

Nov. 20, 1962

J. LINECKER
CARRYING STRUCTURE

3,064,773

Filed July 22, 1958

4 Sheets-Sheet 1

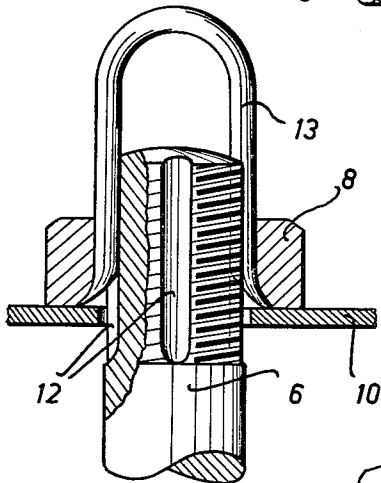
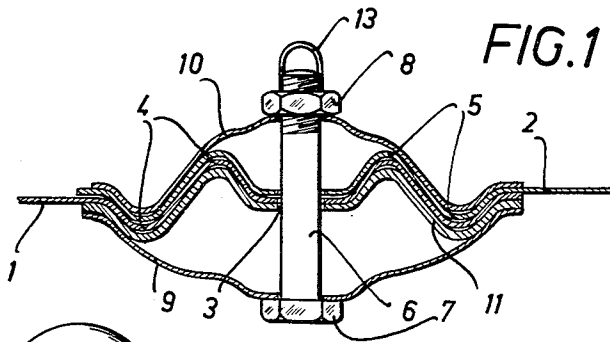
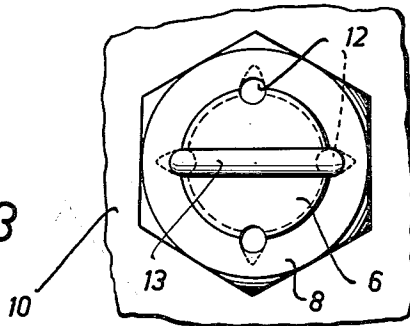


FIG. 3



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FIG. 4

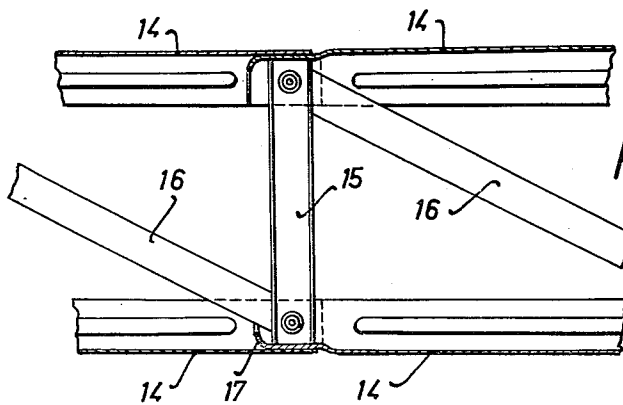
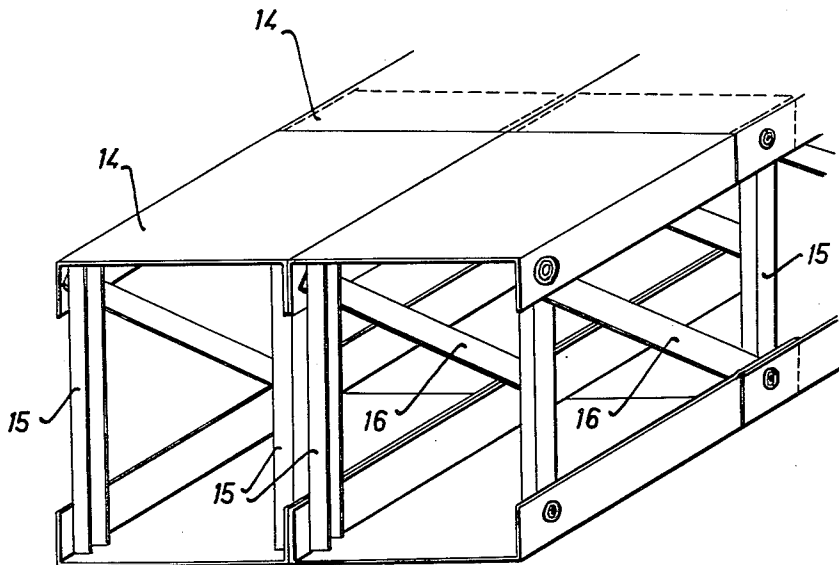


FIG. 5

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4 Sheets-Sheet 3

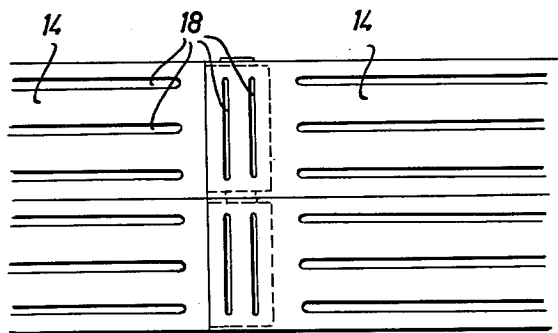


FIG. 6

FIG. 8

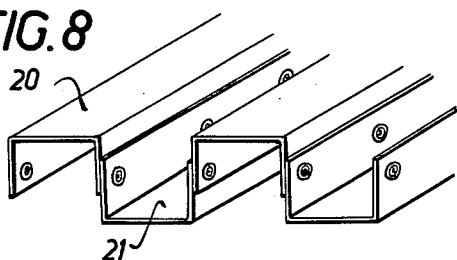


FIG. 9

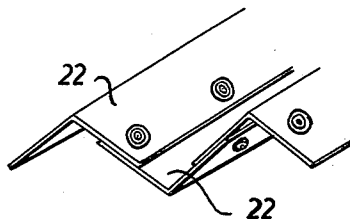


FIG. 7

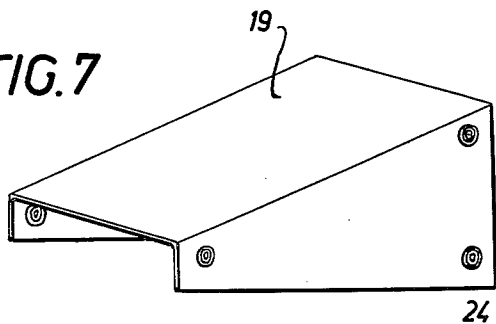
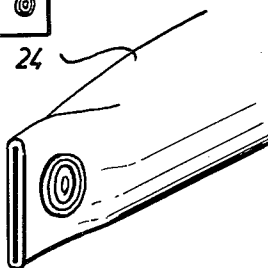


FIG. 11



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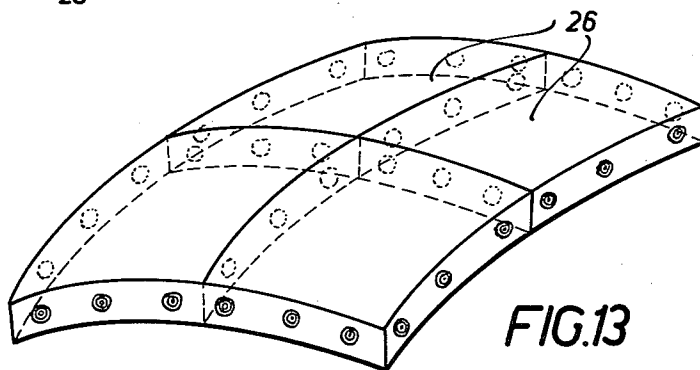
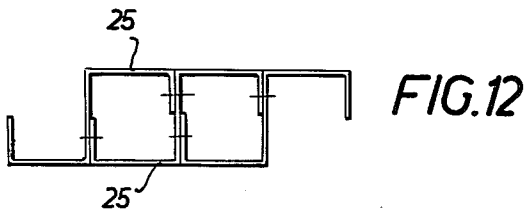
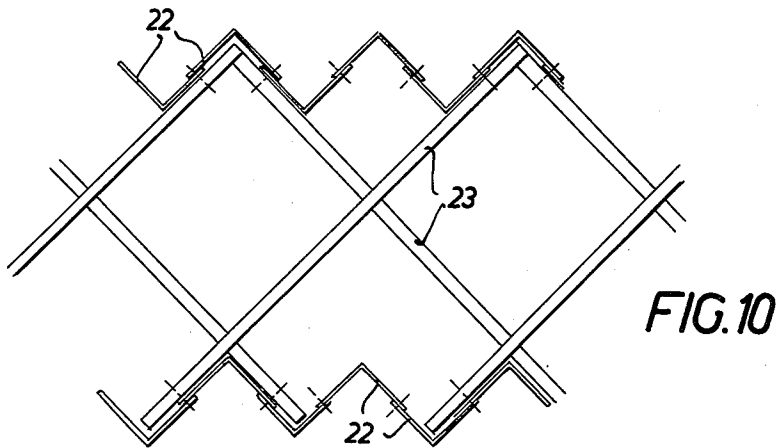
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4 Sheets-Sheet 4



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CARRYING STRUCTURE

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10 Claims. (Cl. 189—36)

Conventional roofs consist of main supports, the so-called bents, of purlins; extending transversely to the bents, of rafters carried by the purlins and of lath, which carries the actual roofing. Thus, several crossing systems are provided, which involve a high expenditure of material and a high construction. To provide a flat underside, an additional gridlike understructure is required. In floors, the spaces between the several joists must also be spanned in a similar manner and with the same disadvantages. The prefabricated structural elements required for the roof or floor constructions are in most cases bulky and heavy so that it is difficult to carry and assemble these parts.

As contrasted therewith it is an object of the invention to provide a roof, floor or wall structure which uses individual elements of relatively small size and light weight, which can easily be manufactured and can be carried and assembled without difficulty, which structure has an adequate carrying capacity and forms a surface by itself so that the need for crossing systems is eliminated.

The invention provides a carrying structure which comprises a plurality of thin-walled sectional building elements having side walls on opposite sides and being assembled with adjacent side walls of adjacent building elements in surface contact with each other, every two such side walls in surface contact with each other comprising joint-forming portions formed, respectively, with concentrically arranged, complementary, interlocking elevations and depressions, said structure comprising also means for forcing said adjacent side walls against each other.

In the carrying structure according to the invention, thin-walled angled and/or arched elements of sheet metal or the like, which may form lightweight beams lying one beside the other, are directly combined to form a surface-closing carrying structure, which spans the entire length and width of the area to be covered, the individual elements having at the joints prefabricated, concentrically arranged interlocking elevations and depressions and being forced together preferably by a clamping screw. Rather than providing spaced individual beams, and bridging the spaces between them by transverse elements, the individual building elements are directly connected to each other to form a surface-closing carrying structure which does not require any understructure but can directly carry the roofing or the like. This results in a considerable saving in material and weight. The individual elements may be made of sheet metal, plastic or the like by machines in predetermined sizes and can easily be carried owing to their light weight. The construction of the joints according to the invention is of special importance. Metal sheets or the like have previously been connected by screws, rivets or welds. Rivets and screws tend to tear out and welding on the site is difficult, particularly with sheets of light metal. In the joint according to the invention the forces occurring are transmitted from one element directly to the other through the sides of the interlocking elevations and depressions so that any clamping screw which is provided is not subjected to shearing stress and has only the function of forcing the elements together which are to be connected. For this reason the clamping screw may be replaced by pasting or welding the individual

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elements at the joints. Tensile and compressive forces will be transmitted in like manner and building elements which lie one behind or beside each other may be connected at the same point with the aid of interlocking depressions and elevations. Another advantage resides in that the joint does not involve any substantial weakening in cross-section because the elevations and depressions even increase the strength of the building elements at the joint and an annular stress pattern results from the concentric arrangement of the elevations and depressions. This concentric arrangement enables also the connection of the elements in any desired direction. The elevations or depressions may consist of closed annular grooves and beads or may only have the shape of a segment or several cup- or cap-shaped individual elevations or depressions may be arranged on one or several concentric circles. These uneven portions are usually pressed concentrically with respect to a hole for receiving the clamping screw so that the entire cross-section of the element is deformed at this point. Depending on the material used for the building elements it is also possible to cast or injection-mould the elevations or depressions at the joints or to provide special discs formed with such uneven portions and to affix them in a suitable manner to the predetermined joint-forming portions of the elements.

In a development of the invention, building elements lying one above the other are connected by thin-walled sectional or tubular vertical and/or diagonal struts and these struts are formed with the same elevations and depressions and are connected therewith to the joints between the building elements themselves. Thus a carrying structure having upper and lower tiers or chords is obtained, which can be assembled in a simple manner from light-weight individual elements and has nevertheless a sufficiently high carrying capacity. The building elements are preferably of channel section and have depending flanges in the upper chord and upstanding flanges in the lower chord, the joint-forming portions being suitably provided only in the flanges. The downwardly open upper chord element has in this case the advantage that the compressive forces and the tensile stresses resulting from the bending of the individual element decrease in the depending flanges and in the case of an equal distribution of the load will always have the same relation to each other. The same applies to the lower chord stressed in tension where a flat underside is provided. The webs of the channel-section building elements afford the wide bearing surface desired. The channel-section, which can easily be obtained, e.g., by flanging, does not only provide for a sufficient structural rigidity of the building elements but enables also the direct connection of the individual building elements to each other and the connection of the struts between the upper and lower chords to the flanges without additional means.

The flanges of the channel-section building elements may be trapezoidal in shape, one joint being provided at the shorter end of the trapezoid and two joints being provided at the longer one. In this case the need for separate vertical and diagonal struts is eliminated.

A construction of particularly low height will be achieved if an open-topped lower chord element and an open-bottomed upper chord are directly connected laterally at their flanges. It is understood that struts for stiffening may be inserted between the directly connected upper and lower chord elements.

Instead of building elements of channel-section, building elements having the shape of angled or arched troughs arranged to face alternately upwardly and downwardly with their open side may also be directly interconnected. If the upper and lower chords of the carrying structure consist of building elements having in cross-section the

shape of a V or W the chords may be connected by struts extending along three-dimensional diagonals. It is also possible to provide building elements consisting of at least two directly connected channel-sections. This cross-sectional shape is particularly suitable for building elements intended for the construction of hollow walls. Panellike, preferably arched building elements angled on all sides may be provided, having joint-forming portions on all side walls. These building elements may be assembled, e.g., like a checkerboard to form an arch or dome and transmit forces in two or more directions. Independently of the form of the building elements the same may be provided with stiffening beads or ribs.

Even in the case of a most accurate manufacture it is not possible so to form and arrange the prefabricated joint-forming portions of the individual elements that perfect registry will be obtained upon assembly. In this connection it must be borne in mind that variations in the thickness of the material must always be expected. According to the invention a compensation is achieved in that the elements to be connected engage each other at the joint-forming portions only with conical surfaces of the elevations or depressions. Any holes provided for the clamping screws may be larger in diameter than the screw bolt itself because the screw does not serve for transmitting forces from element to element. Thus, the manufacturing tolerances regarding the arrangement and formation of the joint-forming portions are insignificant and do not render the assembly more difficult.

In order to transmit the clamping pressure from the clamping screws to the building elements to be connected, solid discs could be used, which are formed on one side in conformity with the elevations or depressions. Such solid discs, however, would add substantially to the weight of the carrying structure as a whole and would thus partly eliminate the advantages which can be achieved. For this reason cambered discs are provided for transmitting the clamping pressure from the clamping screws to the building elements. Owing to their camber these discs are sufficiently rigid in spite of their relatively thin cross-section. These cambered discs have preferably flat annular portions at the centre and at the rim and are slightly concavely drawn in next to the central annular portion. The two annular portions ensure a snug engagement of the nut or the head of the clamping screw, on one side, and of the building element on the other side of the disc, whereas the concave portion provides for an additional increase in rigidity and prevents the disc from being flattened under strong clamping pressure.

It is obvious that the nuts of the clamping screws must be locked against rotation, i.e., against unintended loosening, after they have been tightened. The known lock washers are hardly suitable for this purpose because they require a complicated manipulation on the site. According to the invention the nut of the clamping screw is held against rotation by a stud which is contained in a bore recessed partly in the bolt and partly in the nut and extending parallel to the axis of the bolt. The nut and bolt may be inherently formed with the recesses forming this bore. In that case it is sufficient on the site to move the nut to a position in which the two recesses register and then to insert the stud. This affords the further advantage that the shearing of the stud would have to be effected over a very large cross-section. In order to enable a locking of the nut after small angular movements, two or more such bores parallel to the axis are provided and the locking stud is preferably bent in the shape of a U to form a staple, which can be inserted into two bores at the same time as a double lock. The locking stud is prevented from falling out of the bore by an outwardly directed oblique enlargement of the bore adjacent to the bearing surface of the nut and the end of the locking stud is tapered in the form of a wedge. When the stud is driven into the bore, its tapered end

is outwardly deflected into the enlarged portion of the bore so that the stud is prevented from falling out.

In order to distribute the load transversely across the entire carrying structure, transversely extending bracing ropes are suitably provided at the joints between the building elements and spacers may be inserted, if desired, between the angled flanges of the building elements so that the flanges cannot bend together when the ropes are strained. The bracing ropes may be passed through bores in the clamping screws or the clamping screws may be eliminated and the bracing ropes together with tubular spacers may be used for pressing the building elements together at the joints.

The invention will be explained more fully hereinafter with reference to the accompanying drawings, which show some illustrative embodiments.

FIG. 1 is a sectional view showing a joint between two building elements.

FIGS. 2 and 3 respectively, are enlarged sectional and top plan views showing a locking means for the clamping screw.

FIG. 4 is a perspective view showing a carrying structure.

FIGS. 5 and 6, respectively, are fragmentary longitudinal sectional and reduced top plan views showing a portion of this carrying structure.

FIG. 7 is a perspective view showing another construction of a building element.

FIG. 8 is a perspective view showing a carrying structure having no stiffening struts.

FIG. 9 is also a perspective view showing the assembly of trough-shaped building elements.

FIG. 10 is a diagrammatic view showing the connection of trough-shaped building elements to form a carrying structure.

FIG. 11 is a perspective view showing the end of a tubular strut.

FIG. 12 is a diagrammatic view showing the connection of building elements consisting of double channel-sections.

FIG. 13 is a perspective view of a carrying structure consisting of cambered panel-shaped building elements angled on all sides.

To enable the connection of two metal sheets 1, 2 forming a building element each the same are provided at the joint-forming portion with impressed or struck-out formations 4, 5 substantially of wave-shaped cross-section, which are concentric with a bore 3 and interengage, only the tapered surfaces being in firm contact. When these elevations or depressions in the two sheets 1, 2 are forced against each other, any tensile or compressive forces acting in the sheet metal plane may be directly transmitted from sheet to sheet through the sides of the elevations or depressions. To force the sheets together at the joint, a clamping screw 6 is provided at each joint. This screw extends through the bore 3 and has a head 7 and a nut 8. The clamping pressure is transmitted from the clamping screw to the superimposed sheets 1, 2 by means of cambered discs 9, 10, which have flat annular portions at the centre and rim and are slightly concavely drawn in next to the central annular portion. The disc 10 differs in form from the disc 9 inasmuch as it conforms more closely to the sides of the impressed or struck-out formations. It is also possible, however, to use discs such as 9 on both sides. In order to prevent the sheets 1 and 2 from separating adjacent to the bore 3 under the clamping pressure acting from the outside, and in order to provide for a better distribution of the clamping pressure throughout the joint, additional washers 11 conforming to the elevations or depressions may be used, which may be provided only on one side, as is shown, or on both sides. Several superimposed sheets or other building elements may be connected in the same manner. If one clamping screw is not sufficient, two or more such

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screws may be provided within the concentric rings formed by the elevations or depressions. Sealing or corrosion-preventing means or the like may be introduced into the hollow spaces between the sheets 1 and 2.

To enable the nut 8 of the clamping screw 6 to be locked, bores 12 extending parallel to the axis of the bolt and recessed partly in the bolt and partly in the nut are provided and studs consisting of the limbs of a U-shaped locking staple 13 are inserted into two diametrically opposite bores. Adjacent to the bearing surface of the nut, the bores have outwardly extending oblique enlargements and the ends of the staple are tapered in the form of a wedge so that the latter are outwardly deflected when the staple is being driven. Thus, the staple is prevented from falling out. Strong tension on the staple will cause the deformed ends to be bent inwardly so that the staple 13 can be removed with pliers or the like.

According to FIGS. 4 to 6, building elements 14 are provided which consist suitably of sheet metal and are of channel-section. They are interconnected in the longitudinal and transverse directions and the elements having depending flanges form the upper chord whereas the elements having upstanding flanges form the lower chord of a surface-closing carrying structure. The upper and lower chords are connected by channel-section vertical struts 15 and by diagonal struts 16 consisting of plain metal strips. These struts 15, 16 have similar elevations and depressions as and are connected to the joint-forming portions of the flanges of the building elements 14. Thus, the flanges of the building elements 14, which lie behind and beside each other, the vertical struts 15 and the diagonal struts 16 interengage at the joints with conforming concentric elevations and depressions and all these parts are forced together, as a rule, by only one clamping screw. The carrying structure consists actually only of directly interconnected individual beams, which lie one beside the other and each of which is very light weight. The building elements 14 and the struts 15 and 16 may be prefabricated with sufficient precision to form light and handy individual parts and can be assembled in a simple manner on the site to form the entire carrying structure, because it is sufficient to insert the clamping screw with the washers and to tighten the screw.

In order to enable the channel-section building elements 14 to be pushed one into the other at the joints each of these elements is reduced in width and height by the thickness of the material at one end. A transverse stiffening adjacent to the joint can be obtained by bending the transverse edge 17. The building elements as such are stiffened by forming them with beads 18. The stiffness may also be increased by cambering the web between the flanges. Besides, it is favourable to form the building elements 14 initially only with obliquely angled flanges; to obtain a cross-section having an approximately trapezoidal outline, and to set the flanges at right angles on the site. This will facilitate the carrying of the elements in a nested arrangement.

As is shown in FIG. 7 the flanges of the building elements 19 may be trapezoidally shaped, having one joint-forming portion at the shorter side of the trapezoid and two such portions at the longer side. When such building elements are assembled to form a carrying structure as shown in FIG. 4, separate vertical and diagonal struts may be eliminated.

FIG. 8 shows a carrying structure having a particularly low overall height. An open-bottomed upper chord element 20 and an open-topped lower chord element 21 are directly interconnected laterally at their flanges. Building elements 22 in the shape of angled troughs may be similarly connected as is shown in FIG. 9.

The diagrammatic view of FIG. 10 shows a carrying structure the upper and lower chords of which consist of building elements 22 of V-shaped cross-section interconnected by struts 23 extending along three-dimensional diagonals. These struts 23 do not extend in the plane of

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the drawings but are inclined relative to it. In this case there is no need for vertical struts. It is obvious that the V-shaped building elements could be replaced by elements of W-shaped cross-section.

It is apparent from FIG. 11 that tubular elements 24 may be used as struts and be connected in the same manner to the other building elements. It is sufficient to pinch the tube ends and to provide the appropriate elevations and depressions on these flattened ends.

FIG. 12 shows building elements 25, which have the cross-sectional shape of two direct channel-sections. These building elements are connected as shown and form a carrying structure which is also suitable as a hollow wall.

According to FIG. 13, cambered panel-shaped building elements 26 angled on all sides are provided, which have joint-forming portions on all side walls. These building elements are assembled in a checkerboard pattern to form a dome or arch. They may be connected by struts to a lower chord of similar construction and such a carrying structure can transmit forces in at least two directions. It is obvious that the building elements 26 need not be quadrangular but may be triangular or polygonal.

Regardless of the form or assembly of the individual building elements they may be provided with stiffening members applied thereto, ribs, transverse webs etc. without departing from the scope of the invention.

I claim:

1. A load carrying structure, comprising in combination,
 - (a) two sheet members having respective integral substantially identical joint forming portions of substantially wave shaped cross section;
 - (b) said sheet members each having two faces and the joint forming portion of each sheet member being formed with a plurality of concentric annular projections on one face thereof, said projections defining an annular depression therebetween, and a plurality of annular depressions on the other face, said plurality of depressions respectively corresponding to said plurality of projections and defining an annular projection therebetween corresponding to the depression on said one face;
 - (c) respective faces of the joint forming portions of said sheet members being concentrically superimposed; and
 - (d) fastening means pressing said superimposed faces against each other for holding the respective projections on each of said superimposed faces in interengagement with the corresponding depressions of the other face.
2. A structure as set forth in claim 1, wherein said joint forming portions of said sheet members are of substantially uniform thickness.
3. A structure as set forth in claim 1, wherein said annular depressions and said annular projections are substantially circular.
4. A structure as set forth in claim 1, wherein said joint forming portions of said sheet members are of substantially uniform thickness, and the radii of said projections on each face of said joint forming portions are substantially equal to the radii of the corresponding depressions on the other face.
5. A structure as set forth in claim 1, wherein said joint forming portions are formed with respective central bores therethrough, and said fastening means include clamping screw means passing through said bores.
6. A structure as set forth in claim 5, further comprising a disc member at least partly conforming to a face of one of said joint forming portions remote from the other joint forming portion, and superimposed on said remote face, said clamping screw means including pressure means for urging said disc member and said other joint forming portion toward each other under pressure.
7. A structure as set forth in claim 6, further comprising a washer member having two opposite faces at least

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partly conforming to said remote face and to said disc member respectively and interposed between said disc member and said remote face.

8. A structure as set forth in claim 6, wherein said disc member and said other joint forming portion constitute a pair of cooperating elements, said clamping screw means includes an elongated screw member, and said pressure means includes a head on said screw member engaging one of said elements, and a nut member threadedly movable on said screw member and engaging the other one of said elements.

9. A structure as set forth in claim 8, wherein said pressure means further includes locking means for locking said nut member against threaded movement on said screw member.

10. A structure as set forth in claim 1, wherein said joint forming portions are formed with respective central bores therethrough, and said fastening means include a screw member having a head and passing through said bores, and a nut member threadedly engaging said screw member, said head and said nut member respectively

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spacedly facing the faces of said joint forming portions remote from the other joint forming portion, and two cambered disc members each having an apertured central portion receiving said screw member and a rim portion, said central portions respectively abutting against said nut and against said head, and said rim portions conformingly abutting against annular parts of the respective remote faces of said joint forming portions spaced from the respective central bore.

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