United States Patent [19]

Kolozsvary

[11] **3,921,349**

[45] **Nov. 25, 1975**

[54] **STRUCTURAL COMPONENT AND STRUCTURES COMPRISING THE SAME**

[76] Inventor: **Arpad Kolozsvary,** 180 Morris Ave., Mountain Lakes, N.J. 07046

[22] Filed: **Jan. 25, 1971**

[21] Appl. No.: **109,305**

Related U.S. Application Data

[60] Continuation-in-part of Ser. Nos. 789,845, Jan. 8, 1969, Pat. No. 3,557,501, and Ser. No. 109,169, Jan. 25, 1971, Pat. No. 3,729,876, which is a division of Ser. No. 789,845.

[52] **U.S. Cl.** **52/81;** 52/222; 52/291; 52/582

[51] **Int. Cl.²** **E04B 1/32;** E04B 1/342

[58] **Field of Search** 52/80, 81, 222, 291, 582

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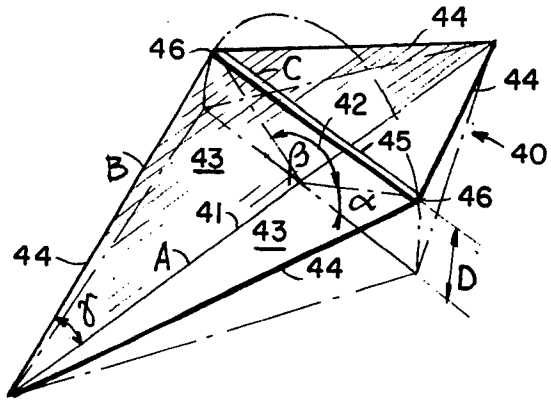
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Primary Examiner—Henry C. Sutherland
Attorney, Agent, or Firm—Shanley, O'Neil and Baker

[57] **ABSTRACT**

Quadrilateral plate components folded along one of their diagonals, the fold angle of each component being optionally variable so that the desired fold angle may be selected during assembly of a structure and maintained by transverse restraining means, which are attached to the components' apices lying at opposite sides of the fold line, which transverse restraining means may be of variable length adjustable to achieve the desired fold angle; the component's free sides having connection surface means so designed that identical folded plate components can be interconnected in various positions relative to each other to thereby build up a great variety of structures having different overall configurations, ranging from planar surfaces to complex, non-developable surfaces with multiple curvatures. Where the restraining means are rigid the components can be shipped in flat or folded condition with the restraining means not connected in restraining relation.

18 Claims, 27 Drawing Figures



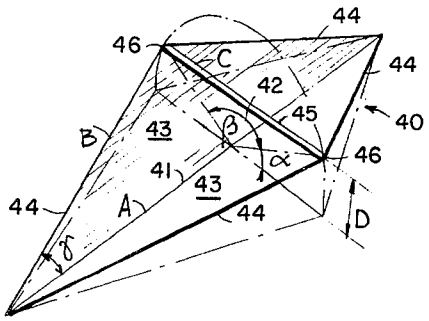


FIG. 1

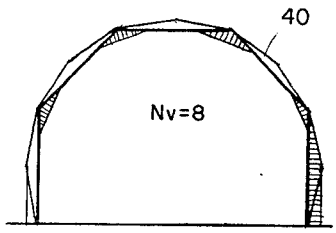


FIG. 2

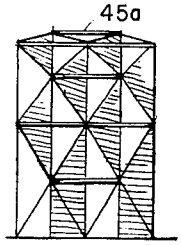


FIG. 2a

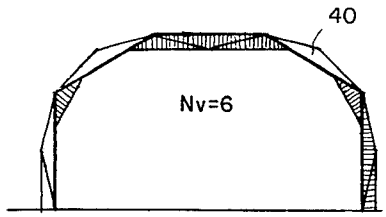


FIG. 3

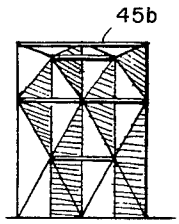


FIG. 3a

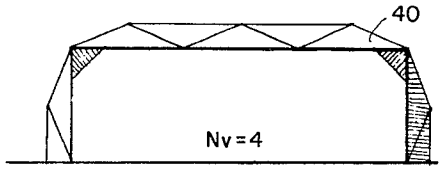


FIG. 4

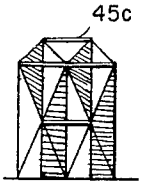


FIG. 4a

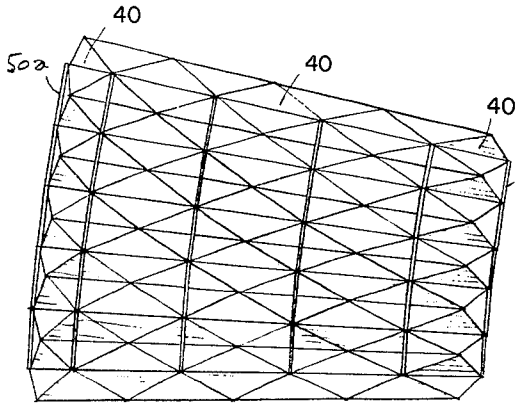


FIG. 6

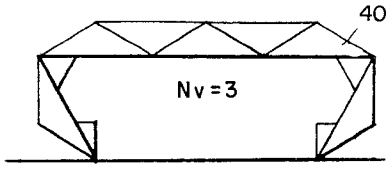


FIG. 5



FIG. 5a

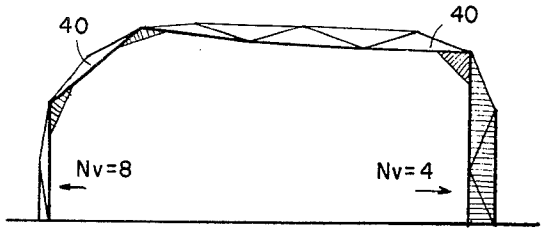


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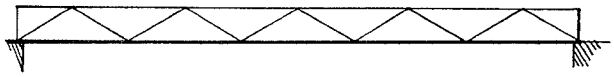


FIG. 8

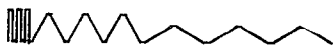


FIG. 9

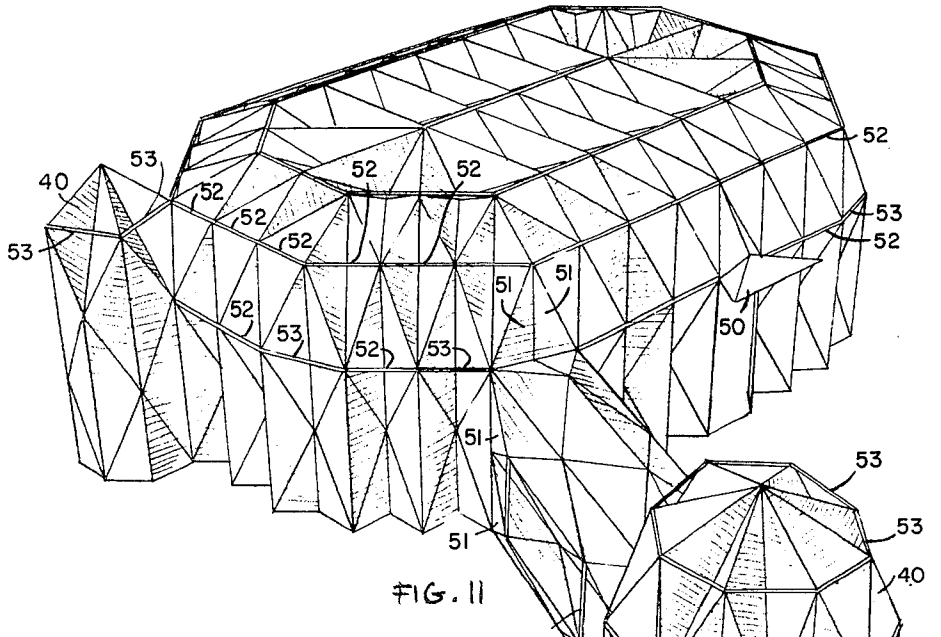

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FIG. 11

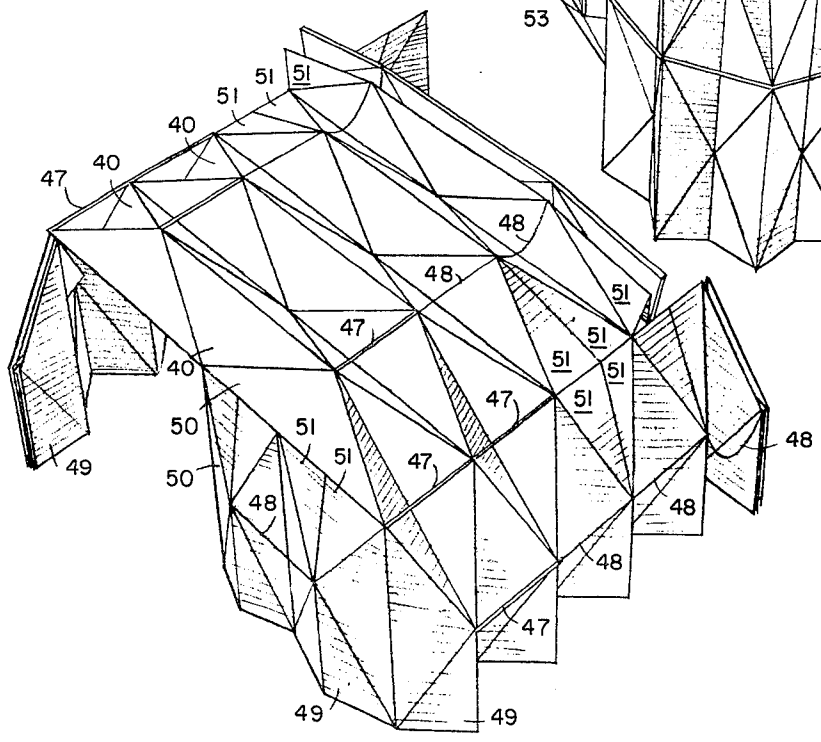

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FIG. 10

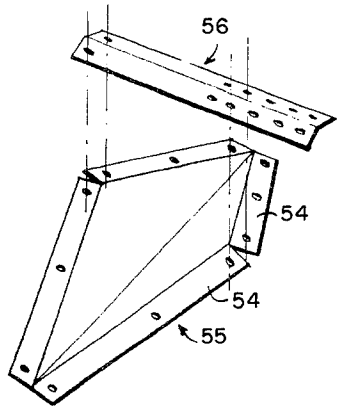


FIG. 12

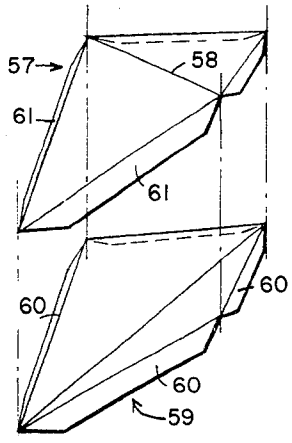


FIG. 13

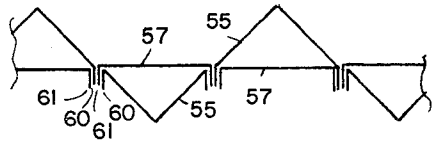


FIG. 14

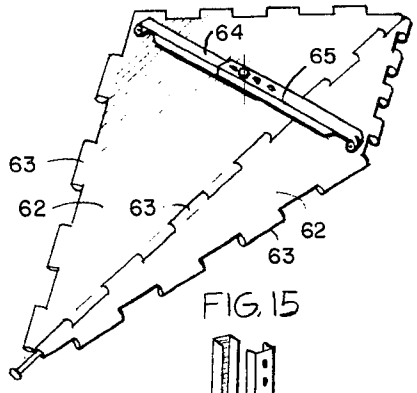


FIG. 15

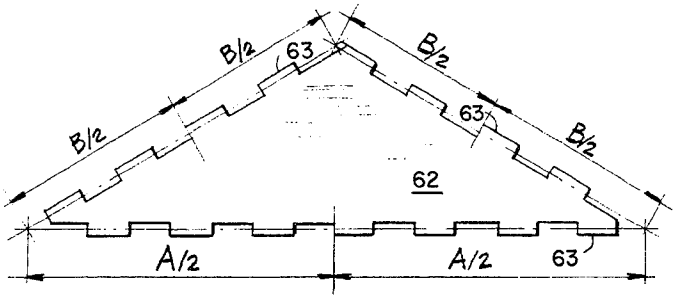


FIG. 17

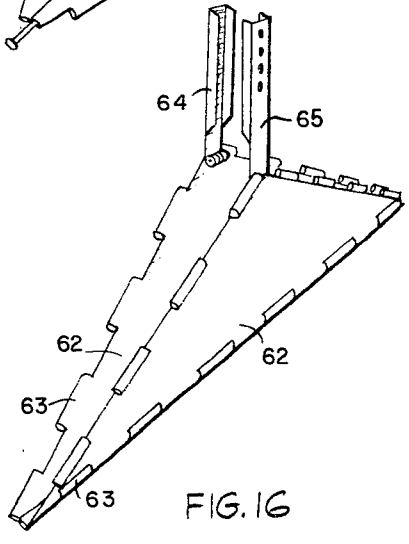


FIG. 16

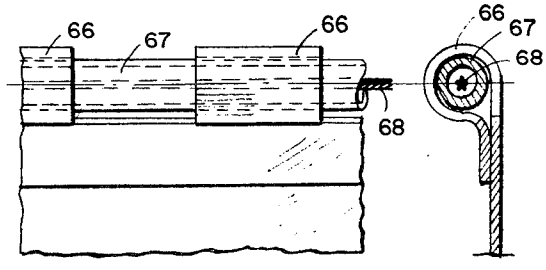


FIG. 18

FIG. 19

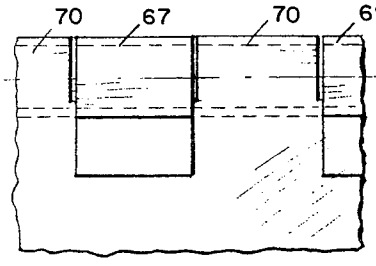


FIG. 20

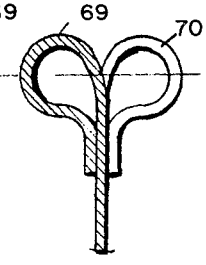


FIG. 21

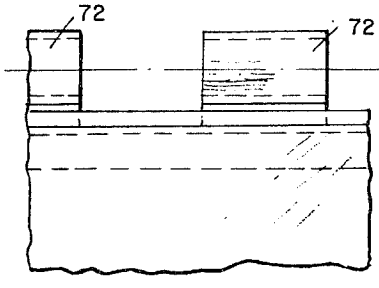


FIG. 22

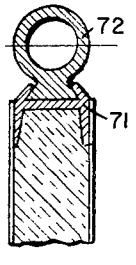


FIG. 23

STRUCTURAL COMPONENT AND STRUCTURES COMPRISING THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my copending application Ser. No. 789,845, filed Jan. 8, 1969, now U.S. Pat. No. 3,557,501 and Ser. No. 109,169 Filed Jan. 25, 1971, a division of application Ser. No. 789,845, now U.S. Pat. No. 3,729,876.

BACKGROUND OF THE INVENTION

Folded quadrilateral plate components are eminently suited for widespread use in structures of all kinds, because of their structural efficiency and because they approximate desired curvatures with straight lines and planar surfaces that are simple to prefabricate and assemble. The advantages of such structural components have long been recognized and there are numerous existing structures and known designs which employ prefabricated folded quadrilateral components. However, their use in the prior art has been limited to cylindrical or dome-like structures, which meant that for a given set of components only a single type of structure with a given curvature could be built, making the components not suitable for standardization and mass production. This limitation was due to the positioning of the folded quadrilateral components which were, without exception always placed with their concave side to the exterior, so that all the prior art's joints were identical ridges. I have discovered and disclosed in my copending patent application, Ser. No. 789,845, a new reversible joint concept which permits the interconnection of identical folded quadrilateral components not only in the same, concave-to-concave relative fold position, but also in reversed, concave-to-convex position. Through this optional component reversibility, it has become possible to assemble a great variety of different structures using only a single type of folded quadrilateral components.

As described in my aforementioned patent application, the components' dimensions, including the fold angle are dependent upon the selected values of Nv, which is the number of components in the cross section of a cylindrical assembly and Nh, which is the number of components meeting at the center of a star-like assembly of components. Since Nv is characteristic of parallel assemblies and Nh is characteristic of radial assemblies, the fold angle of a component, if intended to be used only in either a selected single Nv parallel system or in a single Nh radial system, can be chosen at will. However, if the component, designed in accordance with my aforementioned patent application, is to be used in structures that are part parallel and part radial, there is only one fold angle that satisfies a selected pair of Nv and Nh values and a component so designed cannot be used in structures having different Nv and Nh values.

Intent on further expanding the versatility of identical folded quadrilateral components so that the advantages of standardization and mass production would be maximized, I have discovered that this can be achieved by changing the reversible component's fold angle from constant to variable. However, introducing the fold angle as a variable into my structural system described

in my aforementioned patent application presents geometric and structural problems of much complexity that the prior art offers no guidance in solving. The prior art does contain various systems of foldable diamond plate component assemblies, but it is impossible to assemble these components to provide structures that are part parallel, part radial and/or are a combination of plane and curved surfaces, which I have discovered to be the very criteria of structural versatility. The prior art does not offer any solution for instance to the problem of transverse instability of flat sawtooth assemblies because the prior art does not reverse the fold position of any of its components and, therefore, it does not suggest straight assemblies.

These and other similar problems which have heretofore made unlimited structural versatility impossible through the use of identical folded quadrilateral components are fully met by the component of my present invention, which is designed in accordance with the geometric principles of my referenced copending patent application so that two such components may be connected to each other in either parallel or radial relative fold line positions and in either identical or reversed relative fold angle positions, and which components have a variable fold angle and utilize a transversal restraining member to maintain the fold angle as required by the component's location in the structural assembly.

The primary object of this invention is, therefore, to provide a foldable quadrilateral plate structure component which can be used in a geometrically unlimited variety of structures including all Nv and Nh designs and doubly curved surfaces, which has heretofore not been possible with identical folded quadrilateral plate members.

Another important object of this invention is to greatly increase the efficiency of all structures made of folded quadrilateral plate components by adjusting in the field the structural depth of the cross sections in accordance with desired span and loading.

A further important object of this invention is to provide entire structural assemblies or portions thereof which can be preassembled, stored and shipped in a collapsed form, to be expanded to their full size at the site of installation, requiring minimum field connections and which may also be repeatedly opened and closed by opening and closing the fold angles of a plurality of their foldable quadrilateral components.

A still further important object of this invention is to provide structural assemblies of folded plate structural components of adjustable fold angle in which the direction of the fold angle of a plurality of the folded plate structural components of the assembly is reversed relative to that of other folded plate structural components in the assembly.

DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of the basic structural component.

FIGS. **2** through **5** are end elevational views and FIGS. **2***a*–**5***a* are the respective side elevational views of different parallel assemblies of the structural components.

FIG. **6** is a plan view of a structure having curved ground plan.

FIG. **7** is an end elevational view of the structure shown in FIG. **6**.

FIG. 8 is a schematic side view of a flat saw-tooth roof assembly.

FIG. 9 is a schematic cross section of the structure shown in FIG. 8.

FIG. 10 is a perspective view of a structure having partially retractable roof and wall portions.

FIG. 11 is a perspective view of a structure comprising parts of various configurations.

FIG. 12 is a perspective, exploded view showing the disassembled parts of a structural component.

FIG. 13 is a perspective, exploded view showing disassembled parts of another type of structural component.

FIG. 14 is a schematic cross section of a structural assembly comprising a plurality of the structural components of FIG. 13.

FIG. 15 is a perspective view of a structural component having continuous hinges and including an extensible restraining member.

FIG. 16 is a perspective view of the structural component, shown in FIG. 15, partially closed.

FIG. 17 is a view in elevation of a triangular portion of the structural component shown in FIG. 15.

FIG. 18 is a fragmentary view in elevation of a hinged joint for single skin components.

FIG. 19 is a view in cross section of FIG. 18.

FIG. 20 is a fragmentary view in elevation of a double-hinged joint for single skin components.

FIG. 21 is a view in cross section of FIG. 20.

FIG. 22 is a fragmentary view in elevation of a hinged joint for double skin components.

FIG. 23 is a view in cross section of FIG. 22.

DETAILED DESCRIPTION

FIG. 1 shows the basic structural component which is obtained by folding a flat quadrilateral plate **40** which is generally, but not necessarily, a rhombus or diamond, along its longer diagonal **41**, thereby creating a dihedral angle **42**, which is enclosed by two identical triangular portions **43** of the component, each triangular portion **43** having free edges **44**. The quadrilateral plate is of foldable construction which means that the dihedral angle **42** can be readily altered. To maintain the fold angle at a desired degree, a transverse restraining member **45**, generally in the form of a tie rod, is secured to the apices **46** of the triangular portions **43** which lie outside of the fold line **41**. The folded quadrilateral plate member **40** and the transverse restraining member **45** connected together comprise the erected basic structural component of this invention.

FIG. 1 also shows the basic component's principle dimensions A, B, C, D and angles α, β, and γ. The relation of these dimensions and angles to each other is a function of selected Nv and Nh geometries and the formulae which express this relationship can be found in my aforementioned U.S. Pat. No. 3,557,501. The significant improvement that the present invention makes is that structural assemblies of folded quadrilateral components formed from identical structural elements are no longer limited to a single Nv or Nh system.

FIGS. 2 through 5 show, by way of illustration, four of the geometrically unlimited varieties of structural assemblies that can be made using foldable plate members **40** which are identical but for their transverse restraining members **45** having a variable length. In the illustrations the two isosceles triangular portions of the foldable quadrilateral plate members **40** have acute angles $\gamma = 30°$.

Setting first the length of the transverse restraining member **45***a* shown in FIG. **2***a* at C = 0.54A we get an arched structure in the Nv = 8 system as better illustrated in FIG. **2.** By reducing the length of the restraining member **45***b* shown in FIG. **3***a* to C = 0.51A the same components can be assembled into the Nv = 6 structure illustrated in FIG. **3.** To build the Nv = 4 structure of FIG. **4,** the length of the restraining member **45***c* shown in FIG. **4***a* should be set at C = 0.4A. These are but a few examples of the many variations possible with the component of the present invention.

Only even numbers are used in the foregoing examples for Nv to assure the verticality of the wall portions of the structures. As shown in FIG. **5,** the Nv = 3 assembly of the same foldable plate members **40** does not have vertical walls. Furthermore, because of the $\gamma = 30°$ angle, this assembly in the Nv = 3 formation has a fold angle B = 0° or conversely when the assembly has been completely flattened the assembly is in the Nv = 3 formation. This flattened condition is suitable for shipping or storage when the components' light weight permits the handling of the structure as a preassembled unit.

Owing to the foldable components of this invention, it is not only possible to vary Nv from structure to structure, but the Nv can even vary within a single structure. Such a structure can be built over a curved ground plan, as seen in FIG. **6.** The cross section of the same structure, shown in FIG. **7,** clearly illustrates the transition from Nv = 4 at one support to Nv = 8 at the other. By removing the inclined and vertical components from the Nv = 8 side, we can obtain a cantilevered canopy structure, which is very efficient because of the gradual increase of its structural depth away from the free end of the overhang.

In the structures of the preceeding examples, the components of some rows are in identical fold positions relative to an adjacent row while in others they are reversed. FIG. **8** shows a flat sawtooth roof in which every row of components has been reversed relative to its two adjacent rows. Structures of this type should be constructed with a depth designed in accordance with the given span and loading for maximum material efficiency and control of deflections. This requirement can be readily met with folded quadrilateral components of the present invention having a variable fold angle which can be set to provide the desired structural depth. FIG. **9** illustrates the inverse relationship between fold angle and structural depth in a structure such as that shown in FIG. **8.**

Components having a variable fold angle also permit the periodic opening and closing of roof or wall portions of the structural assembly. Such a structure is shown in FIG. **10.** A two component wide part of this structure is built as an Nv = 4 frame, to provide stability, while in the rest of the structure the roof and wall portions can be independently retracted. The frame portion of the structure is rigidized by tie bars **47** while the retractable portions utilize cables **48** as transverse restraining means. When a cable is used as a transversal restraining member, it may be a permanently affixed part of the component, using turnbuckles, loops or other suitable means to vary its length. Such components may be advantageously used in all structures which have uniform loading and are continuously supported. The transversal half **49** and longitudinal half **50** components which are used at base and wall connections as well as around openings in FIG. **10,** are exact

halves of the full-size folded quadrilateral plate member **40** and therefore do not represent a different component type. However, at the junction of the retractable wall and roof portions and at the top of the gates, hinged triangular infill panels **51** may be advantageously employed with a suitable sliding mechanism to facilitate opening and closing the structure.

Although identical foldable quadrilateral plate components can be used in various Nv and Nh combinations, the preferred ones are those which can achieve maximum spatial versatility with a minimum number of different tie bar lengths. A combination of Nv = 4 and Nh = 8 was used in the structure of FIG. **11** which has, in spite of its complex shape, only two different tie bar lengths. The shorter tie bars **52** hold a $\beta = 90°$ fold angle while the longer tie bars **53** maintain a $\beta = 135°$ fold angle. Of course, the identical folded quadrilateral plate members **40** can be used in any radial structure if that is not combined with a parallel structure, i.e., if it comprises a complete star assembly at its center. For instance, the dome-like roof of the smaller structure in the foreground of FIG. **11,** which is connected to the main part of the structure through a covered walkway, has a star assembly comprising eight components, while the smaller extension tower shown connected directly to the left side of the main structure has a star assembly comprising only four components.

The primary purpose of FIG. **11** is to show an example of the many structural variations which are possible with identical foldable quadrilateral components, requiring only two different length settings for the restraining members. The more different restraining member lengths are used, the closer the possible assembly variations approach infinity. FIG. **11** also illustrates the other two features, which besides the variable fold angle also contribute to this versatility. These features are the reversibility of fold angles, which accounts for flat or curved surfaces, and the optional fold line positions, i.e., the fold lines of adjoining components being either parallel or intersecting or in skewed position, which accounts for parallel or radial assemblies or combinations of both. Describing the difference between parallel and radial assemblies in terms of the relative positions of the acute and obtuse apices of two components' adjoining triangular portions connecting through a common joint, it can be observed that in parallel assemblies the connections are acute to obtuse, while in radial assemblies the obtuse apex of one of the triangles is contiguous to an acute apex of the other triangle.

The foldable components themselves can either be made of integral, homogeneous sheet materials which incorporate integral hinge means by using readily bendable or foldable along diagonal **41** or they may be formed of discrete triangular portions **43, 43** which have mechanical or plastic hinge means interposed between them. FIG. **12** shows a component unit which may be formed of a relatively thin, foldable sheet of metal or plastic, with joint flanges or connecting surface means **54** laterally extending along the four sides of the folded quadrilateral plate member **55.** The transverse restraining member **56** is shown as a folded strip of a similar plate material. These components are connected to identical components by bolts and nuts which are placed into the bolt holes provided in the components' joint flanges **54.** A series of corresponding bolt holes are also provided in the transverse restraining member **56.** Any suitable connection means can be used instead of the bolts and bolt holes. The desired fold angle is obtained by selecting the suitable bolt holes in member **56** to which the flanges **54** of the folded quadrilateral plate member are bolted. In a structural assembly of a plurality of such components, the transverse restraining members **55** will be connected in partially overlapped relation with a fastening element or bolt passing through more than one restraining member.

The component shown in FIG. **13** may be made of sheets of paper, plastic, and the like. The transversal restraining member **57** itself is a quadrilateral folded along its shorter diagonal **58,** and therefore when the folded quadrilateral plate member **59** and the transversal restraining member **57** are secured to each other by gluing, stapling or otherwise connecting their joint flanges **60** and **61** together, the resulting component has the shape of a tetrahedron. The length of fold line **58** of restraining member **57** may be shortened by stapling or adhesive bonding together a folded seam prior to the assembly of the structure. However, if paper or other similarly inexpensive material is used it will be more feasible to provide a different restraining member for each different fold angle. In the completed structure the components' joint flanges **60** and **61** are folded towards the interior, as shown in FIG. **14,** secured together by staples, clips, adhesives, etc. Components similar to those shown in FIGS. **12** and **13** may also be made of nonfoldable sheet materials, using spring steel or a plastic hinge, such as a polypropylene extrusion, along the fold lines. Plastic hinges may also be used in structures assembled in the factory from non-releasably connected components.

FIGS. **15** and **16** show a component in which the quadrilateral plate member comprises two separable triangular portions **62** foldably secured to each other by a series of pin-connected mechanical hinge loops **63.** Similar hinge loops or connecting surface means **63** are provided along the four free joint sides of the component, serving as parts of releasable, foldable, connection means. The assure component interchangeability, it is very important that the identical hinge loops **63** be continuously staggered around the three sides of the triangular plate member **62** and that the end of a hinge loop **63** be located at the precise midpoint of each side of the triangular plate member **62** as shown in FIG. **17.** A form of tie bar for this component type may comprise two separable parts, **64** and **65** each pivotally connected to the apex or obtuse corner of a triangular plate member **62.** The tie bar parts **64** and **65** have a plurality of bolt holes to provide a tie bar of different lengths when its two parts **64** and **65** are secured to each other by one or more bolts, as shown in FIG. **15.** The same component is shown in FIG. **16** partially collapsed.

FIGS. **18** and **19** show a convenient way of forming one type of bolt loops **66** by providing rectangular perforations along the edges of the triangular plate members **62** and then rolling this edge portion over itself and securing the contacting parts by welding, adhesive bonding, riveting, and the like. The hinge pin **67** is shown to be a hollow tube through which a high strength cable **68** may be pulled during assembly of the structure for the purpose of posttensioning.

The hinge loops **66** in FIGS. **18** and **19** are shown to be offset to one side of the triangular plate member in order that the hinged components may be completely collapsed towards that side.

FIGS. 20 and 21 show double joint loops 69 and 70 which allow complete closing of the fold angle towards either side. This type of hinge is also useful as connecting surface means when more than two components are to be connected through one joint, as is the case at internal supports of multispan structures assembled of identical folded quadrilateral components.

Transversal restraining members made of a quadrilateral sheet folded along its shortest diagonal, similar to the restraining member 57 shown in FIG. 13 but having marginal hinge loops instead of flanges, can also be used with components having double joint loops.

Although the component types of FIGS. 12 through 21 are shown as components made of a single sheet of material, they can be readily adapted to use in double skin or sandwich-type construction, comprising two of such folded quadrilateral sheets, which are disposed in a spaced, parallel relation to enclose a suitable insulating or rigidizing core. A different hinged joint or connection surface means for sandwich-type components is shown in FIGS. 22 and 23. Here the external portion of the marginal framing member 71 of the sandwich plate is formed like a trough or channel, of which the flanges are inclined towards each other, to provide a receptacle for the base extension of the hinge loop 72, said base extension having side surfaces inclined to complement the inclination of the said receptacle's flanges, as shown in FIG. 23. The hinge loops 72 may be cut from long extrusions and inserted into their receptacle, to which they are welded, riveted or adhesive bonded at spaced intervals. Similar joint configuration to that in FIGS. 20 and 21 with the hinge loop offset toward either side of the sandwich plate may be employed if the complete closing of the fold angle is desired.

The joints of collapsible structural assemblies made of non-releasably connected foldable quadrilateral components are sealed at the factory. The joints between components assembled at the building site may be sealed by caulking, adhesive tape, elastomeric gaskets and the like. Permanently assembled, non-releasable structures may also receive coatings made of synthetic or cement-base materials, applied in situ for additional protection or increased strength.

I claim:

1. A structural component comprising
a. a first triangular portion having a long straight side extending between two apices and two shorter sides meeting at a third apex,
b. a second triangular portion similar to the first triangular portion having a long straight side extending between a first apex and a second apex and two shorter sides meeting at a third apex,
c. means connecting the long side of the first triangular portion to the long side of the second triangular portion to hold the connected sides in coinciding relation,
d. hinge means included in means (c) whereby the connected triangular portions form a folded plate component in which the fold angle is adjustable,
e. restraining means connected to the first triangular portion in the neighborhood of the third apex, of the first triangular portion and
f. means associated with the second triangular portion in the neighborhood of the third apex of the second triangular portion for coaction with restraining means (e) to hold the first and second triangular portions at a given fold angle to one another against at least some forces tending to alter the angle.

2. The structural component of claim 1 in which
g. means (e) comprises a nonextensible, flexible connection member.

3. The structural component of claim 1 in which
g. means (e) comprises a rigid connection member to hold the first and second triangular portions at a given fold angle to one another against forces tending to increase or decrease the angle.

4. The structural component of claim 1 in which
g. triangular portions (a) and (b) are integrally formed from homogeneous sheet material, and
h. hinge means (d) are bendable portions of the homogeneous sheet material integral with the triangular portions (a) and (b) along the length of the long side of each triangular portion.

5. The structural component of claim 1 in which
g. hinge means (d) comprise hollow members disposed along the long side of each triangular portion and pintle means extending through the hollow members.

6. The structural component of claim 1 in which
g. means (e) include adjustable means for adjustable coaction with means (f) to hold the first and second triangular portions at any one of a plurality of given angles to one another.

7. The structural component of claim 1 in which
g. means (e) and (f) comprise an elongated, rigid structural member having one end portion connected to the first triangular portion in the neighborhood of the third apex and having adjustable means for connection to the second triangular portion in the neighborhood of the third apex.

8. The structural component of claim 7 in which
h. the adjustable means comprise a plurality of fastening elements, and
i. the second triangular portion includes complementary fastening element means for registering with any one of the fastening elements of the adjustable means.

9. A structural component as claimed in claim 1 in which:
g. each free side of each triangular portion has connecting surface means associated therewith,
h. each connecting surface means being structurally complementary to each of the other connecting surface means for connection of contiguous connection surface means of one of a plurality of contiguous corresponding components with a third apex of said structural component contiguous either to a third apex or a first apex of said contiguous corresponding component and with the fold angle of said structural component in either the same or in reversed relation to the fold angle of said contiguous corresponding structural component.

10. A structure comprising a plurality of structural components, each structural component comprising
a. a first triangular portion having a long straight side extending between two apices and two shorter sides meeting at a third apex,
b. a second triangular portion similar to the first triangular portion having a long straight side extending between a first apex and a second apex and two shorter sides meeting at a third apex,
c. means connecting the long side of the first triangular portion to the long side of the second triangular

portion to hold the connected sides in coinciding relation,

d. hinge means included in means (c) whereby the connected triangular portions form a folded plate component in which the fold angle is adjustable,

e. restraining means connected to the first triangular portion in the neighborhood of the third apex of the first triangular portion,

f. means associated with the second triangular portion in the neighborhood of the third apex of the second triangular portion for coaction with restraining means (e) to hold the first and second triangular portions at a given fold angle to one another against at least some forces tending to alter the angle,

g. connecting surface means associated with each free side of each triangular portion,

h. each connecting surface means of each structural component of the structure being structurally complementary to each connecting surface means of each other structural component of the structure for connection of contiguous connection surface means of contiguous structural components of the structure with a third apex of each structural component contiguous either to a third apex or a first apex of a contiguous structural component and with the fold angle of each structural component in either the same or in reversed relation to the fold angle of a contiguous corresponding structural component, and

i. connection means coacting with contiguous connecting surface means (g) of contiguous structural components of the structure to hold all the structural components together.

11. A structure as described in claim **10** in which

j. connection means hold at least some contiguous structural components with third apices of triangular portions contiguous.

12. A structure as described in claim **10** in which

j. connection means hold at least some contiguous structural components with the third apex of one triangular portion of one structural component contiguous to the first apex of one triangular portion of another structural component.

13. A structure as described in claim **10** in which

j. connection means coact with contiguous connecting surface means (g) of adjacent components of the structure to hold all the components together with the folds of all components facing in the same direction.

14. A structure as claimed in claim **13** in which

k. connection means hold at least some contiguous structural components with third apices of triangular portions contiguous.

15. A structure as claimed in claim **13** in which

k. connection means hold at least some contiguous structural components with the third apex of one triangular portion of one structural component contiguous to the first apex of one triangular portion of another structural component.

16. A structure as described in claim **10** in which

j. connection means coact with contiguous connecting surface means (g) of adjacent components of the structure to hold all the components together with the folds of a plurality of the components in reversed fold position relative to the fold position of the other components.

17. A structure as claimed in claim **16** in which

k. connection means hold at least some contiguous structural components with third apices of triangular portions contiguous.

18. A structure as claimed in claim **16** in which

k. connection means hold at least some contiguous structural components with the third apex of one triangular portion of one structural component contiguous to the first apex of one triangular portion of another structural component.

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