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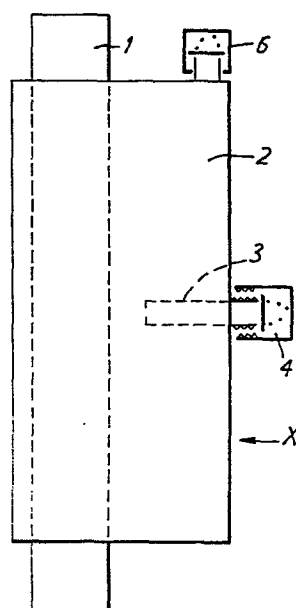
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(54) Improvements to breathing apparatus.

(57) In a breathing apparatus of the closed circuit type wherein breathable air is recirculated with the removal of carbon dioxide and the replenishment of oxygen, the breathable air is cooled by causing it to flow through a conduit (1) in heat exchange relationship with a reservoir (2) containing a liquid refrigerant medium which has a boiling point below the maximum desired temperature of the breathable air supply. The reservoir is vented to allow escape of refrigerant gas through an adjustable pressure relief valve (4), whereby cooling of the breathable air supply is effected through a progressive boiling away of the refrigerant liquid from the reservoir, the boiling point of the liquid being controlled by means of a corresponding adjustment of the pressure relief valve.



EP 0 148 543 A1

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INCOMPLETE DOCUMENT



IMPROVEMENTS TO BREATHING APPARATUSBACKGROUND OF THE INVENTION

This invention concerns improvements in or relating to breathing apparatus.

5 There are two main types of breathing apparatus in use at the present time. One type consists of an air or other respirable gas supply from a cylinder controlled by a demand valve, operated by the wearer (commonly called open circuit type). In this type the
10 full volume of each breath is taken from the cylinder. The British Standard test for breathing apparatus specifies a minute volume of breathing of 40 litres a minute (BS 4667 1974). This has been shown to accurately reflect that actually needed in practice. For practical
15 purposes the largest size oxygen cylinder a man can carry in a breathing apparatus has 2000 litres of air in it and this charged weights some 15 kilograms. It is seen from these figures that the maximum duration of this type of breathing apparatus is 60 minutes at this
20 flow.

When the requirement for a breathing apparatus is for a longer duration of up to 4 hours, a second type of breathing apparatus is used. This type of apparatus, commonly referred to as the closed circuit type, consists
25 of an oxygen cylinder or other oxygen supply feeding

into a recirculating system. The circuit of this system includes a reservoir bag and a carbon dioxide absorber, together with non-return and relief valves. This system is well known and has the advantage that the oxygen supply from the cylinder can now be at the rate absorbed by the wearer's lungs and is approximately 1 - 3 litres per minute depending on activity. This means that the oxygen used for a 4 hour duration is now only 720 litres maximum (at 3 litres per minute) giving a large weight saving. The disadvantage of all known systems of this type, however, is that the absorption of carbon dioxide by an absorbent material, usually soda lime in a cannister, involves an exothermic reaction. The amount of heat produced by this reaction is of the order of 1000 calories per minute for the figures given earlier, and thus the medium breathed by the wearer of the apparatus is correspondingly heated.

As breathing apparatus is commonly used in hot environments such as fires or mines, this heat is not easily dissipated and consequently places a physiological strain on the wearer. The British Standard test mentioned earlier specifies an inhaled oxygen temperature of less than 40°C in an ambient of 30°C 85 - 90% relative humidity. It has been shown that if this inhaled oxygen temperature could be reduced below the body temperature of 37°C , great benefit would result for the wearer, as

he would now pass heat to the apparatus instead of taking heat from it. Many methods to achieve this have been tried, for example, coolers using latent heat of fusion of ice or other substances, but these to be effective are too heavy for the wearer. Evaporation of water has been also tried but as the relative humidity of the environment is high, elevated flows of oxygen are needed in combination with this, again producing too heavy an apparatus.

SUMMARY OF THE INVENTION

It is an object of the invention to overcome at least some of the disadvantages of the known breathing apparatus referred to above by providing a simple and readily portable means of cooling the medium to be breathed, for example in a breathing apparatus of the kind wherein the breathed medium is to be recycled.

It is a further object of the invention to provide an improved breathing apparatus incorporating such means for cooling a breathing medium.

In accordance with the invention, a breathable medium is cooled by passing the medium through a conduit in heat exchange relationship with a reservoir containing a liquid which has a boiling point below the maximum desired temperature of the breathable medium, said reservoir being vented to allow escape of liquid

vapour therefrom, whereby cooling of said breathable medium passing through said conduit is effected through a progressive boiling away of the liquid from said reservoir, and means being provided for controlling
 5 the vapour pressure within said reservoir and thus the boiling point of said medium, whereby the temperature of said medium is correspondingly controlled.

There are available a variety of non-inflammable and non-toxic refrigerant media which satisfy the
 10 requirement for a liquid to be used in accordance with the invention, which can be stored under their own vapour pressure, and the latent heat of evaporation of which enable effective cooling of the breathable medium.

Examples of suitable refrigerant media are:-

15	Formula:	Designated:	Boiling point at atmospheric pressure:
	$C\ Cl_3F$	R 11	23.7°C
	$C\ HCl_2F$	R 21	8.9°C
	$C_2Cl_2F_4$	R114	3.6°C

20 The refrigerant medium and the operating pressure of the pressure release valve should be selected in such a combination as to provide for boiling-off of the liquid at an appropriate temperature of the breathable medium. The latent heat of vaporisation of
 25 the liquids referred to above is such that less than

1 kilogram of liquid is evaporated during the normal duration of the apparatus.

5 In accordance with a preferred feature of the invention, the pressure release valve is manually adjustable to provide means for optionally controlling the temperature of the breathable medium. This gives the enormous advantage that the wearer of a breathing apparatus can himself set the temperature of the in-
10 haled medium by a control on the apparatus and can vary this to suit his needs in varying ambient temperatures. For example, he can select a lower inhaled oxygen temperature in high environmental temperatures and promote body cooling. The boiling point of R11 at 2 bar absolute pressure is 45°C. This gives a blow-off value and reser-
15 voir pressure of only 15 P.S.I. (1 bar) above atmospheric pressure so that this agent alone gives a range of 23.7 - 45°C over the pressure range of 0 to 15 P.S.I. above atmospheric pressure.

20 The invention further provides a cooling device for use in the method of the invention comprising a fluid flow conduit, a reservoir in heat exchange relationship with said conduit, a body of liquid contained within said reservoir, and pressure relief value means for venting said reservoir to atmosphere. The said
25 conduit may consist of a tube or other vessel with an

adequate surface area in the breathing circuit in thermal contact with the reservoir of liquid. The boiling point of the liquid may then be selected in accordance with the vapour pressure curve for this liquid and the pressure maintained in the reservoir by adjustment of the pressure relief valve which may be under the control of the wearer.

The device in accordance with the invention can be stored fully charged ready for instant use. The reservoir can be constructed in one or more parts so that the refrigerant liquid is either inside or outside the breathing circuit tube or vessel. It can also be constructed on the principles of the "non-spill inkwell" so that it is not filled to more than 50% of its volume. The blow-off outlet is then located in the centre point of the reservoir so that the wearer can assume any position, such as head down, without loss of liquid.

The cooling device in accordance with the invention can be incorporated as a part of a complete breathing equipment or may be adapted for adding to existing breathing apparatus. Moreover, although the device is primarily intended for use with breathing apparatus, it will be appreciated that it may also have other uses where the cooling of fluid medium is desirable.

Figure 1 is a side view of the one embodiment of a cooling device in accordance with the invention that may be incorporated into a standard breathing apparatus circuit,

5 Figure 2 is a view corresponding to Fig. 1 in the direction of the arrow X in Fig. 1,

Figure 3 is a plan view corresponding to Fig. 2,

10 Figure 4 is a front elevation, partly in section, of a breathing apparatus in accordance with the invention incorporating a cooling device,

Figure 5 is a side elevation, partly in section, of the device shown in Fig. 4, and

15 Figure 6 is a fragmentary cross section of a pressure relief valve of the kind utilised in the devices shown in Figs. 1 - 3 and Figs. 4 and 5 respectively.

20 Referring to Figs. 1 - 3 of the drawings, a tube 1 for connection into the circuit of a breathing apparatus passes through a reservoir vessel 2. The tube 1 may have fins, balls, wire wool or other means inside to increase the surface area for heat exchange with the breathable medium. The tube 1 is set off centre so that the inner end of a filling and venting tube 3 is located in the volumetric centre of the reservoir, so that when

M I S S I N G

The breathing apparatus comprises an outer casing formed by two opposed panel members 7 and 8 of dished configuration, the member 7 serving to support the reservoir 2 of refrigerant, as well as a canister 9
5 containing a carbon dioxide absorbing medium, and an oxygen cylinder 10. The member 8 serves to enclose a breathing bag 11 connected on the one hand to an outlet 12 from the canister 9, and on the other hand to an inlet 13 to the cooling tube 1. The other end of
10 the cooling tube 1 is coupled to a breathing tube 14 leading to a mouthpiece 15, which mouthpiece is further coupled via an exhaust tube 16 to a conduit 17 leading to the canister 9. In conventional manner the mouthpiece 15 incorporates non-return valves, not
15 shown, which operate in a direction such that air is inhaled from the tube 14 and exhaled to the tube 16.

The oxygen cylinder 10 comprises a supply valve and regulator 18 of conventional type, by means of which oxygen can be supplied at a controlled rate
20 to the breathing bag 11.

In the operation of the device described, air breathed by the wearer is recirculated through the system in the direction indicated by the arrows. Thus, air from the breathing bag 11, containing oxygen
25 supplied from the cylinder 10 is inhaled via pipe 1

and breathing tube 14, and then exhaled via tube 16 and conduit 17 to the canister 9 wherein carbon dioxide is absorbed from the air by the absorbent medium present in the canister 9, before the air returns to the breathing bag 11 to be recharged with oxygen from the cylinder 10. The air to be breathed is cooled by the tube 1 serving as a heat exchanger as described above in the case of the device of Figs. 1 - 3. The temperature of the air to be breathed is thus determined by the boiling point of the refrigerant medium contained within the reservoir 2 and maintained under a predetermined vapour pressure by means of the adjustable relief valve 4. As in the case of the embodiment of Figs. 1 - 3, the sensing tube 3 connected to the relief valve 4 communicates with the volumetric centre of the reservoir 2 which, as shown more clearly in Fig. 5, is less than half filled with refrigerant medium so that the refrigerant liquid cannot itself enter the tube 3.

The construction of the valve 4 is illustrated in more detail Fig. 6, wherein it will be seen that the sensing tube 3 engages with a valve body 25 fitted in the wall of the reservoir 2 and providing a valve seat 26 for a valve member 24 having a stem 24A guided within a bore 22A of an adjustable valve cap 22 in screw threaded engagement with the valve body 25. A compress-

ion spring 23 engages between the cap 22 and the valve member 24, and thus force of the spring, and the corresponding pressure at which the valve member 24 is released from the valve seat 26 is determined by the
5 extent to which the cap 22 is screw threaded on to the valve body 25. The cap 22 incorporates a vent 27 to allow escape of refrigerant gas released by the valve member 24. A locking screw 21 serves to enable locking of the valve cap 22 in a selected position of adjustment.

10 The construction of the valve member 6 is substantially similar to that of the valve member 4 as illustrated in Fig. 6 with the exception that the sensing tube 3 is omitted.

CLAIMS

1. A method of cooling a breathable medium, wherein the medium to be breathed is passed through a conduit in the heat exchange relationship with a reservoir containing a liquid which has a boiling point above the ambient temperature conditions prevailing in the said reservoir but below the maximum desired temperature of the breathable medium, said reservoir being vented to allow escape of liquid vapour therefrom whereby cooling of said breathable medium passing through said conduit is effected through a progressive boiling away of the liquid from said reservoir, and the maximum pressure within said reservoir is controlled in order correspondingly to control the temperature of said breathable medium.

2. A device for cooling a breathable medium comprising a fluid flow conduit, a reservoir in heat exchange relationship with said conduit, a body of liquid contained within said reservoir, and means venting said reservoir to atmosphere, said venting means comprising and adjustable pressure relief valve.

3. A device according to Claim 2, wherein the venting

means includes an outlet conduit extending to said pressure relief valve from substantially the volumetric centre of said reservoir and the said body of liquid is such that it fills less than half of the volume of the said
5 reservoir.

4. A device as claimed in Claim 2, wherein said liquid is a refrigerant liquid having a boiling point at atmospheric pressure which is below 40°C.

5. A device as claimed in Claim 4, wherein said liquid
10 comprises a refrigerant selected from the group comprising types R11, R21 and R114.

6. A device as claimed in Claim 4, wherein the said adjustable pressure relief valve is arranged to enable the pressure within said reservoir to be set within a
15 range of 1 - 21 bar absolute pressure.

7. A breathing apparatus comprising, a reservoir of breathable air; first conduit means communicating via non-return valve means from said air reservoir to a respirator means; second conduit means communicating from
20 said respirator means, via non-return valve means, to a container of carbon dioxide absorbing medium; third conduit means communicating from said container to said air reservoir to complete a respiratory circuit for said breathable air; and a source of oxygen for replenish-
25 ing the oxygen content of air contained within said reservoir, characterised in that at least one said conduit means is in heat exchange relationship with a body of

liquid refrigerant medium contained within a reservoir vented to atmosphere by means of an adjustable pressure relief valve means having a predetermined range of optionally selectable release pressures, the said refrigerant liquid being selected to have a boiling point so related to the range of release pressures provided by the pressure relief valve that, in use, a corresponding variation can be obtained in the temperature of the breathed air by varying the setting of the pressure relief valve.

8. A breathing apparatus as claimed in Claim 7, characterised in that said pressure relief valve means includes an outlet conduit extending thereto from substantially the volumetric centre of the refrigerant reservoir and the body of refrigerant liquid fills less than half of said reservoir.

9. A breathing apparatus as claimed in Claim 7, characterised in that said refrigerant liquid is selected from the group comprising types R11, R21 and R114.

AMENDED
CLAIMS

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Claims:

1. A respiratory apparatus comprising a closed or semi-closed circuit (1,14,15,16,17,13) wherein exhaled gases, prior to reinhalation, pass through a regenerating means (9,10) and a heat exchanger (1,2) for effecting cooling of the
5 gases by indirect heat exchange with a coolant vapour evaporated to atmosphere from a body of liquid refrigerant medium contained in a reservoir (2) coupled to said heat exchanger (1,2), characterised in that said liquid storage reservoir (2) is closed by means of a manually adjustable
10 pressure relief valve (4) whereby said liquid refrigerant medium is stored under a selected vapour pressure and evaporation of the liquid refrigerant medium takes place within the storage reservoir (2) under the influence of heat transferred from a conduit (1) of said closed cir-
15 cuit with which said storage reservoir (2) is in heat exchange relationship whereby the breathing temperature of the recirculated gases is controlled in accordance with ambient conditions.
- 20 2. An apparatus as claimed in claim 1 characterised in that the said body of liquid refrigerant medium and the range of adjustment of said pressure relief valve (4) are so selected that under normal ambient conditions the said relief valve (4), in a corresponding setting can maintain
25 a closure for said storage reservoir (2) whereby a charge of said refrigerant medium is conserved ready for use.
3. An apparatus as claimed in claim 1 or 2 characterised in that said pressure relief valve (4) includes an outlet
30 conduit (3) extending thereto from substantially the volumetric centre of the refrigerant reservoir (2) and the body of refrigerant liquid fills less than half of said reservoir.

4. An apparatus as claimed in any one of claims 1 - 3, characterised in that said refrigerant liquid is type R11, R21 or R114.
- 5 5. An apparatus as claimed in any one of claims 1 - 4, characterised in that said liquid is a refrigerant liquid having a boiling point at atmospheric pressure which is below 40°C.
- 10 6. An apparatus as claimed in any one of claims 1 -5, characterised in that the said adjustable pressure relief valve (4) is arranged to enable the pressure within said reservoir to be set within a range of 1 - 21 bar absolute pressure.

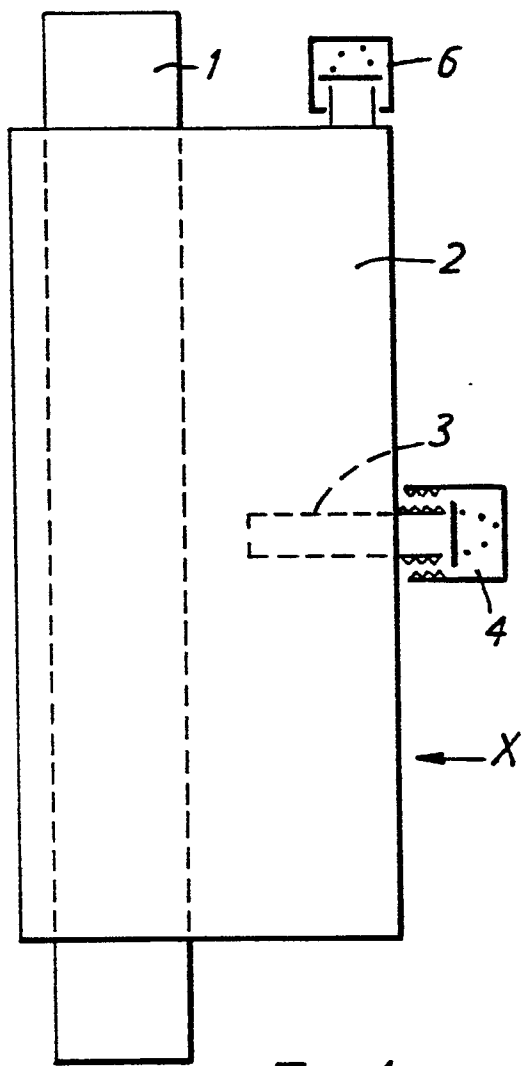


FIG. 1

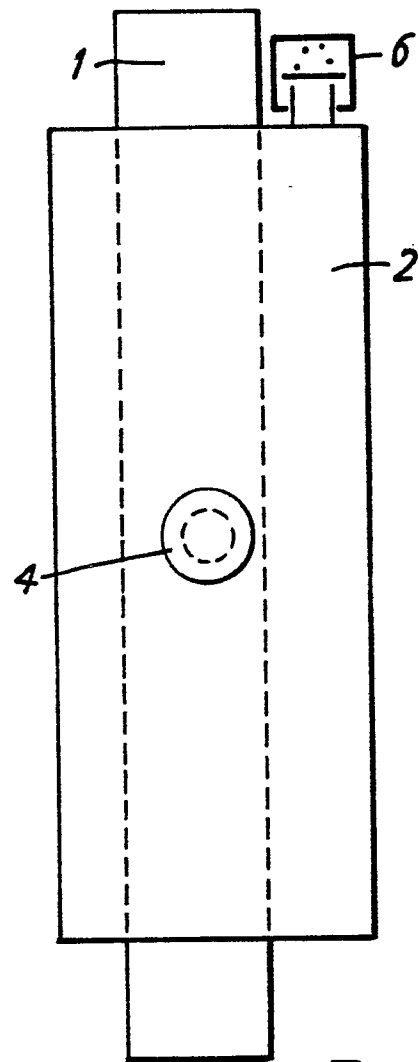


FIG. 2

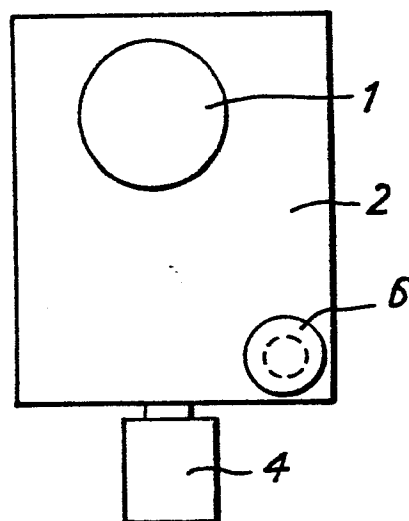


FIG. 3

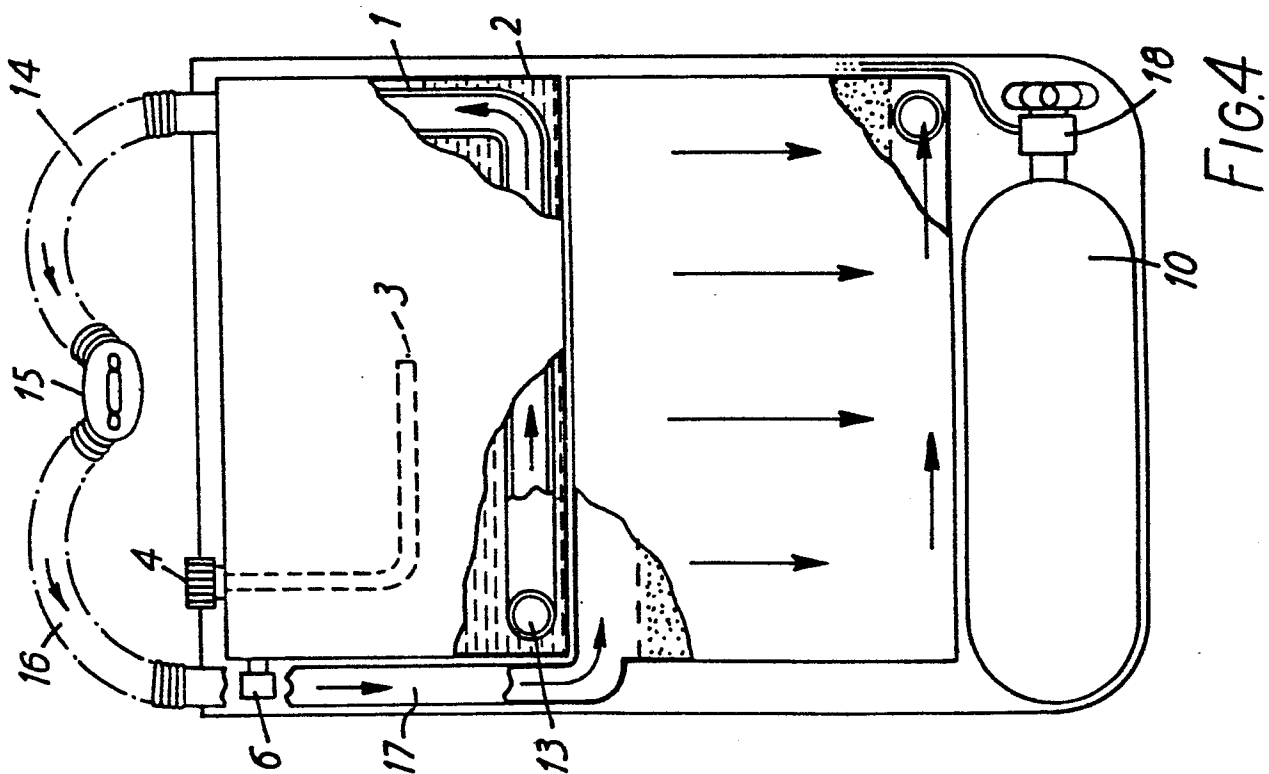


FIG. 4

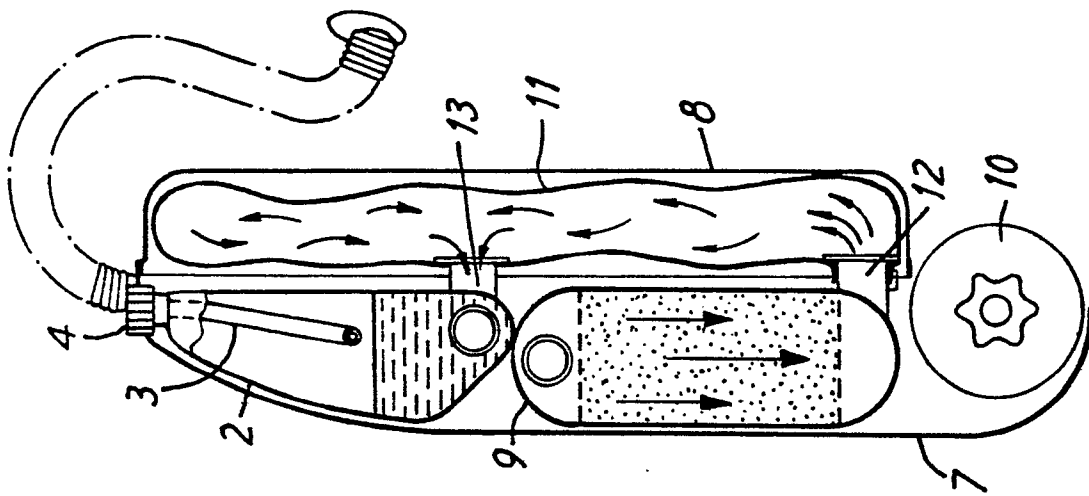


FIG. 5

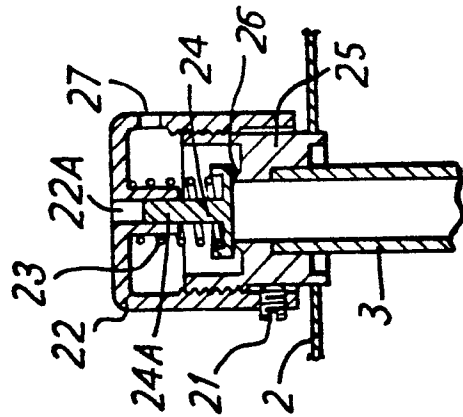


FIG. 6



European Patent
Office

EUROPEAN SEARCH REPORT

0148543

Application number

EP 84 30 0140

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. ³)
X	GB-A-1 194 944 (L'AIR LIQUIDE) * Pages 2,3,4; figures 1,2 *	1,2,4 5,7,9	A 62 B 9/00
X	DE-C- 881 155 (BRUENER) * Pages 1,2 *	1,2,4 7	
A	GB-A- 733 473 (NAT. RESEARCH DEVEL. CORP.) * Page 2, line 67 - page 3, line 101; figures 2,3 *	1,2,4 7,9	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
			A 62 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12-09-1984	Examiner WOHLRAPP R.G.
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			