

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
15 November 2007 (15.11.2007)

PCT

(10) International Publication Number
WO 2007/128571 A2

(51) International Patent Classification:
A61M 16/00 (2006.01) *A61M 16/06* (2006.01)

(21) International Application Number:
PCT/EP2007/004064

(22) International Filing Date: 8 May 2007 (08.05.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/798,607 8 May 2006 (08.05.2006) US

(71) Applicant (for all designated States except US): **MEDIZINISCHE UNIVERSITÄT INNSBRUCK** [AT/AT];
Christoph-Probst-Platz 1, A-6020 Innsbruck (AT).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **KOCH, Robert**
[—/AT]; Wetterherrenweg 16b, A-6020 Innsbruck (AT).

(74) Agent: **VOSSIUS & PARTNER**; Siebertstrasse 4, 81675
Munich (DE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **HELMET**

(57) **Abstract:** A helmet is provided which comprises a housing in which a person's head can be received. The housing is made of a flexible material. The helmet further comprises a collar means for air-tight application to the person's neck, an air inlet means and an air outlet means. The air inlet means is adapted to be connected to an air pump which can be preferably operated by hand and/or by foot and/or an air tank for providing an overpressure within the helmet. The air pump can preferably be disassembled for ease of transportation or in order to provide storage means, such as a sealable drinking bottle.



WO 2007/128571 A2

Helmet

The present invention relates generally to a helmet for respiration wherein air is filled in the helmet from the outside, so that a person wearing the helmet can be provided with air. In particular, the present invention relates to a helmet which can be used for person's suffering under acute mountain sickness (AMS).

Commonly, helmets for artificial respiration are known as shown, e.g., in US 2005/0199235 A1. Such helmets are used generally in medicine in reanimation, intensive care and pneumology units. The helmet as disclosed in US 2005/0199235 A1 comprises a container body in which a patient's head can be housed. Further, the helmet comprises a collar for air-tight application to the patient's neck. The collar consists of a rigid ring equipped with a series of connections. The connections are adapted to be connected to a ventilation machine and further to devices such as catheters.

In EP 1 279 411 A2 a helmet for artificial respiration is disclosed which comprises a containment body which includes an air intake port that can be connected to a ventilation apparatus and an outlet port. The front portion of the helmet is made of a semi-rigid material which is preferably non-deformable. Further, the helmet comprises a base ring which is anatomically contoured and which further includes a sealing collar.

Further, in EP 1 170 026 a helmet for artificial respiration is disclosed which comprises a containment body which has an air intake to be connected to a ventilation apparatus and an outlet. The helmet further comprises a suffocation-preventing valve which is suitable to connect the inside of the containment body to the outside if a pressure below a pre-settable value occurs inside the helmet.

However, such helmets are neither intended nor suitable to be used for persons suffering under acute mountain sickness (AMS).

Acute mountain sickness (AMS) relates to a family of related medical conditions that sometimes develop when people travel to altitudes above 2500m. There is a wide variation

in both the speed of onset, the severity of symptoms and also the height at which they occur - this is different for each person. The problems are caused by lack of oxygen.

Most people feel at least a little unwell if they drive, fly or travel by train from sea level to 2500m. Headache, fatigue, undue breathlessness on exertion, the sensation of the heart beating forcibly, loss of appetite, nausea, vomiting, dizziness, difficulty sleeping and irregular breathing during sleep are the common complaints. These are symptoms of acute mountain sickness, which usually develop during the first 36 hours at altitude and not immediately on arrival. Well over 50% of travellers develop some form of AMS at 3500m, but almost all do so if they ascend rapidly to 5000m.

There is unfortunately no way of predicting whom AMS will seriously trouble and who will escape it. In less than 2% of travellers AMS occurs in several serious forms at 4000m to 5000m and occasionally lower. High altitude pulmonary edema (HAPE) is one, in which fluid accumulates in the lungs and causes severe illness (which may come on in minutes) recognised by breathlessness and sometimes a bubbling sound in the chest.

Early pulmonary edema should be suspected if breathlessness at rest occurs or if someone has what appears to be a persistent cough or chest infection causing breathlessness. Patients with pulmonary edema are dangerous ill and should be treated as an emergency and evacuated to a lower altitude. Frequently treatment with portable hyperbaric chambers and a descent of only 500m is sufficient to improve the situation dramatically.

High altitude cerebral edema (HACE) is another form of AMS. It is due to fluid collecting within the brain causing the victim to become irrational, drowsy and confused over a period of hours – their walking will become unsteady and double vision, headaches and vomiting may occur. Again, the condition is a serious one and evacuation to low altitudes mandatory. Portable hyperbaric chambers and steroid drugs such as dexamethasone are used in treatment.

In the prior art portable hyperbaric chambers are known such as the Gamow bag, the Certec bag and the PAC (Portable Altitude Chamber) which are used to treat severe forms of altitude illness. They are all similar to the extent that they are air-impermeable bags that

completely enclose the patient, and are inflated to a significant pressure above ambient atmospheric. This effects a physiological “descent”. This can be demonstrated with an altimeter inside the bag, and marked improvements in oxygen saturation are measurable with a pulse oximeter. The extent of the descent depends on the altitude at which the bag is used, as an example, at 4250m (14,000 ft), the inside of the bag is equivalent to 2100m (7,000ft).

Typical treatment protocols are to put the patient into the bag, pump it up until the pop-off valves hiss, and keep the patient at a pressure for one hour. Unless your bag has a CO₂ scrubber system, you need to continue pumping several times per minute to flush fresh air through the system. At the end of the hour, the patient is removed from the bag and reassessed. Additional cycles of “descent” and reassessment are continued as needed until either the patient is clinically improved enough to not need further hyperbaric treatment, or is able to actually descend. Experience has shown that high altitude pulmonary edema (HAPE) typically requires 2-4 hours of hyperbaric treatment, and high altitude cerebral edema (HACE) typically requires 4-6 hours of hyperbaric treatment.

However, such portable hyperbaric chambers have several disadvantages. First of all, patients with severe high altitude pulmonary edema (HAPE) may not tolerate lying flat. Further, patients often feel very uncomfortable being captured for several hours in such a hyperbaric chamber. A further disadvantage is that it can get very cold for the patient lying motionless for several hours at high altitude. Conversely, if the sun is shining on the hyperbaric chamber or bag the sun intense at altitude can heaten up the bag so that the patient can get “cooked” inside the bag. Another disadvantage is that the zipper of the bag takes a lot of wear, and is the weak point – this is where leaks eventually show up. Furthermore, the portable hyperbaric chambers cause additional weight. The Gamow bag, pump and daypack carrying case weigh roughly 7kg (15 lbs.). In case a patient is treated in the hyperbaric chamber, it is normally not possible to transport the patient to a lower altitude. Further, the chambers are not available for all climbers at every wanted altitude.

The object of the invention is therefore to provide a device which overcomes the disadvantages of the prior art.

This object is achieved by a helmet as claimed in claim 1. According to the invention as claimed a helmet is provided which comprises a housing in which a person's head can be received. The helmet further comprises a collar means for an at least essentially air-tight application to the person's neck. Further, the helmet comprises an air inlet means which is adapted to be connected to an air pump and/or an air tank, wherein the air pump can be preferably operated by hand and/or by foot for introducing air into the helmet. Furthermore, the helmet is made of a flexible material.

The helmet according to the invention has the advantage, that, e.g., a person which suffers under acute mountain sickness can be provided with the helmet, wherein the helmet can be filled with air to provide a predetermined pressure within the helmet. A further advantage is, that the air can be filled in the helmet by using a simple air pump which can be operated by hand and/or by foot since the air inlet means of the helmet is adapted accordingly. Thus the person wearing the helmet or any other person can easily pump air into the helmet. A further advantage is that no special pump or pumping apparatus has to be provided but a simple air pump can be used which is cheap and obtainable everywhere. Further, the collar means provides an air-tight application to the person's neck.

The helmet has the advantage, that the person while wearing the helmet is still able to sit or to walk and thus does not have to lie down motionless as it is the case when a hyperbaric chamber is used. A further advantage is, that the person wearing the helmet is able to move so that this person has the possibility to descent or to climb to a lower altitude. This is not possible when using a hyperbaric chamber. Further, the helmet can be manufactured at low costs. A further advantage is that the helmet can be folded together due to the flexible material of the helmet, so that the helmet is very space saving. Furthermore, the helmet is very light weight in comparison to the hyperbaric chamber and can be very easily transported by a person.

Further embodiments of the invention are described in the dependent claims.

The invention will now be described with reference to the figures, in which

Figure 1 shows a front view of a first embodiment of the helmet,

Figure 2 shows a sectional side view of the helmet of Figure 1,

Figure 3 shows a front view of a second embodiment of the helmet,

Figure 4 shows a partial view of the first embodiment of the helmet and the collar means,

Figure 5 shows a harness as an attaching means,

Figure 6 shows a further embodiment of the harness as an attaching means,

Figure 7 shows a helmet according to the second embodiment, wherein the helmet is connected to an air pump and comprises a PEEP valve,

Figure 8 illustrates a part of the helmet of the first and second embodiment, wherein the helmet is connected to an air tank,

Figure 9, shows the helmet of Figure 4, wherein as an optional feature a valve element is provided, wherein a person can exhale air through said valve element,

Figure 10, shows an air pump which can be disassembled, and

Figure 11, shows a piston as used in the air pump of Figure 10, which can be disassembled.

In the embodiments of the invention, the helmet 2 comprises a housing 4 in which a person's head can be received. The housing 4 provides at least one side portion and a top portion. The housing 4 can form a continuous encasement or the side portion and the top portion of the housing 4 can be for example welded, adhered and/or sewed together. Further, at least a portion of the housing 4 can be made of a transparent material for example a transparent plastic material, so that a person wearing the helmet can look through the helmet.

The housing 4 as shown in Figures 1 to 4, 7 and 9 further comprises a collar means 6 for air-tight application to the person's neck. The collar means 6 can be made from the same

material as the housing 4 or can be made from a different flexible, semi-flexible and/or rigid material. The material(s) of the helmet and the collar means can be made out of plastic material, e.g., PVC or any other suitable material which can contain PVC. Preferably, the material(s) is/are suitable for temperatures, e.g., below -40°C . According to a preferred embodiment, the flexible material(s) is/are still flexible below temperatures of -40°C . Further, the material(s) do not cause material cracking at temperatures below -40°C . In a further embodiment icing on the inside of the helmet can be prevented.

The housing 4 is preferably adapted to receive an overpressure for altitude compensation for treating a person which suffers, e.g., under acute mountain sickness.

Recent studies have shown that a short term treatment with overpressure leads to a rapid resolve of the symptoms of acute mountain sickness (ASM) in particular of high altitude pulmonary edema (HAPE) and high altitude cerebral edema (HACE).

The collar means 6, e.g., as shown in Figures 1 to 4 can be formed as part of the helmet 2, wherein the collar means 6 can comprise at least one air bag 10 which can be filled with air. The collar means 6 provides preferably a defined circumference, so that when the air bag 10 is filled with air an air-tight application to a person's neck is provided. The collar means 6 can be expandable in radial direction of the helmet 2 like an elastic band, wherein the collar means 6 provides sufficient strength so that a defined circumference is achieved to provide a sufficient sealing function between the neck of a person and the air bag 10. In an alternative embodiment, the collar means 6 is flexible but not expandable in a radial direction of the helmet 2. In a further embodiment not shown, the collar means 6 can comprise a rigid ring element. In a further alternative embodiment as shown, e.g., in Figure 4, a strip or belt 12 can be provided, wherein the strip or belt can be expandable or not. The strip or belt 12 can be welded, adhered and/or sewed with the helmet 2 or can be for example welded inside the helmet 2 as shown in Figure 4.

This has the advantage, that the collar means 6 provides a kind of sealing between the person's neck and the air bag 10, so that when the inside of the helmet 2 is filled with air, the air cannot unintentionally leak to the outside. Further, an additional sail 14 for sealing the neck portion to the outside can be provided as shown in Figures 2, 3 and 4.

Further, an attaching means 20 can be provided which can comprise a harness as shown, e.g., in Figures 1, 2 and 4 to 6. The harness can be, e.g., a chest harness, a seat harness and/or a harness which is fixed around the armpits as shown, e.g., in Figure 2.

The harness can comprise, as shown in Figure 5, a buckle 22 for removable fixing the helmet 2 to the body of the person wearing the helmet 2.

According to the invention as shown, e.g., in Figures 1, 3 and 7, the helmet 2 comprises an air inlet means 8 which is adapted to be connected to an air introducing means 24 for introducing air into the helmet 2. As shown in Figure 7, the air introducing means 24 is preferably an air pump 24 which can be, e.g., operated by hand and/or by foot. Examples of such air pumps are commonly known air pumps which can be normally used, e.g., for balls, for dinghies (rubber dinghies), for airbeds, for bicycles, for hyperbaric chambers etc.. Such air pumps have the advantage, that they are cheap and everywhere obtainable.

Figures 10 and 11 show a further example of an air pump and its piston which can be disassembled, e.g. for ease of portability. As shown in Figure 10, this embodiment of the air pump 24 comprises a piston 42 with a handle 43 and a piston-sleeve 41 closed with a cover piece 44. By applying force on the handle 43, the piston head 46 can be driven back and forth within the piston-sleeve 41, by which air is introduced into the piston-sleeve 41 by suction and blown out by compression. For this purpose, the handle 43 comprises air inlet and outlet openings, indicated as circular openings in Figure 10. However, it is obvious for a person skilled in the art that many other suitable locations of air inlets and outlets can apply, e.g. air inlets and outlets can be placed on the cover piece 44 by conventional design of airways combined with the use of corresponding air valves (not shown in figures). After removing the cover piece 44 from the piston-sleeve 41, e.g. by snapping or screwing the cover-piece 44 off the piston-sleeve 41 depending on the closing mechanism used, the piston 42 can also be removed from the piston-sleeve 41, e.g. by pulling on the handle 43. This leaves the piston-sleeve 41 empty, which can then be used as storage means such as a container used for storage or transportation purposes, e.g. a storage-box or a drinking bottle containing a drinking liquid the traveller desires to transport for later consumption. For this purpose, a further cover-piece for closing and sealing the container, e.g. the storage-box or

drinking bottle, can be provided, e.g. for closing the drinking bottle in a substantially watertight manner for secured transportation of liquids. It is obvious for a person skilled in the art that many types of cover-pieces may be suitable for this purpose, e.g. water sealed cover-pieces which can be fastened on the drinking-bottle, e.g. by a snap-in or screwing mechanism. Further, such water sealed cover-pieces used for the drinking bottle can comprise further openings, such as sealable openings and/or openings suitable for attaching adaptors, which can be used for dispensing liquids from the drinking bottle, without requiring the cover-piece to be removed from the drinking bottle. Further, as illustrated in Figure 11, the piston 42 can be assembled as a multipart component and then compactly disassembled for saving space, e.g. for ease of transportation. For this purpose, the junctions 45 attaching the different parts of the piston 42, can be designed for providing rigid fastening means by e.g. snapping, click-in or screwing mechanisms, whereas many other suitable solutions of fastening means are known and obvious for a person skilled in the art.

An air pump 24, as illustrated in Figures 7 and 10, can be adapted to deliver, e.g., 2 liter per pull both when the lever of the pump is moved in an upward and in a downward direction. To avoid that the CO₂ value within the helmet 2 raises, the helmet 2 should be, e.g., flushed or flowed with an adequate amount of fresh air, e.g., at least 35 liter per minute or more. This can be achieved, e.g., by the air pump as illustrated in Figure 7 by pumping approximately every 6 seconds.

For example, with the helmet 2 according to the invention a decent of, e.g., at least 300m or more can be simulated at an altitude of 3000 m (altitude of, e.g., the Stubai glacier).

Further, as shown in Figure 8, the helmet 2 can be provided with an additional air inlet means to be connected to an air tank (oxygen cylinder) or the air inlet means 8 itself can be adapted to be connected to the air pump and/or said air tank 26. In case the air inlet means 8 is adapted to be connected to both either the air pump or the air tank 26 a respective adapter can be provided for example.

In the first and second embodiment, as shown in Figures 1, 3 and 7, an air outlet means or air valve element 16 is provided to discharge air from the inside of the helmet 2 to the outside.

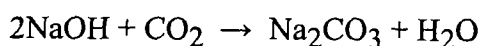
This is necessary to flush or flow fresh air through the helmet. The air valve element 16 is for example a PEEP valve as illustrated, e.g., in Figure 7. The PEEP valve is suitable to control the pressure within the helmet 2. In particular, a PEEP valve can prevent a sudden pressure drop. However, it is obvious for a person skilled in the art that any other suitable valves can be used.

The air inlet means 8 and/or the air valve element 16 can be arranged on the housing 2 as shown in the Figures and/or on the collar means 6 (not shown).

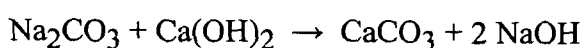
In the second embodiment as shown in Figures 3 and 7, the helmet 2 further comprises an access means 18 for providing an access to the person. The access means 18 is preferably arranged substantially in front of or below the mouth of the person. The access means 18 can be, e.g., a zipper or an opening which can be removably closed by a cover, e.g., a screw cap or a cover removable by a zipper. This has the advantage, that for example in case a person has to vomit, the helmet does not have to be completely removed.

As shown in Figure 3 the helmet of the invention can be provided in addition with a system 28 to recycle air exhaled by a person wearing the helmet. In this connection, the helmet can be provided with a substance(s) to absorb CO₂ from the air exhaled by a person wearing the helmet. For example soda lime or carbon dioxide absorbent lime or bary lime can be used to absorb CO₂ from exhaled air. The lime for absorbing CO₂ can comprise, e.g., Ca(OH)₂, NaOH and H₂O. In particular, the lime can comprise approximately 80% of Ca(OH)₂, approximately 3% to 4% of NaOH and approximately 15% of H₂O. Further, the lime can comprise impurities of iron compounds and aluminium compounds of approximately 1% to 2%. A lime granule comprises normally a core of Ca(OH)₂. Further, this core is covered with a layer of aqueous NaOH. The absorption of CO₂ by the soda lime is as follows:

1. Reaction on the surface of the granule:



2. Reaction between the surface of the granule and its core



The soda lime or carbon dioxide absorbent lime or bary lime can be provided for example in the form of granulate(s) or pellet(s). The pellet(s) or granulate(s) can be provided in at least one pad 28 which can be arranged within the helmet 2. In this connection, the pad 28 can be inserted, e.g., through the access means 18 and positioned on the air bag of the collar means 6. Further, the pad can be provided with an adhesive to preferably removably attach the pad to the inside of the helmet, wherein the pad after use can be replaced by a new one. As an other option, the helmet and the pad can be provided with a Velcro strip element to attach the pad to the inside of the helmet. It is obvious for a person skilled in the art that other attaching means can be used to attach the pad to the inside of the helmet.

Systems to recycle exhaled air are also known for example from the Wenoll System.

Furthermore, as shown in Figure 9, the helmet can be provided with an additional valve element 30, wherein a person wearing the helmet can exhale air through said valve element 30. This has the advantage that the CO₂ concentration can be reduced within the helmet, when the person exhales through said valve element 30. Further, the delivery rate of the air pump or air tank can be reduced.

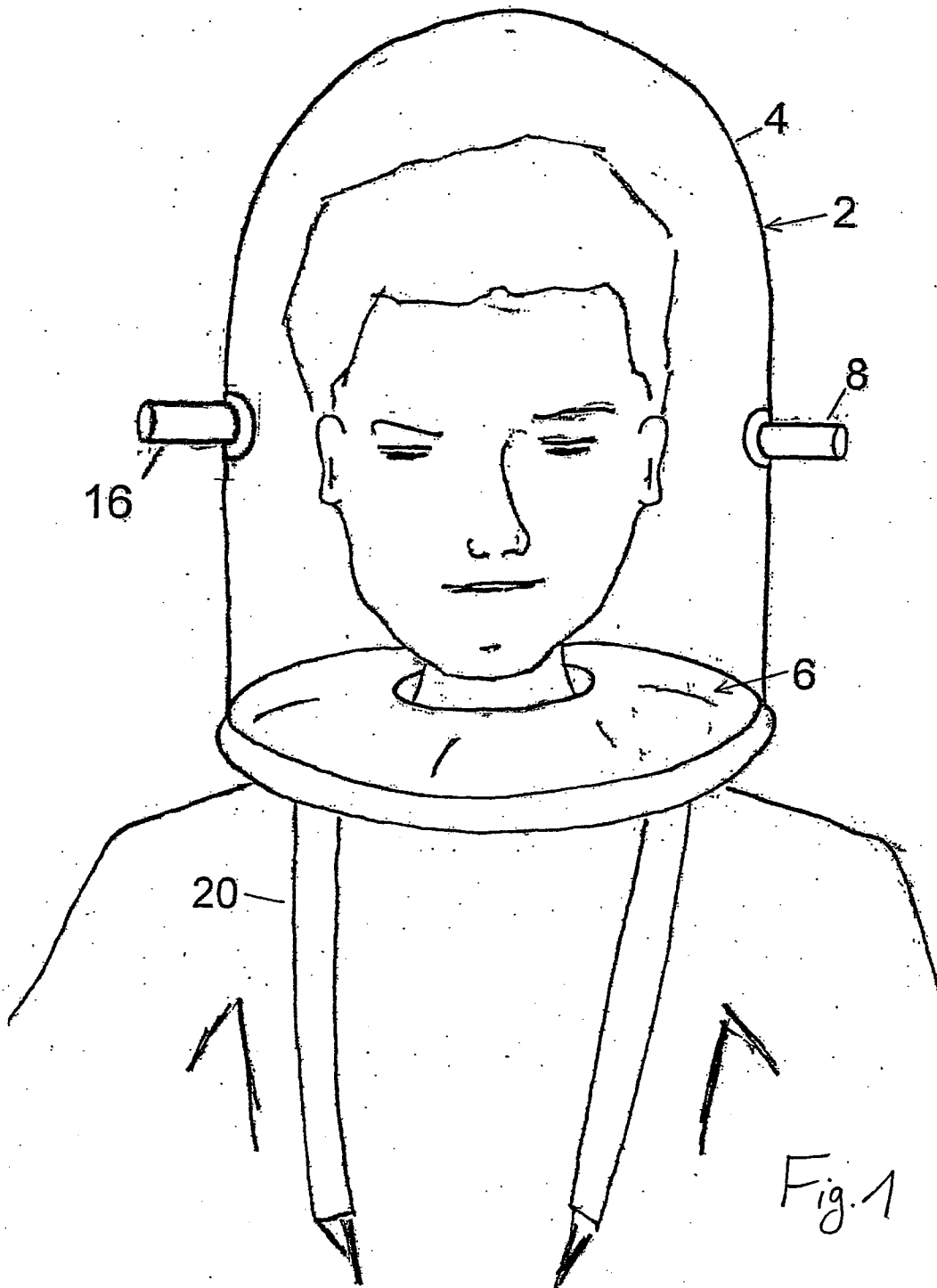
The invention as described is not limited to the particular embodiments described above. It is obvious to a person skilled in the art that the different embodiments can be combined with each other or at least features of such different embodiments.

Claims :

1. A helmet (2) for a person comprising:
a housing (4) in which a person's head can be received, wherein the housing (4) is made of a flexible material,
a collar means (6) for an at least essentially air-tight application to the person's neck,
an air inlet means (8) which is adapted to be connected to an air pump and/or an air tank for introducing air into the helmet (2), and
an air outlet means (16).
2. A helmet according to claim 1, wherein the air outlet means is an air valve element (16) to discharge air to the exterior, wherein the air valve element (16) is preferably a PEEP valve.
3. A helmet according to any of claims 1 or 2, wherein the air inlet means (8) and/or the air outlet means (16) are arranged on the housing (4).
4. A helmet according to any of claims 1 to 3, wherein the housing (4) is adapted to receive an overpressure for altitude compensation.
5. A helmet as claimed in any of claims 1 to 4, comprising an access means (18) for providing an access to the person, wherein the access means (18) is preferably arranged substantially in front or below the mouth of the person.
6. A helmet as claimed in any of claims 1 to 5, wherein the housing (4) is made of a flexible plastic material.
7. A helmet as claimed in any of claims 1 to 6, wherein the collar means (6) is made of a flexible and/or semi-flexible plastic material.
8. A helmet as claimed in any of claims 1 to 7, wherein the collar means (6) comprises a rigid ring.

9. A helmet as claimed in claims 6 or 7, wherein the plastic material is suitable for temperatures preferably below -40°C.
10. A helmet as claimed in any of claims 1 to 9, wherein the collar means (6) comprises at least one air bag (10) which can be filled with air to provide air-tight application to the person's neck.
11. A helmet as claimed in any of claims 1 to 10, comprising attaching means (20) for attaching a harness to fix the helmet to the body of the person.
12. A helmet as claimed in claim 11, wherein the attaching means (20) comprises at least one snap-fastener and/or button and/or loop and/or buckle (22).
13. A helmet as claimed in claims 11 or 12, wherein the harness is a chest harness and/or a seat harness and/or a harness which is fixed around armpits.
14. A helmet as claimed in any of claims 1 to 13, wherein soda lime and/or carbon dioxide absorbent lime and/or bary lime is provided in at least one pad, wherein the pad is arranged within the helmet to absorb CO₂ from exhaled air.
15. A helmet as claimed in any of claims 1 to 14, wherein a valve element (30) can be provided on the helmet, so that a person wearing the helmet can exhale air through said valve element (30).
16. Air pump (24) for a helmet according to any one of the preceding claims, which can be operated by hand and/or by foot and which can be disassembled for space-saving storage of the air pump (24) or for providing storage means by at least one of the disassembled parts of the air pump (24).
17. An air pump (24) as claimed in claim 16, which can be disassembled such that its piston-sleeve (41) can be used as storage means.

18. An air pump (24) as claimed in claim 17, further comprising a cover piece which can be used for closing and/or sealing the storage means.
19. An air pump (24) as claimed in claim 18, wherein the storage means is a drinking bottle and the cover piece used for closing and/or sealing the drinking bottle provides a substantially watertight closure.
20. An air pump (24) as claimed in claim 19, wherein the cover piece used for closing and/or sealing the drinking bottle comprises openings, such as sealable openings and/or openings suitable for attaching adaptors, which can be used for dispensing liquids from the drinking bottle.
21. An air pump helmet (24) as claimed in any one of claims 16 to 20, wherein the piston (42) of the air pump (24) can be disassembled for space-saving storage.
22. Helmet system with a helmet according to any one of claims 1 to 15 and a pump according to any one of claims 16 to 21.



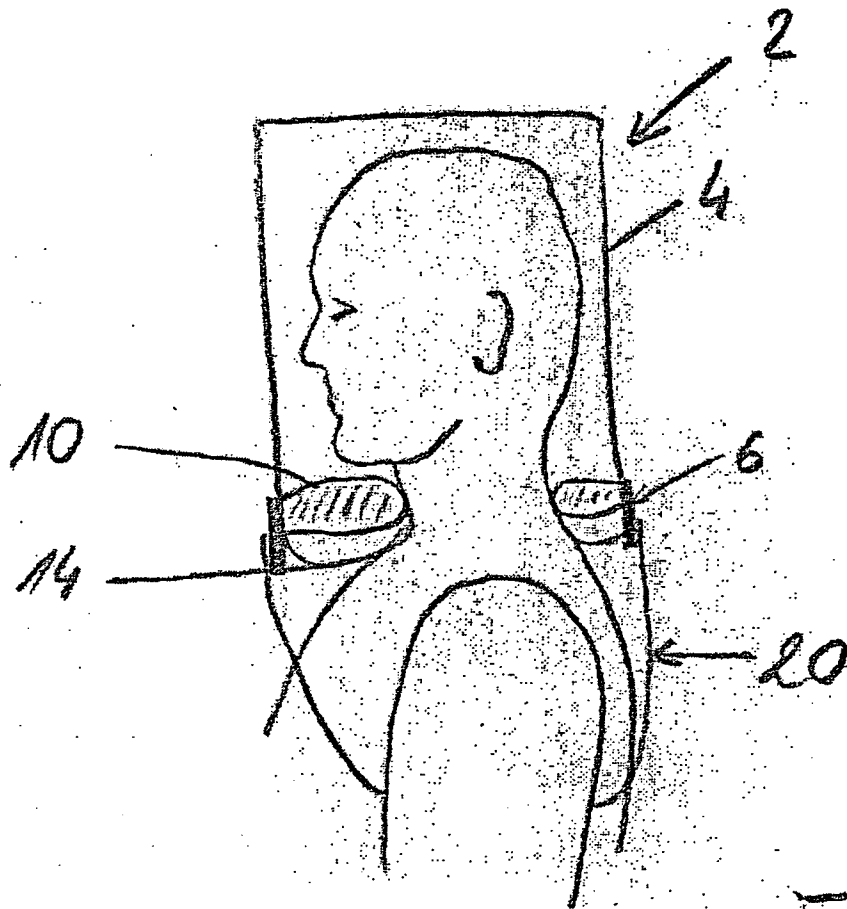


Fig 2

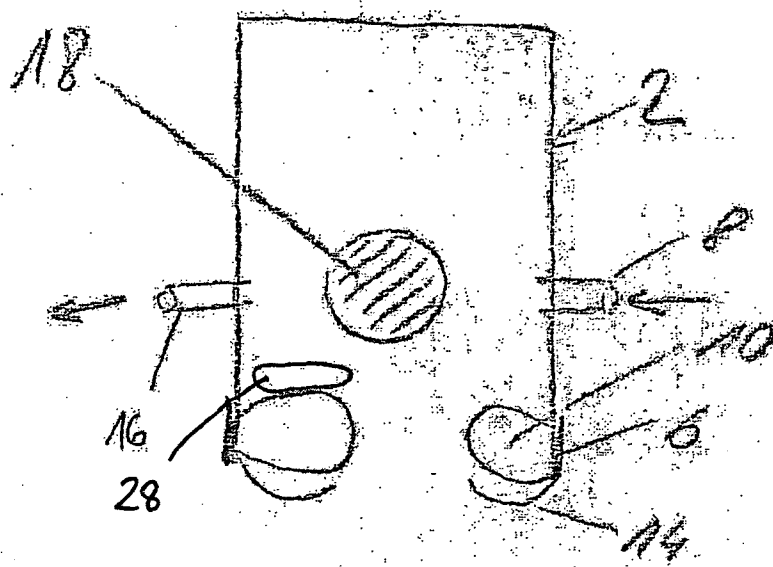


Fig 3

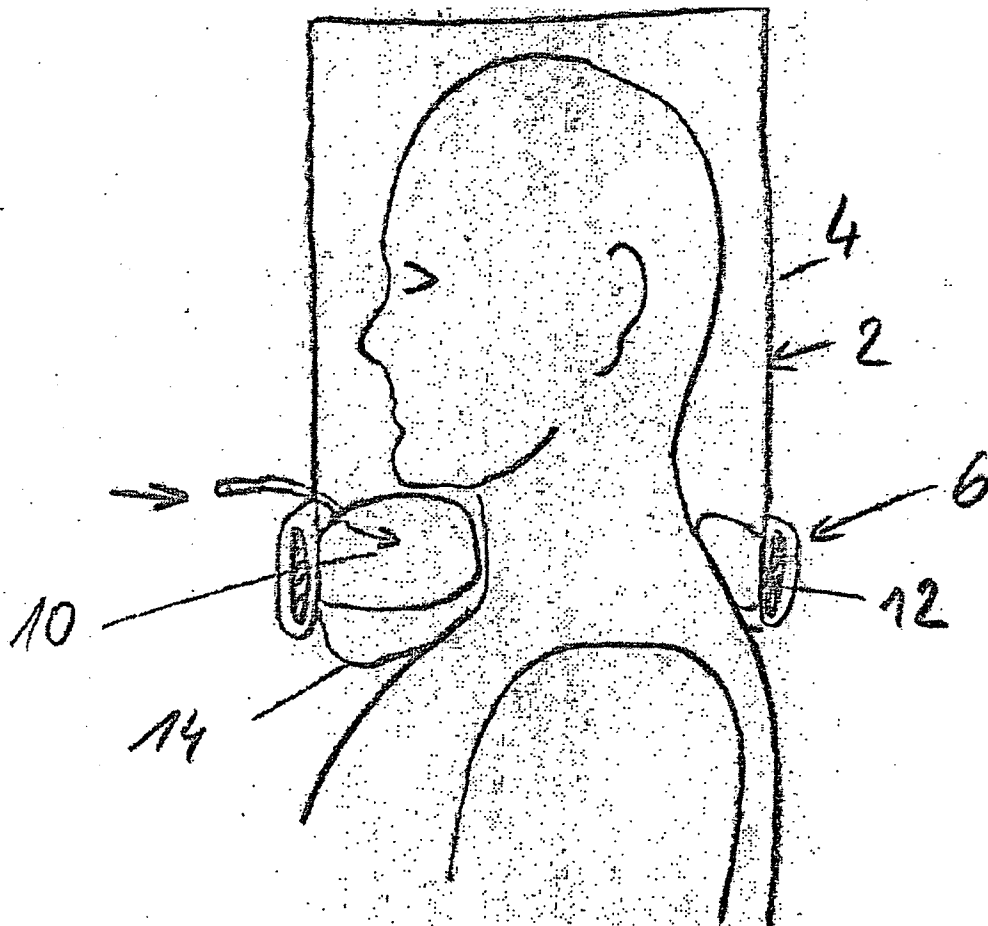


Fig 4

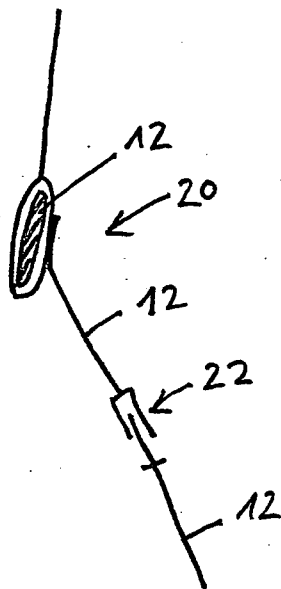


Fig. 5

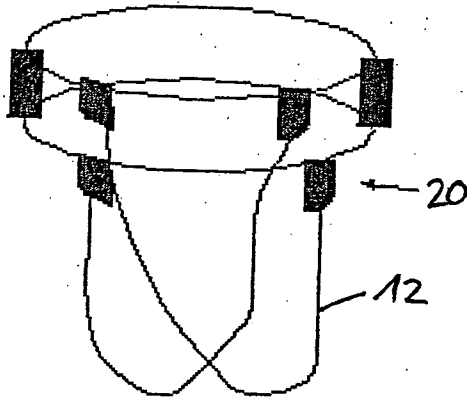


Fig.6

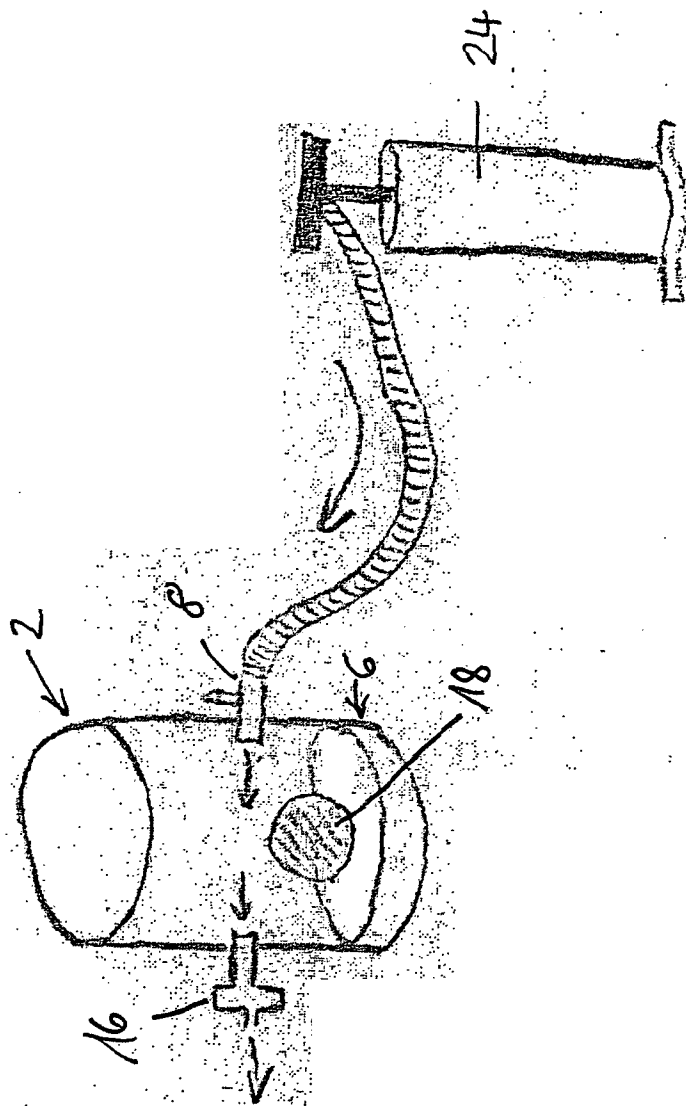


Fig 7

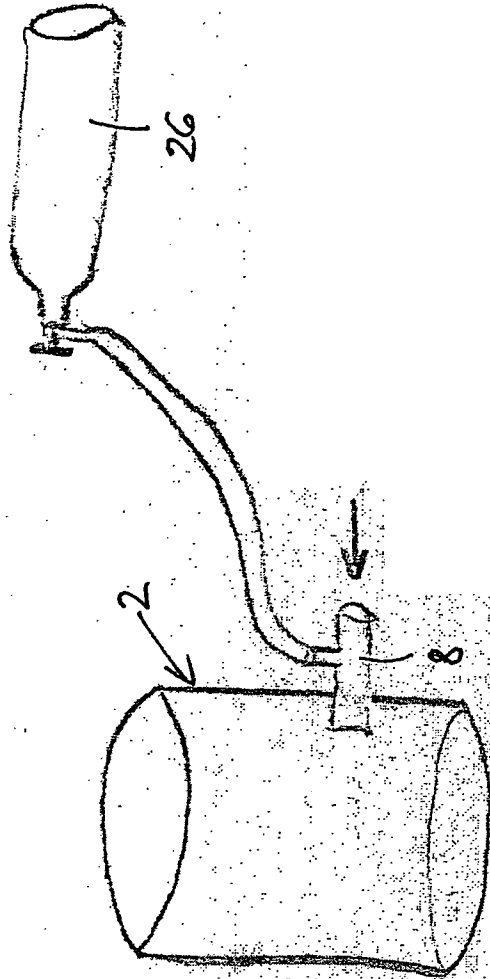


Fig 8

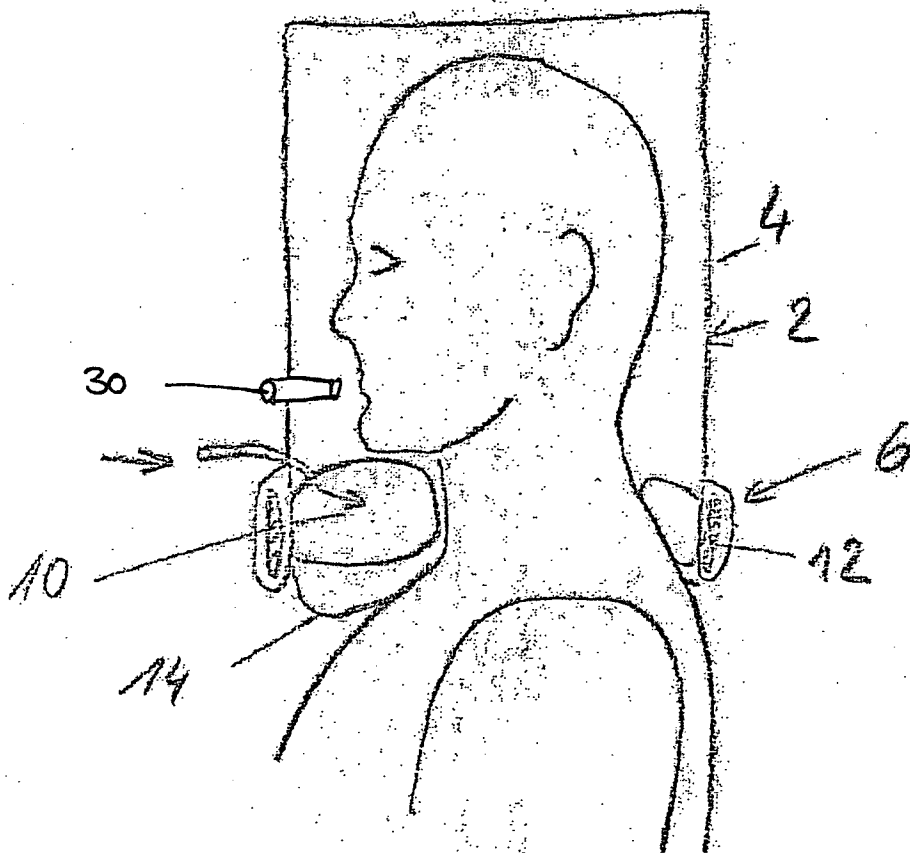


Fig 3

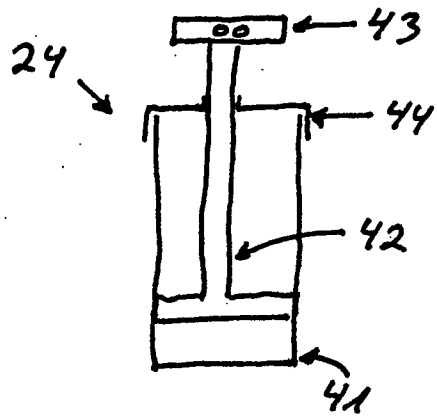


Fig. 10

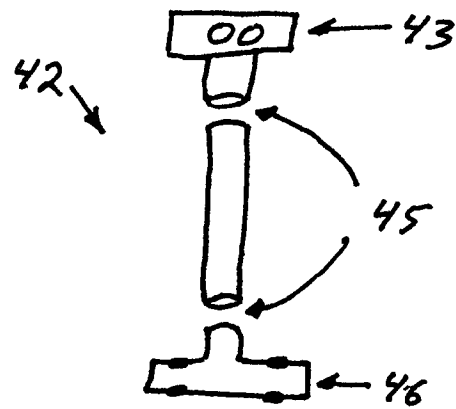


Fig. 11