Oct. 9, 1962 M. KESSLER 3,057,119

METHOD OF ERECTING PRE-STRESSED BUILDING CONSTRUCTION

Filed Aug. 9, 1957 3 Sheets-Sheet 1

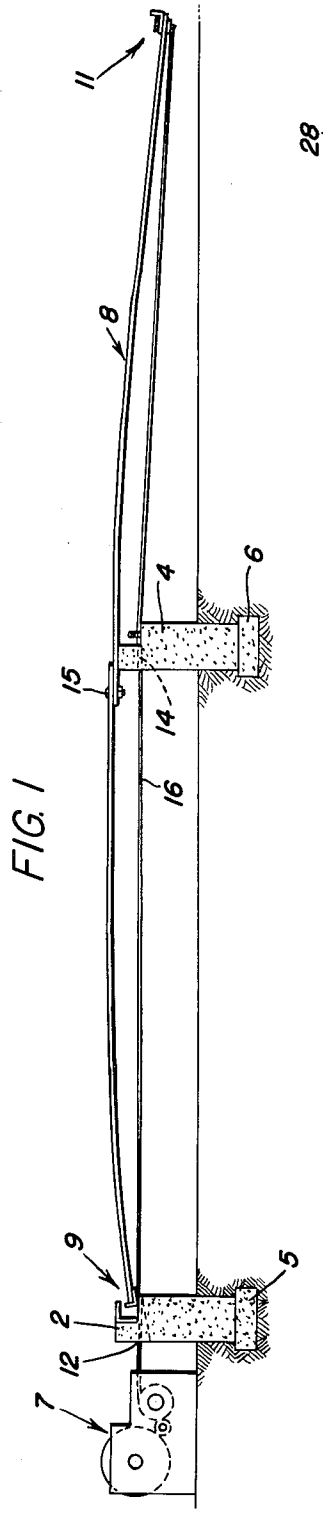


FIG. 1

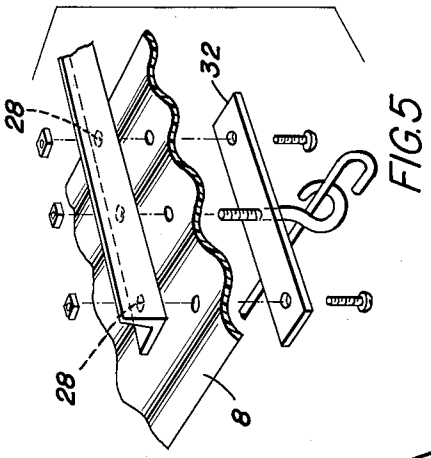


FIG. 5

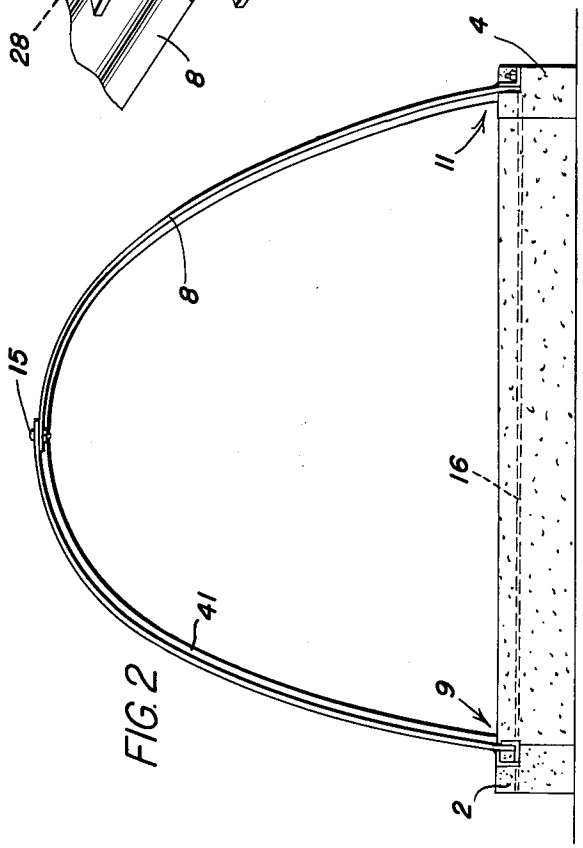


FIG. 2

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METHOD OF ERECTING PRE-STRESSED BUILDING CONSTRUCTION

Filed Aug. 9, 1957 3 Sheets-Sheet 2

FIG. 3

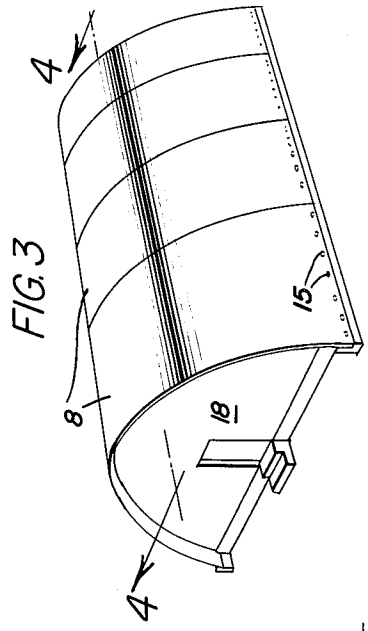


FIG. 8

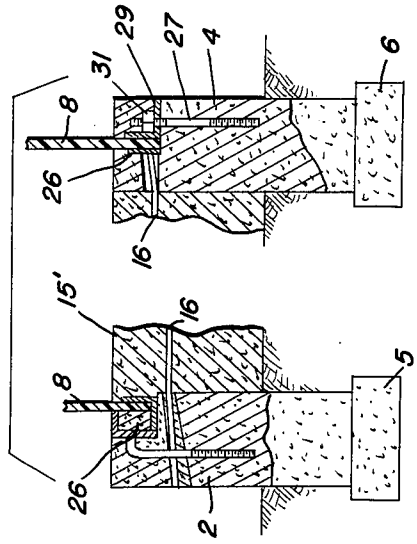


FIG. 4

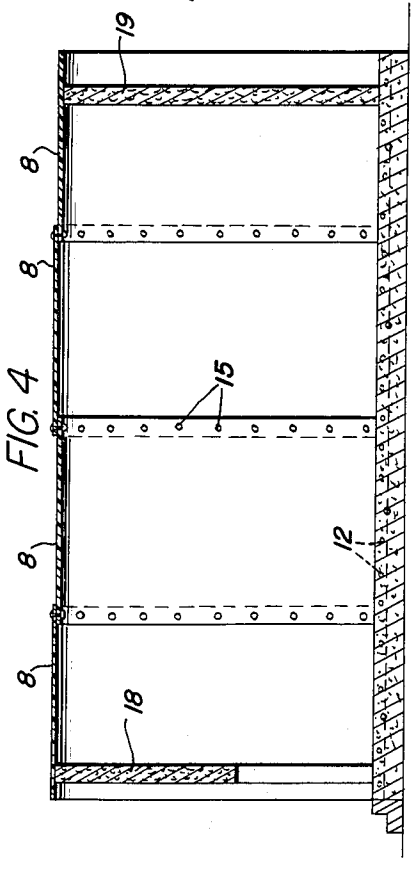


FIG. 6

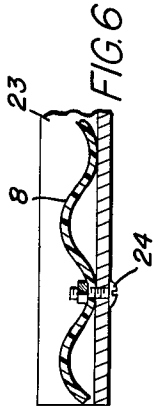
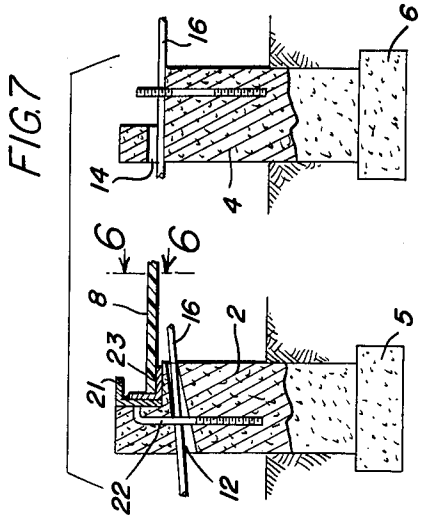


FIG. 7



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Oct. 9, 1962 M. KESSLER 3,057,119

METHOD OF ERECTING PRE-STRESSED BUILDING CONSTRUCTION

Filed Aug. 9, 1957 3 Sheets-Sheet 3

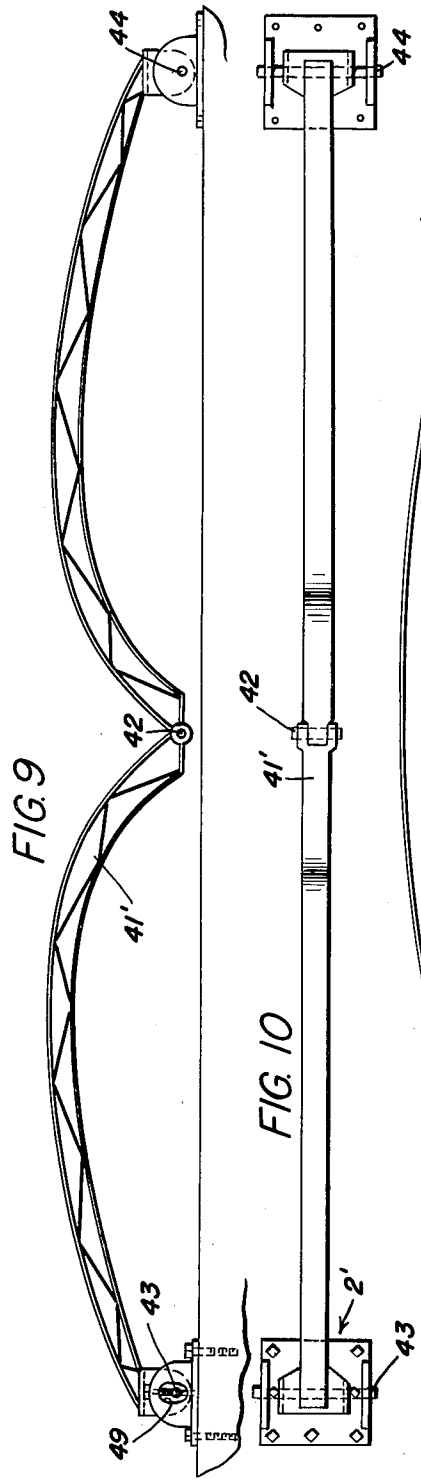


FIG. 9

FIG. 10

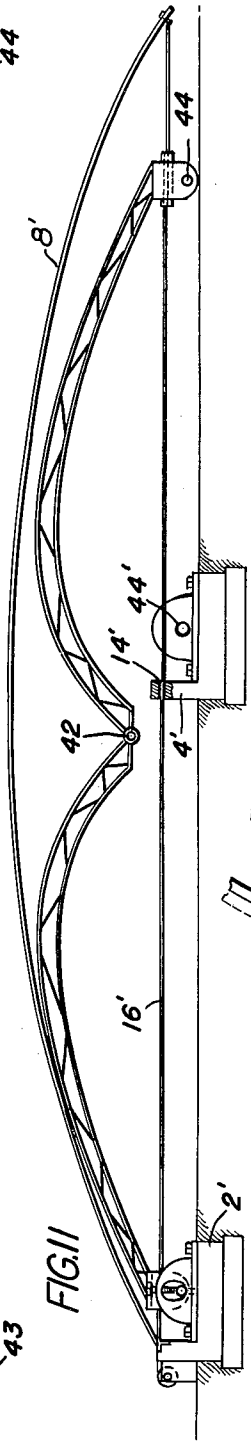


FIG. 11

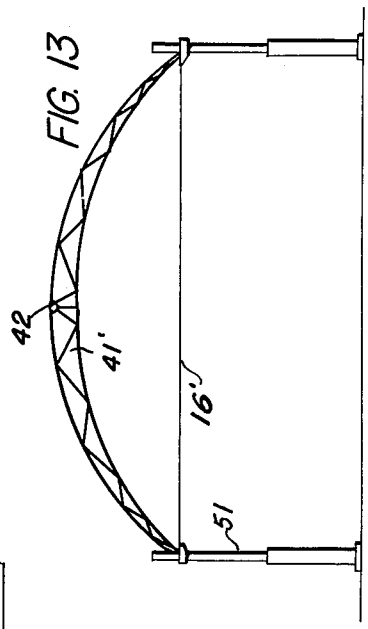


FIG. 13

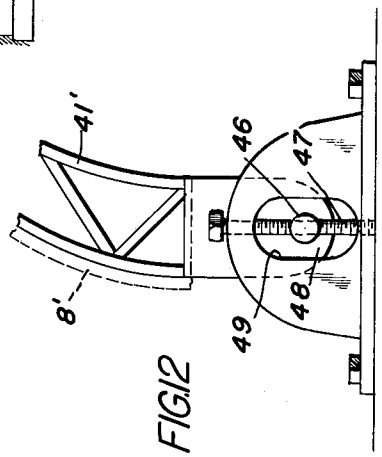


FIG. 12

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3,057,119

METHOD OF ERECTING PRE-STRESSED BUILDING CONSTRUCTION

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Filed Aug. 9, 1957, Ser. No. 677,251
3 Claims. (Cl. 50—531)

This invention relates to a building construction and has for its primary object the provision of an improved building construction which can be quickly and inexpensively erected to provide a rigid, sturdy, permanent enclosure.

It is a major object of the invention to provide a pre-stressed roof and side wall structure which has great strength but which requires little or no supporting frame structure, and which can be quickly erected by relatively unskilled labor. While the major utility contemplated for the invention is in connection with storage or utility structures, the invention is also applicable to house construction and to any other type of building construction.

According to the invention, large flat sheets of flexible construction material, which may be corrugated for strength like corrugated glass-fiber plastic sheets are laid upon a previously-made foundation or footing so that the middle portion of the sheet is bowed upwardly, and the ends are then forced or drawn toward each other in situ to cause the middle portion to arch upwardly to the desired height; the ends are then fastened to the foundation structure to form a structure generally similar in shape to the well-known Quonset hut. Instead of glass-fiber sheets, it will be apparent that metal or other sheet material may be used, but there are certain advantages in the use of glass-fiber for the present purpose, notably in their light-transmitting properties and in their extreme resilience and elasticity, and resistance to elastic "set," which enables the structure to retain its pre-stressed properties, which greatly adds to the strength of the resultant structure.

In the preferred form of the invention, the sheet ends are drawn together by steel cables, which cables remain in the finished structure.

The specific nature of the invention, as well as other objects and advantages thereof, will clearly appear from a description of a preferred embodiment as shown in the accompanying drawings, in which:

FIG. 1 is a schematic view of the invention prior to erection;

FIG. 2 is an end view of the erected roof and side wall structure;

FIG. 3 is a schematic isometric view of one form of the completed structure;

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a detail view showing the manner of fastening the cable to the far end of the sheet;

FIG. 6 is a sectional view taken on line 6—6 of FIG. 7;

FIG. 7 is a transverse sectional view of the foundation structure and sheet prior to erection;

FIG. 8 is a view similar to FIG. 7, after the sheet is in place, and with cement flooring poured around the cables;

FIG. 9 is a side view of a modified form of construction, using a hinged truss as a supporting member;

FIG. 10 is a top view of the structure shown in FIG. 9;

FIG. 11 is a side view similar to FIG. 1, showing the truss and sheeting prior to erection;

FIG. 12 is a detail view of the truss supporting hinge; and

FIG. 13 shows a modified construction in which the structure is used as a roofing member.

Referring to FIG. 1, a side wall foundation is first prepared for the two long sides of the structure, as shown at 2 and 4, each of which is preferably a low foundation

wall erected on suitable footings 5 and 6 placed at a proper distance below the ground level, as required by local building codes. A large built-up sheet 8, which is usually built up of two or more sheets to obtain the required length, is placed with one end 9 abutting the inner side of foundation member 2 and the other end 11 projecting well beyond foundation member 4, which causes the middle portion to bow upwardly due to the weight of the end portions of the sheet. Foundation 2 has a plurality of holes 12 through it, which may be formed by inserting short pieces of pipe at suitable points before the foundation is poured, if the foundation is built of cement, and foundation 4 has a number of similarly made transverse holes 14. A cable 16 is passed through each aligned pair of holes 12 and 14 and is fastened in any suitable manner to the far end 11 of the combined sheet 8, as will be shown in more detail below. The other end of cable 6 is connected to a pulley or other traction mechanism generally indicated at 7 as a power winch or capstan, although any form of hand-operated pulley or winch may be used for this purpose. As the pulley is operated to draw in the cable 16, it is apparent that end 11 of the sheet 8 will be drawn up against foundation 4 as shown in FIG. 2, while the middle portion of the sheet will rise into the air to form the desired enclosure. The ends of the sheet are then fastened to the foundation member in any suitable manner, and the cable 16 may then be removed if desired, or alternatively, and preferably, the cable 16 may be fastened to foundation member 2 and left in place, after which a cement floor 15' may be laid, as shown in FIG. 8, between the foundation members over the cable, which then adds to reinforce the concrete and also to provide a pre-stressed structural element which minimizes the lateral forces on the foundation elements 2 and 4.

The ends 18 and 19 (FIG. 4) of the enclosure may then be built up in any desired or conventional fashion of masonry, framing, corrugated sheeting, etc., similar to the construction of a Quonset hut.

FIG. 7 shows in more detail the manner in which the sheet 8 may be fastened to the side foundation or wall 2. Foundation element 2 is provided with a recess or rabbet at its inner top side. Angle iron 21, to which is welded a rod 22, is set into the cement before it has hardened to form a metal backing with a lip formed by the top side of the angle, adapted to engage the lower leg or angle iron 23 fastened to the edge of sheet 8, to prevent any possibility of sheet 8 slipping up from the foundation while it is being drawn into the arched position. Angle member 23 is fastened to sheet 8 in any suitable manner, as by bolts 24 (FIG. 6) or in any other conventional fashion. It will be seen that the coacting projecting legs of the two angle irons 21 and 23 thus cooperate to insure that the sheet does not slip off, although normally there is no tendency to do so because of the direction in which the force is applied. After the sheet is arched and in place, as shown in FIG. 8, the space between the two angle irons 21 and 23 can be filled with cement grouting as shown at 26, which can readily be poured because of the corrugations in the sheet 8, thus making a waterproof junction.

Foundation element 4 is also preferably provided with a metal backing plate 26, suitably fastened to the cement of the member 4, and also has bolts 27 pre-set into it. Corresponding holes 28 are provided in angle member 29, attached to the opposite edge of sheet 8, and as the edge is seated on the foundation member 4, it is guided into mating engagement with the bolts 27, and then fastened down by nuts 31 or in any other suitable manner. The far edge 11 of the sheet is also preferably provided at the points where the cable 16 is attached to it, with a further short plate 32 (FIG. 5) and a hole drilled

through the assembly for the passage of an I-bolt 33, to which cable 16 may be fastened in any conventional manner, shown as a hook 34. Alternatively, the I-bolt 37 could be omitted, and the cable passed through the hole 38, entirely through the sheet, and back through the next adjacent hole along the edge of the sheet 8, and so all the way back to foundation member 2, whereby each length of cable will provide two tension members, or any other suitable fastening means may be employed.

If the material of the sheets is made sufficiently heavy and rigid, no internal bracing under the roof is required, but in some cases it may be more economical to use a lighter sheet material and support it with any suitable structure or framework which will be erected under the raised roof sheet, so that this can be quickly and inexpensively done. Such a structure is shown in FIG. 2, where a bracing member 41 is provided at a suitable point or points along the length of the enclosure. In a small enclosure, member 41 may be a single unitary metal arch raised by manpower after the enclosure 8 is erected.

The structure of FIGS. 3 and 4 is adequate for relatively short lengths, since the end walls serve adequately as supporting members, but in many cases a longer structure is required. Of course, if the sheeting material is made sufficiently thick, no internal bracing is required, but where the advantages of plastic sheeting are desired, this material is relatively expensive, and it is possible to use a much lighter grade of sheeting, and yet obtain great strength, if an occasional transverse bracing member such as 41 is used as an intermediate supporting means for sheds (e.g., storage sheds) that are very long relative to their width. Particularly great strength is obtainable if the transverse truss member is put into stressed relation with the outer skin structure, as will be shown below.

For use with large enclosures, FIGS. 9 and 10 show such a truss member 41', which is hinged at 42 and also at the ends 43 and 44, so that it can be initially laid flat, as best shown in FIG. 10, with one end hinge 43 fastened to the foundation 2'; this foundation member also supports one end of the sheeting material 8', in any suitable manner, which may be similar to that shown in FIG. 1, or in any other suitable manner, not shown in detail, since it will be apparent that this can be accomplished in various ways. The far hinge 43 is provided with an aperture 44 through which cable 16' is passed; this cable also passes through an aperture 14' in foundation member 4', similar to the arrangement shown in FIG. 1. It will be understood that due to the great length of these sheets, they are preferably formed of smaller sheets fastened together, as best shown in FIGS. 1–4, and this is done in place while the sheet is more or less flat on the ground, the individual sheets being preferably pre-punched (or drilled) with the necessary holes at their edges for the reception of the bolts or rivets (as shown, e.g., at 15 in FIGS. 1–4). This feature is of great importance in reducing the cost, since the work can be done by relatively unskilled workmen without special scaffolding or other special tools, as is now required for the erection of such structures as Quonset huts and other sheet metal structures, due to the fact that these prior art structures are assembled as they are being erected, and not, as in the present invention, pre-assembled on the ground and then raised into final position.

It will be apparent that as the cable 16' is drawn in, the combined roof and truss structure will be raised as before, until hinge member 44 can be fitted on its mating piece 44' and a hinge pin inserted to fasten the truss member in place. The outer sheet or skin 8' is then also fastened to the foundation as before, to produce a structure generally similar to that shown in FIG. 2, except that in this case the hinged truss is employed.

It is very desirable that the truss be in firm stressed contact with the sheet at all points, and in order to insure this, one or both of the end hinges may preferably be provided with an arrangement, as best shown in FIG. 12, whereby, after the structure has been raised, the hinge pin 46 can be raised a few inches. For this purpose the pin is shown provided with a threaded transverse aperture through which a screw bolt 47 is inserted, which also passes through suitable apertures in the lower half 48 of the hinge. The aperture 49 in said lower hinge half is not round but oval, as shown, whereby as screw bolt 47 is turned down, the hinge pin 46 is raised, thus forcing the truss 41' into fully stressed contact with the underside of the sheet 8' against which it presses. In this way the roof and truss make a single rigid structural member of great strength.

It should be noted that the sheets 8 are preferably fastened together not only with bolts or rivets as shown, but also with cement, applied before the sheets are joined. Suitable cements are available, e.g., those containing epoxy resins, which cure and set at ambient temperature to join the sheets into substantially an integral member. For this purpose, I prefer to use a slow curing epoxy cement which is applied while the sheets are being assembled on the ground, but does not set until after the entire structure is erected, thus insuring maximum strength at the sheet junctions.

Alternatively, the side walls, instead of being mere foundation members, may be made sufficiently high to serve as full side walls for the structure, as shown in FIG. 9, the arched construction previously described serving only as an integral roof member. In this case, the cables 16' are left in place as tension members after the roof is erected, the method of erection being very similar to that shown in connection with FIG. 1. The side walls 2' and 4' are made sufficiently high so that there is head room under the cables 16', so that in this case the walls may be of any standard construction, and the arched-sheet and cable structure serves as an integral self-supporting roof structure. One way of doing this is shown in FIG. 13. The structure of FIG. 11 is set up as before, except that the foundation members 2' and 4' are omitted and any temporary stop members, which may be stakes driven into the ground, are used instead to temporarily support the ends of the sheeting (and trusses, where trusses are used). Alternatively, the foundation members 2 and 4 may be used, except that the holes 12 and 14 are omitted, and the cable 16 is passed over the foundation, or through notches left therein. When the arched structure is raised, the cables 16 are fastened to it at both ends, in any suitable manner, so that the cables and arch form a unitary stressed structure independent of the foundation. Jacks 51, such as screw jacks are then employed to raise the arched roof to a suitable height, and side and end walls then erected in any known manner, which may be of masonry construction, sheet metal, or wood. In this way, the construction of the roof, which is usually the most expensive part of the enclosure, is greatly facilitated, since the labor cost of constructing the roof in the manner described, while it is on the ground, is very much less than by conventional methods.

For very large structures, where a hinged truss is used, the truss may be provided with several hinges such as shown at 42, which may be desirable to reduce the size of the individual truss pieces so that they may easily transported to the site of the building. The only requirement is that the truss be so laid out that all of the intermediate hinges are higher than cable 16' when the cable is first tightened, as shown in FIG. 11, so that the truss will arch upwardly.

It wil also be apparent that instead of drawing in a cable, the far end 11 of the sheet could be pushed into place, as by the use of tractors or bulldozers, and the ends of the sheet then suitably fastened in place. By "large structural arch" in the claims is meant a structural arch too large to be handled by unaided manpower alone.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be

made in construction and arrangement within the scope of my invention as defined in the appended claims.

I claim:

1. Method of erecting a large structural arch of flexible self-supporting, semi-rigid sheet material into its position of use which comprises assembling a number of smaller sheets of said material in situ flat on the ground, by fastening adjacent edges of said smaller sheets together to form a larger sheet having two longitudinally extending edges, supporting the central portion of said assembled sheet during assembly so that the center portion thereof between said edges is initially arched slightly upward with respect to said edges, applying a generally horizontal compressive force to the ends of said assembled sheet material to urge said ends toward each other and thereby raise said center portion to form a desired arched configuration, and securing said ends to maintain said arched configuration.

2. The method according to claim 1, said individual sheets being of flexible plastic material, said sheets being joined by applying cement to the contiguous portions thereof prior to erection of the arch, and erecting the arch before said cement has set.

3. Method of erecting a large structural arch of flexible sheet material which comprises erecting two parallel low foundation wall members, said members extending for a short distance vertically above the ground level; assembling a number of sheets of said material in side-by-side relation by fastening adjacent edges of said sheets together to form a large sheet having one dimension substantially coextensive with the length of said foundation wall members, with one edge of said large sheet lying against the interior side of one of said wall members, and the opposite edge of said large sheet extending well past the other wall member, whereby said other wall member supports the central axis of the sheet in a slightly arched condition well above the ground level; applying a generally horizontal compressive force to said opposite edge of said large sheet to bring said opposite edge toward said other wall member while raising the center of the sheet into an arch, until said opposite end is adjacent said other wall, and fastening said opposite end to said other wall member.

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