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⑤④ **Modular bearing structure, triangular in shape, for the construction of geodetic vaults.**

⑤⑦ A modular supporting structure consisting of a frame having the shape of an isosceles triangle, formed by three tubular bars (1,2) connected by a joint element (3) at the top vertex and by two joint elements (4) at the two base vertices, the length of the base joint elements (4) being exactly half of the length of the top joint element (3), so that at each node of the trelliswork composed of several modular supporting structures, two adjacent base joint elements (4) being part of two separate to adjacent modules, are perfectly positioned over a top joint element (3) being part of a third module under the two above adjacent modules.

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Triangular, modular supporting structure for constructing geodetic vaults

This application for a design patent relates to a triangular, supporting modular structure for constructing trellis geodetic vaults, be they cloister vaults, barrel vaults or spherical domes.

There are many well known systems for constructing vault roofing but all, to a lesser or greater extent have the same problem of difficult assembly, often requiring costly scaffolds and reinforcements.

In addition, the majority of structures used for the construction of vault roofing are made in such a way that after having been installed, they generally can not easily be extended or reduced according to possible future requirements.

The aim of this invention is to design a new modular supporting structure for vault constructions being, simple and inexpensive to construct, fast to assemble, easy to transport thanks to reduced sizes and weight, and being versatile, i.e. easy to adapt to the most varied requirements with the possibility of easily extending or reducing the same in the future.

The modular supporting structure according to the invention consists of a frame having the shape of an isosceles triangle, consisting of three tubular bars joined by means of a joint element at the top vertex and by two joint elements at the two base vertices, the length of the base joint elements being exactly half of the length of the top joint element so that at each node of the trelliswork, realized using several modular supporting structures according to the invention, two adjacent base joint-elements being part of two separate adjacent modules, are perfectly positioned over a top joint element being part of a third module under the two above adjacent modules.

The modular structure according to the invention is shaped so that at each node of the trelliswork the bars of the adjacent modules are perfectly aligned, i.e. the horizontal bars of the adjacent modules are positioned exactly along the same horizontal axis, while each slanted bar of the superimposed modules is positioned exactly along the same slanted plane with all the longitudinal axes of the corresponding slanted bars being part of the various superimposed modules.

In a preferred embodiment of the invention the above joint elements consist of thick box shaped sheet plate sleeves whose cross section has a "U" profile. The base of this "U" shape forms, which the two parallel and opposite sides, an angle equal to the half of the "alpha" angle corresponding to the angle at the centre of each circular section in which the geometric circle of the roofing vault is subdivided for the construction of trellis vaults.

Two half-sleeves as above are fitted at the two base vertices of the modular structure, the length of these being equal to half of the top sleeve which is obviously upside down with respect to the base half-sleeves, so that the ends of the two slanted bars can be filled and bolted into the parallel and opposite sides of the two sleeve and of the base half-sleeves, at the top and at the bottom respectively.

A shelf is welded under the central side of the base half-sleeves, the same being turned towards the inside of the triangular frame and ending with a transverse tubular spacer which perfectly fits into the horizontal tubular bar of the modular structure in question. At the two ends of this bar there is a hole for the bolt which passes the above tubular spacer to fix both half-sleeves to the base bar.

At each node of the trelliswork formed by several modular structures according to the invention, and composed of top and base joint elements constructed according to the preferred embodiment as described above, two base half-sleeves being part of two adjacent modules, are positioned precisely over a top sleeve being part of a third module under the above adjacent modules.

At each node, each sleeve is fixed firmly to the two overlying half-sleeves by means of a pair of bolts which pass the matching and superimposed bases of the sleeve and half-sleeve.

According to another preferred embodiment of the top and base elements joining the bars of the modular structures, the same consist of a pair of gusset plates in which the ends of the bars are inserted and bolted.

The sizes and shape of the top pair of gusset plates, in which the two slanted bars of the triangular frame join, are obtained by positioning the two base pairs of half-gussets next to each other. The bottom edges of the half-gussets are bent around a horizontal axis to form an "alpha" angle equal to the angle at the centre of each circular section in which the geometric circle of the vault is divided for the construction of trellis "vaults".

The two top gusset plates are characterized by a double 90° horizontal bend of their upper edges, which are consequently parallel but closer with respect to their lower edges, so that at each node of the trelliswork realized using several modular structures as described above, a male and female type coupling occurs in such a way that the upper edges of each pair of top gusset plates exactly fits into the bent lower edges of two pairs of base half-gusset plates being part of two adjacent modules.

In this case the final fixing between the top and base joint elements can be made by means of a

pair of bolts passed through the upper edges drawn closer together, of a pair of top gusset plates and through the bent lower edges of two pairs of base half-gusset plates.

For major clarity the description of the invention continues with reference to the enclosed drawing tables used descriptively rather than in a limiting sense, in which:

- fig. 1 illustrates the modular structure according to the invention, with joint elements constructed with sleeves and half-sleeves made of "U" box shaped sheet plate;

- fig. 2 illustrates a node of a trelliswork realized using several modular structures in the version illustrated in fig. 1;

- fig. 3 is the section of fig. with the plane III-III of fig. 2;

- fig. 4 illustrates the modular structure according to the invention with top and base joint elements constructed with a pair of gusset plates and a pair of half-gusset plates, being suitably shaped and die-bent;

- fig. 5 illustrates a node of a trelliswork realized using several modular structures in the version illustrated in fig. 4;

- fig. 6 is the section of fig. 5 with the plane VI-VI of fig. 5;

- fig. 7 is a schematic representation of the break down of the geometric arch of a vault in circular sectors, with "alfa" angle at the centre, for the construction of trellis vaults;

- fig. 8 is a schematic representation of a section of trelliswork constructed using several modular structures according to the invention;

- figs. 9 and 10 illustrate two ridge joint elements constructed in the two above versions, one using "U" die-bent sheet plate sleeves, the other using a couple of gusset plates suitably shaped and die-bent.

With reference to figures 1, 2 and 3, the modular supporting structure according to the invention and according to its first preferred embodiment, consists of a frame having the shape of an isosceles triangle, formed by a tubular base bar (1) and by two slanted tubular bars (2) with holes (1a) and (2a) at their ends.

The two slanted bars (2) are connected by means of a joint sleeve (3), made of a "U" box metal element positioned upside down, into whose opposite sides the ends of the converging bars (2) are fitted; the converging bars are fixed to the top sleeve (3) by means of bolts, which are not illustrated in the enclosed drawings, and which pass through holes (3a) made for this purpose on the sleeve (3) and through the holes (2a) of the bars (2), where an internal tubular spacer (2b) is welded as illustrated in section A-A of fig. 1.

Connection between the slanted bars and the

horizontal base bar (1) is by means of two half-sleeves (4) each consisting of a metal box element having the same shape, but turned upside down with respect to that of the sleeve (3), having half the length of the latter.

The end of each bar (2) is fitted into the opposite sides of the box shaped element (4) where it is fixed firmly by means of bolts which pass through a hole (4a) made on the half-sleeves (4) and through the bushing (2b), welded in the bar (2) at the height of the above end holes (2a).

Connection between the bar (1) and the two side half-sleeves (4) is by means of a shelf (4b) welded on each half-sleeve (4) and ending with a transverse tubular spacer (4c) which perfectly fits into the bar (1) to allow the passage of the bolt which is fitted into the holes (1a) of the bar (1) so as to fix the latter to each half-sleeve (4).

With reference to figs. 3 and 7 attention is drawn to the fact that the base of the box elements (3) and (4) is slanted with respect to the horizontal direction of an angle equal to half the "alpha" angle at the centre of each circular section in which the geometric circle of the vault is divided, so that by positioning several modules on top of one another, the same are on differently slanted planes whose track forms a broken line coinciding with the spans of the circular sections in which the vault geometric circle is divided, as illustrated for purposes of clarification in fig. 7.

With reference to fig. 2, attention is drawn to the fact that the holes (3a) and (4a) of the base half-sleeves (3) and of the top sleeve (4) respectively are positioned so that by placing two half-sleeves (3) on top of a sleeve (4) the axes of the bars (2) cross at point N, through which the axis of the horizontal bars (1) also passes, forming the node, in which the longitudinal axes of the trelliswork bars, converge.

With reference to figures 4, 5 and 6, it can be noted how, according to a second preferred embodiment of the top and base elements joining the bars of the modular structure, these joint elements consist of pairs of gusset plates having suitable shape and sizes, in which the ends of the bars are bolted.

In particular, the pair of top gusset plates (30) in which the slanted bars (2) converge, is formed by two identical, adjacent metal plates, each of which has two holes (30a) through which two bolts - not illustrated in the drawing - pass and fix the two slanted bars (2) inside the pair of gusset plates (30) respectively.

The latter pair of top gusset plates are characterized in that they have a double bend of 90° along the upper edges of each plate between which there is a space less than the existing space between the lower edges of these plates in which

the ends of the slanted bars (2) are fitted and bolted.

Each base element joining the slanted bars (2) and the horizontal bar (1) consists of a pair of half-gusset plates (40) composed of two identical adjacent metal plates, whose shape and sizes are half that of the plates forming the pair of top gusset plates (30).

There is a hole (40a) on the pair of base half-gusset plates (40) for the bolt - not illustrated in the drawing - which fixes the slanted bar (2) inside the pair of half-gusset plates (40).

There is also a hole (40b) on the pair of half-gusset plates (40) for the bolt which fixes the end of the horizontal bar (1) in the pair of base half-gusset plates (40).

With reference to fig. 6 attention is drawn to the fact that the lower edges of this pair of base half-gusset plates (40) are bent around a horizontal axis by an "alpha" angle equal to the angle at the centre of each circular section in which the geometric circle of the vault is divided (see fig. 7) for the construction of the trellis vault.

The distance between the two plates forming the pair of base half-gusset plates (40) is such that the edges drawn closer together, of the pair of top gusset plates (30) can fit perfectly into the lower bent edges of said pair of base half-gusset plates (40) where these edges drawn closer together can be fixed firmly by means of a bolt passing through holes (40c) and (30c) on the edges drawn closer together of the base half-gusset plates (40) and on the lower bent edges of the top gusset plates (30) respectively.

With reference to fig. 9 attention is drawn to the fact that if the top sleeve is a ridge sleeve, i.e. a part of the module with which the trellis structure ends at the top, it has two side shelves (3b) terminating with a transverse spacer (3c) for connecting the horizontal bars (10) which join the top vertices of the adjacent modules with which the trellis structure ends at the top, as shown in fig 8.

With reference to fig. 10 attention is drawn to the fact that if the top gusset plate is a ridge gusset plate, it has two holes (30b) for the bolts connecting the horizontal bars (10) which join the top vertices of the adjacent modules with which the trellis structure ends at the top; in this case there is no double 90° bend of the upper edges of the gusset plates.

Claims

1) A modular, supporting triangular structure for constructing geodetic vaults, consisting of a frame having the shape of an isosceles triangle, formed by three tubular bars connected to each other by a

joint element at the top vertex and by two joint elements at the two base vertices, whose length and shape are half that of the top joint elements, in than in a preferred embodiment the above top and base joint elements consist respectively of sleeves (3) and half-sleeves (4) obtained by means of a "U" shaped metal box element, into whose opposite sides the ends of the converging bars (2) are fitted, these being fixed to the top sleeve (3) and to the base half-sleeves (4) by means of bolts fitted into holes (3a) and (4a) on the sleeves (3) and the half-sleeves (4) and into holes (2a) on the end of the bars (2) where an internal tubular spacer (2b) is fitted to prevent deformation when the above bolts are tightened; the connection between the horizontal bar (1) and the two lateral base half-sleeves (4) is obtained by welding on each half-sleeve (4), a shelf (4b) ending with a transverse tubular spacer (4c) which perfectly fits into the bar (1), to allow the passage of the bolt which is fitted into the holes (1a) of the bar (1) so as to fix the latter to each half-sleeve (4).

2) A triangular, modular supporting structure for constructing geodetic vaults according to the previous claim characterized in that the base of the box elements (3) and (4) is slanted with respect to the horizontal direction of an angle equal to half of the "alpha" angle at the centre of each circular section in which the geometric circle of the vault is subdivided.

3) A triangular, modular supporting structure for constructing geodetic vaults, consisting of a frame in the shape of an isosceles triangle, formed by three tubular bars connected by a joint element at the top vertex and by two joint elements at the base vertices, whose length and shape are half that of the top joint elements, in that in a preferred embodiment, the above top and base joint elements consist respectively of pairs of gusset plates (30) or semi-gusset plates (40) having suitable shape and sizes, into which the ends of the bars are bolted:

- the pair of top gusset plates (30) into which the slanted bars (2) converge, consists of two identical and adjacent metal plates characterized by a double 90° bend along the upper edges of each plate, between which there is a space less than the existing space between the lower edges of these plates, on which are holes (30a) for the bolts which fix the bars in the pair of gusset plates (30);
- the pair of base semi-gussets (40) consists of two identical and adjacent metal plates on which there are two holes (40a) and (40b) respectively through which the bolt which fixes the slanted bar (2) and the bolt which fixes the horizontal bars (1), pass.

4) A triangular, modular supporting structure for constructing geodetic vaults, according to claim 3), characterized in that the lower edges of the pair of

base semi-gusset plates (40) are bent around a horizontal axis of an "alpha" angle equal to the angle at the centre of each circular section in which the vault geometric circle is subdivided for the construction of trellis vaults.

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5) A triangular, modular supporting structure for constructing geodetic vaults according to claims 3) and 4), characterized in that the space between the two plates forming the pair of base gusset plates (40) is such that the edges drawn closer together, of the pair of top gusset plates (30) drawn closer together can be exactly fitted into the lower bent edges of said pair of base semi-gusset plates (40) where these edges drawn closer together can be firmly fixed by means of a transverse bolt, for which there are holes (40c) and (30c) on the edges drawn closer together, of the base semi-gusset plates (40) and on the lower bent edges of the top gusset plates (30) respectively.

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6) A triangular, modular structure for constructing geodetic vaults according to claim (1) characterized in that, should the top sleeve be a ridge sleeve, this will have two side shelves (3b) ending with a transverse spacer (3c) far connecting the horizontal bars (10), joining the top vertices of the adjacent modules, with which the trellis structure ends at the top.

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7) A triangular, modular supporting structure for constructing geodetic vaults according to claim 3), characterized in that, should the gusset plate be a ridge gusset plate, it will have two holes (30b) for the bolts which connect the horizontal bars (10) joining the top vertices of the adjacent modules with which the trellis structure ends at the top, in that the double 90° bend is no longer made along the upper edges of the gusset plates.

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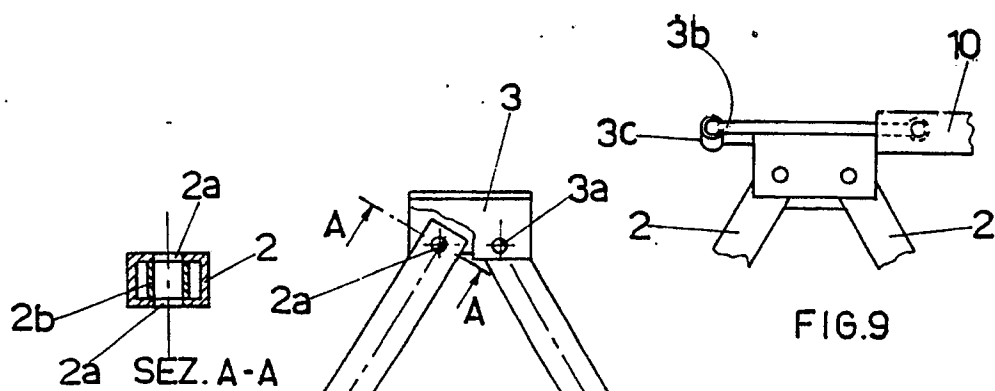


FIG. 1

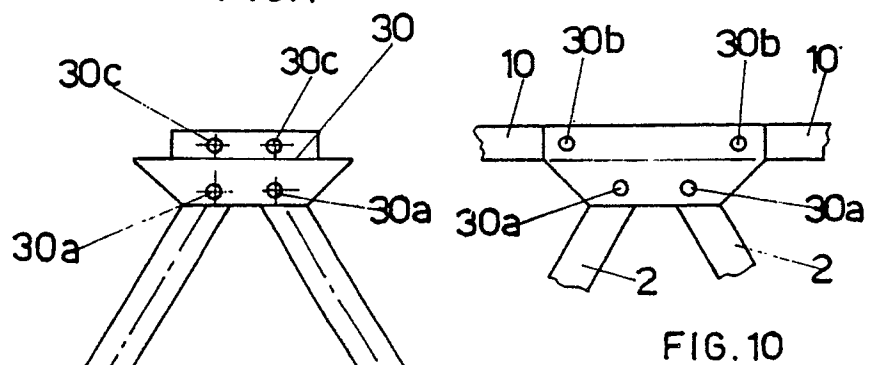


FIG. 10

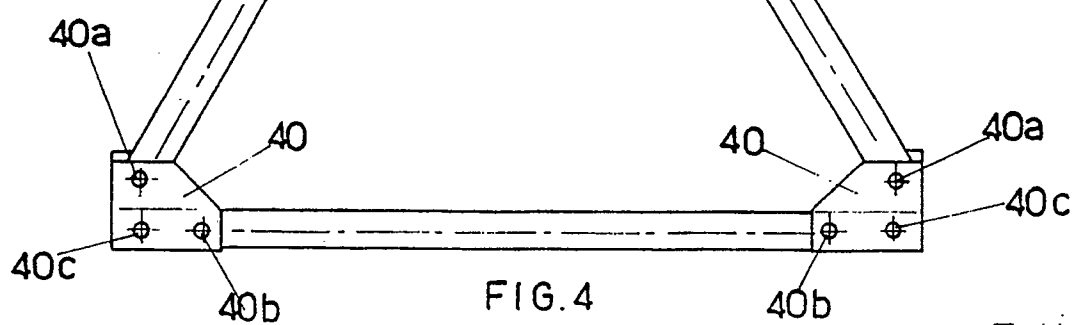


FIG. 4

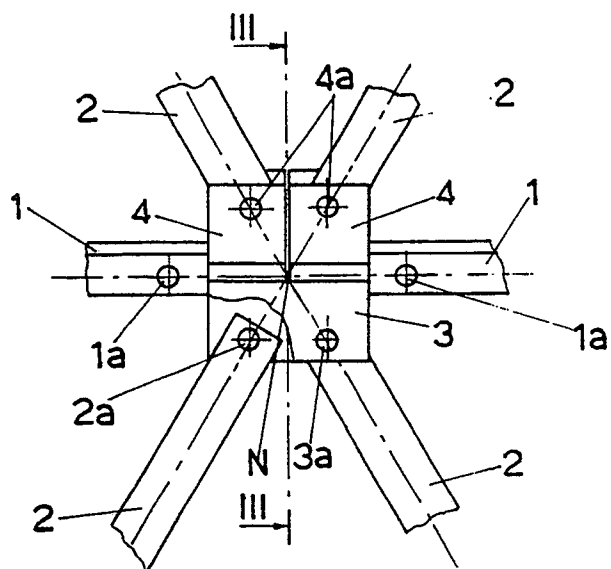


FIG. 2

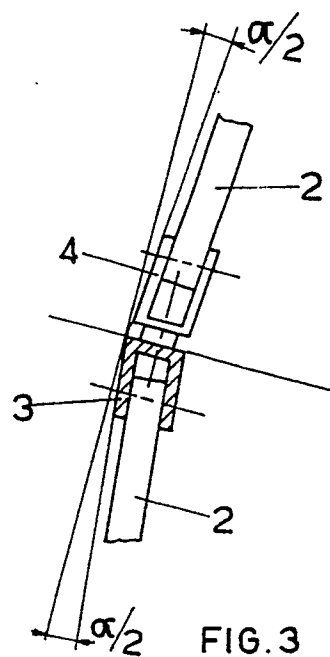


FIG. 3

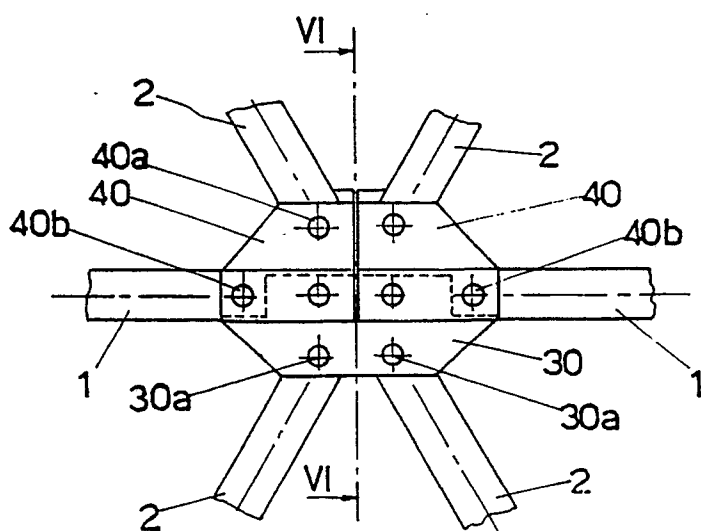


FIG. 5

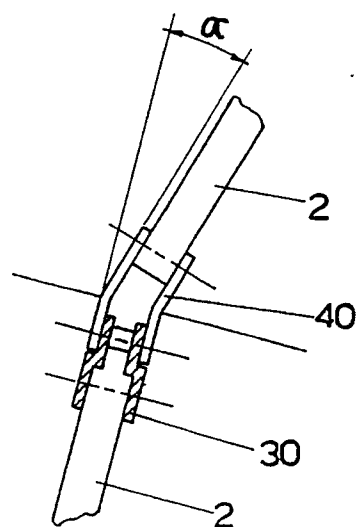


FIG. 6

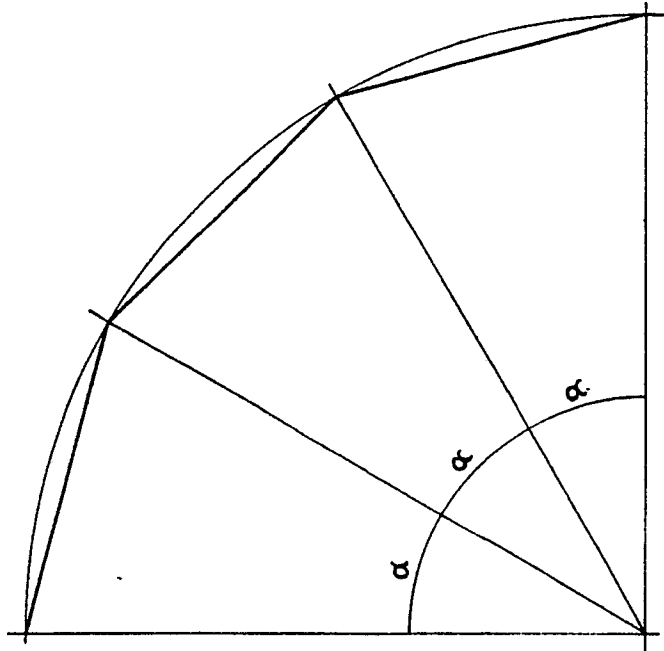


FIG.7

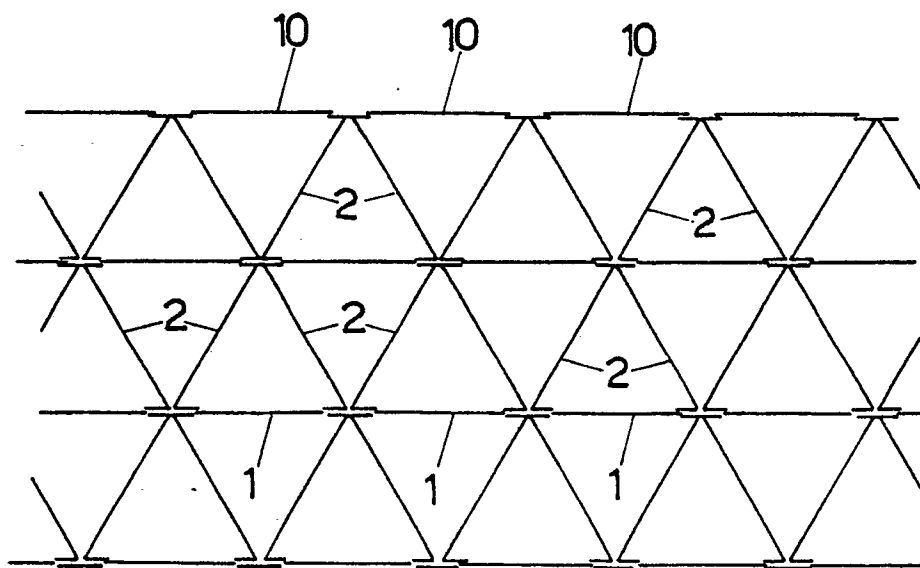


FIG.8



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 83 0068

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 009 543 (T. SMRT) * Column 2, lines 32-45; column 2, line 62 - column 3, line 29; figures 1-4 *	1,3	E 04 B 7/10 E 04 B 1/32
A	US-A-3 255 556 (R. D'AMATO) * Column 3, lines 11-68; figures 2,3 *	1,3	
A	GB-A- 929 862 (TUBEWRIGHTS LTD) * Page 1, lines 55-68; figures 4-6 *	1	
A	CH-A- 213 713 (C. CAMINATI) * Page 2, lines 44-51; figures 5,6 *	1	
A	US-A-3 959 937 (L. SPUNT) * Column 2, lines 46-51; figure 6 *	2	
A	DE-A-2 421 920 (B. LEITNER) * Page 5, lines 4-21; figures 1,3 *	4	
A	US-A-4 542 759 (P. KYNER) * Column 6, lines 4-10; figures 20,21; column 4, lines 3-10; figures 10,11 *	3,5	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-4 464 073 (A. CHERRY) * Column 3, line 52 - column 4, line 3; figures 12,13 *	6	E 04 B
A	FR-A-2 080 921 (GREIMBAU-LIZENZ GmbH) * Page 11, lines 5-7; figure 3 *	7	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 10-10-1989	Examiner KRIEKOUKIS S.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			