective view of a portable breathing unit embodying various features of the present invention;

FIGURE 2 is a front elevation view of the unit
15 shown in FIGURE 1;

FIGURE 3 is a side elevation view of the unit with the case cut away;

FIGURE 4 is a side elevation view of the closed case;

20 FIGURE 5 is a diagrammatic view of the valve system used in the breathing unit to regulate the flow of fresh oxygen;

FIGURE 6 is a rear elevation view of the air bag utilized in the unit;

25 FIGURE 7 is a plan view of the collapsed air bag illustrating how it is folded for storage within the case;

FIGURE 8 is an elevation view of an air scrubber partially in cross section utilized in the
30 apparatus;

FIGURE 9 is an elevation view, partially cut away, of the user mouthpiece and exhalation and inhalation tubes.

FIGURES 10 and 11 are views similar to FIGS. 1
35 and 2, respectively, illustrating another embodiment of the invention.

FIGURE 12 is a diagrammatic illustration of air flow through the apparatus.

FIGURE 13 is a diagrammatic illustration of carbon dioxide levels in the air flow.

Illustrated in Figure 1 is an emergency breathing apparatus 10 which, in times of emergencies or breathing difficulties, may be used to provide air to the user. For example, the apparatus 10 may provide a full hour of air for the user in heavy exertion and heavy breathing situations. Breathable air is contained in a flexible bladder 12 or air bag which expands and contracts as the user inhales air therefrom and exhales thereinto. Oxygen is supplied from a container 14 through appropriate valves and regulators to the air bag 12 through a conduit 16 for continuously replenishing oxygen used in respiration. The user inhales air through an inhalation conduit 18 connected directly to the air bag 12 and to an inhalation port 20 of a user mouthpiece 22 and exhales through an exhalation port 24 of the mouthpiece. The exhaled gasses flow through an exhalation conduit 26 to an inlet port 28 of a scrubber 30 (Fig. 3). After being cleaned of respiration by-products, primarily carbon dioxide, in the scrubber 30, the air exits through an outlet port 32 (Fig. 3) of the scrubber and flows through a return conduit 33 to the air bag 12 where it is replenished with oxygen.

The breathing apparatus 10 is contained in a case 34 (Fig. 4) which includes a shell 36 having a rear surface 38 adapted for lying against the user's body, e.g. his chest, and a cover 40 therefor. The shell 36 is attached to an appropriate harness 42 which, when worn by the user, allows him to wear the apparatus 10 with his arms free. The front cover 40 is sealed to the shell 36 with means such as a gasket 44 (Fig. 4) or the like providing a sealed region 44 around the apparatus. Maintenance of the hermetic seal provides a strong indicia that the apparatus has not been tampered with and is in good working order.

In accordance with the present invention, the self contained breathing apparatus 10 is lightweight and

relatively inexpensive in operation and is constructed to allow the user to control his demands for oxygen and the usage thereof in order to conserve the oxygen over a prolonged period of time and usage. In this connection, the oxygen bottle 14 is provided with an "on-off" valve 46 (Fig. 5) which can be manually operated by a user-actuated knob 47 (Fig. 1) between an open position to allow oxygen flow from the bottle and a closed position at which the flow is stopped. This is in contrast to some prior art systems in which the oxygen continues to flow to empty the bottle once the valve was open, thereby severely limiting the time usage and the availability of oxygen to a one time usage situation. Further, the conservation of oxygen is improved by the use of a demand regulator means 48 (Fig. 5) and the air bag 12 and scrubber 30 which allows reuse of the air exhaled by the user after it has been scrubbed of carbon dioxide by the scrubber. The demand regulator 48 allows oxygen to flow to the air bag 12 in accordance with the usage needs of the user. Thus, the apparatus 10 is capable of providing low constant flow and a very high demand oxygen flow, such as to miners who are doing heavy labor in an emergency situation, or of providing very low oxygen demand flow as where an emphysema patient needs only a few breaths of oxygen enriched air on a short term and infrequent basis. The preferred oxygen bottle 14 is provided with means such as a fitting 50 to facilitate its being refilled. The ability to refill is important to allow the apparatus to be used repeatedly.

Preferably, the weight of the apparatus 10 is reduced by using an oxygen bottle 14 formed of a metallic lining and a non-metallic synthetic material such as wound fiber glass forming a composite structure and by using a plastic material to form the carrying case 34 for the apparatus rather than heavier all metal bottles and metal carrying cases. Preferably, the carrying case 34 is formed of transparent plastic which allows visual

examination of the internal contents of the case to reveal any damage to the apparatus which might occur as a result in banging the case while being transported. The preferred case 34 is also sealed. The transparent
5 case allows visual inspection of the seal and moisture indicating particles or material 115 are not necessary but may be used. This material changes color when exposed to moisture, thereby visually warning the user that the hermetic seal for the case has been breached.

10 In accordance with a further aspect of the invention, air from the scrubber 30 flows to the air bag 12 for mixing with incoming oxygen and is allowed to cool before being returned through the inhalation conduit 18 which bypasses the scrubber 30 returning
15 scrubbed air to the mouthpiece 22 so that the scrubbed air is not reheated when returning to the user's mouthpiece. The preferred chemical bed removes carbon dioxide from the exhaled air primarily in an exothermic reaction which increases substantially the temperature
20 of the exhaled air which should, for the comfort of the user, be reduced in temperature before entering the mouth of the user. The preferred scrubber 30 includes an exterior housing or metal cannister 52 with heat radiating means 54.

25 Heretofore, scrubbers were not constructed with the view that the miner or other user may already have a breathful of hydrocarbons when he first puts on the mouthpiece, and the user was cautioned against exhaling large amounts of hydrocarbons into the scrubbing means.
30 In the scrubber 30 of this invention; however, a molecular sieve material 56 (Fig. 8) is placed before a carbon dioxide reactive material 94 to remove hydrocarbons. Preferably a second molecular sieve material 60 is placed after the reactive material 58 to
35 likewise clean the air before it is being discharged into the breathing bag 12. The molecular sieve also absorbs water keeping the filter dry and breathing resistance low.

The air bag 12, which is designed to hold about 5 liters S.T.P. of readily available air, is formed of material that flexes easily to minimize breathing resistance and to be folded into a compact configuration when not in use. The air bag 12 as best seen in Figure 1, is tubular in shape having a front panel 62 and a back panel 64 sealed together, e.g., with heat seals, and a pair of side panels 66. When the cover 40 of the case 34 is removed from the shell 36, the air bag 12 extends generally horizontally beyond the sides of the shell. Prior to use, the air bag 12 is folded in three, as best seen in Figure 7, with both ends folded against the middle. As soon as air or oxygen enters the bag 12, the bag unfolds and expands to its inflated configuration (Fig. 1). The bag 12 has an inlet port 67 through which oxygen demand regulator enters, an outlet port 68 connected to the inhalation conduit 18 and a return port 70 connected to the return conduit 33. The air bag 12 also has a relief valve means 72 to relieve excess pressure assuring low breathing resistance.

Heretofore, metal containers were used to contain high pressure oxygen or chemicals which react to produce oxygen, and the apparatus 10 of the present invention reduces weight through use of a composite cylinder 14. Preferably the cylinder 14 is formed of a wound fiberglass member with an aluminum thin wall inner lining. Such cylinders 14 are capable of holding oxygen at upwards of 3000 psi, and a cylinder which carries a one hour supply of oxygen, i.e. 157 liters S.T.P., may weigh less than 2 pounds. Furthermore, such cylinders 14 may be used over and over again, and the inlet fitting 50 allows the oxygen cylinder to be recharged after use.

The conduit 16 from the oxygen demand regulator to the air bag 12 has appropriate gauges and regulators for controlling the flow of oxygen to the air bag thereby prolonging the supply of available oxygen. A cylinder pressure gauge 74 in the valve 46 measures the

cylinder pressure at all times for ascertaining the pressure and providing an accurate indication of the remaining oxygen within the cylinder 14. When the apparatus 10 is used, the on-off valve 46 is opened by the knob 47 to inflate the air bag 12 with substantially pure oxygen and provide immediate relief for an oxygen-low user. The on-off valve 46 further provides for intermittent use of the apparatus 10, a feature particularly advantageous in prolonging usefulness of the apparatus in situations where the user may rely partially on the ambient atmosphere or may be at rest in a hazardous environment. Such a feature is unavailable in chemically generated oxygen supplies which, once activated, continue to produce oxygen until exhaustion of one of the reactants. A valve unit 76 (Fig. 5) includes a reducing regulator 78 which reduces the pressure to a level which can be utilized by the demand regulator. From the pressure reducing regulator 78, the air flows in one of two branches (Fig. 5), through either a constant flow valve 80 or the demand regulator 48. The constant flow valve 80 provides about 1.5 - 1.8 liters S.T.P. of oxygen per minute to the bag 12, i.e., enough to sustain a moderately active man. The demand regulator 48 is also responsive to the downstream pressure in the air bag 12 replenishing the extra oxygen used up by an active man.

The mouthpiece 22 (Fig. 9) includes a flange 82 formed of flexible material insertable into a user's mouth and shaped to fit against the inner surface of the user's lips. For gripping by the user's teeth, a pair of bits 84 are provided on and extend from the flange 82 on either side of a breathing opening 83, and the user grips the bits 84 with his teeth. The inhalation port 20, to one side of the mouthpiece, carries a valve seat 85 to support a one-way inhalation valve 86 (Fig. 9) which moves to a closed position to close the passageway through the inhalation port 20 when the user exhales and places a positive pressure thereon and moves to an open

position to open the passageway when the user inhales and produces a negative pressure thereon. The exhalation port 24 on the other side of the mouthpiece 22 carries a one-way exhalation valve 87 mounted to the same valve seat 85 which operates in the reverse, moving to open the passageway through the port when the user exhales a positive pressure thereon and close the passageway when the user inhales and places a negative pressure thereon. Thus a one way flow of air is established through the apparatus 10, the user always drawing fresh air directly from the air bag 12 as he inhales and exhausting used air through the scrubber 30 when he exhales.

Location of the inhalation valve 86 and exhalation valve 87 at the mouthpiece 22 rather than at a remote location, as is the case in some breathing units, reduces dead space, i.e., the space between the lungs and the mouth and including the region of the breathing apparatus up to the valves as an extension of the mouth. Reduction in dead space achieves a corresponding reduction in oxygen usage.

The inhalation valve 86 and exhalation valve 87 are preferably adapted to equalize breathing loop resistance to inhalation and exhalation. In the closed loop, the inhalation conduit 18 is connected directly to the breathing bag which in turn is supplied by the oxygen bottle 14 while the exhalation conduit 26 is connected to the flow resistant scrubber 30. Thus, the resistance is higher on the exhalation side. To equalize resistance for more natural breathing, the inhalation valve 86 is designed with greater breathing resistance than the exhalation valve 87.

The unitary valve seat 85 in the mouthpiece 82 has an inhalation opening 121 encircled by an annular flange 122 on the side of the valve seat 85 facing the user and exhalation opening 123 encircled by an annular flange 124 facing away from the user. Each of the openings 121, 123 is disposed eccentrically relative to

the corresponding flange 122, 124, and the valves 86, 87 are held to the valve seat 85 at their centers and are centered relative to the valve flanges to establish peripheral contact therewith to close off flow through the openings.

As a preferred means to equalize the pressure, the inhalation valve is an umbrella valve 86 and the exhalation valve is a disc valve 87. The inhalation or umbrella valve 136 is a unitary piece of flexible material, e.g, silicone rubber, having a stem 125 which extends through an aperture 126 in the valve seat 125 relative to the flange and a flap 127 which seats along the annular flange 122. The stem 125 includes a cylindrical center segment 128 matched in diameter and length to the aperture 126, a conical upstream segment 129 having a maximum diameter greater than the opening and a cylindrical downstream segment 130 greater in diameter than the opening. When the conical upstream segment 129 is pulled through the aperture 126, the stem achieves an interference fit with the valve seat flange 122 sealing the aperture and securely holding the valve 87 along the valve seat 85. The flap 127 includes a circular region 131 extending laterally from the downstream end of the stem and an annular peripheral region 132 that angles back toward the seat 85 for abutting an inclined outer surface 133 of the flange. The angling of the annular peripheral region 132 from the circular region 131 increases the resistance of the flap 127 to deformation in response to air pressure change.

The exhalation or disc valve 87 on the other hand, has relatively little resistance to deformation. The disc valve 87 is a circle of flexible material having a central opening 134 by which it is held to a knob 136 of the valve seat by a washer 135. When held at its center against the seat 85, the peripheral regions of the disc valve 87 press against the rim of the flange 124 giving the disc valve a convex-concave

configuration. The disc valve 87 deforms outwardly with relatively little resistance in response to the pressure of exhaled air.

The preferred scrubber 30 is a combination
5 lithium hydroxide-molecular sieve scrubber. As
hereinabove described, carbon dioxide reacts with solid
lithium hydroxide to form either lithium bicarbonate or
lithium carbonate. The molecular sieve of porous
10 material, e.g. a form of zeolite, removes water
particles, hydrocarbons and other chemical waste
by-products of respiration.

The scrubber 30 (FIG.8) is designed to maximize
contact of the scrubbing material and for replacement of
a charge 94 of scrubbing material whereby the scrubber
15 can be refurbished. The scrubber 30 comprises the
generally cylindrical cannister 52 having a
non-removable cover 88 at its outlet end and an
optionally removable cover 90 at its inlet end that
allows for replacement of the charge 94 of scrubbing
20 material. Generally, the flow of exhausted air is
through the inlet port 28, through the cover 90, into a
region 92, through the charge 94 of scrubbing material,
and out through the axially disposed outlet port 32 of
the non removable cover 88. Interior of the ports 28,
25 32 at each end is a fine mesh metal screen 97 which
filters out larger particles and a layer 98 of filtering
material, e.g. glass wool, to collect fine dust
particles.

The end molecular sieve layer 56 collects
30 water, hydrocarbons and other impurities from the
exhaled air. In particular, the first upper layer 56
prevents the continual contamination of the breathing
air. The lower layer 60 of molecular sieve material
traps additional impurities as noted above and
35 particularly water, lest water tend to clog the filter
screens 98. Respiratory impurities are substantially
removed by the lithium hydroxide and the molecular sieve
material and the total effect of passage through the

scrubber 30 is purified, heated carbon dioxide depleted air.

Because heated air becomes uncomfortable to breathe, particularly under the conditions where the emergency apparatus might be used, the exterior of the cannister 52 which is in contact with the, presumably cooler, ambient atmosphere is coated with a radiation material 54 to reject heat. The air from the scrubber 30 enters the air bag 12 which has a large surface area in contact with the cooling ambient air and is mixed therein with expanding cooler oxygen from the oxygen bottle 14. Oxygen-replenished air flows to the mouthpiece 22 through the inhalation conduit 18 bypassing the heat producing scrubber 30. The combined effect of the measures taken to dissipate the scrubber produced heat is to maintain the air which the user inhales below about 115°F, a temperature at which the user can breath in reasonable comfort.

The shell 36 of the case 34 includes the substantially rectangular back 38 wall and side walls 106 extending outward therefrom. The cover 40 (Fig. 4) has a similar shape having a rectangular outer wall 108 and side walls 110 extending therefrom for peripheral mating with the side walls of the shell. Latches 112 hold the cover 40 to the shell 36 and the sealing gasket 114 or other sealing means is interposed between the shell and cover for sealing the interior region 44. The cover 40 is preferably deeper than the shell 36.

The case 34 provides a region 44 (Fig. 4) of sufficient volume for containing the breathing apparatus. The breathing bag 12, oxygen bottle 14, the valve unit 76 and the scrubber 30 are each attached by straps, brackets or the like to the interior surfaces of the shell 36. The case 34 is packed with the mouthpiece 22, the conduits and the folded air bag 12 packed loosely therein. In a well packed case, the loose members are disposed in the spaces between the secured members to afford a substantially complete view of the

apparatus therewithin.

The apparatus 10 may be stored for extended periods of time in areas which provide for easy access by the user in times of emergency. Such areas, e.g., a mine, often contain foul, dirty atmosphere, and from time to time, the apparatus in the sealed case 34 is transported to a new work area. The hermetically sealed case 34 protects the apparatus against dirt, pollutants and damage caused by impact during periods of non use.

10 While emergency breathing apparatus is commonly stored and imported in metal cases, it is found that several advantages accrue from encasing the apparatus in a strong durable and transparent material such as a polycarbonate.

15 Hygroscopic material, e.g., cupric sulphate, which changes color as it collects moisture, may be sealed within the case 34. A loose packet 115 (Fig. 4) of hygroscopic material for visual observation may be stored in the case. While color change is generally

20 indicative of a broken seal, in very dry atmospheres, a broken seal may not result in sufficient pick-up of water vapor to effect a noticeable color change. In a transparent case 34, the collection of dust and moisture within the case is an alternative indication of a broken

25 seal. The secondary indicia of the integrity of the seal obviates the need to test stored units by submerging them in water.

If the cover 40 and/or the shell 36 is formed of transparent material, the pressure gauge 74 on the oxygen line 16 need not extend through the wall of the case 34 but may be read through the sealed case to ascertain the supply of oxygen. Furthermore, disrepair of the apparatus can be observed without breaking the seal. Whereas one might when needed open a metal case

35 with its seal intact only to find a hose which has become disconnected through jarring of the case making the unit non-serviceable. Such obvious malfunctions can be easily detected by visual inspection through the

transparent case.

The weight of a polymeric shell 36 and cover 40 may be less than about one pound. The combined use of a polymeric case 34 and a wound fiber glass, aluminum
5 lined oxygen container 14 may reduce the weight of the unit 10 by two pounds or more. Units 10, particularly provided for respiratory patients, may be sealed in a hinged case to be opened and later closed to reestablish the hermetic seal thus preventing exhaustion of
10 scrubbing material between periods of intermittent use.

It has been found that with heavy exertion, and heavy useage of the system for a prolonged period of about an hour that the carbon dioxide level being inhaled begins to rise to a level considered to be too
15 high, e.g. about 1.5 percent by volume even though there is enough lithium hydroxide in the scrubber 30 to last for one and a half hours. Because the lithium hydroxide does not appear to be totally expended, it does not appear necessary to increase the size of the scrubber 30
20 with attendant cost increase and weight increase.

Instead, and in accordance with the invention, means have provided to increase the residence time or the transit time of the gas being exposed to the scrubber 30 while retaining substantially the same size
25 for the scrubber 30 to maintain the carbon dioxide at acceptable levels even after one hour of heavy useage of the apparatus. This is achieved in the embodiment of the invention, illustrated in FIGURES 10 and 11 by substituting an air bag 226 for the exhalation conduit
30 26 so that a larger volume of exhaled air, e.g. about 2 liters, is present and exposed for a longer period of time to the lithium oxide in the scrubber 30. More specifically, the collapsible air bag 226 of the same material as the air bag 12 is connected at one end to
35 exhalation port 24 of the mouthpiece and at the other end to the inlet port 28 of the scrubber 30. When the user exhales, the second air bag 226 will expand toward its full capacity of two liters to store air therein in

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contrast to the same exhalation breath that would have driven most of the exhaled breath through the exhalation conduit 26 which holds a very substantially smaller volume than that of the second air bag. With the

5 conduit 26 of the apparatus of FIGURES 1-9, most of the exhaled air flowed quickly through the conduit 26 and through the scrubber 30 to the air bag 15. As will be explained in connection with FIGURES 12 and 13, exhaled air stays in air bag 226 until the next inhalation and
10 this provides increased transit time and reduced flow rate through the scrubber resulting in a longer exposure of the carbon dioxide to the lithium hydroxide and a keeping of the carbon dioxide level below 1.5 percent for a substantially longer period than one hour. It is
15 preferred that air bag 12 be made smaller, e.g. to hold about 3 or 4 liters rather than 5 liters used for the bag 12 in the embodiments of FIGURES 1-9. Thus, the additional two liters in the bag 226 will pull from the bag 226 and through the scrubber 30 as the smaller bag
20 12 is being exhausted during an inhalation cycle.

Referring now to FIGURE 12, there is a diagrammatic illustration of volume and pressure of the air flow during inhalation and exhalation time periods. As measured at the mouthpiece, the exhalation volume
25 shown by the solid line curve 200 rises from about zero to a peak volume at point 201 on the curve 200 while the pressure is rising in a generally similar manner as shown by the dotted line curve 205 which has a peak 206 for the peak pressure.

30 At the mouthpiece, the inhalation cycles, shown on the negative side of a zero pressure line begins slowly and increases as shown by the dotted curved line section to a negative pressure that is greater in value than the positive pressure during exhalation. The
35 volume of scrubbed air drawn in through the mouthpiece from the bags 12 and 226 is indicated by the curved line segment 214. The inhalation and exhalation curves may be thought of generally sinusoidal.

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FIGURE 13 is a diagrammatic illustration of the carbon dioxide concentration (or level)by volume in the air being exhaled and inhaled. With the old system, during exhalation, the carbon dioxide present in

5 exhalation has little carbon dioxide therein and as the exhalation continues the exhalation becomes richer in carbon dioxide. Thus, carbon dioxide level rises from about zero at the beginning of exhalation to about 7 percent at the end of exhalation as shown by the curve

10 230 in FIGURE 13. At the end of exhalation, the percentage of carbon dioxide terminates abruptly until the next exhalation. Another dotted line 232, shows the carbon dioxide level at the inlet port to the scrubber

15 30. With about one-half of the air of the exhalation flowing into the scrubber, the percent of carbon dioxide will rise to about one-half of that for curve 230, viz. about 3 or 3-1/2 percent as represented by the dotted line curve 232 in FIG. 13. With the second bag, the scrubbing action continues during the subsequent

20 inhalation and the air pulled from the bag 226 begins at 3-1/2 percent and drops as it is scrubbed to zero percent carbon dioxide, as shown by the dotted line 234.

The user, e.g., a miner, should check his unit

25 10 daily for the integrity of protective adhesive seals which are placed over the junction of the shell 36 and cover 40, for change of color of the moisture indicator 115 within the case 34, for dust or moisture within the case, the pressure of oxygen within the cylinder 14, as read by the gauge 74, and the condition of the apparatus

30 within the case 34. In times of emergency, the user breaks the seal and removes the cover 40. He dons the unit 10 by placing the harness 42 over his neck and body harness around his body and quickly turns the knob 47 opening the on-off valve 46 thereby inflating the air

35 bag 12. To limit inhalation to his mouth, he clamps a nose clip 119 to his nostrils. Preferably the nose clip is loosely attached closely adjacent to the mouthpiece for ready availability. He inserts the flange 82 of the

mouthpiece 22 and grips the bits 84 with his teeth, and inhales a breath of substantially pure oxygen.

Thereafter the user makes any necessary further adjustments in his harness 42 and continues to breathe
5 through the mouthpiece 22 until the emergency has passed. Where possible, the user may aid in his own rescue, his arms being free to take the steps necessary to extricate himself. Under heavy exertion, the supply of oxygen is sufficient to last more than a full hour.
10 Also, with second air bag the carbon dioxide level may be kept low, i.e. below 1.5 percent, even with heavy exertion by the user. If the situation precludes self extrication, the user should remain as passive as possible to minimize his oxygen intake, and if fully
15 passive, may extend the life of the oxygen supply to upwards of six hours. If the area is ventilated, albeit poorly, the user may further prolong the life of his oxygen supply by intermittently relying on the ambient atmosphere and periodically turning on the on-off valve
20 46 and inhaling from his unit 10.

In accordance with a further aspect of the invention, the transparent plastic case may be made with anti-static properties to reduce the likelihood charge of static electricity being accumulated on the case and
25 causing a subsequent spark discharge. To this end, it is preferred to add an anti-static additive to the plastic being molded into the cover so that ultimate cover is more electrically conductive and less of an electrical insulator on to which static electricity may
30 collect and build.

All of the components of the apparatus are reusable. The oxygen bottle 12 is replenishable through the inlet fitting 50 attachable to an exterior source of pressurized oxygen. The scrubber 30 is rejuvenated
35 merely by removing for replacement or by removing the cover 90 and replacing the charge 94 of filtering material. Reusability is particularly advantageous for patients subject to repetitive short term needs over a

long period of time. After exhaustion of a supply of oxygen, the unit 10 is returned to the manufacturer's representative for service including oxygen charging, scrubbing charge replacement and case resealing. By
5 providing substantially completely reusable equipment, the cost to the consumer is kept down. The cost is further minimized by the user controlled on-off valve 46 which permits intermittent use of the apparatus over extended periods between recharging.

10 While the invention has been described in terms of a preferred embodiment, modifications obvious to one with ordinary skill in the art may be made without departing from the scope of the invention. For example, while the carbon dioxide scrubber has been described in
15 terms of a lithium hydroxide scrubber, other substances are known which react with air-carried carbon dioxide, and scrubber charges utilizing other substances may be used.

Various features of the invention are set forth
20 in the following claims.

CLAIMS:

1. A portable emergency breathing apparatus comprising: a carrying means for said apparatus, a high pressure container for containing a supply of oxygen, a demand regulator means for controlling the flow of
5 oxygen from said container in accordance with the demands of the user, an air bag for containing a supply of breathable air and for receiving oxygen from said container, scrubbing means for scrubbing carbon dioxide from the exhaled air from the user and connected to said
10 air bag to return scrubbed air to said breathing bag, mouthpiece means connected to said breathing bag to allow the user to intake air therefrom and connected to said scrubbing means to deliver exhaled air thereto, and valve means operable by the user to start and to stop
15 the flow of oxygen from said container in accordance with the needs of the user.
2. An apparatus in accordance with Claim 1 in which a conduit means for carrying air to said mouthpiece means bypasses said scrubbing means to
20 deliver air directly from said breathing bag to said mouthpiece means without passing through said scrubbing means.
3. An apparatus in accordance with claim 1 or claim 2 which said carrying means comprises a hermetically
25 sealed case of transparent plastic.
4. An apparatus in accordance with any of claims 1 to 3 in which said high pressure container is formed with a wound strengthening member of a non-metallic synthetic material to hold oxygen at high pressures.
- 30 5. An apparatus in accordance with any of claims 1 to 4 in which said high pressure container is provided with means for connection to a charging device for refilling the container for reuse.
6. An apparatus in accordance with any of claims 1 to 5 in
35 which said scrubbing means includes a metal container having a carbon dioxide reactive material therein and in which said metal container is configured to provide heat

radiation to transmit the heat being generated during the carbon dioxide reaction.

7. A portable emergency breathing apparatus comprising: carrying means for said apparatus including
5 a sealed case, a high pressure container for containing oxygen gas under high pressure, an air bag connected to said container for receiving oxygen therefrom, a mouthpiece means for insertion in the mouth of the user and for connection to said air bag for receiving air
10 from said air bag, and scrubbing means connected to said mouthpiece for receiving exhaled air and for removing carbon dioxide therefrom for reuse by the user, said scrubbing means including a layer of molecular sieve material for purifying the exhaled air which may contain
15 a considerable amount of hydrocarbons initially during initial use, reaction material for reacting with the carbon dioxide, and another layer of molecular sieve material following the carbon dioxide reactive material.

20 8. An apparatus in accordance with Claim 7 in which said molecular sieve comprises a zeolite material and said carbon dioxide reactive material comprises lithium hydroxide.

9. An apparatus in accordance with claim 7 or claim 8
25 which said scrubbing means includes a metal cannister exposed to radiate heat therefrom.

10. In combination, emergency breathing apparatus and a case therefore, said breathing apparatus comprising an air bag for containing a supply of
30 breathable air, a high pressure oxygen container formed of a metal and non-metalic synthetic material in fluid communication with said air bag to deliver oxygen thereto, an inhalation means connected to said air bag and an exhalation means connected to said scrubbing
35 means, said inhalation means having a one-way valve which opens when the user inhales and closes when the user exhales, said exhalation means having a one-way valve which opens when the user exhales and closes when

the user inhales, said case including a shell formed of a polymeric material and means to attach said breathing apparatus thereto, a cover formed of a polymeric material, and sealing means interposed between said shell and said cover for maintaining a hermetically sealed region around said breathing apparatus prior to use.

11. A combination in accordance with Claim 10 wherein at least one of said shell and said cover are formed of a transparent polymeric material.

12. A combination in accordance with Claim 11 wherein said polymer is polycarbonate.

13. A combination in accordance with any of claims 10 to 12 wherein said oxygen container is provided with means for refilling the container for reuse.

14. A combination in accordance with any of claims 10 to 13 wherein said scrubbing means comprises a cannister and a charge of carbon dioxide reactive material contained therein, said cannister having a coating of radiation material to transfer heat from the exterior of said cannister.

15. Emergency breathing apparatus comprising an air bag for containing a supply of breathable air, an oxygen container and a conduit connecting the same to said air bag, a mouthpiece means having an inhalation valve means and an exhalation valve means, said inhalation valve means having a valve which opens when the user inhales and closes when the user exhales, said exhalation valve means having a valve which opens when the user exhales and closes when the user inhales, an inhalation conduit connecting said air bag to said inhalation valve means, scrubbing means for removing carbon dioxide from a mixture of gases, said scrubbing means having a cannister, a charge of carbon dioxide reactive material contained therein, an inlet port and an outlet port, an exhalation conduit connecting said exhalation valve means to said inlet port of said scrubbing means, and a return conduit connecting said

outlet port of said scrubbing means to said air bag.

16. Apparatus in accordance with Claim 17 wherein said inhalation valve provides greater resistance to breathing than said exhalation valve.

5 17. Apparatus in accordance with Claim 16 wherein said inhalation valve is an umbrella valve and said exhalation valve is a disc valve.

18. A portable emergency breathing apparatus comprising: a carrying means for said apparatus, a high
10 pressure container for containing a supply of oxygen, a first air bag for containing a supply of breathable air and for receiving oxygen from said container, a scrubber for scrubbing carbon dioxide from the exhaled air from the user and connected to said air bag to return
15 scrubbed air to said breathing bag, a mouthpiece connected to said breathing bag to allow the user to intake air therefrom and connected to the scrubber to deliver exhaled air thereto, and a second air bag connected to the mouthpiece for receiving exhaled air
20 containing carbon dioxide from the mouthpiece and connected to the scrubber to deliver air thereto to increase the transit time of the exhaled air through the scrubber.

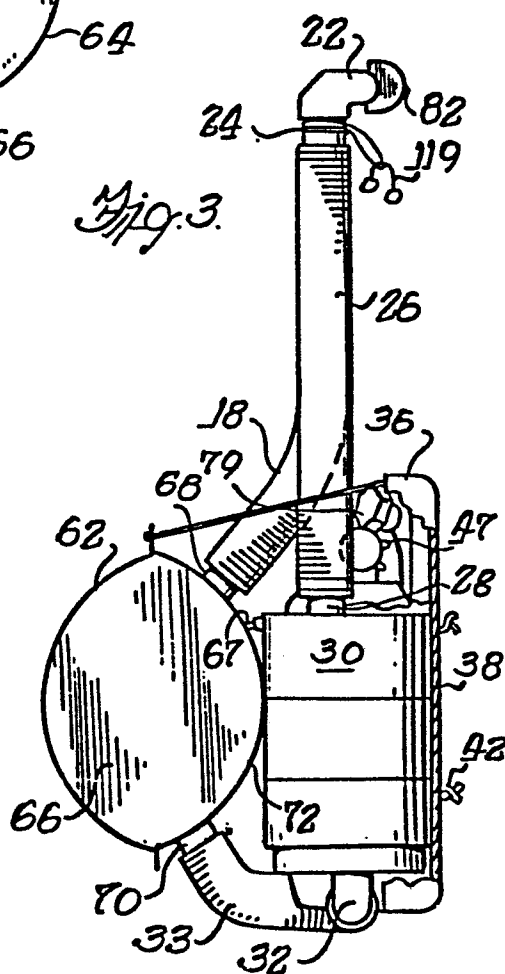
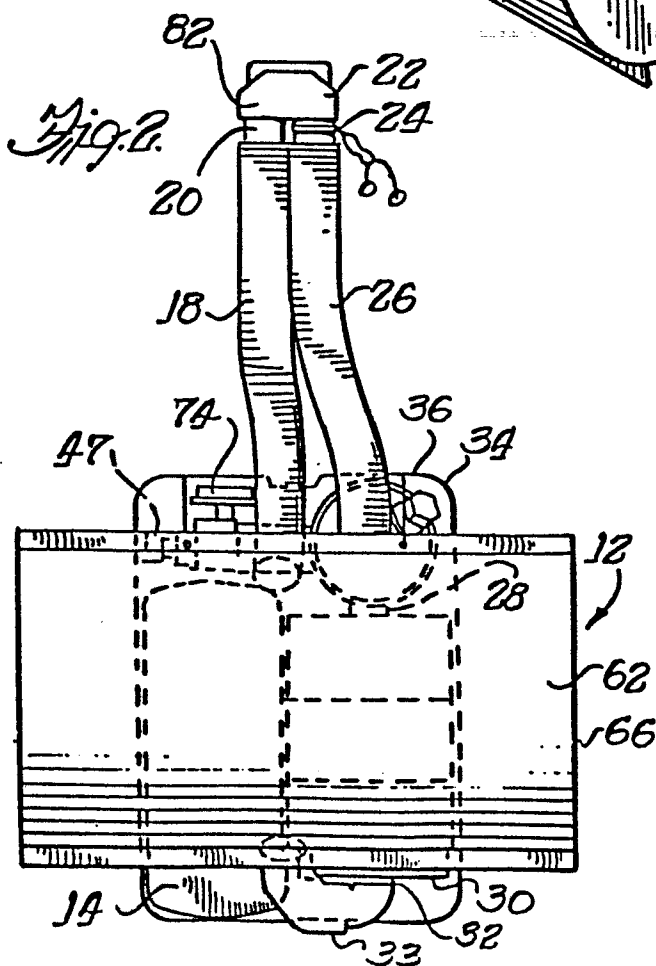
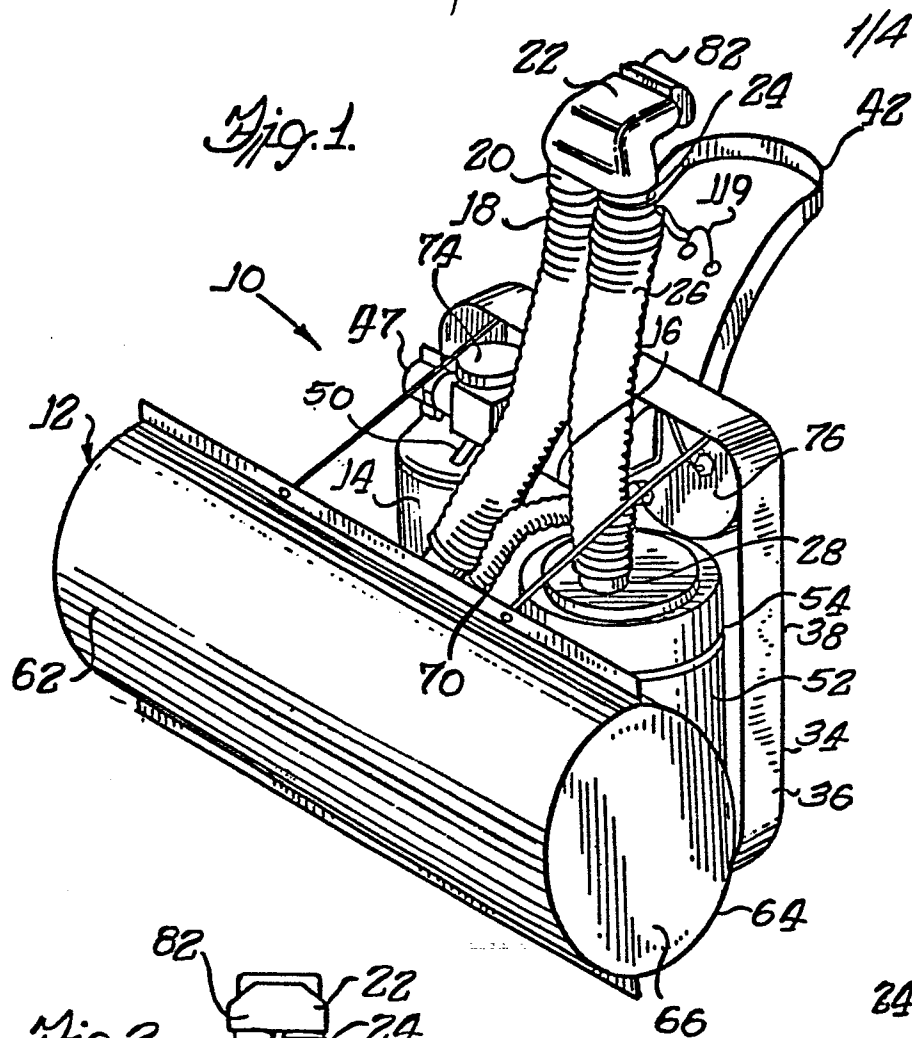
19. An apparatus in accordance with Claim 18 in
25 which the air bag is expandable and collapsible for holding an expanded volume of about two liters of air.

20. A portable emergency breathing apparatus comprising: a carrying means for said apparatus, a high pressure container for containing a supply of oxygen, an
30 air bag for containing a supply of breathable air and for receiving oxygen from said container, scrubbing means for scrubbing carbon dioxide from the exhaled air from the user and connected to said air bag to return scrubbed air to said breathing bag, mouthpiece means
35 connected to said breathing bag to allow the user to intake air therefrom and connected to said scrubbing means to deliver exhaled air thereto, the container being a composite container having a metal layer and a

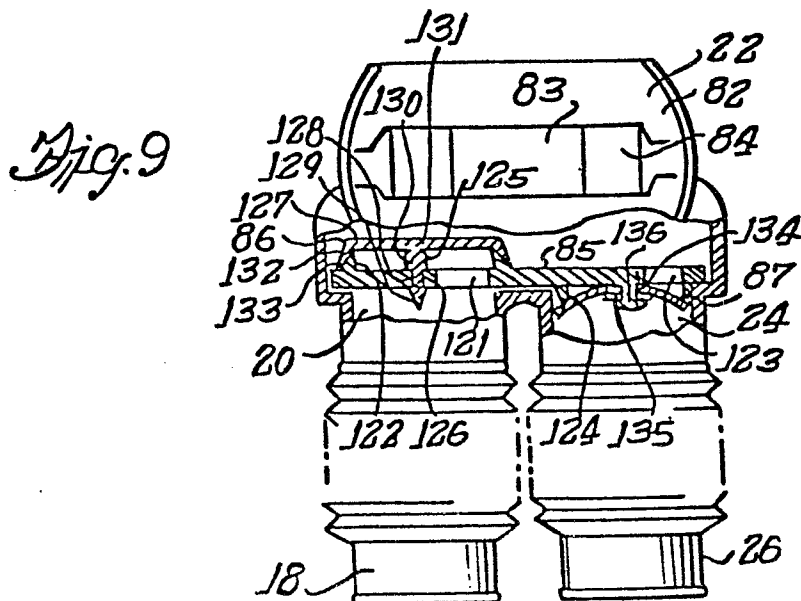
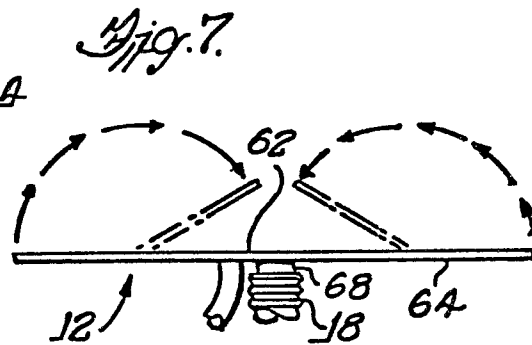
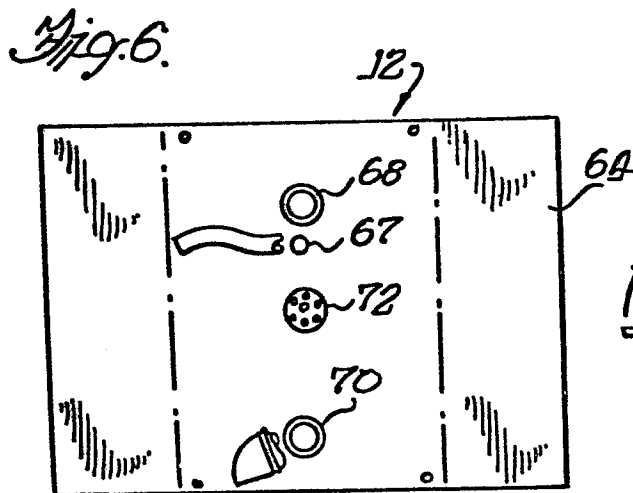
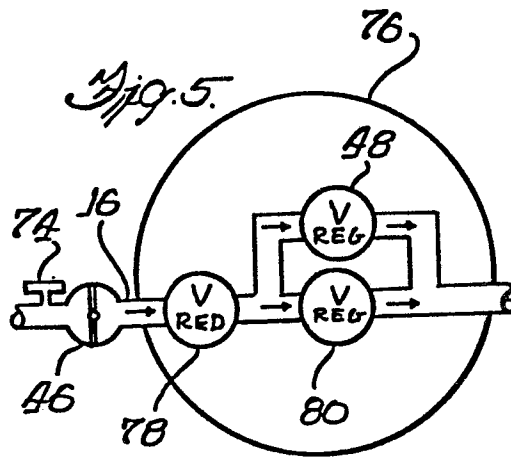
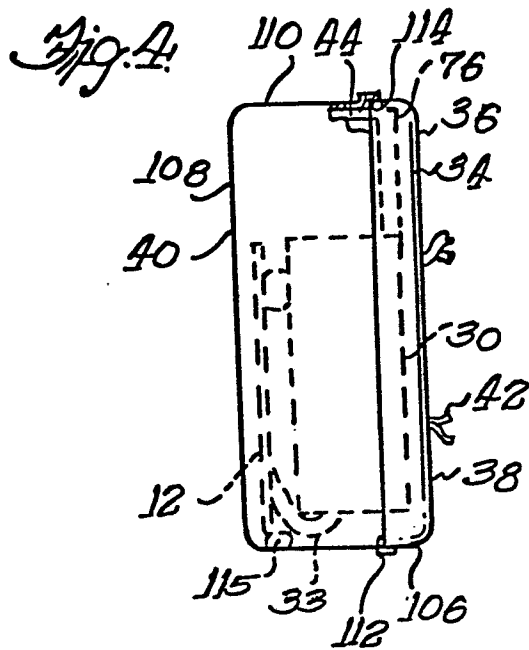
wound outer layer to hold the oxygen at a predetermined pressure.

- 5 21. An apparatus in accordance with Claim 20 in which said carrying means comprises a plastic case for holding the apparatus and antistatic means for the plastic case to reduce buildup of static electrical charges on the plastic case.

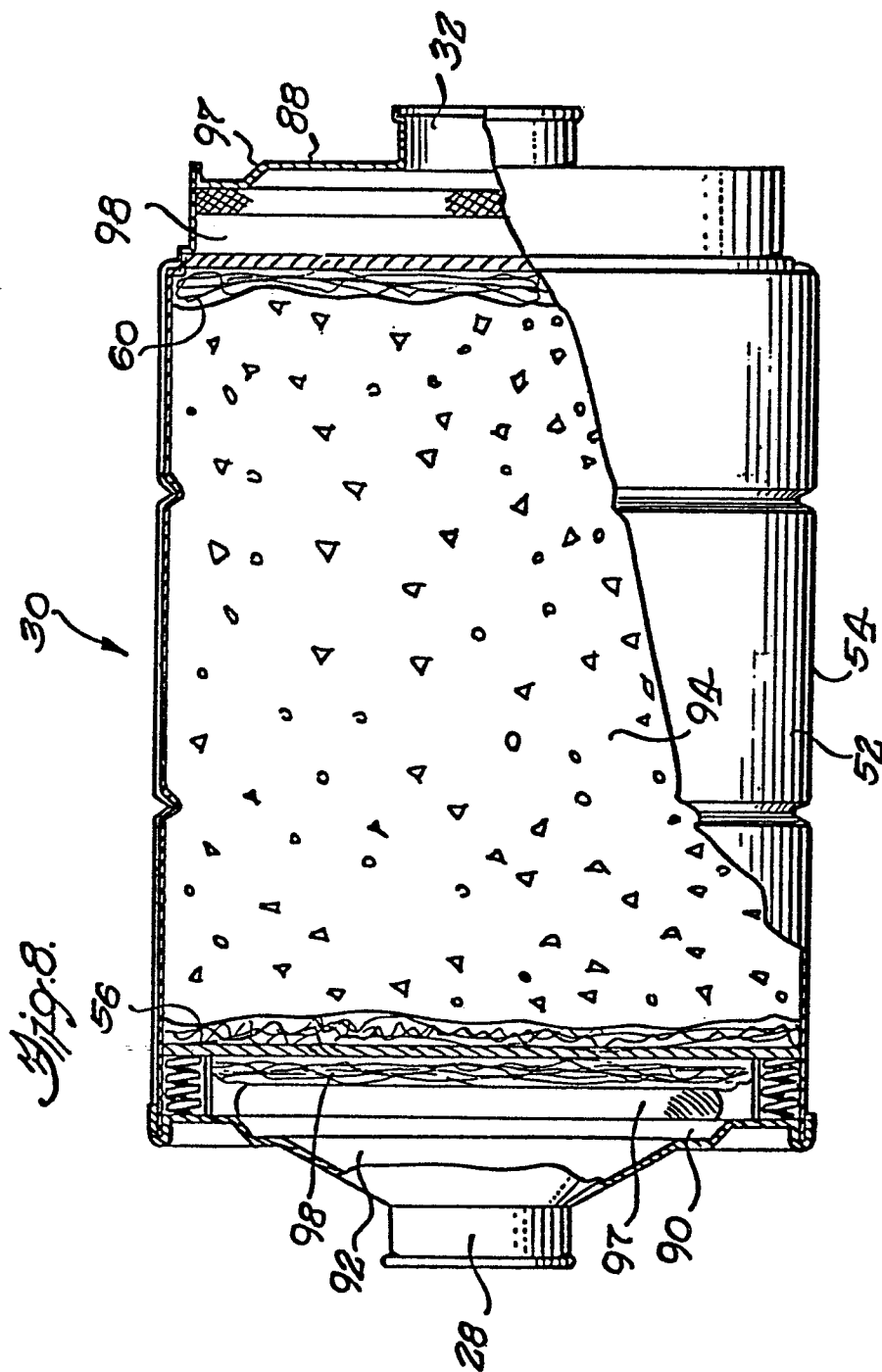
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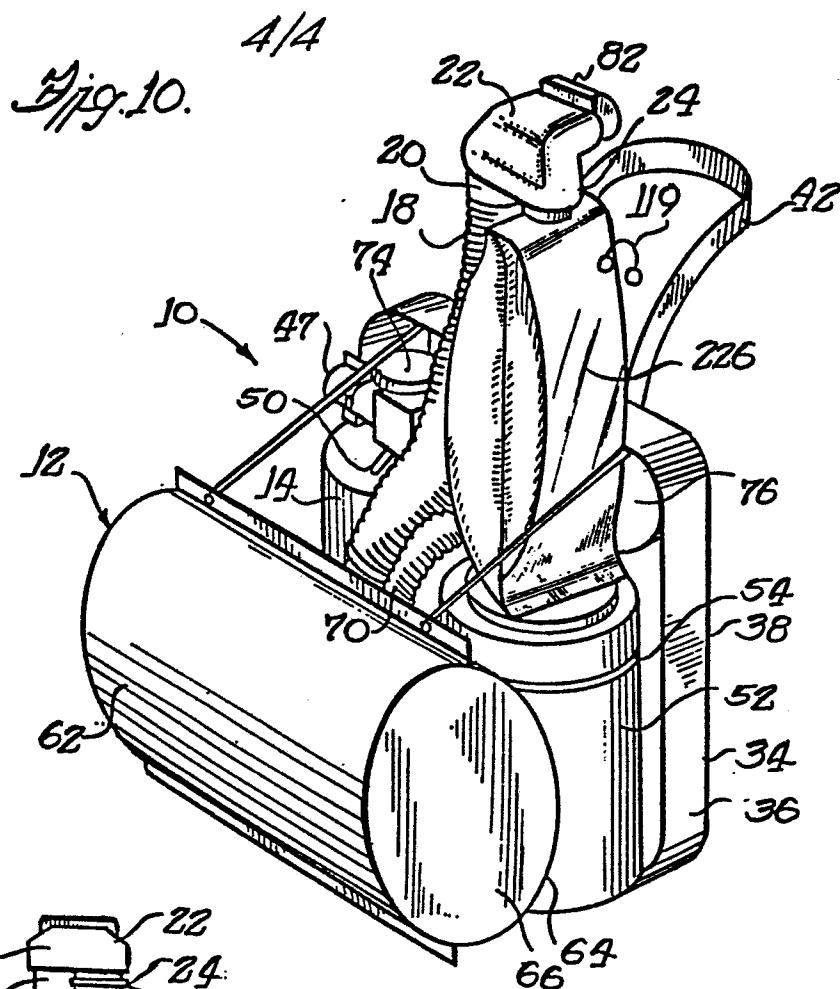


Fig. 11.

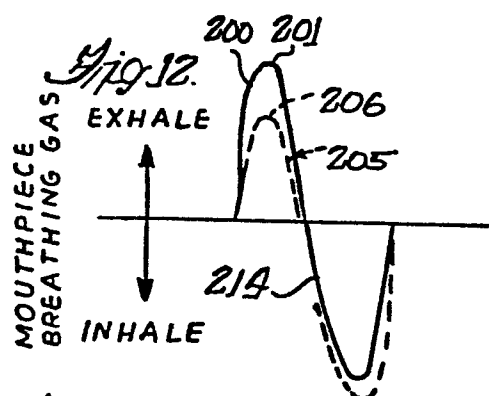
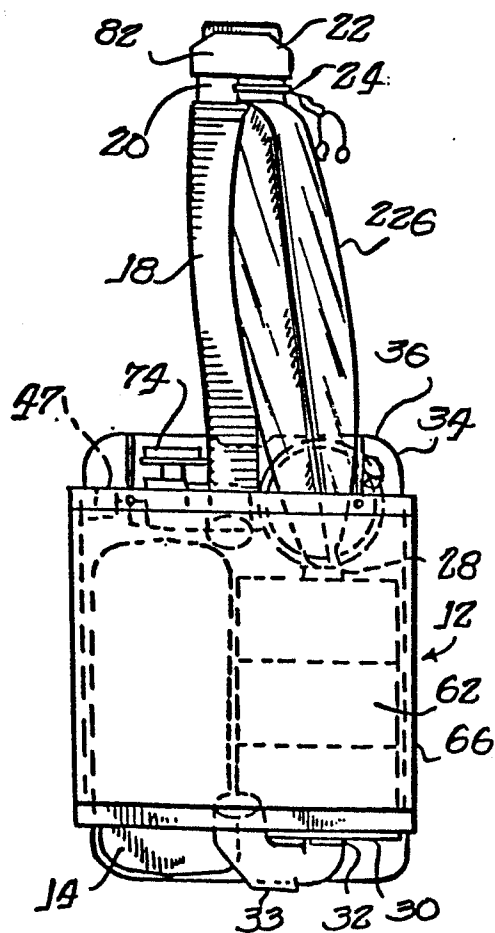
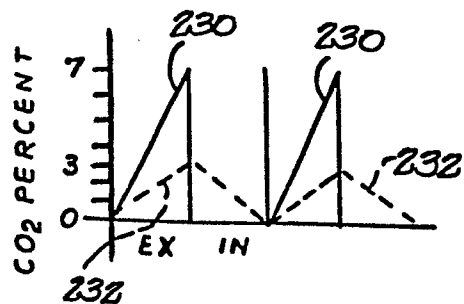


Fig. 13.





European Patent
Office

EUROPEAN SEARCH REPORT

0079709
Application number

EP 82 30 5745

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	--- US-A-1 625 419 (McCAA) * Whole document *	1,2,6, 7,10, 15,20	A 62 B 7/04 A 61 M 16/00
X	--- US-A-4 154 234 (BAKER) * Claim *	1,18, 19	
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The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 26-01-1983	Examiner KANAL P K
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			



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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
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