# United States Patent [19]

**Flam**

[11] **3,828,378**

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[54] **SUPPORT MEANS FOR THE EVEN DISTRIBUTION OF BODY PRESSURE**


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[73] Assignee: **Johnson & Johnson,** New Brunswick, N.J.



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[21] Appl. No.: **276,506**

[52] **U.S. Cl.** .......................................... **5/345 R,** 5/91
[51] **Int. Cl.** .......................... **A61g 7/02,** A47c 27/22
[58] **Field of Search** ................. 5/91, 345, 355, 361; 797/DIG. 1, DIG. 2



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[57] **ABSTRACT**

A mattress is provided having a gradation of its compression modulus such tht the weight of a person reclining thereupon is distributed uniformly. In the preferred embodiment, intersecting cut scores extend partially into the mattress and at their intersections provide upstanding columnar tufts. The mattress is especially useful for supporting patients susceptible to decubitus ulcers or who have traumatized skin resulting from burns and the like.

The surface area of the columnar tufts and the variance of the depth of the cut scores in the preferred embodiment reduces the pressure on body surfaces not only to below that which would occlude arteries, but on some surfaces to below the value determined to occlude capillaries. In one embodiment, areas of highest expected pressure are recessed below the mattress surface. The mattress can be wet-proofed by applying a film to clusters of the columnar tufts.


**6 Claims, 13 Drawing Figures**

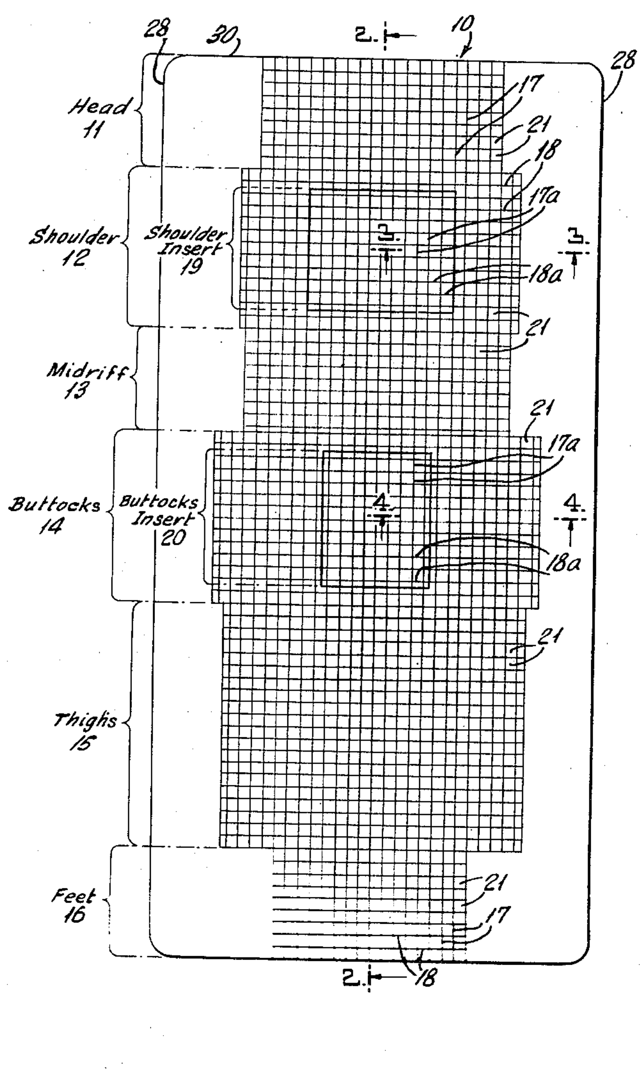


FIG. 1.

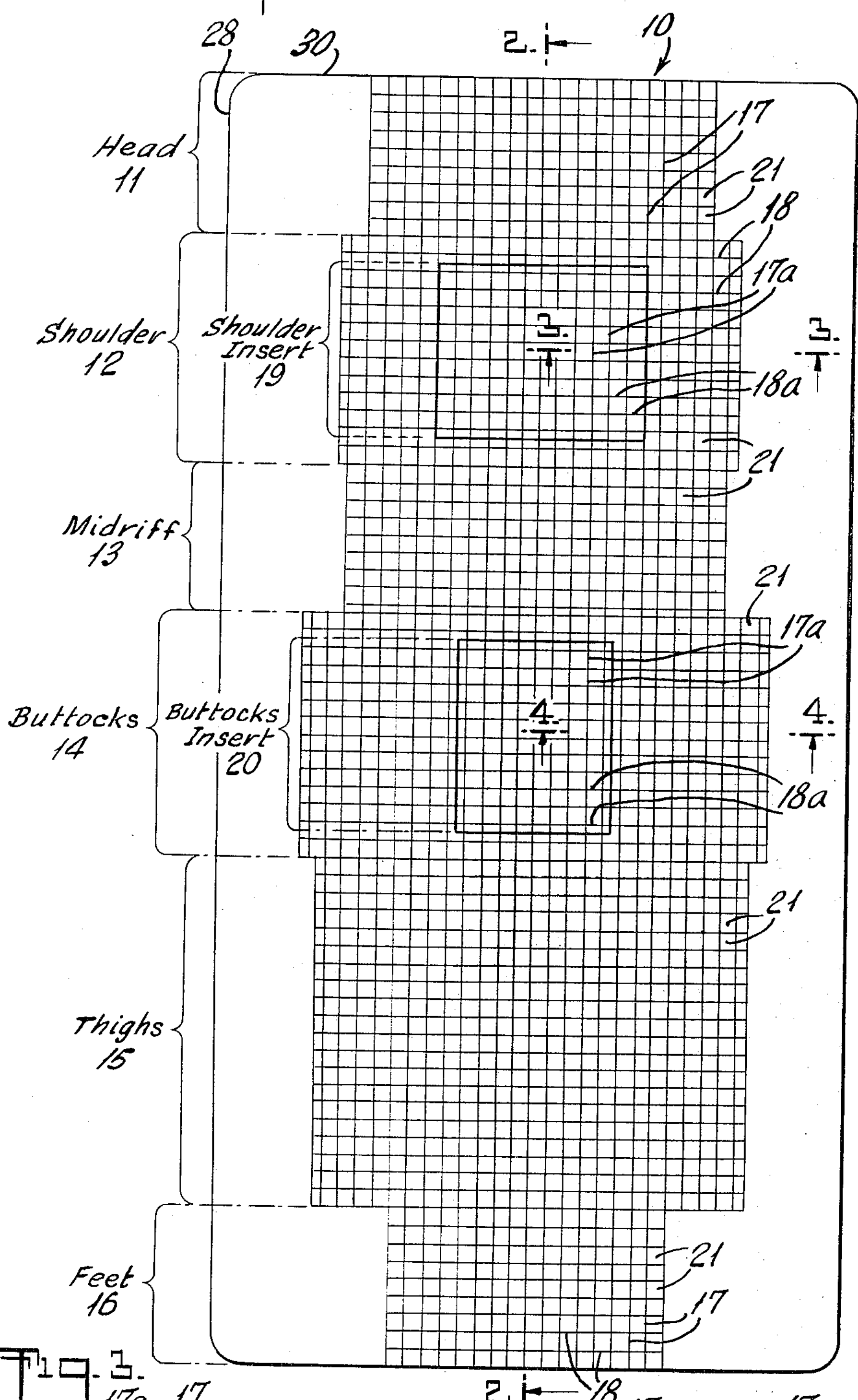



FIG. 2.

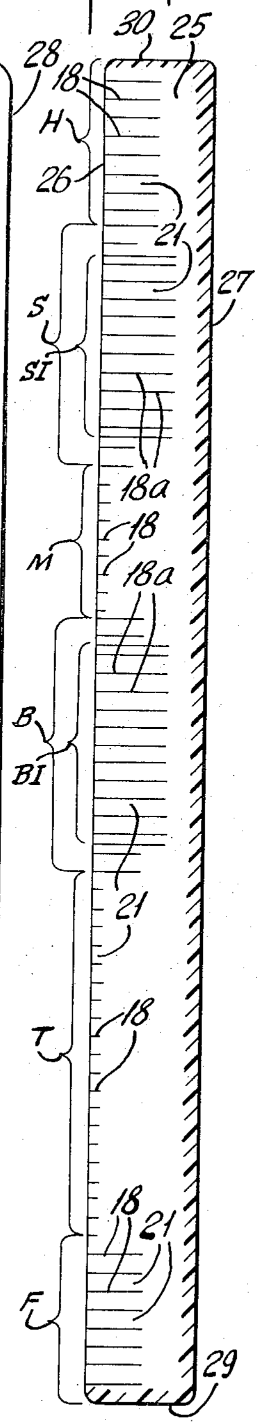
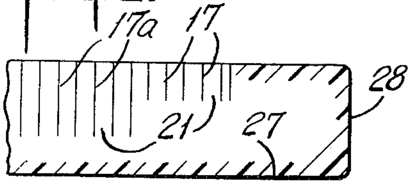



FIG. 3.



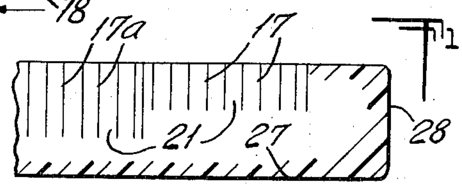




FIG. 4.

PATENTED AUG 13 1974

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Fig. 5.

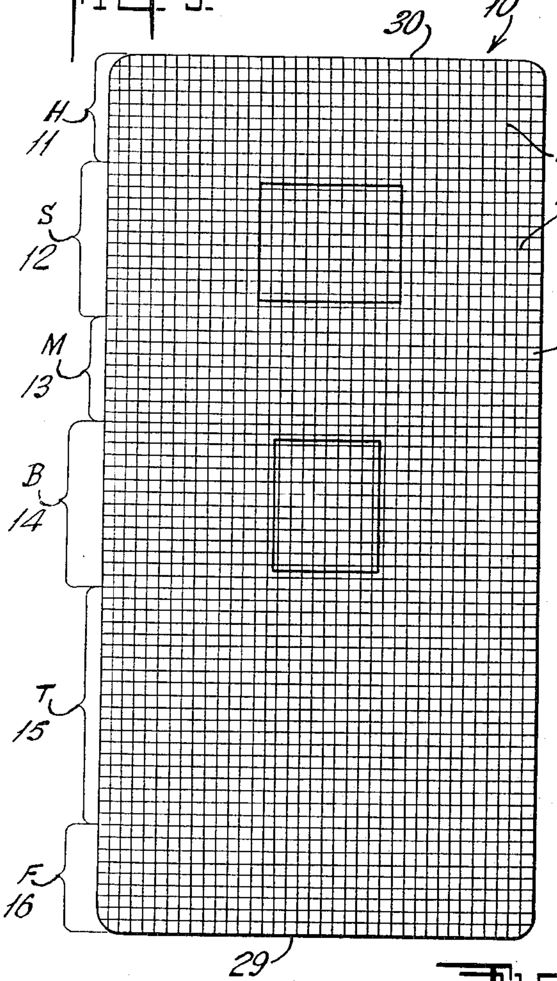



Fig. 6.

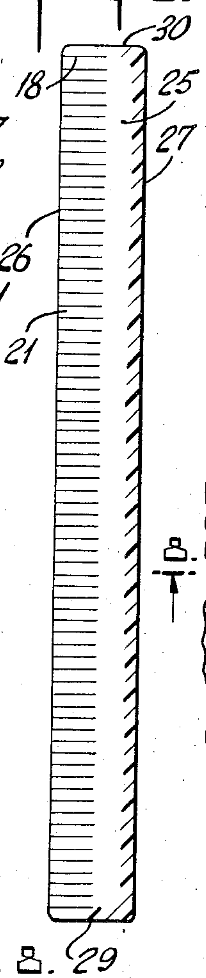



Fig. 7.

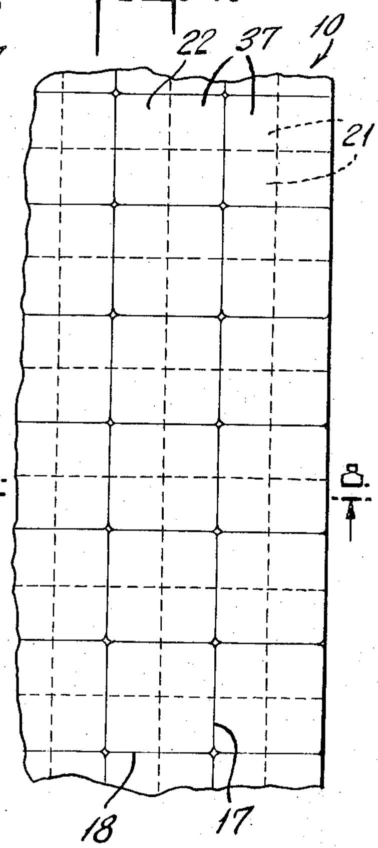
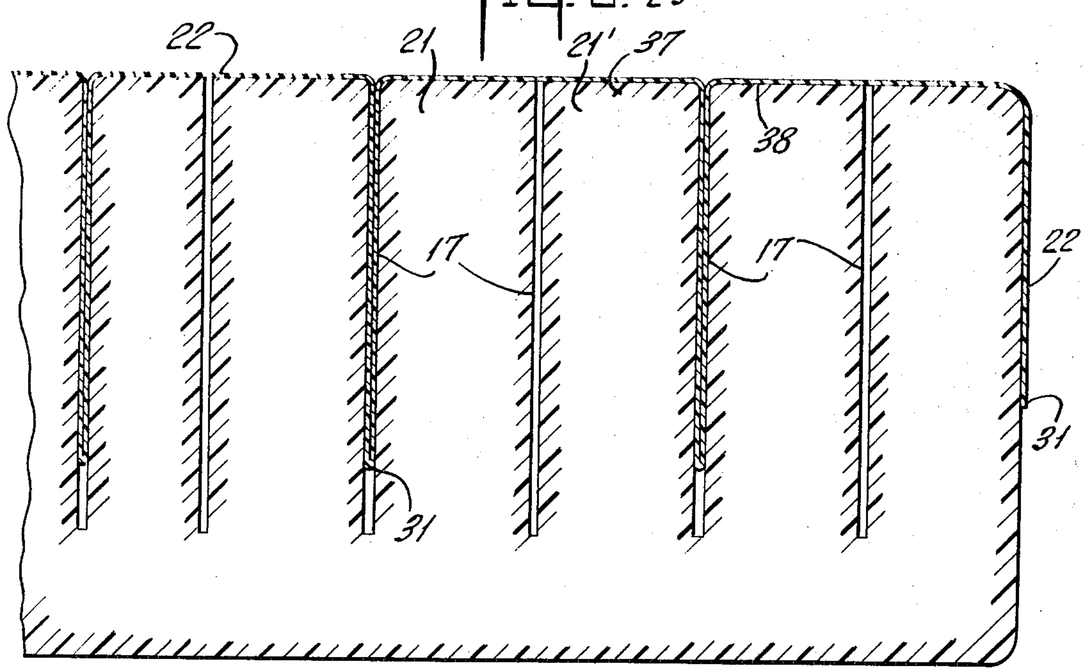



Fig. 8.



PATENTED AUG 13 1974

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Fig. 9.

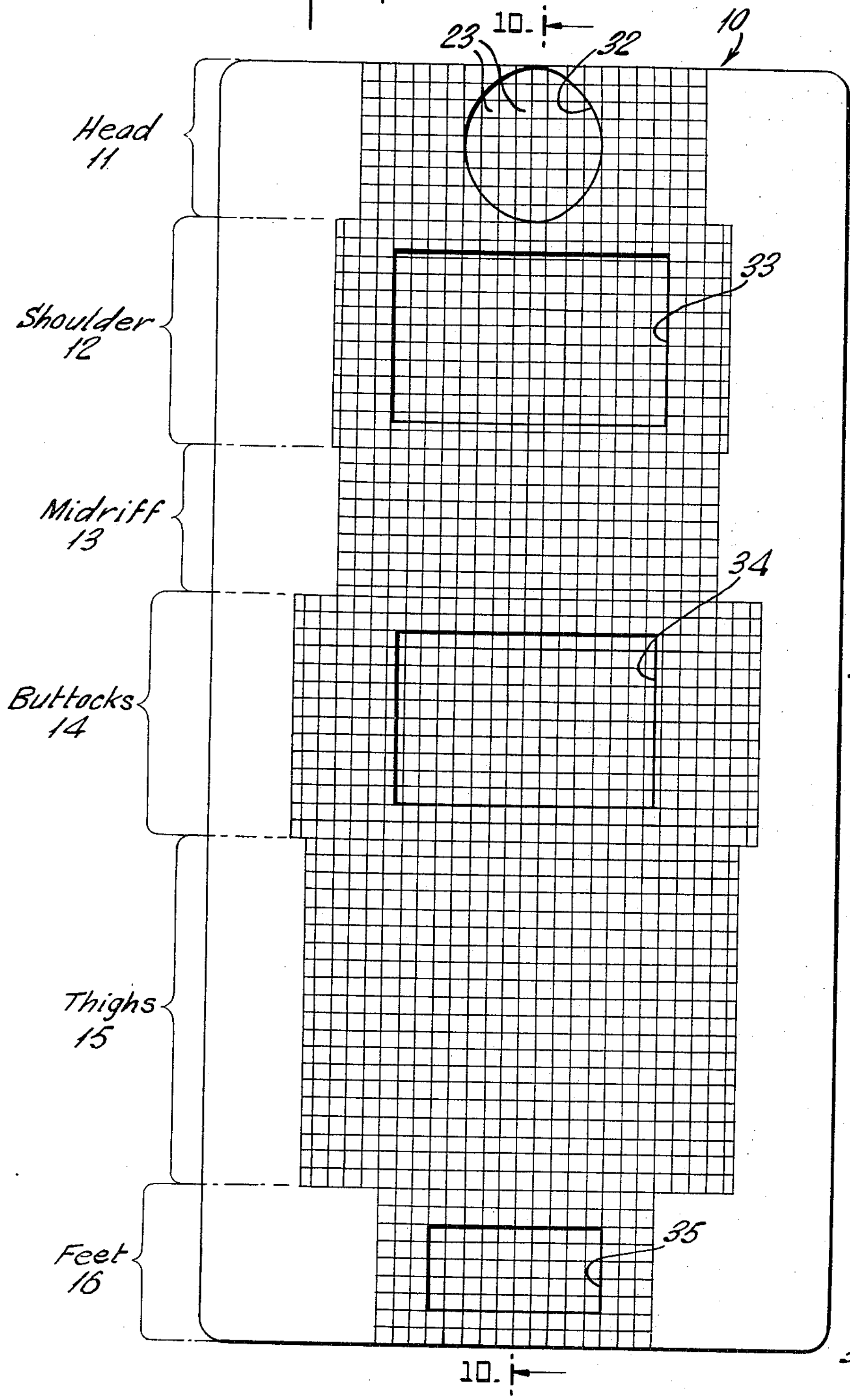


Fig. 10.

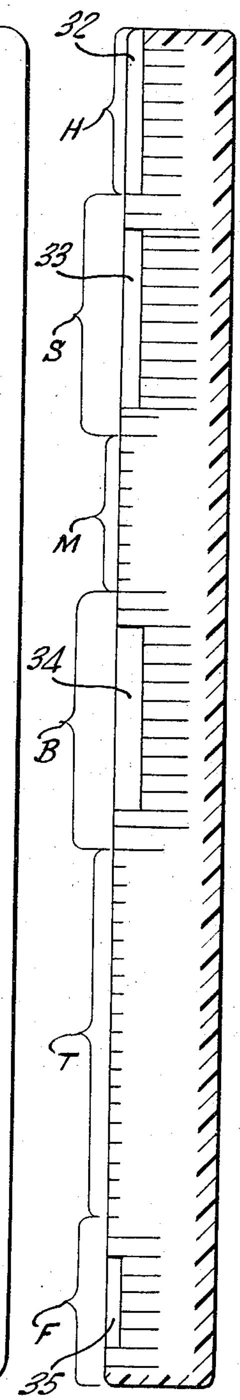

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Fig. 12.

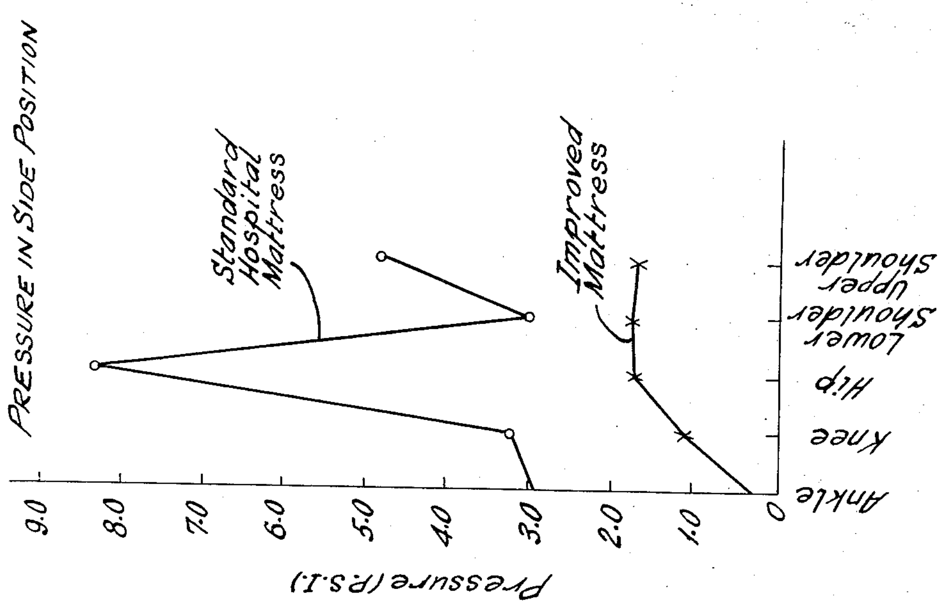



Fig. 11.

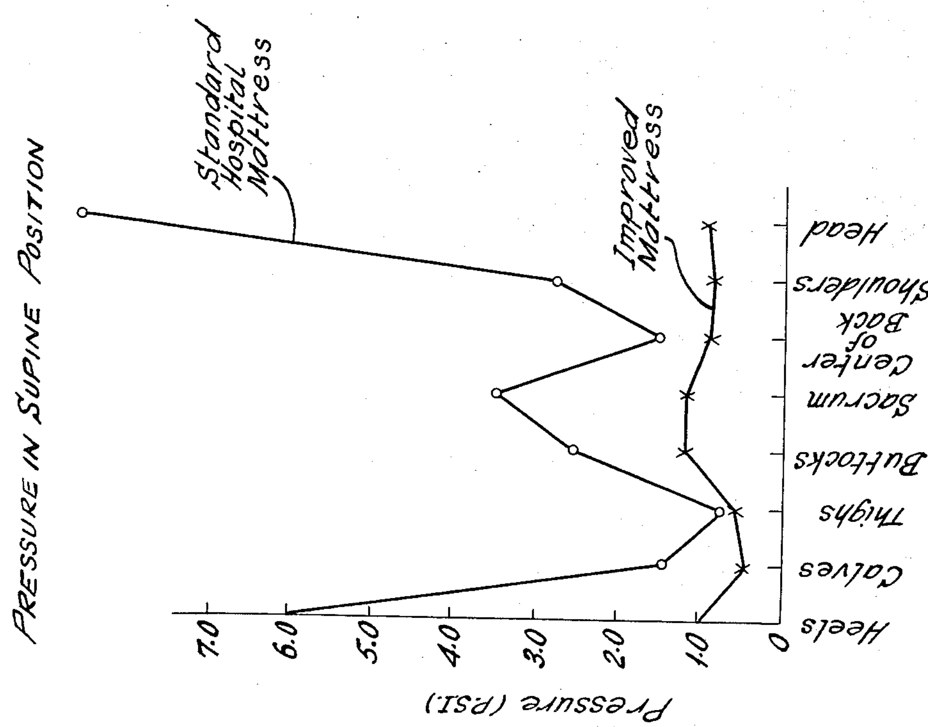
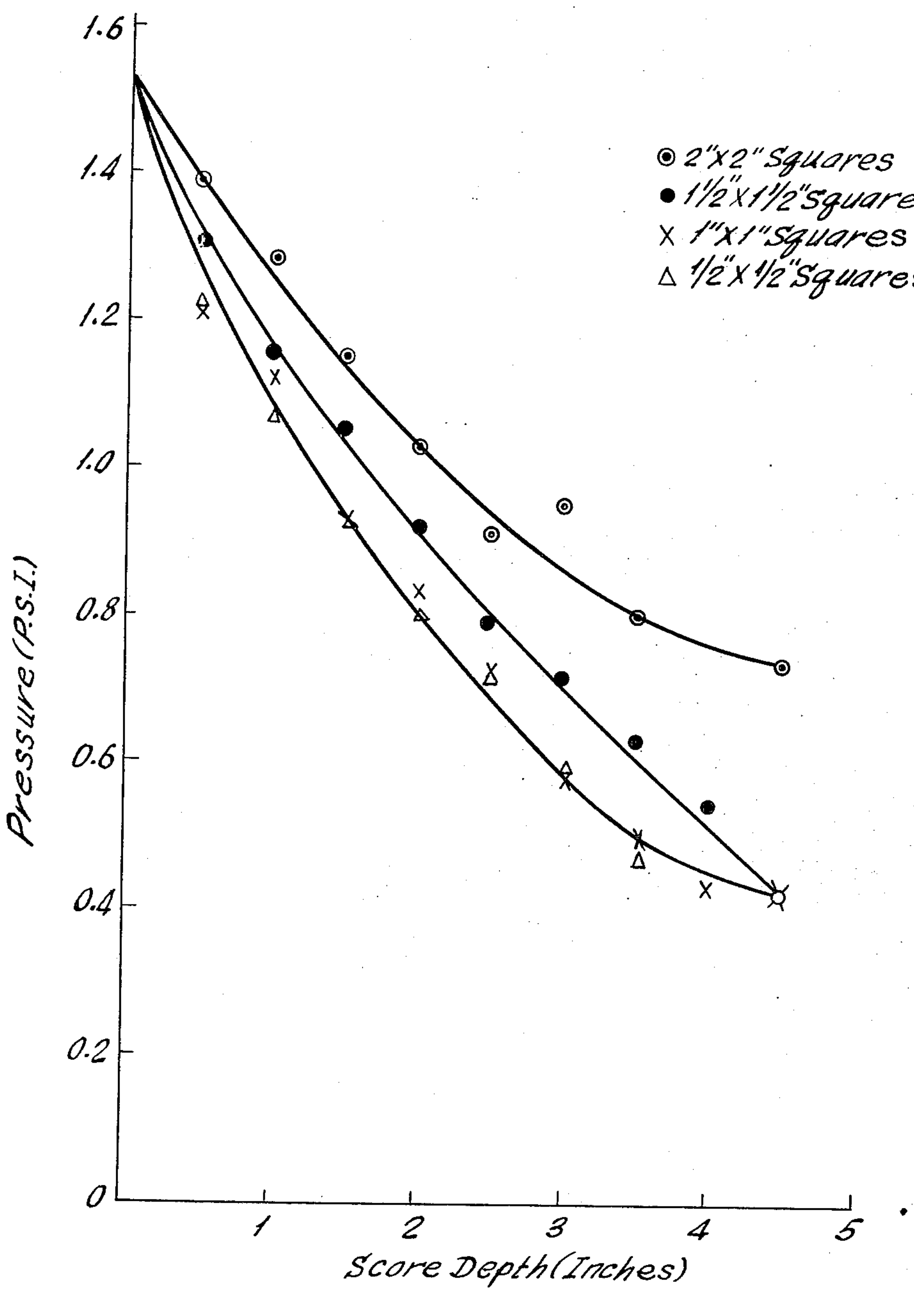


Fig. 13.

PRESSURE VS. SCORE DEPTH



# SUPPORT MEANS FOR THE EVEN DISTRIBUTION OF BODY PRESSURE

## DISCLOSURE OF THE INVENTION

This invention relates to pads or mattresses for supporting the mass of the human body in an even weight distribution thereon. More particularly, it relates to foamed mattresses for distributing the body mass of medical or surgical patients, especially those who have suffered trauma to the skin, such as extensive burns, a massive allergic reaction or the like. In particular, this invention relates to an improved mattress which so distributes body weight that regions of excessive pressure are eliminated and arteries are not occluded thereby eliminating a prime cause of decubitus ulcers or bed sores.

The uneven distribution of body weight on mattresses is not only uncomfortable to patients, but far more serious from a medical standpoint, it can lead to the development of decubitus ulcers, commonly known as bed sores. Decubitus ulcers develop when the blood supply is reduced sufficiently to starve the affected tissue. The major physical cause of this blood supply impairment is external pressure acting on the affected site. The rapidity of ulcer formation is a function of both the intensity and duration of the pressure. For example, studies indicate that pressures of 500 mm Hg (10 psi) will produce ulcers in 2 hours of exposure, while 10 hours exposure at a pressure of 150 mm Hg (3 psi) are required to produce ulcers. Further studies indicate that pressures in excess of 32 mm Hg (0.6 psi) are sufficient to partially occlude the blood vessels which nourish the skin. At that pressure, even though occluded, some blood would circulate, but at a reduced volume. Such circulation would, even though impaired, nevertheless continue so long as the pressure on the skin did not exceed the blood pressure of the arteries. If that latter pressure is exceeded, however, the tissue starves.

When so severely impaired, the diminished blood supply starves the tissue. The more sensitive subcutaneous tissues are first damaged, then the deeper tissue, and later the skin becomes necrotic. An ulcer once established, unless the patient becomes ambulatory or the pressure is removed, is often progressive, becoming subject to infection, and in severe cases becoming gangrenous. A decubitus ulcer in the ultimate stage can reveal enormous destruction, sometimes with exposure of bone.

Elderly patients, who often have a poor nutritional reserve, are especially liable to develop ulcers when confined to bed for extended periods. Thus, while nutritional status and other factors affect the course of the development of decubitus ulcers, it is generally recognized that reduction of pressure on sensitive areas is the best preventative. Such relief can only basically be achieved by two means.

One means to achieve relief from pressure is to dynamically shift the sites of high pressure at intervals frequent enough to prevent long term impaired blood circulation. Such shifting of pressure sites can be done manually or by a mechanical device such as a turning (Stryker) frame.

Another means of preventing or treating decubitus ulcers is to provide for supporting the patient so regions of high pressure do not develop, even though the patient himself remains static. For example, a pillow, or doughnut shaped support emplaced under or around a potential or actual ulcer site, or a recess in a mattress under such a site have been employed in attempts to support sensitive areas, but are generally unsatisfactory in eliminating regions of high pressure. This is because while the desired result may be achieved in the affected locality, it is accomplished by shifting the excessive pressure to the immediately surrounding area, where ulceration may then occur.

Water beds as well as fluidized beds have been successful in decubitus ulcer prophylaxis and treatment as a means of weight distribution, but are expensive and cumbersome. Further, many existing buildings are not structurally designed to carry the weight of these devices, especially if there are a large number of beds devoted to ulcer prone patients. That those skilled in the art have, in order to solve the problem of decubitus ulcers, found it necessary to turn to water beds and like devices with all their inherent disadvantages such as being cumbersome, their weight together with the threat of possible leaking, underscores the lack of an acceptable mattress.

Although foam mattresses have been employed previously, when one reclines on an unsegmented foam mattress surface, his weight deforms the mattress setting up not only vertical forces, but also lateral forces. These lateral forces can be excessive to one susceptible to decubitus ulcers or having suffered skin damage. It has been suggested in U.S. Pat. No. 3,512,190 that these lateral forces, therein referred to as the hammock effect, can be overcome by segmenting the mattress into independent tufts of a common height secured to a common base. The construction there disclosed is intended to correct lateral forces encountered in the usual nighttime mattress and such construction does not successfully reduce pressures developed on the body to or below the point where decubitus ulcers might otherwise develop.

Hence, the primary object of this invention is to provide a mattress which distributes the mass of a body lying thereupon in an even manner.

A further object of this invention is to provide a mattress which so distributes body weight that the pressure on those points where decubitus ulceration can develop is reduced.

A still further object of this invention is to provide a foamed mattress that is of essentially waterproof construction, yet retains its weight distribution qualities.

These, together with other objects and advantages are met by providing a mattress of resilient construction, preferably a unitary mattress of polyurethane foam, having a variable compression modulus such that a substantially uniform pressure is achieved on each point of the surface area of the body in contact with the mattress. The compression modulus is defined as the ratio of compression stress to the deformation. This variable modulus has been accomplished by providing increased compliance in the areas supporting bony prominences such as, for example, the occipital portion of the skull, shoulders, and more rigidity at the midriff and thigh regions of a patient in the supine position. Thus, the compression modulus for the portion intended for supporting the head is less than or equal in value to that portion intended for supporting the feet, which portion in turn has compression modulus less than that portion intended for supporting the buttocks. Further, the compression modulus of that portion intended for supporting the buttocks is lower than that portion for supporting the shoulders, which in turn has a compression modulus lower than that portion intended for supporting the midriff. In addition, the compression modulus of that portion intended for supporting the midriff is less than or equal to the compression modulus for that portion intended for supporting the thighs.

It has been found that if a foam mattress carries a plurality of cross cut scores which cooperate to define upstanding columnar tufts which preferably are contiguous to one another and either the depth of such columnar tufts into the body of the mattress or the area of tufts exposed to the patient receiving surface on the upper surface of various portions of the mattress are varied as shall be hereinafter described, such a relationship between the various compression moduli can be achieved.

Generally, the deeper the scores which define the columnar tufts the more compliant the tuft. A cluster of tufts, each having a smaller surface area exposed to the patient receiving surface also will be more compliant than a single scored tuft of equal total surface area having a score of equal depth.

As used herein, depth of score refers to the depth of cut of a score into the body or interior of the mattress core. Area of a tuft refers to that portion of a tuft exposed to the patient receiving surface.

This invention can be more thoroughly understood by the following description with reference to the drawings in which:

FIG. 1 is a plan view of the mattress of this invention illustrating the preferred pattern of columnar tufts;

FIG. 2 is a cross sectional view through 2—2 of FIG. 1 showing in particular the relative depths of the columnar tufts in various portions of the mattress;

FIG. 3 is a cross sectional view through 3—3 of FIG. 1 showing in particular the relative depth of scoring of the central portion of the region intended to support a patient's shoulder when reclining thereon in the side position;

FIG. 4 is a cross sectional view through 4—4 of FIG. 1 showing in particular the relative depth of scoring of the central portion of the region intended to support a patient's buttocks when reclining thereon in the supine position and the patient's hip when reclining in the side position;

FIG. 5 is a plan view illustrating a mattress similar to that of FIG. 1 but tufted over the entirety of the patient receiving surface;

FIG. 6 is a side cross sectional view of a mattress having a uniform depth of scoring of the entire mattress;

FIG. 7 is a plan view of a still further embodiment illustrating a wetproofing feature of this invention;

FIG. 8 is a cross sectional view through 8—8 of FIG. 7;

FIG. 9 is a plan view of still another embodiment of the mattress of this invention wherein recesses are included in various portions of the patient receiving surface;

FIG. 10 is a cross sectional view through 10—10 of FIG. 9;

FIG. 11 illustrates the pressure reductions achieved with the greatly improved mattress of this invention when a body is thereupon in a supine posture;

FIG. 12 illustrates similar improvement over the standard hospital mattress when one is lying thereupon in a side posture; and

FIG. 13 illustrates the relationship between the surface area of that surface of a columnar tuft exposed to the patient receiving surface and the depth of the score into the core of the mattress.

Referring now to the drawings, and especially to FIGS. 1 and 2, there is shown mattress **10** having core **25**, sidewalls **28**, top end wall **30**, and bottom end wall **29**. Sidewall **28** as well as the end walls **29** and **30** can be fitted with handles (not shown) to facilitate any movement and emplacement of mattress **10**. An upper patient receiving surface **26** of mattress **10** is designed and intended for receiving the weight of a patient reclining thereupon and the bottom surface **27** is intended to abut a hospital mattress, a box spring or similar structure for supporting mattress **10** during use.

The mattress **10** preferably has a solid cellular foam structure and can be fabricated of any resilient foamed material, e.g., rubber or polyurethane having the requisite compliance. In the embodiment shown in FIG. **1**, the preferred material is an uncored flexible slab polyurethane foam having a 25 percent Indentation Load Deflection value of about 9.5 to 14 lbs. Indentation Load Deflection value is the force in pounds necessary to produce a 25 percent indentation in a 15×15×4 inch sample using a flat indentor foot having a surface area of 50 $inches^2$. This preferred material has a density of about 1.0 to 1.6 $lbs./ft.^3$. To provide for maximum safety, the mattress material is preferably treated with any of the well known fire retarding materials, and in general the foam material sold as P1100 fire retardant foam by General Foam Division of Tenneco Chemicals, Inc., New York, New York, has been found especially satisfactory.

In order to achieve the gradation or differential of compliance which will enable the patient's weight to be evenly distributed upon mattress **10**, as shown in FIG. **1**, the patient receiving surface **26** of mattress **10** is apportioned into various sectors, each sector designed to support a particular portion of the body. The sectors are the head sector **11**, the shoulder sector **12** (including the shoulder insert **19**), the midriff sector **13**, the buttock sector **14** (together with the buttock insert **20**), the thigh sector **15** which also supports the calves, and the feet sector **16**.

A first set of cut scores **18** the members of which are substantially parallel to one another, intersects a second set of cut scores **17**, also having substantially parallel members, to define a plurality of contiguous columnar tufts **21** in the interior core **25** of mattress **10**. Tufts **21** are therefore supported at their base by the unscored interior core **25** of mattress **10**. These tufts **21** have their upper surface coextensive with and are part of patient receiving surface **26**. In general, this upper surface of each tuft **21** will be in the range of 0.25 to 4 $inches^2$. The cross sectional shape of this upper surface of tuft **21** is not critical. However, if it is desired to have contiguous tufts each of the same geometric pattern, it is necessary that the tuft surface must either assume the shape of a rectangle, a diamond, a triangle or a hexagon. Octagonal tufts are suitable except that contiguous octagonal tufts will surround or circumscribe a square. In the preferred embodiment the tuft surface is either rectangular or even more preferably square shaped.

It should be realized that if the patient receiving surface cross section of a tuft assumes a shaped configuration, then the score lines **17** and **18** will assume a zigzag path and at least over a portion of their length coincide. The cut scores generally have a surface area exposed to the patient receiving surface **26** of from 0.25 to 4 $inches^2$. The tufts can be of a greater surface area, but in those portions of the mattress for example, the head sector **11**, where a comparatively high level of compliance is required, a surface area of 4 $inches^2$ will usually not supply sufficient compliance even when cut scores **17** and **18** extend to a depth of greater than 4 inches into the mattress core **25**. That is, the compliance can no longer practically be increased by deepening the depth of score, but only by decreasing the surface area of tuft **21** exposed to surface **26**. Tufts **21** having such a surface area of less than 0.25 $inches^2$ have also reached the practical limit of increasing the compliance through reducing the area. Furthermore, mattresses **10** having tufts of less than 0.25 $inches^2$ are more difficult to fabricate especially if there is to be introduced a water proof plastic layer as shown in FIG. **8** and as will later be described in detail.

As shown in FIGS. **1** and **2** the preferred embodiment comprises cut scores **17** which are parallel and extend longitudinally across mattress **10**. Cut scores **18** are likewise parallel to each other extending laterally across mattress **10** meeting scores **17** at a 90° angle and thereby define a tuft **21** having a square cross section at surface **26**. Scores **17** and **18** can be formed by conventional means such as a knife blade or hot wire or alternatively can be formed into the mattress during the forming of the solid core **25** by having a mold shaped to provide the score lines **17** and **18**. If the score lines **17** and **18** are cut in the foam the expansibility of the foam fills the void of the cut score which was formerly separated by the cutting means prior to its removal. Thus, a mattress formed by this means will have the contiguous tufts **21** in intimate contact with one another. If the mattress has tufts **21** formed therein during the foaming and curing in a mold, the tufts although contiguous, can at least to some extent along cut scores **17** and **18** be slightly spaced apart. When the tufts **21** are slightly spaced apart, such spacing is especially suitable for a later described embodiment shown in FIG. **8** wherein a film sheet surrounds a plurality of tufts along the cut scores **17** and **18**.

In order to provide the gradient of compliance previously set forth scores **17, 18** vary in depth or in surface area to provide the requisite compliance. As can be seen from FIG. **13** the same compliance can be achieved by having a larger surface area scored to a deeper depth. In the embodiments shown in FIGS. **1** and **2** the surface area of each tuft **21** is constant and therefore the depth of scoring will vary over the various sectors of mattress **10**. Thus, the compliance of the various sectors whether achieved by the depth of scoring or by decreasing the surface area of tufts **21** exposed to surface **26** has the following relationship:

Head sector **11** $\geqslant$ Feet sector **16** > Buttock sector **14** > Shoulder sector **12** > Midriff sector **13** $\geqslant$ Thigh & Calf sector **15**.

Clearly from reference to FIG. **13**, an equivalent compliance can necessarily be obtained by means of increasing the score depth or by providing a tuft **21** with a smaller surface area, and these values can be determined from FIG. **13** or be determined experimentally without undue difficulty.

Generally, persons confined to a reclining position find the supine posture most comfortable. Nevertheless, it is often desirable for bed ridden patients to recline in the side position. An important feature of the preferred embodiment is that it provides for a more equalized weight distribution for patients in the side position as well as those patients in the supine position. In order to accomplish this, a shoulder sector insert **19**, and a buttock sector insert **20** are included within the shoulder sector **12** and the buttock sector **14** respectively in mattress **10**. In these inserts, **19** and **20**, the lateral and longitudinal cut scores **17** and **18** extend to a greater depth into core **25** than do the cut scores **17, 18** which are located in the peripheral portion of the shoulder and buttock sectors **12** and **14**. The result of this deeper score into the core **25** of mattress **10** is that lower pressures are produced at the shoulder and hip when the patient is reclining in the side position. The depth of the scoring of the insert, if such scoring is desired, should be approximately twice the depth of the cut scores located in the peripheral area. Of course, a similar result can be achieved by decreasing the surface area of tufts **21** in the insert sectors **19** and **20**, over the area of the tufts in the surrounding peripheral area while the depth of the cut scores remains constant.

FIGS. **3** and **4** respectively show the relationship of the peripheral portion and insert portions of the shoulder and buttocks respectively, wherein cut scores **17*a*** and **18*a*** extend to a greater depth in the shoulder insert sector and buttock insert sector, than the immediately surrounding cut scores **17, 18**. This enables the insert sectors to have the increased compliance necessary to properly distribute the weight of a patient in a side position. This increased compliance is a preferred embodiment for those who prefer that position or for medical reasons such as burned areas, are confined to the side position. It should be noted that the side and supine positions have been specifically referred to because they are the most common positions adopted by bed ridden patients. The mattress of this invention, however, is equally suitable for use by patients who assume other reclining positions such as the prone position.

In FIG. **5** there is shown an embodiment similar to that shown in FIGS. **1** and **2**, however, the scoring extends throughout the entire surface **26** of mattress **10**. Thus, the lateral cut scores **18** run the entire width of mattress **10** and longitudinal cut scores **17**, the entire length.

In FIG. **6** there is shown an embodiment where the score depths are uniform throughout the entire core **25** of mattress **10**. Although this mattress does not give the optimum weight distribution achieved by the preferred embodiment, it does provide for a great improvement over those mattresses which are currently used since the weight distribution is superior due to the fact that the surface area of tufts **23** is less than four square inches. Alternatively, the density of the foam in the various sectors can be varied such that the gradient of compliance heretofore specified is achieved. Such differential of foam densities can be independent of any scoring, although more desirable mattresses can be obtained with at least some scoring as shown in FIG. **6**.

FIGS. **7** and **8** illustrate an embodiment which includes a means for wet-proofing the mattress. Although the surfaces of tufts **21** including **26** can be sprayed with a substance which dries to form a waterproof film or heat treated to fuse and close the exposed pores of the cellular material comprising mattress **10**, it has been found that a film covering of thin flexible material is preferred. Yet, such a film must not adversely affect the weight distribution properties of mattress **10.** Merely fitting a film sheet, however thin, over entire surface **26** of mattress **10** seriously affects the compliance gradient, and reintroduces regions of high and undesirable pressure. Referring to FIG. **7** there is shown a film sheet **22** completely covering the surface **26** cluster **37** including a plurality tufts **21.** Sheet **22** is a plastic water impermeable or resistant barrier, such for example, as polyurethane or polyethylene film. Referring to FIG. **8** it is seen that this film extends downward into the cut scores **17, 18** between tufts **21** and **21'**, so as to surround cluster **37.** In the embodiment shown, cluster **37** includes four tufts. Individual tufts could be surrounded with film, but there does not appear to be any advantage which would compensate for the additional labor. Above nine tufts per cluster the compliance begins to become adversely affected. It is preferable to seal, e.g., by heat, the inner surface **38** of sheet **22** to surface **26** of tufts **21.**

In operation, individual clusters **37** are independently compressed downward. While expansional forces of the foam are usually sufficient to keep film **22** within the cut score **18,** a small amount of an adhesive or a heat sealant means can be applied at a discrete point **31** for example at the base of the cut score to hold the film in place within each cut score **38** as well as at side wall **28** of mattress **10.**

Table I illustrates the uniform pressures achieved on a mattress constructed according to this latter embodiment, including an elastic sheet.

TABLE I

| SUPINE POSITION | | SIDE POSITION | |
|---|---|---|---|
| Location | Pressure (psi) | Location | Pressure (psi) |
| Heels | 1.5 | Ankle | 1.4 |
| Calves | 0.6 | Knee | 1.7 |
| Thighs | 0.8 | Hip | 2.0 |
| Buttocks | 1.0 | Lower Shoulder | 1.9 |
| Sacrum | 0.8 | Arm | 2.1 |
| Center of Back | 1.2 | Upper Shoulder | 1.6 |
| Shoulders | 1.3 | | |
| Head | 1.9 | | |

It is important to appreciate that these pressures are those which result when a patient reclines on an embodiment that include both the wet-proofing feature and an elastic sheet. Thus, the illustration is one that is a practical mattress which can be employed in day-to-day use to assist in the reduction of the incidence of decubitus ulcers.

In a still further embodiment there are recessed portions in those areas of the mattress that are subjected to higher pressure, such as the head, shoulders, buttocks and feet. Thus, in FIGS. **9** and **10** there is shown recess **32** in the head portion and recess **33** in the shoulder portion, and recess **34** in the buttock portion, and recess **35** in the foot portion. These recesses occupy those regions where pressure is excessive and in an embodiment having recesses there are illustrative dimensions listed in Table II below. Because the recesses do not extend to the base of the cut scores, columnar tufts **23** are also present in the region of the recesses. The dimensions of a recess are not critical. If a recess is employed, it generally will lie within the central area of a sector and be of a smaller length and width than the sector itself.

TABLE II

| Region of Recess | Dimensions Of Recesses Depth of Recess (inches) | Length of Recess (inches) | Width of Recess (inches) |
|---|---|---|---|
| Feet | 1 | 5 | 10 |
| Buttocks | 1.25 – 1.5 | 10.5 | 14.5 |
| Shoulders | 1 | 9 | 15.5 |
| Head | 0.75 | 9.5 | 7.5 |

In FIGS. **11** and **12** there is shown for comparison the pressures developed on various body parts, both in the supine and in the side position in a standard hospital mattress and the improved mattress of this invention. As can be seen, the pressure distribution in the side position as shown in FIG. **12,** shows a far better profile than is attained with the standard hospital mattress.

More importantly, the pressure profile for the improved mattress when the patient reclines for the supine position is nearly level thus showing that the weight distribution is nearly uniform over the entire surface of the mattress. This is to be contrasted to the hospital mattress where there are excessive pressures placed upon the sacrum and the head together with the buttocks, heels and shoulders.

Now, having described the novel mattress of this invention, those skilled in the art will have no difficulty in making changes and modifications which do not depart from the scope or spirit of the invention as set forth in the following claims.

What is claimed is:

**1.** A variable compression modulus mattress having improved properties of weight distribution for a human body lying thereon comprising a resilient, unitary foam core and a body receiving surface, said core and surface having a plurality of cut scores to form columnar tufts and the surface having a plurality of sectors with each sector being of a variable compression modulus, whereby various portions of the body when resting on the sectors will exert a pressure such that the entire body weight is evenly distributed over the surface of the mattress.

**2.** The mattress of claim **1** wherein the foam core is polyurethane.

**3.** The mattress of claim **1** wherein the foam core is rubber.

**4.** The mattress of claim **1** wherein the sectors have cut scores of varying depth.

**5.** The mattress of claim **4** wherein the surface of the columnar tufts in each sector have varying surface area.

**6.** The mattress of claim **1** wherein each sector is recessed below the body receiving surface to receive a particular portion of the body.

* * * * *