Aug. 19, 1969 J. K. HUGHES 3,461,635

BUILDING WALL SECTIONS APPROXIMATING A PREDETERMINED CURVATURE AND METHOD OF MAKING THE SAME

Filed April 26, 1967 5 Sheets-Sheet 1

Fig. 1.

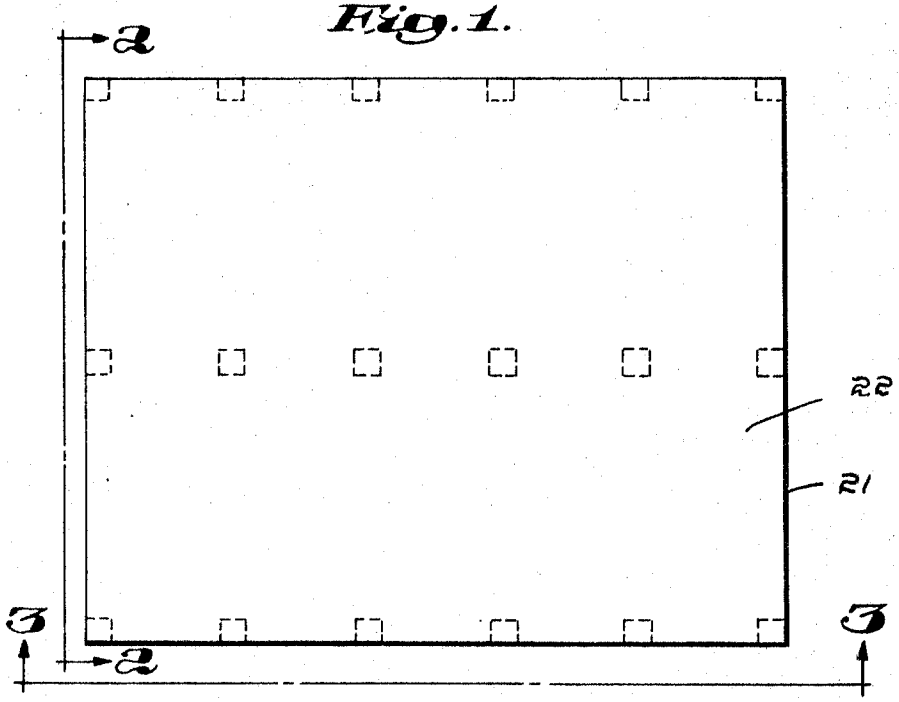



Fig. 2.

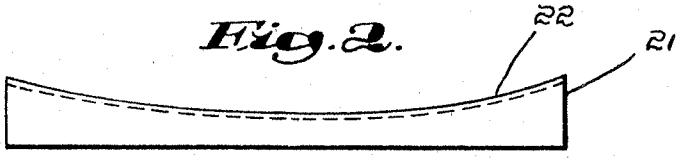
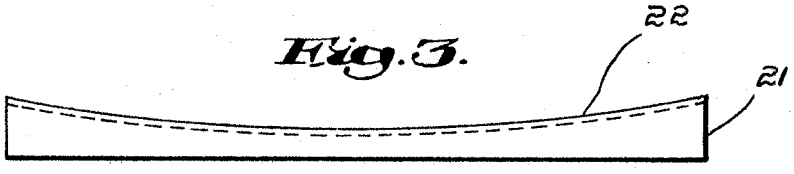



Fig. 3.




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Fig. 4.

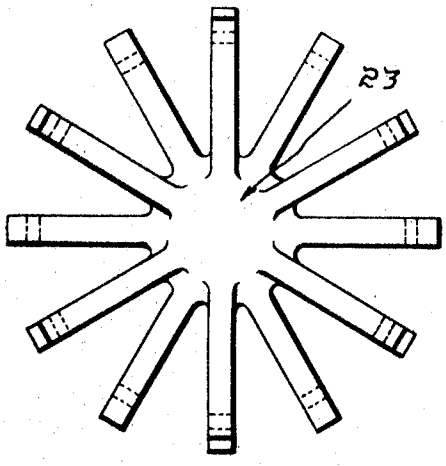



Fig. 6.

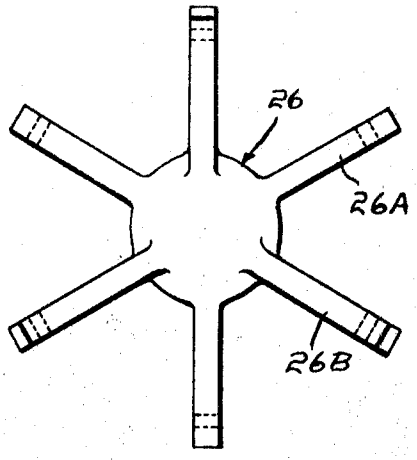



Fig. 5.

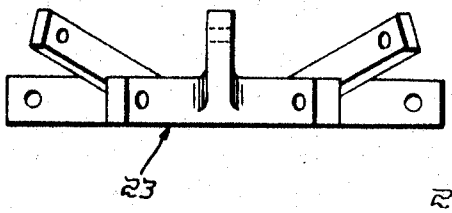



Fig. 7.

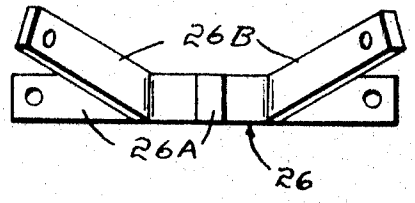



Fig. 8.

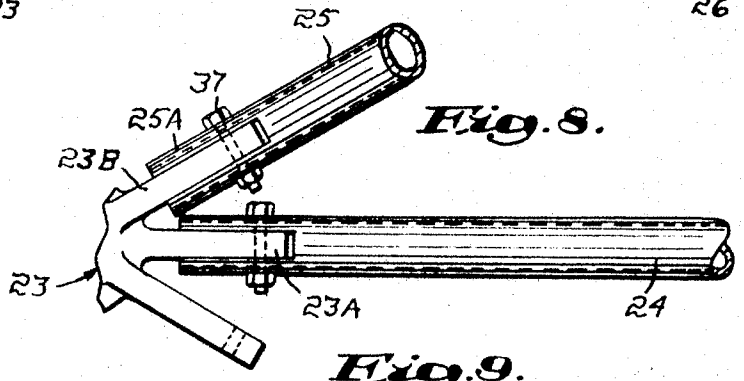



Fig. 9.

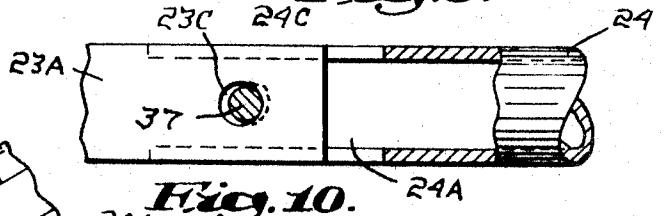
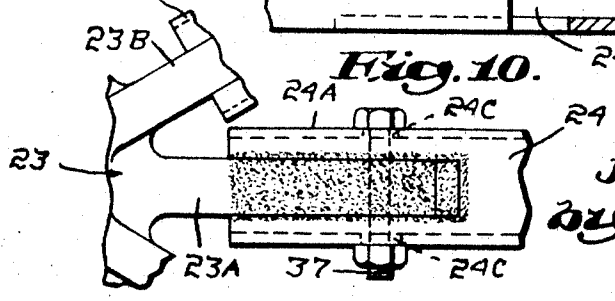


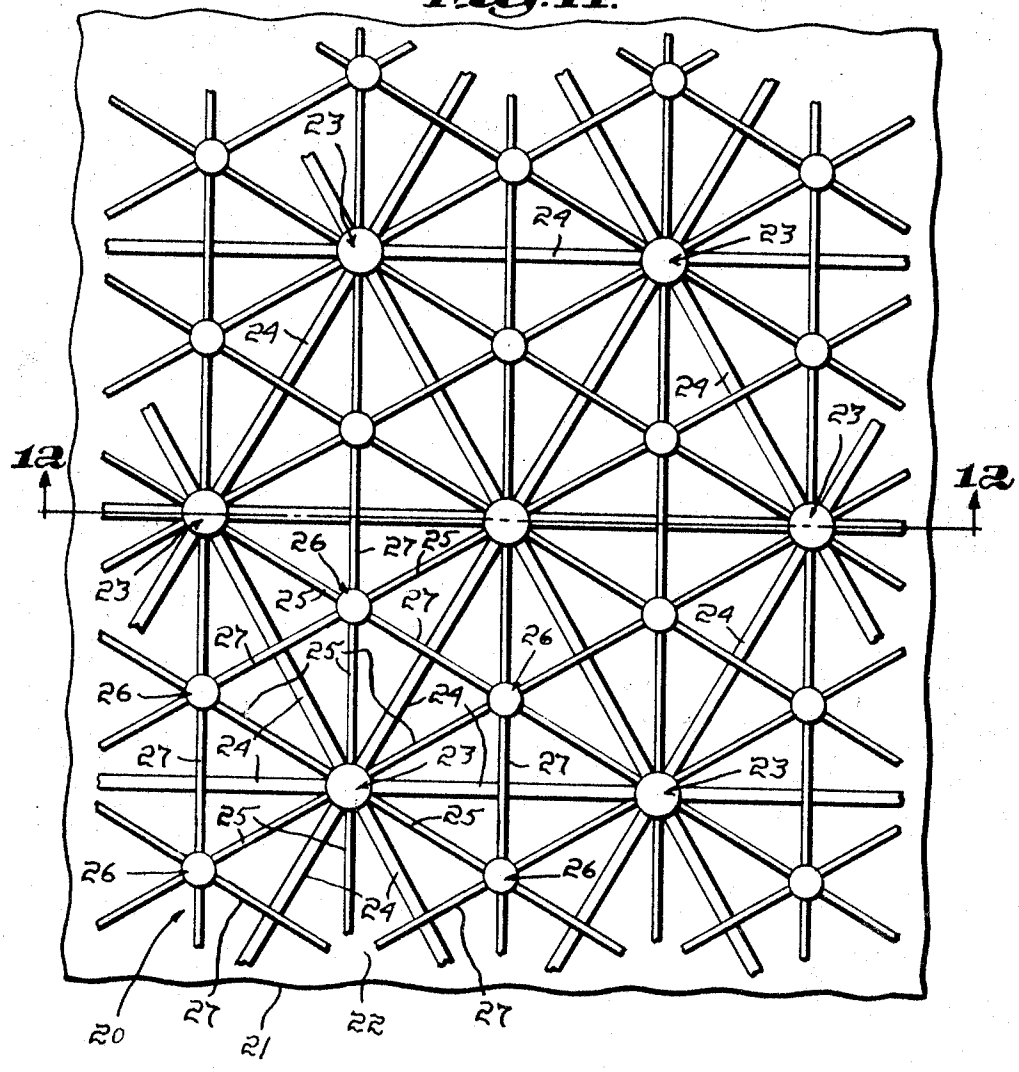

Fig. 10.




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Fig. 11.



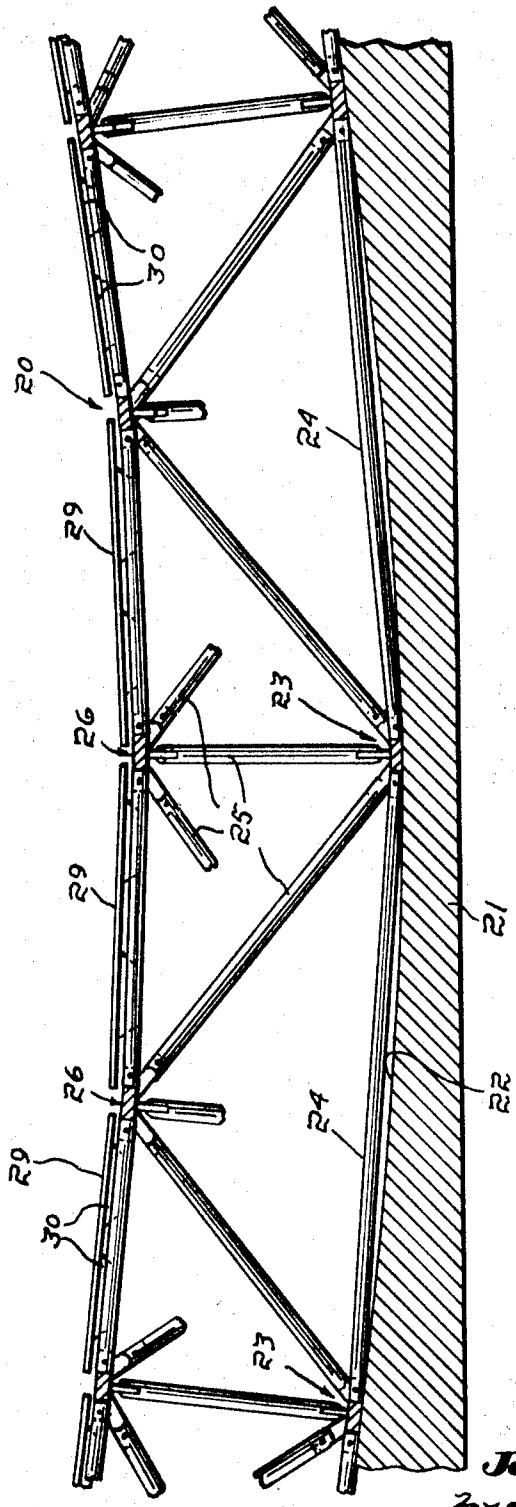

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BUILDING WALL SECTIONS APPROXIMATING A PREDETERMINED CURVATURE AND METHOD OF MAKING THE SAME

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Fig. 12.




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BUILDING WALL SECTIONS APPROXIMATING A PREDETERMINED CURVATURE AND METHOD OF MAKING THE SAME

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Fig. 13.

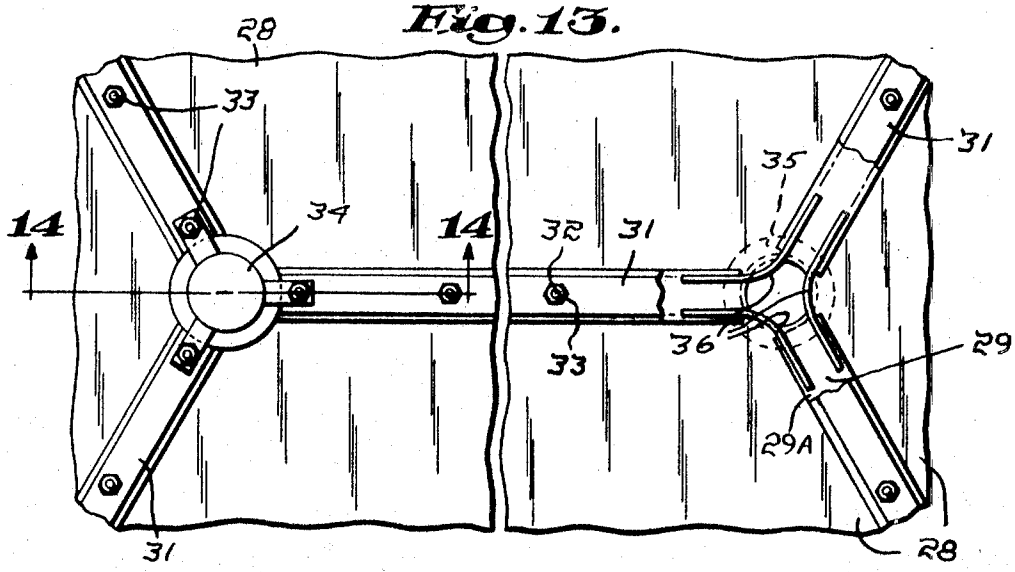



Fig. 14.

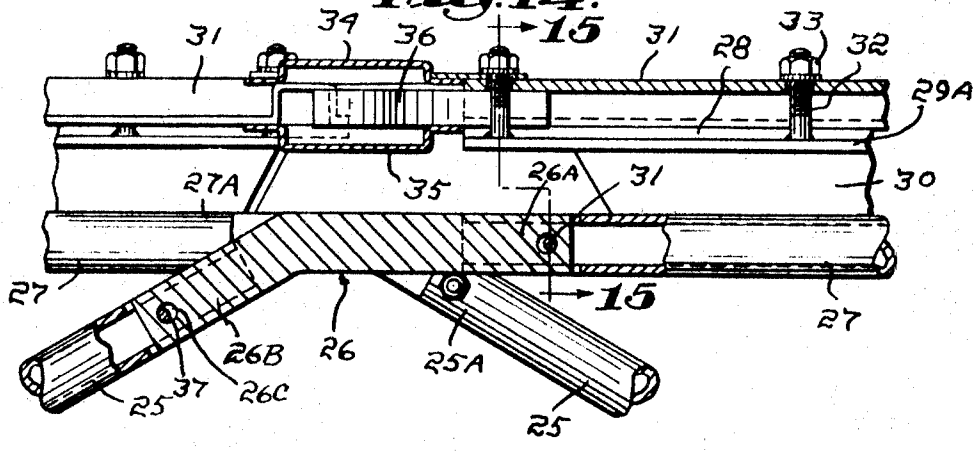
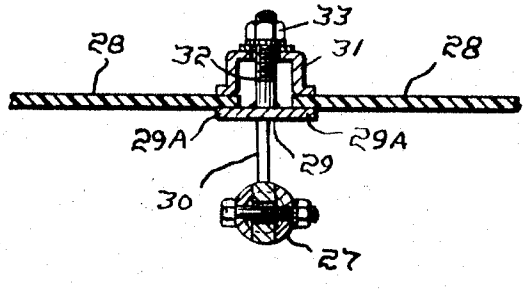



Fig. 15.




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3,461,635

# BUILDING WALL SECTIONS APPROXIMATING A PREDETERMINED CURVATURE AND METHOD OF MAKING THE SAME

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Int. Cl. E04h 12/14, 12/20; E04b 1/04
U.S. Cl. 52—645 9 Claims

## ABSTRACT OF THE DISCLOSURE

Building wall sections and method of making the same, the wall sections comprising polygonal frames that are angularly disposed relative to each other in at least one direction to approximate a predetermined curvature and consisting of hubs and members first loosely connected to ensure that the hubs lie on a theoretical curved surface corresponding to that curvature and then rigidly interconnected.

A type of building that has been proposed has a wall structure consisting of a plurality of polygonal frames angularly interconnected to approximate a sphere. Such structures are disclosed in United States patents.

Buildings of this type merit acceptance for certain purposes but the problem is how to construct them on a practical basis. The general objective of the present invention is to enable such buildings to be accurately erected at a cost that makes their construction costs competitive with those of buildings that are of more conventional shapes. In accordance with the invention, this objective is attained by a wall section construction and method of making it. The wall section comprises at least one wall formed by a plurality of hubs interconnected by a plurality of frame-defining, straight connecter members, the hubs having radial arm portions and the connector members have end portions and the arm and end portions being joined by loose connections that permit angular and axial movements therebetween during the assembly of a section to ensure that the hubs are so positioned as to lie in a theoretical curved surface meeting the curvature requirement of the building's design prior to effecting a rigid connection between the loosely connected end and arm portion. Where the wall section is to include inner and outer walls, both walls are similarly constructed and their hubs have a second series of radial arm portions. A plurality of brace connector members are provided and these have end portions with a loose connection between them and appropriate ones of the second series of radial arm portions of the inner and outer hubs. In accordance with the method, a work surface is provided that corresponds to the theoretical curved surface on which the hubs of a wall are placed with the loose connections ensuring that they do not become displaced as the assembly of a section progresses.

In the accompanying drawings, there is shown an embodiment of the invention illustrating these and other of its objectives, novel features, and advantages.

In the drawings:

FIGURE 1 is a plan view of a work support where the curvature of the building wall calls for a concave jig,

FIGURE 2 is an edge view thereof taken along the indicated lines 2—2 of FIGURE 1,

FIGURE 3 is an edge view of the jig taken approximately along the indicated lines 3—3 of FIGURE 1,

FIGURE 4 is a top plan view of an outer wall hub,

FIGURE 5 is a side view thereof,

FIGURE 6 is a fragmentary top plan view illustrating brace and frame connector members and the loose connection between them and a hub,



FIGURE 7 is a fragmentary section taken lengthwise of the loosely connected end and hub arm portions,

FIGURE 8 is a like view but with the end and arm portions welded together,

FIGURE 9 is a top plan view of an inner hub,

FIGURE 10 is a side view thereof,

FIGURE 11 is a top plan view of a fragment of a wall section assembled on the jig,

FIGURE 12 is a section taken approximately along the indicated lines 12—12 of FIGURE 11,

FIGURE 13 is a fragmentary plan view, on an increased scale, of a wall section with panes secured thereto,

FIGURE 14 is a section, on a further increase of scale taken approximately along the indicated lines 14—14 of FIGURE 13, and

FIGURE 15 is a section taken approximately along the indicated lines 15—15 of FIGURE 14.

In the embodiment of the invention illustrated by the drawings, the building to be erected in accordance therewith is of a spheroidal design, say the design illustrated by the patent to Fuller No. 2,682,235 and is to made in sections, such as the section 20, several of which complete an annulus defining a horizontal wall portion of predetermined height.

The sections of each horizontal portion may vary one from the other to provide such features as entrances while the sections of the different annular portions may and, in some cases, do vary as to dimensions and characteristics of its structural components and geometrical limitations. Each section, however, shares a common curvature requirement imposing precise limits on its construction.

To ensure accuracy in construction, each section 20 is assembled on a jig 21 having a work surface 22 large enough to enable a section 20 to be assembled thereon that usually is as large as available cranes can handle or, if assembly is remote from the building site, as large as transportation facilities permit. The work surface 22 is concave and its radius is that of the sphere which the building approximates.

In the construction of a building section 20, a plurality of hubs, generally indicated at 23 are placed on the work surface 22 and these are interconnected by straight connector members 24 to provide a wall framework characterized by a plurality of frames which are shown as hexagonal. The hubs 23 may best be seen in FIGURES 4 and 5. Other polygonal shapes are contemplated and are, in fact, required in some of the sections.

As both an outer and an inner wall are required in the building wall structure being detailed herein, straight brace connector members 25 are connected to the hubs 23 of the outer wall defined by these and the frame connectors 24. The brace connectors 25 are connected to generally indicated hubs 26 which are interconnected by straight, connector members 27 to provide an inner wall framework shown as having frames of the same shape as but smaller than those of the outer wall. The hubs 26 may best be seen in FIGURES 6 and 7.

In the wall structure shown in the drawings, the outer wall is to remain as open framework while the inner wall is to be completed by frame inserts which are shown as transparent panes 28, see FIGURES 13–15. The panes 28 are mounted on the oppositely disposed seats 29A marginally of mounts 29, the mounts being anchored as at 30 to the connector members 27, each of which is common to two frames. The panes 28 are held against the seats 29A by a U-shaped retainer 31. Each mount 29 has, centrally of its seats, a series of studs 32 which extend through the retainer 31 to enable the retainer to be secured as by nuts 33. At the junction of the mounts and retainers, there are plates 34 and 35 closed as by sealing strip 36.

Such sections, when completed as to a desired length

and width, are hoisted into position and the hubs and connector members of the abutting sections are joined together in a manner subsequently more fully described. It will be appreciated that it is preferred that, along two edges of a section, there will be hubs without protruding connector members and along the other two edges there will be connecting members without hubs. Sections **20** are added to the building in a generally circular manner as the sections of other courses may and usually do differ in various ways, lighter materials and shorter connector members being but typical examples.

It will be appreciated that not only the appearance of the building but also its erection requires that each section be so precisely assembled that all its hubs will lie on a theoretical curved surface, the concave jig surface **22** for example. While in the assembly of each section, each hub **23** initially rests on the surface **22**, the connector members are all straight and long, particularly the connector members **24**, small errors in their dimensions or in their connections with the hubs can cause hub displacement with resulting error that would become larger as the erection of the wall structure progressed. The problem is, of course, much more difficult to cope with in double walls than in the case of a single wall. It is also more serious as the number of connector members attached to a hub increase.

In the illustrative embodiment of the invention and as may be seen in FIGURE 11, there are six outer frame connector members **24** attached radially to each hub **23** and there are also six brace connector members **25** attached thereto and extending angularly away from the frames defined by the members **24** towards the inner framework with each brace connector member **25** being postioned between two outer frame connector members **24**. Each hub **26** has three inner frame connector members **27** and three brace connecting members **25** connected thereto and the polygon defined by the connector members **27** and the hubs **26** to which the brace members **25** of one outer hub **23** are connected has that hub at its center and has the sides intersected by appropriate ones of the outer frame connector members **24**.

In accordance with the invention, assembly errors are avoided without imposing impractical requirements on the production of the various connector members and hubs by first loosely joining the hubs and connector members in a manner permitting limited axial and pivotal movement between them and then rigidly interconnecting them, when the assembly has progressed suitably, with their hubs on the work surface **23**.

This result is attained by providing each hub with a first and second set of radial arm portions, the arm portions of the two sets being indicated by suffix additions "A" and "B", respectively, to the reference numeral for the appropriate hub, see FIGURES 4 and 5 for the hub **23** and FIGURES 6 and 7 for the hub **26**. The arm portions A of each hub are in the same plane and the arm portions B extend at an acute angle away from that plane. Each connector member has end portions indicated by the suffix addition "A" to the reference numeral therefor, see FIGURES 8, 9, and 10. In the assembly, the end and arm portions to be interconnected overlap to permit them to be interconnected as by a bolt **37**. For this purpose the end and arm portions to be interconnected have holes indicated by the suffix addition "C" added to the appropriate reference numerals and at least one and desirably both are oversized relative to the bolts **37** to permit the initially desirable pivotal and axial relative movement when the assembly of a section progresses sufficiently to ensure that the hubs **23** of the assembly as thus completed are then on the surface **22**.

The connector members may conveniently be steel tubing and thus end portions established as forks by slotting the tubing. The arm portions of the hubs are desirably lugs of oblong section and the overlapping portions are of such extent that sufficient surface is provided for an effective weld in any adjusted position of the loosely connected portions. It should be noted here that any other means for effecting a connection may be employed. For example, bolted connections can be used relying on one or more bolts. It will also be noted that the lugs, the hub arm portions, are so disposed that the end portions of the connector members may be fited in place with their movement being in generally radial directions.



When a section **20** is completed, it is hoisted into its approximate position and then fitted in place in the wall structure. The hub and connector members of abutting sections are then interconnected and the connections rendered rigid.

In the foregoing description, it has been assumed that the panes **28** were added to each section as it was formed. The panes **28** may, of course, be added after the section has been incorporated into the building wall and the procedure followed depends on various conditions. The wall structure may have either inner or outer frames and where, as shown, it contains both, the panes **28** may be added to either or both.

I claim:

**1.** A wall section for use in erecting the wall structure of a building of the type in which polygonal frames are angularly disposed relative to each other in at least one direction to approximate a predetermined curvature, said wall section comprising a plurality of hubs each hub including a plurality of radial arm portions, a plurality of straight frame members, each frame member including end portions, and a loose connection between each end portion of the frame members and appropriate one of the arm portions permitting angular and axial movement therebetween during the assembly of said section to ensure that said hubs are positioned to lie in a theoretical curved surface meeting said curvature requirement prior to effecting a rigid connection between said loosely connected end and arm portions, the loosely connected end portions of each connection overlapping one another, and each connection including a pivot, the overlapping portions having pivot-receiving holes, the holes of at least one of the overlapping portions being oversized relative to the pivot, and each overlap providing interengaged surfaces exposed lengthwise of the overlap for an effective weld in any adjusted position of the loosely connected portions.

**2.** The wall section of claim **1** in which the frame members are tubular and the end portions of the frame members are open-ended slots and the arm portions are oblong in cross section with their long dimension approximately equal to the diameter of the frame members and their short dimensions such as to fit the slots.

**3.** The wall section of claim **1** in which the curvature is two directional.

**4.** A wall section for use in erecting the wall structure of a building of the type in which polygonal frames are angularly disposed relative to each other in at least one direction to approximate a predetermined curvature, said wall section comprising a plurality of inner and outer hubs, a plurality of straight inner and outer frame members, a plurality of straight brace members, each hub including a first and second series of radial arm portions, each member including end portions, a loose connection between the end portions of the outer frame members and the arm portions of the first series of the outer hubs thus to provide an outer wall, a loose connection between the end portions of the inner frame members and the arm portions of the first series of the inner hubs, thus to provide an inner wall, and a loose connection between the end portions of the brace members and the appropriate ones of the arm portions of the second series of the inner and outer hubs thus to space said inner and outer walls apart, said loose connections permitting limited angular and axial movement between the connected portions during the assembly of said section to ensure that said hubs are positioned to lie on a theoretical curved surface meeting said

curvature requirement prior to effecting a rigid connection between said loosely connected arm and end portions, the loosely connected end portions of each connection overlapping one another, and each connection including a pivot, the overlapping portions having pivot-receiving holes, the holes of at least one of the overlapping portions being oversized relative to the pivot, and each overlap providing interengaged surfaces exposed lengthwise of the overlap for an effective weld in any adjusted position of the loosely connected portions.

5. The wall section of claim 4 in which the frame members are tubular and the end portions of the frame members are open-ended slots and the arm portions are oblong in cross section with their long dimension approximately equal to the diameter of the frame members and their short dimensions such as to fit the slots.

6. The wall section of claim 4 in which the curvature is two directional.

7. In the construction of a wall section of a wall structure of a building of the type in which polygonal frames are angularly disposed relative to each other in at least one direction to approximate a predetermined curvature, the steps of providing a work surface establishing said curvature, joining straight frame members and hubs on said surface with a loose overlap between them to provide said section with each hub resting on said surface with the frame members free to pivot and move axially with respect to any hub to which they are loosely joined and providing exposed weld surfaces substantially coextensive with the overlap, and then welding the overlap after the assembly of the hubs and members of the sections has fixed their relationship.

8. In the construction of a wall section of a wall structure of a building of the type in which polygonal frames are angularly disposed relative to each other in at least one direction to approximate a predetermined curvature, the steps of providing a work surface establishing said curvature, loosely joining straight first frame members and



first hubs on said surface with a loose overlap between them to provide a first wall of the section, loosely joining second straight frame members and second hubs with a loose overlap between them to provide a second wall of the section and interconnecting the hubs of the two walls with brace members with a loose overlap between them to space the two walls apart, the frame and brace members free to pivot and move axially with respect to any hub to which they are loosely joined and providing exposed weld surfaces substantially coextensive with the overlap and welding said overlaps after the assembly of the hubs and members of the section on said surfaces has fixed their relationship.

9. A hub for use in joining connectors in a wall construction of the type having polygonal frames angularly disposed relative to each other to approximate a predetermined curvature, said hubs including a central part, a series of radial arms lying in the same plane, a second series of radial arms extending away from the plane of the first arms, each arm of the second series is located between two arms of the first series, each arm of both series being approximately oblong is cross section with its long dimension at right angles to said plane.

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U.S. Cl. X.R.

52—648