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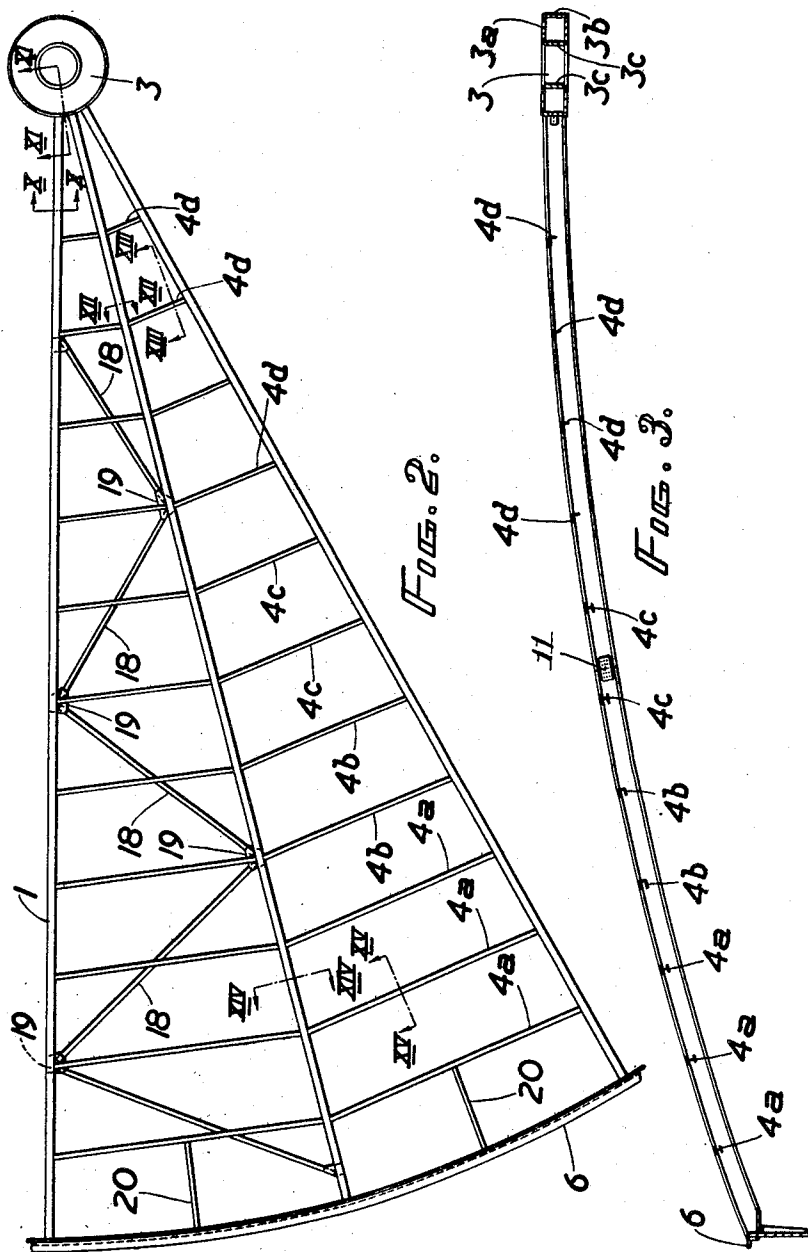
R. H. FOSTER ET AL

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ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

Filed Feb. 19, 1953

5 Sheets-Sheet 2



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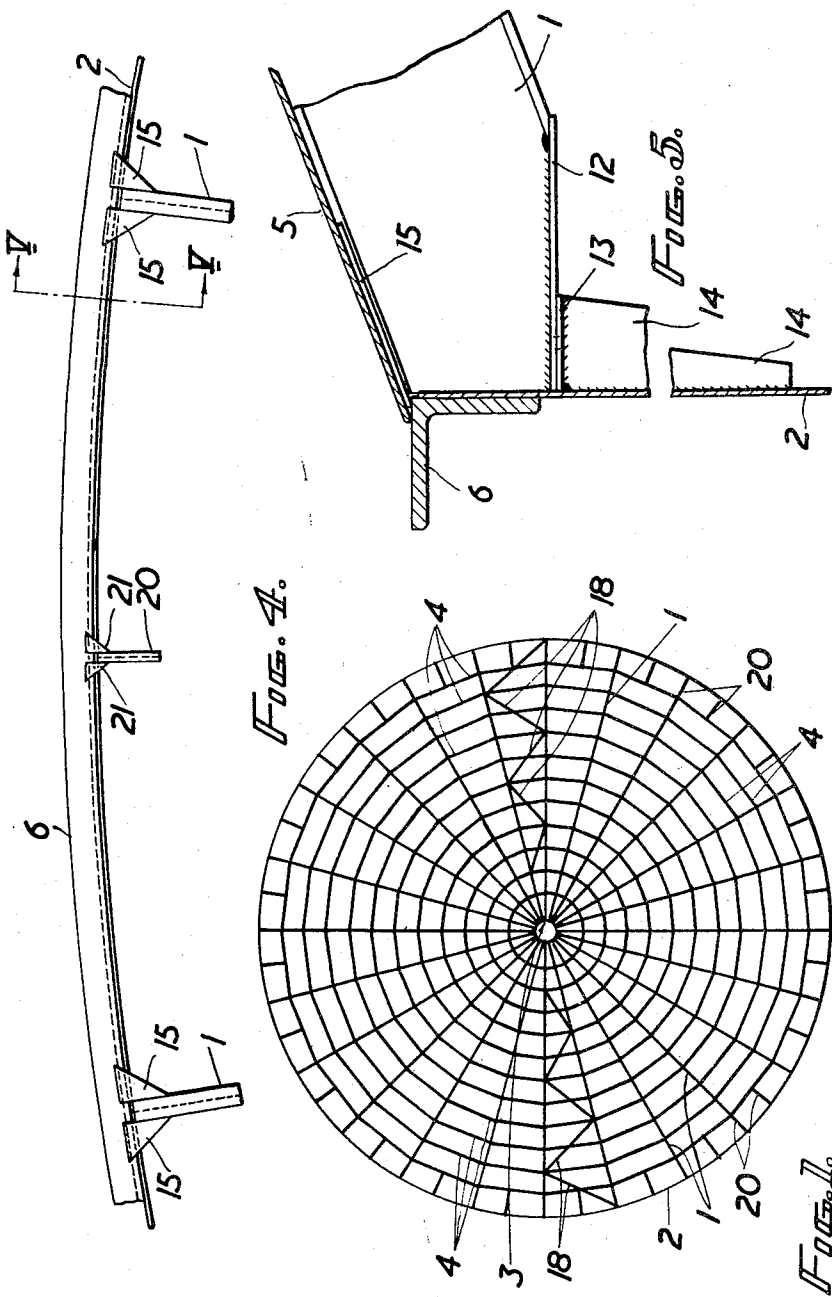
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ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

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5 Sheets-Sheet 1



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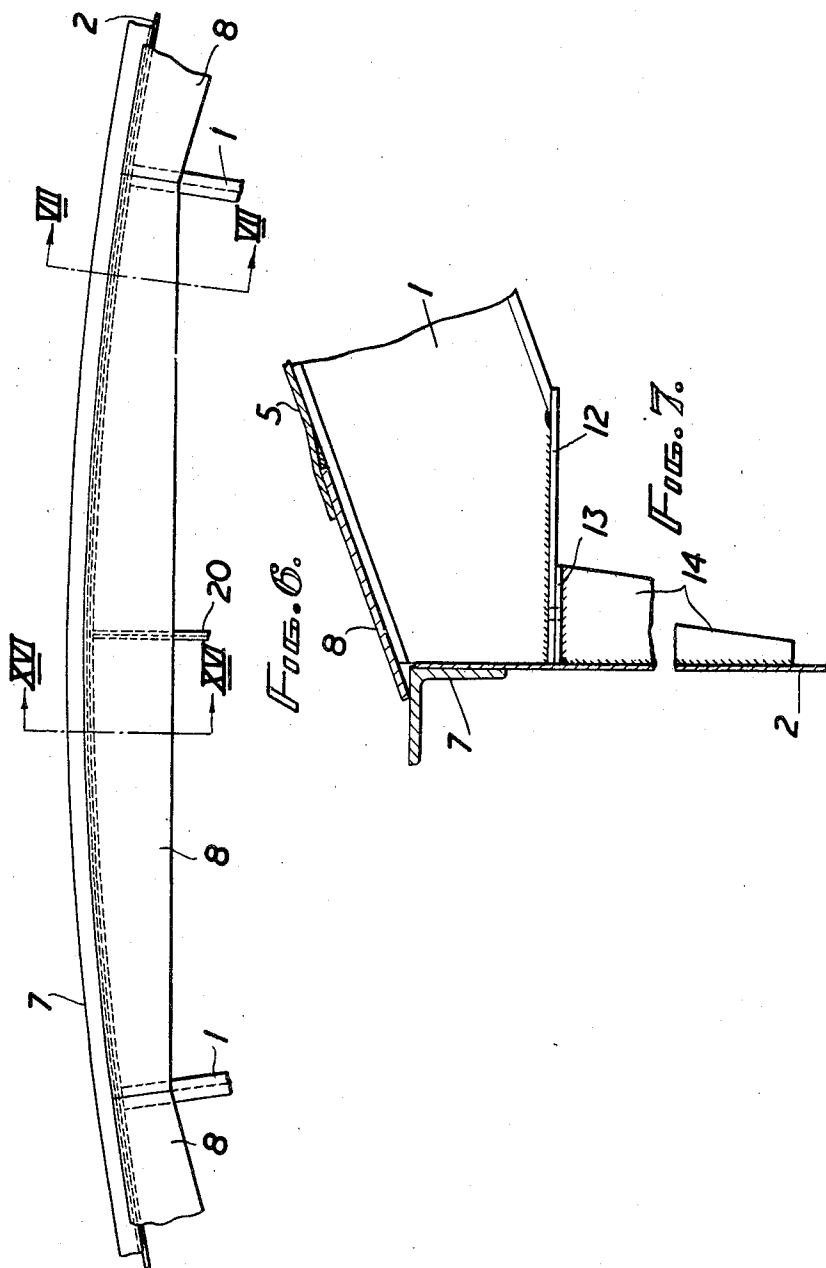
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ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

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5 Sheets-Sheet 3



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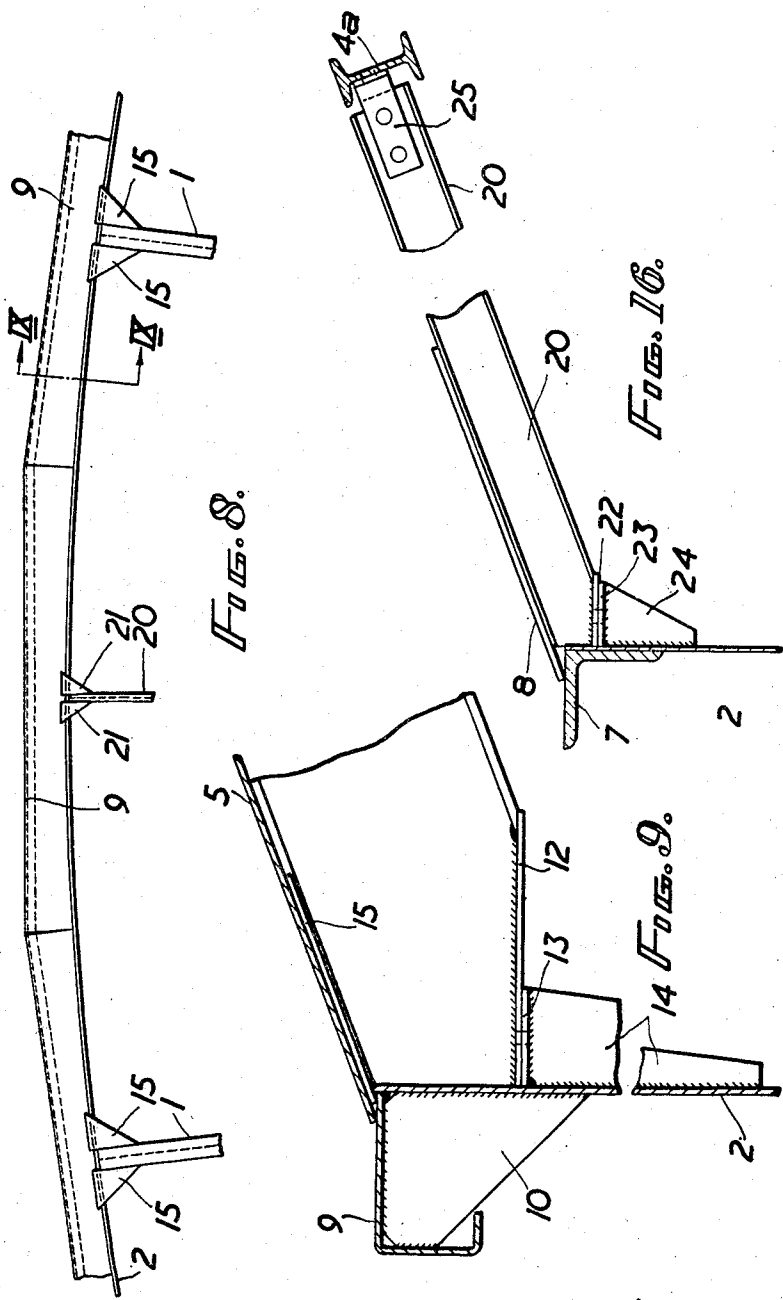
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ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

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5 Sheets-Sheet 4



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ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

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5 Sheets-Sheet 5

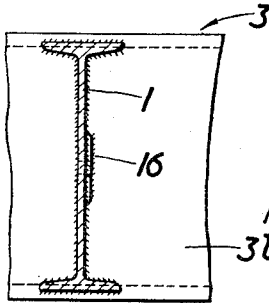


FIG. 10.

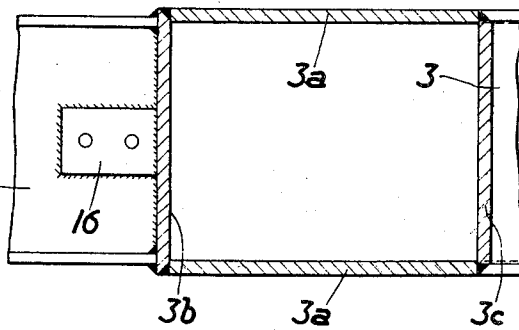


FIG. 11.

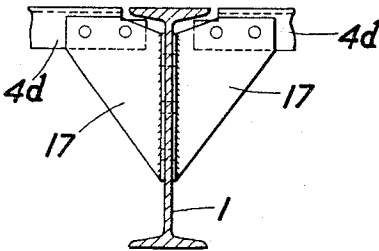


FIG. 12.

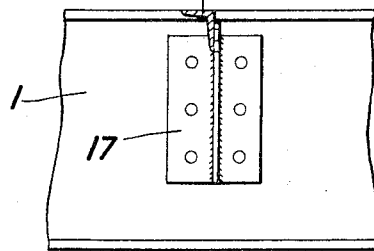


FIG. 13.

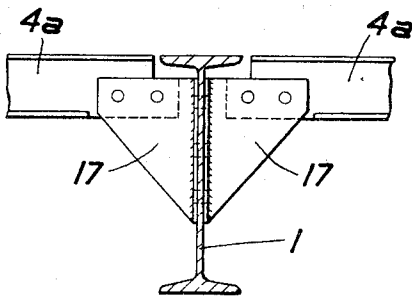


FIG. 14.

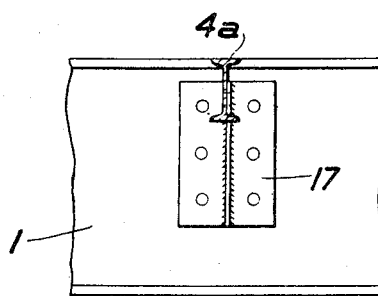


FIG. 15.

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2,773,458

ROOFS FOR STORAGE TANKS OR SIMILAR STRUCTURES

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4 Claims. (Cl. 108—32)

This invention relates to the roofs of tanks for the storage of liquids, or of other similar structures. The invention provides a form of roof construction which permits considerable economies in the amount of steel employed, as compared with previously known forms of roofs.

The invention includes broadly a domed roof for a circular structure such as a liquid-storage tank which comprises a peripheral curb, a plurality of upwardly convex, radially disposed ribs which abut at their outer ends against the curb, a centrally disposed crown member, to which all the ribs are secured at their inner ends, each pair of diametrically opposite ribs having rigid continuity through the crown member and constituting a two-pin arch, and roof sheeting supported upon the arches formed by the ribs.

Other features of the invention will sufficiently appear from the appended claims when read in the light of the following description of the particular embodiments of the invention shown in the accompanying drawings. These drawings show a particular roof construction, together with some of the many possible modifications thereof, which is intended for use upon an oil storage tank having a vertical cylindrical side wall, 144 feet in diameter. It will be understood that this construction is described and illustrated by way of example only and that the invention is not limited to the particular dimensions given, nor to the details of construction described and illustrated.

In the drawings, the several figures of which are drawn to different scales:

Figure 1 is a plan view of the framework of the complete roof, the roof sheeting which covers and is supported by this framework being omitted;

Figure 2 is a plan view of a sector of this framework;

Figure 3 is a vertical radial section through the framework;

Figure 4 is a fragmentary plan view of a peripheral part of the framework;

Figure 5 is a vertical radial section, taken on the line V—V of Figure 4, but showing the roof sheeting in position;

Figures 6 and 7 are views, corresponding respectively to Figures 4 and 5, of a modified construction;

Figures 8 and 9 are views, also corresponding respectively to Figures 4 and 5, of another modified construction;

Figures 10 to 15 are fragmentary sectional views, taken on the correspondingly numbered lines of Figure 2; and

Figure 16 is a vertical radial section taken on the line XVI—XVI of Figure 6.

The roof illustrated is of domed shape, having the form of a segment of a sphere of 200 feet radius. It comprises 24 radially disposed rafters or ribs 1, curved to conform to the domed shape of the roof, which extend from the top of the side wall 2 of the tank to a central crown ring 3, measuring 6 feet in overall diameter. Between each pair of adjacent ribs, there extend 11 circumferentially disposed purlins 4, spaced at equal

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radial distances apart. The roof sheets 5 are supported directly on the ribs and on the purlins which latter, acting as simply supported beams, transmit the load to the ribs 1, which act as half arches.

At the upper edge of the side wall of the tank is a curb, three alternative constructions of which are shown in Figures 4 to 9. In the form shown in Figures 4 and 5, this curb is formed by curved lengths of 8 inch by 8 inch angle 6, site welded into a continuous ring. In the form shown in Figures 6 and 7 the curb comprises a similar but lighter ring formed from 6 inch by 6 inch angle 7 and 24 segmental plates 8, measuring $\frac{3}{8}$ inch thick by 15 inches minimum width, which are also site welded into a continuous ring. In each of these constructions, the curb angles 6 or 7 are secured to the outer surface of the side wall 2, with their horizontal limbs extending outwardly from the upper edge of the wall, by continuous fillet welds at the top of the side sheeting and at the lower edge of the vertical limb of the curb.

In the construction shown in Figures 8 and 9, the curb is formed by 48 plates $\frac{1}{4}$ inch thick bent to form J-sections 9, which are welded together end to end into a continuous polygonal ring. As well seen in Figure 9, the longest limb of the J-section 9 projects horizontally outwards from the side wall 2, the other two limbs extending respectively vertically downwards and horizontally inwards, to lie beneath the longest limb in elevation. The inner edge of the longest limb, which is shaped to conform to the curvature of the side wall 2, is secured to the outer surface of the side wall by continuous fillet welds on both sides of the J-section plate. The J-sections are further secured to the side walls by downwardly tapering web plates 10, disposed in vertical radial planes and fitting partly within the J-sections, each web plate being secured both to the side wall and to two of the limbs of the J-section by continuous fillet welds on both sides of the web plate.

Each rib 1 is formed from H-section joists measuring 15 inches by five inches, joined end to end where necessary by pairs of fish plates 11 (Figure 3). Alternatively, the joists may be joined by a single butt plate inserted between the joist ends and fillet welded to them. As best seen in Figures 5, 7 and 9, the outer end of the rib is cut away on its under side and a horizontal base plate 12 is shop welded to the cut edges of the web and lower flange. This base plate rests on and is bolted to a horizontal cap plate 13 which is welded to the inner face of the side wall 2 and to the upper edge of a vertical stiffener plate 14 of tapered width, welded at its outer edge to the side wall. The stiffener 14 and cap plate 13 together form a stool which takes the vertical reaction of the rib and distributes it gradually down the side wall 2.

In the curb constructions of Figures 4 and 5 and of Figures 8 and 9, a pair of triangular wing plates 15 are shop welded to the outer ends of the upper flange of each rib 1 and are site welded to the curb angle 6 or the J-section 9. These wing plates 15 distribute the thrust of the arch to the curbs and adjacent portions of the side and roof plating. The roof plating 5 is continuous fillet welded along its outer edge to the curb angle or J-section. In the curb construction of Figures 6 and 7, the horizontal thrust from the arch is distributed amongst the annular plate 8, angle section 7, and effective portion of the side wall 2 by intermittent welding of the upper flange of the ribs 1 to the annular plate 8 and by continuous welding of the annular plate 8 to the angle section 7.

The central crown ring 3 is fabricated from steel plates and is 6 feet in outside diameter and about 16 inches in depth. As best seen from Figures 2 and 11, it comprises two horizontal annular plates 3a, connected together by

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two vertical cylindrical plates, the outer one 3b being 6 feet in outside diameter and the inner one 3c being 2 feet 6 inches in inner diameter. The connection between these plates is made by welding. As shown in Figures 10 and 11, the inner ends of the main ribs 1 abut against the outer face of the ring, and are permanently attached to it by continuous fillet welds. For temporary erection purposes, small lugs 16, attached to the outer face of the ring, hold the ribs in position.

The purlins 4 of the three outer circles 4a are of H-section; those of the next two circles 4b are of channel section; those of the next two circles 4c are of lighter H-section and those of the four innermost circles 4d are of angle section. As shown in Figures 12 to 15, the purlins are connected to the ribs 1 through welded T-section brackets 17, bolted to the webs of the ribs and to the webs or depending limbs of the purlins 4, the top flanges or upper limbs of the purlins lying flush with the top flanges of the ribs and being cut away to clear those flanges.

As shown in Figures 1 and 2, two diametrically opposite sets of diagonal bracing are provided, each set comprising five lengths of angle section 18 extending in zig-zag manner between two adjacent ribs 1. The bracing members are bolted at their ends to gusset plates 19 welded to the under sides of the ribs 1 beneath the points of connection of alternate purlins. This bracing assists in effecting accurate assembly of the roof structure and resists any tendency of the roof as a whole, to twist.

Midway between each pair of adjacent ribs or main rafters 1, a short I-section sub-rafter 20 extends inwardly from the curb to the outermost circle of purlins 4. As shown in Figure 16, the outer end of the sub-rafter is connected to the side wall by a stool similar to that of the main rib and comprising a stiffener 24 and cap plate 23, on which rests a base plate 22 welded to the cut away lower edge of the sub-rafter. In the curb constructions of Figures 4 and 5 and of Figures 8 and 9, a pair of triangular wing plates 21 connect the top flange of the sub-rafter 20 to the curb angle member 6 or 9. In the curb construction of Figures 6 and 7, which is the one shown in Figure 16, the top flange of the sub-rafter 20 is connected to the annular plate 8 by intermittent fillet welds. At its inner end the sub-rafter is connected to the purlin 4a through a T-piece 25 welded to the web of the purlin and bolted to the web of the sub-rafter. The sub-rafters assist in maintaining circularity of the curb angle and in preventing buckling of the side and roof sheets.

In assembling the roof structure, the curb angle 6 or 7 or the J-section 9 and the stools 13, 14 and 23, 24 are welded to the side wall 2 and a temporary support is erected to carry the central crown ring 3. The ribs 1 are lifted into position and the purlins 4, sub-rafters 20 and diagonal bracing 18 are assembled. The ribs are then welded to the crown ring. Finally, the roof sheets 5 are laid and welded into a spherical membrane, the edge of which is welded to the curb angle 6, annular plate 8, or J-section 9. The temporary centre support has been retained during all of the preceding assembly, and the load on it has been gradually increased. The ribs have been acting as simply supported beams with vertical reactions at their outer ends to the stools and vertical reactions at their inner ends to the central crown ring.

When the temporary support is now removed, each rib acts as a half arch with continuity through the crown ring. The curb (that is the curb angle 6, or the J-section 9, or the curb angle 7 and annular plate 8, as the case may be) together with adjacent portions of the roof sheets 5 and side sheets 2, supply the abutments of the arch, and, under the dead load of the roof, are put into a state of direct tension and bending. The thrust of the arches in creating tensile and bending stresses in the curb, will tend to straighten out the curb into chords joining the ends of the ribs 1. This tendency is resisted by the sub-rafters 20, which in so resisting, are put into a state of compression.

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Particular attention is called to the following features of the construction described above. (1) The purlins 4 are not rigidly attached to the ribs and do not serve as struts or ties between the ribs. They act as simple beams, transmitting load from the roof sheets 5 to the ribs, leaving the ribs to act as simple segmented circular arches. (2) The curb 6 is put into a state of tension and bending by the thrust of the ribs under the dead load of the roof and any additional load such as snow (or, alternatively, is put into a state of compression and bending by the pull of the roof sheeting, acting as a membrane when the roof is subject to internal pressure greater than the dead load of the roof sheets.) The side plates and roof plates, being rigidly attached to the curb, assist the curb in forming abutments for the arches. (3) The circularity of the top of the side wall of the tank is maintained by the sub-rafters 20 and that portion of the roof sheets which is welded to them. (4) The ribs are subjected to bending stresses in addition to the direct stresses which they carry, the whole cross sectional area of the rib transmitting the direct thrust, while the flanges transmit almost all the bending stresses. The top and bottom plates of the crown ring 3 receive directly the resultant forces from ribs 1 and are made stiff enough to transmit these forces without undue deformation and thus maintain continuity of the arch.

We claim:

1. In a tank having a vertical cylindrical wall and a conical roof, said roof comprising a peripheral curb, a plurality of upwardly convex, radially disposed and diametrically opposite ribs having their outer ends abut against the curb, a centrally disposed crown member to which all the ribs are secured at their inner ends, each pair of diametrically opposite ribs having rigid continuity through the crown member and constituting a two-pin arch, roof sheets secured together to constitute a continuous spherical membrane and secured at its periphery to the curb, said membrane covering the arches formed by the ribs and crown member; said curb comprising a continuous angle section ring having a vertical limb secured to the side wall and a horizontal limb projecting outwardly from said wall, said curb also including an annular plate secured at its outer periphery to the angle section ring and extending inwardly over the outer ends of the ribs and secured to said ribs; said crown member comprising a cylinder and a pair of superimposed horizontal plates secured respectively to the upper and lower ends of the cylinder, and a plurality of circumferentially disposed purlins extending between each pair of adjacent ribs and supporting the roof sheets.

2. A roof as defined in claim 1, including bracing members extending diagonally in zig-zag manner between at least some pairs of adjacent ribs, the remaining ribs being unbraced.

3. A roof as set forth in claim 1, including short sub-rafters extending inwardly from the curb between adjacent pairs of ribs and being secured to the roof sheets.

4. A roof as set forth in claim 1, wherein the purlins of the outer annular area inwardly of the curb are of H-section, the purlins of the next annular area are of channel section and the innermost purlins next to the crown ring are of angle section.

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