ABSTRACT

The specification discloses an air mattress consisting of a number of cells each having a surface which supports a user formed from a material which is gas permeable but is non-permeable to liquids and solids. An air supply is provided for inflating the cells to the required pressure.

18 Claims, 12 Drawing Figures
INFLATABLE SUPPORT APPLIANCE

This invention relates to inflatable support appliances. In particular, air cushions, air mattresses, pillows and the like. It is well known to use physically porous material as the bounding surface of such appliances, so that they may be connected to a source of air under pressure when in use and air may be continuously escaping through the pores and flowing over part of the body of the user.

The background to the present invention includes some shortcomings that have been noted in such appliances. Firstly, for instance, the substantial amount of air that passes through the material in unit time when the difference between the pressures at its opposite faces is of the order required to support, say, a typical body lying on an air mattress. This calls for a large air pump, which may be expensive and noisy. Secondly, the pores of the material have tended not only to transmit air but also to receive and harbour solids and liquids; this has made the appliances hard to clean or sterilize.

A third element of the background to this invention concerns the description of known porous appliances which have usually stressed the need for air to pass through the material from within to outside, where it may pass over the surface of the body of a user. I have now discovered that this effect may often be less important than another, by which water vapour resulting from perspiration by the user may pass in the reverse direction through the material because the water vapour pressure adjacent the user's body exceeds that of the flowing air within the mattress. With fine porous material the invariable clogging of some of the pores by liquid perspiration, dirt etc., can be a disadvantage.

The invention provides an inflatable support appliance having an inlet for connection to a source of gas under pressure and at least those parts of the surface of the appliance that are intended to make contact with a user are formed from a flexible material that is gas permeable but is non-permeable to solids and liquids.

The remaining parts of the surface of the appliance may be formed from a flexible or extensible gas-tight material or the whole of the surface may be formed from the flexible material which is gas permeable but is non-permeable to solids and liquids.

By way of example the flexible gas-tight material which is non-permeable to liquids and solids may comprise a porous base fabric of woven, non-woven or knitted nylon or polyester fabric having a coating of a gas permeable resin such as polyurethane, silicone or vinyl copolymer resin which is non-permeable to liquids and solids.

Some embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a base unit for an air mattress section;
FIG. 2 is a section on the line II—II in FIG. 1;
FIG. 3 is a perspective view of a corresponding cap unit;
FIG. 4 is a section on the line IV—IV in FIG. 3;
FIG. 5 is a side elevation, partly sectioned, of a complete mattress section;
FIG. 6 is a plan view of part of another type of air mattress according to the invention;

FIG. 7 is a diagrammatic side elevation, partly sectioned, of such a mattress;
FIG. 8 is a diagrammatic side elevation of part of a bed containing mattress sections as shown in FIGS. 1 to 5;
FIG. 9 is a plan view of the mattress section of FIG. 5;
FIG. 10 is a plan view of a further form of appliance;
FIG. 11 is a side view of the appliance shown in FIG. 10; and
FIG. 12 is a side view of a complete bed according to the invention.

The mattress section of FIGS. 1 to 5 has a base unit 1 formed as a one-piece moulding in flexible, gas-tight plastics material, for example, flexible PVC or polyurethane-coated fabric. The finished moulding essentially comprises a sheet 2 perforated by four holes 3 and supporting four walls 4, each of which defines a trough-shaped cavity 5. These cavities lie side-by-side and each has one of the holes 3 in its bottom. Each cavity also has a second hole 6 at one end of its wall 4. Reference 7 indicates the rim of each wall 4.

The mattress section is completed by mounting a cap unit 8 over each cavity 5, bonding the lower rim 9 of the cap to the rim 7 of the cavity at 10. Each cap unit is made of flexible material that allows transmission of gas, and is essentially of inverted trough shape. However, pleats 11 are formed at two points down each long side wall of each unit 8, dividing the top surface of each unit into three humps, so that the complete mattress section has a quilted appearance when viewed in plan, as in FIG. 9. The sheet 2 has end flaps 12 by which the mattress section can conveniently be mounted on a base board 13; the flaps 12 carry fastening devices 14, and wrap around opposite edges of board 13 to engage with corresponding devices on the underside of the board. The board has holes 15 to register with holes 3, and the holes 3 are fitted with inlet valves 16 which are accommodated within the holes 15. A pressure gauge 17 records the pressure within each mattress section, and the valves 16 of each section communicate via pressure lines 18 with a pressure regulator 19 and thence with a plenum chamber 20 and a pump 21. In an alternative arrangement the air pressure in the section is controlled by valves in the outlets from the sections.

FIG. 8 shows part of a bed with head frame 22, legs 23 and a main frame 24 comprising a rectangle of right-angle section metal strip. Mattress sections as already described are fitted into the frame by supporting the side edges of their base boards 13 in the longer side members 25 of the frame 24, and so make up a complete bed mattress. Pump 21, controlled by an individual regulator 19 for each section, supplies the various sections with air at a pressure appropriate to the proportion of the weight of the user that the particular section is supporting. While the material of the cap units 8 transmits gas and there may be constant slight leakage of gas through the material of the cap units it is likely that this leakage will not be sufficiently great, or sufficiently controllable and thus exhaust ports may be fitted at one or more of the holes 6 to regulate the throughput, the unused holes being blanked off. Alternatively valves may be provided for regulating escape of air through the holes 6 to control the air pressure in the different sections of the mattress.
The two-part construction of base units and cap units has two advantages in particular. First it economizes in the use of gas-transmissive material, which may be expensive and which can now be confined to those parts of each mattress section which may at some time come into direct contact with the user. Second, by using gas-tight material for the base unit, thoroughput of gas may be minimised, and thus the size of the pump required by each mattress section may be kept low, with corresponding savings in power and decrease of noise. The gas-transmissive material of each cap unit transmits gas but does not retain nor transmit liquids or solids. An important property of the material of the cap units is that they should allow gases, released by a body resting on the mattress section, to permeate through the material and be carried away by the gas flowing through the interior of the section. These gases may include water vapour, resulting say from perspiration of insensible loss, and carbon dioxide which forms at wounds. This process will be aided by maintaining the gas within the section dry and relatively free from carbon dioxide, thus maximising the difference in the direction by super pressures to either side of the material. By maintaining the atmosphere within the section relatively rich in oxygen or some other beneficial gas, a difference of partial pressures in the opposite sense may simultaneously cause that gas to permeate from within the section to the body outside. A desiccant material may also be provided within the cap to dry the air within the cap.

Gas-permeable material is already known in the medical field for use in surgical dressings, in oxygenators in heart-lung machines, etc. Material suitable for use in an appliance according to the present invention could be prepared by taking extensible woven, non-woven or knitted nylon or polyester fabric having a low coefficient of friction as base material, and coating it with a suitable gas-permeable polyurethane, silicone or vinyl copolymer resin, forming a composite structure with a porosity to water vapour of at least about 230 g/sq.m/24 hrs. at 37°C. To produce one such material the first step would be to prepare a catalysed silicone rubber solution to the formula:

Silicone rubber (type SILASTOMER 2421U, as supplied by Midland Silicons Ltd.) 27.048
Catalyst (type PERKADOX PDS 40, as supplied by Novadel Ltd.) 0.952
Toluene 72.0
Total 100.00

This solution should then be spread using a knife over flat bed system directly on to the base material, as above, using a spreading gap of 8–12 thou. over the material and a speed of 2–3 ft/min. The spread should then be dried and cured for 20 minutes at 170°C.

The material of the corresponding base units may be about 0.025 inches thick, and rims 7 and 9 may be slightly overlapped and heat-bonded. This material has a smooth surface without pores and is impermeable to solids and liquids but is permeable to gases including water vapour. The transmitting of the material to gases is relatively low so that the loss of air through the material is relatively low. When fully inflated and unloaded, each mattress section may be about 12 inches deep, will be of the same width as the bed of which it is to form part, and may be of such length that six such units, say, will fit the length of the bed.

In the case of a multi-section mattress various sections of the mattress may be inflated to different pressures according to the weight to be supported by the sections. The sections where the greatest weight is to be supported can be inflated to the highest pressures and the remaining sections are inflated to lower pressures.

The temperature of the air supplied to the bed is regulated and may be pre-heated by cooled as required to influence the temperature of the user of bed and thereby control the metabolism of the occupant. The holes for each section of the bed may be connected to a common exhaust conduit and the exhaust conduits may lead to a location remote from the bed where the air is discharged to atmosphere so that air does not affect the ambient temperature of the air in the vicinity of the bed. Thus where the bed is located in a room the air from the bed is exhausted outside the room and only the very small amount of air escaping from the gas-permeable material of the bed affects the air temperature in the room. Alternatively air from the holes 6 could be directed through suitable conduits to discharge over the upper surface of the bed to warm the occupant of the bed if required.

The different mattress as shown in FIGS. 6 and 7 is of the kind described in co-pending U.K. Patent Application No. 49081/69, and comprises a manifold 26, connected to a gauge 27 and also to a pump 28 by way of a regulator 29 and supporting many closely-packed elements 30, each circular when viewed in plan. Each element is mounted on an individual nozzle 31 projecting from manifold 26 and comprises a lower concertina portion 32, a middle cylindrical portion 33 and an upper cap portion 34. A draw-string 35, attached at its top end to the cap portion 34 and at its lower end to a spider 36 mounted in nozzle 31, limits the expansion of lower concertina portion 32. The top surfaces of cap portions 34 constitute the effective surface of the mattress. When a body rests on the mattress, those elements 30 that take the load of the body are depressed so that their concertina portions 32 contract, as is seen at the right-hand side of FIG. 7. According to this invention, cap portions 34 are made of the kind of material already described with relation to the cap units 8, and the remaining parts of manifold 26 and elements 30 are gas-tight. Concertina portions 32 must be so deep that they are still capable of contracting a little further even when supporting heavy and irregular parts of the body of a user.

For ease of cleaning, disinfection etc., it is most desirable that the whole surface of appliances according to this invention should be capable of being cleaned by a wipe, and therefore should preferably have a smooth surface. Although the invention applies to support surfaces comprising a mixture of gas-tight and physically porous gas-transmissive materials, it is an advantage or the preferred form of the invention, in which gas-permeable material is used, that such material normally presents a smooth surface without pores or other irregularities that may harbour dirt. It is within the scope of the invention that the entire appliance could be surfaced in gas-permeable material.

FIGS. 10 and 11 of the drawings show a further form of appliance comprising a hollow cell 65 in the form of an invention frusto-pyramid which is formed from a flexible heat bondable material. The upper wall 66 of the cell comprises a marginal portion 67 and within the
marginal portion there are three rows of upstanding frusto-pyramids 68 formed in the aforesaid heat bondable gas permeable material. The pyramids are joined together at their bases by heat bonding and to the marginal portion of the base 65 by heat bonding.

Air is supplied under pressure to the cell and is exhausted from the cell in an identical manner to that of the embodiment of FIGS. 1 to 5. A number of drawstrings (not shown) extend between the upper and lower walls of the pyramids 68 to limit upward movement of the upper wall due to air pressure within the cell. The cell may be formed with the dimensions of a complete mattress or a number of cells may be provided side by side to form a complete mattress.

The weight of a user on the appliance first collapses the pyramids 68 engaged by the user until, in an extreme case, the pyramids are turned in side and out. Additional weight causes the side walls of the cell 65 to collapse towards one another. In this way application of stress to the user where the user contacts the surface of the appliance is avoided.

It will be understood that the upper surface of the cell 65 may comprise upstanding cones or hemispheres instead of the frasto-pyramids 68.

A bed made up of support appliances according to this invention need not have a single rigid frame (as shown in FIG. 8) to receive all of them, but could be articulated as shown in FIG. 10 to which reference will now be made. The bed shown in FIG. 10 comprises a chassis 40 mounted on castor wheels 41. A support frame 42 is pivotally mounted about a horizontal axis at 43 on the chassis and a double acting hydraulic ram 44 acts between the frame and chassis to vary the inclination of the frame to the chassis. The frame 42 carries three sub-frames 45, 46 and 47 each of which carries one or more of the mattress sections described above.

One sub-frame 45 is pivotally mounted at one end on lugs 49 located on either side of and adjacent the middle of the frame 42. The sub-frame 45 rests in horizontal attitude on rubber stops 50 on the frame located adjacent one end of the frame and a ram 51 is provided between frame 42 and the sub-frame 45 to tilt the sub-frame upwardly.

The adjacent ends of the sub-frames 46 and 47 are pivotally connected together and their other ends are pivotally supported on slides 52, 53 which slide along the frame 42. A ram 54 is provided between the frame 42 and sub-frame 46 to raise the two sub-frames 46, 47 into inverted V-formation and rubber blocks 56 are provided on either side of the frame 42 to support the sub-frames 46, 47 in horizontal attitude.

A pump 57 operated by hand lever 58 is provided for operating the rams 44, 45, 51, and 54 through control valves 59, 60 and 61. Thus the mattress sections can be angled with respect to one another to change the posture of the user. It is also within the scope of this invention that at least parts of the gas-tight areas of units such as 1 and 30 could be rigid, provided there is no risk of these parts causing discomfort to a user.

1 claim:

1. An inflatable support appliance having a surface for contact by a user, said surface comprising a flexible and extensible continuous material which is non-permeable to solids and liquids but is capable of transmitting water vapour from the outside of said surface to the inner side of said surface when the partial pressure of water vapour at the outer side of the surface exceeds that of the inner side of the surface, said appliance further having an inlet for air and an outlet for discharging the air and means for providing a constant flow of air under pressure to the inlet of the appliance both to support or partially support the user of the appliance and to remove water vapour transmitted to the interior of the appliance by said material to maintain a relatively low water vapour pressure within the appliance and thereby induce excess water vapour on the external side of said surface to pass through the surface to the inside of the appliance to be removed by said air flow.

2. An inflatable support appliance as claimed in claim 1 comprising a base having an integral upstanding wall bounding a trough the bottom of which is formed with said inlet and an inverted trough shaped enclosure formed from said flexible and extensible continuous material secured around its lower periphery to the periphery of the wall.

3. An inflatable support appliance as claimed in claim 1 wherein the base has a plurality of said upstanding walls defining a set of side by side troughs and each trough has an inverted trough shaped enclosure secured thereto.

4. An inflatable support appliance as claimed in claim 3 wherein the inlets for said enclosures are connected to a common inlet conduit connected to said air supply means, the air inlet conduit having a valve control to adjust the pressure supplied to the enclosures.

5. An inflatable support appliance as claimed in claim 4 comprising a number of said bases arranged side by side so that the enclosures form a mattress.

6. An inflatable support appliance as claimed in claim 3 wherein each trough has an outlet and the outlets for each set of troughs are connected to a common outlet pipe to exhaust air from the enclosures at a location remote from the enclosures.

7. An inflatable support appliance as claimed in claim 1 and comprising a plurality of gas-inflatable elements each associated with a respective collapsible portion whereby in operation said surface is able yieldingly to conform to a load supported on said surface by collapse of the collapsible portions associated with hose elements engaged by the load, and at least the upwardly facing parts of said elements being formed from said flexible and extensible continuous material.

8. An inflatable support appliance as claimed in claim 1 wherein each element is a generally upstanding tube closed at its upper end by said flexible gas permeable material and having a semi-collapsed lower portion in the form of a rolling diaphragm.

9. An inflatable support appliance as claimed in claim 1 wherein the surface of the appliance intended to make contact with a user comprises a number of rows of frusto-pyramids formed in said flexible and extensible continuous material.

10. An inflatable support appliance as claimed in claim 9 wherein said surface comprises a cell having the shape of an inverted hollow frusto-pyramid and having flexible sidewalls.

11. An inflatable support appliance as claimed in claim 10 wherein both said surface and the cell are formed from heat bondable material and the frusto-pyramids of the said surface are joined by heat bonding around their lower peripheries and said surface is
joined to the inverted frusto-pyramid by heat bonding.

12. An inflatable support appliance as claimed in claim 10 wherein the cell is elongate in one direction to form a mattress or a number of the cells are arranged side by side to form a mattress.

13. An inflatable support appliance as claimed in claim 5 wherein the appliance is mounted on a bed frame having a number of elements which can be articulated with respect to one another about horizontal axes and which is mounted on a base for pivotal adjustment about a horizontal axis to vary the attitude of the frame as a whole.

14. An inflatable support appliance as claimed in claim 1 wherein said flexible and extensible continuous material comprises a continuous plastics coating capable of transmitting water vapour and a backing layer on which the coating is supported.

15. An inflatable support appliance as claimed in claim 14 wherein the plastics coating is polyurethane, silicone or vinyl copolymer resin.

16. An inflatable support appliance as claimed in claim 14 wherein the plastics coating is capable of transmitting water vapour at a rate of at least 230g/sq.in./24 hours at 37°C.

17. An inflatable support appliance as claimed in claim 14 wherein the backing layer is a woven, non-woven or knitted nylon or a polyester fabric.

18. An inflatable support appliance as claimed in claim 1 wherein valve means are provided for controlling the flow of air through said outlet.