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J. C. HAIN

2,238,111

PREFABRICATED BUILDING CONSTRUCTION

Filed April 27, 1938

3 Sheets-Sheet 1

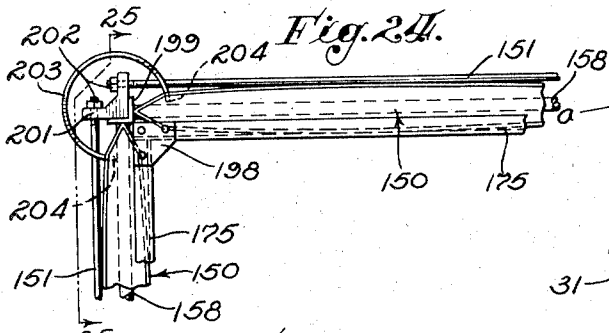


Fig. 24.

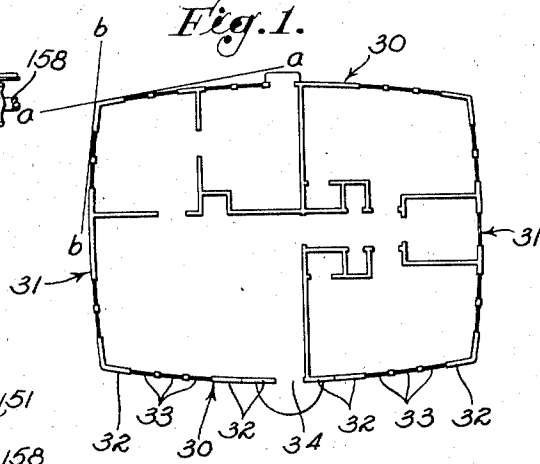


Fig. 1.

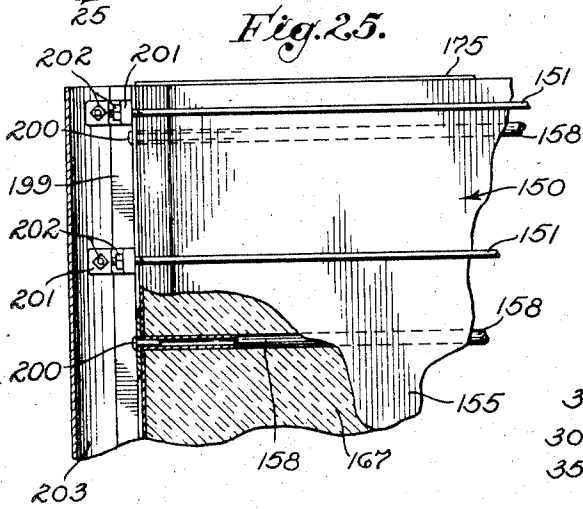


Fig. 25.

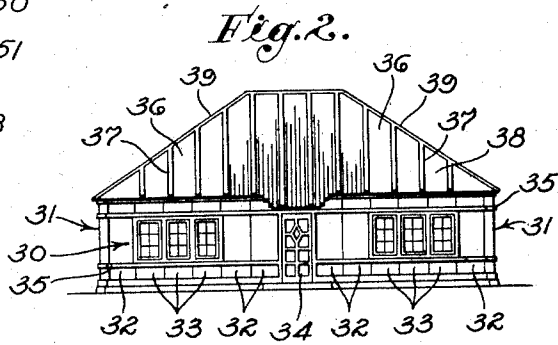


Fig. 2.

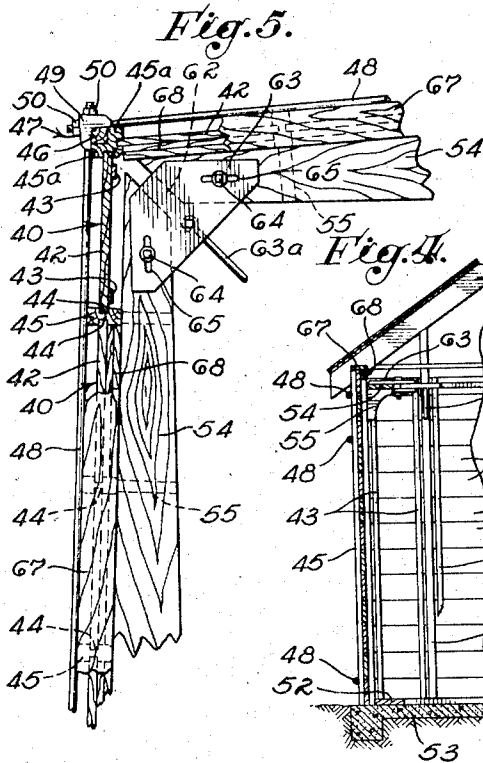


Fig. 5.

Fig. 4.

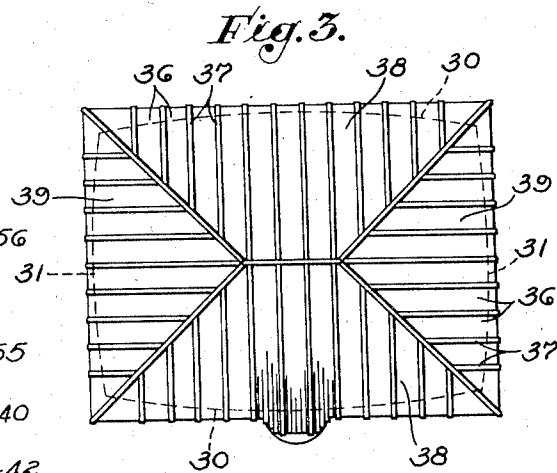


Fig. 3.

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Fig. 10.

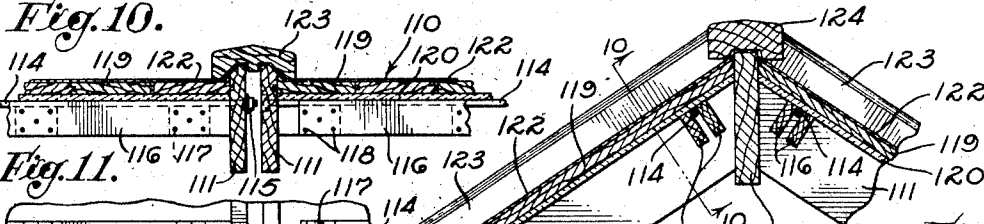


Fig. 11.

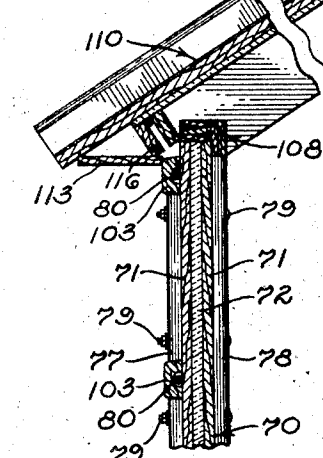
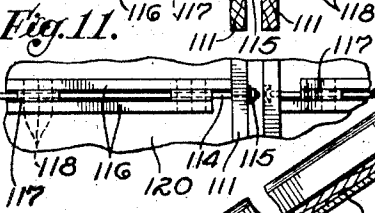


Fig. 6.

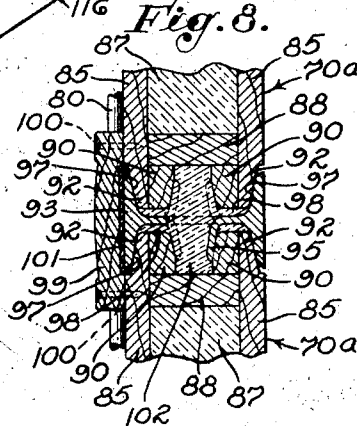


Fig. 8.

Fig. 7.

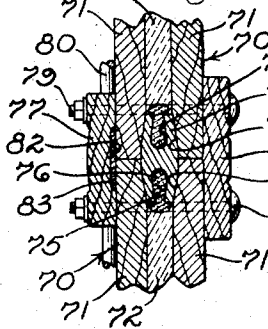


Fig. 9.

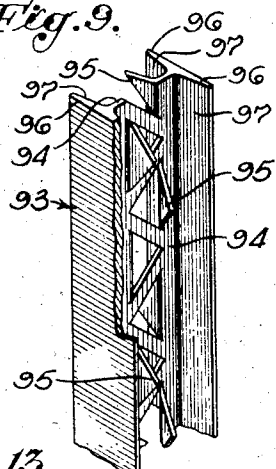


Fig. 15.

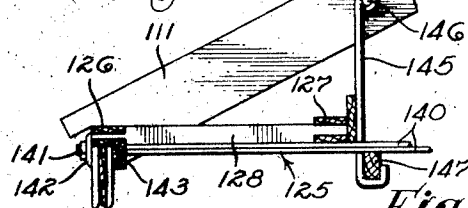


Fig. 12.

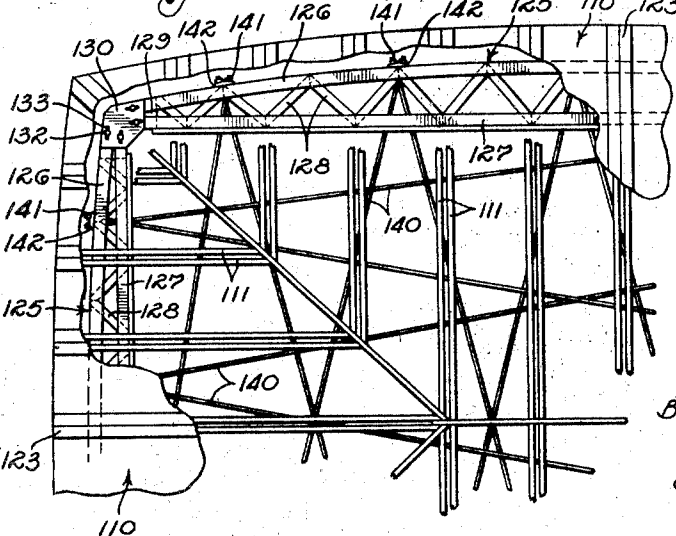


Fig. 13.

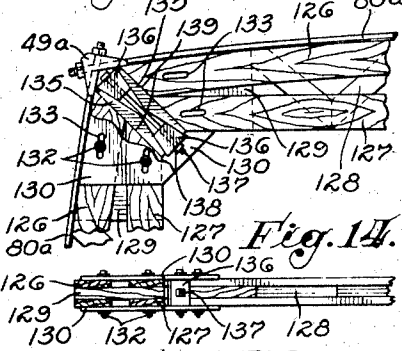
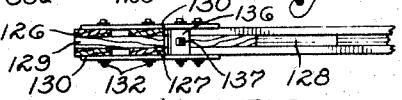


Fig. 14.

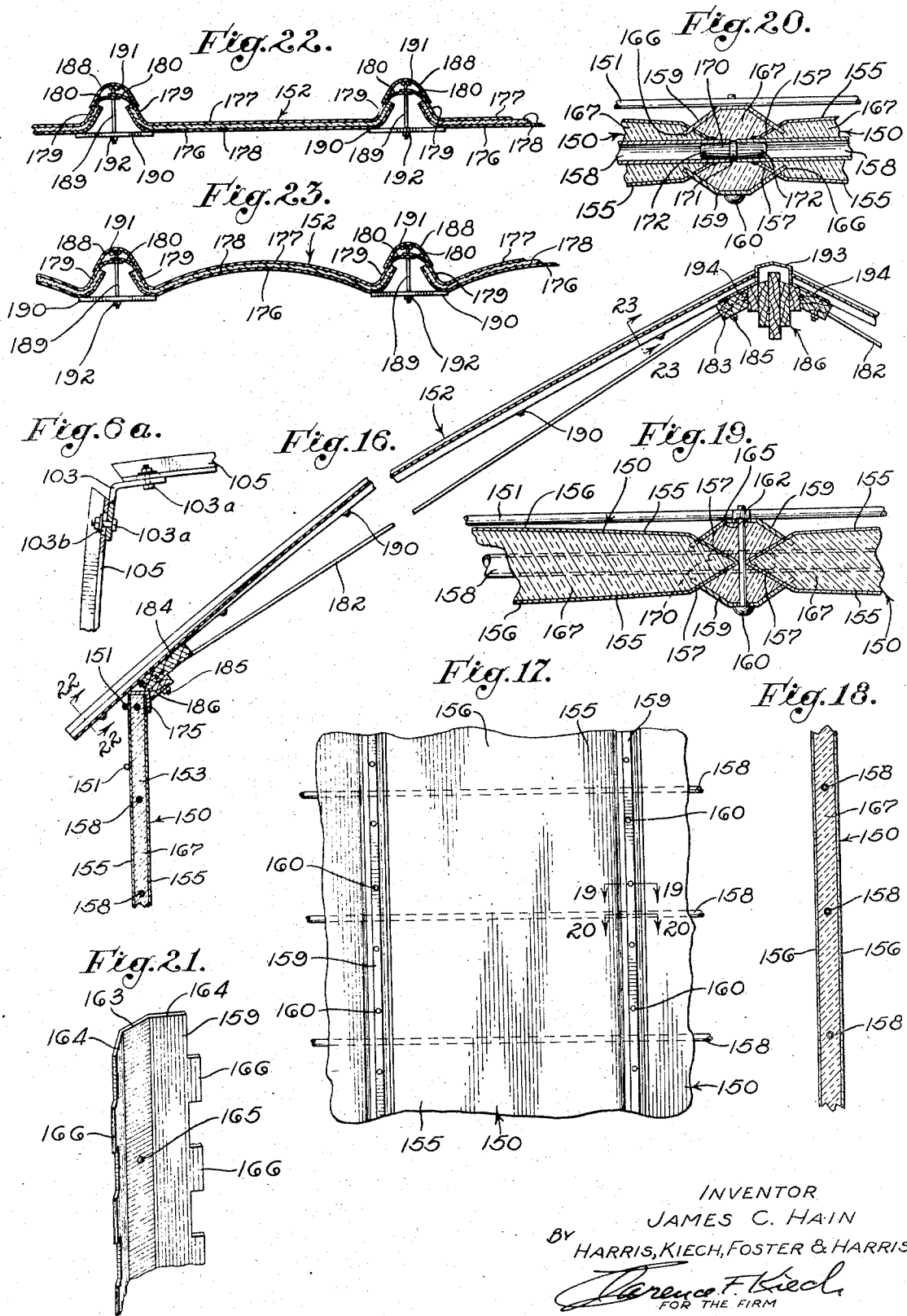


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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,238,111

PREFABRICATED BUILDING CONSTRUCTION

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Application April 27, 1938, Serial No. 204,575

9 Claims. (Cl. 20—1)

My invention relates to buildings with particular reference to prefabricated structures.

The general object of my invention is to provide a relatively inexpensive but efficient and durable building of prefabricated construction that may be readily assembled or dismantled.

One of the important objects of my invention is to achieve strength and rigidity with economical employment of material by incorporating in the construction of the side walls of a polygonal building the principle of an arch. I propose to construct a substantially rectangular building, or building of other polygonal configuration, in which are attained the advantages heretofore inseparably associated with completely circular walls. More specifically, it is my purpose to employ in polygonal buildings walls of hoop-and-stave construction in which the staves are prefabricated panels held in place by means in tension exerting contractive force on the walls. By mass production such panels may be economically produced. A feature of my invention is the conception that such panels may be of width to accommodate complete factory-installed doors and windows.

A further object in mind is to extend the panel principle to other parts of the building with particular reference to the roof, whereby the whole building may comprise factory-made elements adapted to be assembled entirely by semi-skilled labor.

Another object of my invention is to provide a polygonal configuration in plan for a building that will permit a tension means encircling the building to press inwardly throughout the whole periphery of the building including the building corners.

A further object is to provide a stave-and-hoop construction that may be readily tightened to take up shrinkage as required.

One object of my invention is to provide a building construction with minimum framing either in the walls or in the roof construction by designing the walls to be self-supporting and additionally to withstand lateral roof stresses.

A further object in mind is to provide in a hoop-and-stave construction compression members to transmit stresses from one side of the building to an arcuate wall on the opposite side of the building.

The above and other objects of my invention including objects relating to various unique panel constructions will be apparent in my detailed description to follow, considered with the accompanying drawings.

In the drawings:

Fig. 1 is a plan view of a substantially rectangular building with arcuate walls;

Fig. 2 is a side elevation of the same building;

Fig. 3 is a top view of the completed building;

Fig. 4 is a fragmentary vertical section of a simplified and relatively inexpensive embodiment of my invention;

Fig. 5 is a top view somewhat enlarged of a corner of the building shown in Fig. 4, the roof being removed to reveal the wall construction;

Fig. 6 is a transverse section of one-half of a building incorporating a more elaborate form of my invention;

Fig. 6a is a fragmentary plan view of an adjustable joint for floor angles;

Fig. 7 is an enlarged fragmentary horizontal section of a panel joint that may be incorporated in the wall of Fig. 7;

Fig. 8 is a similar view of a second panel construction;

Fig. 9 is a perspective view of a metal stud employed in the panel joint shown in Fig. 8;

Fig. 10 is a section through the roof taken as indicated by the line 10—10 of Fig. 6;

Fig. 11 is a bottom view of the section shown in Fig. 10;

Fig. 12 is a top view of a portion of a building with the roof broken away to show how horizontally disposed trusses may be incorporated in the building construction shown in Fig. 6;

Fig. 13 is a top view on an enlarged scale of a joint between two adjacent trusses in Fig. 12;

Fig. 14 is a side elevation of the structure shown in Fig. 13 with the hoops removed;

Fig. 15 is a fragmentary section showing how a truss of Fig. 12 may be supported from the roof;

Fig. 16 is a fragmentary transverse section of a metal building constructed of panels in accordance with my invention;

Fig. 17 is a fragmentary side elevation somewhat enlarged of the wall in Fig. 16;

Fig. 18 is a transverse section through the wall of Fig. 17;

Fig. 19 is a transverse section through a panel joint taken as indicated by the line 19—19 of Fig. 17;

Fig. 20 is a similar section taken along the line 20—20 of Fig. 17;

Fig. 21 is a perspective view of a joint member employed in Figs. 19 and 20;

Fig. 22 is a section through the metal roof of Fig. 16 taken as indicated by the line 22—22;

Fig. 23 is a similar section taken along the line 23—23 of Fig. 16;

Fig. 24 is a top view on a somewhat enlarged scale of a corner of the side walls in Fig. 16, the roof being removed; and

Fig. 25 is a section through the corner of the building taken as indicated by the broken line 25—25 of Fig. 24.

The building shown in Figs. 1 to 2 is rectangular in general configuration, the walls meeting at junctures corresponding to the corners of a rectangle, but the two side walls 30 and the two end walls 31 are arcuate in plan, each wall curving outward. The walls of the building are constructed on the hoop-and-stave principle, the stave elements being panels preferably wide enough for each panel to accommodate either a complete door or complete window installation. Thus, a side wall 30 in Fig. 1 may comprise from end-to-end, by way of example, a blank panel 32, three successive window panels 33, two successive blank panels 32, a door panel 34, two successive blank panels 32, three successive window panels 33, and a final blank panel 32. These panels are confined by tension members or hoop means encircling the building, the hoops being, by preference, concealed by horizontal members 35. Under the contractive force exerted by the hoop means, the arcuate series of panels become, in effect, a unitary rigid wall in the same manner as the staves in a barrel.

This application of the principle of an arch to building walls results in economy of material and makes it possible to construct walls from factory-produced panels. The windows in the window panels 33 and the door in the panel 34 may be completely installed in the factory production of the panel.

The roof of the building shown in Figs. 1 to 3 may also be of panel construction as will be specifically described later. At this point it is sufficient to note that the roof panels 36 are interconnected by cap strips 37 and are arranged to provide two roof slopes 38 at the side of the building and two end slopes 39.

One of the simplest constructions for a building embodying the principles of my invention is indicated by Figs. 4 and 5. This construction is suitable for garages and minimum cost dwellings. Each of the panels 40 of Figs. 4 and 5 comprises a series of horizontal boards 42 preferably held together before the building is assembled by suitable means such as vertical strips 43. In the assembled building the vertical edges of each of the panels 40 seats in a complementary groove 44 in a vertical stud or joint member 45. At each corner of the building a pair of studs 45a and an additional member 46 are assembled to form a corner post generally designated 47.

The hoop means having cooperation with the series of panels 40 may comprise a continuous series of tension members 48 in the form of rods along each side of the building, the rods being interconnected or anchored to common means at the corners of the building. As shown in Fig. 5, each pair of adjacent rods 48 in a series extending around the building may simply extend through a corner casting 49 and be provided with nuts 50 for adjustable engagement with the casting.

The hoops or tension members 48 press the panels inward against suitable arcuate stiffeners or compression members at the top and bottom of the wall that determine the wall curvature. At the bottom of the wall, the panels may, for example, as shown in Fig. 4, rest against an arcu-

ate strip 52 anchored to the cement floor 53. At the top of the wall the inward pressure of the panels is resisted by a stiffener in the form of a horizontal truss member 54, each of these truss members being held in horizontal position by suitable means such as one or more brackets 55, each bracket being mounted on one of the studs 45.

It will be noted that in such a construction the tension of each of the tension members 48 is distributed in part as compression in the corresponding side wall, in part as lateral pressure against that side wall, and in part as tension in the tension members of the adjacent side walls.

A feature of my invention is the conception of interconnecting the truss members 54 at the corners of the building in an adjustable manner to permit contraction of the assembled series of truss members whenever it is desired to tighten the hoop members 48 to take up shrinkage in the wall of the building and to keep the arched series of wall panels under pressure. To permit such contraction the truss members 54, as well as the strips 67 and 68 at the top of the wall, are of such length as to provide gaps 62 at the corners of the building, a horizontally disposed corner plate 63 bridging at each gap. Each corner plate is adjustably connected with its associated truss members 54 by suitable bolt means 64 extending through complementary slots 65 in the plate. To take up shrinkage, it is merely necessary to loosen the bolt means 64 temporarily and to tighten up the nuts 50. The rigidity of these corners is maintained by properly tightening the bolt means 64. For further rigidity, diagonally opposite plates 63 may be interconnected by diagonal tie rods 63a, as indicated in Fig. 5.

It is contemplated that the side walls of the building will be sufficiently strong not only to withstand normal wind stresses and the like, but also to take care of the roof thrust, the roof being supported directly by the walls. To provide a suitable footing for the roof rafters 56, a suitable horizontal strip 67 of arcuate configuration is laid along the top edge of the wall. Preferably, this strip is reinforced by cooperating pairs of strips 68 mounted on the top board of each panel along the inner face of the panel. The top strip 67 stops short of the corner posts 47 of the building to permit the contractual adjustment described. The rafters at each corner of the building may rest directly on the corner posts 47.

A building having the construction indicated by Figs. 4 and 5 may be assembled by the following procedure. First, the arcuate strip 52 is anchored to the floor 53 and then the horizontal trusses 54 are mounted on temporary supports in approximately the disposition desired in the finished structure. The horizontal trusses 54 are then interconnected by the corner plates 63, and the bolts 64 are tightened with substantial spacing between the ends of adjacent truss members. The panels 40 are arranged along the truss members and temporarily supported in engagement with grooves of the studs 45. Preferably before such engagement the grooves of the studs are liberally supplied with suitable mastic to provide waterproof joints. The means for temporarily supporting the studs in upright position may comprise simply ropes drawn taut against the building wall. When the various panel studs and corner posts are in approximately the positions desired, the rods 48 and the corner castings 49 are assembled and tightened to the desired degree of contraction. The contractual pressure of the

hoop members against the building walls draws the various panels into a unitary structure and compresses the mastic at the joints into waterproof seals. The brackets 55 are then installed to provide permanent support for the trusses 54. Finally, the strips 67 are attached to the top edge of the various side walls for the support of the roof.

While a panel roof is preferred, it will be understood that any type of roof may be employed. The side and end walls of Fig. 1 have greater curvature in plan than circles of diameters equal to the building dimensions normal to those walls. Appreciable curvature is necessary and the greater the curvature, the less material required for given strength. Excessive curvature is not necessary, however, and the rectangular configuration of conventional houses may be substantially retained. For ordinary single family dwellings, I contemplate using walls having radii between 100 and 200 feet long.

The configuration of the building is such that the hoops surrounding the building press inwardly in effective manner at all points including the corners. A feature of my invention is the conception that the required cooperation between the hoop means and all of the panels in the side walls of a building may be achieved so long as the side walls curve outwardly at all points and so long as the curvature of any wall section does not exceed the tangents of the adjacent wall sections. Thus, in Fig. 1, lines *a-a* and *b-b* are tangents of wall sections adjacent the corner of the building. It will be noted that neither wall crosses the tangent of the adjacent wall. So long as the principle indicated by reference to these tangents is kept in mind, the general configuration of a building embodying my concept may be widely varied. The same principle may be expressed by stating that the curvatures of the walls must never be so great as to cause the building configuration to be indented or reentrant at the wall junctures. What may be termed "outwardly bulging" building corners are necessary to permit the hoops to act against the ends of the walls, just as any arch must be anchored at its ends. If the corners are reentrant rather than bulging, tension in the hoops may actually cause collapse of a building of hoop-and-stave construction.

A more substantial wooden construction for an embodiment of my invention is suggested by Fig. 6. Each of the panels 70 is of multiple-ply construction comprising two outer plies 71 of wood and an intermediate layer 72, preferably of suitable heat-insulating material. It is contemplated that the panels 70 will be interlocked at adjacent edges, for example by tongue-and-groove engagement.

One form of joint construction that may be employed for interlocking the two panels 70 is shown in Fig. 7. At each of the side edges of the panel the intermediate layer 72 stops short of the outer plies 71 to form a groove 73, the plies being cut away by preference to give the groove a tapered cross-sectional configuration. A suitable tongue member 74 fills the space formed by opposed grooves to two adjacent channels. Since I contemplate inserting mastic in the tongue-and-groove joint, to provide a waterproof construction, I prefer to cut channels 75 in the tongue to be filled with a mastic prior to assembly of the panels. Mastic is also spread in the bottoms of the groove 73. When the edges

of two panels are forced together, there is a tendency, by virtue of the tapered relationship shown, for the mastic 76 to be forced from the channels 75 against the mastic previously applied to the bottoms of the grooves 73, the result being efficient penetration of the mastic into all crevices in the tongue-and-groove joint. After the panels are forced together sufficiently to cause the adjacent edges to abut against each other, the joint may be covered by outer and inner cap members 77 and 78 respectively, the cap members being secured by suitable means such as bolts 79. The outer cap member 77, which is broken to clear the hoop means or tension rods 80, may be provided with a shallow channel 82 on its inner face to contain mastic 83 for further sealing of the panel joint.

A second multiple-ply panel construction and interlocking arrangement may be employed as suggested by Figs. 8 and 9. Each of the panels 70a has two outer plies 85 spaced apart to provide a relatively wide space which may be filled with insulating material 87 as indicated. Set in from the side edges of the panels are vertical spacer members 88 that interconnect the outer members 85 and cooperate to confine the insulating material 87. The edges of the outer plies 85 extending beyond the spacers 88 are reinforced by inserted members 90 to form two parallel tongues 92 designed to interlock with the metal stud member 93 in the manner shown in Fig. 8.

This stud member 93 may be fabricated from an ordinary I-beam, the web 94 of the I-beam being cut to form four vertical series of laterally bent tongues 95, each series of tongues cooperating with an adjacent flange 96 of the I-beam to form a groove 97 complementary to one of the panel tongues 92. At each panel joint the two panels are interlocked with the stud member 93 in the manner shown by Fig. 8, waterproof mastic being employed in the joint as indicated at 98. The joint may be covered by an outer cap 99 secured by screws 100, the cap being recessed to receive mastic as shown at 101. The described construction leaves a central space in each joint, which may be filled with insulation 102.

The stud members at the panel joints are a feature of my invention. The studs interlock with the panels and are strong enough to make up for door and window openings, and to permit me to employ only two or three hoops around the building.

The wall shown in Fig. 6 is constructed in accordance with Fig. 7, the hoop members 80 being concealed by cover strips 103. The series of panels making up the side wall of the building seats at the bottom in an arcuate angle-iron 105 that is secured by bolts 106 embedded in the concrete foundation 107. Such an angle provides a waterproof juncture, especially if suitable mastic is employed. The top edge of the series of panels may rest against a second compression member comprising an arcuate angle member 108 of ply-wood construction. In the simplest form of my invention these ply-wood angles are rigidly interconnected at the corners of the building with no provision for taking up shrinkage. By constructing the panels of properly seasoned wood, suitably impregnated with waterproofing material, any significant shrinkage may be avoided.

In the building constructed as indicated by Fig. 6, a paneled roof may be employed of the

pattern indicated in Fig. 3, the roof panels being constructed as shown in Figs. 6, 10 and 11. Each of the panels, generally designated 110, includes two longitudinal members 111, each of which is cut at one end to abut a ridge member 112 and is cut at the other end to seat on the angle 108 and to provide anchorage for a horizontal eave plate 113. In each roof panel the two longitudinal members 111 are connected by transverse tie rods 114 that may be tightened by nuts 115. At spaced intervals are pairs of cross members 116, each pair straddling one of the tie rods 114. The cross members 116 are not quite long enough to extend across the space between the two longitudinal members 111, one of these cross members 116 being connected to one of the longitudinal members 111, the other being connected to the other longitudinal member so that the two cross members are in staggered overlapping relationship. Interposed between the two cross members in each pair are spacer blocks 117 to which each of the cross members is connected by nails 118.

It is contemplated that the nails will be sufficiently yielding by bending and the material of the cross members sufficiently soft to permit an extent of relative movement between the cross members of a pair to permit the tie rods to be tightened in compensation for any shrinkage in a series of longitudinal boards 119 that extend in tongue-and-groove disposition between the two longitudinal members 111. A substantial layer 120 of insulating material is interposed between the boards 119 and the cross members 116. The boards 119 are anchored by nails to the cross members 116. The fact that the nails employed to anchor the boards are readily bent and the fact that the nails extend through relatively soft insulating material permit sufficient relative movement between the individual boards and the cross members 116 to allow any tightening required for taking up shrinkage. Finally the upper surface of the panel is covered by suitable waterproof roofing paper 122.

The various panels are laid in side-by-side relationship in the pattern suggested, for example, by Figs. 3 and 12, sufficient space being provided between adjacent panels to permit access to the nuts 115 for tightening the tie rods 114. The spaced panels are then interconnected by cap members 123, which may either be nailed to the underlying members 111, or be held in place by bolts connected to an anchor strip, such as shown in Fig. 22 to be described later. It will be noted that the longitudinals 111 provide longitudinal edge flanges extending upward along each side of each panel and that the caps 123 are complementary to such flanges to provide waterproof joints. Finally the ridges of the roof are capped by suitable members 124.

These prefabricated roof panels may be erected on the job from a traveler by semi-skilled labor. In the particular construction shown, no frame is required in the roof to tie together the panels at opposite sides of the building, since the wall construction is sufficiently strong to take the entire roof thrust. It will be noted that this thrust is met not only by the hoop means 80 but also by the members 108 at the top of the wall, which are tied together to form a means extending continuously around the building. In such an arrangement wind stresses from one side of the building are transmitted across the building and distributed to the hoops on the leeward side of the building. In the construction shown in Fig. 75

6, then, the members 108 at the top of the wall have the following functions:

1. They serve as arcuate forms defining the configuration of the walls.

2. They stiffen the walls.

3. They provide supporting surfaces for the roof panels.

4. Because they are interconnected in a continuous series, the roof stresses on one side of the building are opposed by the roof stresses on the other side of the building.

5. They serve as a means to transmit wind stresses from one side of the building to the other side of the building. Thus, in a building of rectangular configuration, a stiffener 108 may receive the wind stress from the corresponding side wall and transmit that stress through the two adjacent parallel stiffeners to the fourth stiffener which distributes that stress to the opposite side wall and the associated hoops.

In another embodiment of my inventive concept, I employ a more elaborate arrangement of compression members at the top of the building walls, as suggested by Figs. 12 to 15. In this construction, each arcuate side wall is braced at the top by a single compression member in the form of a horizontal truss generally designated 125, each truss comprising an arcuate outer chord generally designated 126 and a straight inner chord generally designated 127 interconnected by diagonals 128. As indicated in the drawings each of the chords may comprise two parallel members on opposite sides of the diagonals. The outer chord member 126 is of angular configuration similar to the previously described compression member 108 and in the same manner engages the top edge of the arcuate wall. The various horizontal trusses 125 extending around the building are interconnected to form a continuous reinforcement. In the preferred form of my invention shown in the drawings, the means for interconnecting the ends of the horizontal trusses is adjustable to permit the series to be contracted or expanded as required. The construction of a suggested adjustable joint now to be described is best shown in Figs. 13 and 14.

At the ends of the horizontal truss members the two truss chords are interconnected and reinforced by a web member 129. Corner plates 130 are placed against the upper and lower faces of the horizontal trusses and interconnected by suitable bolts 132 extending through the material of the trusses. Substantially parallel slots 133 through the corner plates are provided for the bolts 132. It will be noted that these slots are disposed in the general direction of the corresponding side wall, so that the slots cooperate with the bolts in a positive manner at all positions of adjustment to maintain the desired disposition of the series of truss members.

The ends of the horizontal trusses are cut at angles to provide a diagonal space between the corner plates 130. This space is occupied by an adjustable wedge means comprising a pair of wedge shoes 135 and a pair of wedges 136 of complementary configuration. The wedges 136 are adjustably interconnected by a suitable bolt 137 having a nut 138 for adjusting the spaced relation between the two wedges. Tightening the nut draws the two wedges together, forcing the two wedge shoes 135 apart, but in all positions of adjustment the wedge shoes are held in substantially parallel relationship. The procedure for adjusting such a corner connection will be readily understood by those skilled in the art. Nor-

mally the bolts 132 are in tight engagement, but when any adjustment is required these bolts are temporarily loosened to permit manipulation of the nut 138 on the end of the wedge bolt 137.

The hoops 80a, interconnected by corner castings 49a, and extending around the building tend to contract the series of interconnected horizontal trusses and, since all the opposing surfaces at the junctures in the series of horizontal trusses rest flat against each other, the contractual effect of the hoops 80a tends to maintain the desired rectangular disposition of the series of trusses, any departure from the desired normal disposition tending to rotate such opposing surfaces apart. It will be noted that such rotation or spreading apart of the juncture surfaces is also opposed by the bolts 132 coacting with the corner plates 130, the disposition of the slots being such that this effect is provided at all positions of adjustment. Those skilled in the art may readily understand that while the wedge assembly provides substantially parallel planes of juncture 139 at each corner of the building disposed in the direction of the center of the building, these planes need not be parallel.

In any construction having the stiffeners or horizontal trusses at the top of the wall adjustably interconnected, I also contemplate arranging the floor angle irons 108 for adjustment at the corners of the building as suggested by Fig. 6a. The ends of the floor angles 108 are connected to angular bars 103 at each corner of the building, bolts 103a extending through slots 103b in the angles.

Where greater rigidity is desired in the assembly of horizontal trusses, I may interconnect the various trusses by means such as tie rods 140, as shown in Figs. 12 and 15. These tie rods extend across the building at various points and are secured by suitable means such as nuts 141 engaging washers 142. In my preferred construction the tie rods 140 pass through downwardly depending flanges 143 of the arcuate chords, 126, the upper edges of the wall panels being cut away, as desired, to provide clearance for the tie rods. The tie rods are installed after the hoop means have contracted the wall panels into their permanent positions. It will be noted in Fig. 15 that the washers 142 engage both the chord 126 of the horizontal truss and the upper ends of the building panels.

Instead of employing the multiplicity of horizontal tie rods 140 as just described, I may, of course, employ only two diagonal tie rods interconnecting the corner plates 130, as previously described with reference to Fig. 5.

In the course of assembling the building, the horizontal trusses are temporarily supported until the wall hoops are tightened. Thereafter the outer edges of the trusses are supported by the arcuate walls, but additional means is desirable to support the inner edges of the trusses. Such additional means may comprise hangers 145 in the form of iron rods anchored to the roof panels by bolts 146. Where the tie rods 140 are employed, the hangers 145 may support cross beams 147 that in turn brace the rods 140 from below, the horizontal trusses 125 resting directly on the rods.

Figs. 16 to 25 serve to indicate how the principles of my invention may be applied to a metal building. The same structural relationships are involved, the arcuate side walls comprising series of panels 150 pressed inward and together by tension members 151 and the roof being made up

of roof panels 152. In the wall construction shown in Fig. 16, a panel 150 is shown as comprising a hollow metal member containing insulation 153 with the tension members 151 on the outside of the wall.

The preferred metal wall panel is constructed as indicated by Figs. 17 to 21 inclusive. Each of the panels 150 comprises two outwardly bowed metal sheets 155 that are spaced apart throughout the intermediate portion of the panel and are interconnected at the side edges of the panel. More specifically described, each of the panel sheets 155 has an intermediate outwardly arched portion 156 and two inwardly inclined edge portions 157. Incorporated in the panels 150 at suitably spaced levels are horizontal pipes 158 or other suitable hollow members. These pipes are of length to extend from one edge to the other of the panel so that when the panels are assembled in a wall, the pipes in one panel abut end-for-end with the pipes of adjoining panels. The panels may be prefabricated as complete units with the side edges of the sheets 155 welded together and both sheets welded to the pipes 158.

A suitable means for interlocking adjoining panels 150 may comprise a pair of vertical sheet metal channels 159 interconnected by suitable means such as bolts 160 and nuts 162. Each of these channels cut and formed as best shown in Fig. 21 has a central web 163 and two diverging flanges 164. The web has suitable bolt holes 165 and the flanges are cut to form short tongues 166 that engage complementary slots in the panel sheets 155. Preferably, insulating material 167 is packed into the panels proper and also into the spaces at the joints defined by the channel members 159.

To keep the various strings of pipe aligned in the finished wall, I prefer to employ plugs 170 to interconnect adjacent pipe ends as best shown in Fig. 20. Each plug has a central radial flange 171 dimensioned to abut the ends of two consecutive pipe lengths and has tapered ends 172 that may be dimensioned for driving fit into the pipes.

A feature of my invention to be noted is that the arch principle is applied not only to the wall as a whole but also is applied to the construction of the individual panels 150. When the edges of the panel sheets 155 are welded to the pipe members 158, any force laterally against the panel tending to move a panel sheet inwardly places the panel sheet under compression and tends to result in tension in the pipe 158. It is apparent, then, that the pipe members have the following functions,

1. In the wall, as a whole, the pipes serve as compression members to resist contractual forces from the tension members 151.

2. The pipes cooperating with the joint plugs provide positive means for keeping the panels aligned with each other.

3. The pipes in each panel cooperate with the panel sheets 155 to form an arch assembly whereby adequately strong panels may be constructed from relatively thin panel sheets.

4. The pipes lend rigidity to the panels in horizontal planes.

In addition to providing an efficient joint for interconnecting the wall panels, the joint channels 159 have the following functions:

1. The channels lend rigidity to the wall in vertical planes.

2. They retain insulation at the panel junctures.

3. By the arrangement of tongues engaging slots in the panel sheets, the joint channels interlock the adjoining ends of the panels and, together with the plugs 170, prevent relative movement between the panels in the plane of the wall.

4. The joint channels are in themselves arch members when viewed in horizontal section, the arch members interconnecting and reinforcing the arches formed by the panel sheets 155.

5. They serve the same purposes as the studs previously described in the wood construction, i. e., strengthen the walls to compensate for doors and windows.

The compression member at the top of the sheet metal wall to resist the contractual force of the hoop means may comprise simply an arcuate angle iron 175 engaging the top ends of the panels as shown in Fig. 16, and providing supporting surfaces for the roof of the building. While the tension members 151 may touch the mid-sections of the panel sheets 155, it is contemplated that the inward force of the tension members will be taken primarily by the joint channels 159, these channels being sufficiently heavy to carry the stresses involved. Likewise, on the inner side of a wall the vertical web of the angle iron 175 may touch the mid-sections of the panel sheets 155 but will receive stresses from the wall primarily through the joint channels 159. It is apparent that each pair of joint channels, in effect, constitutes a vertical stud having the same relationship to the outer hoop members 151 and to the inner compression members 175 as heretofore noted in the wooden studs 45 of Fig. 5.

Any type of roof may be employed with such a paneled wall, but I prefer to employ prefabricated metal roof panels of the type constructed as indicated in Figs. 16, 22, and 23. Each of these panels 152 comprises a metal sheet 176 and an upper sheet of roofing paper 177 with a layer 178 of suitable insulating material between the two sheets. At the side edges the roof panels are turned upward to provide inclined flanges 179, the roofing paper 176 having marginal portions 180 extending beyond the lower side edges of the metal sheet and the side edges of the intervening insulating material. The roofing paper and the layer of insulating material may be omitted if desired.

A feature of these roof panels is that they are double arched, i. e., arched both longitudinally and laterally whereby exceptional inherent strength may be achieved with relatively thin material. The lateral arching of the sheet is most pronounced at the center of the sheet as indicated by Fig. 23, the sheet being flattened towards its ends as indicated in Fig. 22. To maintain the arched configuration of the sheet in its longitudinal aspect, I may provide two longitudinal tie rods 182 for each panel. These tie rods may be suitably anchored at their opposite ends in a wooden cross member 183 at the upper end of the panel and a second similar cross member 184 towards the lower end of the panel, the cross members being anchored to the panel by suitable means such as bolts 185.

To provide means whereby each panel may be assembled into a unified roof, the upper cross member 183 of each panel is shaped and disposed to rest against a ridge assembly generally designated 186 with the upper end of the panel resting on the ridge assembly, and the lower end of the panel is adapted for engagement with the wall

angle 175, for example, by the addition of a cross member 186 mounted on the lower cross member 184.

The assembled roof panels lie side by side as indicated in Figs. 22 and 23 with the marginal side portions 180 of adjoining panels overlapping. Each of the joints between adjoining channels is capped by an inserted double arched channel 188, and the various elements of the joint are tied together by suitable means such as a series of bolts 189 cooperating with an anchor strip 190 that is substantially coextensive with the channel 188. The bolts 189 may be anchored to the channel 188 by engagement with metal loops 191 welded inside the channel. The bolts 189 extend through suitable apertures in the overlapping marginal portions 180 of the panels and are secured to the anchor strip 190 by suitable nuts 192. It will be noted that the anchor strip 190 is of sufficient lateral extent to engage the body of each roof panel to provide anchorage for placing the bolts 189 under tension. Tightening of the nuts 192 tends to contract the joint assembly and, in effect, makes the panels integral with each other.

To make the assembled roof watertight along the ridge, I provide a metal ridge cap 193 having flanges 194 overlying the upper ends of the roof panels.

In the preferred form of my invention there are three of the hoop means 151, one at the bottom of the wall and two near the top, the additional hoop at the top being provided to take the outward thrust of the roof panels.

The arcuate side walls may be interconnected at the corners of the building and the hoop members anchored in any suitable manner. A suggested corner construction is indicated in Figs. 24 and 25. In this construction the angles 175 extending along the tops of two adjoining walls may be solidly interconnected by a corner plate 198, or may be adjustably interconnected as previously described. The panels 150 at the corner of the building abut edgewise against the legs of a vertical corner angle 199, the pipes 158 in the panels engaging suitable studs 200 mounted on the angle, as best shown in Fig. 25. For each series of hoop members 151 extending around the building, a corner casting 201 is provided, the corner casting seating against the inner faces of the corner angle 199. The hoop members 151 extending along the two adjacent walls pass through apertures in the corner castings 201 and are adjustably retained therein by nuts 202. Finally, the vertical angle 199 and the corner castings 201 may be concealed by a sheet metal housing 203 of circular configuration that has tongues 204 engaging the slots of the adjacent wall panels in the same manner as the tongues 166 of the joint members 159 previously described. This housing is slotted to clear the hoop members 151.

For the purpose of this disclosure and to reveal clearly the principles of my invention, I have described preferred forms of my invention in specific detail. Changes and modifications will be obvious to those skilled in the art, and I reserve the right to all such changes and modifications that properly come within the scope of my appended claims.

I claim as my invention:

1. A building having in combination: a continuous series of substantially horizontal stiffeners in normal disposition defining with their outer edges a polygon having arcuate sides; means adjustably interconnecting said stiffeners at the

corners of the polygon, said means including at least two slots at the end of each stiffener in general longitudinal alignment with the stiffener and means engaged therewith, whereby, at all adjustments of the stiffeners, the interconnecting means tend to maintain said normal disposition of the stiffeners; a series of wall panels disposed around said stiffeners to form the side walls of the building; and means encircling the side walls of the building in tension to press said panels

10 against each other, and against said stiffeners.
 2. An arcuate wall for a building comprising: a series of outwardly bowed sheets; a corresponding series of coextensive oppositely bowed sheets arranged in pairs therewith and forming there-
 15 with panels of lenticular cross-section; means between the sheets of each panel connected to the ends of the sheets to resist in tension any forces tending to straighten the sheets and in compression to resist any forces tending to increase the
 20 curvature of the sheets, said means extending along chords of the curves defined by the sheets and being spaced from the central portions of the sheets; a fixed member arcuate in plan en-
 25 gaging said panels and defining an arcuate wall configuration; and means in tension holding said panels against said arcuate fixed member to form an outwardly bowed arch.

3. A building having in combination: a series of wall panels; a series of vertical studs inter-
 30 posed between said wall panels, said wall panels and studs forming a series of arcuate side walls, said side walls meeting at bulging corners; a series of substantially horizontal arcuate stiffeners corresponding to said side walls and disposed
 35 within said walls and engaging said studs to resist inward pressure from said studs; means encircling the building in tension and pressing said studs inwardly against said stiffeners; and
 40 means interconnecting said encircling means and studs at the ends of each side wall whereby each side wall is compressed end-to-end.

4. In a four-sided building, the combination of: a plurality of panel members arranged in series forming the four separate side walls of
 45 the building; a series of four arcuate stiffener members corresponding to said four side walls of the building, said stiffener members being disposed within and engaging said walls to resist inward pressure from said walls; and means
 50 acting in tension around the building to hold said panel members assembled around said series of arcuate members, said side walls forming outwardly bulging building corners whereby said tension means acts against panel members at
 55 the corners of the building to crowd the panel members against each other inwardly from each end of each side wall to form effective arches.

5. A four-sided building having in combination: a series of four adjustably interconnected
 60 arcuate compression members corresponding to the four walls of the building and defining a building configuration with outwardly bulging corners, the building lines extended outwardly at said corners forming angles between 90° and
 65 180°; a series of vertically disposed wall panels extending along said series of compression members; and adjustable means extending around the building in tension to hold said series of panel members around said series of compression
 70

members, said tension means crowding the panels towards each other inwardly from the corners of the building to form effective arches.

6. A four-sided building having in combination: a plurality of wall panels; a series of four arcuate means adjacent the lower ends of said panels corresponding to the four sides of the building; a second series of four arcuate means corresponding to said first-mentioned arcuate means adjacent the upper ends of said panels, the arcuate means being disposed within the panels and engaging the panels to resist inward pressure from said panels; means in tension around the building holding said panels assem-
 15 bled around both said series of arcuate means, the walls of the building forming outwardly bulging corners whereby said tension means crowds the panels together from the corners of the building to form effective arches; and a pitched roof thrusting outwardly against said wall panels thereby exerting force against said tension means.

7. A four-sided building having in combination: four elevated substantially arcuate compression members in a continuous series corresponding to the four side walls of the building; a plurality of vertically disposed wall panels extending along said compression members, said compression members being disposed within and engaging said plurality of vertically disposed wall pan-
 25 els to resist inward pressure from said panels; means acting in tension around the building to force said wall panels towards said compression members, the walls of the building forming out-
 30 wardly bulging corners whereby said tension means crowds the panels against each other from the corners of the building to form effective arches; and elevated tie rods across the building interconnecting said compression members.

8. A four-sided building having in combination: a series of wall panels disposed to form a series of four arcuate side walls forming four outward-
 35 ly bulging building corners; a series of four arcuate stiffeners corresponding to said four walls and disposed within and engaging said walls to resist inward pressure from said panels; a series of tension members corresponding to said side walls, each tension member being disposed to urge said panels inwardly towards said stiffeners; and means connecting one of said tension mem-
 40 bers both to the ends of the corresponding side wall and to the tension members of the adjacent side walls, whereby the tension in each of said tension members is balanced in part by compression in said corresponding side wall and in part by tension in the tension members of the adjacent side walls.

9. A four-sided building having in combina-
 45 tion: a plurality of wall panels constituting the four walls of the building; a series of four arcuate means corresponding to the four walls of the building, said arcuate means being disposed within and engaging said walls to resist inward pressure from said walls, said walls meeting in outwardly bulging building corners; and means
 50 in tension holding said panels against said arcuate means and crowding said panels against each other inwardly from the ends of the walls to form effective arches.

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