Dec. 30, 1941. J. C. HAIN 2,267,912

BUILDING CONSTRUCTION

Filed April 27, 1938 3 Sheets-Sheet 1

Fig. 1.

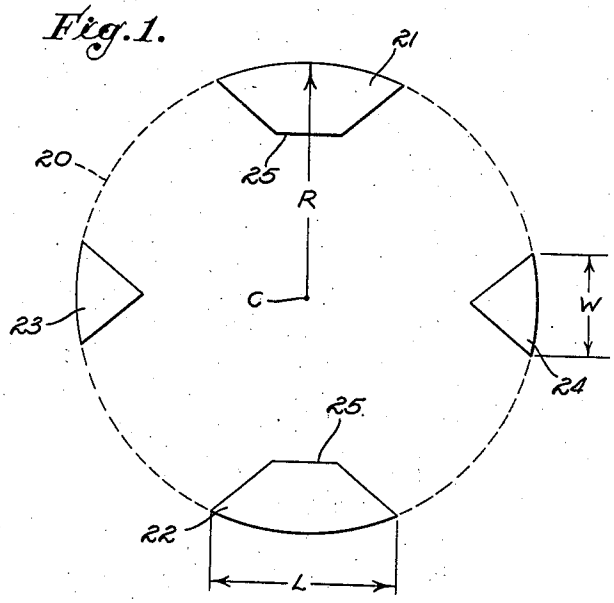


Fig. 3.

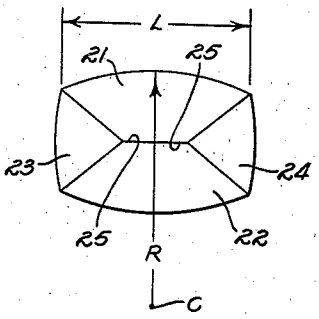


Fig. 2.

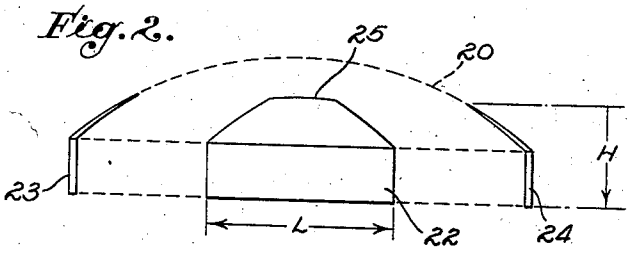


Fig. 4.

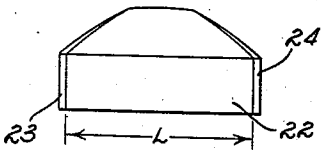


Fig. 6.

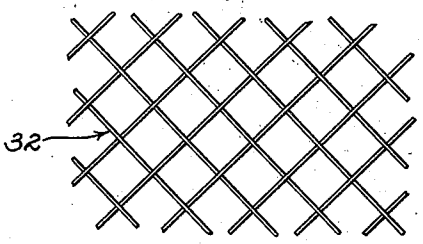
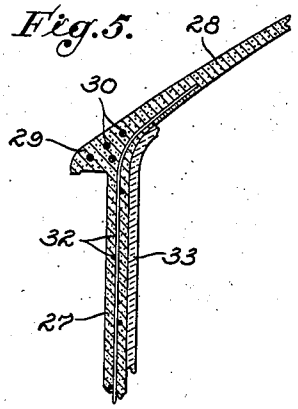


Fig. 5.



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Dec. 30, 1941. J. C. HAIN 2,267,912

BUILDING CONSTRUCTION

Filed April 27, 1938 3 Sheets-Sheet 2

Fig. 7.

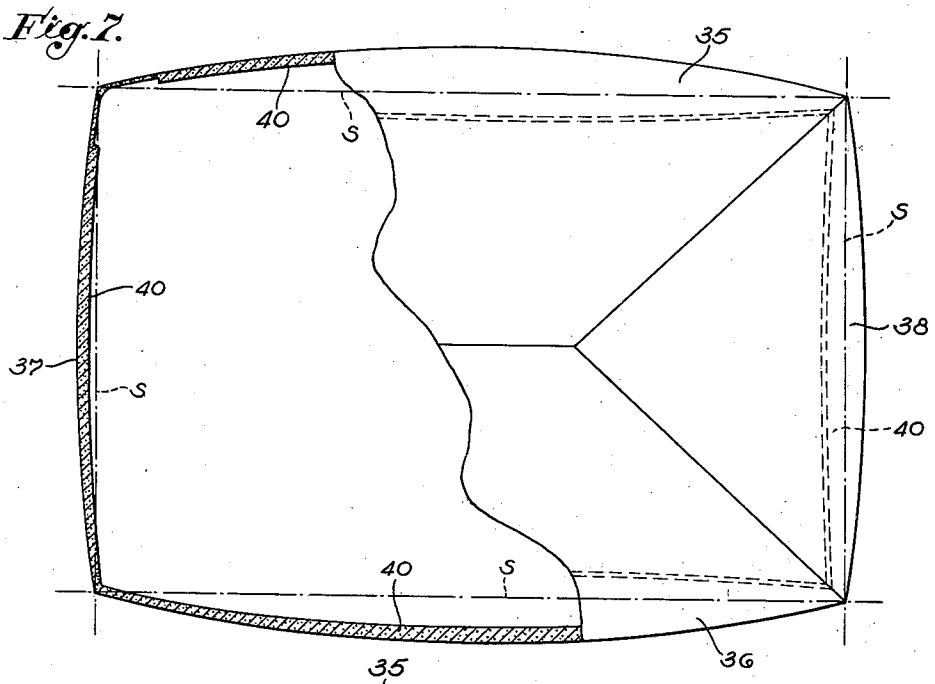


Fig. 8.

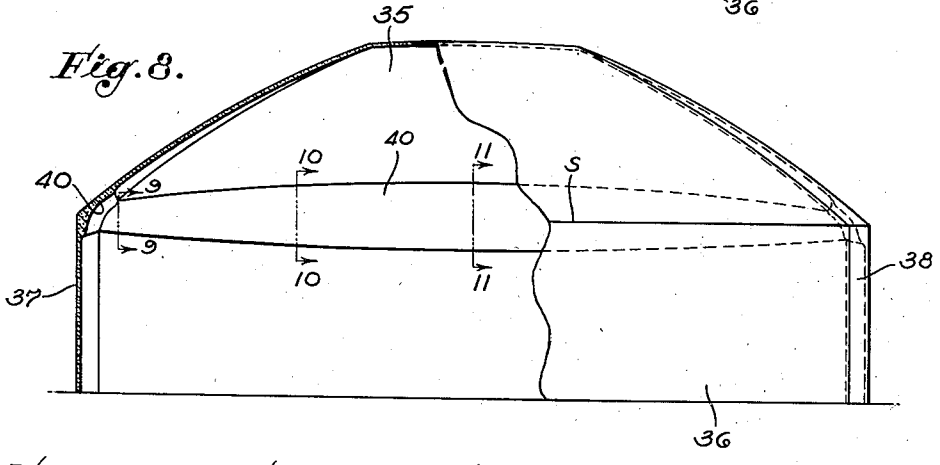


Fig. 9.

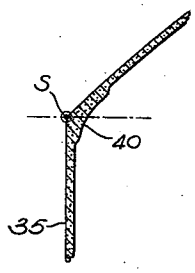


Fig. 10.

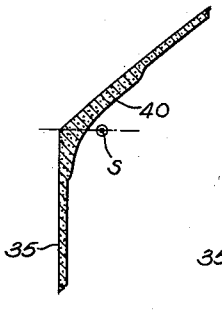
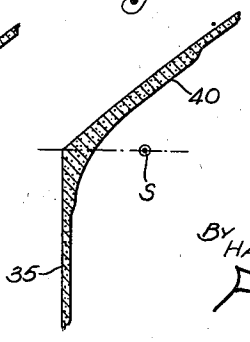


Fig. 11.



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BUILDING CONSTRUCTION

Filed April 27, 1938 3 Sheets-Sheet 3

Fig. 12.

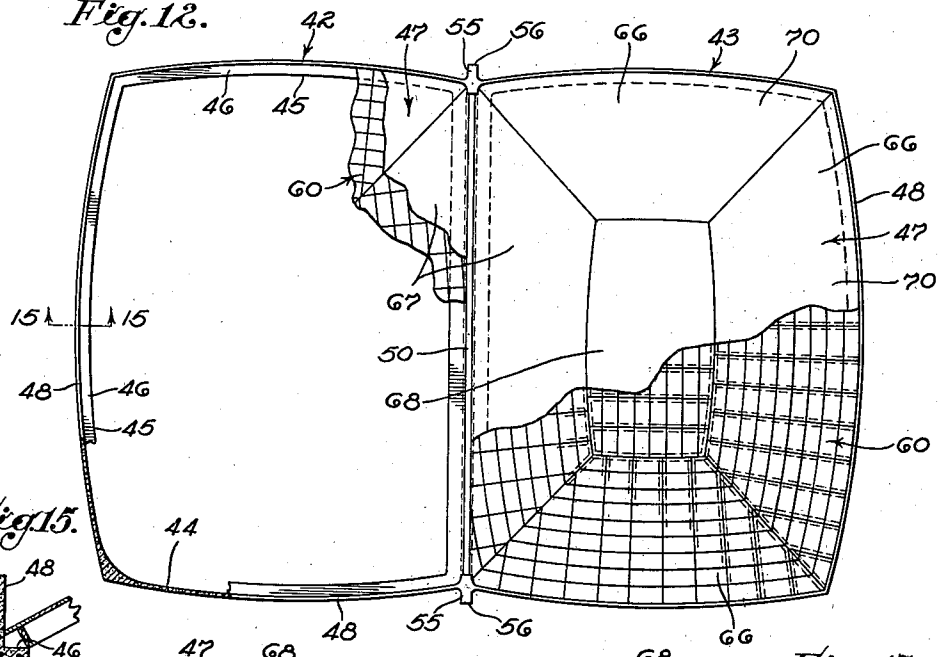


Fig. 15.

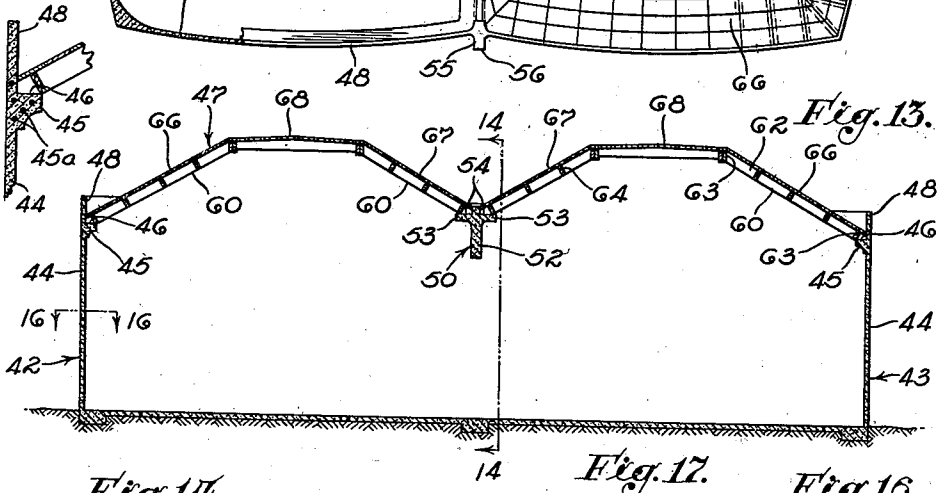


Fig. 13.

Fig. 14.

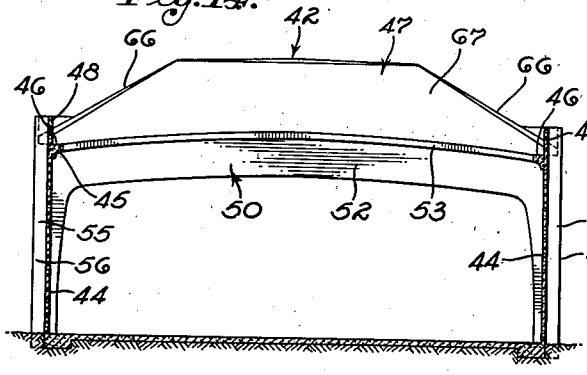


Fig. 17.

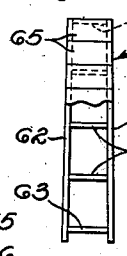
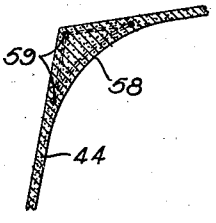


Fig. 16.



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UNITED STATES PATENT OFFICE

2,267,912

BUILDING CONSTRUCTION

James C. Hain, Los Angeles, Calif.

Application April 27, 1938, Serial No. 204,576

6 Claims. (Cl. 72—1)

My invention relates to building structures, particularly concrete structures.

The general object of my invention is to achieve adequate structural strength and efficiency with economical use of material and low labor costs.

The side walls of a building must be designed to resist wind stresses and lateral roof thrusts as well as to support all vertical loads. A relatively thin wall will satisfy the requirements for carrying the vertical loads in compression, but a straight concrete wall in the conventional type of building must be relatively thick, or have special anchorage or bracing to be stable and to withstand the imposed lateral stresses. My invention is characterized by the conception that arcuate walls may be employed without substantial departure from a rectangular floor plan, factors associated with the curvature of the walls being relied upon to a large extent to oppose lateral stresses. By such a construction I am enabled to employ with safety and efficiency relatively thin side walls. In one design, for example, an eight inch concrete wall of the conventional type would be required to satisfy the conditions successfully met by a two inch arcuate wall constructed in accordance with my invention.

In the preferred embodiment of my invention incorporating the broad concept of arcuate walls, it is my object to carry into a substantially rectangular configuration the advantages of a cylindrical configuration. My invention may be approached by considering the fact that a completely circular structure characterized by exceptionally high inherent efficiency may in imagination be divided in any number of ways into sections and then analyzed as comprising such sections cooperating as a unitary combination. For example, the circular side wall of such a structure may be divided by vertical planes into a plurality of sections in edge-to-edge relationship, the circular configuration being continuous throughout each section juncture.

My object is accomplished, in effect, by the procedure of selecting four sections from among such series of circular sections and assembling the selected sections again in an abbreviated series in which the selected sections in edge-to-edge relationship approximate a rectangle. By selecting a radius of curvature substantially longer than a side of the rectangle, the degree of departure from a true rectangle may be reduced to a minimum without losing the advantages of arcuate walls, although, of course, increase of radius of curvature necessitates increase of material for given stresses.

Within each of the reassembled sections, the wall has the same strength and the same character as in the corresponding section of the original circular wall, and the edge-to-edge relationships permit the abbreviated series of circular sections to cooperate in substantially the same manner as in the complete series. The essential difference is that the circular configuration is not continuous through each juncture, but any sacrifice in strength involved in this difference is minimized by consolidating the wall sections into a unitary shell and reinforcing the junctures.

In another form of the invention it is my object to extend the principle of an abbreviated series of circular sections to the roof of the building as well as to the walls. Thus, I may derive my abbreviated series from a domed circular structure with the vertical lines of division cutting through the dome, and obtain thereby a polygonal building in which the roof and walls are consolidated into a unitary shell having inherently substantially all the desirable structural features that characterize the basic structure.

A further object of my invention is to provide continuous reinforcement means for the series of arcuate wall sections to resist roof thrust, and a feature of my invention is that such reinforcement may be incorporated in the juncture between the roof and the side walls of the building. Thus, where a fabricated roof rests upon concrete arcuate walls, the reinforcement may form a shoulder for supporting the roof. Or if the roof and walls are consolidated into a unitary shell, this reinforcement may be in the form of additional thickness at the roof juncture and in one embodiment of my invention may provide the eaves of the building. A further feature of my invention is that such reinforcement may serve as a truss to stiffen the walls and to transmit stress from one end of the building to the other, the reinforcement preferably varying in cross-sectional dimensions in accordance with stress calculations for such truss.

The above and other objects and advantages of my invention will be apparent from my detailed description to follow, taken with the accompanying drawings.

In the drawings:

Fig. 1 shows in plan diagrammatically how the configuration of a building constructed in accordance with my invention may be derived from a basic structure;

Fig. 2 shows the diagram of Fig. 1 in side elevation;

Fig. 3 shows in plan how sections derived from Fig. 1 may be assembled to form a compact building having arcuate walls, in which the walls and roof are consolidated to form a unitary shell;

Fig. 4 is a front elevation of the building shown in Fig. 3;

Fig. 5 is a vertical section showing a cross-sectional configuration for a building shell;

Fig. 6 shows in side elevation the pattern of reinforcing members employed in the wall of Fig. 5;

Fig. 7 is a plan view partly broken away showing a building shell having another cross-sectional configuration;

Fig. 8 is a side elevation of the building of Fig. 7 partly broken away;

Fig. 9 is a fragmentary vertical section slightly enlarged taken as indicated by the line 9—9 of Fig. 8;

Fig. 10 is a similar section taken as indicated by the line 10—10 of Fig. 8;

Fig. 11 is a similar section taken as indicated by the line 11—11 of Fig. 8;

Fig. 12 is a plan view partly broken away indicating the construction of a multiple-unit building incorporating the principles of my invention;

Fig. 13 is a longitudinal vertical section of the building shown in Fig. 12;

Fig. 14 is a transverse section taken as indicated by the line 14—14 of Fig. 13;

Fig. 15 is a fragmentary vertical section on a slightly enlarged scale through the wall, taken as indicated by the line 15—15 of Fig. 12;

Fig. 16 is a fragmentary horizontal section on a slightly enlarged scale through a corner of the building, taken as indicated by the line 16—16 of Fig. 13; and

Fig. 17 is a diagrammatic view indicating the construction of a typical roof panel frame.

As an example of an imaginary basic structure from which a form of my invention may be derived, I show diagrammatically in Figs. 1 and 2 a domed reservoir **20** having a radius R drawn from a center C. Sections may be cut from this basic structure to be reassembled in an abbreviated series of sections which may match edge-for-edge or may be joined by intervening wall sections to form a building. The building shown in Figs. 3 and 4 comprises a series of sections that match edge-to-edge.

A suggested design procedure is to plot on the two views of the basic figure the height H, length L, and width W of the building to be designed, as indicated in the drawings, to derive from the basic figure two complementary side sections **21** and **22** of L length and H height, and two complementary end sections **23** and **24** of the same height and having arcuate walls of W extent. All of the imaginary cuts are in vertical planes and at angles to match. It will be noted that each of the two side sections **21** and **22** has an inner edge **25** that is straight in plan and somewhat arcuate in side elevation, these two edges matching to form the ridge of the derived building. These four sections are then assembled, as shown in Figs. 3 and 4.

The curvature of the arcuate walls is somewhat exaggerated in the diagrams for the sake of clearly indicating the principles involved. For an ordinary family dwelling, it is contemplated that the radius R of the basic figure will be between 100 and 200 feet. Decreasing the radius increases the departure of the dwelling in plan from a true rectangle, but increases the strength factors inherent in the arcuate configuration and consequently lessens the material required in the walls of the structure. It will be apparent to those skilled in the art that the radius of curvature for a particular building will be determined by balancing these considerations. In one situation a minimum departure from a true rectangle will be the limiting factor. In other situations the reduction of stresses in the walls and economy of material being the prime considerations will favor a shorter radius. A further consideration not to be overlooked is that the arcuate configuration is pleasing per se and has certain advantages in favoring sunlight in a house and in providing more floor space per unit length of side wall than possible with walls conforming to a true rectangle. Whatever radius of curvature is selected, the stresses for wind resistance and roof thrust may be readily calculated.

The simple procedure described conveys clearly the principles involved in my invention, but it is to be regarded as illustrative only. It is, of course, not necessary to go through all the motions of laying out a basic figure once the principles are grasped. I may apply the principles of my invention to the walls only or to the roof only of the finished house. I may vary the curvature in various sections, in effect employing sections in a given building that are derived from more than one basic figure. It is also to be understood that the curvature of the basic figure may be other than strictly circular. For example, the basic figure may be elliptical rather than circular or different portions of a single side wall of a finished building may have different radii of curvature.

Where the configurations of both the walls and the roof are derived from a basic figure as suggested above, not only are the wall sections consolidated with each other but the roof sections also are consolidated with each other and with the wall sections as well to form a unitary shell. In the simplest form of my invention the side walls of the shell are of uniform thickness. A feature of the preferred forms of my invention, however, is the conception of incorporating in the building shell an integral reinforcement means in the vicinity of the juncture between the roof and side walls to oppose the stresses caused by the roof thrust. This arrangement permits the employment of walls thin enough to be built up by the pneumatic process in which cement is applied against a single form, the cost of such procedure being considerably lower than the cost of casting relatively thick walls between forms in the usual manner. The proposed integral reinforcement may be formed by merely thickening the wall of the shell and incorporating reinforcement elements therein as required.

A suggested cross-sectional configuration for a building shell is indicated in Fig. 5. The side wall portion **27** of the shell, the roof portion **28**, and the reinforcement portion **29** are consolidated, with the reinforcement portion projecting to provide eaves around the building. Embedded in the reinforcement portion **29** are circumferential reinforcement rods **30**. It is apparent that this projecting reinforcement, by virtue of the fact that it girdles the building, serves, in effect, as a hoop restricting the upper portion of the wall **27**, the hoop being highly efficient for its purpose since it acts in tension to resist the outward thrust of the roof **28**.

The shell proper is preferably also reinforced,

the drawing showing embedded reinforcement rods 32 or other suitable members. Because of the desirability of allowing for earthquake stresses, I prefer to dispose these rods in opposite diagonal directions, as indicated in Fig. 6. Usually such a structure where employed for a dwelling is provided with an interior layer of insulation 33.

In another form of my invention the shell of the building may have the cross-sectional configuration indicated in Figs. 7 to 11. As before, this building comprises two complementary side sections 35 and 36 and two complementary end sections 37 and 38, and the roof and side walls are consolidated to form a unitary shell. The walls are thickened to form a girth reinforcement or series of ribs 40 projecting inwardly from the shell. A feature of my invention is that each of these ribs serves as a horizontal truss cooperating with the associated side wall of the shell. Such a truss, disposed as indicated in the drawings, has the functions of: stiffening the associated side wall; resisting the local outward thrust of the roof; strengthening the juncture of the roof with the side wall; and of serving as a compression member for transmitting horizontal stress longitudinally of the truss member from one end of the building to the other. While this horizontal stress from one end of the building to the other is transmitted through the truss, the direction of the stress may be taken as in a straight line, such line being indicated at S in the drawings. By virtue of these incorporated trusses 40 being disposed in parallel pairs, the stresses caused by wind pressure on one side of the building are transmitted in substantial part to the two ends of the arcuate wall at the opposite end of the building, the arcuate configuration of the wall readily enabling the wall to withstand such stress.

For maximum strength and for economical use of material, I prefer to vary the cross-sectional dimensions of these trusses or ribs in accordance with the variation in stress therethrough. Thus, each of the trusses is of minimum cross-sectional dimension towards the corners of the building and progressively increases to a maximum dimension at the center of the associated side wall as may be understood by referring sequentially to Figs. 9, 10, and 11.

For industrial buildings requiring relatively large floor space, the advantages of my invention may be had by employing a plurality of units consolidated into one structure. Figs. 12 to 17 illustrate, by way of example, an industrial building incorporating two of my units generally designated 42 and 43. In the particular construction shown, only the side walls 44 are of concrete construction. These walls are relatively thin but are reinforced by inwardly projecting ribs 45 that provide shoulders 46 to support the roof generally designated 47. Preferably the ribs 45 have embedded reinforcement members 45a, as indicated in Fig. 15. The side walls have portions 48 projecting above the ribs 45 and forming a parapet around the building.

At the juncture of the two building units 42 and 43, instead of providing an intervening wall I may construct an overhead beam 50 integral with the outer walls of the building, the beam being, by preference, slightly arched as indicated in Fig. 14. The beam may have a vertical web 52 and a pair of oppositely disposed transverse flanges 53 that provide shoulders 54 for supporting the roof. The ends of the overhead beam 50 are supported by columns 55, which columns may have portions 56 serving as buttresses on the exterior of the building.

It is apparent that by consolidating two building units in the manner described, I provide an extensive floor space without any columns. It would be possible, of course, to design one large unit the size of the units 42 and 43 combined, but it will be apparent to those skilled in the art that the extent of the arcuate wall required for one side of such a large unit would depart from a true rectangle to an excessive degree unless a relatively long radius of curvature were employed. By breaking up the building area into a plurality of units, I minimize the departure of the building as a whole from a true rectangle without the necessity of sacrificing desirable curvature in the wall.

In some installations, particularly in open front buildings or where large doorways are provided, I find it desirable to reinforce corners of the building. Such reinforcement may be provided by thickening the corners, as indicated at 58 in Fig. 16, and embedding special reinforcement members 59.

Any type of roof may be added to complete the building. In the preferred form of my invention the roof comprises a plurality of prefabricated roof panels 60 assembled in a pattern indicated in Fig. 12. The panel illustrated has a frame comprising two longitudinal members 62, end members 63, and intermediate cross members 64. Preferably, the panels are covered by boards or sheathing 65. The panels are arranged in side-by-side relationship to provide three outer roof slopes 66 for each building unit and an inner roof slope 67, the two inner roof slopes 67 extending along the juncture of the two building units. Finally a central series of panels form a relatively flat or slightly arched roof section 68 in the middle of each building unit. These prefabricated panels may be erected on the job from a traveler by relatively unskilled labor, and the roof may be completed by applying layers of roofing paper 70.

For the purposes of this disclosure, I have illustrated specific forms of my invention in detail. It will be apparent to those skilled in the art, however, that the structure shown and described may be radically changed and modified without departing from the principles of my invention. I reserve the right to all such changes and modifications that come within the scope of my appended claims.

I claim as my invention:

1. A concrete building having a consolidated series of side walls and a roof integral therewith to form a unitary shell, said building having the general configuration of sections of a domed circular structure of a diameter substantially greater than the maximum dimension of the building, said sections being in edge-to-edge assembly.

2. A building having the general configuration in plan of a polygon, said configuration being defined by a continuous series of substantially vertical and outwardly curved arcuate side walls of concrete, each of the arcs of said arcuate side walls having a lesser curvature than a circle of a diameter equal to the dimension of the building normal to the side wall and each of said arcuate side walls being of appreciably less thickness than a straight side wall having equivalent strength.

3. A building having the general configuration

in plan of a polygon, each side of said polygon being represented by a single substantially vertical and arcuate side wall forming a single outward curve, each of said side walls being integral with the two adjacent side walls to form a unitary series of side walls, two of said side walls meeting to form outwardly bulging corners at each juncture of contiguous sides of said polygon, and each of said side walls being of appreciably less thickness than a straight side wall having equivalent strength.

4. A building having the general configuration in plan of a polygon, each side of said polygon being represented by a single substantially vertical and arcuate side wall forming a single outward curve, each of said side walls being integral with two adjacent side walls to form a unitary series of side walls, each of said side walls having a lesser curvature than a circle of a diameter equal to the dimension of the building normal to said side wall, and each of said side walls being of appreciably less thickness than a straight side wall having equivalent strength.

5. A building having the general configuration in plan of a polygon, said configuration being defined by a continuous series of substantially vertical and outwardly curved arcuate side walls of concrete, each of the arcs of said arcuate side walls having a lesser curvature than a circle of a diameter equal to the dimension of the building normal to the side wall and each of said arcuate side walls being of appreciably less thickness than a straight side wall having equivalent strength, a roof for said building and a substantially continuous reinforcement integral with said side walls in the vicinity of the juncture of said roof and said side walls to resist outward thrust of said roof.

6. A building having the general configuration in plan of a polygon, each side of said polygon being represented by a single substantially vertical and arcuate side wall forming a single outward curve, each of said side walls being integral with the two adjacent side walls to form a unitary series of side walls, two of said side walls meeting to form outwardly bulging corners at each juncture of contiguous sides of said polygon, and each of said side walls being of appreciably less thickness than a straight side wall having equivalent strength, a roof for said building and a substantially continuous reinforcement integral with said side walls in the vicinity of the juncture of said roof and said side walls to resist outward thrust of said roof.

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