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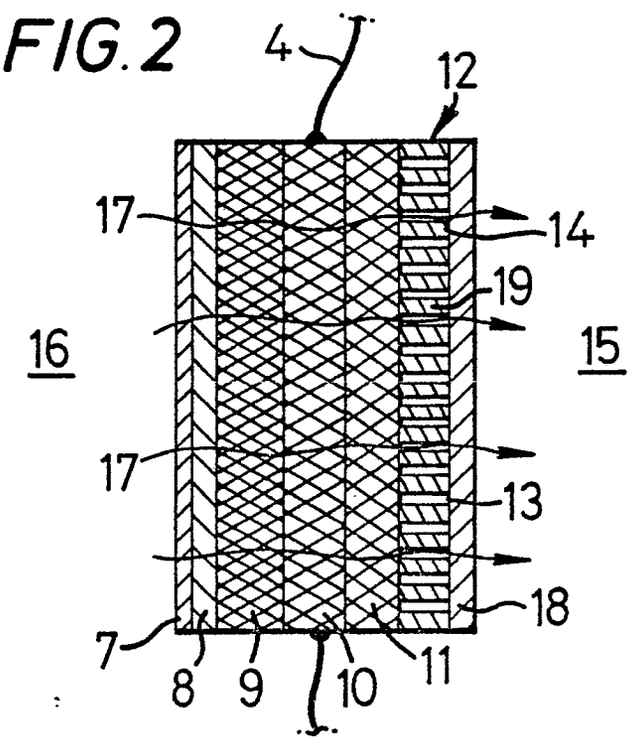
(54) Breathing apparatus.

(57) Breathing apparatus having a heat sink for cooling breathable gas in which the heat sink comprises a material, for example an alloy or a wax, capable of undergoing at least one endothermic solid/solid or solid/liquid phase transition, with a phase transition temperature between 20°C and 100°C, preferably between 40°C and 80°C. The breathing apparatus may be of the closed loop, partially-closed-loop or open loop type.

FIG. 2



EP 0 356 000 A2

BREATHING APPARATUS

This invention relates to a breathing apparatus and in particular to a breathing apparatus having a heat sink for cooling breathable gas.

Breathing apparatus to protect individuals from the effects of a harmful environment may comprise a filter which removes toxic or harmful substances from air in the harmful environment so that it may be inhaled by the individual. In a fire related emergency such a filter is required to remove soot and smoke particles as well as toxic or harmful gases such as carbon monoxide. Such breathing apparatus may have the disadvantage that the air inhaled through the filter is hot because of the fire related emergency. Furthermore, if the filter removes the toxic or harmful gases by a reaction which is exothermic, the air is further heated.

Breathing apparatus to protect individuals from a harmful environment may comprise a closed-loop or partially-closed-loop breathing system having a filter to remove toxic or harmful gases (for example carbon dioxide), from recirculated breathable gas. This breathable gas may become increasingly hotter as it is recycled, particularly if the filter removes the harmful gases by an exothermic reaction.

Heat sinks for cooling breathable gas are known which use liquid/gas, solid/gas and solid/liquid endothermic phase transitions, for example UK patent application number GB 2,122,907 relates to the use of forced evaporation of liquid; UK patent application number GB 2,038,188 relates to the use of solid carbon dioxide or ice and UK patent application number GB 2,151,490 relates to the use of water ice. Such heat sinks have a disadvantage that they may be difficult to store and in particular they may require refrigeration before use.

Thus according to the present invention there is provided a breathing apparatus comprising means for supplying breathable gas to an individual and a heat sink adapted to remove heat from the breathable gas, the heat sink comprising a material capable of undergoing at least one endothermic solid/solid or solid/liquid phase transition with a phase transition temperature of between 20 °C and 100 °C. Preferably, the phase transition temperature is between 40 °C and 80 °C.

Also according to the present invention there is provided a method of protecting an individual from a harmful environment comprising supplying said individual with breathable gas from a breathable gas supply, the gas being cooled by a heat sink comprising a material capable of undergoing at least one endothermic solid/solid or solid/liquid phase transition with a phase transition temperature between 20 °C and 100 °C, preferably between 40 °C and 80 °C.

The breathable gas supply means may comprise at least one filter capable of removing toxic or harmful gases from air inhaled from the environment or from a closed-loop or partially-closed-loop breathable gas supply.

The material may be a polymer, an organic compound, for example camphene, naphthalene or stearic acid or may be a metal alloy, for example Wood's metal (bismuth 50%, lead 25%, tin 12.5% and cadmium 12.5%). Preferably, the material is a wax and most preferably, the wax has a melting point between 20 °C and 100 °C. The wax may be an animal, vegetable, or mineral wax and most preferably is a microcrystalline wax. The wax may be a mineral wax as is supplied by Kerax Limited, Chorley, Lancashire with reference number Kerawax 1301.

The material may be contained in a heat sink having a tortuous path through which the breathable gas may flow. The material may be contained in a heat sink comprising one or more sealed containers in heat exchange relationship with the breathable gas. The containers may form some of the cells of a honeycomb structure. The containers may be a plurality of interconnected cavities formed between two pressed sheets. The material may be contained in a heat sink comprising a plurality of containers, for example spheres, in heat exchange relationship with filter and/or catalyst material of the breathing apparatus.

According to the present invention there is provided a protective hood or suit adapted to enclose the head of an individual, comprising breathing apparatus as hereinbefore described. The protective hood or suit may be adapted to enclose all or part of the body of an individual. The protective hood or suit may comprise heat resistant plastics material.

The invention will now be described by way of example only and with reference to the accompanying drawings.

Figure 1 shows in schematic cross-section an individual wearing a protective hood having breathing apparatus comprising a filter pack having a heat sink according to the present invention.

Figure 2 is a cross-section of the filter pack of Figure 1.

Figure 3 is an exploded view of the construction of a heat sink as is shown in Figure 2.

Figure 4 is a cross-section of part of a heat sink as in Figures 2 to 3.

Figure 1 shows in schematic cross-section an individual (1) wearing a protective hood, (2). The hood (2) is fabricated from a transparent, heat

resistant plastics material (4) and has a neck seal (3) which in use, forms a substantially air-tight seal with the neck of the individual. The hood (2) has a filter pack (5), through which in use, air may be inhaled by the individual. The hood may have more than one filter pack.

The filter pack (5) of Figure 1 is shown in elevated cross-section in Figure 2. The pack (5) comprises a layer of flame/heat retardant material (7) on the face of the pack which in use, is adjacent the outside environment (16) of the hood. The filter pack (5) comprises a layer of particulate removing filter (8) and layers (9) (10) (11) of adsorbent and catalyst materials designed in use, to remove or render innocuous toxic or harmful substances in the air from the outside environment of the hood. The filter pack (5) comprises a heat sink (12). The heat sink (12) has a honeycomb structure having some channels (13) through which in use, air (17) inhaled by the individual through the filter pack (5) may pass from the outside environment (16) to the inside (15) of the hood. The cells (19) of the honeycomb surrounding the channels (13) are sealed and contain wax (14) having a high heat capacity, for example as supplied by Kerax Limited, Chorley, Lancashire reference number Kerawax 1301. This wax has a latent heat capacity of about 220 J per gm and undergoes at least one phase transition between about 50 °C and 75 °C. It is believed that this wax may undergo a solid/solid phase transition as well as a solid/liquid phase transition in this termperature range. The inner face of the filter pack (5) has a layer of flame/heat retardant material (18) adjacent the inside (15) of the hood.

In use, the individual (1) pulls the hood (2) over his head such that the neck seal (3) forms a substantially air-tight seal with the neck. The individual (1) inhales air (17), which may be hot due to a fire related emergency, from the outside environment (16) of the hood through the filter pack (5). The filter (8), adsorbants (9) (10) and catalyst (11) remove or render innocuous toxic or harmful substances in the inhaled air by reactions at least some of which are exothermic. The inhaled air (17) passes through the channels (13) in the heat sink (12) and is cooled by heat exchange with the wax (14) in the sealed honeycomb cells (19) around the channels (13) as the wax undergoes at least one phase transition with resultant absorption of heat. As the individual exhales, at least some exhaled air may pass back through the filter pack (5) so as to cool the heat sink (12).

Figures 3 and 4 show how a heat sink (12) such as in Figure 2 was made. Figures 3 shows, in exploded perspective view, two end plates (20), (21) and a honeycomb (22) which when assembled formed the heat sink (12). Figure 4 shows, in cross-section transverse to the cell axes of the honeycomb (22), part of the heat sink (12) as assembled with wax (14). The heat sink was made using two sheets (20), (21) of aluminium foil 16.0 cm by 11.0 cm by 50 micrometres thick. The honeycomb (22) was also of aluminium and had cell walls 0.025 mm thick, with a wall to wall distance of 3.2 mm and a cell lenght of 5 mm. These dimensions where chosen for efficient heat exchange between the air and the wax. To construct the heat sink, one sheet (21) was bonded to the honeycomb (22) using an expoxy adhesive resin which was stable to temperatures up to about 150 °C. The required cells were then filled with hot wax, for example as supplied by Kerax Limited Chorley Lancashire reference number Kerawax 1301. Some cells (24) were left empty, as shown in Figure 4. Then the second sheet (20) was bonded onto the honeycomb (22). The channels (13) through the heat sink were made by perforating the sheets (20), (21) adjacent to the empty cells (24) with a sharp punch of 1 mm diameter. To ensure correct alignment, the first sheet (21) was perforated before the cells were filled with wax and then the second sheet (20) was bonded to the honeycomb. The heat sink was annealed by heating to 80 °C then allowing to cool to room temperature over 16 hours. Other cooling rates of 1 °C/min, 1 °C/min, and 20 °C/min may also be used. It is believed that this results in the formation of a microcrystalline structure of the wax with a high latent heat capacity. The resultant heat sink contained about 35g of wax. It is envisaged that a proctective hood as is shown in Figure 1 may have two such heat sinks or one large heat sink having about 100g of wax.

In an alternative embodiment the material may be contained in a plurality of interconnected cavities formed between two pressed sheets. Such a heat sink was made by pressing a regular array of interconnected depressions into two sheets of aluminium which were lacquered on one side and coated with polypropylene on the other. The sheets were then aligned with the depressions cooperating to form interconnected cavities with the polypropylene coating on the inside. The sheets were welded together using the polypropylene. The cavities were filled with wax through the interconnecting passages, the inlets to which were then sealed. Finally holes were punched in the sheets between the cavities to provide passages for air to flow through.

Claims

1. A breathing apparatus comprising means for supplying breathable gas to an individual and a heat sink adapted to remove heat from the breatha-

ble gas, the heat sink comprising a material capable of undergoing at least one endothermic solid/solid or solid/liquid phase transition with a phase transition temperature of between 20 °C and 100 °C.

2. A breathing apparatus according to claim 1 in which the phase transition temperature is between 40 °C and 80 °C.

3. A breathing apparatus according to claim 1 or claim 2 in which the material is a metal alloy.

4. A breathing apparatus according to claim 1 or claim 2 in which the material is a wax.

5. A breathing apparatus according to claim 4 in which the wax is a mineral wax.

6. A breathing apparatus according to any one of the preceding claims in which the means for supplying breathable gas comprises at least one filter capable of removing toxic or harmful gases from air inhaled from the environment.

7. A method of protecting an individual from a harmful environment comprising supplying said individual with breathable gas from a breathing apparatus according to any one of the preceding claims.

8. A protective hood adapted to enclose the head of an individual comprising breathing apparatus according to any one of claims 1 to 6.

FIG.1

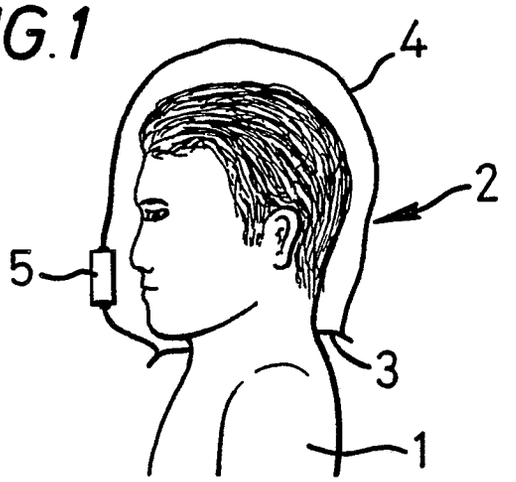
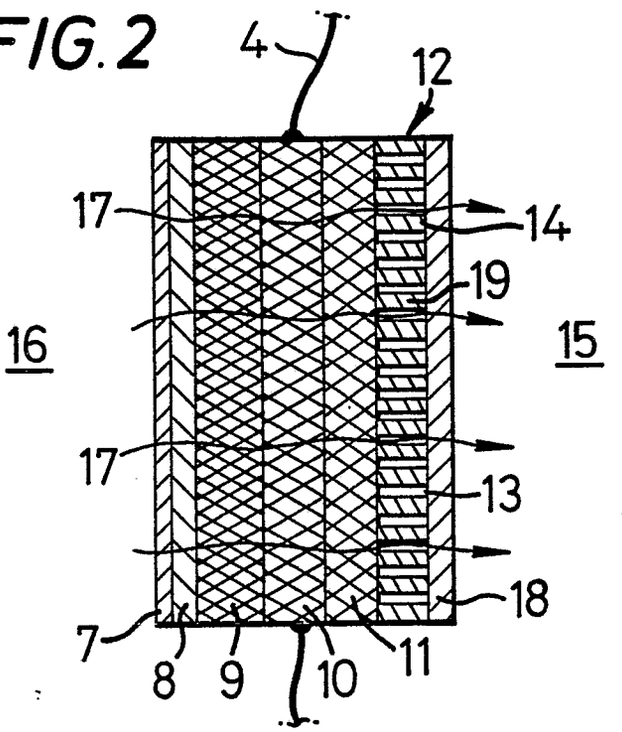


FIG.2



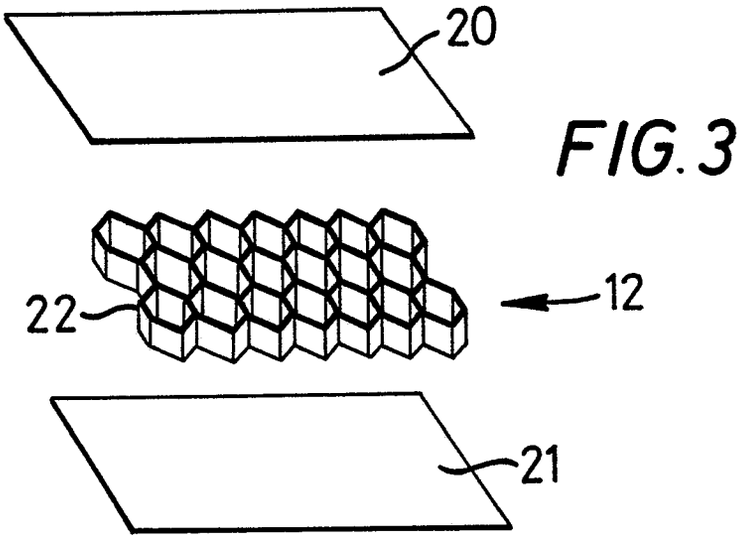


FIG. 3

FIG. 4