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2,223,418

CONCRETE DOME FOR BUILDINGS

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2 Sheets-Sheet 1

Fig. 1

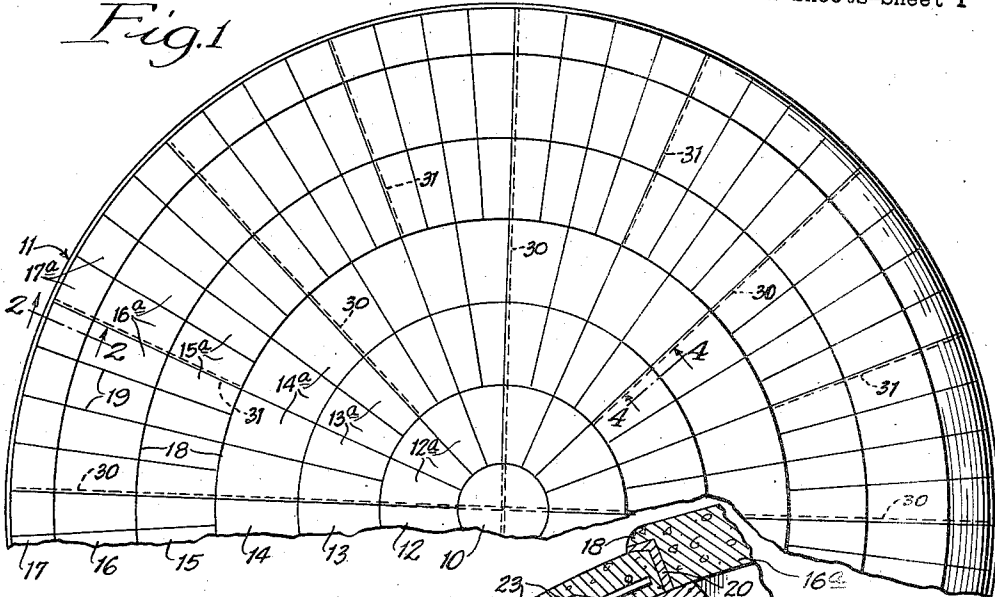


Fig. 2

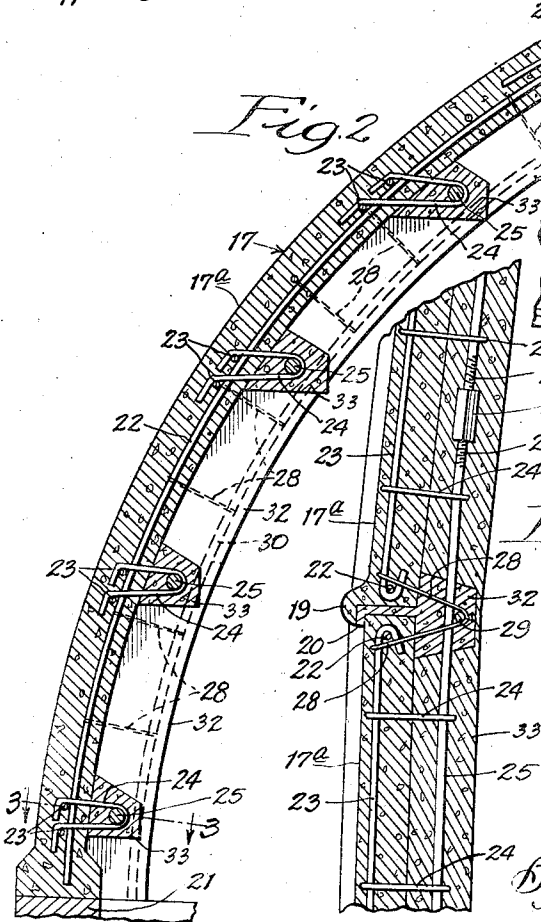


Fig. 3

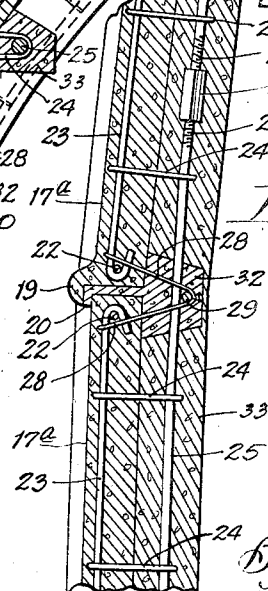
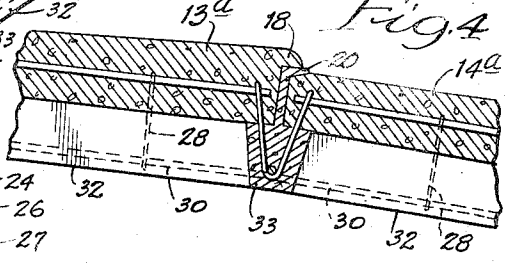


Fig. 4



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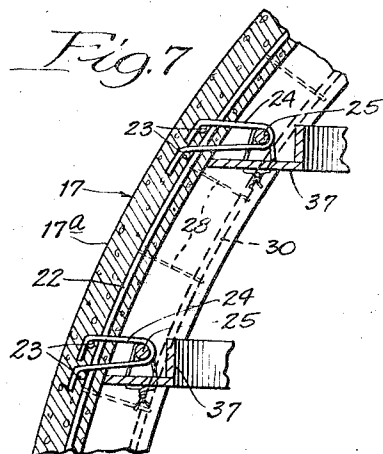
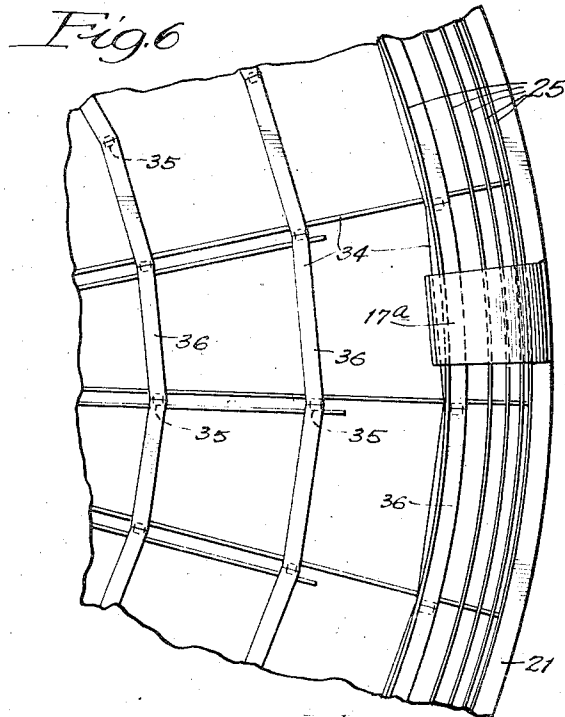
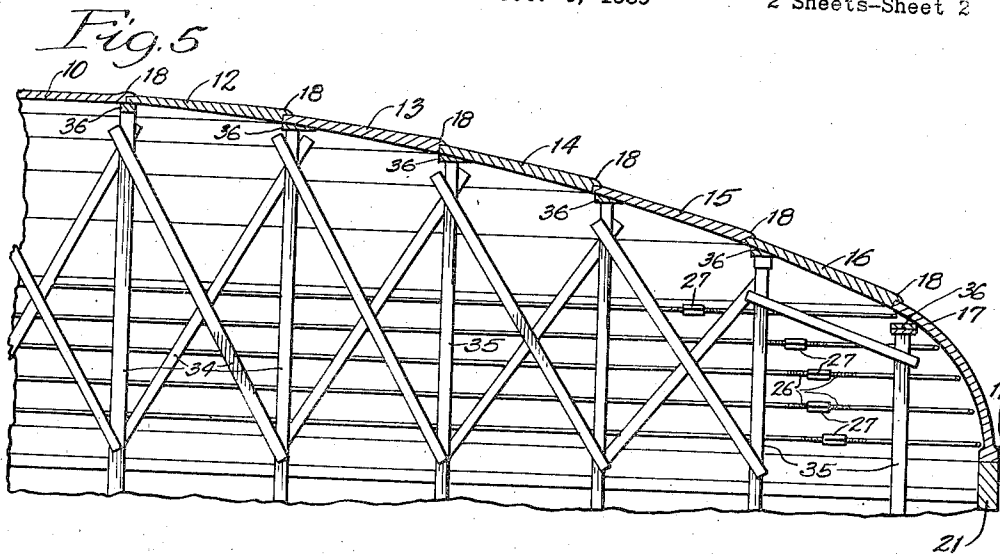
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CONCRETE DOME FOR BUILDINGS

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10 Claims. (Cl. 103-4)

The present invention is directed primarily to a concrete dome for a structure which is circular, or substantially so, such a dome being the most economical and satisfactory type of roof which has yet been devised where a permanent and fireproof roof is desired for structures of this character. However, in the past it has been the practice in the building of such domes to employ forms which are very expensive and are useless after the structure is built, and which moreover are expensive to remove. Great saving will therefore result if the dome can be pre-cast in sections in a plant provided for that purpose and then brought to the building site and assembled on light form work.

In the building of small domes which are cast in the field according to present methods, the thickness of the slabs produced is ordinarily much greater than the strength required to compensate for the stresses encountered, which results in a waste of material, as well as excessive weight which must be adequately supported.

Domes constructed in accordance with the practice of the present invention may be precast in sections of properly computed thickness without waste of material and adequately supported in such a manner as to prevent the development of stresses which might result in cracking or disintegration.

In all domes, howsoever constructed, the middle or peak portion of the dome is in circular compression, while the outer or marginal portion is in circular tension, and the point of change from tension to compression will depend upon the shape of the dome. All domes are subjected to a slight bending on radial lines under uniform loads, but when properly designed the bending is so slight that it is easily resisted by a thin section. Where partial or concentrated loads are encountered, however, the dome slabs are subjected to both radial and circular bending.

In the dome of the present invention due account is taken of all of these factors and the design is intended to compensate against circular tension in the outer or marginal portion of the dome in such a way as to confine the circular compression to that portion of the dome slab which is computed to be in circular compression in the analysis of the stresses and also to confine the circular tension to that portion of the dome slab which is computed to be in tension. Failure to take due account of these factors results in heavy bending stresses in the slab, and results in an unsafe and unsatisfactory structure.

Further objects and details will appear from a

description of the invention in conjunction with the accompanying drawings, wherein,

Figure 1 is a fragmental top plan view of a dome embodying the features of the present invention;

Fig. 2 is an enlarged cross sectional elevation taken on line 2-2 of Fig. 1;

Fig. 3 is a sectional plan view taken on line 3-3 of Fig. 2;

Fig. 4 is a sectional elevation taken on line 4-4 of Fig. 1;

Fig. 5 is a sectional view showing the interior of the partially assembled dome with the circular stress rods exposed;

Fig. 6 is an enlarged view of a portion of the exterior of the dome looking downwardly toward the exposed circular stress rods; and

Fig. 7 is a fragmental sectional view showing the positioning of the forms employed in the pouring of concrete to embed the stress rods in the completion of the structure.

The dome as a whole consists of concentric rows of slab sections extending from the center cap 10 to the margin 11 of the dome, the outer edge of each row overlapping the inner edge of the next adjacent row of the series. As shown, the rows are designated from the interior outwardly as 12, 13, 14, 15, 16, and 17, although obviously a greater or lesser number of rows may be employed, depending upon the size and character of the structure.

The outer or marginal row 17 is the one which embodies the principal features of the present invention and which is in the greatest degree subjected to the expansive thrust occasioned by the weight of the inner portion of the dome and is hence subjected to a circular tension stress which is counteracted by the structural features presently to be described.

Each of the circular rows or courses is composed of a plurality of interfitted pre-cast concrete sections of inwardly tapering formation, which sections in the respective rows or courses may be conveniently designated as 12^a, 13^a, 14^a, 15^a, 16^a, and 17^a.

The width of the sections in the progressively enlarging rows will vary, as shown, by subdividing the outer rows or courses to such an extent that none of the sections will be excessively broad in the outer courses. Thus the number of sections in rows 13 and 14 will be double the number in row 12, and the number of sections in rows 15, 16, and 17 will be double the number in rows 13 and 14.

The general sectional contour of the dome

here shown is best illustrated in Fig. 5, which shows a relatively flat broad dome, although it will be understood that it is equally possible to employ the principles of the present invention in the construction of domes having a higher or more truly circular configuration.

As illustrated in Figs. 2 and 4, each of the slab sections, with the exception of the sections in the marginal row 17, is provided along its outer edge with an undercut which affords a flange 18 adapted to overlie the inner edge of the sections in the next succeeding row.

As illustrated in Fig. 3, each of the slab sections, including the slab sections in the marginal row 17, is provided along one of its side edges with an undercut affording a flange 19 which overlies the contiguous flat edge of the adjacent section in the row. This affords an interfitting or overlapping arrangement for all of the joints throughout the entire dome, and in like manner the marginal edge of the circular cap section 10 is flanged to overlie the inner edge of the slab sections in the inner row 12. However, it is preferred to allow space between the adjacent edges for the application of a cement or mortar filling 20, which fills out under the overlap and effectively unites and seals the joints.

The above general description applies to all of the slab sections composing the inner courses from 12 to 16 inclusive, but the slabs of the marginal course 17 are of special construction, which will now be described in detail.

In the relatively flat dome herein particularly illustrated, it will be noted that the sections of the inner courses are relatively flat or plane, although formed of slightly increased thickness toward the lower or outer edges to provide for the overlap, but the sections composing the marginal course are of curving formation in radial cross section, as well as circumferentially, and constitute the outer or base portion of the dome which, along with its lower edge, rests directly upon the circular wall 21 of the structure which supports the dome itself.

Each of the slab sections has embedded therein a plurality of arcuate reinforcing rods 22 which are preferably located near the side edges of the sections (Fig. 3), but which may if desired be further supplemented by additional rods spaced at intermediate locations. The reinforcing rods 22 curve upwardly in conformity with the curvature of the marginal slab sections and the rods afford points of connection for embedded circumferential rods 23, the ends of which are hooked over the rods 22 as shown in Fig. 3.

The circumferential rods 23 are arranged in pairs and serve as points of connection for tension loops 24, the inner ends of which in each instance are bent around the rods 23 and are embedded therewith in the slab section when being cast, so that the completed slab section will display a series of rows of inwardly projecting loops for the subsequent insertion of circular tension rods 25. As shown, each section 17^a of the marginal course presents five rows of loops in spaced relation to one another and inwardly projecting to receive five tension rods 25, the uppermost of which in the present instance is of somewhat greater diameter than the others.

Each tension rod 25 extends around the entire interior of the dome at the appropriate level, and the rows of loops 24 extend inwardly at

varying angles to enable each of the tension rods, when tightened, to draw inwardly on the contiguous portions of the marginal course to impart a compressive tension to the margin of the dome structure to compensate against the tension stress to which the margin of the dome would otherwise be subjected.

In order to enable the tension rods to be adequately tightened and put under sufficient stress to compensate against the elasticity of the tension rods themselves, each of the rods at its meeting ends is provided with right and left screw threads 26 and a turnbuckle 27 so that the desired tension can be imparted to the rods, which thus tend to contract and draw in on the slab sections with the result that both the tension rods and the slabs with which they are united are pre-stressed to the required degree, the rods being tensioned and the slabs compressed.

The structure is additionally reinforced along the joints by the provision of tie wires 28, which are secured to the embedded rods 23 and extend inwardly from the slab near the meeting edges of the sections, so that their ends may be carried around the downwardly extending ends 29 of alternately spaced radial reinforcing rods 30, or 31, the former of which extend upwardly to the center of the dome and are there united, and the latter of which terminate at an intermediate point as shown in Fig. 1, but which in each case follow the general curvature or contour of the dome. Although the rods 30 and 31 are located at the radial joints, as shown, additional rods of like character may be employed along intermediate lines, if desired.

The above arrangement of rods and ties constitutes the interior metallic reinforcement for the dome, but in the completion of the structure these reinforcing elements are embedded in a series of arch beams 32 and intervening circular ribs 33, which ribs, as shown, lie in intervening relation to the arch beams, and the beams and ribs are of proper dimensions and sufficiently massive to fully embed the metal work and furnish a permanent reinforcing grid or skeleton for the entire dome.

In the assembling of the structure, a light scaffolding 34, or false work (Fig. 5), is built up on the interior of the structure, with the provision of posts or pillars 35 carrying circularly disposed courses of planks 36 properly disposed to underlie the positions occupied by the circular joints between the courses of slab sections. With the scaffolding thus positioned, the sections of the lower or marginal course are laid in position with their side edges in overlapping relation. With the sections thus positioned, five rows of tie rods 24 will be presented inwardly for the reception of the circular tension rods 25 which will be entered through the loops, forming a row of circular bands standing at varying elevations and in concentric relation with the vertical axis of the dome.

Thereafter the radial rods 30 may be positioned with their lower portions in contact with the tension rods and the tie wires 28 will be carried around the radial rods and united by twisting or otherwise, thus tying the slab sections of the marginal course of the metal reinforcing rods. The joints between adjacent slab sections may be filled with mortar, cement, or other suitable bond, at this stage or later, and thereafter the upper courses will be laid in successive order until the uppermost course is laid and the cap is positioned.

tioned. The slab sections of the upper courses will be tied to the metal rods in the manner heretofore described, and this completes the general assembling of the preformed parts of the dome structure.

In order to pre-stress the marginal course of the slab sections before the scaffolding is removed and the dome becomes self-sustaining, the turnbuckles 27 are adjusted to draw in the ends of the stress rods 25 to the desired degree to not only stretch the rods to the extent necessary to exhaust their normal elasticity, but also to impart a compressive stress to the lower course to compensate for the tension or expansive stress to which the marginal course is subjected in resisting the weight of the inner courses of the dome which are necessarily under compression.

After the tension rods and marginal course of slabs have been pre-stressed to the desired degree, suitably shaped pouring forms, such as 37 (Fig. 7), are placed in position to enclose the metal work, and concrete is poured to properly mold the beams and intervening ribs, which completes the structure of the dome. After the concrete has hardened, the forms and scaffolding can be removed and the dome will stand as a permanent self-sustaining structure free from a tendency to crack, sag, or become otherwise deformed. If the steel stress rods were not pre-stressed in the manner described, the elasticity of the steel under tension would cause tension in the adjacent concrete.

In the design illustrated in the drawings, that part of the dome within the marginal course is in circular compression. If the marginal course were reinforced in the usual manner, the reinforcing would be placed in tension, which in turn would be transmitted to the concrete, so that the entire marginal portion of the dome would be in tension, which would tend to deform the dome as such stress would result in cracks in the concrete and also in placing a large part of the interior portion of the dome in tension. Since the total circular tension in the structure must equal the total compression, it necessarily follows that if a large part of the area of the dome inside of the marginal course is forced into tension, the resulting unit compression of the remaining portion of the dome would be very materially increased, since in the circumstances stated the compression must be zero at some point within the inner courses of the dome. Such an inequality in circular compression would tend to change the shape of the dome, with resultant heavy bending and stresses impossible of solution.

By subjecting the marginal tension of the dome to a compressive pre-stressing in the manner described, there will be no tendency to impart tension to any portion of the inner courses of the dome, which will at all points remain in compression, so that abnormal or deleterious inequalities in the distribution of stress will be avoided and the proper weight and dimensions for each portion of the dome properly computed, with a resultant saving in material as well as the avoidance of any distortion in the dome structure itself.

Relatively flat domes of varying height span and of comparatively light weight can be built in conformity with the principles of the present invention without danger of distortion or collapse and in a very rapid and satisfactory manner, since the dome slab sections and metal work can all be prefabricated in factories equipped for the purpose, which reduces the cost of erec-

tion to a minimum, since the use of forms and the pouring of concrete will be confined solely to the formation of the beams and ribs which enclose the metal reinforcement. At the same time the completed dome is entirely free from obtrusive interior beam or truss work of an expensive and unsightly character, since the only breaks in the interior contour of the dome are of slight depth and of a nature which in no way detracts from the pleasing appearance of the structure.

Although the invention has been described with particularity, and in relation to the erection of a relatively broad flat dome, it will of course be understood that the principles here involved are applicable to domes of any desired configuration, since the stresses to which every portion of the dome is subjected can be readily computed and adequately provided for.

I claim:

1. A dome consisting of a marginal course formed of pre-cast adjoining sections of plastic material and inner and upper courses supported upon and abutting in succession against the marginal course and against one another, an inner circumferential metal reinforcement positioned within the confines of the marginal course externally of the body thereof and in contiguous relation thereto, connections between the slab sections and said metal reinforcement, the metal reinforcement being under tension and the sections connected therewith being compressively pre-stressed thereby to compensate for the weight-factor forces of the inner and upper courses tending to impart tension to the sections of the marginal course.

2. A circular dome consisting of a marginal course formed of pre-cast slab sections of plastic material arranged in edge-to-edge abutting relationship and inner courses supported upon and abutting successively against the marginal course and against one another, a plurality of tension rings extending circumferentially around the marginal course externally and on the inner side thereof, and tying means for securing the sections of the marginal course to the tension rings, the rings being under tension and the sections connected therewith being thereby compressively pre-stressed to compensate against forces tending to impart tension to the sections of the marginal course.

3. A circular dome consisting of a marginal course formed of pre-cast slab sections of plastic material arranged in edge-to-edge abutting relationship and inner courses supported upon and abutting successively against the marginal course and against one another, a plurality of tension rings extending circumferentially around the marginal course externally and on the inner side thereof, and tying means for securing the sections of the marginal course to the tension rings, the rings being under tension and the sections connected therewith being thereby compressively pre-stressed to compensate against forces tending to impart tension to the sections of the marginal course, and ribs of plastic material in which the tension rings are embedded.

4. A circular dome consisting of a marginal course formed of pre-cast slab sections of plastic material adjoined along their edges and inner courses abutting successively against the marginal course and against one another, a plurality of tension rings extending circumferentially along the interior of the marginal course, and tying means for securing the sections of the marginal course to the tension rings, the ten-

sion rings being pre-tensioned and the sections connected therewith being compressively pre-stressed to compensate against forces tending to impart tension to the sections of the marginal course, radially extending reinforcing rods downturned at their outer ends and underlying the courses, and tying means for securing the sections of the courses to the radial reinforcing rods.

5 5. A circular dome consisting of a marginal course formed of pre-cast slab sections of plastic material adjoined along their edges and inner courses abutting successively against the marginal course and against one another, a plurality of tension rings extending circumferentially along the interior of the marginal course, and tying means for securing the sections of the marginal course to the tension rings, the tension rings being pre-tensioned and the sections connected therewith being compressively pre-stressed to compensate against forces tending to impart tension to the sections of the marginal course, radially extending reinforcing rods downturned at their outer ends and underlying the courses, and tying means for securing the sections of the courses to the radial reinforcing rods, arch shaped ribs of plastic material embedding the radial reinforcing rods, and circumferentially extending ribs of plastic material embedding the tension rings.

10 6. A circular dome consisting of a marginal course formed of pre-cast slab sections of plastic material adjoined along their edges and inner courses abutting successively against the marginal course and against one another, a plurality of tension rings extending circumferentially along the interior of the marginal course and having their opposed ends oppositely threaded and united by turnbuckles, tying means for securing the sections of the marginal course to the tension rings, the tension rings being pre-tensioned and the sections connected therewith being compressively pre-stressed to compensate against forces tending to impart tension to the sections of the marginal course, radially extending reinforcing rods downturned at their outer ends and underlying the courses, and tying means for securing the sections of the courses to the radial reinforcing rods, arch shaped ribs of plastic material embedding the radial reinforcing rods, and circumferentially extending ribs of plastic material embedding the tension rings.

7. The method of constructing domes which includes assembling a marginal course consisting of pre-cast adjoined sections of plastic material, building up the dome by inner courses standing in circumferential edgewise relation to one another and supported by the marginal

course, threading the individual sections of the marginal course upon an inner split circular tension rod inside the confines of the dome, and drawing the ends of the tension rod together to tighten the same and bind the sections of the marginal course together to equalize and compensate for the inherent circular compression and tension stresses existing in the marginal and inner courses.

8. The method of constructing domes which includes assembling a marginal course consisting of pre-cast adjoined sections of plastic material, building up the dome by inner courses standing in circumferential edgewise relation to one another and supported by the marginal course, threading the individual sections of the marginal course upon an inner split circular tension rod inside the confines of the dome, drawing the ends of the tension rod together to tighten the same and bind the sections of the marginal course together to equalize and compensate for the inherent circular compression and tension stresses existing in the marginal and inner courses, embedding the tightened tension rod completely in an inner ribbing of plastic material and allowing the latter to harden.

9. The method of constructing a concrete dome which comprises erecting a temporary support, positioning upon the support a body formed of plastic material and shaped to provide a dome, slidably connecting a series of split circular tension rods to the dome about the interior thereof at circumferentially spaced points with the rods occupying positions at different elevations within the confines of the dome, drawing the ends of the split tension rods to reduce the effective circumference of the tension rods and apply stresses to the dome to compensate for weight-factors existing in the dome, and thereafter removing the temporary support whereby the dome remains sustained independently thereof.

10. A circular dome comprising a dome-like body of concrete, a plurality of series of anchors partially embedded in the body and having corresponding ends thereof protruding exteriorly of the body inwardly of the confines thereof, the anchors of each series being spaced from each other circumferentially in substantially the same horizontal plane, each series of anchors occupying different elevations within the dome structure, and a split circular tension rod slidably extending through the protruding ends of all the anchors of each series, and means for drawing the ends of each tension rod to contract the latter and compensate for weight-factor stresses existing in the dome body.

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