

[54] **BUILDING STRUCTURE**

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abandoned.

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[51] Int. Cl. **E04b 1/32**

[58] Field of Search **52/80, 81, 82**

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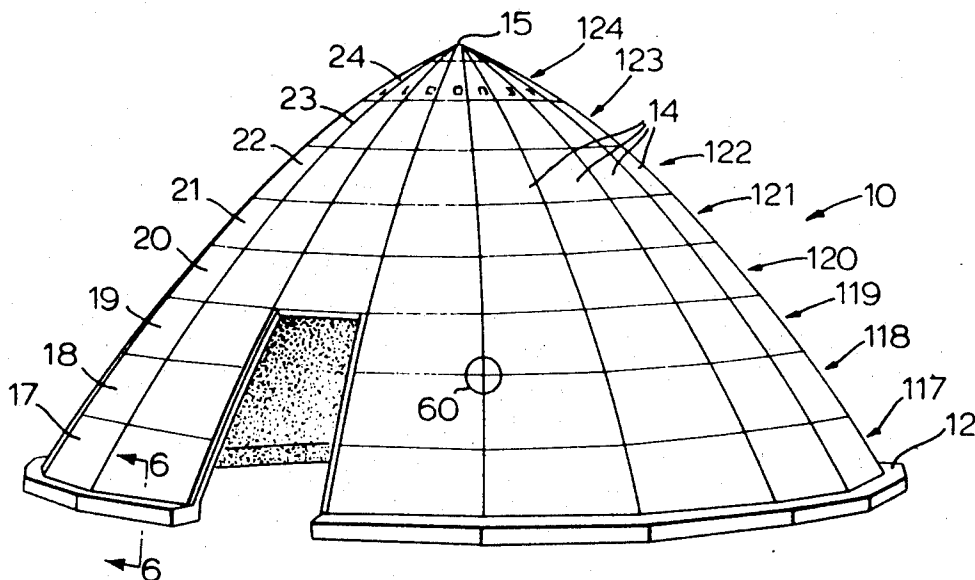
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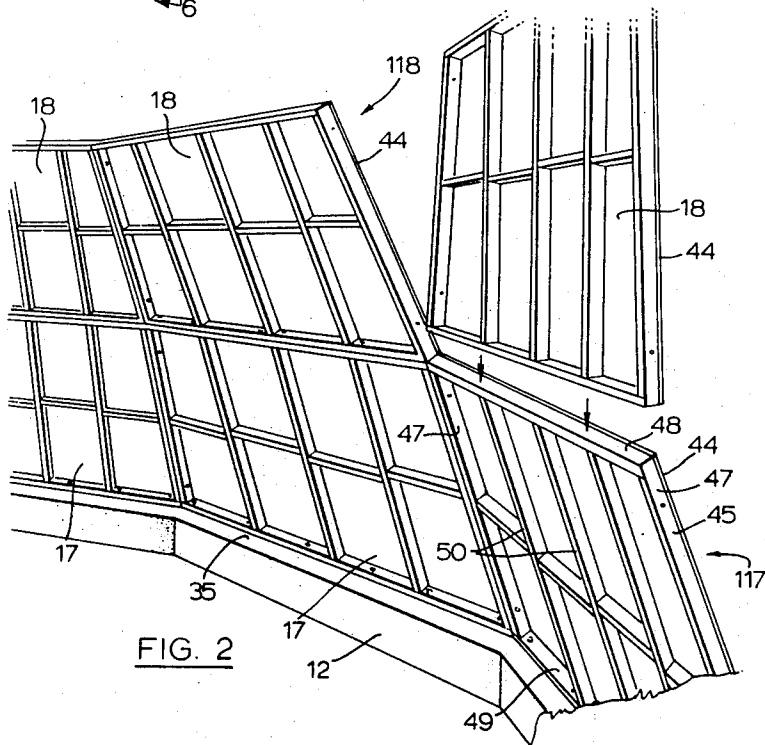
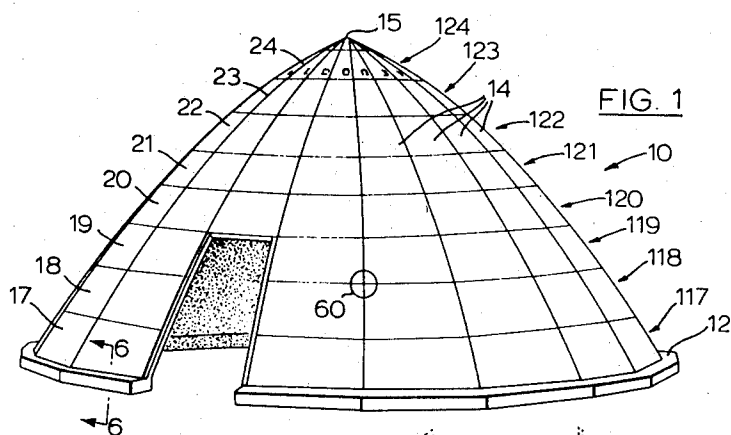
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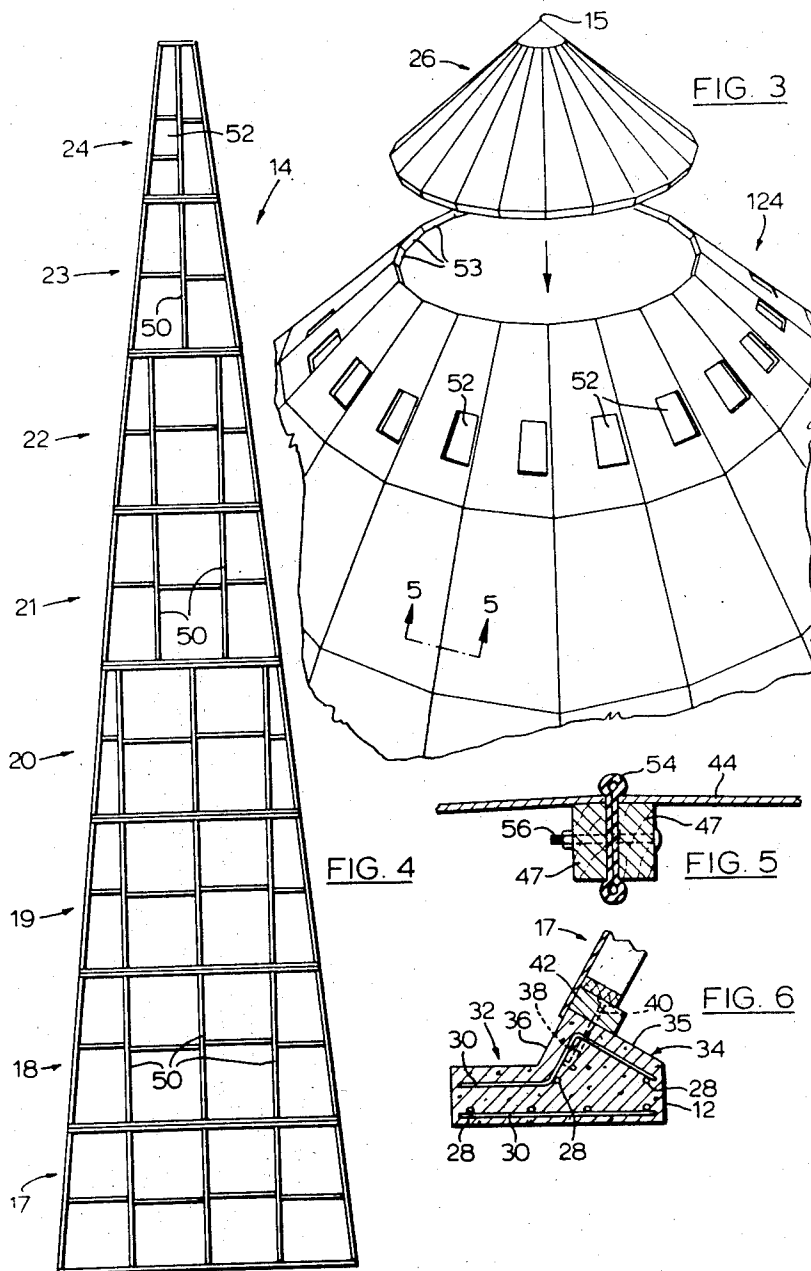
ABSTRACT

A segmented building structure consisting of a plurality of similar wedge-shaped sectors, all converging upwardly and sloping inwardly to form a building resembling a pyramid. Each sector, however, is so shaped that it bulges outwardly slightly, and each consists of several segmental panels of trapezoidal shape. The outward bulge in each sector is achieved by making the acute angle between the bottom edge and a side edge of each segmental panel slightly greater than the corresponding angle in the segmental panel next above it.

12 Claims, 8 Drawing Figures







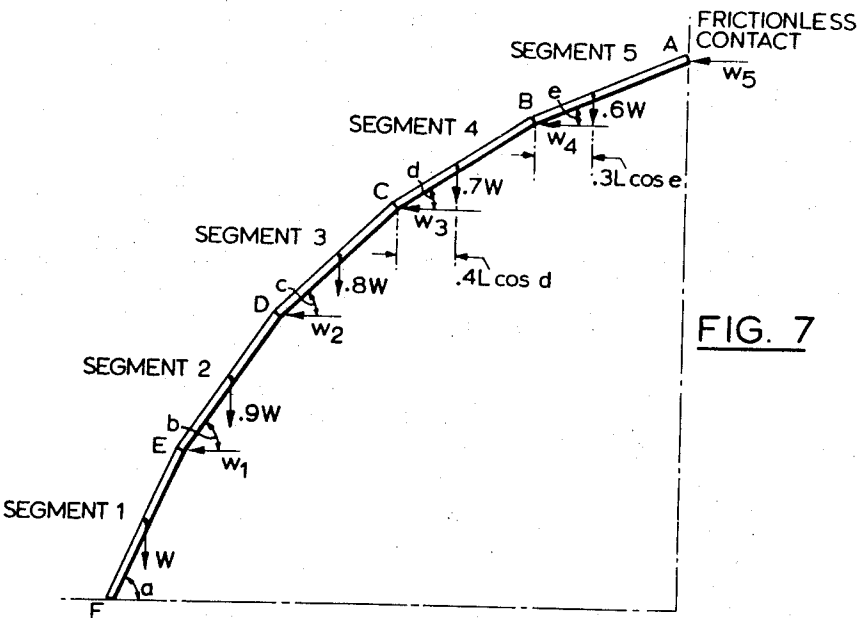


FIG. 7

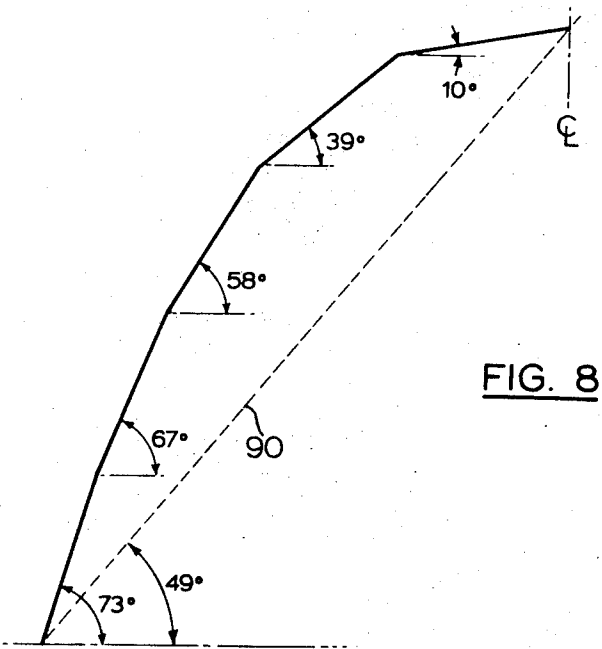


FIG. 8

BUILDING STRUCTURE

This application is a continuation of U.S. Pat. application Ser. No. 84,318, filed Oct. 27, 1970, entitled SEGMENTED BUILDING STRUCTURE (abandoned as of June 9, 1972).

This invention relates to a building structure, and more particularly to a demountable building structure of rigid construction in the form of a hollow shell.

The primary object of this invention is to provide a demountable shell-type building, designed in such a way that it may be assembled from pre-cut panels and erected with a minimum of skill.

Another object of this invention is to provide a demountable shell-type building of segmented construction which can be made substantially water-tight.

Yet another object of this invention is to provide a segmented shell-type demountable building structure which can be erected with a minimum of equipment.

A still further object of this invention is to provide a segmented shell-type demountable building structure which is modular in nature, such that it can be adapted to a number of widely differing uses.

Accordingly, this invention provides a demountable building structure, comprising: a base, a plurality of similar, upwardly convergent and inwardly sloping adjacent sectors, each supported by said base, all sectors being divided into segmental panels at their intersections with a plurality of vertically spaced, hypothetical horizontal planes, the segmental panels defined between each two adjacent horizontal planes constituting a ring of segmental panels, each segmental panel being flat and having the shape of a trapezoid of which the top and bottom edges are parallel and the two side edges are equal in length and convergent, the acute angle between the bottom edge and each side edge diminishing from one segmental panel to the segmental panel next above it, thereby to give each sector a slight outward bulge, the lowermost ring of segmental panels defining a polygon at its contact with the base, said slight outward bulge being less than that necessary to result in a net outward force on any ring of segmental panels.

One embodiment of this invention is shown in the accompanying drawings, in which like numerals denote like parts throughout the several views, and in which:

FIG. 1 is a perspective view of a demountable building structure according to this invention;

FIG. 2 is a view, from inside the structure, of the first two rings of segmental panels in the process of being fitted together;

FIG. 3 is a perspective view of the peak of the demountable building structure, showing the conical cap being lowered into position;

FIG. 4 is an elevational view of one of the sectors of the demountable building structure, with all of the segmental panels lying in the plane of the drawing sheet;

FIG. 5 is a sectional view taken at the line 5—5 in FIG. 3;

FIG. 6 is a sectional view taken at the line 6—6 in FIG. 1; and

FIGS. 7 and 8 are schematic diagrams illustrating calculations discussed in the Supplementary Disclosure.

Turning first to FIG. 1, a demountable building structure 10 is shown, and can be seen to consist of a polygo-

nal base 12, which supports a plurality of similar, upwardly convergent and inwardly sloping adjacent sectors 14. The word "sector" as used herein denotes a wedge-portion of the structure 10, extending from the base 12 to the peak 15. Each sector 14 is in turn divided into segmental panels 17—24, counting from the base 12 upwardly. As shown in FIG. 3, a separate conical cap 26 is adapted to complete the peak 15 of the building structure 10, and the cap 26 is not considered herein to be a part of the sectors 14. The conical cap 26 forms no part of this invention, and could be replaced, for example, by a flat or dome-shaped top. This invention concerns primarily the shape of the sectors 14 and in particular, the slight outward bulge of the sectors, and the opening shown at the top in FIG. 3 could be closed in by any sort and shape of self-supporting cap structure. Furthermore, there may well be instances where it is desirable to leave this opening uncapped, for the passage of a chimney or flue, an antenna, etc.

Attention is now directed to FIG. 6, which shows the base 12 in section. As can be seen, the base 12 incorporates a plurality of longitudinal steel reinforcing members 28, as well as lateral reinforcing members 30. The cross-section of the base 12 includes an outwardly extending foot portion 32, and an upstanding angular portion 34 which has an inwardly sloping surface 35, and an outwardly sloping surface 36. The inwardly sloping surface 35 is normal to the direction of the lowermost segmental panels 17 of the sectors 14 of the building structure 10, while the outwardly sloping surface 36 is parallel with the panels 17. Thus, the surfaces 35 and 36 are perpendicular to each other. Buried head-down in the base 12 are a number of bolts 38 of which the end shank portion 40 projects out of the inwardly sloping surface 35 in the direction of the lowermost segmental panels 17. A suitably bored elongated buttress member 42 is secured as shown in FIG. 6 against the inwardly sloping surface 35 by the bolts 38.

It will be noted, particularly in FIGS. 1 and 2, that the base 12 is polygonal in shape, consisting of a plurality of adjacent, rectilinear sections, all of the same length. The base 12 of the illustrated embodiment is thus a regular polygon. Obviously, too, the elongated buttress member 42 is fitted in sections to the inwardly sloping surface 35 of the polygonal base 12.

As can be seen in FIG. 6, the lowermost segmental panel 17 of each sector 14 is adapted to abut its respective buttress member 42.

An idea of the actual construction of the segmental panels in the illustrated embodiment can best be had by reference to FIG. 2, which shows the polygonal base 12, a part of its inwardly sloping surface 35, and several panels 17 and 18. To avoid confusion, all of the lowermost panels 17 of the sectors 14 will be considered to form a ring, and this ring will be referring to as ring 117. Likewise, the segmental panels 18 will be considered to constitute a ring 118, etc. In FIG. 2, the ring 117 has been partially completed, and three of the segmental panels 17 are shown in proper position on the base 12. Each of the panels 17 consists of an outer sheet member 44, and a frame 45. The frame 45 includes side edge members 47, a top edge member 48, a bottom edge member 49, and intermediate members 50.

It has been found satisfactory to use $\frac{3}{4}$ inch plywood for the outer sheet member 44 and two-by-six frame

members 47-50. In the embodiment shown in the figures, particularly FIG. 2, the side edge members 47 of each segmental panel 17, 18, etc. are provided with four bolt-holes apiece, while the top and bottom edge members 48 and 49 are provided with six bolt-holes apiece, this latter number diminishing for higher segmental panels 19, 20, etc., because of the decreasing lateral extent of the panel with increasing height. As the panels 17, 18, etc. are fitted together, bolts are inserted through the registering bolt-holes, and are used to tighten the panels into position.

In the embodiment shown in the figures, the building structure 10 consists of 20 sectors 14, each sector thus representing 18° of a circle as seen from the peak 15. This also means that the base 12, which is in the form of a regular polygon, consists of 20 sides, and that the obtuse angle between any two adjacent sides is 162°.

It is pointed out that each of the segmental panels is in the shape of a trapezoid of which the top and bottom edges are parallel, and of which the two side edges are of equal length and convergent. Thus, the bottom edge of each panel makes the same acute angle with each side edge, whereas the top edge of each panel makes the same obtuse angle with each side edge. As noted earlier, it is an object of this invention to provide that each sector 14 has a slight outward bulge, as can be clearly seen in FIG. 1, and this construction is accomplished by causing the acute angle between the bottom edge and a side edge of the panels in a sector to decrease very slightly from one panel to the panel next above it. It will also be appreciated that there is a strict mathematical relationship between the leaning angle of each panel (with respect to a horizontal plane) and the acute angle between the bottom edge of each panel and each side edge of each panel. This relationship is as follows: $\cot A = \cos B \times \tan C$, where

$$C = 180^\circ / \text{No. of sides}$$

$$B = \text{The acute angle between a panel and a horizontal plane.}$$

and

$$A = \text{The acute angle between the bottom edge of a panel and one of the side edges of the panel.}$$

In the present case, wherein the building has 20 sides, the relationship becomes:

$$\cot A = \cos B \times \tan 9^\circ$$

Thus, if we choose 57°45' for the angle B in the ring 117, the above formula will yield the value 85°10' for the angle A. All of the segmental panels 17, then, will have the angle 85°10' between the bottom edge and the two side edges. Naturally, it is preferable to provide a slight angulation or chamfer on the side edges 47 so that the edges of the two adjacent panels 17 can be in surface-to-surface contact. The ends of the top and bottom edge members 48 and 49 will also be given an angulation to provide proper fitting.

To obtain the desired slight outward bulge in each sector 14, the angle B would be decreased and the above formula would then be worked out with this new value of B, and solved for a new value of A. The panels 18 would then be cut in accordance with the value for the angle A. The same process would be repeated for the rings 119, 120, etc., with steadily diminishing values for the angles B and A and this general process would result in the shape shown in FIG. 1, in which each sector 14 has a slight outward bulge.

Attention is now directed to FIG. 4, in which the segmental panels 17-24 of a single sector 14 are shown in

flattened condition, with each panel lying in the plane of the drawing sheet. It will be noted that, whereas the panels 17, 18, 19 and 20 each have three intermediate vertical members 50, the panels 21 and 22 have two intermediate vertical members each, and the top panels 23 and 24 have only one.

Although it forms no part of this invention, it might be pointed out here that the individual panels 17-24 are designed such as to facilitate their construction from standard four-by-eight pieces of plywood. The intermediate vertical members 50 in the panels are situated to cover the joins between the adjacent edges of plywood sections. Thus, each panel measures eight feet in height, and the panels diminish in their base dimension from about sixteen feet for panel 17 to about four feet for panel 24.

Additionally, the top panel 24 has a vent or window 52, and a ring of windows 52 is clearly seen in FIG. 3.

The conical cap 26 shown in FIG. 3 can be of any suitable construction, and as mentioned above forms no part of this invention. Where a weather-proof cap is desired, however, it should be so shaped as to fit snugly and in a stable way against the upper ends 53 of the top panels 24 in the ring 124.

Attention is now directed to FIG. 5, which illustrates an optional expedient for improving the water-tight characteristic of the building structure of this invention. This expedient is to provide a gasket made of resilient material between the adjacent vertical edges of the panels. In the actual embodiment shown in FIG. 5, the resilient gasket is in the form of a tubular rubber element 54 which is pinched or squeezed between the side edge members 47 of adjacent panels. Naturally, the gasket could also be employed between adjacent horizontal edges as well. FIG. 5 also shows a bolt 56 in its proper position. Naturally, the rubber element 54 would be perforated at the proper locations to receive bolts such as the bolt 56. The rubber element 54 could be an extrusion of any suitable cross-section.

The specific shape of the building shown in FIG. 1 is an example of the configuration which achieves the objects and ends of this invention. It will be noted that the structure is not a dome-shaped or hemispherical one. Instead, it is more nearly pyramidal in shape. But it is not exactly a pyramid, because of the slight outward bulge in each of the sectors 14. It can be referred to perhaps as a quasi-pyramidal shape.

In the illustrated embodiment, the angle between the lowermost panels 17 and the horizontal is approximately 57° and the angle between the uppermost panels 24 and the horizontal is approximately 35°, but these values are not to be considered as limiting to the scope of this invention.

The advantages of the quasi-pyramidal structure of the present invention can best be pointed out by comparing it to the conventional dome-like structure, as exemplified in Canadian Patent No. 744,895, entitled "Building Structure", issued Oct. 25, 1966 to Ivin L. Heiber. One specific disadvantage of the Heiber structure relates to the undesirable flattened-out shape at the top of his dome. Naturally, this shape is automatically a part of any dome structure, but the disadvantage is that the weight of the upper or central rings of Heiber result in an outward radial thrust from segment to segment which has the effect of shoving the middle segments outwardly away from the centre of the dome, or

in other words "exploding" the central segments. This might not be the case if the central segments, or indeed all of the segments concerned, were sufficiently heavy and could counteract this outward "exploding" force. But unfortunately, it is completely impractical to spend money merely to increase the weight of material in order to overcome a difficulty which is inherent in a faulty design. This particular shortcoming of Heiber's design becomes even more serious when the structure is utilized in countries with heavy snowfall in the winter months. The net result is, of course, that unless during construction of Heiber's dome some provision is made to tie the middle segment rings inwardly to prevent them from exploding out, the building will collapse either under its own weight or under the increased weight of a snow load.

In the building structure according to the present invention, the individual sectors 14 are bulged outwardly only slightly, such that the net outward or "exploding" thrust against the middle rings 120, 121 and 122 is slightly more than counterbalanced by the weight of the segments themselves. In other words, the bulge is not great enough to produce a net outward or "exploding" force on any ring of segmental panels. The result of this construction is that the forces on the panels are almost solely axial in direction, with little or no appreciable columnar bending stresses within the panels or at the horizontal joints between adjacent panels.

It is further pointed out that a structural advantage for the present design inheres in the fact that the weight-supporting thrust in the building is transmitted along meridian lines of the structure. Geometrically, the term "meridian" refers to a line on a surface of revolution which is co-planar with the axis of the surface of revolution. Although the structure shown in FIG. 1 is not exactly a surface of revolution, it is substantially so, and it will be seen that, if this granted, the vertical boundaries between adjacent sectors 14 constitute meridians of the structure. It is, of course, highly advantageous to be able to transmit thrusts in a substantially straight line, with no offsets, and this is what is accomplished in the present invention. By contrast, the structure of Hieber contains no such meridian transmission of thrust, since, as shown particularly in FIG. 9 and in FIG. 2 of his Canadian Patent No. 744,895, there is no registration between the edges of the segments from one ring to another, in which the edges of a given ring are substantially circular, rather than polygonal.

A further advantage of the present structure relates to the fact that the bottom and top edges of all segments in a given ring, such as ring 119, define a regular polygon as does the base 12. As a result of this, the building has considerable resistance to torque or spiral forces, such as might be exerted by eddy wind currents, and which might tend to rotate the upper rings with respect to the lower rings. The resistance to such torque would not be as great in a structure such as that of Heiber, rather than polygonal. The secure seating of one ring upon the ring beneath it is aided by the slight outward bulge in each sector 14, because this latter characteristic produces an interesting phenomenon: namely that at any junction between four panel corners, such as shown in FIG. 1 at the circle 60, the four angles add up to less than 360°, and no three edges are in the same plane.

There is a further advantage to be derived from the slight outward bulge in the sectors 14, and this relates

to the particular adaptability of the present structure for housing piles of particulate material such as coal, sand, salt, etc. Because the structure is simply a self-supporting shell, which has very little resistance to outward pressure, although it is highly resistant to inward pressure against the outside, it is very undesirable that a contained pile of particulate material should contact the inside surface of the structure at any point. Thus, the structure shown in FIG. 1 is capable of storing a conical pile of particulate material whose angle of repose is not greater than the angle between the horizontal and a line extending from the peak 15 to the base 12. In this latter limit situation, the enclosed space of the structure 10 would be fully utilized, and the slight outward bulge of the sectors 14 would ensure that no contact takes place between the particulate material and the building.

It will be appreciated that the structure disclosed herein is suitable for a great many applications: for example, schools, cottages, barns, storage buildings, airplane hangers, greenhouses, etc.

In the appended claims, the word "panel" is intended to include (a) panels having sheet material fastened to a framework (like the panels disclosed herein), (b) panels consisting solely of sheet material with integral rigidifying lips or flanges at the edges for fastening, and (c) panels of an open frame construction without sheet material, for example utilizing aluminum or wood members fastened together in a substantially rigid manner. The open frame type of panel mentioned at (c) above could be utilized in the construction of a greenhouse, for example, and the panels could be provided with some means by which glass panes could be hung on the panels, without placing any load on the glass other than that related to its own weight.

It should be pointed out that the sectors could be of varying widths although economy would dictate the fabricating of identical sectors. Thus, while the base support line is polygonal, it does not necessarily have to be a regular polygon with equal sides and angles.

THEORETICAL CONSIDERATIONS

For any large, self-supporting dome-shaped building, such as that which forms the subject matter of this application, there is a certain "critical curve line" in the vertical plane containing the vertices between adjacent segments in a given sector, and this critical curve line is such that if a building like that in the present invention were designed such that all the inter-segment vertices (joins) lay on this critical curve line, then each ground-to-peak sector would be in perfect static equilibrium, meaning that the downward weight of all of the panels would be exactly balanced by the outward "exploding" force on the panels arising from the convexity of the segment.

To help explain the calculation of the critical curve line, attention is directed to FIG. 7. FIG. 7 is a schematic diagram showing five adjacent segments in a given base-to-peak sector, freely hinged together and assumed to be in ideal condition where the bottom panel 1 is fixed to the base at F but is freely hingeable about that point, and where the top panel 5 rests with a slidable frictionless contact against a smooth vertical wall. It is assumed that the five panels in the sector shown resemble those shown in FIG. 4, but with the top panel 5 converging to a peak.

Given the length, the weight and the location of the centre of gravity of each of the panels 1 to 5, it is possible to calculate the critical curve line for this segment. The method is essentially one of balancing the moment arms about the lefthand end of each segment, beginning with the upper segment 5 and taking the segments in succession down to the lowest segment 1.

Assume that the panels 1 to 5 have the following characteristics:

TABLE I

Panel No.	1	2	3	4	5
Weight	W	0.9W	0.8W	0.7W	0.6W
Length	L	L	L	L	L
angle to hor.	a	b	c	d	e
location of center of gravity	middle	middle	middle	lower end	lower end

Step 1: balance moment arms on segment 5 about B:

$$0.6 W (0.3 L \cos e) = w_5 L \sin e;$$

$$w_5 = 0.18 W / \tan e$$

Step 2: balance moment arms on segment 4 about C:

$$[0.7 W (0.4 L \cos d)] + [0.6 W L \cos d] = w_4 L \sin d;$$

$$w_4 = 0.88 W / \tan d$$

Step 3: balance moment arms on segment 3 about D:

$$[0.8 W (0.5 L \cos c)] + [1.3 W L \cos c] = w_3 L \sin c;$$

$$w_3 = 1.7 W / \tan c$$

Step 4: balance moment arms on segment 2 about E:

$$[0.9 W (0.5 L \cos b)] + [2.1 W L \cos b] = w_2 L \sin b;$$

$$w_2 = 2.55 W / \tan b$$

Step 5: balance moment arms on segment 1 about F:

$$[W (0.5 L \cos a)] + [3 W L \cos a] = w_1 L \sin a;$$

$$w_1 = 3.5 W / \tan a$$

Now, for static equilibrium of all segments,

$$w_1 = w_2 = w_3 = w_4 = w_5;$$

Thus:

$$\tan b = 0.728 \tan a$$

$$\tan c = 0.485 \tan a$$

$$\tan d = 0.251 \tan a$$

$$\tan e = 0.0514 \tan a$$

We may now arbitrarily choose a value for any one of the angles, and work out the value of all the other angles for the condition of static equilibrium. When the profile is constructed graphically with these angles, the "critical curve line" can be seen.

Suppose we arbitrarily choose the angle a at 73°.

$$\tan a = 3.27$$

$$\tan b = 0.728 \times 3.27 = 2.38; \quad \therefore b = \text{approx. } 67^\circ$$

$$\tan c = 0.485 \times 3.27 = 1.585; \quad \therefore c = \text{approx. } 58^\circ$$

$$\tan d = 0.251 \times 3.27 = 0.82; \quad \therefore d = \text{approx. } 39^\circ$$

$$\tan e = 0.0514 \times 3.27 = 0.168; \quad \therefore e = \text{approx. } 10^\circ$$

FIG. 8 shows the profile of the sector using the angle values calculated above. The broken line 90 joins the peak and base of the sector, and defines an angle of approximately 49° with the horizontal.

In the embodiment shown in FIGS. 1-6, the peak-to-base line defines an angle of roughly 45° to the horizontal, although this is not of course a limitation of the invention. To find, for the segments actually used in a given embodiment such as the one shown, the critical curve line which yields a predetermined peak-to-base angle, such as 45°, one first finds the true relationship between the tangents of the different segment angles using the true characteristics for the segments (Table I shows merely approximations); then one arbitrarily selects one of the angles (such as angle a) and calculates the other angles in accordance with the tangent ratios already worked out; then one plots the profile of the segments in a sector using the resulting angles. The peak-to-base angle is measured on the plotted profile, and if it is too great (as was the case in our example plotted in FIG. 8), a new, slightly lower value is chosen for the angle a and the other angles are calculated as before. This new profile is plotted and the peak-to-base angle is measured. If the latter is now too low, a value for angle a somewhere between the first two values is chosen, and the process is repeated. By continuing the series of approximations, it is possible to work out the critical curve line which will give the desired peak-to-base slope.

Naturally, this method assumes that the characteristics of each segment are already known, and if this is so, then the actual profile of the segments in the sector will also be known. Thus, the utilization of the critical curve line theory is as follows:

A. One wishes to erect a segmented self-supporting building consisting of a number greater than 2 of sectors (running base-to-peak), each having a plurality of segments meeting at horizontal planes. One desires to design the building with each sector slightly bulged outwardly for the reasons stated earlier, but does not wish the sector profile to lie outwardly of the critical curve line. Also, the necessary peak-to-base slope has already been established.

B. The first step is to arbitrarily choose a set of angles between the segments and the horizontal plane, and to calculate as nearly as possibly the shapes and sizes of the different segments, the weight of each one, and the location of the centre of gravity of each one.

C. Next one utilizes the foregoing method of sequentially balancing moment arms to determine the necessary ratios between the tangents of the different angles which result in a critical curve line.

D. To ascertain whether the arbitrarily chosen angles yield a profile within the critical curve line, one can follow one of two procedures. The shorter procedure is to assume that angle of the lowest segment to be just the same as that originally chosen arbitrarily, and to calculate the other angles which satisfy the tangential ratios already worked out. Then the critical profile is drawn and the peak-to-base angle of the critical profile is measured. If the peak-to-base line defines a smaller angle with the horizontal than the angle originally established (paragraph A), then the arbitrary profile is within the critical profile and the building will not tend to collapse outwardly from its own weight. The longer procedure is to use a series of approximations as was outlined above in reference to FIG. 8 to determining the critical profile that gives a peak-to-base angle the same as that given arbitrarily (paragraph A). When one has worked out the set of angular values which gives a critical curve line having the requisite peak-to-base slope, this is plot-

ted as a profile, and the original arbitrary profile (paragraph B) is superimposed to see if it lies within the critical curve line.

If a self-supporting dome of the kind disclosed in the present application is built to its own critical curve line as calculated above, it will stand with virtually no lateral force between adjacent segments because the different sectors will be in static equilibrium. In other words, adjacent or side-by-side segments in adjacent sectors will not be pressing against each other. Moreover, the slightest increase in the weight of the top panels or the top portion of the building, such as can be applied by wind, rain or snow, will produce a net "exploding" force on the panels, and will automatically alter the critical curve line, so that the building itself will then fall outside the new critical curve line. Naturally, the difficulties introduced by designing a building at or near its critical curve line can be substantially reduced by wrapping the building with cables along the horizontal planes defined between adjacent segments. However, it is of advantage to do away with the necessity for these cables, by using the weight of the building itself to cause the segments to press inwardly and thereby hold the building together. The only way to ensure this is to construct the building well within its own critical curve line, so that no cables whatever are needed (other than those necessary to span openings in the building, such as doorways), and such that simple bolted connections between the panels intended primarily to keep the edges of the panels aligned will suffice.

The critical curve line theory developed above can also be used to show that any building constructed segmentally in the approximate shape of a hemispherical dome will definitely be designed very close to its own critical curve line, if not outside of the same, provided the segments are approximately of uniform weight per unit area. Thus, any building similar to that disclosed in this application, but which has essentially a dome shape, will definitely require cable wrapping, to avoid the risk that snow, rain or wind loading at the top centre of the dome will cause its collapse.

These considerations having to do with critical curve lines assume added importance within the context of the present invention, which is specifically intended to have a low safety factor, and to be constructed in such a way that compressive forces only must be present between the segments. Thus, the essential focus of the present invention is that of employing the strength characteristics of a building having a slight bulge or convexity in its walls (the same theory that accounts for the strength of an egg shell) while avoiding a design which approaches the critical curve line, thereby ensuring that added snow loads etc. will not produce a net exploding force on the middle segments.

A further reason for putting some curvature into an essentially pyramidal self-supporting dome of the kind disclosed here relates to the necessity of eliminating the change of "wobbling" between adjacent peak-to-base stringers, and to the necessity of making it as difficult as possible to "invert" any given corner between four adjacent segments by inward pressure on the corner. Imagine a tee-pee construction in which rectilinear stringers extended from a common peak to a polygonal base, with horizontal spacer bars located at intervals between each two adjacent stringers. Assume that the spacer bars filled only the function of keeping the

stringers properly spaced from one another, and did not add to the overall strength of the building in any other way. In such a construction, it would be very easy to shove inwardly at the mid-section of any given stringer, and depending on the columnar bending resistance of the stringer, it would not be hard to shove the mid-section of a given stringer inwardly beyond a hypothetical line joining the two adjacent stringers to the left and to the right. If the building of the present invention had only an imperceptible convexity, and thus approximated the hypothetical tee-pee just described, it would be very simple to collapse the building by a slight pressure at the mid-section of one of the sectors, and this of course must be avoided. Thus, it is preferred that the segmented building structure disclosed in this specification be constructed such that the actual profile of a given sector lies outwardly of a hypothetical circular curve line containing the ends of the sector and having its mid-point displaced outwardly from a rectilinear line joining the ends of the sector by a distance which is at least 6 percent of the length of the rectilinear line. It is unlikely that any building structure of the kind disclosed in the specification would be constructed in such a way that the critical curve line did not lie outwardly of the hypothetical circular curve line just defined. Thus, it is preferred that the actual profile of a given sector lie between the critical curve line and the hypothetical circular curve line just defined, preferably closer to the hypothetical circular curve line than to the critical curve line.

In the embodiment drawn in FIGS. 1 - 6, a line containing the inter-segment vertices of the actual profile has its mid-point displaced outwardly from a rectilinear line joining the ends of the sector by a distance which is approximately 6.4 percent of the length of the rectilinear line, and it is thus seen that the embodiment shown in the drawings satisfies the condition that the profile be situated outwardly of the hypothetical circular curve line defined above.

It is also very desirable for the building structure disclosed in this specification to have a reasonably sharp peak, in order to minimize snow loads. This is of course particularly important for a building with a low safety factor, and in which the vertices of the adjacent panels in a segment are anywhere near the critical curve line. Kent's Mechanical Engineers Handbook (11th edition) gives snow loading data as follows: for slopes up to 20° to the horizontal, 30 pounds per square foot of horizontally projected roof surface; for slopes greater than 45°, no snow loading need be considered; for slopes between 20° and 45°, the snow loading can be reduced in arithmetic ratio from 30 pounds to 0 pounds per square foot of horizontally projected roof surface. For practical purposes, it is considered desirable that the sectors of the building structure converge to a peak having a slope of at least about 30° to the horizontal, thereby minimizing the risk that a snow load will cause the effective critical curve line to move inwardly as far as the actual sector profile.

What I claim is:

1. A peaked segmented building structure comprising:
 - a base;
 - a plurality of similar, upwardly convergent and inwardly sloping adjacent sectors, each supported by said base, all sectors being divided into segmental panels at their intersections with a plurality of ver-

tically spaced, hypothetical horizontal planes, the segmental panels defined between each two adjacent horizontal planes constituting a ring of segmental panels, each segmental panel being flat and having the shape of a trapezoid of which the top and bottom edges are parallel and the two side edges are equal in length and convergent, the acute angle between the bottom edge and each side edge diminishing from one segmental panel to the segmental panel next above it, thereby to give each sector a slight outward bulge, the lowermost ring of segmental panels defining a polygon at its contact with the base;

the profile of said slight outward bulge of each sector lying between a straight line and the critical curve line for the sector, and being different from either; said last-mentioned characteristic of the profile being assured by first choosing an actual profile for each sector, by then calculating for each segmental panel in a sector its weight and length and the location of its gravitational center, by then sequentially balancing moment arms about one end of each segmental panel in order to determine the ratios between the tangents of the angles defined between the panels and the horizontal which will place the sector of segmental panels in static equilibrium from the base to the peak, by then using trail-and-error to find the set of angles which (a) satisfies the said ratios, and (b) yields the same peak-to-base angle as occurs with the actual segmental panels for which the weights, lengths and gravitational centers were determined, and finally by ensuring that the actual profile defined by the actual segmental panels lies within and is straighter than the static equilibrium profile calculated as above recited.

2. A segmented building structure as claimed in claim 1, in which the sectors define at their upper ends an opening capable of being closed by any suitably shaped capping structure.

3. A segmented building structure as claimed in claim 1, in which each panel consists of sheet material secured to a framework.

4. A segmented building structure as claimed in claim 1, in which a gasket is pinched between adjacent vertical and horizontal edges of the segmental panels.

5. A segmented building structure as claimed in claim 3, in which adjacent panels have their frameworks secured together.

6. A segmented building structure as claimed in claim 1, in which said polygon is substantially a regular polygon, such that all sectors have substantially the same base dimension.

7. A segmented building structure as claimed in claim 6, in which each panel consists of sheet material secured to a framework, in which adjacent panels have their frameworks secured together, and in which a gasket is pinched between adjacent vertical and horizontal edges of the segmental panels.

8. A segmented building structure as claimed in claim 1, in which the critical curve line is outward of a hypothetical circular curve line containing the ends of the sector and having its mid-point displaced outwardly from a rectilinear line joining the ends of the sector by a distance which is at least 6 percent of the length of said rectilinear line, and in which the said profile lies between the critical curve line and said hypothetical circular curve line, the said profile being closer to the hypothetical circular curve line than to the critical curve line.

9. A segmented building structure as claimed in claim 8, in which the said profile of each inwardly sloping sector defines a curve of which the mid-point is displaced outwardly from a rectilinear line joining the ends of the sector by a distance which is about 6.5 percent of the length of said rectilinear line.

10. A segmented building structure as claimed in claim 1, in which the sectors converge to a peak having a slope of at least 30° to the horizontal, thereby to minimize the risk that a snow load will cause the effective critical curve line to move inwardly as far as the actual sector profile.

11. The invention claimed in claim 1 in which there are at least four contiguous segmental panels arranged with two of the panels adjacent each other in one ring of segmental panels and the other two panels adjacent each other immediately above in the next upward ring of segmental panels, each lower panel of the four being in surface contact with the panel immediately above it along a contact plane inclined inwardly and downwardly with respect to the building structure, the said contact planes for the two lower panels defining between them an obtuse dihedral angle.

12. The invention claimed in claim 1, in which the intersection location of at least two adjacent rings of panels is free of internal support.

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REEXAMINATION CERTIFICATE (627th)

United States Patent [19] [11] **B1 3,820,292**

Fitzpatrick [45] Certificate Issued **Feb. 3, 1987**

[54] **BUILDING STRUCTURE**

[75] Inventor: **John R. Fitzpatrick**, Islington,
Canada

[73] Assignee: **Campcore Inc.**

Reexamination Request:

No. 90/000,787, May 24, 1985

Reexamination Certificate for:

Patent No.: **3,820,292**
Issued: **Jun. 28, 1974**
Appl. No.: **255,643**
Filed: **May 22, 1972**

Related U.S. Application Data

- [63] Continuation of Ser. No. 84,318, Oct. 27, 1970, abandoned.
- [51] Int. Cl.⁴ **E04B 1/32**
- [52] U.S. Cl. **52/81; 52/82;**
D21/114; D25/18
- [58] Field of Search **52/80, 81**

Primary Examiner—H. E. Raduazo

[56]

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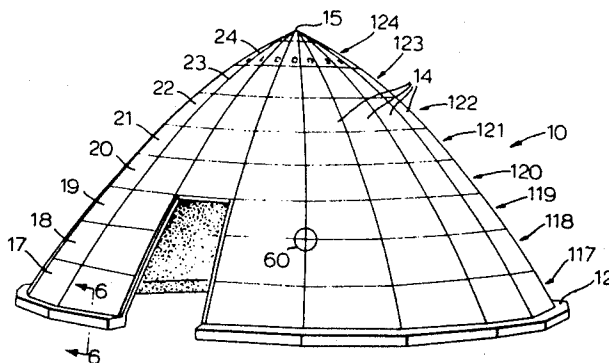
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Sept. 1968 publication of Patentee John R. Fitzpatrick, issued, published and disseminated to the public, and entitled *Report on Construction of Fitzpatrick Dome Emsdale Patrol Yard*, Sept. 1968.

[57]

ABSTRACT

A segmented building structure consisting of a plurality of similar wedge-shaped sectors, all converging upwardly and sloping inwardly to form a building resembling a pyramid. Each sector, however, is so shaped that it bulges outwardly slightly, and each consists of several segmental panels of trapezoidal shape. The outward bulge in each sector is achieved by making the acute angle between the bottom edge and a side edge of each segmental panel slightly greater than the corresponding angle in the segmental panel next above it.



**REEXAMINATION CERTIFICATE
ISSUED UNDER 35 U.S.C. 307**

NO AMENDMENTS HAVE BEEN MADE TO
THE PATENT

AS A RESULT OF REEXAMINATION, IT HAS
BEEN DETERMINED THAT:

5 The patentability of claims 1-12 is confirmed.

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REEXAMINATION CERTIFICATE (967th)
United States Patent [19] **B2 3,820,292**
Fitzpatrick [45] **Certificate Issued Dec. 20, 1988**

[54] BUILDING STRUCTURE

[58] Field of Search 52/81-83;
D21/114; D25/18

[75] Inventor: **John R. Fitzpatrick, Islington,
Canada**

[56] **References Cited**
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[73] Assignee: **Campcore Inc.**

Reexamination Request:

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Patent No.: 3,820,292

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Appl. No.: 255,643

Filed: May 22, 1972

Reexamination Certificate B1 3,820,292 issued Feb. 3, 1987.

Sep. 17, 1968 two-page publication of the Daily Commercial News entitled Ontario Highways Builds a 'Beehive'.

Aug. 26, 1969 print from negative No. 12216 of the Department of Highways of Ontario, Canada.

Primary Examiner—Henry E. Raduazo

[57] ABSTRACT

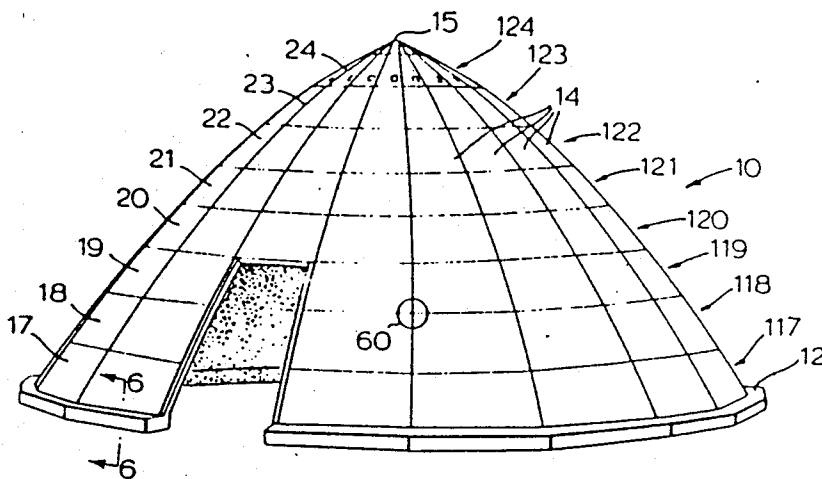
A segmented building structure consisting of a plurality of similar wedge-shaped sectors, all converging upwardly and sloping inwardly to form a building resembling a pyramid. Each sector, however, is so shaped that it bulges outwardly slightly, and each consists of several segmental panels of trapezoidal shape. The outward bulge in each sector is achieved by making the acute angle between the bottom edge and a side edge of each segmental panel slightly greater than the corresponding angle in the segmental panel next above it.

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[52] U.S. Cl. 52/81; 52/82;
D21/114; D25/18



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NO AMENDMENTS HAVE BEEN MADE TO
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AS A RESULT OF REEXAMINATION, IT HAS
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5 The patentability of claims 1-12 is confirmed.

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