May 7, 1946. R. BLICKENSDERFER ET AL 2,399,785

METAL HANGAR OR SIMILAR BUILDING

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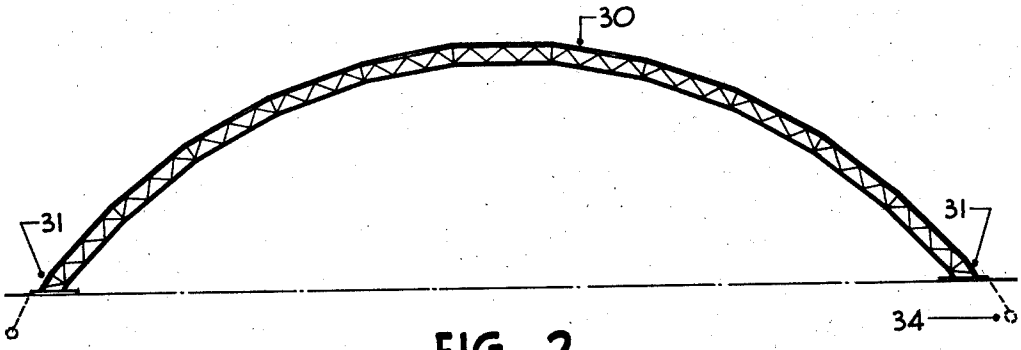



FIG. 2

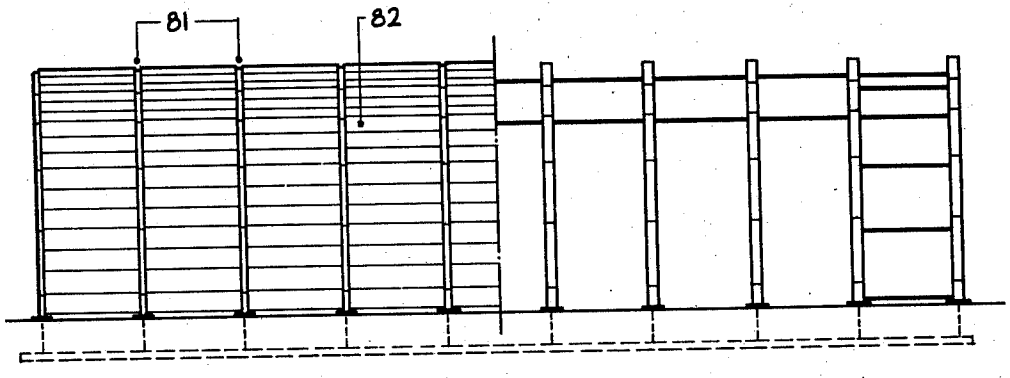



FIG. 1

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METAL HANGAR OR SIMILAR BUILDING

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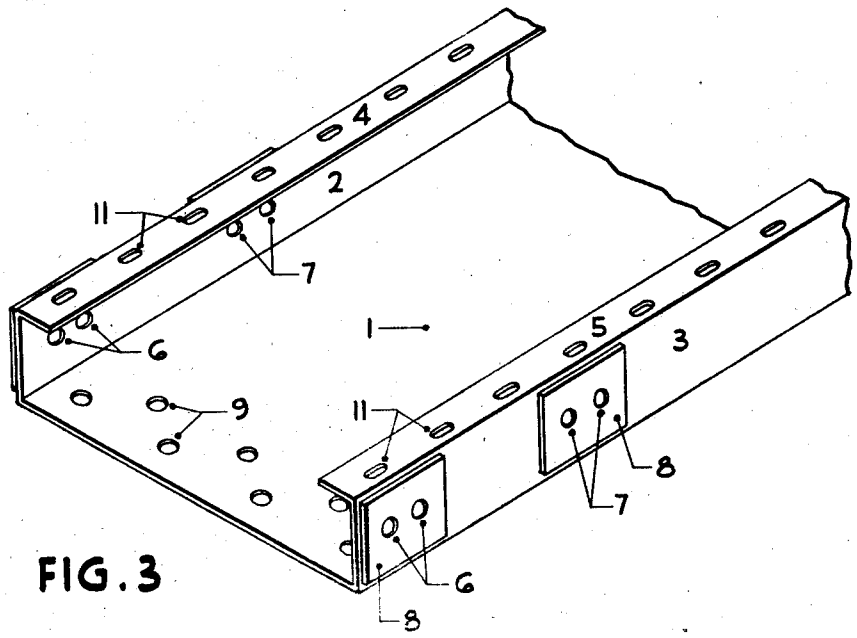



FIG. 3

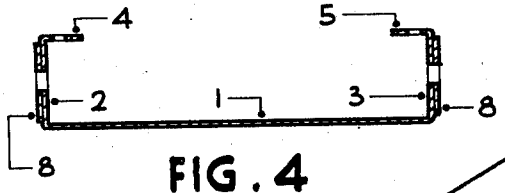



FIG. 4

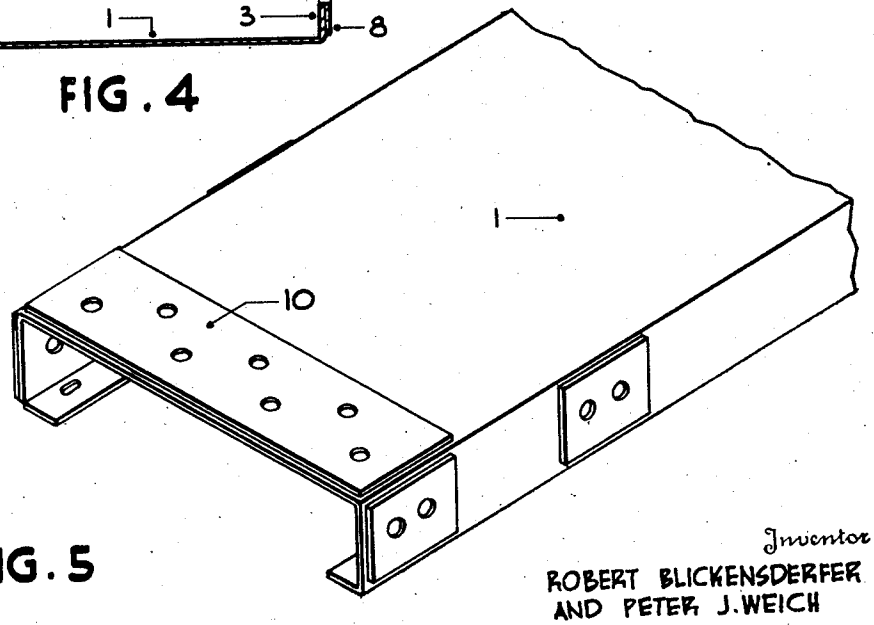



FIG. 5

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METAL HANGAR OR SIMILAR BUILDING

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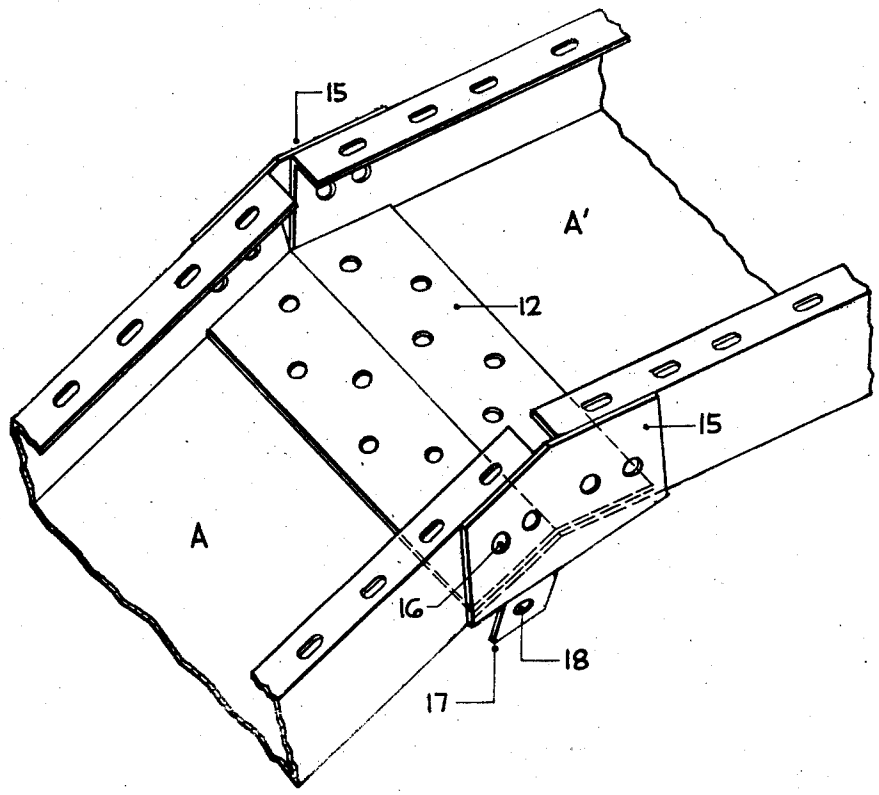



FIG. 6

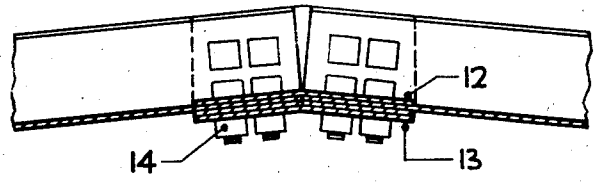



FIG. 7

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METAL HANGAR OR SIMILAR BUILDING

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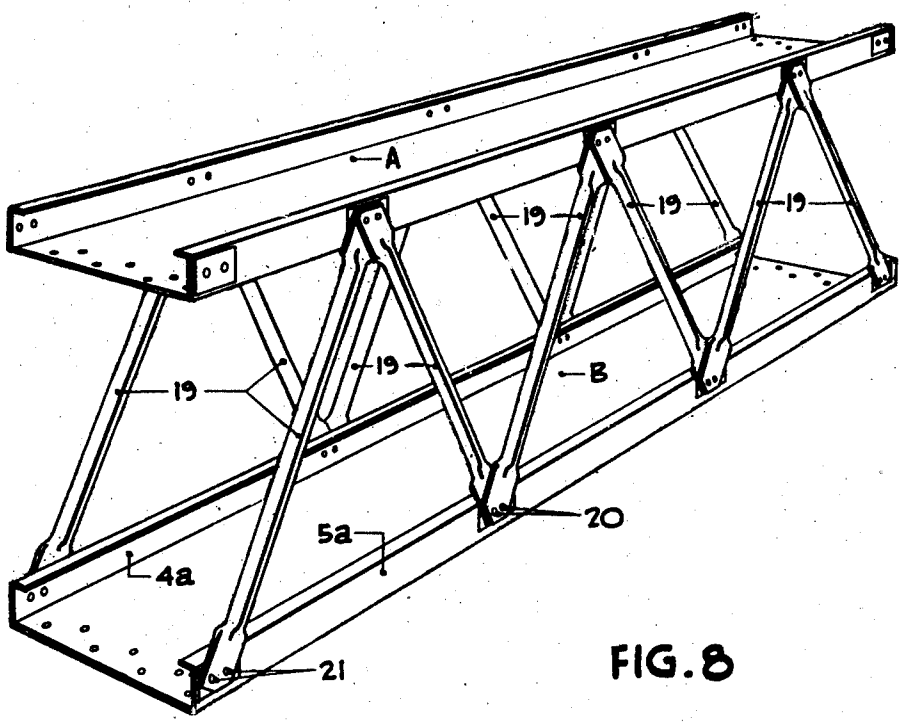



FIG. 8

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METAL HANGAR OR SIMILAR BUILDING

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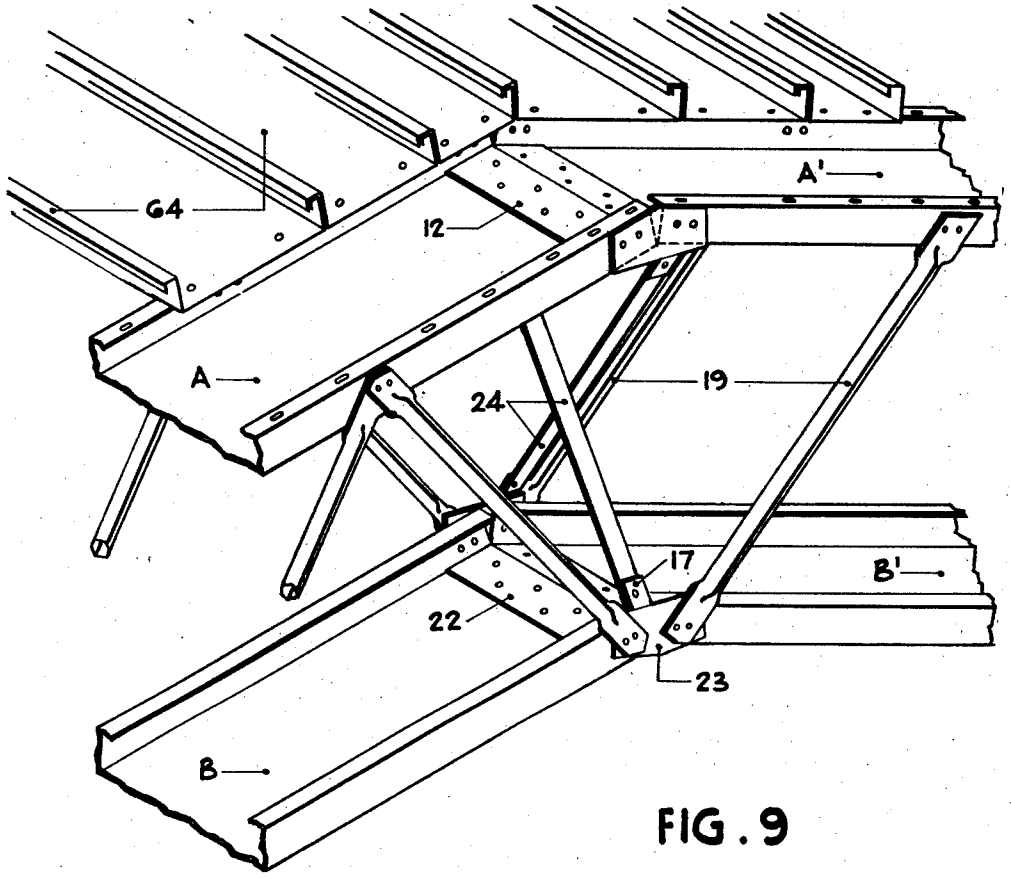



FIG. 9

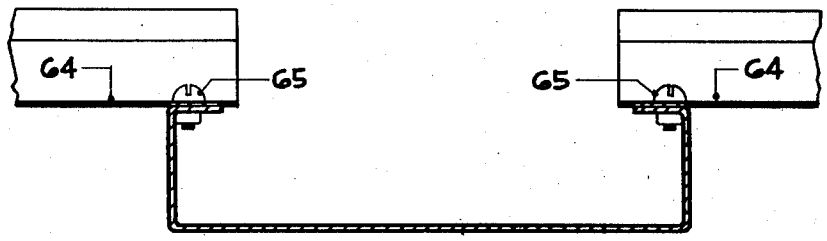



FIG. 10

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METAL HANGAR OR SIMILAR BUILDING

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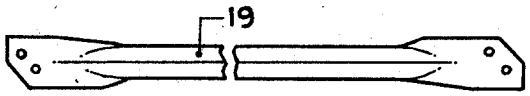



FIG. 11




FIG. 12




FIG. 13




FIG. 14

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METAL HANGAR OR SIMILAR BUILDING

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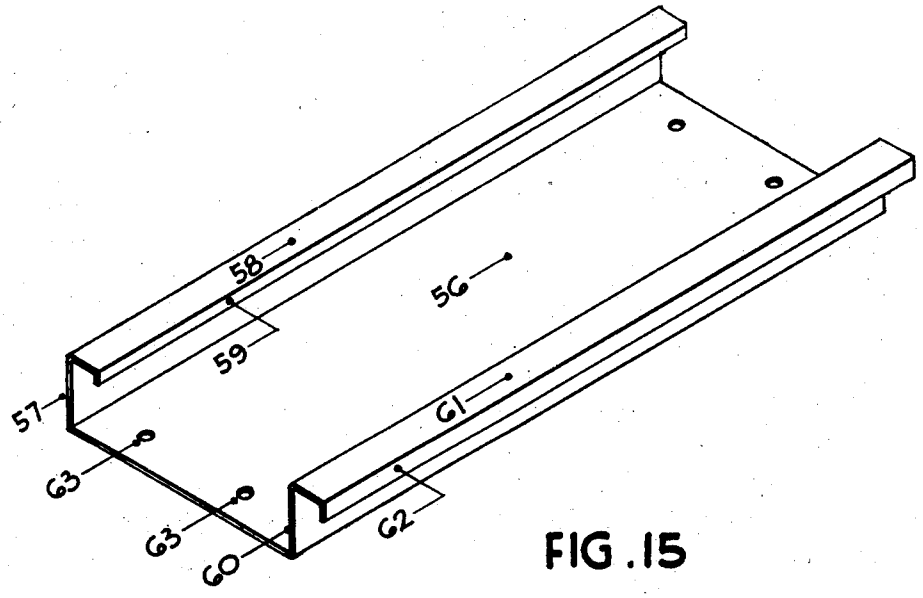



FIG. 15

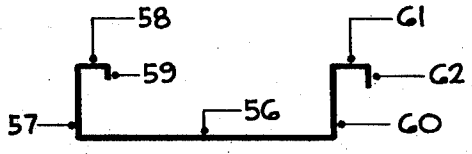



FIG. 16

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METAL HANGAR OR SIMILAR BUILDING

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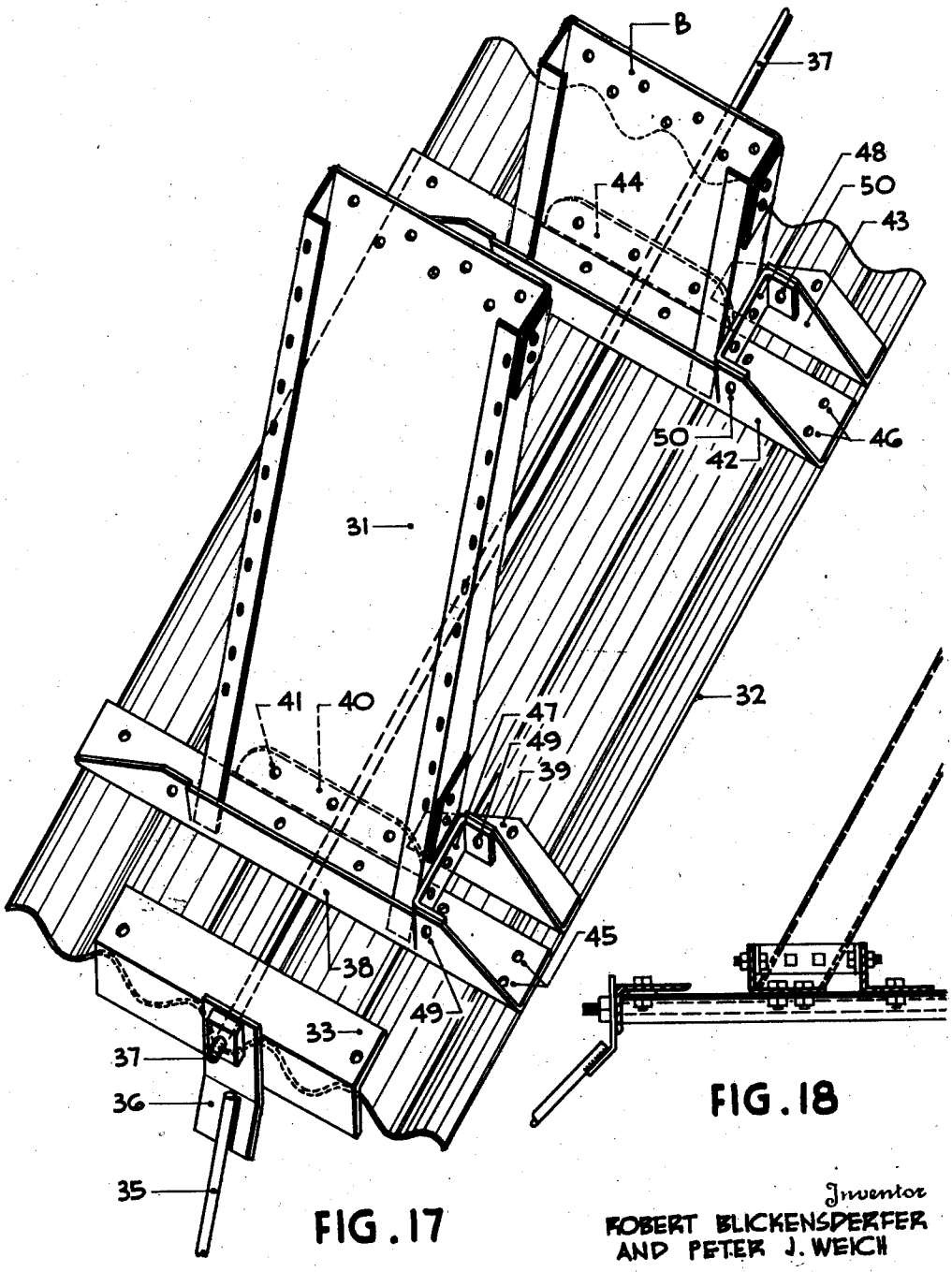



FIG. 17

FIG. 18

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METAL HANGAR OR SIMILAR BUILDING

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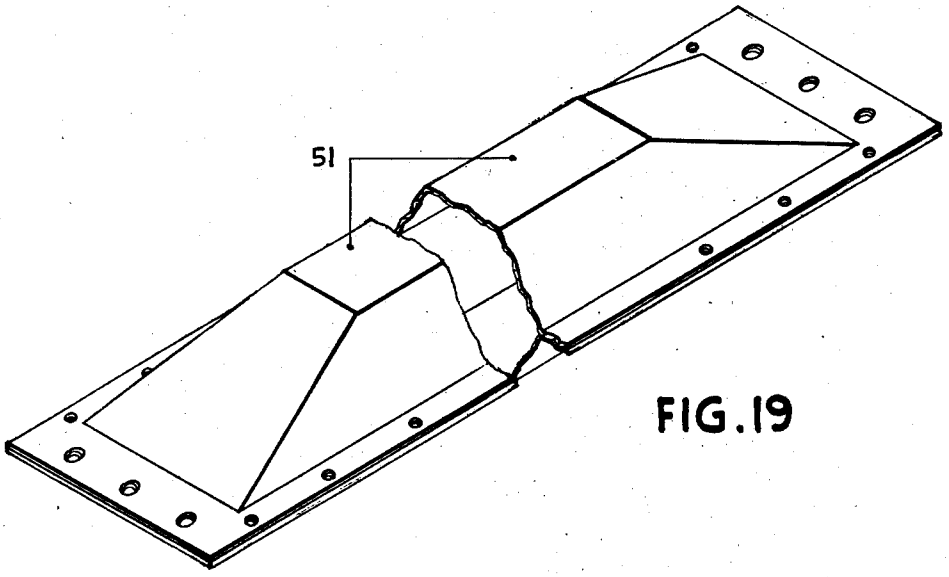



FIG. 19

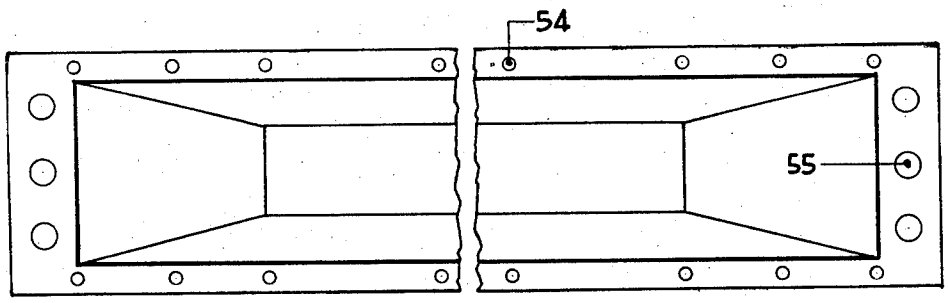



FIG. 20

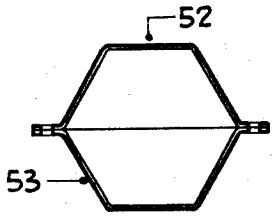



FIG. 21

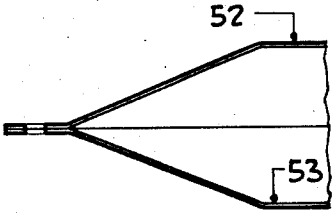



FIG. 22

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METAL HANGAR OR SIMILAR BUILDING

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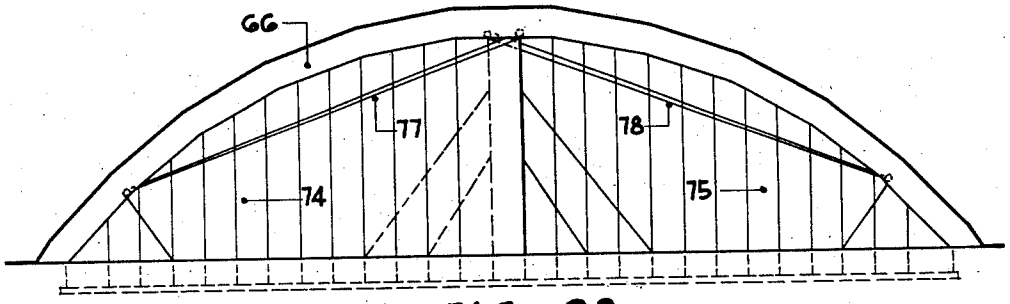



FIG. 23

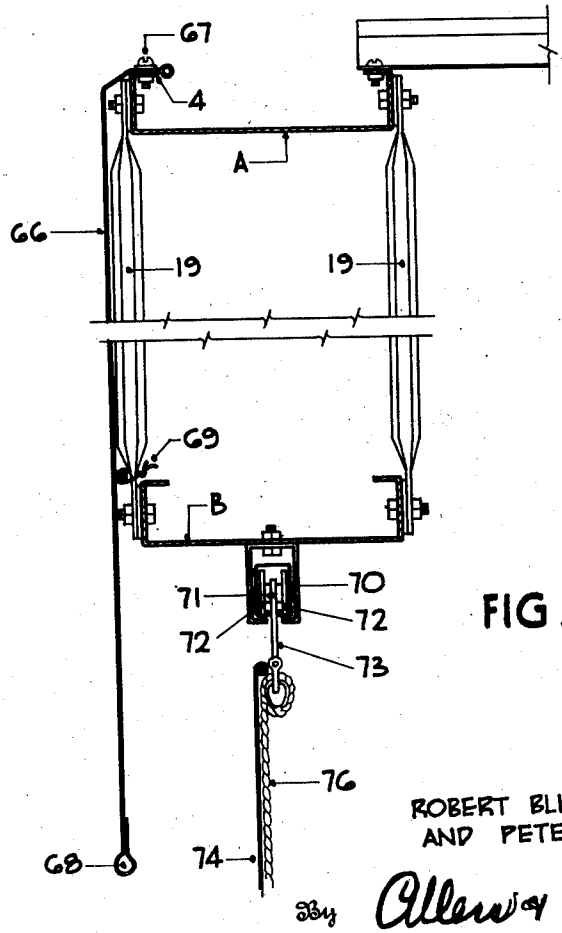



FIG. 24

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METAL HANGAR OR SIMILAR BUILDING

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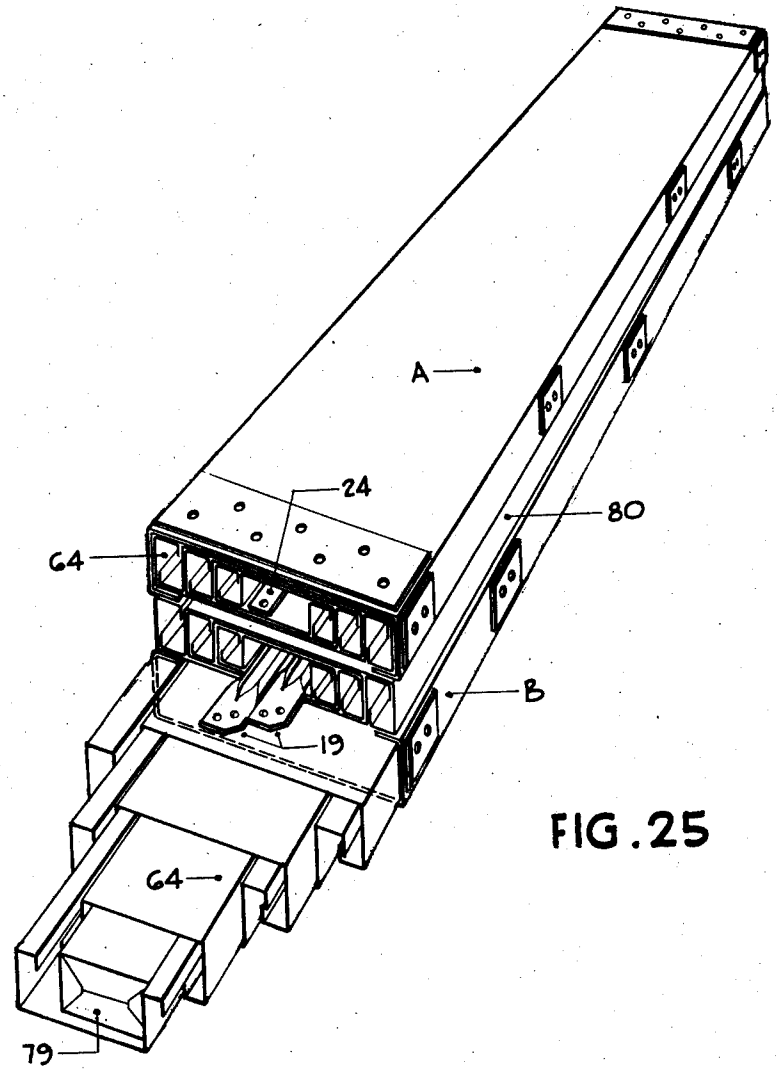



FIG. 25

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Patented May 7, 1946 2,399,785

# UNITED STATES PATENT OFFICE

2,399,785

## METAL HANGAR OR SIMILAR BUILDING

Robert Blickensderfer, Foster, and Peter J. Welch, Middletown, Ohio, assignors to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

Application August 13, 1943, Serial No. 498,494

18 Claims. (Cl. 108—1)

The principal object of our invention is the provision of a new type of building structure, especially one having a wide roof span and suitable for use as a hangar for aircraft or for other uses requiring a building of the general type herein described. One of our objects is to provide such a building so designed and constructed that it may be made of standardized fabricated elements at relatively low cost. It is an object of our invention to provide a building structure which, exclusive of bolts, rods and similar fittings, may be made from parts fabricated of sheet or plate metal, and therefore of relatively low cost.

It is an object of our invention to provide a type of building which can readily be erected in the field and which can likewise be readily demounted and moved to another place. It is an object of our invention to provide for the construction of a building from a minimum number of kinds of parts, which will be small in size and light in weight for the strength and span of the completed structure, and which will nest compactly for shipment, none of the assemblies being of undue dimensions or weight. All of these characteristics make for portability, which is especially important in the use of our structure for military purposes.

It is an object of our invention to provide a building in which the structural elements are relatively few in number because of the utilization of various structural elements for a plurality of purposes, as will hereinafter be set forth.

These and other objects of our invention which will be mentioned in the body of these specifications, or will be apparent to one skilled in the art upon reading them, we accomplish by that certain construction and arrangement of parts of which we will now describe an exemplary embodiment. Reference is made to the accompanying drawings wherein:

Figure 1 is a side elevation of a finished structure made in accordance with our invention.

Figure 2 may be regarded as an end elevation thereof with end closure members removed, or as an elevation of an erected arch.

Figure 3 is an isometric view of the end of a chord member.

Figure 4 is an end elevation thereof.

Figure 5 is an isometric view of the underside of a chord member showing certain reinforcement means.

Figure 6 is an isometric view showing a mode of joining chord members.

Figure 7 is a partial sectional view through two chords in process of being joined together.

Figure 8 is a perspective view showing an upper and lower chord member joined by latticing.

Figure 9 is an isometric view of the juncture of upper and lower chord members, connected by their respective lattices, the joint being cross braced. The view also shows the attachment of panel members to the arch.

Figure 10 is a sectional view across an upper chord member showing the attachment of panels thereto.

Figure 11 is a plan view of one of the lattice members, Figures 12, 13 and 14 being respectively an isometric view, a central cross section, and an end view thereof.

Figure 15 is an isometric view of one of the panels hereinabove mentioned, used to connect arches in the building and to form the roofing and siding of the structure.

Figure 16 is an end view thereof showing its cross sectional shape.

Figure 17 is an isometric view showing a base plate for the arch and the lower end of an arch attached thereto.

Figure 18 is a partial side elevational view of a base plate and the lower end of an arch.

Figure 19 is an isometric view of a lateral strut.

Figures 20, 21 and 22 are respectively a plan view, a central transverse section and a partial longitudinal section of the structure of Figure 19.

Figure 23 is an end elevational view of the completed building structure showing a canvas end closure.

Figure 24 is a transverse section taken through an end arch, showing an apron and a means for mounting the canvas closure.

Figure 25 is a perspective view showing the nestability of the various structural elements going to make up the building of our invention.

Briefly in the practice of our invention, we construct a building comprising essentially a series of spaced arches, and means connecting the arches and serving not only to maintain the arches in assembled relationship but also to furnish the siding or roofing for the building.

The arches are of wide span, and in the exemplary structure are supported on the ground by means of base plates hereinafter to be described. It will be evident in the light of teachings which follow that the bases of the arches could be supported away from the earth on walls, columns, or the like, if desired for any particular purpose. The exemplary embodiment herein described is a

hangar for military aircraft and, being for this purpose essentially a portable and relatively temporary structure, is designed so that its base plates may rest directly upon the earth. Dimensions are not limitations upon this invention; but by way of indicating suitable dimensions for a military hangar, we may say that we have constructed our arches with a span of 152 feet and a height to the bottom chord of 37 feet, and formed buildings from them which, being sectional as hereinafter described, can be made as long as desired.

The arches themselves are, in the exemplary embodiment, made up of top and bottom chord members for taking the tensile and compressive stresses. These members are channel shaped pieces formed of fabricated plate or sheet metal.

They are held together in proper spaced relationship by lattice members for taking the radial shear. The channel shaped chords are both open upwardly, and their respective length is such that when sections of joined chords are themselves joined together at their ends as hereinafter described and in sufficient number, the result will be an arch such as is illustrated in Figure 1. At the joints between assembled sections of upper and lower chords cross bracing is preferably employed.

The arches may be and preferably are fully assembled upon the ground. Base plates are suitably anchored or otherwise fastened in place on the earth or foundation, and the ends of the arch are hinged to these base plates while the assembled arch is still prone. Then by means of masts and tackle the arches can be raised to an upright or vertical position.

Depending upon the length of the building, a series of arches, spaced a desired distance apart, are thus assembled and erected, each on its own base plates. Then the arches are interconnected by fabricated sheet metal panel members. The panels are configured to have interengaging side edges; and their ends are bolted or otherwise fastened to the legs of the channel-shaped top chord member. The panels thus not only hold the erected arches in assembled relationship but they form a weather-tight span between the arches thus acting as siding or roofing for the building. Rainwater falling upon the panels is stopped by the upstanding interlocks at the panel side edges, and flows laterally, emptying from the panel ends into the channel-shaped top chord members. These members form a continuous gutter or channel along the whole length of the arch members; and rainwater is thus conducted along the arches down to the bases of the building. Here, in temporary structures of the type of the exemplary embodiment, the water strikes the arch base plates, flowing thence laterally, so that its force is spent, and undercutting of the base plates is avoided. All connections between the panels and the arches are on the outside of the building and are leakproof.

The base plates of different arches may themselves be initially connected by struts for proper spacing of the arches; and the arches themselves may be connected by lateral struts. In some of our buildings we employ three rows of lateral struts. In others, to resist heavy wind pressure, we may employ a larger number of bracing elements between two or more arches at the ends of the building. The panels themselves, however, act to maintain the arches upright and minimize the need for struts.

The ends of the building may be closed in any way desired; and it is within the purview of our invention to provide a permanent structural end closure, preferably using panels such as those hereinabove mentioned. For temporary or portable military structures, however, a canvas closure may be employed as hereinafter set forth.

Our buildings, being made of standardized parts which nest for shipment as hereinafter described, are readily transported. They may be readily set up in the field without the use of special tools other than simple means for grading the earth (where that may be necessary), tackle to raise the arches, and means for tightening the bolts or other fasteners which are employed. Our buildings may be readily demounted, readily repacked, readily shipped to another location, and there as readily assembled again. The salvage in our structures is complete, except for calking compound where that may be used.

Referring first to Figures 3, 4 and 5, the chord members of our arches are formed from fabricated sheet or plate stock bent to form a channel-shaped body having a web 1, flanges 2 and 3, and inwardly turned portions 4 and 5 at the ends of the flanges. At the ends of the channels the flanges may be perforated as at 6 to be bolted to joining plates hereinafter described. Also at intervals along the lengths of the flanges they are perforated at 7 for the attachment of lattice members hereinafter described. At both places, reinforcing plates 8 may be welded on to the channel flanges if desired. The end of the channel web is perforated as at 9 to receive splice plates; and at this point also the structure may be reinforced by a welded-on plate 10, as shown in the bottom view, Figure 5. The turned over portions 4 and 5 on the flanges of the channels are perforated at intervals throughout their length as at 11 for the reception of the panels by which one arch is connected to another.

As shown in Figures 6 and 7, two chord members, here generally indicated at A and A' may be joined together end to end by means of splice plates 12 and 13, one of which has been shown inside the channel and one outside, though there are instances when a single splice plate will suffice. The chord members A and A' are to be connected together in a slightly angular relationship, depending upon the radius of the arch, for which reason we employ splice plates which are slightly bent. They will have been fabricated in the factory, bent, and perforated with holes such as will match with each other and with the perforations 9 in the chord members when the assembly is effected, as in Figure 7. The assembled relationship may be maintained by bolts 14 or other suitable fasteners. The angular relationship of the chord members will further be maintained by connecting plates 15, suitably shaped as shown in Figure 6 and perforated with holes mating with the holes 6 in the flanges of the channel-shaped chord members. Bolts 16 or other fastening means are employed to hold the parts in place.

For added strength, and especially where the chord members are to sustain heavy compressive forces, the connecting plates 15 may have welded or otherwise attached to them wedge-shaped pieces of sheet or plate metal to lie between the adjacent ends of the flanges of the chord members. These wedges are preferably somewhat thicker than the metal in the chord members.

It may be noted that each of the connecting plates 15 has an ear 17 depending from one side,

located to one side of the center line of the connecting plate and bent to an angle with the plane of the plate. Each ear is perforated as at 18; and their purpose is to provide attachment means for cross ties or braces hereinafter to be described.

It will be seen that bolting together channel-shaped chord members A and A' in endwise relationship forms a continuous channel. The channel formed by the outer chord members will be employed for conducting water in the finished building. Hence, it is desirable that the channel so formed be water-tight or substantially so, though in some types of temporary structures complete water-tightness is not essential. The splice plate 13 is long enough to come out closely to the faces of the connecting plates 15. Perforated sheets of waterproofing material, such for example as asphalt saturated felt or paper, may, if desired, be laid between the chord members and the several splice plates and connecting plates. Or instead, and this is usually sufficient, calking compound may be employed to close all crevices through which water might leak, after the parts are in assembled relationship.

Each arch is made up of inner and outer chord members. Figure 8 illustrates a section of the arch comprising an outer chord member A such as has been described, and an inner chord member B similar in construction to the outer chord member excepting that, first, its length will be somewhat shorter depending on the radius of the arch, and second, the turned over portions 4a and 5a on the ends of the flanges of the channel B need not be perforated, since nothing will be attached to them. The chord members A and B are rigidly connected together and braced in spaced relationship by angularly disposed lattice members 19 bolted to A and B by bolts 20 passing through the perforations 7 in the flanges of the respective channels. It may be noted in Figure 8 that the chord members A and B, regarded as channels, face in the same direction, namely outwardly.

It is convenient to build up the structures shown in Figure 8 by attaching the chord members together endwise. We have already described how the outer chord members A are so attached. The inner chord members B are similarly attached to each other at their ends by the use of splice plates, one of which is indicated in Figure 9 at 22, and also by the use of connecting plates, one of which is indicated at 23. At each juncture of the structures of Figure 8 endwise we prefer to employ cross braces indicated at 24. These may be strap-like members cut from sheet or plate stock and bolted or otherwise attached at their ends to the ears 17 of the splice plates. The displacement of these ears to one side of the center line of the connecting plates permits the cross braces 24 to pass each other as shown in Figure 9. The cross braces 24 will function as tension members but could be given a cross sectional contour designed to impart stiffness to them, if desired.

The lattice members 19, however, must act to resist both compression and tension. They may be formed in a variety of ways, and may merely be fabricated sheet or plate metal channel members flattened at their ends. A preferred fabricated construction is illustrated in Figures 11 to 14 inclusive. Sheet or plate stock is bent to provide a hexagonal section as at 25 (Figure 13). Where the edges of the metal come together as at 26 the seam may be welded continuously or at intervals; or the metal at one face of the polygonal figure may be lapped and spot welded. The ends of the structure can then be flattened as at 27, in a press or otherwise. The flattened ends may be beveled at one corner as at 28 and provided with properly spaced perforations 29 for the reception of the bolts by means of which the lattice members are fastened to the chord members of the arches.

The structures of Figure 8 are successively assembled as described in connection with Figure 9 until a complete arch structure is produced such as that shown at 30 in Figure 2. The various structures of Figure 8 are all preferably standard in shape, construction and dimensions to simplify the erection of the building and the assembly of its parts; but since the completed arch 30 will ordinarily subtend less than the diameter of a full circle, short, outer chord members 31 may be employed at the ends of the arch to terminate the inner and outer chords in the same plane, namely at ground or foundation level, where that is desired.

As with the individual structures of Figure 8, the assembly of the entire arch member 30 is preferably accomplished upon the ground. Then the ends of each arch are attached to base plates, the construction of which will be understood from Figures 17 and 18. The body of each base plate consists of a heavy sheet or plate or metal 32 of elongated shape, somewhat wider than the width of each chord member and somewhat longer than the distance between chord members at the foot of the arch. For strength and stiffness the metal plate 32 is preferably corrugated as shown. At one end of the plate we bolt or otherwise fasten an angular member 33. For temporary buildings we drive or bury a suitable anchor in the ground for each base plate. Such an anchor is diagrammatically indicated at 34 in Figure 2; and in Figure 17 the anchor rod 35 is shown welded to a bracket 36 which in turn may be fastened to the member 33 by an arch tie rod or otherwise. It is advisable to tie together the base plates for each arch so as to prevent spread of the arches. The bolt 37 used to fasten the anchor bracket 36 to the member 33 may be an elongated, threaded rod lying in one of the valleys of the corrugated member 32. The tie may be made up of a series of rods connected together by means of sleeve nuts so as to form a rod of the required length. Or a steel cable may be employed in connection with eye bolts at the base plates for each arch. The cable may be cut to length in the factory and fastened to the eye bolts. Other means for tying together the base plates of each arch may be employed.

For buildings of a more permanent character the base plates 32 may be bolted or otherwise fastened to concrete or masonry foundations, walls, columns or other structural members, as will be readily understood.

For the reception of the end of the outer chord member 31, we fasten to the base plate 32 an angular member 38 having a portion 40 disposed to the base plate at the same angle at which the outer chord member 31 will eventually be disposed to the base plate and spaced from the upstanding, vertical part of the angle 38 substantially the thickness of the chord; and the member 40 is provided with perforations 41 so that it may be ultimately bolted to the end of the chord member 31. Similarly for the inner chord member B the base plate bears an angular

member 42 having a spaced part 44 for attachment to the inner chord member when the arch shall have been erected. Adjacent end portions of the angular members 38 and 42 we provide angular parts 39 and 43 as shown.

In laying out the building, a series of base plates will be installed in spaced relationship down each side of the proposed structure. It is helpful to fasten the base plates in each series together by tie bars which are hereinafter described. The tie bars are not illustrated in Figure 17; but they may be attached to the base plate 32 by bolts passing through perforations 45 or 46 as indicated.

An entire arch will have been assembled while prone upon the ground. An angularly shaped hinge member 47 or 48 (Figure 17) will have been bolted or otherwise attached to one of the flanges of the chord members 31 and B. Before attempting to erect the arch, it is moved so that the hinge members 47 and 48 can be brought respectively between the angular parts 38, 39 and 42, 43 on the base plate, whereupon the hinge members 47 and 48 are bolted to these other parts by bolts passing through perforations 49 and 50 common to the hinge members and the angular parts on the base plate. The arch is now hinged at its ends to its respective base plates; and the base plates are firmly anchored. Therefore, as by means of a mast and tackle, the arch may now be raised into the vertical position illustrated in Figure 2, after which the chord 31 can be bolted to the member 40 and the chord B bolted to the member 44. Parts 47, 39, 48 and 43 are now removed and are reused for subsequent arches.

The tie members between laterally spaced base plates referred to hereinabove, may have a construction similar to the construction of the lattice members illustrated in Figures 11 to 14. Or they may be merely fabricated, channel-shaped pieces of sheet or plate metal. Yet another construction for them is shown in Figures 19 to 22 where each tie member 51 is formed of two pieces 52 and 53, embossed, stamped or drawn to have a central cross section of half a polygonal figure such as a hexagon, being flat at their ends, and having flat, laterally extended flanges. These flanges are bolted or riveted together as at 54 providing a strong structural member. Perforations 55 at the ends of the member are employed in attaching it to the base plate. The various arches of the building may be tied together at intervals throughout their extent by similar tie members if desired. The use of three continuous rows of bracing ties between arches is usual with us. The panel members hereinafter to be described also rigidify the structure, while being slightly elastic so that various base plates in many instances can be set upon ground which is not completely flat or has not been accurately leveled.

When at least a pair of parallel arches have been erected, we attach such struts (Figure 19) as are to be employed, and then we fasten in place the panel members which are illustrated in an exemplary embodiment in Figures 15 and 16.

The panel members which we prefer to employ are those described in Patents Nos. 1,925,417 and 2,148,434 in the names of J. W. Swank and R. M. Calkins et al. and have hitherto been employed in the construction of buildings. They consist of a piece of sheet metal 56, the edges of which are turned upwardly to form an interlocking structure whereby the sheets may be fastened together in side-by-side relationship. Thus at one side of the sheet 56 a portion is turned upwardly as at 57 to form a channel leg, then inwardly as at 58 and downwardly as at 59. At the other edge of the sheet a portion is turned upwardly as at 60, outwardly as at 61 and downwardly as at 62. The width dimensions of the parts 60, 61 and 62 are slightly greater, by approximately the thickness of the sheet itself, than the corresponding parts 57, 58 and 59 at the opposite sheet edge. Thus, in joining sheets in side-by-side relationship, the parts 57, 58 and 59 or one sheet lie inside and make a relatively tight engagement with the parts 60, 61 and 62 of the next sidewise sheet. The ends of the panel are perforated with a series of spaced holes 63 corresponding in spacing with certain holes 11 in the parts 4 and 5 of the upper chord members. The panels may be of relatively thin gauge sheet material, since they are stiffened by the bent interlocking members at their edges. They may be formed of stainless steel or any other suitable material; but for economy are preferably formed of iron or mild steel, galvanized for protection against corrosion. They may also be painted, if desired.

The length of the panels is chosen in accordance with the distance between the arches in the finished building; and Figures 9 and 10 illustrate the manner in which the panels are attached to the inturned portions 4 and 5 of the upper chord members A of the arch. In these figures the panels themselves are indicated at 64, and may be held in place by bolts 65 or other suitable fastening means. The interlock between the edges of the panels forms a watertight joint at that point, and if desired, a strip of waterproofing material may be laid beneath the panels where they join the chords of the arch, or calking or other means may be employed. Water falling upon the panels runs laterally and empties into the upper chord section of the arches, thence running down the arches to the base plates thereof. The panels extend laterally between the arches serving not only to maintain the arches in spaced relation and in upright position but also to furnish siding and roofing for the building itself.

We are not limited to the use of the particular panels shown since other types of panels and even panels of other materials will serve, as well as sheet metal panels having specifically different side interlocks. While the holes 11 in the portions 4 and 5 of the upper chord members have a uniform spacing, and while the holes 63 in the panel sections have the same uniform spacing, it is advantageous to make the panels themselves of different widths (which are multiples of a given dimensional unit). The formation of the panels in different widths permits a more advantageous nesting during shipment, as will hereinafter be more fully described. Three widths of panels are ordinarily provided by us for reducing cubage. Reducing the average width of panels increases strength, and permits the use of lighter gauge sheet materials.

As hereinabove indicated, any suitable end closure may be provided for our building. But for temporary structures a canvas closure arrangement is advantageous and highly portable. Such a closure is illustrated in Figures 23 and 24. To the outer edge portion 4 of the upper chord members A of the end building arch, we attach a depending canvas valance 66 as by bolts 67. The lower edge of this apron may be reinforced further with rope 68 sewn in a sleeve or hem. To minimize flapping, the valance may be tied at intervals to the lattice members 19 adjacent the lower chord member B as at 69.

To the lower chord members B we bolt a trackway 70 of generally channel shape with inturned edges. Within this trackway a series of small carriages 71 having wheels 72 riding on the trackway and provided with depending hangers 73 or the like, are positioned. End closure curtains 74 and 75, reinforced at intervals (preferably along the seams) with rope as at 76 are suspended by means of these ropes to the depending hangers 73. The curtains are so dimensioned as to lap at the center of the end of the building when they are drawn together. Ropes 77 and 78, passing over pulleys may be employed to draw the curtains apart and to draw them together, as will readily be understood.

One of the advantages of the particular standardized building construction which we have disclosed in the manner in which the parts nest together for shipment. The inner and outer chord members form box-like structures in which a plurality of the panel members 64 can be nested as shown in Figure 25. In the central space can be such members as the cross ties 24, the lattice members 19, the tie rods, packages 79 of bolts and nuts, canvas ropes, eye bolts, steel cable and other fittings. A pair of the chord members A and B when thus packed with other elements can be opposed, with or without one or more intermediate nested assemblies 80 of elements. The chord members, being usually of heavy plate iron or mild steel, protect the other contents of the package and it is usually necessary only to pass bands or other fastening means about the package so formed to complete the package for shipment. A band passed longitudinally around the package will usually serve to prevent endwise displacement of the nested elements. For most purposes such a package will be sufficient, but for export shipment or handling in areas of damp or corrosive climate, if additional wrapping is required, it may readily be applied and is facilitated by the rectangular shape of the assembly and its lack of substantial projections.

In a side view of our erected structure, as indicated in Figure 1, spaced channels formed by the upper chords of the several arches are apparent at 81 while between them extend the assemblies 82 of the panel members. Our buildings can be designed for a variety of arch shapes, spans and heights, as will be evident; and because of their sectional nature the length of the structures may be made as great as desired by simply adding more sections, each comprising an arch, the properly anchored base plates, and an assembly of the panel structures. For temporary buildings for military aircraft, it will be sufficient usually to bank earth along the lower edges of the lowermost panel sections; but in more permanent structures a watertight engagement of the lowermost panel sections with a suitable permanent foundation can be effected.

Modifications may be made in our invention without departing from the spirit of it as will be clear in the light of the teachings herein. The chord members, instead of having rectilinear axes, may be themselves curved to fit the curvature of the arch. This is entirely possible because the panel members have little lateral stiffness and are capable of curving laterally quite readily to conform to arcuate inturned portions on the flanges of the chords. The manufacture of curved chords, from a fabricating standpoint, is quite feasible, and may in instances produce a building having a better appearance. The curving of the chords, however, renders impracticable much of the nesting of parts, as above described, so that in instances where cubage is of prime importance, it will not be practiced.

While we have described a hangar for military aircraft as an exemplary embodiment of our invention, the principles herein set forth are applicable to other buildings, many of them of much less size, and having a wide range of industrial and other uses. Where the arch span is not too great, the inner set of chords together with the lattices and the cross-ties may be eliminated. Thus, by way of example, in a building for expositions or fairs or certain industrial uses, arches may be made up having but a single set of chords, i. e., the outer ones, the arch having a span of say 40 feet and the building having inside clear height of 16½ feet, the arches for that building would have each 7 chords connected together endwise as described, with the open sides of their channels turned outwardly, and associated with the panels as hereinabove described. Such buildings will usually be erected on permanent foundations; and they will usually have permanent ends, which can be constructed, as desired, from panels such as we have herein described and such as are referred to in the patents mentioned hereinabove. These panels may be fastened together as set forth in those patents; and the end wall sections thus formed may be engaged in their upper arches in downwardly facing channels of the proper width bolted to the undersides of the chords in the end arches, while the lower ends of the end wall sections may be engaged in channels bolted to the foundation. Such end wall sections may be provided with permanent doors and windows, and louvered or ventilation openings in ways known to the art.

Again it is possible to provide those panels which make up the roofing and arch-siding of our structures with windows to whatever extent may be desired for the uses to which the building will be put. This may be accomplished in a variety of ways, but a simple way of doing it is to provide a window opening in selected panels, a glass or other translucent pane somewhat larger than the opening and a hollow rim with depressed edges somewhat larger than the pane, which edges can be screwed or bolted to the bodies of the panels. Putty or calking compound may be employed to seal such openings as might otherwise be about the edges of the panes.

Needless to say our buildings may be finished in any manner desired, and where they are to be of permanent character, they may be provided with such insulation and interior trim as circumstances warrant. One of the valuable aspects of our invention is that the principles herein taught enable us to produce an adequately strong building of relatively large floor space and head room which nevertheless, as compared with other building structures, is exceptionally economical.

The specific form of the fabricated sections can be changed as will be evident, and in instances other than fabricated sections can be employed. By a "fabricated" part or section we mean one produced from sheet or plate metal by operations inclusive of bending, shearing, pressing, punching, drilling, and the like, as distinguished from sectional shapes directly produced as by rolling in the case of beams, or casting or forging or the like in the case of other members. Our invention, however, is inclusive of the use of members otherwise formed than by fabricating operations, or of both fabricated and non-fabricated parts; though we prefer the fab-

ricated parts where possible for their economy, ease of manufacture without special equipment, and relatively light weight for their strength.

Having thus described our invention in an exemplary embodiment, what we claim as new and desire to secure by Letters Patent is:

1. In a building construction, a plurality of structural arches in substantially parallel relationship and substantially vertically disposed, and means connecting said arches laterally and constituting the primary means for maintaining said arches in vertical, parallel relationship, said means comprising sheet metal, panel-like members having edge-to-edge interlocking means, said structural arch members presenting at their surfaces means forming a continuous channel along the arch, and said interlocking means forming upstanding elements at the edges of said panels, so that rain water falling on said panels, is delivered in directions longitudinally thereof to said channels, and flows down said arches in said channels.

2. A building having essentially an arch shaped cross section and which, exclusive of its end closure members, comprises essentially a plurality of arches in parallel upright relationship and sheet metal panel-like members connecting said arches one to another, forming a continuous watertight span between the said arches, the said arches being tied across at their ends, and the said panel-like members constituting the primary means for maintaining said arches in upright position, each arch being formed of a set of channel shaped members constituting chords, said members having their open sides disposed outwardly, and being connected together at their ends, the said chords being straight, longitudinal, and connected at their ends in an angular relationship by means including laterally disposed connecting plates joined to the flanges of said channel-shaped chords, and of sufficient length and strength to brace said cords in their angular relationship.

3. A building having essentially an arch shaped cross section and which exclusive of its end closure members, comprises essentially a plurality of arches in parallel upright relationship and sheet metal panel-like members connecting said arches one to another, forming a continuous watertight span between the said arches, the said arches being tied across their ends, and the said panel-like members constituting the primary means for maintaining said arches in upright position, each arch being formed of inner and outer channel-shaped members constituting chords, said members being connected together in spaced relationship by diagonally disposed structural lattice members, said inner and outer chord members being of different lengths whereby the arch shape is produced.

4. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions.

5. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially watertight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the ends thereof.

6. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially watertight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the foot thereof, the places of juncture between respective inner chord members and between respective outer chord members having a bracing characterized by crossed ties.

7. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially watertight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the ends thereof, the places of juncture between respective inner chord members and between respective outter chord members having a bracing characterized by crossed ties, each arch having at its ends a base comprising a broad plate, means for anchoring the plate and means for attachment of the arch end thereto.

8. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially watertight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the ends thereof, the places of juncture between respective inner chord members and between respective outer chord members having a bracing characterized by crossed ties, each arch having at its ends a base comprising a broad plate, means for anchoring the plate and means for attachment of the arch end thereto, said last mentioned means comprising means whereby the arch end can be hinged to the base while the arch is in horizontal position, whereafter the arch may be raised to vertical position, pivoting on the said bases.

9. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially water-tight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the ends thereof, the places of juncture between respective inner chord members and between respec-

tive outer chord members having a bracing characterized by crossed ties, each arch having at its ends a base comprising a broad plate, means for anchoring the plate and means for attachment of the arch end thereto, said last mentioned means comprising means whereby the arch end can be hinged to the base while the arch is in horizontal position, whereafter the arch may be raised to vertical position, pivoting on the said bases, and means for tying the bases of an arch to each other to prevent spread of the arch.

10. The structure claimed in claim 3 wherein the outer chord members at least provide inturned portions at the open side of the channel, said panel members being attached at their ends to said inturned portions, said outer chord members being connected endwise with a substantially water-tight joint, and said panel members having side interlocks of upstanding character whereby rainwater falling on said panel members will be delivered longitudinally thereof to the channels of said arches, flowing downwardly therethrough along the arch to a place of delivery at the ends thereof, the places of juncture between respective inner chord members and between respective outer chord members having a bracing characterized by crossed ties, each arch having at its ends a base comprising a broad plate, means for anchoring the plate and means for attachment of the arch end thereto, said last mentioned means comprising means whereby the arch end can be hinged to the base while the arch is in horizontal position, whereafter the arch may be raised to vertical position, pivoting on the said bases, and means for tying the bases of an arch to each other to prevent spread of the arch, the bases of adjacent arches being attached together by tie means capable of resisting thrust.

11. A structural arch for building purposes comprising inner and outer, formed, sheet or plate metal members in the shape of channels, each having a web, upstanding flanges and inturned portions on the upstanding flanges, the outer chord members being of greater length than the inner chord members, the outer and inner chord members, in pairs, being fastened in spaced relationship by means of formed sheet or plate metal, diagonally disposed lattice members, said members being bolted at their ends to the flanges of the respective chord members, the said chord members being attached at their ends to other chord members of the same series and in angular relationship by means of angular splice plates bolted thereto, the flanges of the chord members of the two series being connected together by connecting plates having ears thereon, and a cross bracing at each such joint being formed by cross ties bolted respectively to the ears of the inner and outer connecting plates aforesaid.

12. A structural arch for building purposes comprising inner and outer, formed, sheet or plate metal members in the shape of channels, each having a web, upstanding flanges and inturned portions on the upstanding flanges, the outer chord members being of greater length than the inner chord members, the outer and inner chord members, in pairs, being fastened in spaced relationship by means of formed sheet or plate metal, diagonally disposed lattice members, said members being bolted at their ends to the flanges of the respective chord members, the said chord members being attached at their ends to other chord members of the same series and in angular relationship by means of angular splice plates bolted thereto, the flanges of the chord members of the two series being connected together by connecting plates having ears thereon, and a cross bracing at each such joint being formed by cross ties bolted respectively to the ears of the inner and outer connecting plates aforesaid, the said lattice members being formed sheet or plate elements of polygonal cross section and having flattened ends.

13. A structural arch for building purposes comprising inner and outer, formed, sheet or plate metal members in the shape of channels, each having a web, upstanding flanges and inturned portions on the upstanding flanges, the outer chord members being of greater length than the inner chord members, the outer and inner chord members, in pairs, being fastened in spaced relationship by means of formed sheet or plate metal, diagonally disposed lattice members, said members being bolted at their ends to the flanges of the respective chord members, the said chord members being attached at their ends to other chord members of the same series and in angular relationship by means of angular splice plates bolted thereto, the flanges of the chord members of the two series being connected together by connecting plates having ears thereon, and a cross bracing at each such joint being formed by cross ties bolted respectively to the ears of the inner and outer connecting plates aforesaid, the said lattice members being formed sheet or plate elements of polygonal cross section and having flattened ends, the said arch construction having, at its end portions, shorter chord members to bring the ends of the inner and outer series of chord members to a common plane at the ends of the said arch.

14. A structural arch for building purposes comprising inner and outer, formed, sheet or plate metal members in the shape of channels, each having a web, upstanding flanges and inturned portions on the upstanding flanges, the outer chord members being of greater length than the inner chord members, the outer and inner chord members, in pairs, being fastened in spaced relationship by means of formed sheet or plate metal, diagonally disposed lattice members, said members being bolted at their ends to the flanges of the respective chord members, the said chord members being attached at their ends to other chord members of the same series and in angular relationship by means of angular splice plates bolted thereto, the flanges of the chord members of the two series being connected together by connecting plates having ears thereon and a cross bracing at each such joint being formed by cross ties bolted respectively to the ears of the inner and outer connecting plates aforesaid, the said lattice members being formed sheet or plate elements of polygonal cross section and having flattened ends, the said arch construction having, at its end portions, shorter chord members to bring the ends of the inner and outer series of chord members to a common plane at the ends of the said arch, in combination with a base for each end of the arch, said base comprising a broad metal plate forming an adequate bearing surface for the ends of the arch, and means fastened thereto to which the ends of said arch can be fastened.

15. In combination, an arch having inner and outer chord members and a base comprising a broad, flat metal plate, upstanding means on said plate to which the inner and outer chord members of said arch can be attached, and means

for hinging the inner and outer chord members of said arch to said base while said arch is in a prone position so that said arch may be raised to a vertical position, pivoting on said base, whereafter it may be attached to said first mentioned attaching means.

16. The structure claimed in claim 12 including at its ends a trackway fastened beneath the inner chord members of the end arches, means riding in said trackway for supporting flexible end closure members, flexible end closure members supported thereby, and means for causing movement of the supporting means along said trackway whereby to open and close the ends of said structure.

17. The structure claimed in claim 12 including at its ends a trackway fastened beneath the inner chord members of the end arches, means riding in said trackway for supporting flexible end closure members, flexible end closure members supported thereby, and means for causing movement of the supporting means along said trackway whereby to open and close the ends of said structure, and an apron at each end fastened to the upper chord members of the end arches and depending therebelow beyond the inner chord members of the end arches.

18. In a building a series of upstanding arches each formed of a series of outwardly open channel-shaped members connected together, each arch having sufficient strength, when supported in such manner that its bases can not spread, to maintain an upright position without interior columnar supports, the said arches being interconnected laterally by means forming roofing and siding; said means being connected respectively to the flanges of the channel-shaped arches, leaving the channel-shaped arches open outwardly, and means in connection with said roofing and siding means to divert laterally water falling thereon, and to cause said water to enter said channels.

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