

Feb. 28, 1956

G. B. WOODS
BUILDING UNITS

2,736,072

Filed July 31, 1951

3 Sheets-Sheet 1

Fig. 1.

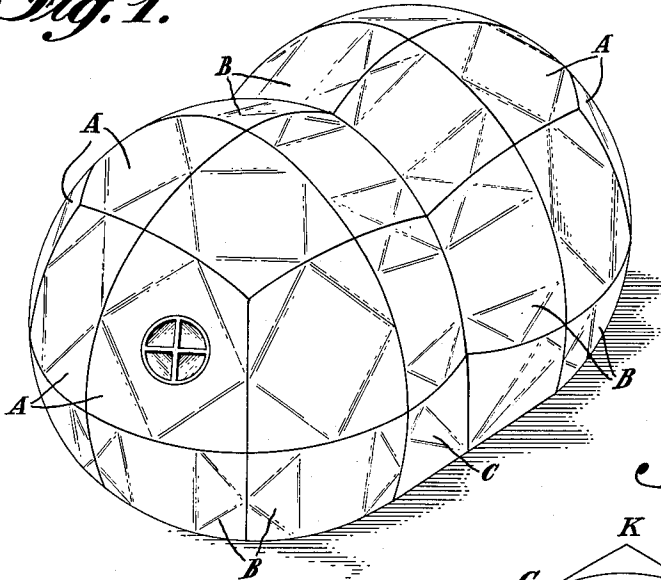


Fig. 2.

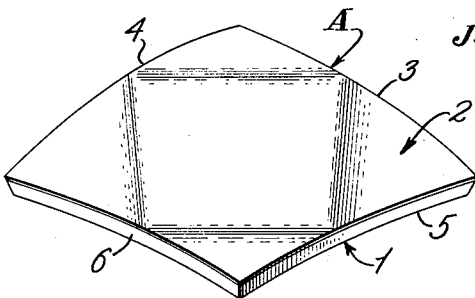


Fig. 4.

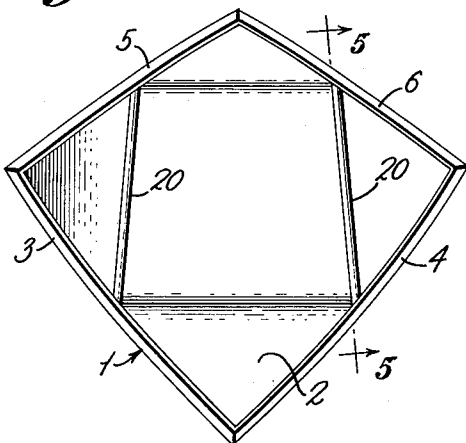


Fig. 3.

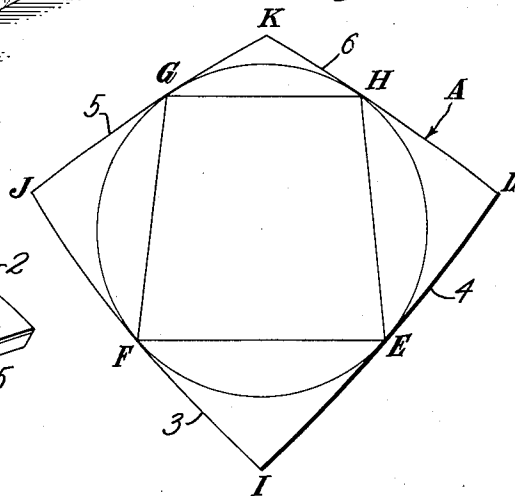
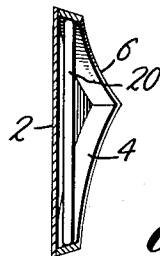


Fig. 5.



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3 Sheets-Sheet 2

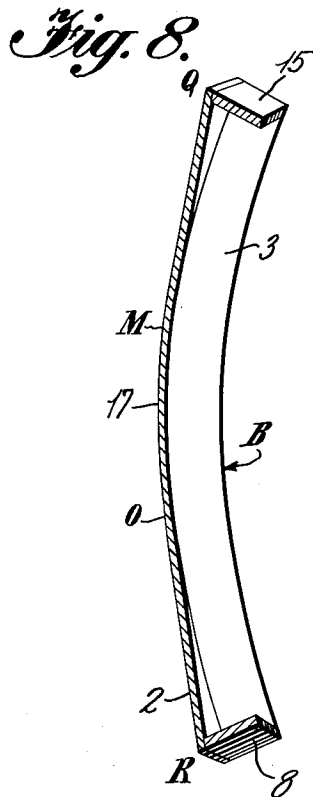
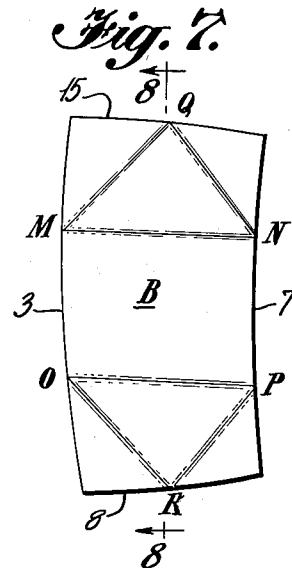
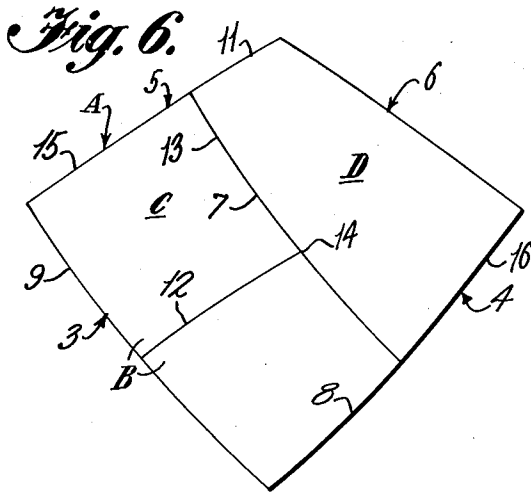
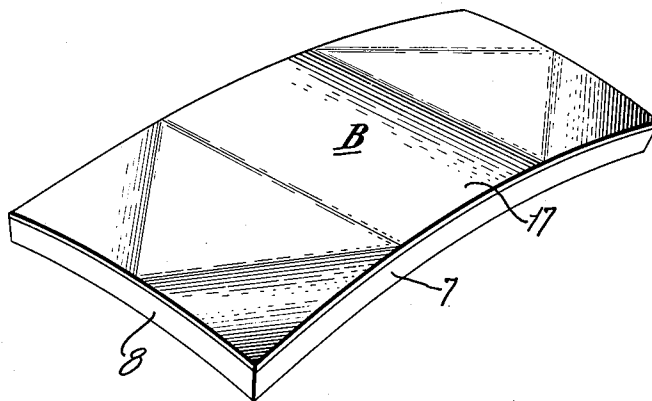


Fig. 9.



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Fig. 10.

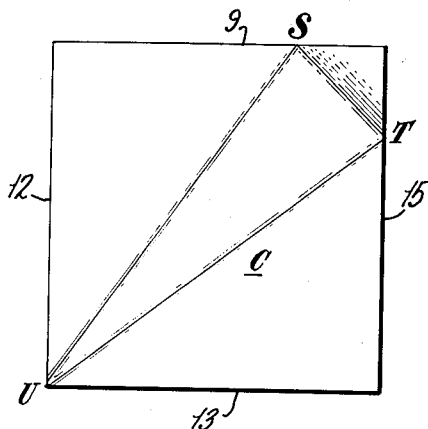


Fig. 11.

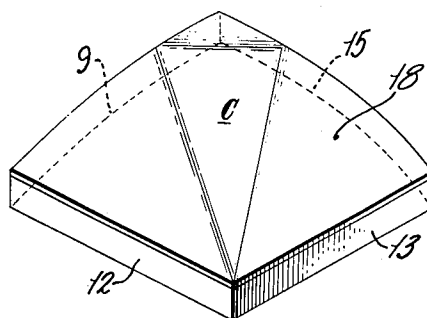


Fig. 14.

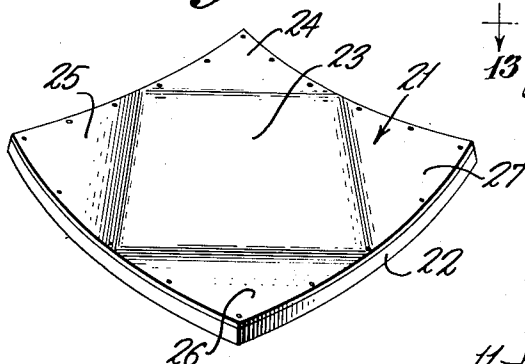


Fig. 12.

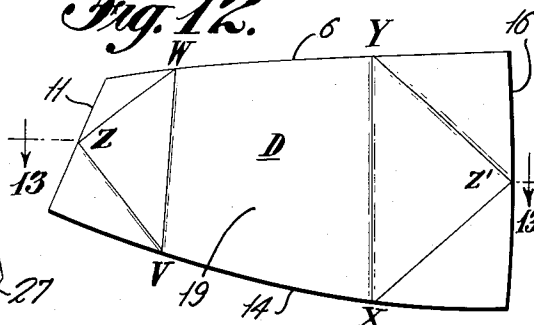


Fig. 13.

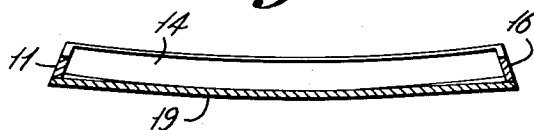


Fig. 15.

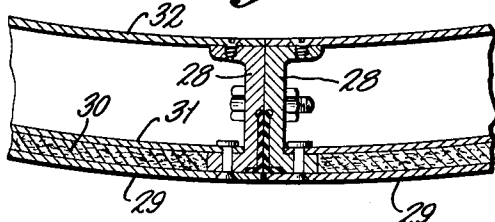
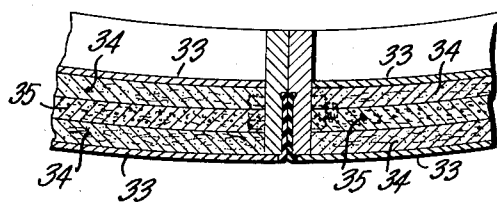


Fig. 16.



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2,736,072

BUILDING UNITS

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Application July 31, 1951, Serial No. 239,500

9 Claims. (Cl. 20—2)

This invention relates to improvements in structures of generally spherical shape, the units from which the structures are built, and the manner of fabrication of the units. Structures of generally similar nature are shown in copending applications, Serial No. 124,073, filed October 28, 1949, now abandoned; Serial No. 178,961 filed August 11, 1950; Serial No. 222,069 filed April 20, 1951, Patent No. 2,705,349 issued on April 5, 1955, and Serial No. 224,015 filed May 1, 1951, Patent No. 2,711,181 issued on June 21, 1955. This application is a continuation in part of each of the aforementioned applications.

In the co-pending applications disclosures have been made of certain structural units from which shelters having spherical surfaces may be erected. The basic unit is an aliquot part of a sphere, and has a shape which is obtained by dividing a regular spherical polygon from its center to the mid-points of its sides. This results in a kite-shaped building unit, all of the sides of which are arcs of great circles of the sphere. In the other applications mentioned, units which are divisions, or modifications, of the basic unit are disclosed.

The disclosures of the co-pending applications are to units and shelters having spherical surfaces. This necessitated moulding the units, which led to somewhat expensive manufacturing costs due to the fact that the flanges which bordered the unit, being radial to the sphere, were converging and, therefore, undercut. Moulding, too, is somewhat slow, and does not lend itself to rapid production.

The object of the present invention is to provide units having the same general characteristics of those disclosed in the above-mentioned applications, but which may be readily fabricated from stock materials.

Another object of the invention is to provide such units which have identical outlines and transverse edge contours as those previously disclosed, to the end that all of the units are completely interchangeable.

Still another object is to provide such units which may be of lighter materials, due to the particular contour, making cross-bracing entirely feasible.

A still further object of the invention is the provision of surfaces adapted to receive conventional windows or other ventilating means.

Other objects of the invention will be apparent from the following description of a practical embodiment thereof, when taken in conjunction with the drawings which accompany, and form a part of this specification.

In the drawings:

Figure 1 is a perspective view of a shelter constructed in accordance with the present invention;

Figure 2 is a perspective view of the basic structural unit;

Figure 3 is a diagrammatic plan view of the basic unit, illustrating the various surface areas of the new unit and the manner in which these surfaces are determined;

Figure 4 is an elevation looking at the back of the new basic unit.

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Figure 5 is a sectional view taken on the line 5—5 of Figure 4;

Figure 6 is a diagrammatic view of the basic unit showing the manner of dividing that unit to obtain the other units employed;

Figure 7 is a diagrammatic plan view of the second unit of the group, illustrating the different surface areas thereon;

Figure 8 is a longitudinal section taken on the line 8—8 of Figure 7;

Figure 9 is a perspective view of the second unit;

Figure 10 is a diagrammatic plan view of the third unit of the group, showing its surface areas.

Figure 11 is a perspective view of this third unit;

Figure 12 is a diagrammatic view of the fourth unit which, when joined to the second unit, forms the basic unit, showing its various surface areas;

Figure 13 is a section through the fourth unit, taken on the line 13—13 of Fig. 12;

Figure 14 is a perspective view of a basic unit or concave side, having its surface covering on the inside, or concave side, of the frame;

Figure 15 is a fragmentary sectional view of the ends of two joined units, showing a means for insulating the units and providing a finishing cover on the inside of the frame; and,

Figure 16 is a similar view showing a laminated structure for the covering, which will provide insulation and strength.

Referring to the drawings in detail, the present invention is concerned with structural units which, when coupled to other units, will construct a shelter of generally spherical contour. The invention is primarily concerned with structural units of the same general characteristics of those disclosed in copending applications Serial Nos. 124,073, 178,961 and 222,069, but which may be fabricated from flat materials, and thereby dispense with expensive and slow moulding processes.

As pointed out above, the basic unit of the group has a kite-like outline which is determined by dividing a regular spherical polygon from its center to the midpoints of its side on great circle arcs, as fully described in application Serial No. 124,073. The resulting piece will be an aliquot part of a sphere, and a predetermined number of the pieces, when joined together, will form a hemispherical shelter. The surfaces of the pieces were true spherical segments.

In application Serial No. 178,961, a division of this basic unit was disclosed, forming a plurality of independent spherical pieces which can be used alone or, when a complete set of the pieces are joined, will form the basic unit. Here again the surface contour was spherical.

In application Serial No. 222,069, a modified unit of one of the divisions of the basic unit was disclosed. In this form, two of the sides of the generally square unit were longitudinally arcuate in a depthwise direction, while the other two were straight. Although in this form there were two straight sides, the surface contemplated was a spherical one.

In the present invention, the basic unit, indicated at A, has the same outline disclosed in the copending applications. It is composed of a flange frame-section 1, and a covering, or surface 2 of sheet material. The frame is formed of the two long members 3 and 4, and the two short members 5 and 6. As defined in the co-pending applications, the angle between the long members is 90 degrees and the angle between each long member and its adjacent short member is 90 degrees. Each of the frame members is curved from end to end on a great circle arc of the sphere of which the unit A is an aliquot part.

The frame members may be formed in any desired way,

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such as cutting from stock material; and the various lengths are joined together in proper angular relation by welding, riveting, bolting, hinges, pins, etc. The outer side of each frame member must lie in a radial plane of the sphere of which the unit is a part.

As mentioned, the skin or covering of the unit is of sheet material. It is a well known fact that sheet material cannot be bent about two intersecting axes, so in order to make the sheet material conform to a frame all of the sides of which are curved, it is necessary that the surface be composed of areas of different contours, each of which is either flat or bent about a single axis.

It is well recognized that whenever a sphere is cut to form a plane, the plane will be bounded by a circle. It will therefore be evident that if a figure having the outline of the unit A has the largest possible circle touching the four sides inscribed upon it, the four points of tangency of the sides to the circle will represent points which lie in the same plane. These points are indicated at E, F, G and H on the diagram, Figure 3. It will be noted that the points E and F on the sides LI and JI, respectively, of the unit are near the mid-points of the respective sides. The distances LH and JG are equal, and equal to the distances EL and FJ. The sides IE and IF are of equal length. Thus if the points E, F, G and H are connected by straight lines, the resulting triangles EHL, FEI and GFJ are isosceles triangles with straight base lines EH, FE and GF. The sides of each of the triangles are equal, and, each being on a great circle arc of the same sphere, follows the same downward curvature. The triangle HGK is also isosceles, but has a wider apex angle. The sides HK and GK have the same curvature.

It will be apparent, therefore, that the frame 1 may be covered by a sheet of material which has a central planar area EFGH, and four triangular corner areas, as each of these triangular areas need only be curved about a single axis to follow the curvature of the adjacent, equally curved frame members. The axis of the curvature in each case will be parallel to the base of the triangular area.

The areas of the surface sheet are clearly shown in Figure 3, but in actual practice a flat sheet of material will be laid upon the frame, contacting the frame at points E, F, G and H, and the corners then bent down. The resulting surface sheet will have no sharp breaks from the flat to the curved areas, as the sheet material will assume a gentle merging from one surface to the other.

The surface sheet may have its edge secured to the frame by welding, screws, or in any other suitable way.

The division of the basic unit to form other structural pieces, as described in application Serial No. 178,961, is diagrammatically shown in Figure 6. The basic unit is divided by a line 7 parallel to its side 3, which intersects the sides 4 and 5. As the line is parallel to side 3, the resulting piece, unit B, will have three sides, 3, 8 and 15, which are arcs of great circles, and the side 7 which will be a small circle arc. The unit B is then divided along the line 12, which is parallel to the side 5 of the basic unit, and spaced from that side a distance equal to the length of line 12. This forms the unit C, bounded by great circle sides 9 and 15 and small circle sides 12 and 13. The remaining portion of the basic unit, after dividing out unit B, forms the unit D, bounded by great circle sides 11, 6 and 16 and small circle side 14. The modified unit C disclosed in application Serial No. 222,069, and with which this application is concerned, will have its sides 12 and 13 straight.

It has been found that if a frame is constructed for unit B, having the sides 3, 8, 7 and 15, and that frame is placed upon a flat surface with the convex edges of its sides in contact with the flat surface, the frame when rocked toward one end will come into stability with the points M, N and Q in contact with the surface. These points, therefore, lie in a single plane. Thus, the tri-

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angular area MNQ may be covered by a flat sheet. The corner triangles, of which MQ and NQ are the bases, have their sides following almost similar curves, so that the covering sheet 17 may be bent down about a single axis in close contact with the frame members in each of these areas. If the frame is rocked to the other end, the points O, P and R are found to be in one plane. Therefore, at this end of the unit the cover will assume a shape conforming to the planar zone OPR, and the curved triangular zones of which OR and PR are the bases. The central portion of the unit defined by MNOP has its opposing frame sections both curving in a longitudinal direction. The flat covering readily conforms to this single curve. Thus in the B unit the covering sheet will have a longitudinally curved mid-section tipped by the flat areas MNQ and OPR, with each flat area being bounded at the sides by triangular downwardly curving areas.

The modified unit C, having two straight and two curved side members, will have three points on its surface which lie in a single plane. These points are the juncture of straight sides 12 and 13, indicated at U, the point S on the side 9, and the point T on side 15. The covering sheet 18, therefore, will have a central zone STU which is flat. The line UT will form the base of one triangular zone which will be curved to cover the area included between the sides 13 and 15. The same condition exists insofar as the area wherein the line SU is the base is concerned. The small triangular area having the line ST as its base has its sides following the same downward curve. The covering sheet will readily follow this curvature to complete the covering of the frame.

The remaining unit of the group, the unit D, is quite similar to the unit B except that its opposite sides are not parallel. The central section of the cover sheet 19 will bend longitudinally in the area VWXY and will terminate in the flat triangular end zones VWZ and XYZ'. The corner triangular areas will each bend downwardly about a single axis as described in connection with the unit B.

It will be apparent from the above that each of the units, the basic unit A and the divisional units B, C and D, may be fabricated from stock material. The frame members may be cut to shape and joined, and a flat sheet may be used to form the surface. The surface will not be truly spherical, as it will have flat areas and areas which are curved about a single axis. The resulting unit, however, will have a generally spherical appearance.

Any of the new units may be joined to old units in the manner that the old units have been previously joined. The curvature of the frame members is identical with the curvature of the flanges of the old units, so that a perfect joint is obtained.

Due to the fact that each of the units has one or more flat surface areas, bracing of the new units is quite simple. Straight brace members may be used, for instance, between adjacent frame members positioned to underlie the edges of the planar surface zones. An example of this is shown by the braces 20 in Figures 4 and 5. The braces have straight sides and edges and may be of similar material to the frame, or they may take the form of rods or tubes.

The flat areas of the units also lend themselves ideally to the placement of windows, as shown in Figure 1. Windows and window frames of conventional design may be used, which was not possible with the old units having spherical surfaces.

Because the frame members have parallel top and bottom edges, the bottom edges will follow great circle arcs of a smaller sphere concentric to the sphere of which the top edges of the frame are great circle arcs. It will be evident, therefore, that a surface sheet may be placed in contact with the bottom, or concave edges of the frame as well as the top, or convex edges. Such an application is shown in Figure 14. The cover sheet 21 will adhere closely to all of the concave edges of the frame 22.

The cover sheet will have a central planar area 23, bounded by the triangular areas 24, 25, 26 and 27, with the sides of the planar zone forming the bases of the triangular areas. The triangular areas will be curved upwardly, rather than downwardly, but in each instance the curvature will be about a single axis.

In Figure 15 several cover sheets are employed. The frame in this case will be formed of flanged members 28, and a cover sheet 29 is secured to its outer side. A second sheet may be placed upon the inner side of the outside frame-flange, and insulation 30 may be used to fill the space between the sheet 29 and the second sheet 31. If desired, the interior of the unit may be covered with a finishing sheet 32.

In Figure 16 a composite, or laminated cover is shown. This cover is formed of the covering sheets 33 to give the desired finish to the unit, the intermediate stiffening sheets 34 adjacent each of the sheets 33, and the central insulation layer 35. This cover will usually be pre-formed, due to its several thicknesses, but it may be made by sequentially placing the sheets upon a mould or the frame until the laminated file is built up, and bonding the laminations together while so held in proper position. This pre-shaped cover may be placed upon the frame and secured to it in any suitable way.

Although a practical embodiment of the invention has been disclosed herein, it will be understood that the precise details are by way of example only, and changes may be made within the scope of the appended claims.

What is claimed is:

1. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, at least two adjacent said side members being arcuate from end to end in the same depthwise direction, a cover of flat sheet material bridging said frame and having its edges bent to conform to the shapes of the edges of said side members upon which it rests and joined thereto, said cover having a planar area bounded by straight lines the corners of which intersect the side edges of the cover and triangular areas at the corners of said cover which are of cylindrical curvature.

2. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, at least two adjacent said side members being arcuate from end to end in the same depthwise direction, a point on the convex edge of one of said arcuate side members and a point on the top of each of the side members adjacent said arcuate side member all lying in a common plane, a cover of sheet material contacting the frame at said points on the said edges of said side members, said sheet curving from lines connecting said points on adjacent sides to follow the contour of said side members to the point of joinder of said adjacent side member, the remaining portion of said cover defining a planar area, and said cover being joined to said frame along the edges of the said side members.

3. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, each of said side members being arcuate from end to end in the same depthwise direction, a cover of flat sheet material having its edges curved to conform to the curvature of the said side members and joined thereto, said cover sheet having a four-sided planar area thereon with the corners of the area each intersecting one side edge of the cover sheet at a point intermediate the ends of the said edge, said cover having four triangular curved areas, the base of each being congruent with a side of the planar area, whereby the corners of the planar area will contact the sides of the frame and the sides of the triangular areas, will conform to the curvature of the adjacent frame sides from the points of contact of the planar area to the corners of the frame.

4. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, each of said side members being arcuate from end to end in the same depthwise direction, the high point of the curvatures of the convex edges of all of the sides lying in a common plane, a cover of sheet material contacting the high points of all the sides with said points defining the corners of a four-sided planar area on said sheet, the remaining triangular corner areas of said cover sheet curving downwardly to follow the contour of the adjacent sides of said frame to the points of joinder of said sides, and said cover sheet being joined to said frame along the edges of the frame sides.

5. A building unit for use in erecting shelters of generally spherical contour comprising, a frame of substantially rectilinear outline having two parallel sides and all of the sides arcuate from end to end in the same depthwise direction, and a cover of sheet material joined to the frame along the edge thereof having a central area which is curved to conform to the curvature of the two parallel sides of the frame, triangular planar end areas having their bases joined to the central curved area of the cover and their apices intersecting the end edges of the cover sheet, and triangular curved areas whose bases are congruent with the sides of the planar areas and whose sides follow the curvatures of adjacent side members to the point of joinder of said side members.

6. A building unit for use in erecting shelters of generally spherical contour comprising, a frame of substantially rectilinear outline having two parallel sides and all of the sides arcuate from end to end in the same depthwise direction, a midpoint on the top edge of each end of the frame and a point on the edge of each of the adjacent frame sides near each end thereof lying in a common plane, a cover of sheet material longitudinally curved in its midsection to conform to the contour of the parallel frame sides intermediate the said points on said sides and contacting the said points on the sides and adjacent ends of said frame with said points defining planar areas on said cover, the remaining triangular corners of said cover being curved to conform to the curvature of the end and said frame members at the corners of the frame, and said cover sheet being joined to the frame along the edges of the frame.

7. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, opposite sides of said frame being parallel to one another, two adjacent sides of said frame being arcuate from end to end in the same depthwise direction and the remaining two adjacent sides straight, and a cover of sheet material having its edges bent to conform to the arcuate sides and contacting the top edges of said arcuate sides and said straight sides, said cover when bent having a triangular planar area having its base corners intersecting the side edges of the cover sheet overlying the arcuate sides of the frame and its apex at the corner of the cover sheet overlying the frame corner between the straight frame sides, and triangular curved areas whose bases are congruent with the sides and base, respectively, of the planar area, whereby the corners of the planar area will contact two of the sides of the frame and the opposite corner and the triangular curved areas will conform to the contour of the sides of the frame from points of contact of the planar area to the other three corners of the frame.

8. A building unit for use in erecting shelters of generally spherical contour comprising, four side members joined together at their ends to form a perimetric frame, the opposite side members of said frame being parallel to one another, two of the adjacent sides of said frame being arcuate from end to end in the same depthwise direction and the other two adjacent sides

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being straight, a point on the top edge of each of the curved sides and the top edge of the corner between the straight sides lying in a common plane, a cover of sheet material having a planar area conforming in shape to the area defined by the said points and corner of said frame and in contact with said points and said corner, triangular areas on said cover having their bases congruent with the sides of said planar area and their sides bent to conform to the contour of the top edges of the adjacent sides, and said cover sheet being joined to the top edges of the four side members.

9. A building unit for use in erecting shelters of generally spherical contour comprising, a slab having a four-sided outline, at least two of said sides being arcuate in the same depthwise direction, said slab having a planar area of straight sided outline with the corners of said area intersecting the side edges of said slab, and triangular areas each having its base congruent with

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the side of the planar area, the slab in the region of the triangular areas being cylindrically curved about an axis parallel to the base of the respective triangle.

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