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(54) **FLUIDIZED BEAD BED WITH INFLATABLE BEAD DIFFUSER**

BETT MIT FLUIDISIERTEN KÜGELCHEN UND AUFBLASBAREM DIFFUSOR

LIT FLUIDISE A BASE DE BILLES, DOTE D'UN DIFFUSEUR DE BILLES GONFLABLE

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to improvements in fluidized patient supporting systems of the type described in US. Pat. No. 5,008,965.

BACKGROUND OF THE INVENTION

[0002] Patients subject to extensive recuperative periods, must remain in bed for extended periods of time. When such patients lie supinely on a conventional mattress, most of the load is born by protuberances of the posterior surface of the body such as the heels, the buttocks, the scapulae, and the occipital region of the head. The relatively small areas of soft tissue at these points are then subjected to high pressures by being compressed between the skeleton and the supporting surface. When this pressure becomes great enough to cause collapse of small capillaries and veins, pressure sores or decubitus ulcers may result. Burn patients also have problems with rubbing against the surface of an immobile conventional mattress surface that can result in the extraction of a skin graft. In order to overcome these problems, hospital beds have been developed which use fluidized granular material (preferably spherical beads) as a supporting medium in order to uniformly distribute the supporting pressure points along the body surface, thus reducing the pressure at the aforementioned critical areas.

[0003] Fluidized bead beds comprise a tank partially filled with a mass of some granular material, the granular material resting on top of a diffuser. A flexible, loose fitting sheet, which is permeable to air but not the granular material, is laid on top of the granular material to form the patient support surface. As gas commonly air, is blown through the diffuser into the granular material fluidizing the material so that a patient laying on top of the covering sheet is buoyantly suspended upon the bed. In this way, the forces imparted to the body are evenly distributed over the body and the chance of decubitus ulcers occurring is greatly lowered. Burn patients lie more comfortably, and the fluidized support medium moves with the body that reduces the likelihood of skin graft extraction. Also, this structure allows body fluids exuded from wounds to flow through the covering and into the granular material away from the patient, quickening the healing process. When the granular material is not being fluidized, the material settles down into a solid structure and contours to the body.

[0004] US 4,694,521 discloses a mat having an upper layer of porous elastic material with fine particles mixed therein and a lower layer of porous elastic material. Air is blown through the mat and is discharged through an air permeable sheet covering the upper surface of the upper layer.

[0005] Although fluidized bead beds are quite satisfactory in accomplishing the objectives enumerated above, they are not without some disadvantages. Conventional fluidized beds are quite heavy, commonly weighing in excess of 900 Kg (2000 lbs). Also, prior art fluidized beds had rigid diffusers, which were at least uncomfortable, if not dangerous, for the patient using the bed to bottom out on.

[0006] Therefore, it is an object of the present invention to provide a fluidized bead bed with a soft surface diffuser.

[0007] It is a further object to provide a fluidized bead bed with an inflatable bead diffuser intermediate the bed tub and the fluidizable beads.

[0008] It is a yet further object to provide a fluidized bead bed with an inflatable bead diffuser intermediate the bed tub and the fluidizable beads that causes the air used to fluidize these beads to be exhausted through the patient support surface.

[0009] It is another of the present invention to provide a fluidized bead bed massing substantially less than 900 Kg. It is a still further object to provide a fluidized bead bed with an inflatable bead diffuser intermediate the bed tub and the fluidizable beds which functions as a soft surface diffuser.

SUMMARY OF THE INVENTION

[0010] According to a first aspect of the invention, we provide a fluidized bead bed comprising an open tank, an inflatable bead diffuser placed within said tank, said diffuser comprising a non-rigid layer, fluidizable beads placed above said diffuser within said tank, a porous cover sheet secured to said tank so that said beads are intermediate said diffuser and said sheet within said tank and said sheet comprises a patient support surface, and air supply means operatively inflating a plenum within said tank defined beneath said diffuser that allows air to escape therefrom to fluidize said beads, characterized in that the diffuser comprises a plurality of inflatable chambers.

[0011] Said bed may comprise monitoring apparatus for monitoring at least one function of the bed.

[0012] Said monitoring apparatus may comprise a microprocessor- based system.

[0013] Said monitoring apparatus may comprise a temperature probe within said tank.

[0014] Said monitoring apparatus may also comprise a transducer to determine how far a patient may be depressed into said bead diffuser.

[0015] Said cover sheet may comprise PTFE.

[0016] Said beads may be contained in a bead pouch.

[0017] The fluidization air may be exhausted through said patient support surface.

[0018] Said beads may comprise a soda-lime core encased within a silicon sphere and range from about 50 to about 150 microns in diameter.

[0019] Each of said chambers may be adjacent at least one other of said chambers.

[0020] Each of the chambers may comprise at least one sidewall which may comprise a baffle.

[0021] Said diffuser may be concave in cross sectional shape.

[0022] Said air supply means may comprise a variable speed air blower.

[0023] Said inflatable air chambers may be inflated to a plurality of pressures.

[0024] According to the present invention, a fluidized bead bed is provided an inflatable diffuser intermediate the fluidizable beads and the tank structure. This inflatable diffuser serves to provide a soft surface underneath the beds to prevent a patient who bottoms out through the beads from coming into contact with the bed tub. Further, by raising the level of the beads, the use of an inflatable diffuser acts to reduce the quantity of beads required to be fluidized in order to provide the desired fluidized therapeutic effects commonly provided by a fluidized bed. This allows the air used to fluidize the beads to be exhausted through the patient support surface. Finally, this also results in a significant reduction of the weight of the bed system.

[0025] The bed comprises a tube or open tank structure, to side rails may be attached, support means, control means, air supply means, an inflatable diffuser, and contained fluidizable beads comprising a patient support surface. The diffuser is place din the bottom of the tub. Fluidizable beads are placed on top of the diffuser, preferably in a bead pouch. An air permeable cover sheet, fabricated from a material such as high air loss PTFE, is secured to the rim of the tub.

[0026] Air is supplied to the inflatable diffuser. This causes the beads to rise within the tank. Air then escapes from the diffuser, in a sufficient quantity to fluidize the beads. The exhaust air from fluidizing the beads then passes through the cover sheet. The exhaust air causes water, or other liquid waste exuded by the patient resting upon the cover sheet to evaporate.

[0027] Many other objects will be evident to those of ordinary skill in the art in view of the foregoing and following descriptions, particularly when considered in light of the prior art and in conjunction with the accompanying drawings. The drawings constitute part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG. **1** is a perspective view of the fluidized bead bed.

FIG. **2** is a top view of the tank with the sheets, fluidization material, and inflatable bead diffuser removed.

FIG. **3** is a sagittal sectional view of the fluidized bead bed of FIG. **1.**

FIG. **4** is a bottom view of the bead diffuser of the fluidized bead bed of FIG. **1.**

FIG. **5** is a cross sectional view of the bead diffuser of the fluidized bead bed of FIG. **1.**

FIG. **6** is a cross sectional view of the air nozzle of the bead diffuser of FIGs. **4** and **5.**

FIG. **7** is a cross sectional view of the air nozzle of FIG. **6** inserted into the fluidization port located on the bottom of the tank.

FIG. **8** is an exploded view of the air blower assembly of the fluidized bead bed.

FIG. **9** is a perspective view of the foot pedestal and framed box for housing the air blower assembly.

FIG. **10** is a cross sectional view of the three piece perimeter bumper for securing the sheets to the tank rim.

FIG. **11** shows a perspective sectional view of the three piece perimeter bumper and sheets attached to the tank rim.

FIG. **12** shows a control panel for operating the fluidized bead bed of FIG. **1.**

FIG. **13** shows an alternative embodiment of an inflatable bead diffuser of the fluidized bead bed of FIG. **1.**

FIG. **14** shows an alternative embodiment of an inflatable bead diffuser and bead pouch of the fluidized bead bed of FIG. **1.**

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] As required, preferred embodiments of the present invention are described herein; however, the disclosed embodiments are merely exemplary of the invention that may be embodied in various forms. The figures are not necessarily to scale; some features may be exaggerated to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but as a basis , for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention.

[0030] FIG. 1 shows a perspective view of a preferred embodiment of the present invention, hereinafter referred to as a fluidized bead bed **100.** The fluidized bead bed **100** comprises an open tank structure **101** which is mounted on top of a head pedestal **102** and foot pedestal **103.** As shown, the head pedestal **102** and foot pedestal

103 are positioned on top of a platform support surface **104.** Side rails **107*a-b*** can be fastened to the side of the tank **101** to provide patient safety. Where side rails **107*a-b*** are used, an adjustable latch assembly **108** is provided to raise or lower the side rails **107*a-b*** when patient or user access is required. A control panel **109** enables the user to control the operation of the bed in a manner described more fully below. It is preferable to provide a hand control **110** (not shown) to enable either the care giver or the patient to control the fluidization of the bead bed **100.** As is further disclosed herein, a flow of pressurized air to fluidize a quantity of fluidizable material contained within the tank **101** is provided by an air blower assembly **701** which is preferably housed within the foot pedestal **103** (FIG. 3). A preferred patient support surface is formed by placing a top cover sheet **106** in overlying relation to a top **313** filter sheet (FIG. 3), and attaching the cover sheet **106** to the tank rim **105.** A preferred top cover sheet **106** is made of a high air-loss GORE-TEX material which enables the fluidization air to be exhausted through the patient support surface. This preferred embodiment supplies a therapeutically beneficial flow of air against the patient's body which aids in the evaporation and removal of any moisture on the patient's skin.

[0031] FIG. 2 is a top view of the bottom surface **203** of the tank **101.** The bottom of the tank **101** is constructed with four holes **201*a-d*** which provide ports for establishing an air conduit between the bead diffuser **301** and the air blower assembly **701.** Though FIG. 2 illustrates the use of four holes **201*a-d*** in a staggered position on the bottom of the tank **101,** it should be evident to someone skilled in the art that different arrangements and numbers of connecting ports may be used without departing from the scope of the i invention. In another preferred embodiment, as shown in FIGs. 2 and 3, a fifth hole **202** is used to provide a communication port between a temperature probe **305** located within the tank **101,** and a microprocessor-based system adapted to correspondingly increase or decrease the temperature of the pressurized air flowing through the beads **303.** In this way, the temperature of the beads **303** is continuously monitored by the probe **305** which operably signals the heating and cooling system to adjust the air temperature as is necessary to maintain patient comfort. While a temperature probe **305** can be positioned within the air conduit or the air blower assembly, it is preferable to position the temperature probe within the tank **101** to provide a temperature reading which more accurately reflects the temperature of the patient support surface.

[0032] Referring to FIGS. 3, 4, and 5 a preferred embodiment of the present invention comprises an inflatable bead diffuser **301** which rest against the bottom surface **203** of the tank **101.** In this embodiment, the inflated bead diffuser **301** provides an upper diffuser surface **310** which is elevated relative to the generally horizontal bottom surface **203** of the tank **101.** As shown in FIG. 3, a fluidized patient support surface is formed by a quantity of fluidization material **303** supported on top of the normally inflated bead diffuser **301.** In this embodiment, the bead diffuser **301** when in an inflated condition increases the height of the fluidized patient support surface relative to the bottom surface **203** of the tank **101.** As compared to the prior art, an inflatable bead diffuser **301** therefore provides the means for significantly reducing the quantity of fluidization material **303** required to form a fluidized patient support surface.

[0033] In its preferred embodiment, the bead diffuser **301** is initially placed into the tank **101** in a deflated condition, and an air blower assembly **701** provides the necessary flow of air to inflate the bead diffuser **301** and fluidize a quantity of material 303 supported thereon. As illustrated in FIG. 7, the inflatable bead diffuser **301** is assembled with four air nozzles **501*a-d*** specially designed to insert into four fluidization ports **302*a-d*** which are set into four holes **201*a-d*** constructed on the bottom of the tank **101.** An air conduit is provided between the bead diffuser **301** and the air blower assembly **701** using flexible air hoses **308*a-d*** attached at a first end to the air blower assembly **701** and a second end to the fluidization ports **302*a-d.*** In this preferred embodiment, a flow of inflation and fluidization air generated by the air blower **701** flows through the air hoses **308*a-d*** to the attached fluidization ports **302*a-d*** and into the bead diffuser **301** through the air nozzles **501*a-d*** releasably inserted into the fluidization ports **302*a-d.***

[0034] As shown in FIG. 6, a preferred air nozzle 501 is integrally attached to the bottom surface **311** of the bead diffuser **301**. In a preferred assembly, an air nozzle **501** is coupled to the bottom surface **311** of the bead diffuser **301** by first inserting the air nozzle **501** through the air holes cut into two disk shaped swathes of fabric material **602*a-b.*** The fabric disk **602*a-b*** are preferably constructed of a "REGENCY" fabric, which is a high strength laminated nylon taffeta fabric manufactured in China and distributed in U.S.A. by John C. Tucker Co., Inc. Another fabric disk **604** having a center air hole is then placed on the top surface of the circular head **608** of the air nozzle **501.** The top fabric disk **604** is also preferably constructed of REGENCY. Using conventional sewing techniques, the fabric disks **602*a-b*** and **604** are sewn together to securely fasten the circular head **608** of the air nozzle **501** within a three layer fabric disk **605.** The air nozzle **501** is then inserted through a hole cut into the bottom surface **311** of the bead diffuser **301.** When so positioned, the air nozzle **501** projects out of the bead diffuser **301,** and the circular head 608 contained within the three-layer fabric disk **605** rest against the bottom surface **311** of the bead diffuser **301.** Once the air nozzle **501** is inserted through the hole in the bottom surface **311,** the fabric disk **605** is sewn to the surface **311.** A no air-loss disk patch **603** is placed over the top surface of the three-layer fabric disc **605** to eliminate air leaks. The circular patch **603** preferably includes an adhesive surface **607** which adheres the patch **603** to the top surface of the fabric disk **605,** and to the bottom surface **311** of the bead diffuser **301.** As illustrated in FIG.

6, the perimeter **606** of the circular patch **603** is greater than the perimeter of the fabric disk **605** so that when the patch **603** is adhered to the bottom surface **311** of the bead diffuser **301,** the fabric disk **605** is securely fastened between the patch **603** and the bottom surface **311** of the bead diffuser **301.** In this manner, the circular patch **603** forms an air-tight seal which prevents any air-loss between the circular head **608** of the air nozzle **501** and the bottom surface **311** of the bead diffuser **301.** As illustrated in FIGs. 6 and 7, a relatively gas-tight fit between the air nozzle **501** and the corresponding fluidization port **302** is provided by an "O" ring seal **601** which occupies a groove fabricated into the neck of the air nozzle **501.**

[0035] In a preferred embodiment, illustrated in FIG. 3, the fluidization material **303** is contained within a bead pouch **307** that is supported on top of the inflatable bead diffuser **301.** The bead, pouch **307** is preferably an integral component of the inflatable bead diffuser **301,** however, the bead pouch **307** can be separately assembled without departing from the scope of the present invention. The fluidization material preferably consists of medical grade silicone spherical beads **303** of the type commonly employed in air fluidized bead support systems. Such beads **303** generally comprise a soda-lime core encased within a silicone sphere, and range in size from 50 to 150 microns in diameter. As can be appreciated from FIG. 3, the diffuser surface **310** of the inflatable bead diffuser **301** is integral to the bottom bead support surface **309** of the bead pouch **307.** The side walls of the bead pouch **307** are formed by attaching one edge of a fabric skirt **304** to the outer perimeter **314** of the top diffuser surface **310** of the bead diffuser **301,** and attaching the second edge **of the fabric** skirt **304** to the tank rim **105.** In this manner, the fabric skirt **304** frames the outer perimeter **314** of the top diffuser surface **310** of the bead diffuser **301,** and forms the side walls of the pouch **307** for containing the fluidization material therein. The top surface of the bead pouch **307** is formed by placing a bottom filter sheet **306** over the top of the beads **303** contained within the side walls of the fabric skirt **304,** and attaching the peripheral edges of the filter sheet **306** to the tank rim **105.** A second top filter sheet **313** is then placed over the bottom filter sheet **306,** draped over the tank rim **105,** and attached along the outer tank wall. In this preferred embodiment, the pressurized air flowing through the inflatable bead diffuser **301** vents through the bottom surface **309** of the bead pouch **307** and fluidizes the quantity of beads **303** contained within the pouch **307.** Though the preferred embodiment discloses the use of a single bead pouch **307** to contain the beads **303** therein, it should be evident to those skilled in the art that alternative bead pouch **307** arrangements may be constructed without departing from the scope of the invention. For example, a plurality of adjacently attached bead pouches can be transversely positioned across the top of the bead diffuser **301** to provide a suitable fluidized patient support surface.

[0036] In a preferred embodiment, a bead diffuser **301** is constructed of an inflatable material that is distendable upon receiving pressurized air from a pressurized air source. Thus, as can be appreciated from FIG. 3, the flow of pressurized air into the bead diffuser 301 forms a plenum space **315** between the bottom surface **203** of the tank **101,** and the quantity of beads **303** supported on top of the bead diffuser **301.** As shown, inflation of the plenum space **315** elevates the diffuser surface **310** relative to the bottom surface **203** of the tank **101.** As will be evident to those skilled in the art, this embodiment of the presently disclosed fluidized bead bed **100** provides several significant advantages over the prior art. First, elevating the diffuser surface **310** is desirable because it significantly reduces the quantity of beads **303** necessary to form a fluidized patient support surface. This reduction in the quantity of beads **303** substantially decreases the weight of the fluidized bead bed **100** over that of prior fluidization patient support systems. For example, conventional fluidized patient support systems may weigh in excess of 2,000 pounds; however, the presently preferred fluidized bead bed **100** weighs less than 1,000 pounds. Second, the inflatable bead diffuser **301** functions as an air mattress to prevent the undesirable effects associated with what is known in the art as "patient bottoming out." By way of illustration, an occupant of a fluidized support system, for various reasons, may sink through the fluidized beads **303** to the tank bottom **203.** This "bottoming out" effect may result in a patient being lacerated by system components located on the bottom of the tank, such as rivets, bolts, and/or systems probes. In the presently disclosed invention, were a patient to sink through the beads **303,** the patient would merely come to rest on top of an inflated bead diffuser **301** and not the tank bottom **203.** The presently disclosed inflatable bead diffuser **301** therefore provides cushioned support to patients who experience "bottoming out".

[0037] FIGS. 4 and 5, illustrate a bottom and cross sectional view of a preferred bead diffuser **301,** respectively. Referring to FIG. 4, the outer perimeter of the bead diffuser **301** is specially designed to be substantially similar to the inner perimeter of the tank **101** (FIG. 2). In this manner, the side surfaces **312*a-b*** of a normally inflated bead diffuser **301** fit tightly against the inner wall of the tank **101.** This sealed fit prevents any portion of the bead pouch **307** and beads **303** contained therein from sliding down between the inner walls of the tank **101** and the bead diffuser **301.** As shown, the bead diffuser **301** forms an inflatable enclosure having a substantially rectangular body with a circular head end **403** and a squared foot end **404.** The air nozzles **501*a-d*** are integrally coupled to the bottom surface **311** of the bead diffuser **301** so as to properly align with the air holes **201a-d** located on the bottom of the tank **101** (FIG. 2).

[0038] As illustrated in FIG. 4, another opening **401** is provided for inserting into the bead diffuser **301** one or more transducers and/or probes for monitoring various bed functions. More particularly, such monitoring apparatus can include a temperature probe **305,** a pressure transducer and/or a distance sensing transducer operable to determine how far a patient is depressed into the bead diffuser **301.**

[0039] FIG. 5 shows a cross sectional view of a preferred bead diffuser **301** in a substantially inflated form. In its preferred embodiment, an inflatable bead diffuser **301** comprises nine inflatable air chambers **502*a-i*** adjacently positioned to at least one other air chamber. Referring to FIG., 4, each inflatable air chamber **502*a-i*** extends longitudinally the entire length of the bead diffuser **301.** At least a portion of the upper surface of each inflatable air chamber **502*a-i*** is comprised of a fabric material specially adapted to facilitate the flow of pressurized air out of the inflated bead diffuser **301** at a rate sufficient to fluidize a quantity of fluidization material resting against the upper surface of the bead diffuser **301.** In this preferred embodiment, the upper surface of the bead diffuser 301 is therefore operable as a diffuser surface **310.** The top diffuser surface **310** of each inflatable air chamber **502*a-i*** is preferably constructed from a high-airloss nylon mesh weave fabric such as that commercially available from W.L. Gore & Associates under the trademark "GORE-TEX." Alternatively, the diffuser surface **310** can be assembled using low-airloss fabric material in which the fabric includes a multiplicity of air apertures that channel the flow of fluidization air out of the bead diffuser **301.** Such a diffuser surface **310** can be fabricated by using a standard industrial sewing machine, without spooled thread, to needle the apertures into the low-airloss GORE-TEX fabric material. It should be understood by those skilled in the art, however, that alternative diffuser surfaces and means for fabricating such diffuser surfaces can be used without departing from the scope of the invention.

[0040] In a preferred assembly, the bottom surface **311** and side surfaces **312*a-b*** of the bead diffuser **301** are made of a low or no air-loss fabric material. In this manner, the pressurized air within the bead diffuser **301** does not flow out through the bottom surface **311** and side surfaces **312*a-b,*** but is forced upwardly through the diffuser surface **310.** A suitable, no air-loss fabric material for assembling the bottom surface **311** and side surfaces **312*a-b*** is a polyurethane-backed nylon fabric material commercially available under the trademark "K-KOTE." Alternatively, a low air-loss GORE-TEX fabric material can be used to construct the side surfaces **312*a-b.*** It should be understood by those skilled in the art, however, that various other no air-loss or low air-loss materials may be used to construct the bottom surface **311** and side surfaces **312*a-b*** of the inflatable bead diffuser **301** without departing from the scope of the invention. In another preferred embodiment, the fabric skirt **304** is assembled using either no air-loss K-KOTE or low air-loss GORE-TEX to prevent fluidization air from escaping between the fabric skirt **304** and the inner wall of the tank **101.**

[0041] Referring to FIGS. 4 and 5, each inflatable air chamber **502*a-i*** has at least one side wall formed by an air baffle **402*a-h,*** respectively. In this embodiment, the air baffles **402*a-h*** serve primarily to prevent bowing of the inflatable air chambers **502*a-i,*** and to support the upwardly flow of fluidization air through the diffuser surface **310.** Each air baffle is preferably made of a low air-loss GORE-TEX fabric material having an upper edge that is attached to at least a portion of the diffuser surface **310,** and a lower edge attached to at least a portion of the bottom surface **311** of the bead diffuser **301.** In a preferred assembly, each air baffle **402*a-h*** is sewn to the respective surfaces, **310** and **311,** using conventional sewing techniques. As disclosed above, it is desirable that the bottom surface **311** and side surfaces **312*a-b*** be substantially air-tight to prevent a reduction in the flow of fluidization pressure through the diffuser surface **311.** Therefore, where baffles **402a-h** are attached to either the bottom surface **311** and/or side surface **312*a-b,*** it is a preferred that the air baffle be assembled using welding or heat-sealing techniques which form an air-tight seal at the respective site of attachment. It should be understood by those skilled in the art that alternative methods of forming a relatively air-tight seal between the air baffle and the attachment surface can be used without departing from the scope of the invention.

[0042] As shown in FIG. 4, the head end **406** and leg end **407** of each air baffle **402*a-h*** is not attached to the head end **403** or leg end **404** of the bead diffuser **301.** This preferred assembly provides air passages **405** at the ends of each air baffle **402*a-h*** which allows the fluidization air to flow into each chamber **502*a-i.*** In this way, pressurized air flowing through the air nozzles **501*a-d*** and into the bead diffuser **301** is able to equalize throughout the bead diffuser **301** by flowing through the air passages **405.** Air passages (not shown) can also be provided for by placing air openings at various locations along the length of each air baffle **402*a-h.***

[0043] As illustrated in FIG. 5, a preferred bead diffuser **301** is specially designed such that a cross sectional profile of the bead diffuser **301** discloses a concave shaped diffuser surface **310.** More specifically, the inflatable chambers **502*a-i*** of the bead diffuser **301** form a trough which extends lengthwise along the upper diffuser surface **310.** As shown, the two outer inflatable chambers **(502a** and **502i)** are specially designed to form an upper diffuser surface **310** which is elevated relative to the diffuser surface **310** defined by the three inner inflatable chambers **(502*d-f*).** The four inflatable chambers **(502*b-c*** and **502*g-h*)** intermediately positioned between the two outer inflatable chambers **(502a** and **502i)** and three inner inflatable chambers **(502*d-f*)** form an upper diffuser surface which slopes downwards from the diffuser surface defined by the outer chambers **(502a** and **502i)** to the diffuser surface defined by the inner chambers **(502*d-f*).** A preferred assembly for forming a concave shaped bead diffuser **301** includes fabricating air baffles 402*a-h* with differing heights, whereby the air baffles forming the side walls of the outer inflatable chambers are of a greater height relative to the air baffles forming the side walls of the inner most inflatable chambers. In this way, the greater the height of the baffle relative to the bottom surface **311** of the bead diffuser **301,** the greater the height of the diffuser surface **310** relative to the bottom surface **311** of the bead diffuser **301.** A concave shaped diffuser surface **310** is highly advantageous in that the quantity of fluidization material required to form a fluidized patient support surface is further reduced as compared to a substantially horizontal diffuser surface. More particularly, the fluidized material situated nearest to the tank wall normally forms the patient support surface for supporting the patient's extremities. As the patient's extremities normally weigh less than the patient's body, less fluidization material is generally required to support the patient's extremities. A preferred bead diffuser **301** comprising upright inflatable chambers (**502a** and **502i**) effectively reduces the quantity of beads **303** needed to form the patient support surface which supports the patient's extremities: Likewise, as compared to the outer chambers **(502a** and **502i),** the inner inflatable chambers **502*e-f*** are specially designed to form a diffuser surface **310** which is more distal to the fluidized patient support surface and is, therefore, able to support the greater quantity of fluidization material generally required for supporting the heavier head, torso, and leg portions of the patient's body. It should be understood by those skilled in the art that a diffuser surface **310** can be variously shaped without departing from the scope of the present invention. For example, the diffuser surface **310** could simply define a horizontal surface.

[0044] An exploded view of a preferred air blower assembly **701** for supplying a flow of air through the diffuser surface **310** at a rate sufficient to fluidize the beads **303** supported thereon is illustrated in FIG. 8. In a preferred embodiment, the air blower assembly **701** is housed within a framed box that occupies and is conveniently removed from within the' foot pedestal **103.** As shown in FIG. 9, the framed box **705** is set upon a pair of front wheels **702** and rear wheels **703** (not shown) to provide the user with convenient access to the air blower assembly **701.** To access the air blower assembly **701** for purposes of repair and general maintenance, the foot end cover **704** of the foot pedestal **103** is removed, and the framed box **705** is simply rolled out of the foot pedestal **103.** Once the framed box **705** is removed from within the foot pedestal **103,** a hinged top cover **718** is easily lifted to reveal the individual components of the air blower assembly **701.** In another preferred embodiment, the side walls and supporting, surfaces of the framed box **705,** and the head and foot pedestals **(102-103)** are fabricated out of a light-weight composite material to further reduce the overall weight of the fluidized bead bed **100.**

[0045] Referring to FIG. 8, a preferred air blower assembly **701** comprises two electric motor driven air blowers **709*a-b*** which supply a flow of pressurized air sufficient to inflate the bead diffuser **301** and fluidize the fluidization material **303** supported thereon. The air blowers **709*a-b*** are preferrably variable speed type blowers which provide for adjustments in the air flow rate so as to enable the bed user to selectively alter the level of fluidization. In a preferred operation, room air is initially filtered through two air filters **708*a-b*** before entering the air blowers **709*a-b*** through air connection ports **719** (not shown). Pressurized air is channeled out of the air blowers **709*a-b*** through discharge ports **720*a-b*** and into discharge hoses **716*a-b*** which provide an air conduit between the air blowers **709*a-b*** and a heat exchanger **711.** To prevent the air blower assembly **701** from becoming overheated during operation, three exhaust fans **717** are provided which function to draw heat away from the air blower assembly **701.** A preferred heat exchanger **711** includes a heating element **721** (not shown) which is operable to maintain the temperature of the pressurized air within a preferred range of about 26.7 °C to 37.7 °C (80 to 100 degrees Fahrenheit). A furnace filter 714 is also provided to clean the air used to cool the heat exchanger 711. Pressurized air is discharged from within the heat exchanger 711 into four flexible air hoses 308*a-d* which provide air conduits between the heat exchanger 711 and the bead diffuser 301. In this manner, pressurized air flows through the flexible air hoses 308*a-d* and into the bead diffuser 301 which becomes inflated and fluidizes the beads 303 supported thereon. The fluidization air is then exhausted through the bottom 306 and top 313 filter sheets which are permeable to air but not to the beads 303.

[0046] In another preferred embodiment, as illustrated in FIG. 8, at least one of the four flexible air hoses 308*a-d* is in fluid communication with one or more auxiliary air hoses 713*a-b* via a valve assembly 712. As shown in FIG. 8, air flowing through the air hose 308d can be diverted by the valve assembly 712 and into two auxiliary air hoses 713*a-b* for the purpose of providing pressurized air to an inflatable patient support system (not shown), or other system requiring pressurized air for proper operation.

[0047] A preferred embodiment for attaching the fabric skirt 304, the bottom filter sheet 306 and the top filter sheet 313 to the tank rim 105 are illustrated in FIGs. 10 and 11. Referring to FIG. 11, three strips (1001, 1002, and 1003) of a hook or loop fabric material is attached to the tank rim 105. One such suitable hook and loop fabric is well known in the art, and is commercially available under the trade mark "VELCRO". An opposing hook or loop VELCRO strip for adhering to the strips attached to the tank rim 105 is secured to the perimeter edge of the fabric skirt 304, the bottom filter sheet 306 and the top filter sheet 313. As shown in FIG. 11, the bead pouch 307 is formed within the tank 101 by extending the fabric skirt 304 upward along the inner wall of the tank 101 and attaching the VELCRO strip on the perimeter of the fabric skirt 304 to the first strip 1001 of VELCRO extending about the inner edge of the tank rim 105. The upper surface of the bead pouch 307 is formed by attaching the VELCRO strip on the bottom filter sheet 306 to a second VELCRO strip 1003 positioned about the outer edge of the tank rim 105. As disclosed above, attaching the fabric skirt 304, and the bottom filter sheet 306 to the tank rim 105 forms the preferred bead pouch 307. In this way, the beads 303 are easily removed for the purpose of normal maintenance or replacement by simply removing the bottom filter sheet 306. A top filter sheet 313, as illustrated in FIGS. 3 and 11, is placed in overlying relation to the bottom filter sheet 306. As shown, the perimeter edge of the sheet 313 is stretched over the tank rim 105, and attached to a third VELCRO strip 1002 attached to the outer wall of the tank 101. It should be understood to those skilled in the art that alternative means for attaching the respective sheets 304, 306 and 313 to the tank rim 105 can be used without departing from the scope of the invention.

[0048] In a preferred embodiment, as shown in FIGs. 10 and 11, both prevention of patient injury and attachment of the respective sheets 304, 305 and 313 is accomplished using a three piece flexible bumper assembly 904 to overlap the rigid tank rim 105. As shown in FIG. 10, an inner perimeter bumper 901 is placed over the attached sheets (304, 305 and 313), and securely fastened to the inner perimeter of the tank rim 105. A corresponding outer perimeter bumper 902 is fastened to the outer perimeter of the tank rim 105. After the inner and outer perimeter bumpers are secured to the tank rim 105, a middle perimeter bumper 903 is used to demountably engage the inner 901 and outer 902 perimeter bumpers and, thus, secure the bumper assembly 904 to the tank rim 105. Once the flexible bumper assembly 904 is installed, a top cover sheet 106 is fitted over the bumper 904 to form a preferred patient support surface.

[0049] FIG. 12 illustrates a control panel 109 which serves as the primary interface for controlling and adjusting the functions of the presently disclosed fluidized bead bed 100. Referring to FIG. 1, the control panel 109 is shown extending from the foot pedestal 102. In a preferred embodiment, the control panel 109 can be stored out of view and in a closed position within the foot pedestal 102. In use, fluidization of the beads 303 is activated or deactivated by switching the ON/OFF switch 1101 to its respective ON or OFF position. The ON light 1105 is illuminated as long as the ON/OFF switch 1101 remains in an ON position. Once the fluidization switch 1101 is turned ON, the air flow adjustment 1102 is used to increase or decrease the flow of fluidization air into the bead diffuser 301 and up through the beads 303 supported thereon. In an alternative embodiment, fluidization may be suspended without deflation of the bead diffuser 301. This embodiment allows the patient to remain accessible on top of the inflated bead diffuser 301 even though fluidization is suspended.

[0050] To ensure patient comfort, a temperature adjustment 1103 is provided which enables the care giver or patient to increase or decrease the temperature of the fluidization air flowing through the beads 303 and out the patient support surface. It is preferable that the temperature of the beads 303 be adjustable between the range of 26.7 °C (80 degrees Fahrenheit) at the minimum setting, and 37.7 °C (100 degrees Fahrenheit) at the maximum setting. Illumination of the heat light 1107 or cool light 1106 verifies that the system is either heating or cooling the beads 303 as selected.

[0051] In another preferred embodiment, the patient is provided with a hand control 110 to control the bed 100 fluidization functions (not shown). In this preferred embodiment, the main control panel 109 is equipped with a fluidization lock-out switch 1104 to prevent fluidization from being inadvertently activated or deactivated from the hand control 110. The fluidization locked out light 1108 illuminates when this control function is activated.

[0052] Though a preferred embodiment of an inflatable bead diffuser 301 is disclosed above, it should be understood by those skilled in the art that alternative inflatable bead diffuser 301 assemblies and configurations may be used with a fluidized bead bed 100 without departing from the scope of the invention. For instance, FIG. 13 shows a substantially inflated bead diffuser 301 comprising three separately inflated chambers (1300*a-c*) which define a foot section 1301a, a torso section 1301b, and a head section 1301c. In this alternative embodiment, each chamber 1300*a-c* is in fluid communication with at least one air blower assembly 701 via three flexible air hoses 308*a-c*, as described above (not shown). More particularly, each chamber 1300a-c is assembled with integral air nozzles 501*a-c* which insert into fluidization ports 302 located on the bottom of the tank 101. As described above, the fluidization ports 302 are positioned in such a manner as to properly align with the air nozzles 501*a-c* when the bead diffuser 301 is positioned against the bottom surface 203 of the tank 101. In another embodiment, the rate of air flowing into each chamber 1300*a-c* can be regulated so as to enable the bed user to adjust the fluidization of the beads 303 immediately above each chamber 1300*a-c*. This selective fluidization can be accomplished by placing each chamber 1300*a-c* in fluid communication with distinct variable speed air blowers, or by providing one or more adjustable air valves operable to increase or decrease the flow of air from the air source to each respective chamber 1300*a-c*. In this manner, fluidization of the beads 303 corresponding to each section 1301*a-c* of the patient's body can be increased or decreased as is necessary to form an adequate fluidized patient support surface. For example, a patient torso section which may be significantly heavier relative to the head and leg portions of a patient's body can be provided with greater support by merely decreasing the fluidization pressure within the torso section 1301*b* of the bead diffuser 301. Separate air blowers and/or air valves can be individually actuated from either the control panel **109** or hand control **110** to adjust the fluidization above the respective section **1301*a-c*.**

[0053] In another alternative embodiment, the bead diffuser chamber **1300c** described above can be raised or lowered to elevate a patient resting on top of the fluidized patient support surface. Referring to FIG. 14, an inflatable air bladder **1401** in a substantially inflated form is shown positioned between the bead diffuser chamber **1300*c*** of the bead diffuser **301,** and the bottom surface **203** of the tank **101.** Under inflation conditions, an air source provides pressurized air through an air conduit connected to the inflatable air bladder **1401** (not shown). As shown in FIG. 14, the fluidized patient support surface positioned above the head section **1301c** is preferably formed using a multiplicity of adjacently attached bead pouches **1402*a-d*** transversely positioned on top of the bead diffuser **301.** In this manner, elevation of the head section **1301c** of the bead diffuser **301** does not result in the downward displacement of the beads **303,** but the beads **303** remain positioned above the head section **1301*c*** within each of the respective bead pouches **1402*a-d*.** A separate bead pouch **307** rest on top of the leg section **1301*a*** and torso section **1302*b*.** It should, however, be understood by those skilled in the art that alternative numbers and/or arrangements of bead pouches can be used to form a fluidized patient support surface without departing from the scope of the invention.

[0054] While the description given herein reflects the best mode known to the inventor, those who are reasonably skilled in the art will quickly recognize that many omissions, additions, substitutions, modifications and alternate embodiments may be made of the teachings herein. Recognizing that those of reasonable skill in the art will easily see such alternate embodiments, they have in most cases not been described herein in order to preserve clarity.

Claims

1. A fluidized bead bed (100) comprising:

   an open tank (101);
   an inflated bead diffuser (301) placed within said tank (101), said diffuser (301) comprising a non-rigid layer;
   fluidizable beads (303) placed above said diffuser (301) within said tank (101);
   a porous cover sheet (106) secured to said tank (101) so that said beads (303) are intermediate said diffuser (301) and said sheet within said tank (101) and said sheet (106) comprises a patient support surface; and
   air supply means (701) operatively inflating a plenum (315) within said tank (101) defined beneath said diffuser (301) that allows air to escape therefrom to fluidize said beads (303),

   characterized in that the diffuser (301) comprises a plurality of inflatable chambers (502*a-i*).

2. A bed (100) according to claim 1 wherein said bed (100) also comprises monitoring apparatus for monitoring at least one function of the bed (100).

3. A bed according to claim 2 wherein said monitoring apparatus comprises a microprocessor- based system.

4. A bed according to claim 2 or claim 3 wherein said monitoring apparatus comprises a temperature probe within said tank (101).

5. A bed according to any one of claims 2 to 4 wherein said monitoring apparatus also comprises a transducer to determine how far a patient is depressed into said bead diffuser (301).

6. A bed (100) according to any one of the preceding claims wherein said cover sheet (106) comprises PTFE.

7. A bed (100) according to any one of the preceding claims wherein said beads (303) are contained in a bead pouch (307).

8. A bed according to any one of the preceding claims wherein said beads (303) comprise a soda-lime core encased within a silicon sphere and range from about 50 to about 150 microns in diameter.

9. A bed (100) according to any one of the preceding claims wherein the fluidization air is exhausted through said patient support surface.

10. A bed (100) according to any one of the preceding claims wherein each of said chambers (502a-i) is adjacent to at least one other of said chambers (502a-i).

11. A bed (100) according to any one of the preceding claims wherein each of the chambers (502) comprises at least one sidewall which comprises a baffle (402).

12. A bed (100) according to any one of the preceding claims wherein said diffuser (301) is concave in cross sectional shape.

13. A bed (100) according to any one of the preceding claims wherein said air supply means (701) comprise a variable speed air blower.

14. A bed (100) according to any one of the preceding claims wherein said inflatable air chambers (502) may be inflated to a plurality of pressures.

Patentansprüche

1. Bett mit fluidisierten Kügelchen (100), welches umfasst:

eine offene Wanne (101);
einen aufgeblasenen Kügelchendiffusor (301), der in der Wanne (101) platziert ist, wobei der Diffusor (301) eine nicht-starre Schicht umfasst;
fluidizierbare Kügelchen (303), die über dem Diffusor (301) in der Wanne (101) platziert sind;
eine poröse Abdeckfolie (106), die an der Wanne (101) befestigt ist, sodass die Kügelchen (303) sich zwischen dem Diffusor (301) und der Folie in der Wanne (101) befinden und die Folie (106) eine Oberfläche zur Aufnahme eines Patienten umfasst; und
Luftzuführmittel (701), die einen unter dem Diffusor (301) definierten ausgefüllten Raum (315) in der Wanne (101) operativ aufblasen, der ermöglicht, dass Luft daraus austritt, um die Kügelchen (303) zu fluidisieren,

dadurch gekennzeichnet, dass der Diffusor (301) mehrere aufblasbare Kammern (502 a-i) umfasst.

2. Bett (100) nach Anspruch 1, **dadurch gekennzeichnet, dass** das Bett (100) auch eine Überwachungseinrichtung zur Überwachung wenigstens einer Funktion des Bettes (100) umfasst.

3. Bett nach Anspruch 2, **dadurch gekennzeichnet, dass** die Überwachungseinrichtung ein System auf Mikroprozessorbasis umfasst.

4. Bett nach Anspruch 2 oder Anspruch 3, **dadurch gekennzeichnet, dass** die Überwachungseinrichtung eine Temperatursonde in der Wanne (101) umfasst.

5. Bett nach einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet, dass** die Überwachungseinrichtung auch einen Messwandler umfasst, um zu bestimmen, wie weit ein Patient in den Kügelchendiffusor (301) eingesunken ist.

6. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Abdeckfolie (106) PTFE umfasst.

7. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Kügelchen (303) in einem Kügelchenbeutel (307) enthalten sind.

8. Bett nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Kügelchen (303) einen Natronkalk-Kern umfassen, der in einer Silizium-Kugel eingeschlossen ist, und von etwa 50 bis etwa 150 Mikrons im Durchmesser reichen.

9. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Fluidisierungsluft durch die Oberfläche zur Aufnahme des Patienten abgegeben wird.

10. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** jede der Kammern (502 a-i) benachbart zu wenigstens einer anderen der Kammern (502 a-i) ist.

11. Bett nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** jede der Kammern (502) wenigstens eine Seitenwand umfasst, die eine Ablenkwand (402) umfasst.

12. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** der Diffusor (301) eine konkave Querschnittsform aufweist.

13. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Luftzuführmittel (701) ein Gebläse mit variabler Geschwindigkeit umfassen.

14. Bett (100) nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die aufblasbare Luftkammern (502) auf mehrere Drücke aufgeblasen werden können.

Revendications

1. Lit de billes fluidisées (100) comprenant :

un réservoir ouvert (101) ;
un diffuseur de billes gonflé (301) placé à l'intérieur dudit réservoir (101), ledit diffuseur (301) comprenant une couche non rigide ;
des billes pouvant être fluidisées (303) placées au-dessus dudit diffuseur (301) à l'intérieur dudit réservoir (101) ;
une feuille de revêtement poreuse (106) fixée audit réservoir (101), de telle sorte que lesdites billes (303) sont situées entre ledit diffuseur (301) et ladite feuille à l'intérieur dudit réservoir (101), et ladite feuille (106) comprend une surface de support de patient ; et
des moyens d'alimentation d'air (701) gonflant de façon opérante un plenum (315) à l'intérieur dudit réservoir (101) défini au-dessous dudit diffuseur (301) qui permet à l'air de s'échapper à partir de celui-ci pour fluidiser lesdites billes (303),

caractérisé en ce que le diffuseur (301) comprend une pluralité de chambres gonflables (502a-i).

2. Lit (100) selon la revendication 1, dans lequel ledit lit (100) comprend également un appareil de contrôle pour contrôler au moins une fonction du lit (100).

3. Lit selon la revendication 2, dans lequel ledit appareil de contrôle comprend un système à base de microprocesseur.

4. Lit selon la revendication 2 ou la revendication 3, dans lequel ledit appareil de contrôle comprend une sonde de température à l'intérieur dudit réservoir (101).

5. Lit selon l'une quelconque des revendications 2 à 4, dans lequel ledit appareil de contrôle comprend également un transducteur pour déterminer à quel point un patient se trouve enfoncé dans ledit diffuseur de billes (301).

6. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel ladite feuille de recouvrement (106) comprend du PTFE.

7. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel lesdites billes (303) sont renfermées à l'intérieur d'une poche à billes (307).

8. Lit selon l'une quelconque des revendications précédentes, dans lequel lesdites billes (303) comprennent un noyau à base de soude et de chaux, logé à l'intérieur d'une sphère de silicium et présentent un diamètre allant de 50 jusqu'à environ 150 microns.

9. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel l'air de fluidisation s'échappe à travers ladite surface de support du patient.

10. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel chacune des chambres (502a-i) est contiguë à au moins une autre desdites chambres (502a-i).

11. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel chacune des chambres (502) comprend au moins une paroi latérale qui comprend une chicane (402).

12. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel ledit diffuseur (301) est de forme concave en coupe transversale.

13. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens d'alimentation d'air (701) comprennent une soufflante d'air à vitesse variable.

14. Lit (100) selon l'une quelconque des revendications précédentes, dans lequel lesdites chambres d'air gonflables (502) peuvent être gonflées à une pluralité de pressions.

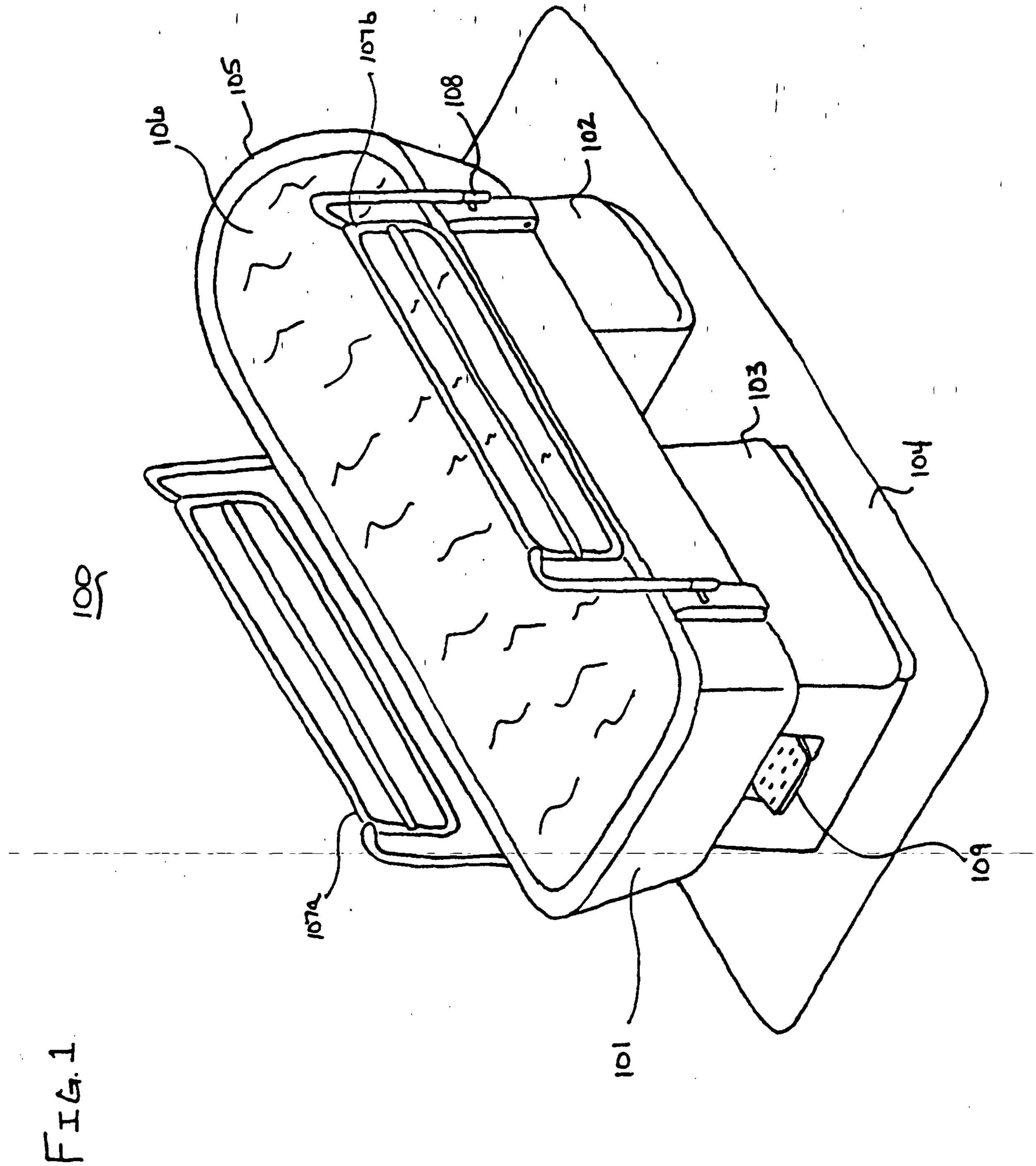


FIG. 1

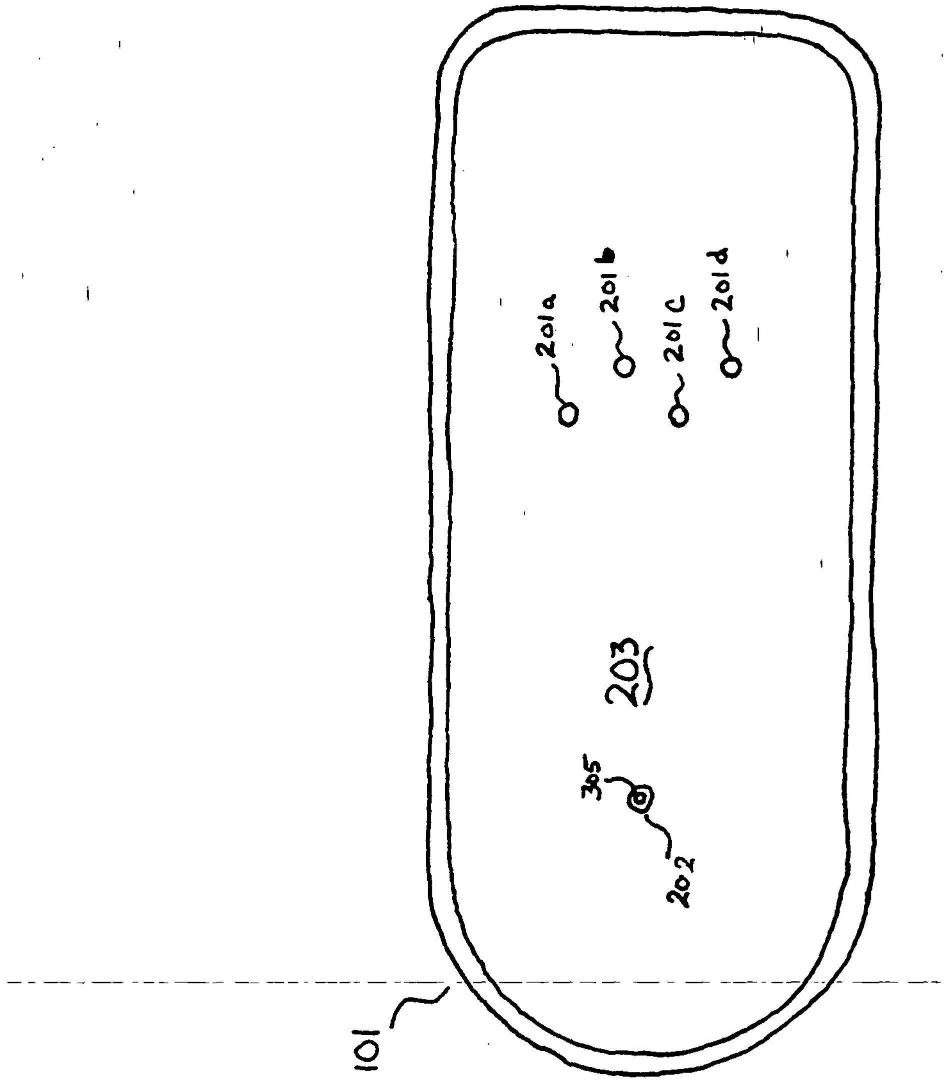


FIG. 2

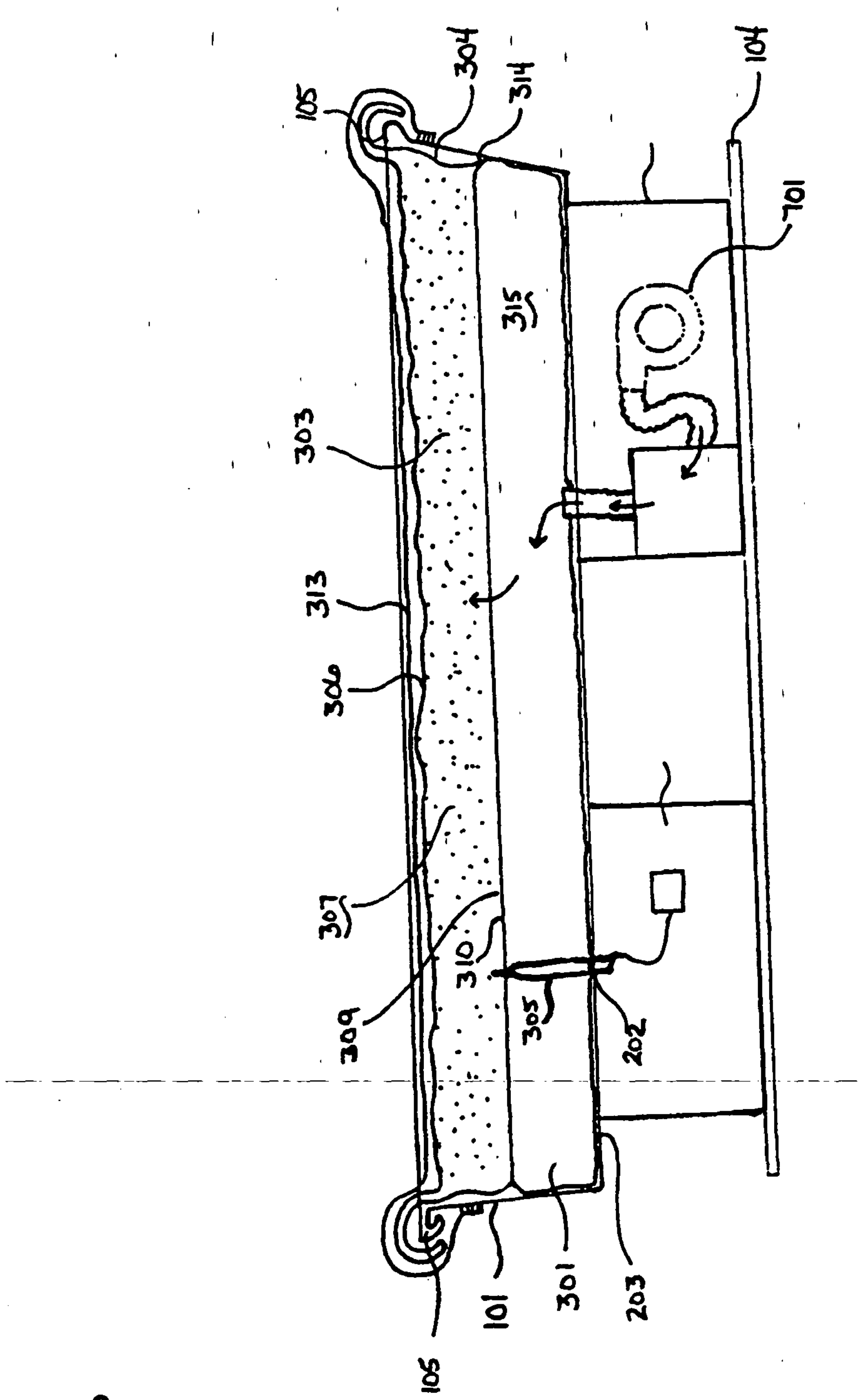
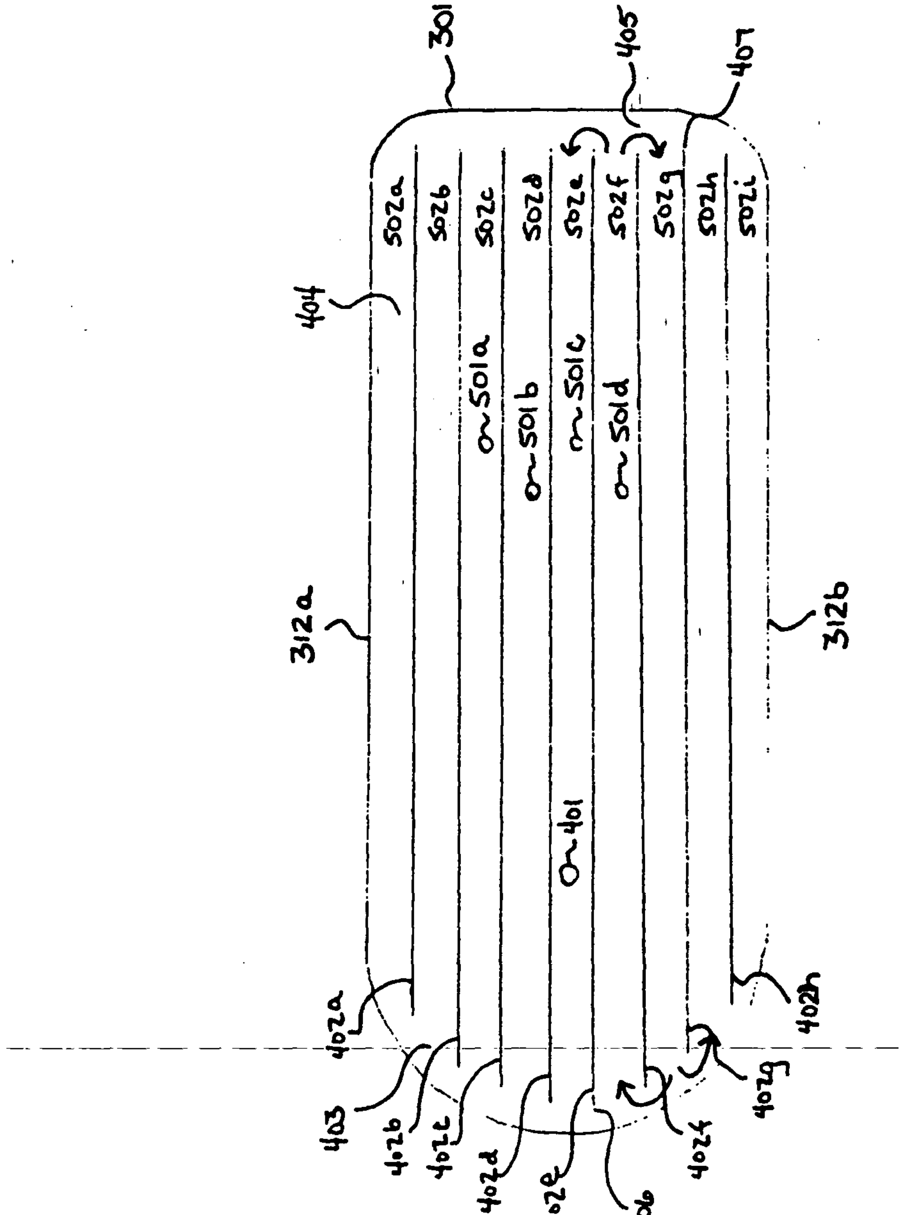

105
304
314
104
701
315
303
313
306
307
309
310
305
202
101
301
203
105

FIG. 3


301
405
407
404
502a
502b
502c
502d
502e
502f
502g
502h
502i
501a
501b
501c
501d
312a
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401
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402c
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402f
402g
402h
403
406

FIG. 4

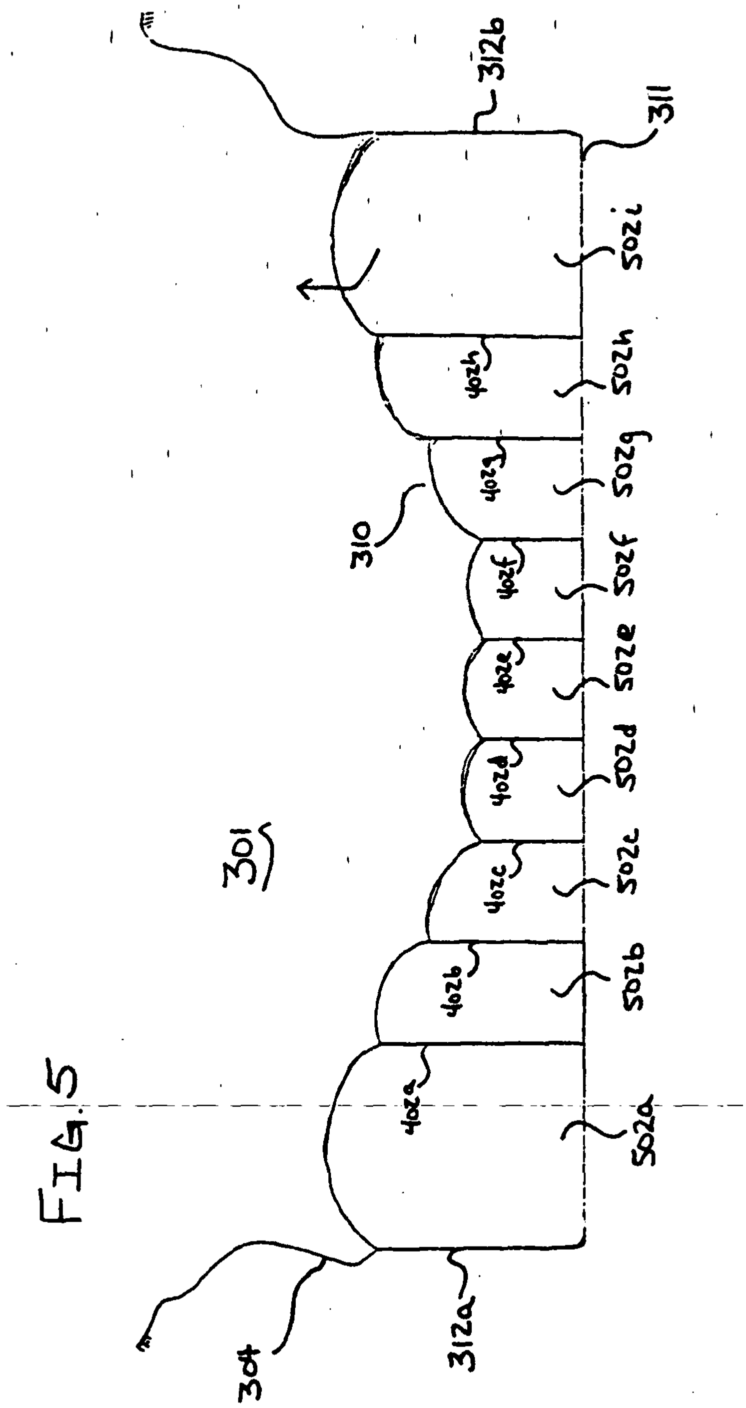

301
304
310
311
312a
312b
402a
402b
402c
402d
402e
402f
402g
402h
502a
502b
502c
502d
502e
502f
502g
502h
502i

FIG. 5

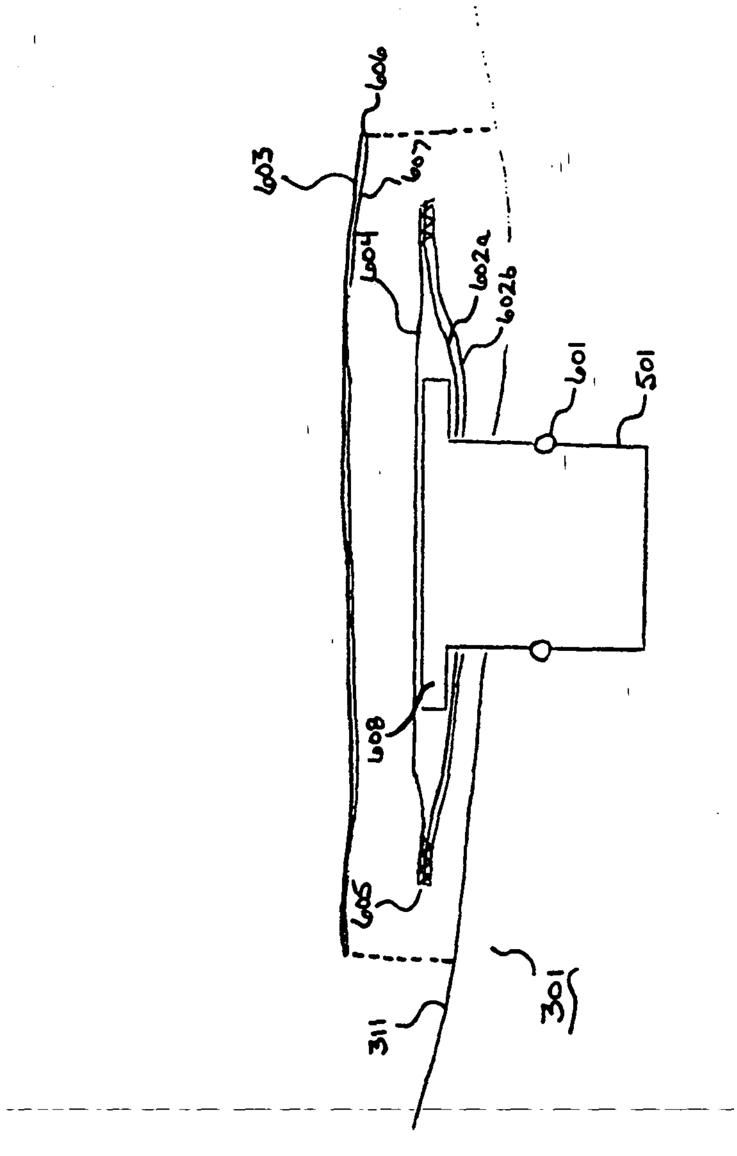


FIG. 6

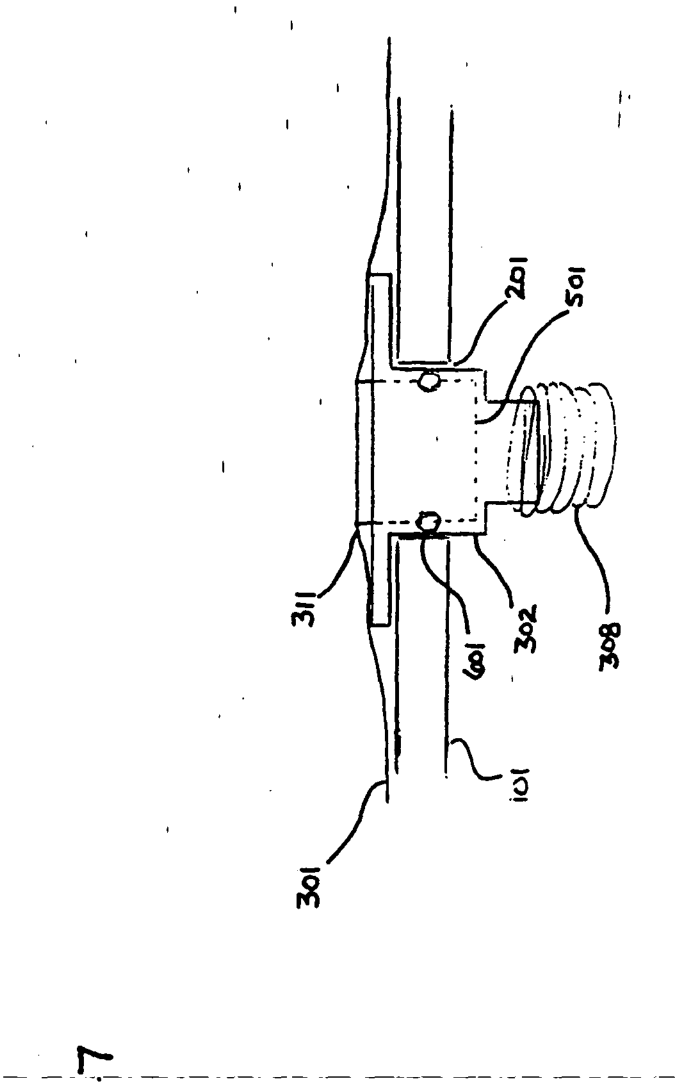


FIG. 7

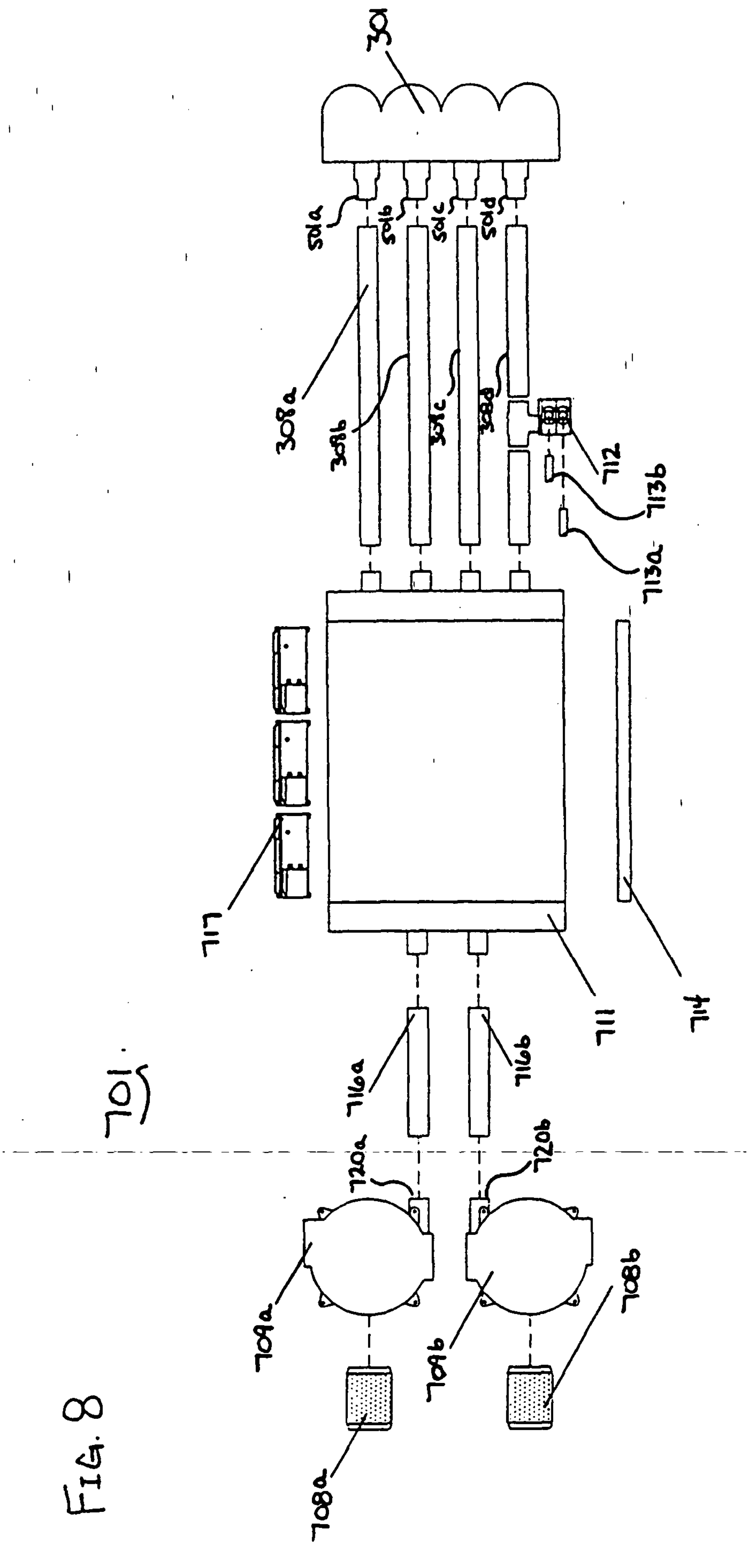

301
501a
501b
501c
501d
308a
308b
308c
308d
712
713b
713a
717
711
714
716a
716b
701
720a
720b
709a
709b
708a
708b

FIG. 8

FIG. 9

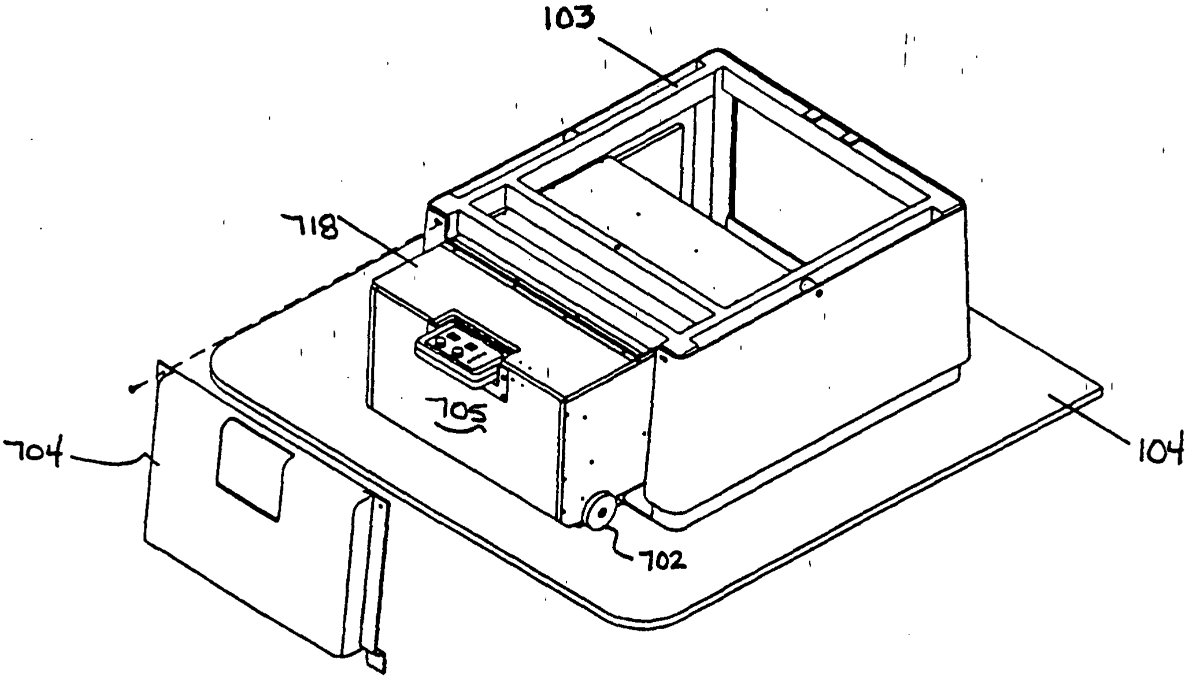


FIG.10

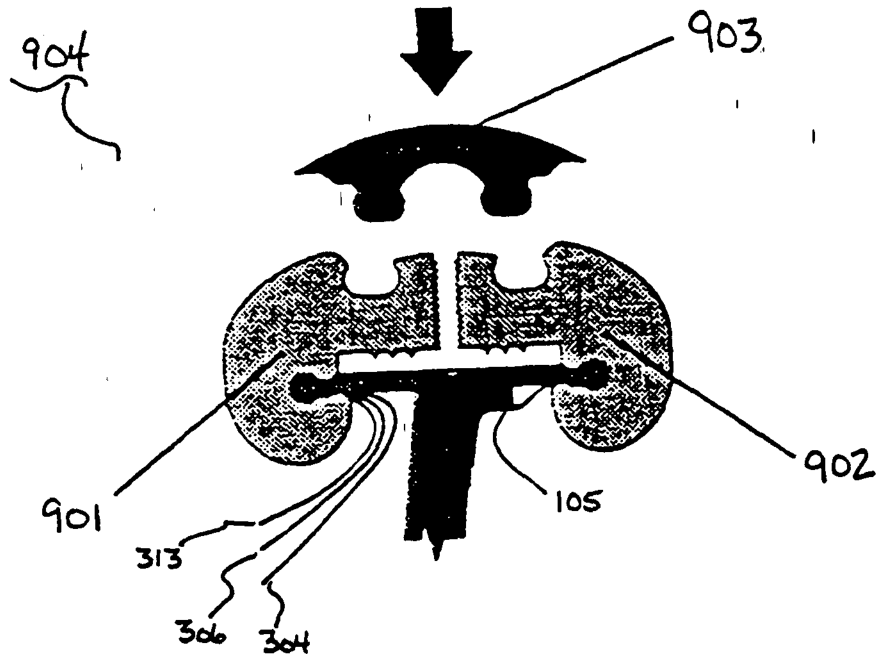
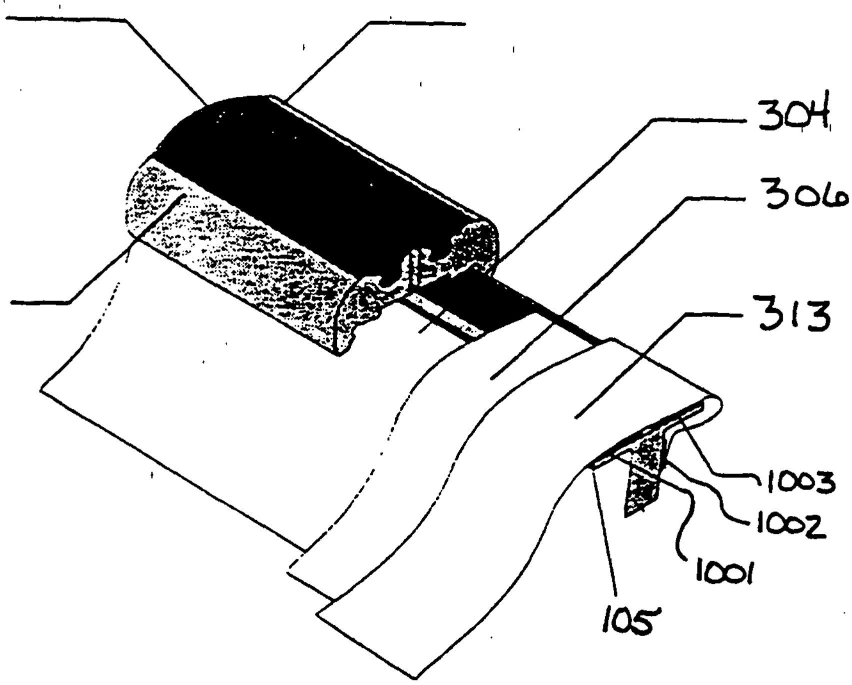


FIG. 11



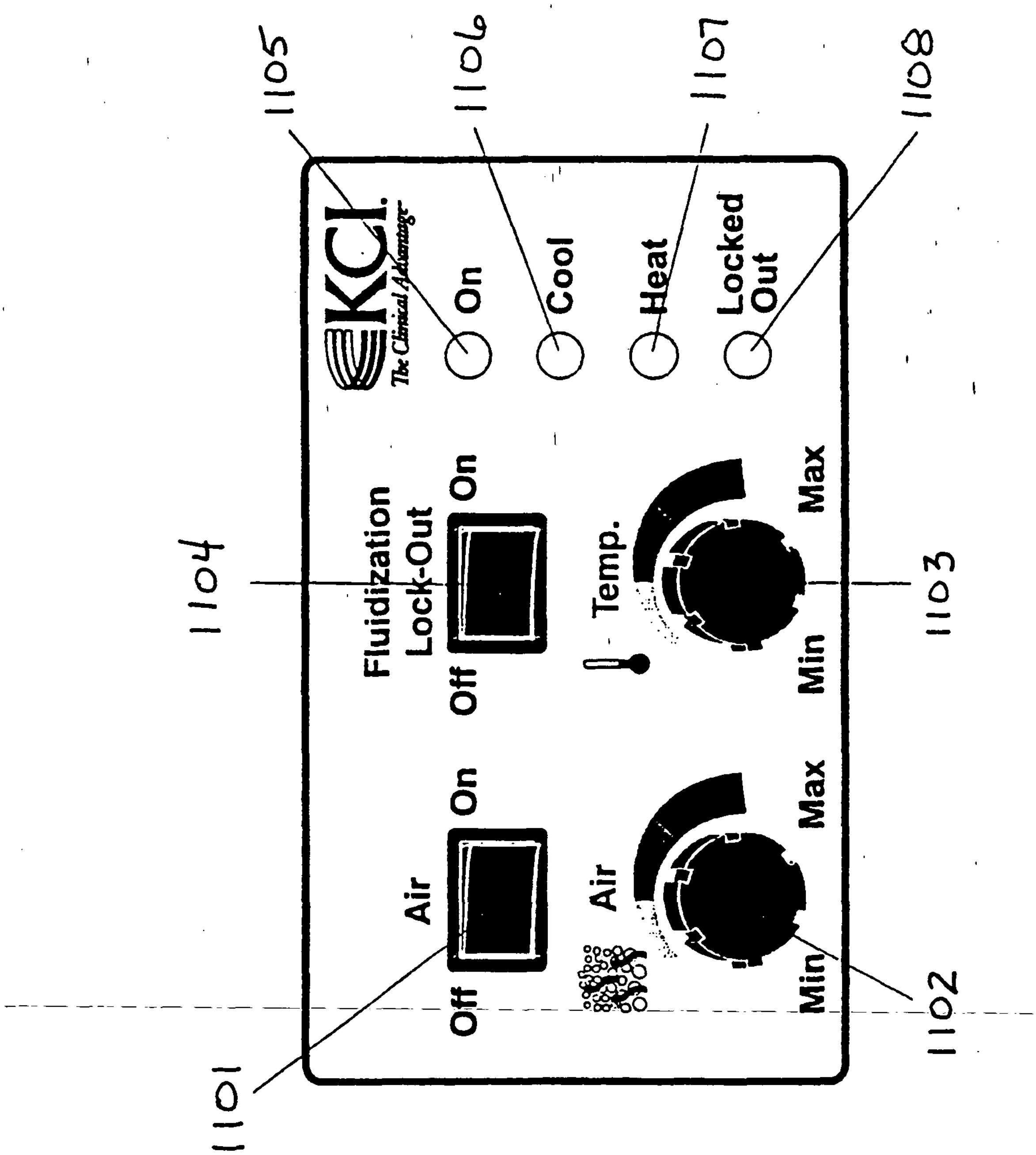

1105
1106
1107
1108
KCI
The Clinical Advantage
On
Cool
Heat
Locked Out
Fluidization Lock-Out
Off
On
Temp.
Min
Max
1104
1103
Air
Off
On
Air
Min
Max
1101
1102

FIG. 12

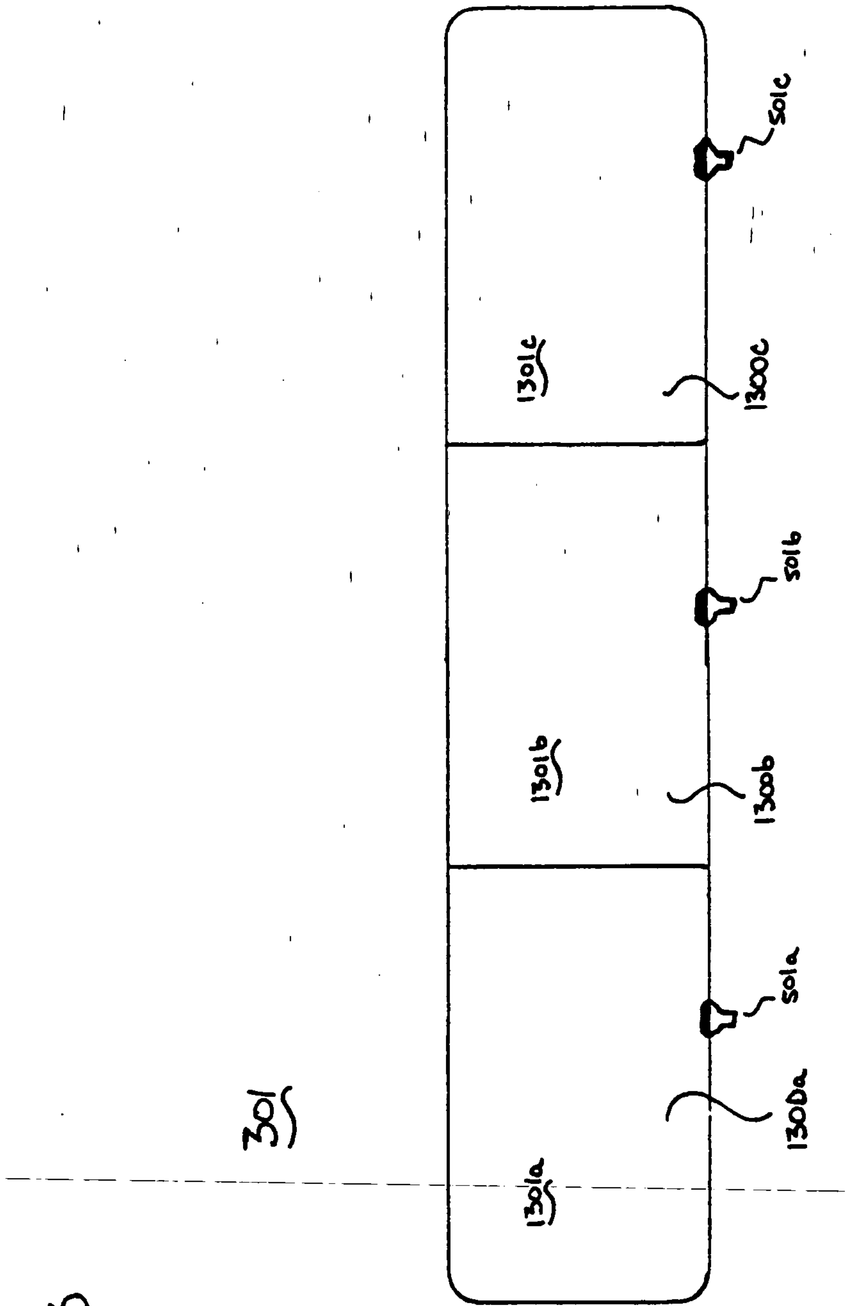


FIG. 13

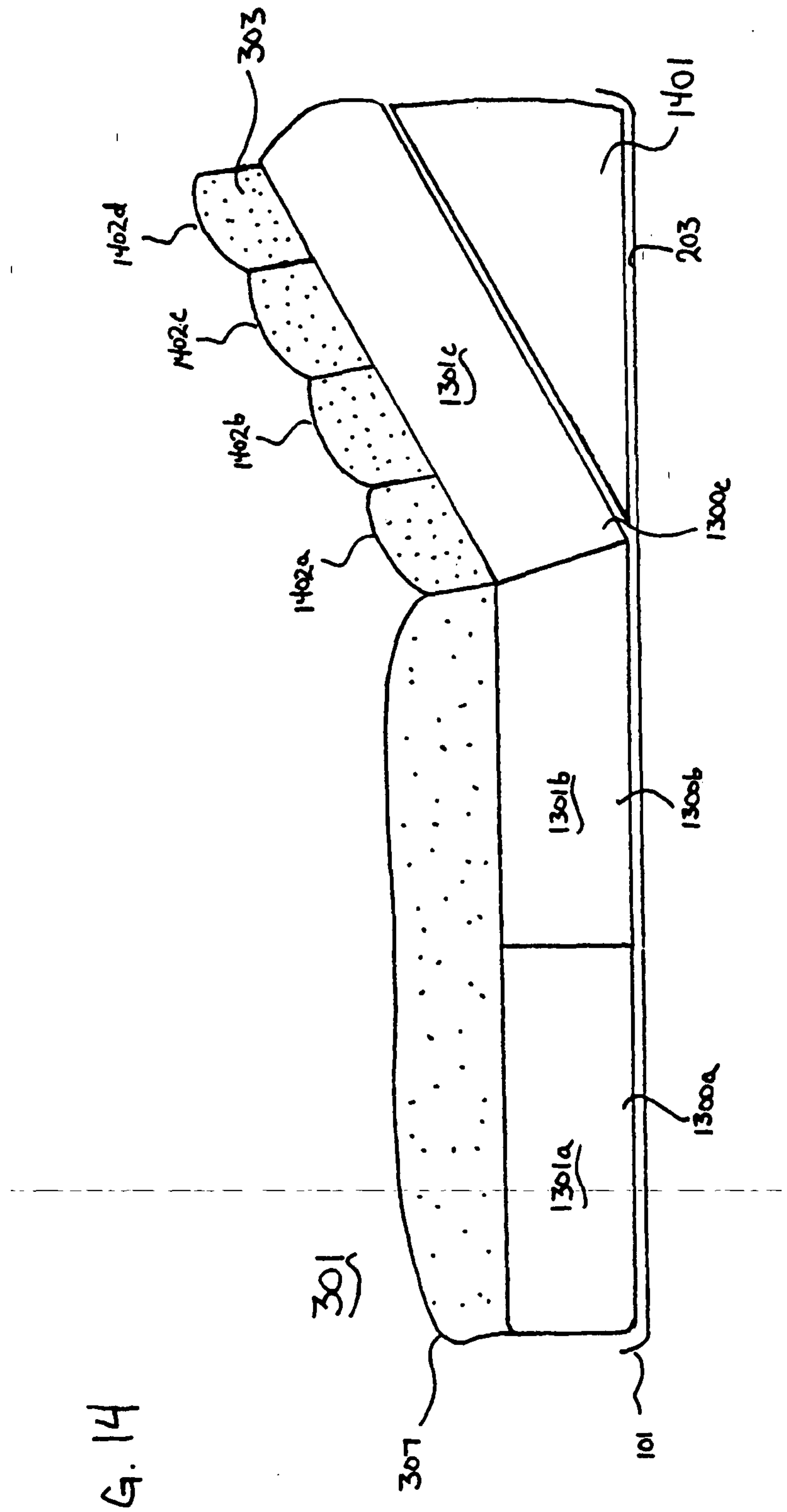

303
1401
1402d
203
1402c
1301c
1402b
1402a
1300c
1301b
1300b
1300a
1301a
301
307
101

FIG. 14

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 5008965 A **[0001]**
- US 4694521 A **[0004]**