

(19)



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(11)

EP 0 878 150 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.11.1998 Bulletin 1998/47

(51) Int Cl.⁶: **A47C 27/10, A47C 27/18**

(21) Application number: **98303914.0**

(22) Date of filing: **18.05.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

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(30) Priority: **17.05.1997 GB 9709958**

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(54) Inflatable support

(57) An inflatable support (e.g. a mattress or seat cushion) comprises a plurality of elongate inflatable cells (12) containing a solid deformable material such as resilient foam, beads or fibres. Typically, the cells are inflated and deflated periodically by means of a pump

(P). The solid within the cells reduces the volume of air within the cells, and thus a pressure pump of a lower rating for supplying pressurised air can be used. Moreover, if the supply of pressurised air should fail for any reason a patient on the mattress will still be supported by the deformable material within the cell.

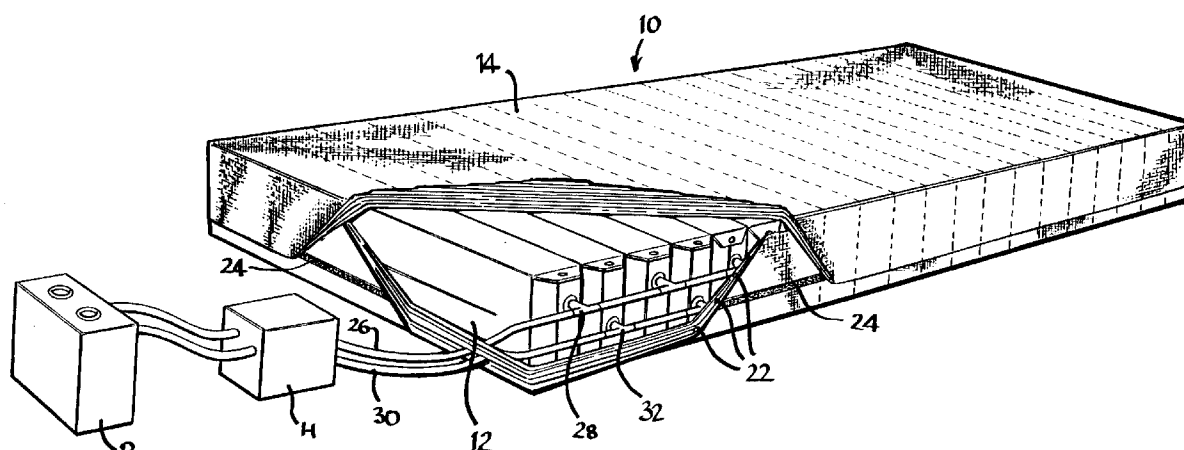


FIG. 1

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Description

The present invention relates to inflatable supports and in particular, but not exclusively, to inflatable supports such as mattresses and cushions for the prevention of, and/or relief from, decubitus ulcers on bed-ridden or relatively immobile patients.

Decubitus ulcers occur when blood flow through the skin capillaries is occluded by virtue of the fact that tissue is compressed for a prolonged period by the weight of the person and a support surface. A person who is healthy responds to nervous signals from the area of tissue in question when the tissue has been compressed for some time, and the person will thus automatically shift position to relieve the compressed area, thereby enabling blood flow to recommence. This procedure repeats itself indefinitely.

However, people without the ability to move themselves, e.g. comatose, obtunded or severely disabled people, cannot relieve the pressure in this way, and thus if they are allowed to remain in the same position, parts of the tissue die and become ulcerated, producing what are commonly termed "pressure sores". The problem also arises with elderly people who have restricted movement. The problem is exacerbated by diet, immobility, possible low blood pressure/volume and poor skin perfusion.

The traditional way of preventing or relieving bed pressure sores has been to turn the patient frequently, thus causing a different area of the patient to be compressed from time to time. However, this is not always practical or possible.

An alternative way is to place the patient on an overlay, with a view to contacting more areas of the body in order to spread the patient's weight.

However, although such an overlay is comfortable, it frequently does not prevent or relieve pressure sores, since the pressure relief obtained in the areas most at risk (e.g. bony prominences) is very often insufficient to enable re-establishment of the blood flow.

The use of inflatable cushions and mattresses for the purposes of avoiding pressure sores and the like is also well known. An example of the prior art is EP0528666A which discloses a mattress having a plurality of elongate inflatable cells arranged transversely to the longitudinal direction of the mattress and in which each cell is periodically inflated at higher and lower pressures to vary the areas of support and thereby greatly reduce the risk of pressure sores.

Whilst the aforementioned prior art operates extremely effectively, a need has been expressed for a self-contained or portable support which could be used, inter alia, as a seat cushion. One problem in implementing this need is the requirement to ensure that should the supply of inflating air fail, deflation of the support should not result in the patient being supported on a hard surface beneath the mattress or cushion, which could increase the likelihood of the formation of pres-

sure sores.

In accordance with a first aspect of the present invention an inflatable support comprises an inflatable cell containing a deformable solid material.

Such a patient support device can be made into a mattress or cushion and would normally be used with an air supply whereby the support can be periodically inflated and deflated as in the prior art to shift the regions of support on the patient. However, should the inflating air supply fail the patient will still be supported by the deformable material, which will minimise the risk of formation of pressure sores until the air supply is restored. Preferably, the support comprises a plurality of inflatable cells and preferably the solid material is resiliently deformable.

In one embodiment, the solid within the cells comprises a block of solid material, such as foamed material. For example, the foamed material may be a foamed plastics such as polyurethane foam. The block of material may be laminated.

The solid material may be secured (e.g. glued) to one or more of the cell walls, e.g. one or both side walls and/or a base wall. As the cell expands, the foam is thereby stretched. When the inflating pressure is removed, the resilience of the foam helps to expel the air more quickly from the cell.

The solid may be in particulate form, e.g. a plurality of beads. Preferably the particles are resiliently deformable. A suitable material would be a foamed plastic such as foamed polyurethane.

The solid may be substantially non-resiliently deformable. For example the solid may comprise fibres, such as polyester fibres, or feathers.

The support may comprise first and second cells containing a deformable solid material, one being located above the other. The solid material in the first and second cells may be different from one another.

The first and second cells may have a common wall and may or may not communicate with one another.

The inflatable support may additionally comprise one or more cells which contain no solid material. Alternatively, or in addition, the inflatable support may comprise one or more non-inflatable cells which may or may not contain solid material.

Preferably, the support comprises means (e.g. a pump such as an electric or hand-operated pump) for inflating the or each inflatable cell.

Where there is a plurality of inflatable cells, the cells are preferably elongate and preferably arranged parallel to each other.

The support may be in the form of a mattress or a seat cushion.

By way of example only, specific embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view of an embodiment of mattress in accordance with the present invention;

Fig. 2 is a perspective view of one of the inflatable cells of the mattress of Fig. 1;

Fig. 3 is a cross-section of the cell of Fig. 2, looking in the direction of arrows III - III;

Figs. 4 to 10 are cross-sections through a first to seventh variations respectively of the cell construction of Fig. 3;

Fig. 11 is a perspective view of a further embodiment of an inflatable cell of a mattress in accordance with the present invention;

Fig. 12 is a perspective view of an end portion of a further embodiment of mattress in accordance with the present invention;

Fig. 13 is a perspective view (partly cut away) of a portion of a further embodiment of mattress in accordance with the present invention;

Fig. 14 is a perspective view (partly cut away) of a portion of a further embodiment of mattress in accordance with the present invention;

Fig. 15 is a perspective view of an embodiment of seat cushion in accordance with the present invention;

Fig. 16 is a perspective view of a modification of the seat cushion of Fig. 15;

Fig. 17 is a cross-section through a further variation of cell construction in accordance with the present invention; and

Figs. 18a and 18b are cross-sections in the deflated and inflated state respectively of a further variation of cell construction in accordance with the present invention.

Referring firstly to Figs. 1 to 3, an inflatable rectangular mattress 10 comprises a plurality of elongate inflatable cells 12 which are arranged parallel to one another transversely to the longitudinal direction of the mattress. The mattress 10 is provided with a removable cover 14 of microporous vapour permeable material. Each end of the upper wall 16 of each inflatable cell is provided with a projecting flap 18 having an aperture 20 therein which is adapted to receive the head of a respective one of a plurality of securing studs 22 attached to a portion of the mattress cover 14 in order to secure the cells in position. It will also be noted that the mattress cover can be held firmly in position over the assembly of cells by means of strips 24 of a hook and loop faster (e.g. VELCRO - Registered Trade Mark).

In the embodiment described, alternate cells 12 are connected together by means of a first pressurised air supply pipe 26 and a plurality of T-shaped connectors 28. Similarly, the other group of alternate cells are connected together by means of a second pressurised air supply pipe 30 and a plurality of T-shaped connectors 32. The pipes 26, 30 are fed with pressurised air from an electrically operated pump P (e.g. powered from the mains electricity supply and/or by means of batteries) via an electrical heater H.

The cells 12 are formed from flexible polyurethane

sheeting which is radio-frequency welded into an elongate cell of generally rectangular cross-section. As best seen in Figs. 2 and 3, an internal dividing wall 34 extends between the central regions of each of the upstanding longitudinal side walls 36 of each cell, dividing the cell into an upper sub-cell and a lower sub-cell. This internal wall is provided primarily to assist in retaining the rectangular cross-section of the cells when they are inflated, which in turn minimises bulging of the mattress in use. As shown in Fig. 2, the dividing wall 34 does not extend for the whole length of the cell and thus the upper and lower sub-cells communicate freely with each other.

As illustrated in Figs. 2 and 3, each of the upper and lower sub-cells is partly filled with an elongate block 38, 40 of polyurethane foam. In this particular embodiment, the upper block of foam 38 is selected to be softer than the lower block of foam 40. As a typical example, the upper block of foam may have a hardness of 110N and a density of 40kg/m³ and the lower block of foam may have a hardness of 150N and a density of 40kg/m³. The properties of the foams can be selected as required and may, for example, be skinned foam, closed cell foam or any other type of foam. The hardness and density of the foams may also be varied. Typically, the blocks 38, 40 of foam are approximately the same width as the respective sub-cell in which it is located and the height of each foam block 38, 40 is typically about 75% of the height of the sub-cell in which it is located.

In use, the air supply pipes 26, 30 are connected to the pump P supply (similar to that disclosed in EP 0528666A) which alternately applies a higher pressure to one of the sets of connected cells and a lower pressure to the other set of connected cells. The supply of pressurised air is arranged to change the set of cells to which the higher and lower air pressures are applied on the basis of a predetermined programme.

As illustrated schematically in Fig. 2, the uppermost wall of each inflatable cell is provided with a series of very small holes H formed by means of a laser. The use of a laser allows very accurately dimensioned holes to be formed and results in a mattress in which a small controlled amount of air A is deliberately allowed to leak from the surface in contact with a patient. The use of laser-drilled holes in the surface of inflatable mattresses is known and helps to remove moisture and assists in the healing of wounds.

In contrast to the prior art arrangements, when a cell is supplied with air at a lower pressure it is possible in some circumstances for the patient to be at least partially supported by means of the foam within the cell. In practice, if a patient comes into contact with the foam filling then it is likely to be in contact with the softer foam 38 in the upper sub-cell of the cell as a whole.

One of the benefits of the present invention is that when the air supply changes the supply of air from a high pressure to a low pressure or vice versa, the change of pressure within a cell occurs much more rapidly than with the prior art since a lower volume of air is

involved as a result of the presence of the resilient foam within the cells. This overcomes a problem sometimes encountered with the prior art devices in which the gradual changeover in pressure can result in displacement of a patient along the mattress.

In view of the smaller volume of air within the cells, it is also possible to use a pressure pump of a lower rating for supplying the pressurised air, which not only results in a significant cost reduction but also permits portable or self-contained supports to be constructed and operated more easily. In the past, portable units have suffered from the disadvantage that they have been relatively bulky as a result of the relatively large pump required to inflate the cells and have always required a supply of mains electricity to operate the pump.

Moreover, in view of the fact that the foam contributes to the support of a patient, pumps of a lower pressure rating can be used.

Moreover, should the supply of pressurised air fail for any reason, resulting in eventual deflation of the cells, the patient on the mattress will still be supported by the softer upper foam block 38 and the harder lower foam block 40. Support of the patient by means of the foam will minimise the likelihood of the formation of, or the deterioration of, pressure sores until the supply of pressurised air can be restored. This is in contrast to the prior art, in which failure of the air supply and consequent deflation of the cells results in the patient being supported by the hard supporting surface on which the mattress is placed, which can result in the formation or deterioration of pressure sores.

An alternative cell filling is illustrated in Fig. 4. In this embodiment, the internal dividing wall 34 is omitted and in addition only a single block of resiliently deformable foam 42 is used within the cell. As for the filling of Fig. 3 the height of the foam block 42 is approximately 75% of the height of the cell. The cell is otherwise identical to that of Figs. 1 to 3.

In the variation shown in Fig. 5, the dividing wall 34 is again omitted but instead of having a block of foam the filling is formed from particulate material and comprises resiliently deformable expanded polystyrene beads 44. As for the filling of Fig. 3, the upper level of the beads corresponds approximately to 75% of the height of the cell. The cell is otherwise identical to that of Figs. 1 to 3.

In both the Fig. 4 and 5 embodiments, the operation and construction is otherwise identical to that of the first embodiment, in that a patient may be partially supported by the filling when the lower pressure is applied to the cell but will provide resilient support to the patient in the event of air supply failure.

In the variation shown in Fig. 6, the construction is identical to that shown in Fig. 3, except that one or both of the elongate side faces S, S' of the foam blocks 38, 40 is/are bonded by means of a layer of adhesive to the inner face of the adjacent side wall 36 of the cell 12 in which it is located. Optionally, the lowermost face F, F'

of each foam block 38, 40 is also bonded to the inner face of the adjacent base wall portion of the cell 12 in which it is located.

Since the foam 38, 40 is resiliently deformable and is attached to at least the side walls 36 of the cell, when a cell is inflated the foam 38, 40 within the cell will stretch. When the applied pressure is removed, the resilience of the foam blocks will tend to pull the opposed side walls back together, thus helping to expel air from within the cell and thereby assisting in reducing the pressure within the cell more rapidly.

Similarly, in the variation shown in Fig. 7, the construction is identical to that shown in Fig. 4, except that one or both of the elongate side faces S" of the foam block 42 (and, optionally the lowermost face F" of the foam block 42) is/are bonded to the adjacent inner face of the walls of the cell 12 by means of a layer of adhesive. This variation has the same advantages as described for the variation of Fig. 6 in helping to deflate the cell when the applied pressure is removed, except that the deflating effect is even more pronounced since there is no dividing wall joining opposing side walls of the cell 12 (corresponding to the wall 34 of Figs. 3 and 6) and thus the foam block 42 tends to be stretched further when pressurised air is applied to the cell.

In the variation shown in Fig. 8, the dividing wall 34 is again omitted but instead of containing a block of foam or expanded polystyrene beads the cell 12 contains a fibrous filling 60, typically of polyester fibres. Such a filling is deformable but is not particularly resiliently deformable. Nevertheless, the fibrous filling is effective to provide support when the cell is deflated. The construction and operation are otherwise identical to the embodiment of Figs. 1 to 3.

In the variations shown in Figs. 9 and 10, the constructions are identical to the constructions of Figs. 6 and 7 respectively, except that the foam blocks 38, 40, 42 are laminated foam blocks, in that they comprise a plurality of different layers 38a, 38b, 40a, 40b, 42a, 42b, 42c bonded together. The different layers may be of any desired hardness or density in order to produce a laminated block having the desired characteristic. For example, the block 38 may comprise a lower layer 38b of a greater hardness and density than an upper layer 38a to which it is bonded.

In the variations of Figs. 9 and 10 the foam blocks 38, 40, 42 are shown as being bonded to the adjacent inner face of the cell wall by a layer of adhesive but the blocks may instead be bonded on only some faces or on no faces (corresponding to Figs. 3 and 4). The number of layers in the laminated blocks may also be varied from the constructions shown, and the characteristics of each layer may be selected as desired.

It should be observed that the construction and filling of the cells described in Figs. 1 to 10 are examples only and other cells may be used. Moreover, a combination of cells with different cell fillings (for example, but not exclusively, selected from those of Figs. 1 to 10) may

be used to produce a mattress with different support characteristics in different areas.

The embodiment shown in Fig. 11 is very similar to that shown in Figs. 1 and 2 and can incorporate any or all of the variations thereof. The only significant difference is that the dividing wall 34' of the embodiment of Figs. 1 and 2 is extended such that it extends along the whole length of each of the inner elongate side walls of the cell 12 and additionally extends along the two end walls of the cell, whereby the dividing wall 34 in the construction of Fig. 11 divides the cell 12 into two sub-cells 12a, 12b which are inflatable independently of each other. Each of the sub-cells 12a, 12b is connected to a respective air supply pipe 26, 30 by means of a T-connector 28.

Depending on the source of pressurised air, the upper and lower sub-cells 12a, 12b may be arranged to be inflated and deflated simultaneously but at different pressures. Alternatively, the upper and lower sub-cells 12a, 12b may be arranged to be inflated and/or deflated at different times and may be arranged to be inflated at the same or different pressures.

The variation of Fig. 12 is shown as being a variation of the construction of Figs. 1 and 2 but it may equally well be a variation of the construction of Fig. 11. In the variation of Fig. 12, not all of the cells are arranged to be inflatable and deflatable. In Fig. 12, the end cell 12' is shown as being completely sealed, having no connections to an external source of pressurised air and no holes H for the controlled escape of air. The end cell 12' is shown as being sealed since this is one of the cells which will provide least support to a patient. However, any cell or a plurality of cells may be sealed. The sealed cell may (but need not) contain a solid filling. The construction and operation of this embodiment are otherwise identical to that of Figs. 1 to 3, with the possible modifications to the solid within the cells as described previously.

The embodiment of Fig. 13 comprises a mattress having a plurality of elongate, parallel transversely extending cells 60 as in the previous embodiments. The cells are normally covered with a microporous vapour permeable material 14 as in the first embodiment, but this has been omitted from the drawings for clarity. However, the construction of the cells 60 is different. The cells are formed from upper and lower sheets 70, 72 of flexible polyurethane sheeting which are radio-frequency welded together at a plurality of parallel transversely-extending welds 74 to form a plurality of transversely extending parallel elongate inflatable cells 60. Lateral, longitudinally extending edge seams 75 also define the cells 60. Each cell 60 is also provided with an elongate solid core 76 of polyurethane foam extending along the whole length of the cell. The cells are connected to one of two pressurised air supply lines 26, 30 by means of a respective T-piece connector 28, 32, (not shown in Fig. 13) as in the embodiment of Figs. 1 and 2. The operation of this embodiment is identical to that of Figs. 1 and 2.

Only one corner of the mattress has been illustrated, but the whole mattress has substantially the same length and width as in the embodiment of Figs. 1 to 3.

The embodiment of Fig. 14 is similar to that of Fig. 13 having a plurality of elongate, parallel, transversely extending cells 80 comprising upper and lower sub-cells 80a, 80b, similar to the embodiments of Figs. 1 to 3 and 11. The cells are normally covered with a microporous vapour permeable material 14 as in the first embodiment, but this has been omitted from the drawings for clarity. The cells are formed from an upper sheet 82, an intermediate sheet 84 and a lower sheet 86 of flexible polyurethane which are radio-frequency welded together at a plurality of parallel transversely-extending welds 86 to form the cells 80. Lateral, longitudinally extending edge seams 88 also define the cells. The presence of the intermediate sheet 84 forms the upper and lower sub-cells 80a, 80b divided by the intermediate sheet 84. Each of the upper and lower sub-cells 80a, 80b contains an elongate solid core 90 of polyurethane foam. The sub-cells 80a, 80b are connected to one of two pressurised air supply lines 26, 30 by means of a respective T-piece connector 28, 32, (not shown in Fig. 14) as in the embodiment of Fig. 11. The operation of this embodiment is identical to that of Fig. 11. As for Fig. 13, only one corner of the mattress has been illustrated, but the whole mattress has substantially the same length and width as in the embodiment of Figs. 1 to 3.

The embodiment of Fig. 15 is virtually identical to the earlier embodiments, with the exception that instead of being in the form of a mattress the support is of such a size that it forms a seat cushion 46, in this particular embodiment comprising eight inflatable cells 12 (inflated by means of a pump P via a heater H as in the first embodiment, but omitted from Fig. 15) in the form of two groups of four interconnected cells each with its respective air supply pipe 48, 50. The cushion of Fig. 6 can be constructed in any of the manners described previously and can contain any of the fillings that could be used for the mattresses as described previously. The cushion is otherwise operated identically, and works identically, to the mattress as described previously.

The embodiment of Fig. 16 is a cushion of identical construction to that of Fig. 15 except that the air supply pipes 48, 50 and air pump P of that embodiment are replaced with a hand-operated bellows pump 94. The bellows pump 94 can be used to inflate the cushion manually when desired and although it does not provide any alternating pressure it does nevertheless provide additional support if the patient should contact the solid filling within the cells.

A further variation is illustrated in Fig. 17. The embodiment of Fig. 17 is very similar to that of Fig. 6 except that instead of a single internal dividing wall 34 two parallel spaced apart dividing walls 34a, 34b are provided, dividing the cell into three sub-cells, each containing a respective block of foam 38', 39', 40'. In the embodiment illustrated, the side walls and the base wall of each of

the foam blocks are glued to the inner face of the respective adjacent wall of the cell, but this need not be the case. Also, the solid fillings of the sub-cells may be varied, as for the previous embodiments. Moreover, more than two dividing walls, e.g. three or four walls, may be used. The dividing walls may allow the sub-cells to communicate, as in the Fig. 3 embodiment, or may isolate the sub-cells from each other, as in the Fig. 11 embodiment.

A further variation is illustrated in Figs. 18a and 18b. In this embodiment, the cell 12 itself is identical to that of Fig. 7. The cell contains a block of compressible foam 43 whose upper and lower faces F are each glued to the respective inner face of the upper and lower walls of the cell 12. The side walls of the block 43 are not glued to the inner faces of the side walls of the cell. Thus, when the cell is not inflated (as shown in Fig. 18a) the side walls of the cell are slack and the foam is in its relaxed state since the height of the foam block when relaxed is chosen to be smaller than the maximum height of the side walls of the cell.

When the cell is inflated as in the previous embodiments (as shown in Fig. 18b), the vertical expansion of the cell causes the previous slackness of the cell side walls to be taken up and causes the foam block to be placed under tension. Thus, when the applied pressure is removed, the stretched foam block 43 will resume its relaxed state, thereby assisting in expulsion of air from the cell.

The invention is not restricted to the details of the foregoing embodiments. For example, other types of fillings could be used. Or, mixtures of different types of filling materials could be used. Indeed, the material within the cells need not be the same for each cell. It would be possible for one type of filling to be arranged in a first area on the mattress or cushion (where, for example, more pressure is commonly applied) and for other fillings to be used in other areas to suit the intended region of support on the body. It would also be possible for the solid fillings to be included in only some of the cells, perhaps in those areas which are most important for pressure relief.

Claims

1. An inflatable support comprising an inflatable cell containing a deformable solid material.
2. An inflatable support as claimed in claim 1, comprising a plurality of inflatable cells containing a deformable solid material.
3. An inflatable support as claimed in claim 1 or claim 2, wherein the solid material is resiliently deformable.
4. An inflatable support as claimed in claim 3, wherein

the solid material comprises a block of solid material.

5. An inflatable support as claimed in claim 4, wherein the block of solid material is laminated.
6. An inflatable support as claimed in any of claims 3 to 5, wherein the solid material comprises a foamed material.
7. An inflatable support as claimed in claim 6, wherein the foamed material comprises a foamed plastics material.
8. An inflatable support as claimed in any of claims 4 to 7, wherein the solid material is secured to one or more cell walls.
9. An inflatable support as claimed in claim 8, wherein the solid material is secured to a cell side wall.
10. An inflatable support as claimed in claim 8 or claim 9, wherein the solid material is secured to opposed side walls of a cell.
11. An inflatable support as claimed in any of claims 8 to 10, wherein the solid material is secured to a cell base wall.
12. An inflatable support as claimed in claim 8, wherein the solid material is secured to opposed upper and lower cell walls.
13. An inflatable support as claimed in claim 12, wherein the height of the solid material in its relaxed state is smaller than the maximum height of the cell side walls.
14. An inflatable support as claimed in claim 1 or claim 2, wherein the solid material is in particulate form.
15. An inflatable support as claimed in claim 14, wherein the solid material comprises a plurality of deformable beads.
16. An inflatable support as claimed in claim 13, wherein the beads are resiliently deformable.
17. An inflatable support as claimed in claim 14 or claim 15, wherein the beads comprise a foamed material.
18. An inflatable support as claimed in claim 1 or claim 2, wherein the solid material is substantially non-resiliently deformable.
19. An inflatable support as claimed in claim 18, wherein the solid material comprises fibres.

20. An inflatable support as claimed in any of the preceding claims, comprising a first cell containing a deformable solid material and a second cell containing a deformable solid material, the first cell being located above the second cell. 5
21. An inflatable support as claimed in claim 20, wherein the solid material in the first cell differs from that in the second cell. 10
22. An inflatable support as claimed in claim 20 or claim 21, wherein the first and second cells have a common wall.
23. An inflatable support as claimed in any of claims 20 to 22 wherein the first and second cells communicate with each other. 15
24. An inflatable support as claimed in any of claims 20 to 22, wherein the first and second cells do not communicate with each other. 20
25. An inflatable support as claimed in any of the preceding claims, further comprising one or more cells containing no deformable solid material. 25
26. An inflatable support as claimed in any of the preceding claims, comprising one or more sealed inflatable cells. 30
27. An inflatable support as claimed in any of the preceding claims, comprising means for inflating the or each inflatable cell.
28. An inflatable support as claimed in claim 27, comprising a pump for inflating the inflatable cells. 35
29. An inflatable support as claimed in claim 27 or claim 28, comprising means for varying or altering the pressure within the or each inflatable cell. 40
30. An inflatable support as claimed in any of the preceding claims, wherein the cells are elongate.
31. An inflatable support as claimed in claim 29, wherein the cells are arranged parallel to one another. 45
32. An inflatable support as claimed in claim 30 or claim 31, wherein the support is elongate and the cells are arranged transversely to the longitudinal direction. 50
33. A mattress comprising an inflatable support as claimed in any of the preceding claims. 55
34. A seat cushion comprising an inflatable support as claimed in any of claims 1 to 32.

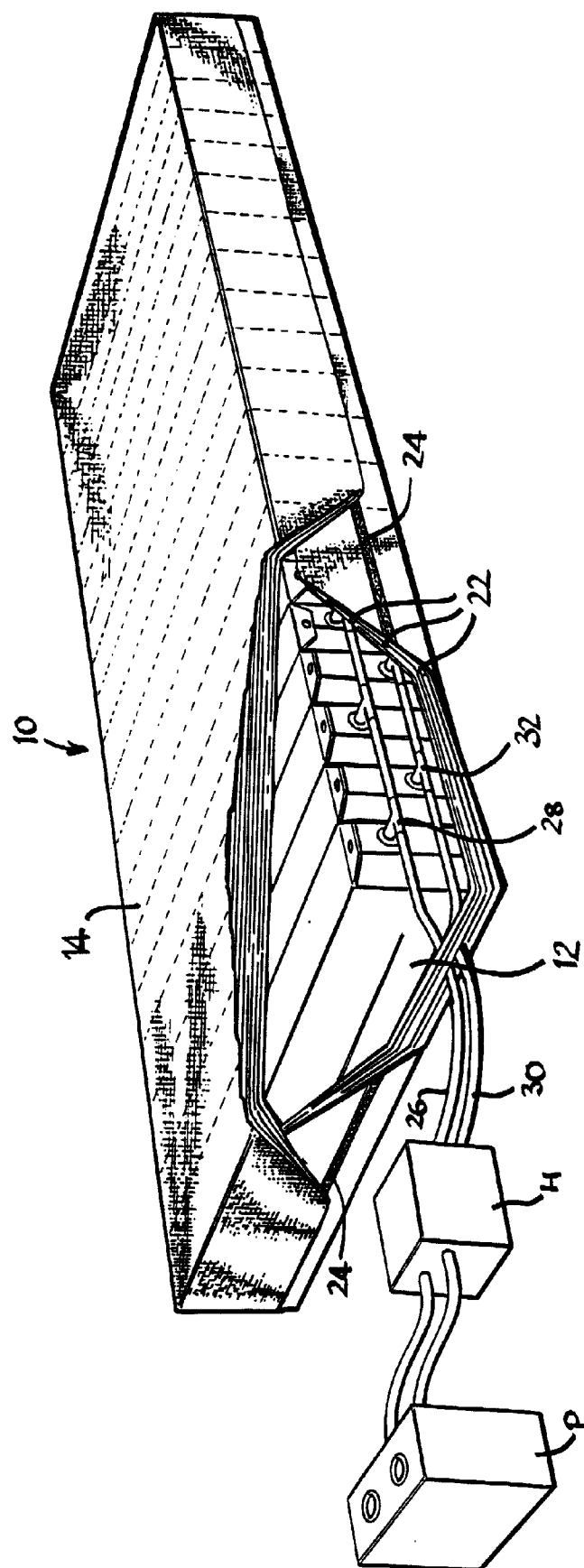


FIG. 1

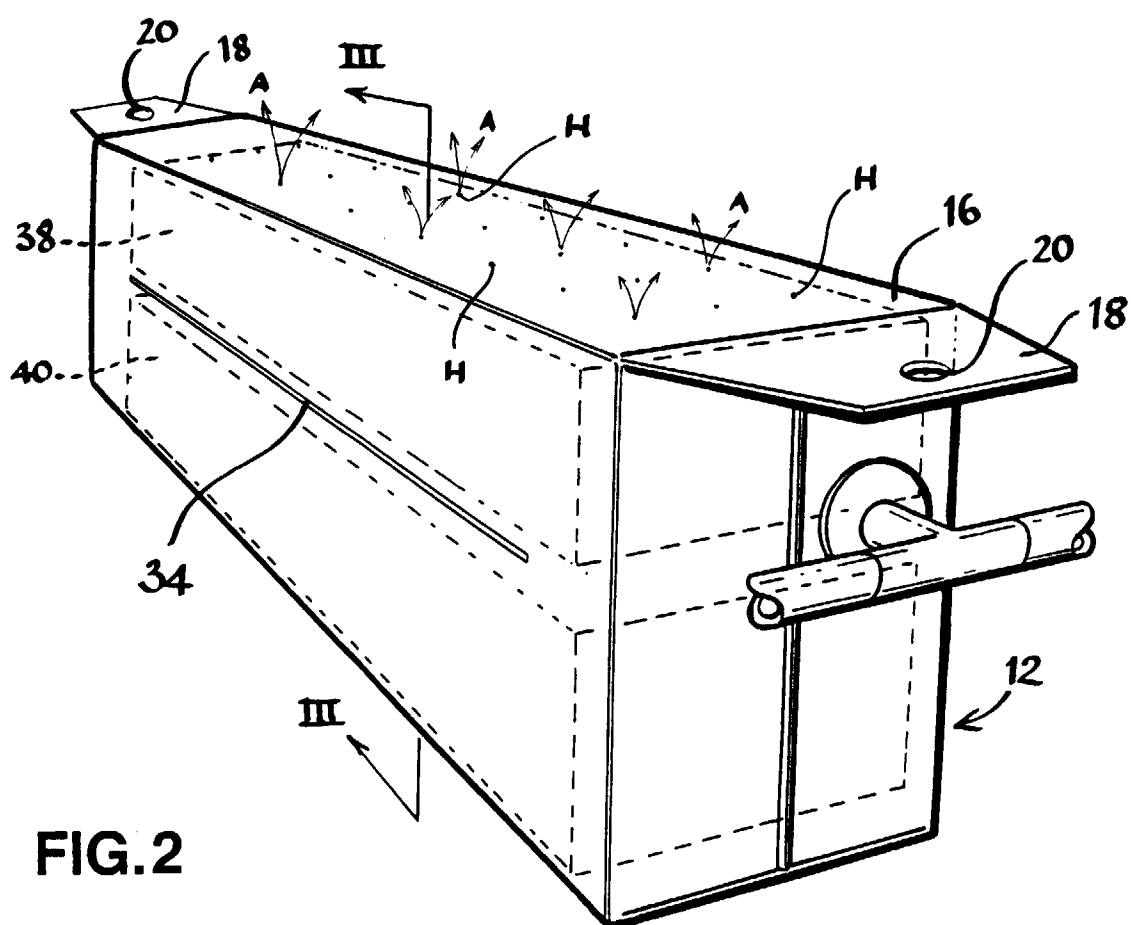


FIG.2

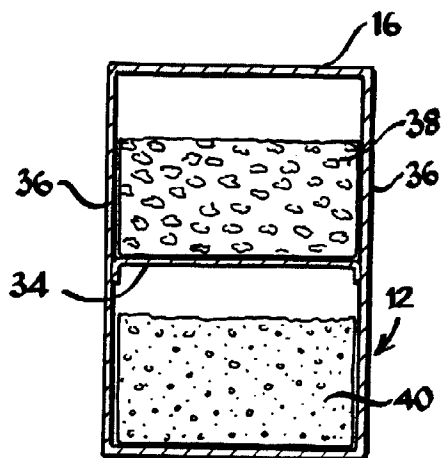


FIG. 3

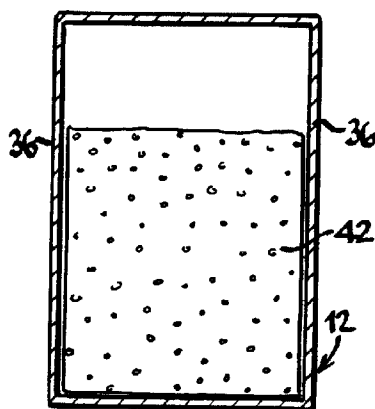


FIG. 4

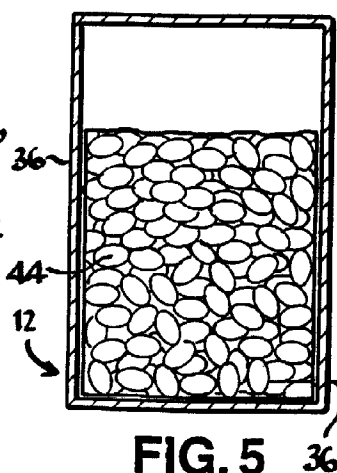


FIG. 5

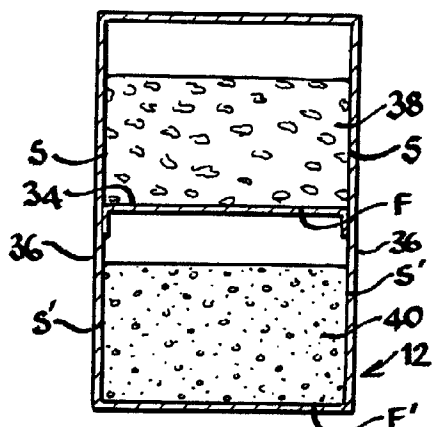


FIG. 6

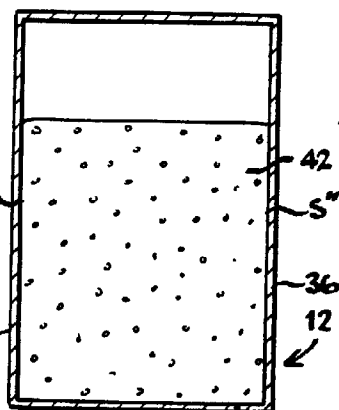


FIG. 7

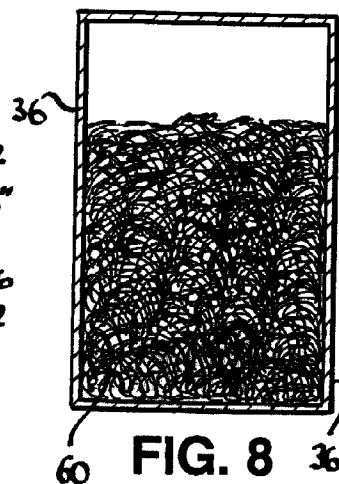


FIG. 8

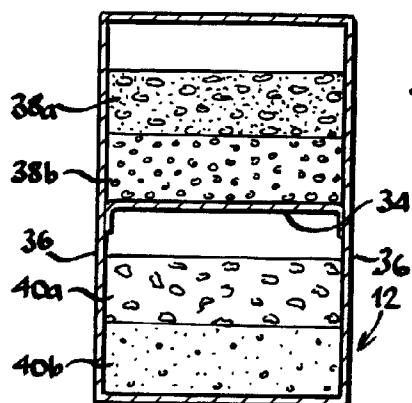


FIG. 9

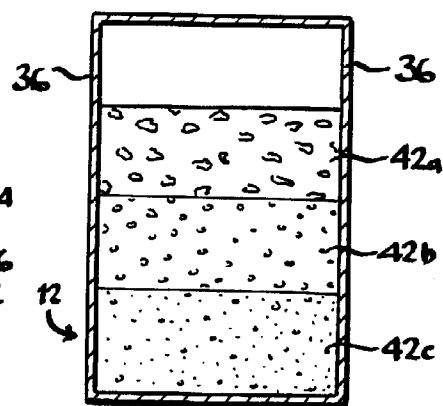


FIG. 10

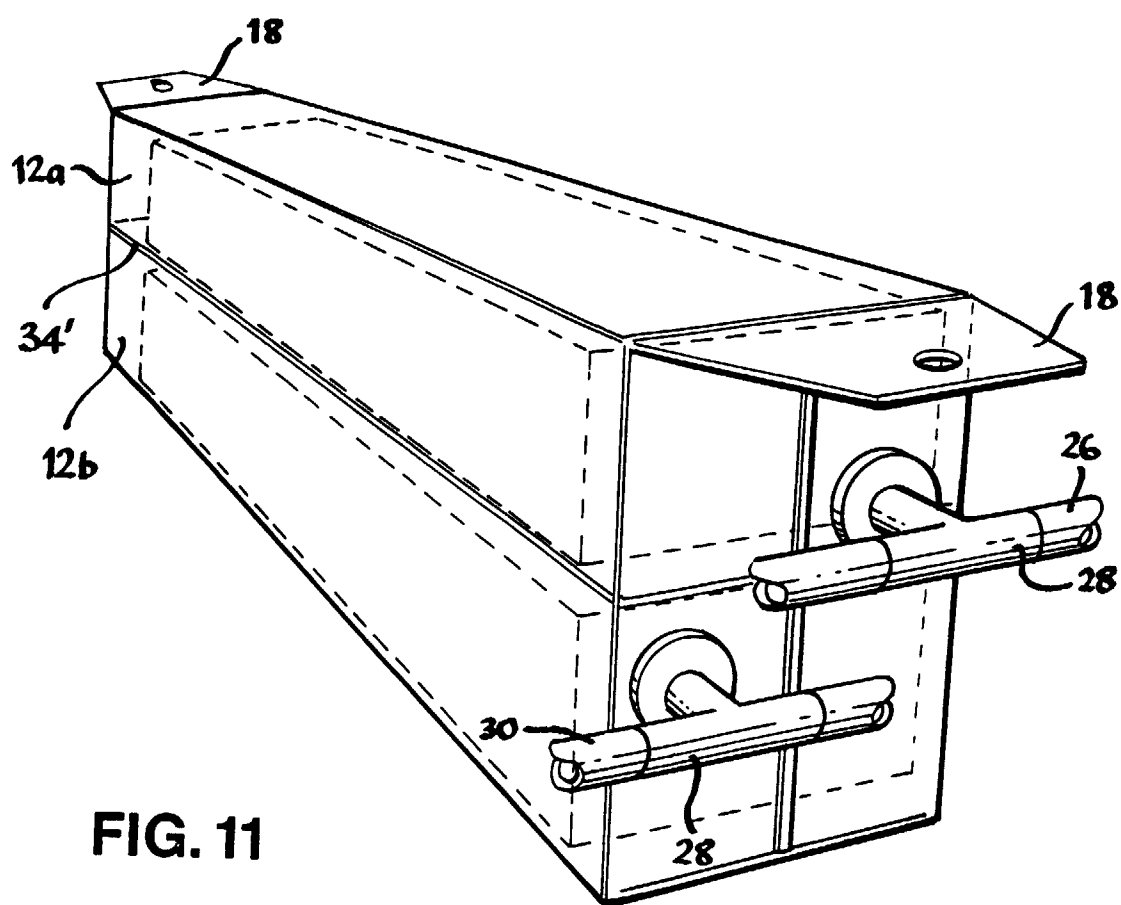
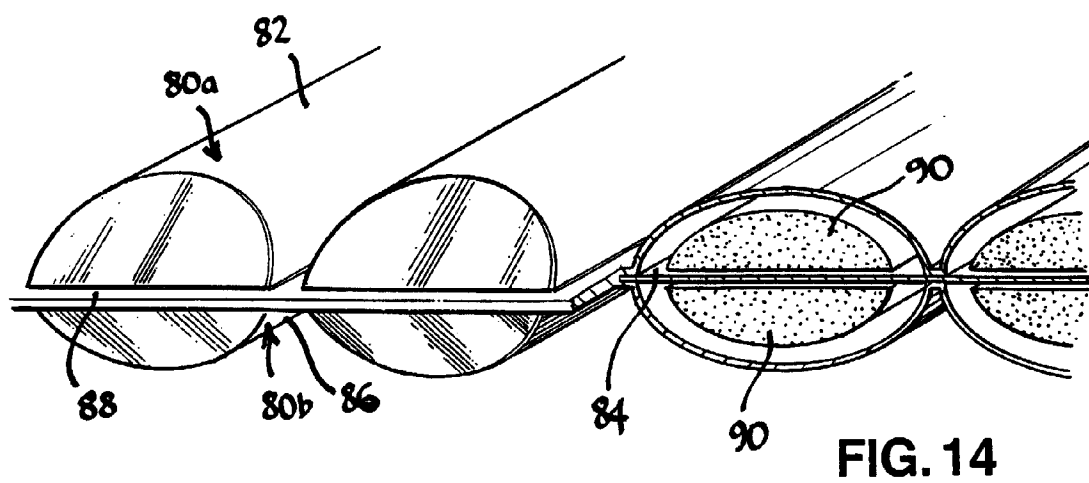
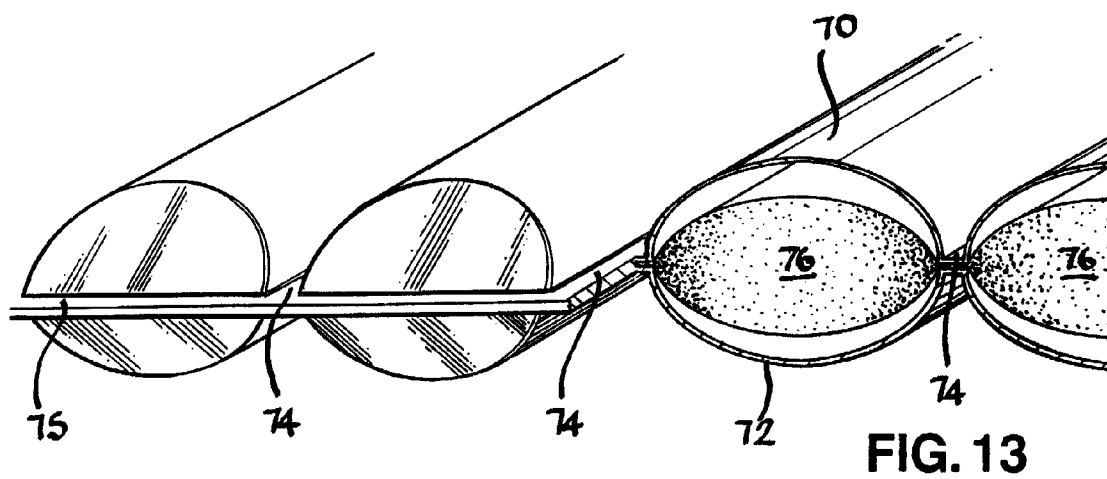
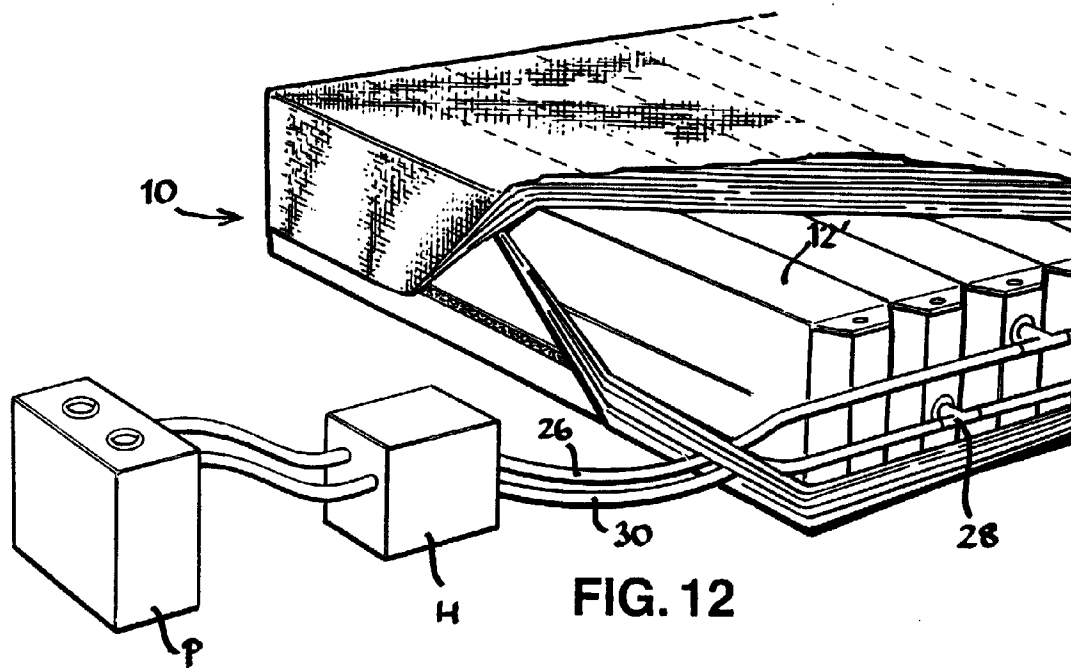
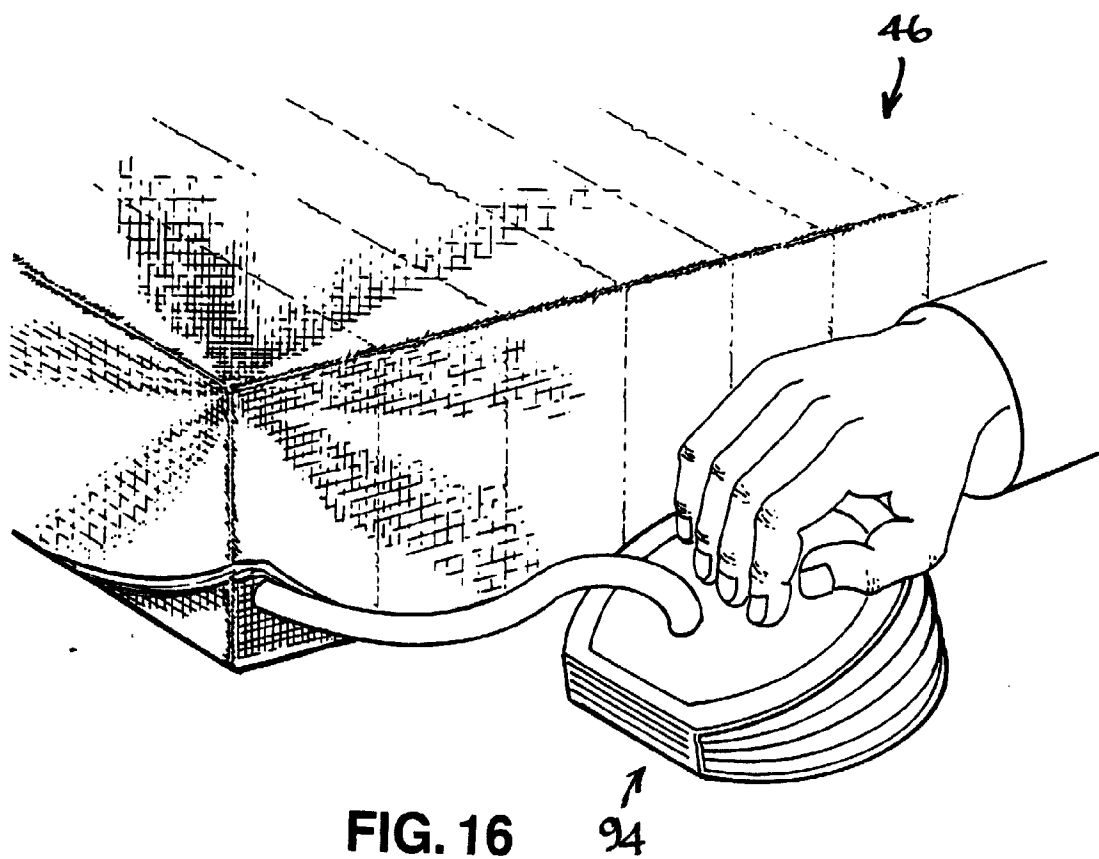
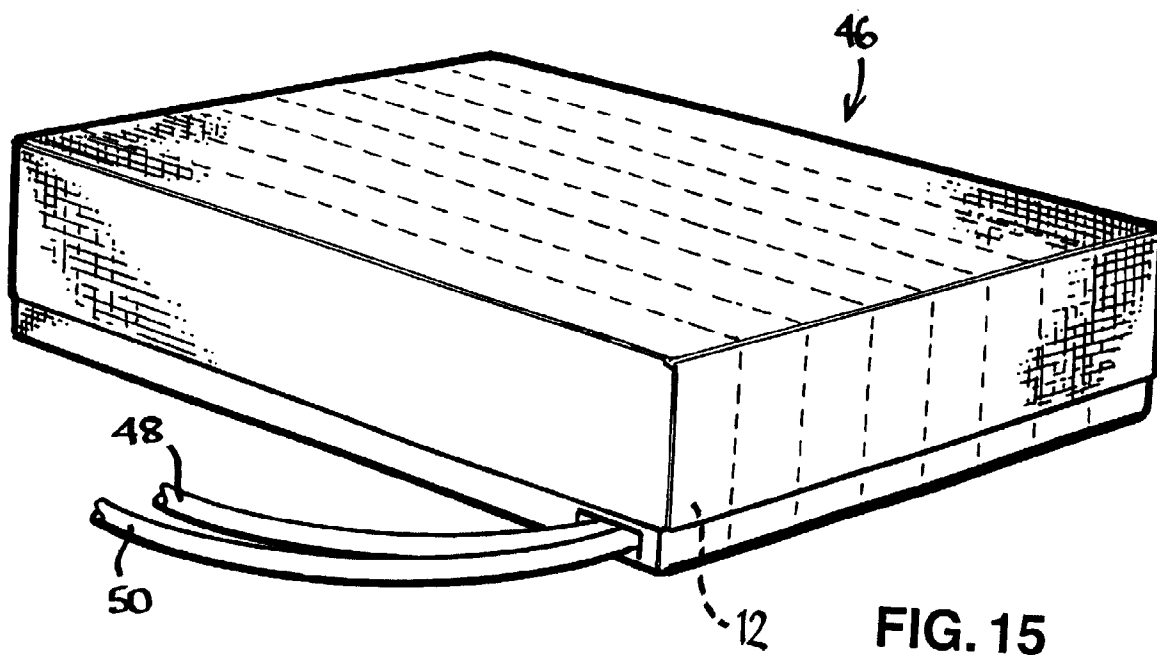


FIG. 11





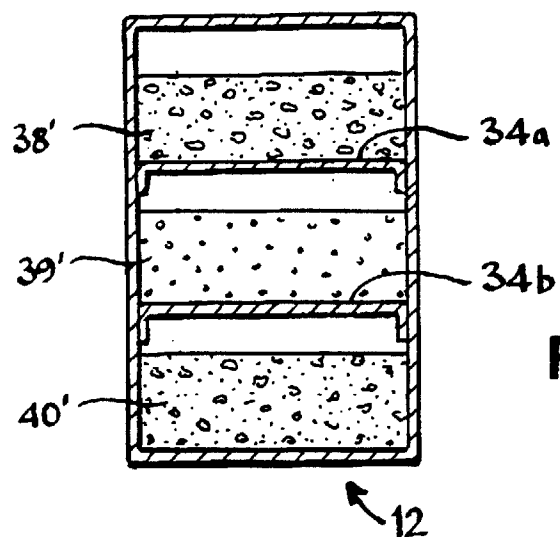


FIG. 17

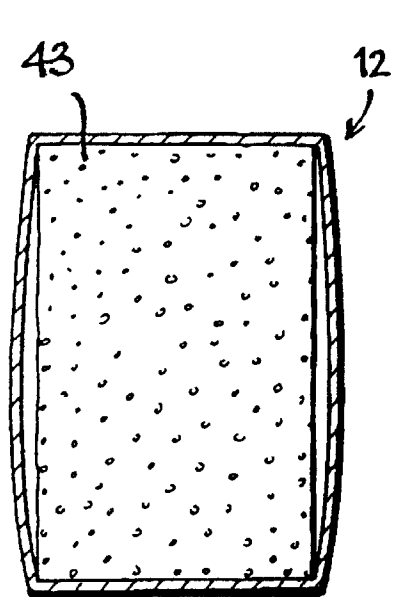


FIG. 18a

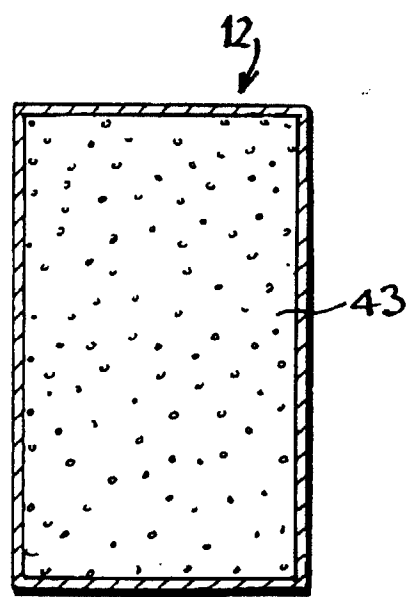


FIG. 18b