

Nov. 17, 1959

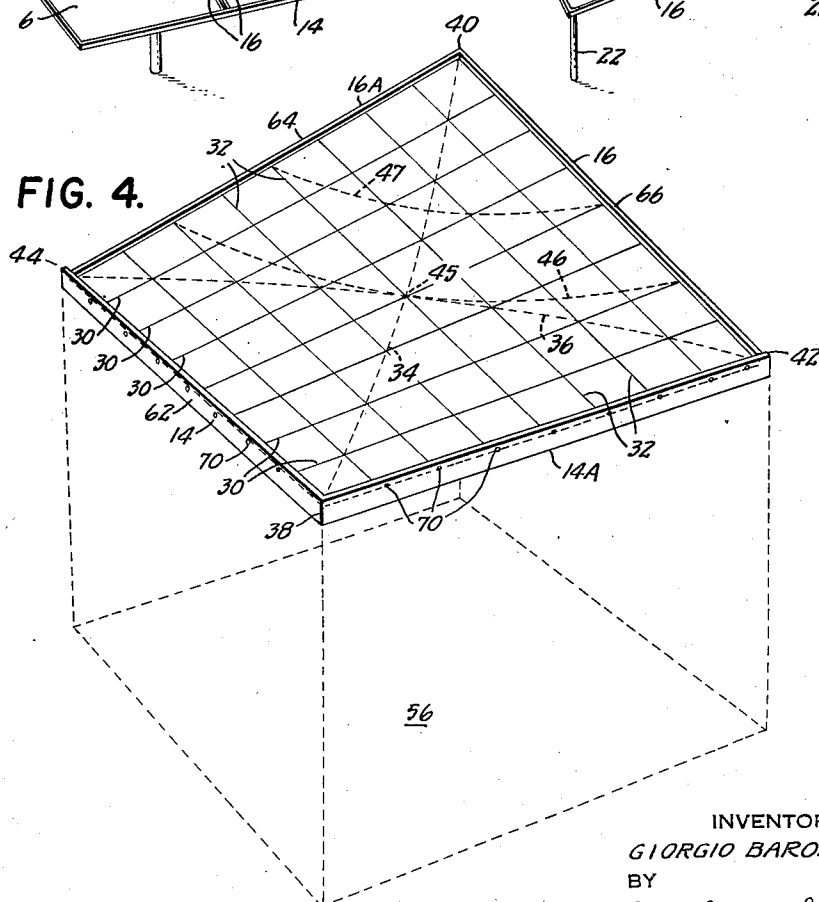
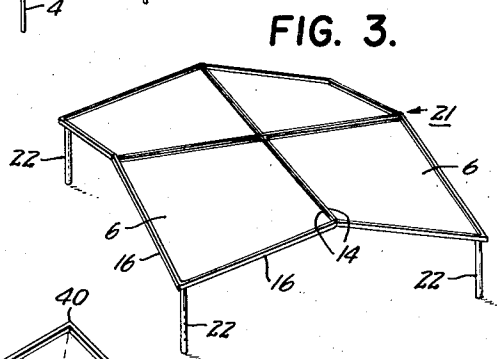
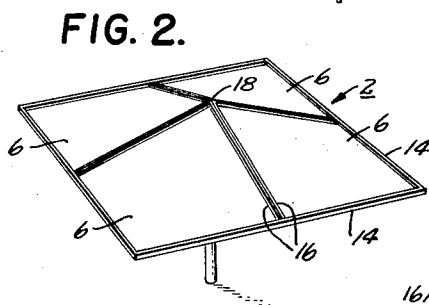
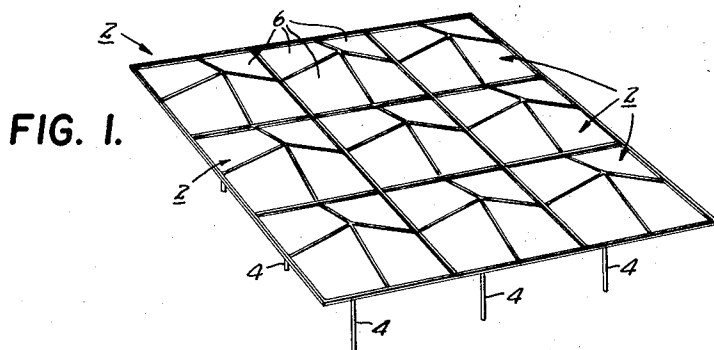
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2,912,940

ROOF CONSTRUCTION

Filed Aug. 26, 1952

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 5.

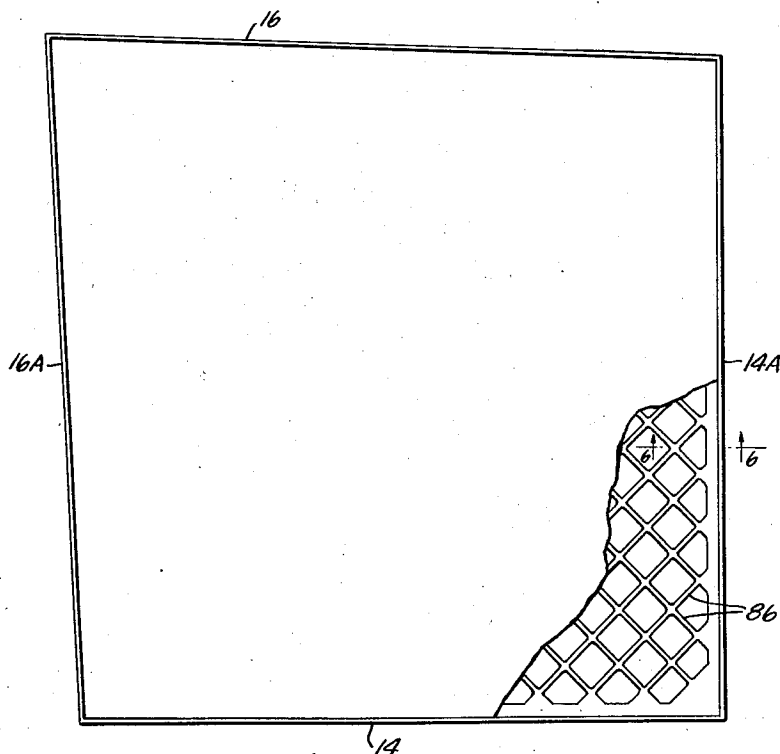


FIG. 6.

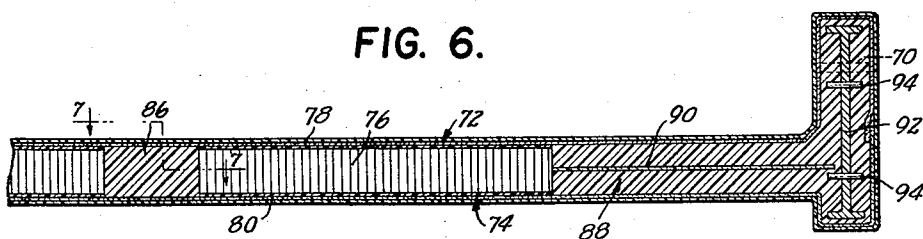
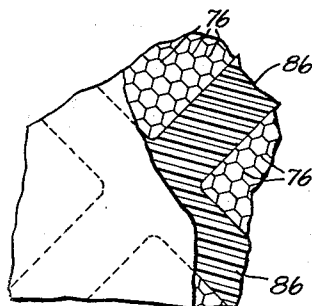


FIG. 7.



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ROOF CONSTRUCTION

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Application August 26, 1952, Serial No. 306,480

13 Claims. (Cl. 108—1)

This invention is in the field of prefabricated roof construction.

In a preferred embodiment of the present invention, a roof is prefabricated from glass and plastic materials with upper and lower surface layers separated by lightweight or cellular material.

Each roof section has a hyperbolic paraboloidal form which causes the stresses produced by its own weight and external factors such as snow, etc., all to lie along the direction of the roof surface so that bending stresses are non-existent. Each roof section has a parabolic form along both diagonals so that the strength of the section is increased relative to its flexural stiffness and the required number of support points for a roof composed of these sections is reduced to a minimum. Reinforcing elements are placed in each roof section along these diagonals.

A further aspect of the present invention is that these sections are shaped so that they can be connected together in several different ways to produce different basic roof contours, and each section can be turned upside-down and readily assembled with other sections in either position.

The various aspects, objects, and advantages of the present invention will be in part apparent from and in part pointed out in the following description considered in conjunction with the accompanying drawings, in which:

Figure 1 is a perspective view of a large area roof embodying the present invention;

Figure 2 is an enlarged perspective view of one of the roof units from which the roof shown in Figure 1 is formed;

Figure 3 shows another roof unit formed of four roof sections similar to the sections forming the roof unit of Figure 2 but assembled in a different arrangement and having four supporting columns;

Figure 4 is an enlarged perspective view of a single roof section of the type used to form the roof constructions shown in Figures 1, 2, and 3;

Figure 5 is an imaginary plan view of the roof section of Figure 4 showing approximately how it would appear if it could be flattened out in one plane, part of the surface being cut-away to show the interior construction;

Figure 6 is an enlarged partial sectional view taken along the line 6—6 of Figure 5; and

Figure 7 is an enlarged partial cross-sectional view taken along the line 7—7 of Figure 6.

The relatively large area roof of Figure 1 is composed of nine square roof units of the type generally indicated at 2 in Figure 2. The edges of these units are secured together by bolts or other fastening means as will be described later. Each unit 2 has a single supporting column 4 beneath its central portion, so that only nine columns are required for the entire roof. These roof units 2 can be assembled to form a roof of any desired size, only one supporting column being required for each roof unit.

The roof unit 2, as shown best in Figure 2, is composed of four similar separate pre-formed sections 6 which are

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suitably bolted together. Each of these sections is formed with a pair of outside edge portions 14 and a pair of inclined edge portions 16 which are fastened to the edges of adjacent sections, the four sections coming together at a peak 18 over the supporting column 4. The outer edges 14 of the sections 6 form a square horizontal periphery around the roof unit 2.

As shown in Figure 3, each of the sections 6 can be turned upside down with their respective horizontal edge portions 14 placed adjacent each other and then can be bolted together to form a roof unit 21. The edge portions 14 are now positioned internally and connected to the edges of adjacent sections to form horizontal roof ridges. The edge portions 16 are now on the outside and slope downwardly to the four corners each of which is supported by a column 22. The roof unit 21 uses four support columns 21 but they are smaller than the columns 4.

Several roof units 21 can be fastened together to form a larger roof. For example, nine of the units can be used to form a roof similar to the one in Figure 1. Sixteen supporting columns would be required.

Many other and different roof assemblies with varied contours suitable for a wide variety of different uses can be made from the roof sections 6. For example, an overhanging porch roof can be made by attaching a pair of the sections 6 to one side of the roof unit 21 with their inclined edges 16 fastened along two adjacent inclined edges of the roof unit, in other words by attaching one-half of roof unit 2 of Figure 2 to one side of the unit 21 of Figure 3. Also, the unit 2 can be turned upside down and used to provide a roof in which the edges are higher than the center, a drain pipe being positioned in the center. This shape of roof is useful in railroad stations where it is desirable to protect passengers who are boarding trains from rain, etc., a series of such units connected in a line being used to form the rain sheds over the loading platforms.

In Figure 4, the enlarged perspective view of one of the roof sections 6 shows the hyperbolic paraboloidal form of the roof surface. The section 6 has two horizontal edges, indicated at 14 and 14A respectively, and two inclined edges indicated at 16 and 16A respectively. The roof surface extends between these edges in a continuous double curved sheet having a hyperbolic paraboloidal form.

In order to show the curvature of the roof surface, seven equally spaced straight line elements, 30, are shown lying in vertical planes perpendicular to the edge 14. Similarly, seven straight line elements 32 are shown lying in vertical planes perpendicular to the edge 14A, and each intersecting the lines 30.

In a mathematical sense, these elements may be called the generating elements for the roof surface, and although these line elements 30 and 32 are straight, lines on the roof surface created by the intersection of the roof surface with vertical planes extending in a diagonal direction from corner to corner of the section 6 form parabolic curves 34 and 36 respectively. It should be noted that the curve 34 extending from the corner 38 to the corner 40 is a parabola which is concave upward with its vertex at the corner 38, whereas the parabola 36, extending between the corners 42 and 44 has its vertex 45 at the intersection of the two curves and is convex upward. The intersection of horizontal planes with the roof surface are a series of hyperbolic curves. For example, a horizontal plane through points which are one-quarter of the way up along each of the inclined edges 16 and 16A, intersects the surface along the hyperbolic curve 46, and a horizontal plane through the mid-points of these edges 16 and 16A forms the hyperbolic curve 47.

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As shown in Figure 4, the roof section 6 has a square perpendicular projection 56 on any horizontal plane. That is, by projecting the four corners 38, 40, 42, and 44 of the roof section onto a horizontal plane by means of imaginary projection lines, a square pattern 56 results. Thus, it is seen that although the roof section 6 has a hyperbolic paraboloidal form, it has a square horizontal projection and thus easily fits together with other sections to form roof units, such as the units 2 and 21 and other more complex larger area roofs as explained above.

If either of the opposed pairs of edges is increased in length, for instance by relatively increasing edges 14 and 16, the perpendicular projection of the roof section becomes a rectangle. Hence, when such sections are assembled into roofs, the resulting floor pattern is basically rectangular rather than square.

There are many types of construction wherein it is more desirable for esthetic reasons or other considerations, to use roof sections having such a rectangular projection. For example, in the construction of homes, rectangular floor patterns are more customary than square floor patterns. Thus, it should be understood that these roof sections can have either rectangular or square projections, and as used herein the word "rectangle" is intended to include a "square."

An advantage of the hyperbolic paraboloidal roof surface is that the stresses therein lie among the direction of the surface of the roof so that the surface itself assumes the various loads imposed upon the roof. Thus, bending or flexural stresses are minimized and it is not necessary to use any rafters or equivalent support members which are required to support conventional roofs today. In order to give a rough, even if not mathematically exact, picture of how the stresses align themselves in the roof section shown in Figure 4, imagine that it is connected together with three more similar sections to form a roof unit of the form with a single center support shown in Figure 2. And imagine that the roof is uniformly loaded as by a thick blanket of snow. The corner 38 tends to move downwardly and thus a tension stress occurs in the whole roof surface along the direction of the curve 34 so that the corner 38 is supported from the peak corner 40 somewhat in the manner as the center of a suspension bridge is supported from either tower by a cable having a parabolic curve form.

At the same time, the action of the whole central area of the roof surface around the point 45 is to tend to sag, creating a compression stress along the direction of the diagonal parabolic curve 36, much as the load on any parabolic archway causes a compression stress in the arch. In reality the hyperbolic-paraboloidal surface represents the materialization of the three-dimensional diagram of the stresses. For uniformly distributed loads such stresses (all pure shear, and consequently resolving themselves into pure tensions and pure compressions) are uniform all over the surface.

The effect of these stresses in the roof surface is to create a compressive stress in the edges 14 and 14A which becomes greatest at the corners 42 and 44. Thus, in a roof unit such as is shown in Figure 2, the corners 42 and 44 bear against the corresponding corners of the adjacent roof sections with considerable compressive force. The edge portions 16 and 16A carry tension stresses caused by the distribution of the stresses as explained above.

When the roof section 6 is inverted for use in a roof unit similar to that shown in Figure 3, the distribution of stresses is reversed so that the portions which formerly carried tension stresses now carry compression stresses, and vice versa.

The edges of the roof sections preferably are strengthened by flanges in order to carry these stresses. Bolt holes 70 along the flanges permit the sections to be assembled easily.

Figures 5, 6, and 7 show the details of construction of

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the roof sections 6. As shown in Figure 6, the roof includes an upper layer 72 and lower layer 74 held in spaced relationship by an intervening spacing layer 76 of light-weight material.

Figure 5 shows an imaginary developed view of the roof section 6, which would be obtained approximately by spreading the roof surface out on a horizontal plane. In this development, the edges 14 and 14A remain at right angles to each other, but the edges 16 and 16A form an acute angle.

The surface layers 72 and 74 comprise a plastic matrix material with one or more layers 78 and 80 of glass filaments or fibers, embedded therein, to form reinforcing elements. And the central layer 76 comprises groups of cells of a light-weight cellular material separated by reinforcing struts or webs 86 of the plastic material. These cells 76 are formed of any suitable light-weight material such as paper, asbestos compounds, plastic, etc. and are arranged so that the reinforcing webs 86 extend in diagonal directions across the roof in alignment with the principal stresses in the roof.

In order to resist compressive stresses which would tend to move the layers 72 and 74 inwardly toward each other, the walls of cells 76 extend perpendicularly to the layers 72 and 74 to provide maximum resistance to these compressive stresses without adding excessively to the weight of the roof. As shown in Figure 7, the units 76 of cellular material may have hexagonal openings; or they may be formed with rectangular, circular, or triangular sections or they may be irregularly shaped as by using layers of corrugated material such as ordinary straw board of the type from which many shipping cartons are formed.

The individual glass filaments or fibers in the reinforcing layers 72 and 74 preferably extend in a generally diagonal direction to provide maximum resistance to tension stresses in the layers 72 and 74. In practice, a considerable proportion of these fibers are more randomly oriented and thus reinforce the plastic against stresses which do not follow the diagonals, for instance as might be caused by a non-uniform load or by a load at essentially a single point on the roof, such as a person standing on the roof.

In applications wherein it is not necessary that the roof section be invertible top for bottom, these fibers of glass may all extend in the same direction. However, whenever the sections are fabricated for use either side up, approximately one-half of the glass reinforcing elements in each of the glass blanket layers 72 and 74 may be oriented in directions generally along one of the diagonals and the remaining fibers along the other diagonal so that they will assist in resisting the tension stresses no matter which surface of the section 6 is turned up.

One of the flanges for strengthening the edge of the roof section is shown in Figure 6. The portion of the roof adjacent the edge is strengthened further by a peripheral web 88, wider than the web 86 and which extends completely around the roof section 6 between the edge flange and the cells 76. This web may be formed of plastic and may have another layer 90 of the glass filamentary material imbedded therein about midway through the web. The plastic web 88 preferably is formed integrally with the web 86 and with the plastic of the flange which is molded around a reinforcing beam 92 of steel, aluminum, magnesium, or the like. The layers 78 and 80 of glass fibers extend completely around the flange 64.

It should be noted that the greater part of the flanges along the horizontal edges 14 and 14A as shown in Figure 4, projects above the top surface of roof section 6 whereas the flange along the inclined edge portions 16 and 16A substantially project further below the roof section 6.

Thus, no matter whether the roof section is used as,

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shown in Figure 2 or the other side up as shown in Figure 3, the flanges of the roof sections which are attached together always have their wider portion extending downwardly. Bolt holes 70 (Figure 6) in the wider portion of the flange permit easy assembly of the roof units.

The prefabrication of the section 6 may be done as follows. A form having the desired inclination and curvature is constructed with a depression around the periphery to receive the flange around the section. A film or sheet of thermosetting plastic is laid thereon, extending out to the periphery of the form and down into the bottom of the depression and up the outside, and then the glass fiber layer 80 in the form of a continuous thin blanket is laid down on top of it, also extending out to the periphery of the form and into the depression. A second film or sheet of plastic is laid over this, thus forming the surface layer 74. This layer 74 is then subjected to heat and pressure to shape it to the contour of the form, the heat being sufficient to at least partially set the plastic. The cellular units 76 are positioned on the plastic. The reinforcing beams 92 are placed around the edge of the section with some plastic inserted thereunder on top of the layer 74, and the ends thereof fastened together by riveting or bolting with the use of suitable brackets and gusset plates to form a continuous loop around the roof. Plastic material is then placed between the units 76 to form the continuous reinforcing elements 86, and the extra plastic material 88 is laid around the edges and around the steel beam 92. The extra reinforcing layer 90 of glass filaments may be imbedded in this material 88, and the edge of the glass fiber blanket 80 is wrapped around the beam 92. This layer of the roof is also partially set by heat and pressure.

The other surface layer 72 is built up from a layer of plastic, the blanket of glass fibers 78 and a final layer of plastic. This blanket 78 is wrapped down around the beam 92 and overlaps the edge of the lower glass blanket 80 which is folded up around the outside of the plastic surrounding the beam 92 as shown. The whole section is then completely cured or set by heating while subjected to considerable pressure.

For best results, the total thickness of the roof section should be at least five times as thick as each of the layers 72 and 74 and in most instances may be ten or twenty times as thick.

The type of plastic to be used depends upon the particular application. Phenolics, vinyl, or epoxy plastic materials can be used. Reclaimed hardened rubber or wood-base plastics such as hydroxylin are useful in many applications. Cellulose acetate or other thermoplastic materials sufficiently low in cost can be used.

If desired, transparent plastic material can be used so that the resulting roof section is translucent and can serve as a skylight. By the use of colored plastic material or by using colored glass fibers or both, the roof section can be made to act as a light filter.

Although the hyperbolic paraboloidal form of the roof section 6 has been described as having a rectangular projection, it is understood of course that this double curved surface can be shaped with many different projections. For example, a roof unit having properties like that shown in Figure 2 can be built up from roof sections having a hyperbolic paraboloidal surface form and an equilateral or isosceles triangular projection on the horizontal plane. Likewise, five and six sided roof sections can be used in certain applications requiring different roof contours. Another advantage of the hyperbolic paraboloidal roof surface is that since it is generated by two pluralities of straight line elements, it is possible to construct these various sections with straight edges even though the roof surface is a double curved surface.

In order to obtain the optimum stress conditions in the surface of the roof sections, the reinforcing beams

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92 along the edges of the section may be pre-stressed. To obtain good bonding action between the plastic in the edge portions and these reinforcing beams, transverse tabs or pins 94 may be inserted through the web of the beam 92, or suitably shaped holes may be formed in the web so that when the plastic is cast around the beam 92 it will flow into these holes and unite with the plastic on the other side of the web to form an integral structure therewith.

It is, of course, apparent from the above disclosure that in a roof constructed according to the present invention, as shown in Figures 1, 2, and 3, the roof can be supported solely by individual columns. Thus, the walls of the building need not support the roof and therefore can be of inexpensive construction. Moreover, it is possible to use these roofs for tent-like structures in which the walls are merely cloth or other light-weight sheet material.

From the foregoing, it will be apparent that the roof units and sections incorporating the present invention are well-adapted to attain the ends and objects set forth herein, and that the illustrated constructions are subject to a wide variety of modifications so as to best fit the roof unit to the needs of each particular use. It will be apparent also that various features of the invention may be used at times to advantage without a corresponding use of other features. Thus, for those applications where it is not desirable to use plastic, other materials such as plywood, metal, or sheet material can be substituted for the plastic layers, but lighter materials such as aluminum, magnesium, light-weight alloys, or plastic or the like are usually to be preferred.

What is claimed is:

1. A reversible prefabricated roof section having a rectangular perpendicular projection on the horizontal plane, said section comprising first and second spaced layers of a plastic material, the perpendicular projection of the layers forming a rectangle, two of the edges being straight and lying in a common horizontal plane and the other two edges being straight and inclined relative thereto, the surface of each of said first and second layers being hyperbolic-paraboloidal as generated by a first and a second plurality of straight line elements, the lines of said first plurality extending between opposite straight edges of the roof section and being perpendicular to one of said two edges lying in a horizontal plane, the lines of said second plurality intersecting the lines of said first plurality and being perpendicular to the other of said two straight edges lying in a horizontal plane, a third layer of light weight spacing material positioned between said layers and having sufficient resistance to compressive stresses to maintain the layers in said spaced relationship, the two straight horizontal edges each having upstanding flanges including fastening means adapted to abut against and fasten to the horizontal edges of other similar roof sections, and the two straight inclined edges each having depending flanges including fastening means adapted to abut against and fasten to the inclined edges of other similar roof sections.

2. A prefabricated roof section as claimed in claim 1 including a plurality of elongated reinforcing elements in at least one of said layers, a preponderance of said elements extending generally diagonally of said roof section.

3. A prefabricated roof section as claimed in claim 1, said lightweight spacing material including a plurality of rectangular lightweight units diagonally oriented in rows, and reinforcing strips diagonally arranged and extending between respective rows of said lightweight units.

4. A prefabricated roof section as claimed in claim 3 including a plurality of elongated reinforcing elements in said plastic layers and having an orientation generally in the same direction as said reinforcing strips.

5. A prefabricated roof section as claimed in claim 3 wherein said spacing material is distributed over sub-

stantially the entire area of said roof and said rectangular units include cellular material having elongated openings extending transversely from one of said layers to the other, and wherein said plastic material is pellucid and said cellular material permits the passage of light between and through said spaced layers.

6. A prefabricated roof section having four straight edges and defining a rectangular projection on a horizontal plane, a first pair of said straight edges meeting at a first corner and lying in a horizontal plane; a second pair of said straight edges meeting at a second corner diagonally opposite said first corner and being inclined upwardly from the plane of said first pair of straight edges, said roof section comprising first and second relatively thin substantially uniform spaced layers of plastic material, each of said layers having a hyperbolic paraboloidal curvature, a third relatively thick layer sandwiched between said first and second layers and holding said first and second layers in said spaced relationship, said four straight edges each including a reinforcing beam extending therealong said third layer comprising a plurality of units of a relatively lightweight and bulky material, each of said units having a resistance to compressive stresses perpendicular to said first and second layers, said units being substantially regularly arranged in a spaced relationship with respect to each other in said third layer, said units each including a plurality of cells and being diagonally positioned with respect to said straight edges and defining diagonal spaces extending through said third layer, said diagonal spaces beginning and ending at points near the reinforcing beams in said edges and a plurality of reinforcing elements extending through the spaces between adjacent ones of said units in a direction diagonally of said section, said reinforcing elements appearing straight as seen perpendicular to the plane of said first pair of straight edges and being secured along their lengths to both of said spaced surface layers and extending diagonally across said roof section in both directions with their ends being secured in position near said reinforcing beams and forming a diagonal lattice in said third layer integral with said spaced layers and with said straight edges.

7. A reversible prefabricated roof section comprising first and second relatively thin substantially coextensive spaced layers of a plastic material, a third relatively thick layer of cellular material between said first and second layers and serving to hold first and second layers in said spaced relationship, said third layer comprising a plurality of separate spaced units, the axes of the voids in said cellular material having an orientation generally perpendicular to said first and second layers so that each of said units has a resistance to compressive stresses perpendicular to said first and second layers, a plurality of elongated reinforcing elements extending diagonally along the spaces between said units, said roof section having a rectangular projection onto a horizontal plane with two adjacent edges being horizontal and the other two being inclined, the horizontal edges having an upwardly extending flange, and the two inclined edges having a downwardly extending flange.

8. A prefabricated integral roof section having four straight edge portions and a rectangular projection on a horizontal plane, a first pair of said edge portions meeting at a corner lying in a common horizontal plane and a second pair of said edge portions being inclined upwardly from said common plane and meeting at a second corner diagonally across from said first corner and elevated above said first corner, said roof section comprising first and second relatively thin substantially uniform spaced layers of plastic material extending between said straight edge portions, each of said layers having a hyperbolic paraboloidal curvature, a third layer relatively thick sandwiched between said first and second layers and having a hyperbolic paraboloidal shape conforming thereto and acting to hold said first and second

layers in said spaced relationship, said third layer comprising a plurality of units of a relatively light-weight and bulky cellular material, each of said units having numerous voids therein, the axes of the voids in said cellular material having an orientation generally perpendicular to said first and second layers so that each of said units has a resistance to compressive stresses perpendicular to said first and second layers, said units being substantially regularly arranged in a spaced relationship with each other in said third layer and being diagonally oriented with respect to said straight edge portions, and continuous strips of plastic material in said third layer running between said units in a direction diagonally of said section and forming a lattice pattern, the ends of said strips being integrally secured to said edge portions at diagonally opposite points of the roof section, and opposite sides of said strips being integral with said first and second layers to form an integral roof section.

9. A reversible prefabricated roof section comprising first and second substantially uniform spaced layers of a pellucid plastic material each having a hyperbolic-paraboloidal curvature having four straight edges, two of said straight edges meeting at a first corner and lying in a plane, the other two of said edges meeting at a second corner diagonally opposite said first corner and inclined upwardly with respect to said plane, said first two straight edges each having a flange thereon extending upwardly from the roof surface, said second two straight edges each having a flange thereon extending downwardly from the roof surface, and light weight cellular spacing material positioned between said layers and having elongated openings extending transversely from one of said layers to the other arranged to permit the passage of light between said layers and through said layers.

10. A prefabricated integral roof section having a rectangular perpendicular projection on a horizontal plane, said roof section having four straight edge portions, a first pair of said edge portions meeting at a first corner and lying in a common horizontal plane and the other pair of said edge portions being inclined relative to said common horizontal plane and meeting at a second corner which is diagonally opposite said first corner and which is offset from said common horizontal plane, said edge portions each including a reinforcing beam extending therealong, first and second relatively thin spaced surface layers extending between said straight edge portions, each of said layers having a hyperbolic paraboloidal curvature and being defined by a first and second plurality of straight line elements, the lines of the first plurality extending between opposite edge portions of the roof section and being perpendicular to one of said first pair of edge portions, the lines of the second plurality intersecting the lines of said first plurality and being perpendicular to the other of said first pair of edge portions, and a third relatively thick layer of lightweight and bulky material sandwiched between said first and second layers having a thickness at least five times the thickness of either of said surface layers, said third layer having a hyperbolic paraboloidal curvature conforming to said first and second layers and acting to hold said first and second layers in spaced relationship, said third layer comprising a plurality of cellular units each having a plurality of voids therein and presenting substantial resistance to compressive stresses perpendicular to the surfaces of said first and second layers, said cellular units being regularly arranged diagonally of said roof section and having diagonal spaced extending therebetween, and continuous strips of material extending diagonally of said roof section from edge to edge along the spaces between said units, said strips forming a diagonal lattice in said third layer, said strips appearing straight as seen perpendicularly to the plane of said first pair of edge portions and being in integral contact with the inner surfaces of both of said first

and second layers and being secured thereto to form an integral roof section.

11. An integral prefabricated roof section comprising, first and second relatively thin uniformly spaced sheets of a plastic material, each of said sheets having four straight edge portions and four corners, and having a rectangular planar projection, said sheets each defining a continuous double curved surface extending between said edge portions, each of said surfaces being of a hyperbolic paraboloidal shape such that the intersection thereof with a first vertical plane passing through a pair of diagonally opposite corners of said roof section is a parabola which is concave upwards and the intersection thereof with a second vertical plane passing through the other pair of diagonally opposite corners thereof is a parabola which is convex upwards, each of said sheets having filaments of tension-resisting material imbedded therein and extending diagonally of the roof section and a third substantially uniform layer of lightweight and bulky cellular material having a resistance to compressive stresses in a direction perpendicular to said first and second sheets sandwiched between said first and second sheets and acting to hold said first and second sheets with a substantially uniform spacing, and a diagonal lattice of reinforcing elements in said third layer and passing through said cellular material, the ends of said elements being secured to diagonally opposite edge portions of the roof section, and the inner surfaces of said sheets being secured to said elements along their lengths to form said lattice integral with said first and second layers.

12. A prefabricated integral roof section having four straight edges and a rectangular planar projection, a first and a second of said edges meeting at a corner and lying in a common plane, a third and the fourth of said edges meeting at a corner diagonally opposite said first corner and being inclined from said common plane, said roof section comprising first and second relatively thin substantially uniform spaced sheets, each of said sheets having a hyperbolic paraboloidal curvature, a plurality of reinforcing elements imbedded diagonally in each of said sheets, a relatively thick third layer of bulky cellular material sandwiched between said sheets and having a hyperbolic paraboloidal shape conforming thereto and acting to hold said first and second sheets in said spaced relationship, the axes of the voids in said cellular material having an orientation generally perpendicular to said first and second sheets to resist compressive stresses perpendicular to said first and second sheets, said third layer including a plurality of diagonally oriented units of the cellular material, said units being substantially regularly arranged in a spaced relationship with each other, continuous reinforcing strips extending between said units and arranged to form a diagonal lattice pattern, said strips being integral with said first and second sheets,

said third layer being bounded by a peripheral web extending along said straight edges and the ends of said diagonal reinforcing strips being integrally secured to said peripheral web, and a reinforcing member forming a flange extending along said four straight edges outside of said peripheral web.

13. A reversible prefabricated roof section adapted to be installed with either side upward and having four straight edge portions and a rectangular projection on a horizontal surface, a first pair of said edge portions meeting at a first corner and lying in a common plane, a second pair of said edge portions being inclined upwardly from said common plane and meeting at a second corner diagonally opposite to said first corner and elevated above said common plane, said roof section having a hyperbolic paraboloidal surface extending between said straight edge portions, said surface being defined by a first and a second plurality of straight line elements, the lines of the first plurality extending between opposite straight edge portions and being perpendicular to one of said first edge portions, the lines of the second plurality intersecting the lines of the first plurality and being perpendicular to the other of said first pair of edge portions, an upstanding flange member extending along both straight edge portions of said first pair, and a downwardly extending flange member extending along both straight edge portions of said second pair, said flange members being an integral part of said straight edge portions and each having a series of bolt holes therein at spaced points therealong, the bolt holes in the upstanding flange members being above the surface of the roof and those in the downwardly extending flange members being beneath the roof surface, whereby, upon inversion of the roof section the bolt holes to be used are accessible from beneath.

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