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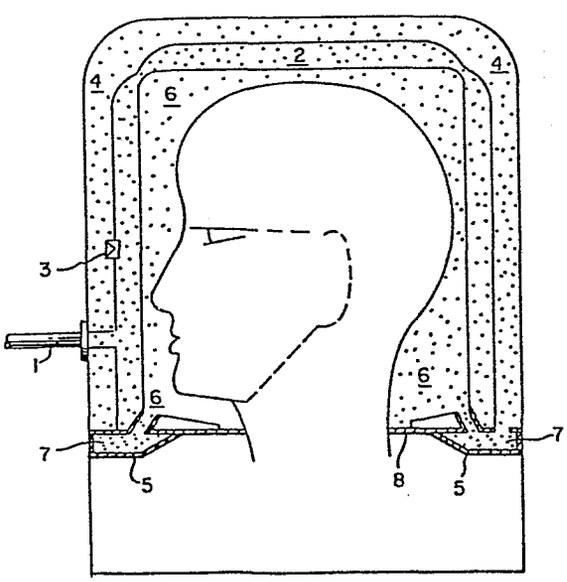
## (54) Decompression and toxic fume protection apparatus.

(57) Apparatus comprising an inner chamber (6) adapted to surround the head of the wearer, an inflatable and concentric outer chamber (2), a gas reservoir (4), means for removal of carbon dioxide (5) and passageways for the circulation of gas through the apparatus.

F I G. 1




EP 0 197 641 A1

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# Decompression and Toxic Fume Protection Apparatus

## Background of the Invention

A continuing concern for the aircraft industry is apparatus for the protection of passengers against either decompression in flight or toxic fumes resulting from on-board fires. Previously, oxygen masks and other apparatus have been provided for passenger use. However, previous apparatus do not satisfy the need for individual smoke protection of 30 minutes or more, and the size and weight of apparatus previously available has limited its use in aircraft. Typically the ratio of equipment poundage to minutes of protection was on the order of 1:0.5 to 1:3. In addition, much of the equipment previously available for decompression or toxic fume protection is complicated to use and might be of limited value to an aircraft passenger in an emergency situation. Accordingly, a continuing need exists for an uncomplicated, light-weight apparatus that will provide extended protection against toxic fumes in an aircraft environment. Similarly, a need exists for such an apparatus in a variety of other applications such as hotels and hospitals in which it may be necessary to escape from a smoke-filled environment with an apparatus that provides at least about 30 minutes of breathable air for the user.

## Summary of the Invention

The present invention provides an improved apparatus for protection against decompression and toxic fumes, particularly in an aircraft environment, which permits more complete utilization of available oxygen.

Specifically, the instant invention provides a breathing device having an inner chamber and an

inflatable outer chamber concentric with and surrounding the inner chamber, the inner and outer chambers being adapted to surround the head of a wearer;

a gas reservoir;

a gas inlet leading to the outer chamber and a valve permitting gas to flow from the outer chamber to the reservoir; and

a passageway to permit gas to flow between the reservoir and the inner chamber through a $CO_2$ removal means,

the outer chamber being inflatable to a rigidity sufficient to maintain substantially constant volume of the inner chamber while the wearer is breathing.

## Brief Description of the Drawings

Fig. 1 is a cross-sectional view of a breathing device of the present invention having a $CO_2$ removal means in a circumferential configuration surrounding the neck of the wearer.

Fig. 2 is a cross-sectional view of a breathing device of a present invention wherein the $CO_2$ removal means is positioned adjacent to the gas inlet.

Fig. 3 is a planar view of the details of construction that can be used for the inflatable outer chamber of the present devices.

## Detailed Description of the Invention

The present invention provides a breathing device having concentric inner and outer chambers. The outer chamber is inflatable to a rigidity sufficient to maintain a substantially constant volume of the inner chamber while the wearer is breathing. The device also includes a reservoir connected to the inner chamber by way of a carbon dioxide removal means.

A wide variety of materials can be used for $CO_2$ removal. These include, for example, alkali metal hydroxides and oxides and sodium carbonate. Of these, the lithium and sodium salts are preferred, and lithium hydroxide in particulate form is particularly preferred. In addition, $CO_2$ absorbants in liquid or gel form can be used. The quantity of $CO_2$ absorbant used will vary according to the absorbant selected and the capacity of the hood. In general, about from 50 to 500 grams can be used in the present invention. It has been shown that about from 3 to 4 grams of lithium hydroxide are required for removal of carbon dioxide during each minute of closed circuit breathing in an environment of substantially pure oxygen. Preferably, about from 75 to 150 grams of $CO_2$ absorbant are used in the present devices.

The $CO_2$ removal means can be integrated into the present breathing device in a wide variety of configurations. The $CO_2$ removal means can be contained in a separate chamber positioned, for example, as a ring around the neck of the wearer. In another embodiment, the $CO_2$ removal means can be exterior to the remainder of the hood structure, for example, in a compartment, canister or hose adjacent to the inlet. The positioning of the $CO_2$ removal means exterior to the hood permits the replacement or renewal of the $CO_2$ removal means for reuse of the hood.

In accordance with a preferred embodiment of the present invention, a breathing device is provided which consists of three concentric chambers, the chambers being designated as an inner chamber, an inflatable outer chamber and a reservoir. The inner chamber is nested within the inflatable chamber which is nested within the reservoir. In the operation of

the breathing device, gas is passed from an outside source, such as the fresh air and/or oxygen supply on an aircraft, to the inflatable outer chamber of the breathing device. The outer chamber is inflatable to a rigidity sufficient to maintain substantially constant volume of the inner chamber within the breathing device while the wearer is breathing.

A valved mechanism is provided to permit passage of the gas, whether fresh air, oxygen enriched air, or pure oxygen, from the outer chamber to the reservoir. A passage is also provided from the reservoir, through a $CO_2$ removal means, to the inner chamber. Accordingly, with the breathing of the wearer, oxygen and/or air is drawn only from the reservoir. In this manner, the inflatable outer chamber is kept at substantially constant volume while the wearer is breathing.

In the breathing cycle, inhalation by the wearer draws air from the reservoir, through the $CO_2$ removal means, and into the inner chamber. The exhaling pressure of the wearer forces exhaust air through the carbon dioxide absorber, and back to the reservoir.

The invention can be more clearly understood by reference to the drawings, in which like numbers are used for like elements in the figures.

In Figure 1, gas is supplied through inlet 1, from a source, not shown, of fresh air, oxygen, or both, to inflatable outer chamber 2, surrounding the head of the wearer. When the inflatable outer chamber is substantially fully inflated, the gas passes through valve 3 into reservoir 4, here shown as an additional outer concentric chamber. Inhaling of the wearer causes flow from the reservoir through $CO_2$ removal means 5 to inner chamber 6. Exhaling by the

wearer causes passage of exhaust breath back through the $CO_2$ removal means and to the reservoir. The $CO_2$ removal means is here illustrated as an annular ring, containing $CO_2$ absorbant 7, through which the air is circulated in its passage between the reservoir and the inner chamber. The hood is also provided with annular neck seal 8.

Another embodiment of the invention is illustrated in Figure 2, in which the $CO_2$ removal means is exterior to the inner, outer and reservoir elements surrounding the head of the wearer, and is in the form of canister 21 containing $CO_2$ absorbant 22.

The outer chamber is inflatable to a rigidity sufficient to maintain substantially constant internal volume while the wearer is breathing. A typical construction which can be used for this function is illustrated in Figure 3, in which the reservoir is fabricated from two layers of thermoplastic material 31 and 32, the two layers being heat sealed at seams 33 to provide a plurality of pockets 34 having upper and lower portions 34A and 34B. Alternatively, the sheets can be adhesively bonded as required. The area between the upper and lower portions is sealed together to provide visibility band 35. The visibility band is interrupted by full length air pockets 36 which increase the rigidity of the structure when inflated.

A wide variety of construction materials can be used for the breathing devices of the present invention. Particularly satisfactory are polymeric films, such as polyethylene, polypropylene, nylon, polyvinyl chloride, polyurethane, fluoropolymers and polyethylene terephthalate. Such films are particularly useful in forming the inflatable outer chamber. Heat resistant materials such as polyimide

films are preferably used for the exterior wall of the breathing device. Those films commercially available from E. I. du Pont de Nemours and Company as Kapton polyimide films have been found to be particularly satisfactory. The exterior surface of the breathing device can be metalized for further heat reflectivity, using techniques well known in the art.

The breathing devices of the present invention provide several advantages over similar devices previously known in the art. The present devices permit, through the inflatable outer chamber, a constant volume while the wearer is breathing. Moreover, with the carbon dioxide removal means integrated into the breathing device, upon disconnecting the device from the gas supply, maximum utilization of the oxygen in the gas contained within the hood can be obtained. Without the $CO_2$ removal means, the available oxygen can be utilized to a substantially lesser extent, with increasing build-up of carbon dioxide.

The breathing devices of the present invention can be used in a wide variety of applications, including aircraft cabin interiors, hospitals, and residential and commercial interiors. When used in conjunction with a gas source, such as those available on an aircraft, the user can breathe in a toxic fume environment or in a decompression situation for virtually unlimited periods of time. Upon disconnection from a gas source, up to about 45 minutes of breathable and usable air, with the carbon dioxide removal means, are available.

The present hoods can be safely stored for extended periods without deterioration of their operating capabilities. However, it is preferred that the hoods be stored in a sealed container to insulate the devices from changes in environmental conditions.

The present apparatus makes more effective use of the oxygen supply systems currently in place on commercial aircraft for decompression protection. The oxygen masks previously provided on aircraft provide the user with a mixture of oxygen and ambient air, while the present devices provide the user with a substantially pure oxygen for decompression as well as smoke protection. Moreover, the present invention does not require a pump or pressure source for operation of the $CO_2$ removal means once the hood has been fitted.

CLAIMS

1. A breathing device, comprising an inflatable outer member surrounding and defining an inner chamber, a gas reservoir, a gas inlet to the outer member and a valve permitting gas to flow from the outer member to the reservoir, and a passageway to permit gas to flow between the reservoir and the inner chamber through a $CO_2$ removal means, the outer member being inflatable to a rigidity sufficient to maintain substantially constant the volume of the inner chamber while the wearer is breathing.

2. A breathing device according to claim 1, wherein the $CO_2$ removal means is disposed within a ring around the neck of the wearer.

3. A breathing device according to claim 1, wherein the $CO_2$ removal means is in a container exterior to the body of the breathing device.

4. A breathing device according to claim 1 or 2, comprising 50 to 500 grams of $CO_2$ removal means selected from alkalai metal hydroxides and oxides and sodium carbonate.

5. A breathing device according to claim 4, wherein the $CO_2$ removal means comprises lithium hydroxide.

6. A breathing device according to claim 4 or 5, comprising 75-150 grams of particulate $CO_2$ removal means.

7. A breathing device according to any preceding claim, wherein the reservoir comprises a chamber at least partially surrounding the inflatable outer member.

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FIG. 1

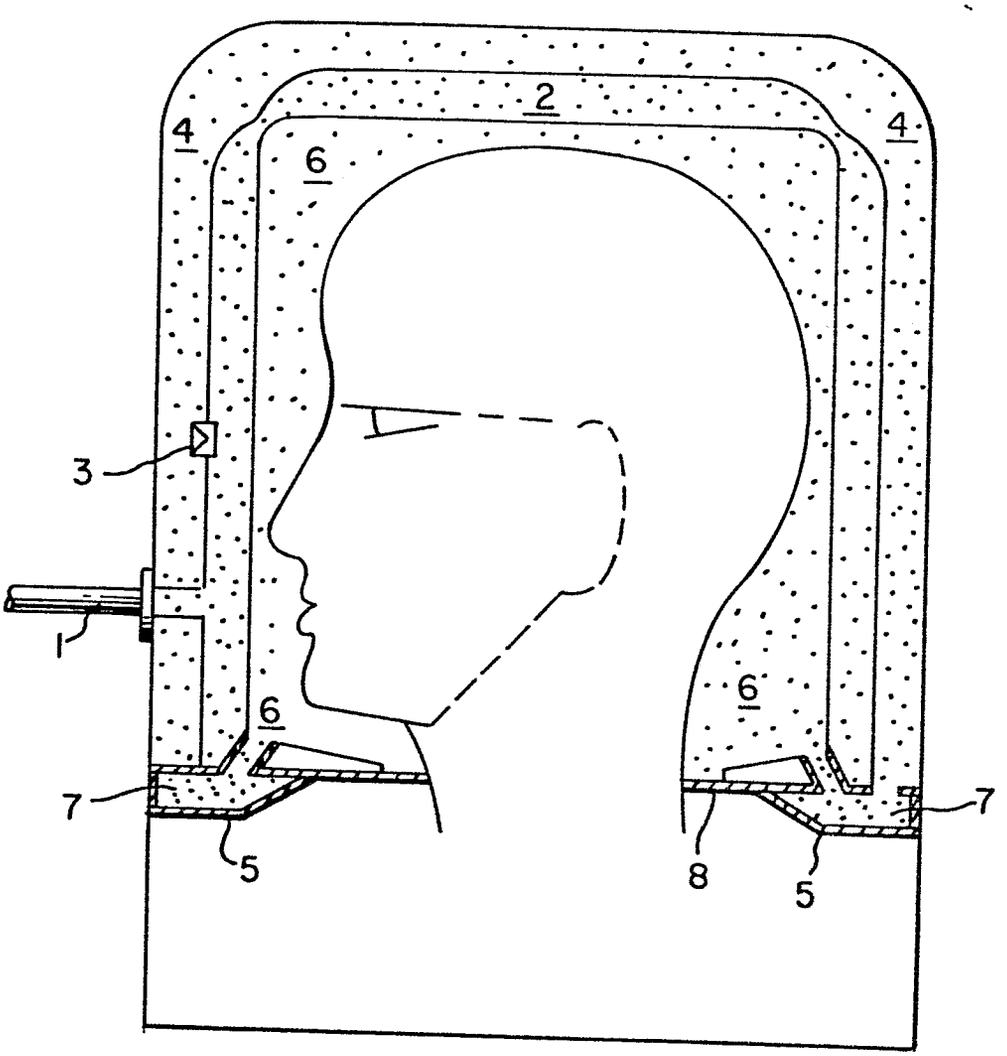

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FIG. 2

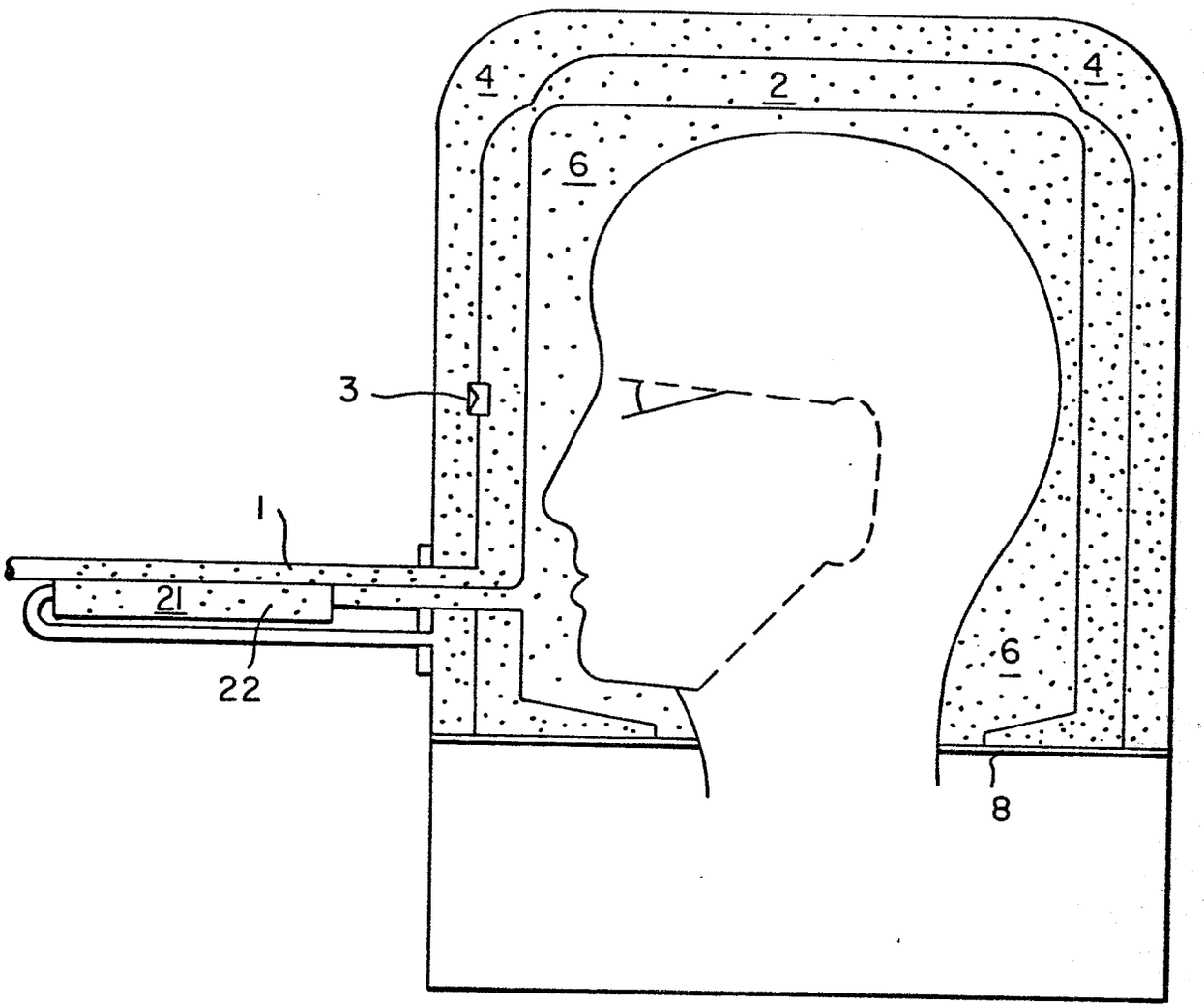
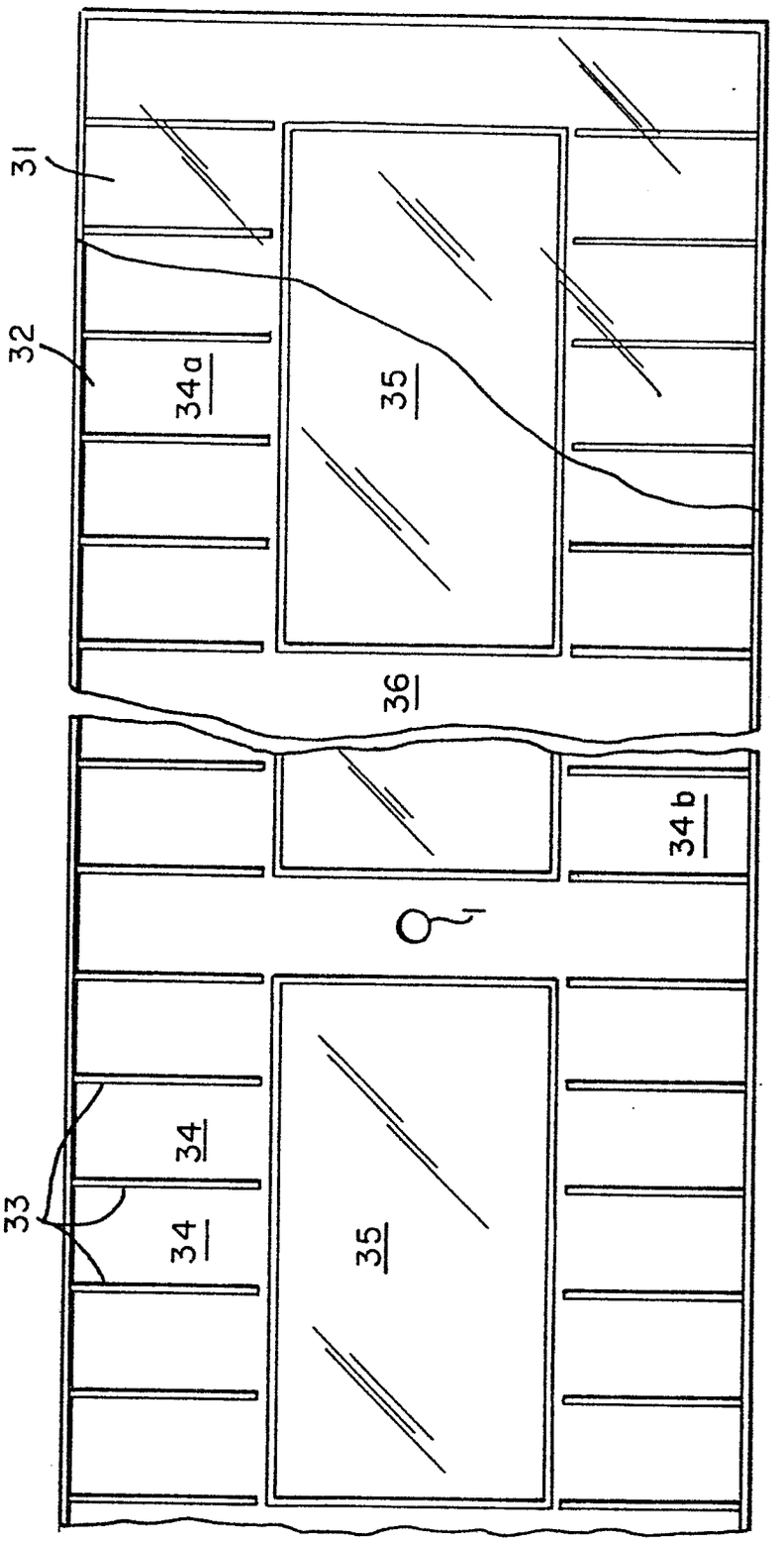


FIG. 3



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# EUROPEAN SEARCH REPORT

0197641
Application number

EP 86 30 1282

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.4) |
|---|---|---|---|
| A | US-A-3 976 063 (HENNEMAN et al.) * claims 1, 4; figure 7 * | 1,3 | A 62 B 7/08<br>A 62 B 17/04 |
| A | US-A-3 565 068 (BICKFORD) * claim 1; figure 1 * | 1 | |
| A | DE-C- 647 560 (GIRAUDET DE BOUDEMANGE) * claim; figures 1, 2 * | 1 | |
| A | US-A-4 164 218 (MARTIN) * claim 1; figures 1, 2 * | 1 | |
| A | FR-A-1 599 791 (COMMISSARIAT A L'ENERGIE ATOMIQUE) * claim 1; figure * | 1 | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| A | US-A-3 895 625 (DELEST) * claim 1 * | 1,2,4 | A 62 B 7/00<br>A 62 B 17/00<br>A 62 B 18/00<br>A 62 B 19/00 |
| A | US-A-3 906 945 (NETTELAND et al.) * claim 1 * | 4,5 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 20-06-1986 | KANAL P K |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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