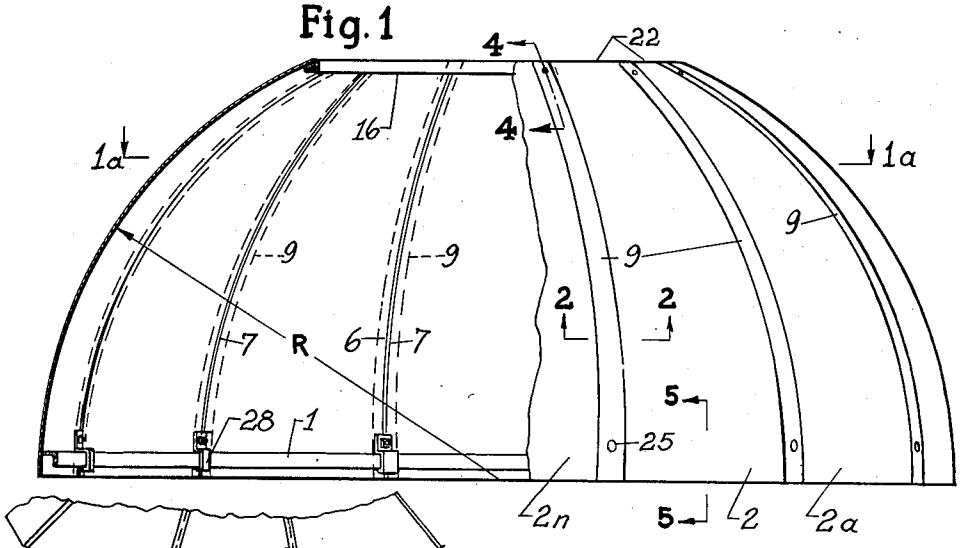
Jan. 15, 1952 R. STEMMONS ET AL 2,582,723

DOME SHAPED ROOF

Filed March 10, 1948 3 Sheets-Sheet 1

Fig. 1



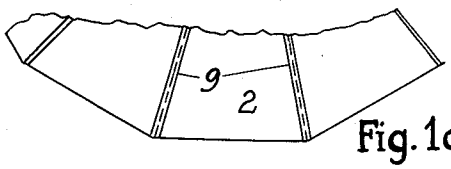


Fig. 1a

Fig. 3

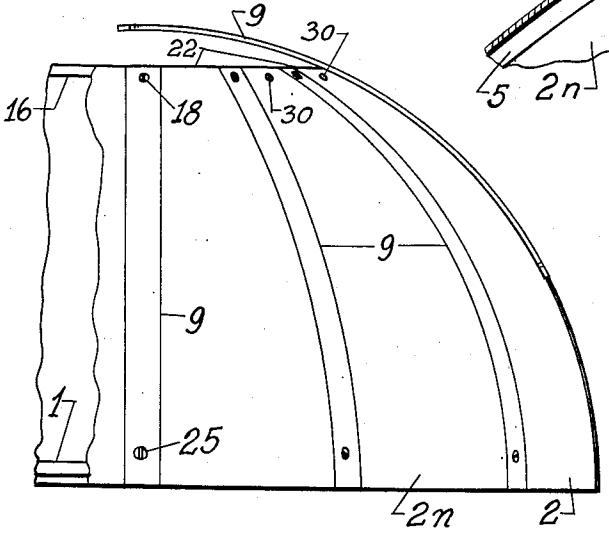


Fig. 4

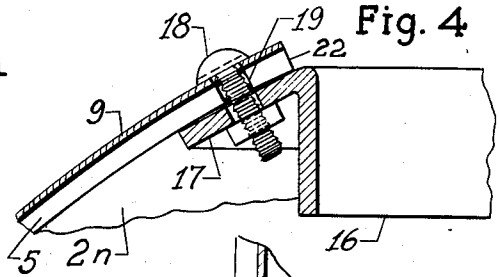


Fig. 5

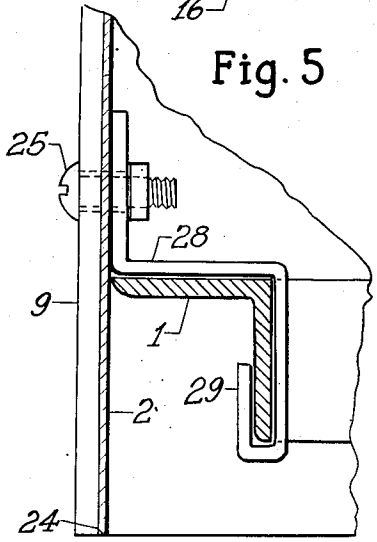
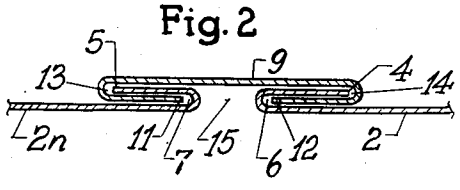


Fig. 2



INVENTORS
Walter L. Edel
Robert Stemmons

BY Arthur J. Robert

ATTORNEY

Jan. 15, 1952 R. STEMMONS ET AL 2,582,723

DOME SHAPED ROOF

Filed March 10, 1948 3 Sheets-Sheet 2

Fig. 7

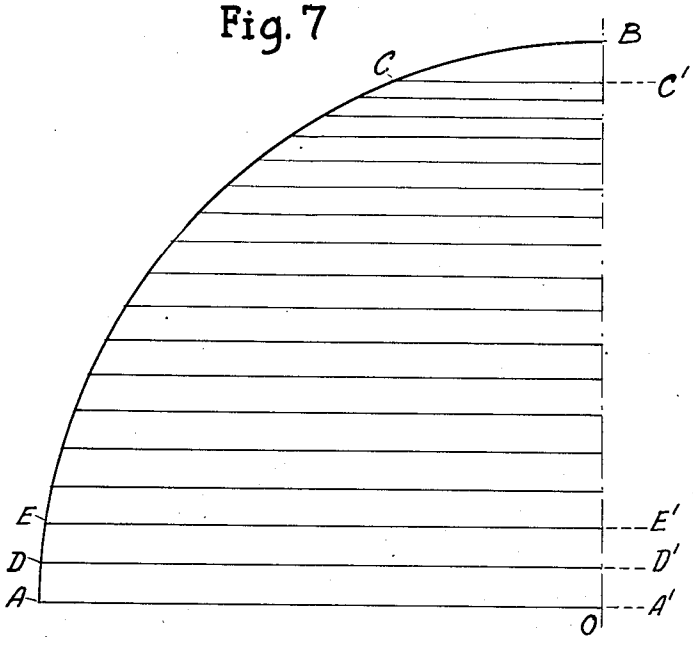


Fig. 6

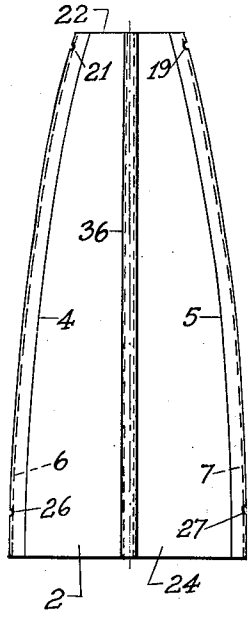


Fig. 8

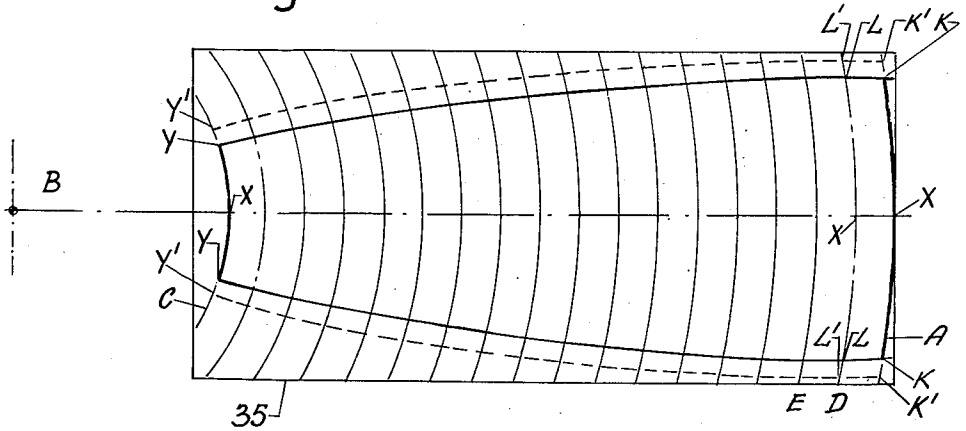


Fig. 14

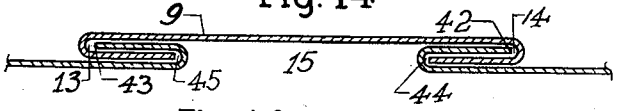
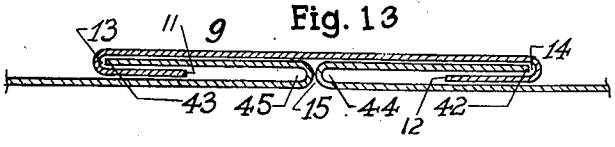


Fig. 13



INVENTORS
Walter L. Edel
Robert Stemmons

BY

ATTORNEY

Jan. 15, 1952 R. STEMMONS ET AL 2,582,723

DOME SHAPED ROOF

Filed March 10, 1948 3 Sheets-Sheet 3

Fig. 9

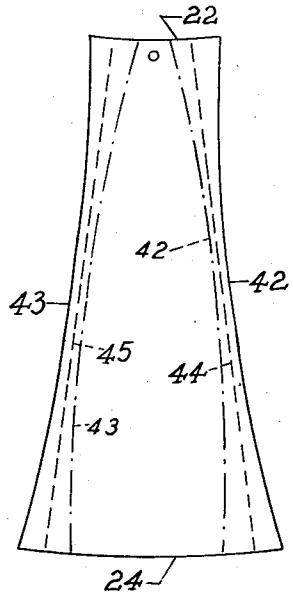


Fig. 10

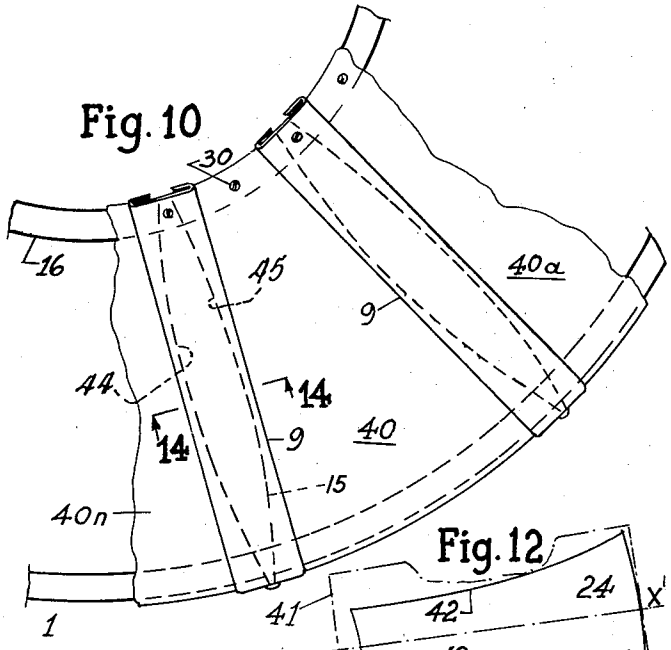


Fig. 12

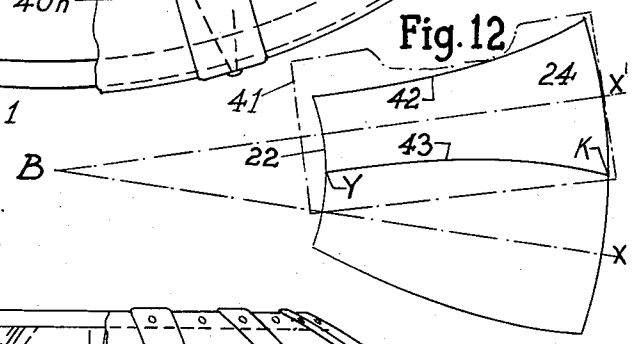
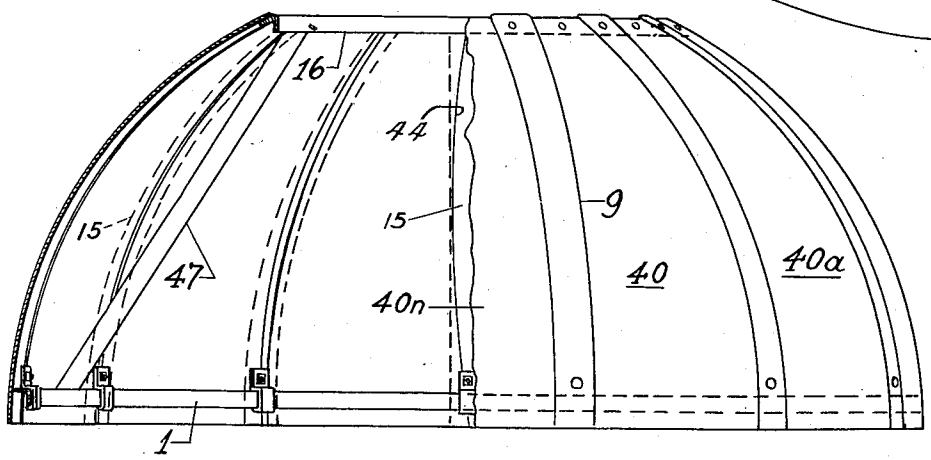


Fig. 11



INVENTORS
Walter L. Edel
Robert Stemmons

BY Arthur J. Robert

ATTORNEY

Patented Jan. 15, 1952

2,582,723

UNITED STATES PATENT OFFICE

2,582,723

DOME-SHAPED ROOF

Robert Stemmons, Middletown, Ohio, and Walter L. Edel, Louisville, Ky., assignors to Clayton & Lambert Manufacturing Company, Louisville, Ky., a corporation of Delaware

Application March 10, 1948, Serial No. 14,035

10 Claims. (Cl. 108—32)

1

This invention relates to sectional dome shaped roofs employed in constructing silos and other small buildings, and relates in particular to roofs of the pseudo-spherical type.

A dome or spherical shaped roof possesses great rigidity because of the curvature of the roof plates, but entails difficulties in installation. A true hemispherical dome can be made from flat sheets only by an expensive drawing or like operation to curve the sheet in two planes. To eliminate the expense of the drawing operation it has been proposed to construct pseudo-spherical domes of cylindrical curved tapered segments. A roof so constructed is not a true sphere, although it is generally designated as spherical. Such a pseudo-spherical roof is exemplified by Patents Nos. 2,092,722 to Bangert; 2,151,234 to Rutten et al.; 2,176,712 to Hanson and 2,187,616 to Cowin.

Pyramidal roofs have been constructed of triangular sections hooked along the edges and united by an interlocking C-shaped strip slideable along the hooked edges, as for example, in Patent No. 953,827 to Haas. However, this construction has not been employed in dome-shaped roofs, which generally are held assembled by a more complicated structure. Thus, for example, Bangert, supra, employs overlapped flat roof segments secured together and to internal separate ribs by a multiplicity of bolts passed therethrough and through overlapping strips which seal the joints between segments. His construction requires a relatively long time for assembly because the large size sheets make them awkward to manipulate to secure registration of the bolt holes, and the insertion and tightening of the numerous bolts unduly increases the time required for assembling the roof. Cowin or Hanson employs roof plates with channeled overlapping edges and internal ribs held together by a multiplicity of bolts along the ribs. The insertion and tightening of the bolts in this construction also is time consuming and is difficult. Rutten et al. employs flanged plates and inverted channel members bolted to and overlying adjacent plates. All the above pseudo-spherical structures embody a multiplicity of parts and the structures require considerable time to be assembled.

It is an object of the present invention to provide a dome-shaped roof structure of prefabricated parts, which is of simple construction and which can be assembled at the site in a relatively short time.

A further object is the provision of a dome-shaped roof structure composed of a plurality of segments which are held assembled by a readily attached clamp strip.

2

A further object is the provision of a dome-shaped roof structure composed of a plurality of segments having channeled edges, the edges of the segments being formed substantially parallel to a great circle.

In accordance with the present invention there is provided a dome-shaped roof composed of a plurality of segments each having hooked or reverse channel edges on the outer or convex surface thereof, so formed that after the sheet is bowed in the curvature of the dome, the extreme bent over or free edges of the sheets lie substantially parallel to a great circle of a sphere. Adjacent roof segments preferably are tied together by a curved double channel locking strip, substantially C-shaped in cross section, interlocked with the channels on the edges of the segments. In assembly, the locking strip is applied to one end of the channels of a pair of adjacent roof segments, and is forced lengthwise over the adjacent hooked channel edges of the segments to hold them in assembled relation. The locking strips then are secured against accidental removal in any suitable manner.

The end portions of each segment preferably are cut on curves so that when the segments are assembled in bowed relation, the lower or wider ends conform substantially to the equatorial circle of a hemisphere, and the curvature of the upper or smaller ends are such as to correspond substantially to a small circle parallel to the equatorial circle. The upper ends are secured to a flanged annulus of suitable diameter, and the lower ends are secured to a flanged ring on the wall structure, preferably by clips which are secured to the roof segments engaging the top of the ring and hook under the flange.

It is not necessary that the bottoms of the channels of the roof segments conform accurately to a great circle. In some instances, departure from a great circle is desirable to allow for aberrations in the silo structure although too great a variation from a great circle makes the roof difcult to assemble. The bottoms of the channels of adjacent segments are held in position by engagement with the C-shaped locking strip which covers the joint and makes it weatherproof.

In laying out the roof segments from flat sheet stock, the number of segments or sections being predetermined, the flat stock is cut to form a segment whose longitudinal or free edges are properly curved. When these edges are properly

curved and the margins forming them are folded over, such free edges remain curved. However, when the segment is now bowed, the free edges form arcs parallel to a great circle. When the edges are laid out on a convex curve which is substantially the development of a quarter circle on a flat surface, the edges are parallel to the developed great circle and are bent so that the bottoms of the channels conform substantially to a great circle. When laid out on a negative concave curve and the edge portions are bent on a straight line, the channel bottoms of the sheet depart considerably from a great circle, although the bent over edges lie parallel to a great circle. If desired, one edge can be cut convex and the other edge negative or concave so that when the edges are bent over and the segments are assembled, a considerably reduced gap is provided as compared to the structure where the edges are all laid out on a negative or concave curve.

The invention will be described in greater detail in connection with the accompanying drawing wherein Figures 1–8 disclose one embodiment of my invention and Figures 9–14 another embodiment, and wherein:

Figure 1 is a side elevation with parts broken away showing a roof constructed according to the present invention,

Figure 1*a* is a section taken on line 1*a*—1*a* of Figure 1,

Figure 2 is a section taken on line 2—2 of Figure 1,

Figure 3 is a fragmentary side elevation illustrating the mode of assembling the roof,

Figure 4 is a fragmentary section taken on line 4—4 of Figure 1,

Figure 5 is a fragmentary section taken on line 5—5 of Figure 1,

Figure 6 is a side elevation of a curved roof segment embodying my invention and ready for assembly,

Figures 7 and 8 illustrate one method of developing the roof segment illustrated in Figure 6,

Figure 9 shows a modified form of roof segment before it is bowed,

Figure 10 is a fragmentary plan view of a roof constructed of segments illustrated in Figure 9,

Figure 11 is a side elevation of Figure 10 with parts broken away,

Figure 12 illustrates the development of the segment shown in Figure 9,

Figure 13 is a section along line 13—13 of Figure 10, omitting the ring 1; and

Figure 14 is a section taken along line 14—14 of Figure 10.

Referring to the drawing, Figures 1 to 5, the wall structure of the building carries a ring 1 which preferably is L-shaped in cross-section, to which the bottom of the roof structure is fastened, as will hereinafter appear. The roof comprises a plurality of segments 2, 2*a*, . . . etc. 2*n*, which may be alike, and each of which is curved substantially upon a radius R, so that each segment is an arc of a cylinder. The number of segments employed for a roof structure ordinarily is determined by the diameter of the roof and the sizes of sheet metal available. For example, sheet metal strips in widths above 36 inches command a premium, so for economical reasons, the segments employed would be less than thirty-six inches at their greatest width, and the number of segments is determined accordingly as will hereinafter appear.

Referring to Figure 6, each segment 2 has its side edges 4 and 5 doubled back or reversely bent to form channels 6 and 7, the form of the channels being shown in section in Figure 2. Adjacent segments are held assembled on the roof by a double channeled bowed locking strip 9 which has its edges 11 and 12 doubled back to form the opposed channels 13 and 14. In assembled relation the side edge 4 of one segment is received within the channel 14 on one side of the locking strip, and, on the same side the edge 12 of the locking strip is received in the channel 6 of that segment. The opposed side edge 5 of the adjacent segment is received within the other channel 13 of the locking strip, and the edge 11 of the locking strip is received in the channel 7 of that segment. The space 15 between channels 6 and 7 is shown in Figure 2 on an exaggerated scale, and in some instances the exterior surfaces of the channels 6 and 7 will be in contact throughout their length, thus substantially eliminating the space 15. At the top, the roof segments support a ventilator ring member 16 having a conical flange 17 (Fig. 4) to which the roof segments are secured by bolts 18 passing through the locking strip and through notches 19 and 21 of adjacent roof segments near the top edge 22. Adjacent the bottom edge 24, (Fig. 5) bolts 25 pass through the locking strip and notches 26, 27 (Fig. 6) of adjacent roof segments to secure an angular hook 28 thereto, the end 29 of the hook engaging around the ring 1, secured to the silo wall, by which the roof is anchored to the wall.

The assembling of the roof now will be described: Referring to Figure 3 the bottom ring 1 is suitably secured to the silo wall and the top ring 16 is suitably braced in position while two adjacent segments 2 and 2*a* are positioned between the rings and may be secured thereto by bolts 30 passing through ring 16. A bowed locking strip 9 now is applied at the upper edges 22 of the segments in interlocking relation, with edges 4 and 5 of the segments received in channels 14 and 13 respectively of the strip, and edges 11 and 12 of the strip received in channels 7 and 6 respectively of the segments. The strip now is slid downward in this relation until the ends of the strip coincide with the lower and upper ends of the roof segments. A bolt 18 then is passed through a preformed hole in the locking strip, through the mating notches 19, 21 of adjacent segments, and through a preformed hole in ring 16, and is held in position by a suitable nut. At the bottom, a bolt 25 is passed through a preformed hole in the locking strip and through mating notches 26, 27 of adjacent segments. The end 29 of hook 28 is engaged under ring 1 and the bolt 25 is received in a suitable hole in the other end of the hook, the bolt being retained by a suitable nut.

Having thus secured two segments together and to the rings 1 and 16, another pair of segments are positioned substantially diametrically opposite and the assembly operation repeated with the second pair of segments. Then, a pair of segments are similarly assembled in each roof quadrant, and the spaces between assembled segments progressively filled in by segments which are locked to the adjacent segments. By proceeding in this manner instead of assembling the segments progressively around the dome, the spacing 15 between the segments is more or less evenly distributed about the dome, so that no difficulty is encountered in positioning the last segment in place. The bolts then are all tightened. Although in Figure 2 the segment edges

4 and 5 are shown spaced from the bottoms of channels 14 and 13, and the edges 11 and 12 are shown spaced from channels 7 and 6, it is to be understood that, depending on the width of the reversed edge portions, some or all of the segment edges will engage the bottoms of the channels of the locking strip. Also, the exterior edges of channels 6 and 7 of adjacent segments will contact at one or more points so that at such contacting points space 15 is eliminated.

The bolts 25 and hooks 28 anchor the roof to the silo wall, the hooks allowing for aberrations of the wall from a true circle. At the top, the bolts 18 tie the roof to the ring 16 which receives a ventilator fitting. These bolts also prevent the locking strips 9 from sliding out of position. It will be understood that if desired, other means may be provided for this purpose.

The roof illustrated and described can be shipped either flat or bowed, and can be assembled quickly and easily, and there are relatively few bolts to be inserted. The bolts employed pass between adjacent segments, so that this construction avoids the difficulties encountered in prior dome structures which require alignment of bolt holed in overlapping springy loose metal members. Furthermore, by eliminating bolts intermediate the ends, the inconvenience and difficulties attending the insertion of the bolts in springy portions of the roof is avoided. Roofs of this type may range in size up to about twenty feet in diameter, and because of the steep pitch of the dome a man cannot securely cling to the dome at the middle to apply bolts through the roof. In addition, the weight of the roof, compared with prior dome structures is decreased, and lighter gauge metal can be used for the segments.

The segments can be laid out by several development methods, and one such method now will be described. Referring to Figure 7, a circle is laid out from the center O, the equatorial diameter of the circle along line AO being the diameter of the roof as viewed in plan. To economize on space in the drawing, only a quadrant OAB of the circle is shown; and corresponding points on the arc of the adjacent quadrant are represented by the primed letters. Thus, AA' represents the diameter equal to twice the radius OA. The point C represents the end of the dome at the annulus 16. The arc AC is now divided into any desired number of equal spaces AD, DE, etc., seventeen such spaces being shown. The points D, E, etc. now are projected horizontally parallel to diameter line AO, to form chords DD', EE', etc., CC', which are diameters of small circles of a sphere. The circumference of the circle of diameter AA' is calculated, and having a known width of sheet metal 35 (Figure 8), the number n of segments to be employed is determined by dividing the circumference by the width of the sheet, due allowance being made for bending and trimming the edges.

On the sheet 35 a series of concentric circles are laid out about the polar point B as the center, and intersecting the center line or meridian X, the radius of the first circle A being the arcuate distance BA. The next circle D is drawn on a radius equal to the arcuate distance BD, etc. until the last circle C, drawn on the radius of arcuate distance BC, is scribed. Assuming, for illustration, that the roof will contain fourteen segments, the circumference of the great circle of diameter AA' is divided by $2n$, or twenty-eight, and this value, designated as XK is laid out on the arc of circle A (Figure 8) on each side of the center line. The circumference of a small circle of diameter DD' now is calculated and divided by $2n$, and this value XL is laid out on the arc of circle D on each side of the center line. Similarly the circumference of a small circle of diameter EE' divided by $2n$ is laid out on each side of the center on arc of circle E, etc., and finally the circumference of the small circle of diameter CC' is laid out on circle C to provide the value XY. Now, a curve is drawn joining the points K, L . . . Y, and the outline of the roof unit now is formed by the curved lines KXK, KLY, YXY and YLK.

The outline thus formed makes no provision for the formation of the channels 6, 7 at the edges KLY. This allowance is made by adding to the outline illustrated by a constant amount along circles A, D, E, etc. to C, as shown by the dotted lines Y'K'. Now when the sheet is cut the edges Y'K' represent free edges 4 and 5 of Figure 6. These edges then are reversely bent along both fold lines YK so that the arc Y'Y' represents the top edge 22, and arc K'K' represents the bottom edge 24. The channels 6 and 7 now are formed at the edges, and then the sheet is bowed upon a radius R (Figure 1) to conform to a cylindrical surface. In elevation the bowed segment will appear substantially as shown in Figure 6, with the top and bottom edges 22, 24 appearing substantially as straight lines. The bottom edge 24 conforms substantially to an equatorial circle. and edge 22 conforms to a small circle parallel to the equatorial circle. The reversed edges 4 and 5 lie on the convex side of the segment, and as the channel bottoms 6 and 7 lie substantially on great circles of the sphere, the edges 4 and 5 are parallel thereto. Thus, each segment constitutes a curved surface tangent to a sphere along the centerline of the segment, and the edges 4 and 5 are not necessarily true to great circles of the sphere.

In the modification shown in Figure 6, there is an elevated median rib 36 formed on the convex side. This rib may be provided where the width of the segment makes a median reenforcement desirable, and to provide for the formation of this rib an additional constant amount is added to the values K'K', L'L', etc. Now, when the median rib is formed this added material is taken up in the rib, and the edges then are turned back and the unit is bowed to form a roof segment. It is apparent that as each segment includes allowance for the edge channels, and may include allowance for the rib 36, that these allowances must be included in determining the width of the sheet required for each segment. This modification is bowed before shipment to the erecting site. If desired, more than one rib 36 may be provided, in which case the ribs are symmetrically arranged about the middle of each segment.

In the modification illustrated in Figures 9 to 11 wherein like parts are designated by like reference numerals, the modified roof segments 40, 40a, etc. . . . 40n are secured together by strips 9 as previously described in connection with Figures 1 to 5. However, the segments are of modified shape, and a modified form of edge channel is employed. This construction will be described in connection with the explanation of the development of the segments. The segment is laid out on a flat sheet 41 as shown in Figures 9 and 12, with the edges 22 and 24 developed by the curves YY and KK as described in connection with Figure 8. To develop the side edges 42 and 43, a flat unit cut out on the lines KYYK of

Figure 8 is placed on a sheet of metal 41 so that its centerline BX makes an angle with the centerline BX' of the sheet. This angle is 360° divided by the number of sheets or segments n in the dome. The edge KY now is scribed on sheet 41 to provide edge 43, and the opposite edge 42 is laid out in a similar manner. Thus, the development of the curve KY on sheet 41 on each side of the centerline BX may be regarded as the negative of a developed great circle. By reversely bending the edges 42 and 43 on radial fold lines 44 and 45, the edges 42, 43 become the positive development, and lines 44 and 45 become the bases of the channels. When the segment is bowed the edges 42 and 43 become parallel to a great circle. The fold edges 44, 45, however, now become bowed and provide a space 15 therebetween which tapers gradually from a maximum at about the middle as shown in Figure 14, toward both ends of the segment where the space is substantially closed, as shown in Figure 13. Because the end channels 44, 45 thus formed in the segments are deeper at the ends than at the middle, the double channel strip 9 is made wider. Also, because the relative large space 15 makes assembly of the segments more difficult, it is preferred to brace the ventilator ring 16 by means of suitable stay bars 47 (Figure 11) welded thereto and to the ring 1. Three such stay bars preferably are employed.

This modification is assembled the same as that illustrated in Figures 1 to 5. After securing two roof segments in place a curved clamping strip 9 is slid over the adjacent channel members of adjacent segments, the roof being secured to the top and bottom rings, as previously described.

The roof constructed according to the present invention is of light weight but rigid, and is easily and quickly assembled. If desired one edge of each segment may be formed parallel to a developed great circle, and the other edge parallel to a negative development of a great circle. Each edge thus will be parallel to a great circle after it is reversely folded, and a bowed locking strip, intermediate in width between that employed in the modification of Figures 1 to 6, and that in Figures 9 to 11, is employed to hold the segments assembled. In such modification the space 15 will be somewhat narrower at its mid point than in the modification shown in Figures 9 to 11. It will be understood that primarily the edges of the roof segment sheets are substantially parallel and that it is not necessary that the bottoms of the segment channels be in contact or even parallel, although contact at two or more points is preferred. Various modifications may be made in the invention without departing from the spirit or scope thereof.

It will be appreciated that the embodiments shown in Figures 1–3 and Figures 9–14, relate to a semi-spherical roof composed of a horizontal succession of vertically extending and tapering sections. Each section curves upwardly from a base circle extending concentrically around the vertical axis of the sphere to a smaller similarly extending circle. Each curved section also has its side margins bent over its convex face to form opposed channels which open toward each other.

Each of these channels has a bight or fold edge, which, when the sections are in assembled relationship, oppose the adjacent fold edge of an adjacent section at a joint line which extends between them along a great circle of the sphere. Each channel also has a straight circular free edge which extends in parallel relationship to the adjacent great circle joint line. By "straight

circular" free edge, we mean a circular edge which extends along the plane of a circle without departing substantially from such plane. This circle need not be a true circle but, in the preferred embodiment, is as true as can readily be attained in structures of this character.

It will now be appreciated that, when this straight circular free edge, which is designated by the numeral 4 in the embodiment of Figures 1–8 and by the numeral 14 in the embodiment of Figures 9–14 is developed upon a plane surface, it will necessarily form an edge outline of predetermined concave curvature. The reverse is true. Hence, if the flat blank, for a given finished curved section, is provided with side marginal channels facing each other and if the free edge of each channel is trimmed or otherwise arranged to present said predetermined concave curvature (which coincides with the concave outline formed by the plane surface development of the circular free edge of the corresponding channel on the finished section), then, when such flat channeled blank is cylindrically bent longitudinally to the great circle curvature of the sphere, the concave free edge of each channel will straighten out to form the aforesaid circular edge. This is precisely what is done in the process of making each of the embodiments of Figures 1–8 and 9–14.

Thus in the first embodiment, the side edges are trimmed to a convex curvature. Each side margin is then folded over a similarly curved fold line to form the channels. The curvature of each edge and of the adjacent fold line is not only the same but is predetermined to cause the free edge automatically to have the desired concavity when it is folded over. This may be clear upon realizing that the fold line has a convex side and a concave side and that its concave curvature is parallel to the desired concave outline formed by said plane surface development.

In Figures 9–14, the flat blank is provided with side edges which are formed with the same concave curvature that is formed by said plane surface development. When this margin is bent over a straight fold line, it retains the same concave curvature which is now positioned to coincide with the concave outline formed by said plane surface development.

We claim as our invention:

1. A pseudo-spherical dome roof comprising a plurality of roof segments each bowed to conform substantially to the surface of a cylinder and having reversed side margins forming side channels which longitudinally extend in the direction of the bow and transversely overlie the convex side of the segment and which have bight and free edges, the free edge of each channel being substantially parallel to a great circle of a sphere; and a double channel curved strip of substantially uniform width receiving said reversed margins of adjacent segments for holding said segments in assembled relation.

2. A dome roof as specified in claim 1 wherein the bight of at least one channel of each segment conforms generally to a great circle.

3. A dome roof as specified in claim 1 where the bights of both channels of each segment conform generally to a great circle.

4. A dome roof as specified in claim 1 wherein the bight of at least one channel of each segment developed on a plane surface presents a substantially straight line.

5. A unit for a dome-shaped roof comprising a bowed segment having a bottom edge and reversed side margins forming side channels over-

lying the convex side of the segment, each channel having a bight and a free edge and each free edge being substantially parallel to a great circle of a sphere.

6. A segment for a dome-shaped roof as specified in claim 5 wherein the bights of said channels conform substantially to great circles.

7. A segment as specified in claim 5 wherein the bight of at least one of said channels developed on a plane surface presents a substantially straight line.

8. A unit for a dome-shaped roof comprising a bowed segment having a bottom edge and reversed side margins forming side channels which overlie the convex side of the segment and which have bight and free edges, the latter being substantially parallel to a great circle of a sphere; said segment having an embossed rib formed substantially along the median line thereof.

9. An improved section for semi-spherical roofs, of the type composed of a horizontal succession of sections wherein each section curves and tapers upwardly, from a base circle extending concentrically around the vertical axis of the sphere to a smaller similarly extending circle, with each of its upwardly curved side margins opposing the similarly curved side margin of an adjacent section at a joint line which also curves upwardly along a great circle of the sphere, comprising: a curved section of the foregoing character having its side margins bent over its convex face to form opposed channels which open toward each other, each channel having an upwardly curved bight or fold edge, which when the sections are in assembled relationship opposes the adjacent similarly curved fold edge of an adjacent section along the great circle joint line extending between them, and a straight circular free edge which is substantially parallel to said great circle joint line.

10. An improved semi-spherical roof comprising: a horizontal succession of sections, each

section curving and tapering upwardly, from a base circle extending concentrically around the vertical axis of the sphere to a smaller similarly extending circle, with each of its side margins opposing the adjacent side margin of an adjacent section at a joint line which extends along a great circle of the sphere, each curved section having its side margins bent over its convex face to form opposed channels which open toward each other, each channel having a bight or fold edge which, when the sections are in assembled relationship, opposes the adjacent fold edge of an adjacent section along the great circle joint line extending between them and a straight circular free edge which is substantially parallel to said great circle joint line; and means for securing said sections together in assembled relationship, said means including a securing strip of substantially uniform width, and of C-shape in cross section to provide opposed grooves opening toward each other, said strip being arranged over the great circle joint line between adjacent sections with one of its grooves receiving the adjacent straight circular free edge of the channel on one section and with its other groove receiving the adjacent straight circular free edge of the channel on the adjacent section.

ROBERT STEMMONS.
WALTER L. EDEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
240,868	Waters	May 3, 1881
849,294	Ware	Apr. 2, 1907
968,061	Kramer	Aug. 23, 1910
2,176,712	Hanson	Oct. 17, 1939
2,187,616	Cowin	Jan. 16, 1940