United States Patent [19]

Haake

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[54] **ORTHOPEDIC SUSPENSION**

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[51] **Int. Cl.** **A61f 5/40**

[58] **Field of Search** ..... 128/94, 87, 82, 83, 128/89, 84, DIG. 20; 2/DIG. 3

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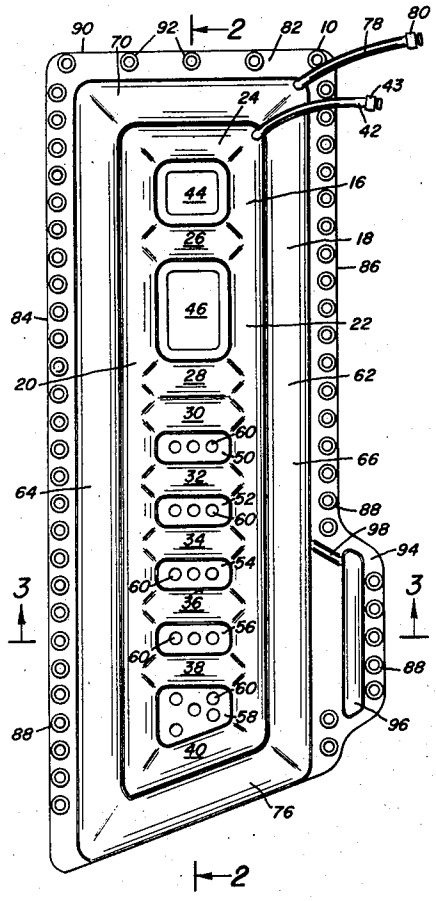
[57] **ABSTRACT**

An orthopedic suspension or splint which is especially adapted for balanced suspension is described. The suspension is provided by a body of soft, flexible, non-metallic material. Rigidity for immobilization and alignment of the limb during the recovery period is provided by longitudinal and transverse air cells which are inflated at the time of installation of the suspension. The suspension is semi-rigid and bends at the exact point where the joints of the limb flex, thus facilitating installation and avoiding the need for additional attachments.

22 Claims, 6 Drawing Figures



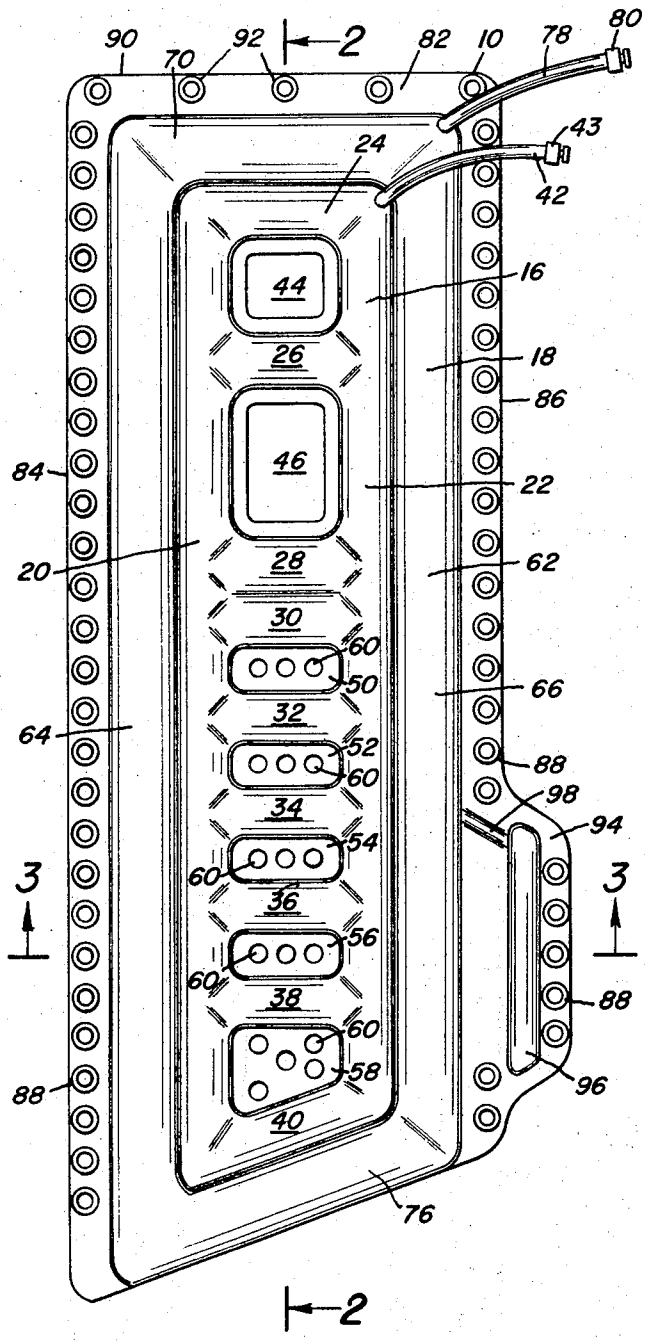


FIG. 1.

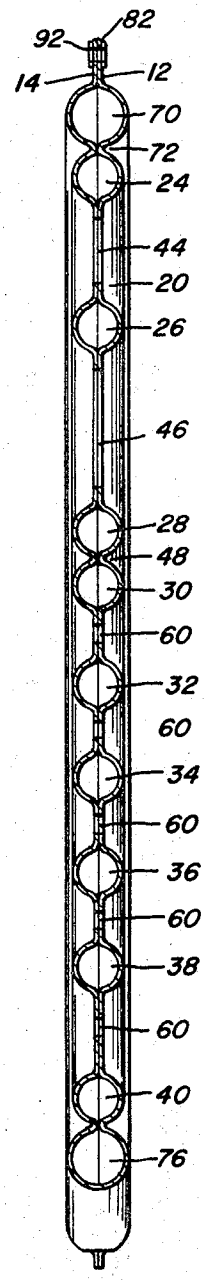


FIG. 2.

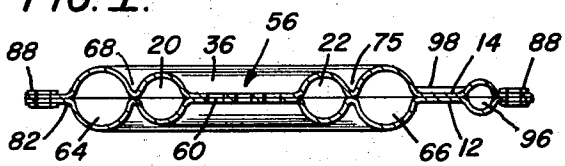


FIG. 3.

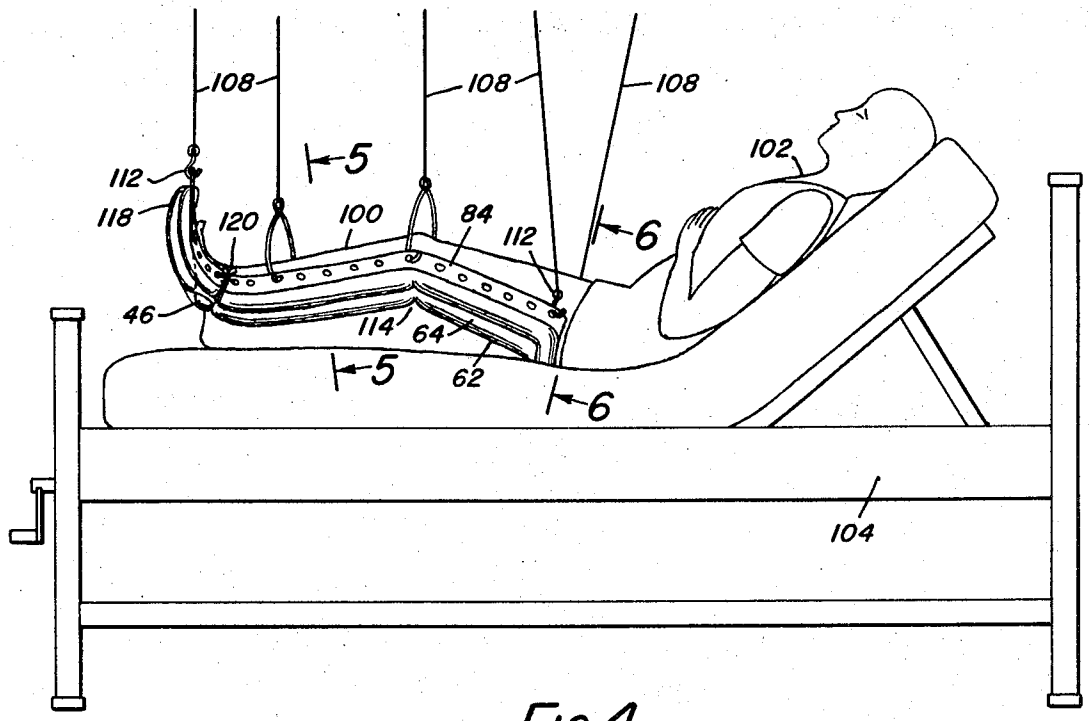


FIG. 4.

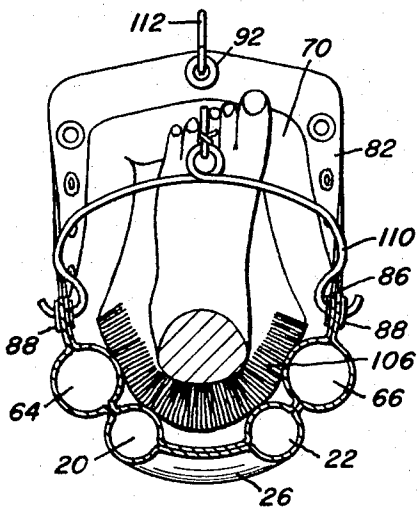


FIG. 5.

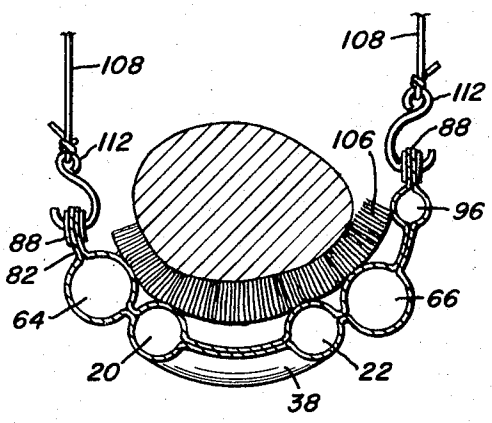


FIG. 6.

ORTHOPEDIC SUSPENSION

The present invention relates to orthopedic suspensions and particularly to an orthopedic suspension or splint for providing alignment and balanced suspension with relative immobilization of limbs while healing progresses, as after injury or surgery.

The orthopedic apparatus provided by the invention is especially suitable for use with a balanced suspension mechanism, as is provided by an overhead frame, weights and pulleys or spring system which balances the apparatus against the weight of the limb so that it is held suspended.

Conventional orthopedic appliances which serve as splints, particularly those adapted for suspension, have a metal frame generally covered with fabric upon which the limb rests. By a limb is meant, the lower or upper extremity of the patient's body. While the metal frame adequately immobilizes and aligns the limb, it, and its appurtenances introduce several problems. Such problems are principally physiologic. The metal parts apply pressure against the body, as by digging into the skin. The pressure against tissues, especially nerves, is extremely torturous for the patient, particularly where the limb must be immobilized for long recovery periods, say one or more weeks. Even the fabric used in conventional splints causes discomfort to the patient, as for example in the formation of ridges and kinks in the fabric especially when the patient tries to bend the limb; these ridges and kinks applying pressure to the limb causing discomfort. Another area of problems arises out of the installation of the conventional splint. Each metallic frame and any attachments thereto are fabricated to fit each patient, or else a large inventory of frames, parts and attachments are required. Still further difficulty in installation of conventional metallic frame splints, resides in the proper location and length of hinges so as to permit the limb to bend. Even with such hinges the frames may be excessively rigid, especially for sidewise movement of the limb, since the splint either prevents or does not follow such movements. Conventional splints are difficult to maintain with requisite degree of cleanliness. Inasmuch as the metallic material used in conventional splints is not radiolucent, such splints mask and can diffuse radiation; thus interfering with radiography and even requiring, in certain cases, an undesirable additional amount of radiation.

It is an object of the present invention to provide an improved orthopedic suspension wherein the foregoing problems, difficulties and disadvantages are substantially eliminated.

It is a further object of the present invention to provide an improved orthopedic suspension which, when in use, does not interfere with physiologic functions, such as the exercising of the limb under suspension.

It is a still further object of the present invention to provide an improved orthopedic suspension which readily bends at the flexure point of the limb and does not require special attachments to facilitate flexure.

It is a still further object of the present invention to provide an improved orthopedic suspension which uniformly distributes pressure over the limb.

It is a still further object of the present invention to provide an improved orthopedic suspension in which the amount of pressure applied to the limb can be readily controlled to accommodate differences in the weights of various limbs.

It is a still further object of the present invention to provide an improved orthopedic suspension which facilitates independent movement of sections of an extremity without extra attachments, as for example providing a plantar flexion resistive section as part of the suspension itself so as to enable exercise of the foot and ankle.

It is a still further object of the present invention to provide an improved splint which is operative in traction as well as in suspension.

It is a still further object of the present invention to provide an improved orthopedic suspension which affords ventilation to reduce skin maceration due to retained heat and moisture.

It is a still further object of the present invention to provide an improved orthopedic suspension which is easily cleaned and may be re-used.

It is a still further object of the present invention to provide an improved orthopedic suspension which is reliable and remains operative even if somewhat damaged.

It is a still further object of the present invention to provide an improved orthopedic suspension which is easily repaired and or restored to operation without disturbing the patient.

Briefly described, an orthopedic suspension provided by the invention utilizes a body of flexible material wherein the rigidity necessary for immobilization and alignment of the limb is provided by longitudinal and transverse cells which are filled with a pressurized fluid medium, such as air. The suspension is an integral, unitary structure which nevertheless has facility for articulation such that it does not require additional attachments, hinges, or the like, in order to enable the limb to bend at the joints. Means are provided, as for example, longitudinal flanges extending along the edges of the suspension body, for maintaining the body with the limb supported thereon, in balanced suspension. As an additional feature, an auxiliary air cell may be provided in a portion of the flange to stiffen the flange, as at the base or rear end of the suspension which supports the heavier portion of the limb, so as to more uniformly distribute the pressure on the limb and resist tearing or abrasion of the flange.

A still additional feature of the orthopedic suspension is in the provision for pockets, either to afford ventilation for the limb or to allow a portion of the limb such as the heel to extend therethrough and facilitate installation. A plurality of pockets for receiving limb portions, such as the heel, may be provided at different locations. Also the pockets may be of different dimensions, thereby allowing the same suspension to fit various patients of different physical size and stature. Inasmuch as the suspension is completely non-metallic, it is radiolucent. The splint material may be non-hydroscopic thereby facilitating cleaning and re-use. Separate valves may be provided for introducing air into different sections of the splint; thus providing for adjustment of pressure and degree of rigidity to meet the needs and physiological functions of various patients, yet providing sufficient rigidity for alignment and immobilization.

The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof will become more readily apparent from a reading of the following description in connection with the accompanying drawings in which:

FIG. 1 is a plan view of an orthopedic suspension provided in accordance with the preferred embodiment of the invention;

FIG. 2 is a longitudinal sectional view of the suspension as shown in FIG. 1;

FIG. 3 is a transverse sectional view of the suspension shown in FIG. 1;

FIG. 4 is a view showing the suspension illustrated in FIGS. 1, 2 and 3, in use in the balance suspension of the lower extremity of a patient;

FIG. 5 is a sectional view, the section being taken along the line 5—5 in FIG. 4; and

FIG. 6 is another sectional view, the section being taken along the line 6—6 in FIG. 4.

As shown in FIGS. 1, 2 and 3, the orthopedic suspension is an oblong body 10 which is fabricated from two sheets 12 and 14. The material of these sheets is desirably soft, flexible, non-hydroscopic material which can be heat-sealed. Soft vinyl material is preferred. The body has formed therein a plurality of inner 16 and outer 18 cells which are adapted to contain a pressurized fluid medium. While pressurized air is the medium used in the preferred embodiment of the invention illustrated herein, which may be termed a pneumatic suspension, other fluid media both liquid and gaseous may be used.

The inner plurality of air cells consists of a pair of longitudinal cells 20 and 22. Connecting these cells are a plurality of transverse or lateral cells, 24, 26, 28, 30, 32, 34, 36, 38, and 40. The rearwardmost of these cells is at an acute angle or bias to the longitudinal cell 20. This construction facilitates installation of the rearward portion of the body 10 at the gluteal region of the patient, as will be apparent from FIG. 4. The transverse cells 24 to 40 extend into the longitudinal cells at opposite ends thereof, such that the entire plurality of inner cells 16 may be filled by way of a hose 42 having a valve 44 at the end thereof. Any source of compressed air, even a sphygmomanometer hand pump may be used for this purpose. It may be noted at this juncture that the amount of air pressure used is adjustable to provide the necessary degree of rigidity and pressure to accommodate for the weight and other needs of the patient.

The transverse cells 24 and 26 and the cells 26 and 28 are spaced from each other to form open pockets 44 and 46. The spacing between the cells 26 and 28 is larger than the spacing between the cells 24 and 26, so that the pocket 46 is larger than the pocket 44. The heel of the patient's leg can extend into pocket 46. Pocket 44 transmits through it any traction mechanisms as may provide skeletal or skin traction when the section distal to cell 26 is flexed at 90° to provide a foot rest and exercise platform.

The cells 28 and 30 are adjacent to each other and share a common seam 48. The cell 30 and the remaining cells 32 to 40 are spaced from each other and form additional pockets 50, 52, 54, 56 and 58. These pockets are not entirely open or cut away as was the case for the pockets 44 and 46. Instead, the pockets have vents therein which are in the form of circular openings 60; a plurality of such openings being provided in each pocket. The openings provide passage ways for ventilation thereby avoiding skin maceration due to heat and moisture when the suspension is in use. The transverse and longitudinal air cells of the inner cells 22 may, in a preferred form of the invention, be approximately two inches in diameter. The transverse cells 28 and 30 which are adjacent to each other may be somewhat smaller in diameter in that their immediate proximity gives them greater rigidity than the other cells.

The plurality of outer air cells is provided both for the purpose of lending greater rigidity to the suspension and for providing reliability and safety should one of the group of cells (either the inner group 16 or the outer group 18) be damaged and lose inflation. The outer group of cells 18 consists of a pair of longitudinal cells 64 and 66 which share common seams 68 and 75 with the longitudinal cells 20 and 22 respectively. At the forward end of the body 10, a transverse air cell 70 interconnects the upper ends of the longitudinal cells 64 and 66 and extends therebetween. This cell 70 shares a common seam 72 with the transverse cell 24. Similarly a transverse cell 76, which is disposed at an acute angle or bias to the longitudinal cell 64, interconnects the rear ends of the longitudinal cells 64 and 66. The cells of the outer group 18 define a continuous tube which may be filled with pressurized air through a hose 78 having a valve 80 at the end thereof.

Except at the rear end of the body which extends to the gluteal area, the body has a flange 82 along the edge thereof. The air cells of the outer group 18 of cells may suitably be 2½ inches in diameter as measured between the seams 68 or 75 and the flange 82, and the flange may be from 1½ to 2 inches in width. The portion of the flange 82 which extends along the longitudinal edges 84 and 86 of the body has a series of openings each of which may be reinforced by grommets 88 which is desirably of non-metallic material. These grommets receive the hooks or hangers of the suspension mechanism, as shown in FIGS. 4 through 6. The flange along the forward edge 90 of the body 10 also have five grommets 92.

The portion of the flange 82 along the edge 86 of the body which is disposed along the medial region of the patient has an extension 94 which extends outwardly, say, 4 inches from the edge of the longitudinal cell 66. This flange portion has a short longitudinal cell 96 which is in communication with the cell 66 by way of a tube 98 formed between the two sheets 12 and 14 of the body 10. This cell serves as a stiffener so as to lend greater rigidity to that portion of the flange 82 which receives the largest amount of force and weight, thus preventing buckling of the flange extension 94.

FIGS. 4 through 6 illustrate the suspension installed and in use on the leg 100 of a patient 102 disposed on an orthopedic bed 104. The suspension is covered with a layer 106 of lambs wool or other insulating fiber which insulates the skin of the patient's leg from the vinyl or other material of which the suspension body is made. The lambs wool layer extends approximately ½ inch beyond the rear end of the suspension (viz., the proximal end which is disposed at the upper part of the patient's thigh) and upwardly approximately ½ inch into the pocket 46. The fiber layer 106 also extends to a line tangent to the inside edge of the grommets 88 on flanges 82 medial and lateral. This fiber layer provides distribution of limb weight to the cells of the splint and allows aeration of the skin resting on the splint.

The mechanism for suspending the orthopedic suspension or splint is provided by an overhead frame and pulleys or springs and weights (not shown) of conventional design which balance the orthopedic suspension against the weight of the leg 100. Ropes or cables 108 are connected to these weights or springs over the pul-

leys and are also connected to hooks and hangers **110** and **112.** The ends of these hooks and hangers extend through the grommets **88.** It will be noted that the suspension flexes and bends to cradle the leg while it is held in suspension.

The orthopedic suspension bends at the exact point **114** where the knee of the leg **100** flexes. Thus the suspension inherently determines the bending point based upon the forces applied as the leg moves in the suspension. Because the suspension is filled with fluid (air) under pressure, the pressure against the leg does not exceed the pressure in the cells. Accordingly, a constant pressure is maintained on the skin at all points of contact. Because of the semi-rigid character of the orthopedic suspension, motion, for example abduction and adduction of the leg, causes the suspension to move with the leg. The suspension may twist slightly to conform to the leg. In operation the suspension is comfortable at all times including when the patient is exercising, and decreases the energy which the patient is required to exert during exercise.

There are no metallic parts with the possible exception of the valves **44** and **80** (FIG. 1) and hangers **110,** and there are no metal parts adjacent to the skin of the patient. Accordingly, the suspension is radiolucent. The splint may be made in a variety of sizes to accommodate children as well as adults. It will be noted that one suspension serves for the right and left leg. Because of the availability of different heel pockets **44** and **46** the same suspension can accommodate patients of various heights and leg dimensions.

A feature of the suspension is in the provision of the pockets **44** and **46** which provides an active plantar (sole) flexion resistive device for exercise of the foot and ankle. To this end the distal portion **118** of the suspension may be folded upwardly as shown in FIG. **4** and held in folded position by means of elastic ties **120.** Accordingly, the foot of the patient is held comfortably in place and provides a plantar flexion platform which is dynamic in that it is depressed as the patient exercises the foot and ankle. The platform is covered with a flannel or lambs wool or synthetic fabric to prevent the skin from contacting the vinyl material.

It will be noted that the orthopedic suspension has space for placement of traction ropes if the leg is to be placed in traction. The non-hydroscopic material of which the suspension is constructed is easily cleaned. After each individual use the suspension is cleaned by washing or immersing in cleaning solution (e.g., a strong detergent); then, the suspension may be used on another patient.

From the foregoing description it will be apparent that an improved orthopedic suspension has been provided which is easily installed and is more physiologic than suspensions heretofore available. While a preferred embodiment of the suspension is described, variations and modifications therein within the scope of the invention will doubtless become apparent to those skilled in the art. Accordingly, the foregoing description should be taken as illustrative and not in any limiting sense.

What is claimed is:

1. An orthopedic suspension which comprises

a. a flexible limb-supporting body,

b. said body having a plurality of cells for containing a pressurized fluid medium,

c. at least one of said cells extending longitudinally of said body,

d. the others of said cells extending laterally of said body,

e. means for introducing said pressurized fluid medium into said cells to provide a plurality of semi-rigid supporting members adapted to extend longitudinally and transversely of a limb, and

f. means for attachment of a suspension mechanism on said body for exerting lifting forces to bend said laterally extending cells and cradle said limb therein while said limb is held in alignment with said longitudinally extending cells.

2. The invention as set forth in claim **1** wherein a plurality of said others of said cells are spaced from each other in a direction longitudinally of said body.

3. The invention as set forth in claim **1** wherein said body has another cell extending longitudinally of said body and spaced laterally from said first named longitudinal cell such that said lateral cells extend therebetween.

4. The invention as set forth in claim **3** wherein the opposite ends of said lateral cells are in communication, each with a different one of said longitudinal cells.

5. The invention as set forth in claim **4** wherein a plurality of pockets are defined between a plurality of adjacent pairs of said laterally extending cells and said longitudinal cells.

6. The invention as set forth in claim **5** wherein at least one of the pockets disposed closest and next closest to a first end of said body disposed at the distal end of said limb is open.

7. The invention as set forth in claim **6** wherein the distance in a direction longitudinally of said body between a first of the lateral cells closest to said first end of said body and the second of said lateral cells adjacent thereto is smaller than the distance in said longitudinal direction between said second lateral cell and the third of said lateral cells which is adjacent to said second cell and on the opposite side thereof from said first cell, the pocket between said first and second cell being smaller than the pocket between said second and third cells, both said last named pockets being open so that a portion of the distal portion of said limb can extend therethrough.

8. The invention as set forth in claim **7** wherein said pockets other than said open pockets have vents therein.

9. The invention as set forth in claim **4** wherein said body has another pair of longitudinal cells each between a different one of said first named longitudinal cells and a longitudinal edge of said body, and means for filling said other pair of longitudinal cells with said pressurized fluid medium.

10. The invention as set forth in claim **9** including another pair of lateral cells respectively disposed between the forward most and rearward most of said first mentioned lateral cells which extend between said first named longitudinal cell and the forward and rearward lateral edge of said body.

11. The invention as set forth in claim **10** wherein the opposite ends of said first mentioned lateral cells extend into different ones of said first named lateral cells, and the opposite ends of each of said other pair of lateral cells extend into different ones of said other pair of longitudinal cells to provide outer and inner communicating cells.

12. The invention as set forth in claim 11 wherein said pressurized fluid introducing means includes separate hoses communicating respectively with said outer and inner communicating cells.

13. The invention as set forth in claim 11 wherein said body has flanges extending between said outer communicating cells to the longitudinal edges of said body.

14. The invention as set forth in claim 13 wherein said flanges extend along the forward end of said body between said longitudinal edge flanges so as to form a unitary flange extending around the longitudinal sides and forward end of said body.

15. The invention as set forth in claim 13 wherein one of said longitudinal edge flanges has a portion which extends outwardly from said body to define an area of oblong shape, said area having a cell extending in a direction longitudinally of said body therein, said last named cell being in communication with another of said body cells for receiving said pressurized fluid medium.

16. The invention as set forth in claim 15 wherein said flanges have a plurality of openings therein for receiving members for supporting said body.

17. The invention as set forth in claim 11 wherein longitudinal cells of said inner and outer communicating cells which are disposed along the opposite edges of said body are in juxtaposition with each other.

18. The invention as set forth in claim 11 wherein the lateral cells of said inner and outer communicating cells which are disposed along the rearward end of said body are at an acute angle to the longitudinal cells located along one of the longitudinal edges of said body.

19. Apparatus for orthopedic suspension of a limb which comprises

a. an oblong member of flexible material defining a pair of longitudinal cells for containing pressurized fluid and a plurality of transverse cells also for containing a pressurized fluid, said transverse cells extending between said longitudinal cells, and

b. means for attachment of a suspension mechanism along the longitudinal edges of said member for exerting lifting forces to bend said transverse cells and cradle said limb therein while said limb is held in alignment with said longitudinal cells.

20. The invention as set forth in claim 19 wherein said flexible material is a non-metallic material impervious to said fluid medium.

21. The invention as set forth in claim 20 wherein said fluid medium is air.

22. The invention as set forth in claim 19 wherein said member has other pairs of longitudinal and transverse cells surrounding the first named longitudinal cells and to ones of said first named transverse cells located closest to the forward and rearward end of said body, said other pairs of cells being of larger diameter than said first named cells.

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