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Hemmelsbach

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[54] **MODULAR STRUCTURE FORMED OF INTERCONNECTED TUBULAR MEMBERS**

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[52] **U.S. Cl.** ..... **52/86;** 52/93; 52/648; 52/650; 135/3 R

[51] **Int. Cl.**[2] **E04B 1/32;** E04B 7/02

[58] **Field of Search** ..... 52/648, 650, 649, 655, 52/86, 81, 63, 82, 93; 135/3 R

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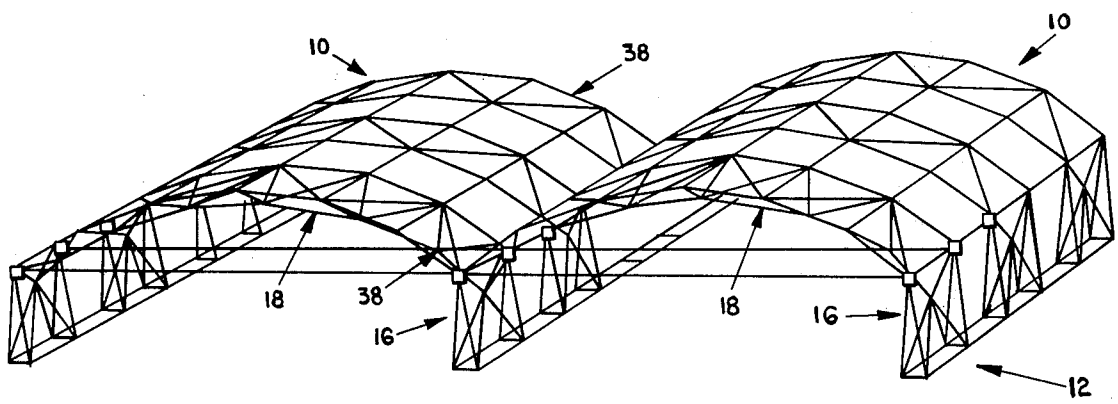
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Assistant Examiner—Leslie A. Braun
Attorney, Agent, or Firm—McGarry & Waters

[57] **ABSTRACT**

A modular structure formed of interconnected tubular members comprises a plurality of domed truss sections aligned in end-to-end relationship, but spaced apart and interconnected by spacer tubes, so as to form a stretched truss structure. Each truss section comprises a section of a domed roof, formed of inverted pyramidal truss units having rectangular bases, and a pair of support towers supporting each end of each section of the domed roof and acting as the side walls of the modular structure. Each support tower comprises a rectangular base formed of tubular members and support struts extending upwardly from each corner of the base, with the support struts on each side of the support tower being interconnected at a common point at the top thereof. Diagonal reinforcement tubes extend across the bases of the pyramidal truss units and provide additional rigidity for the stretched truss structure. Reinforcing tubes interconnecting the corners of the support towers at a common point maintain the structural rigidity of the support towers.

16 Claims, 7 Drawing Figures



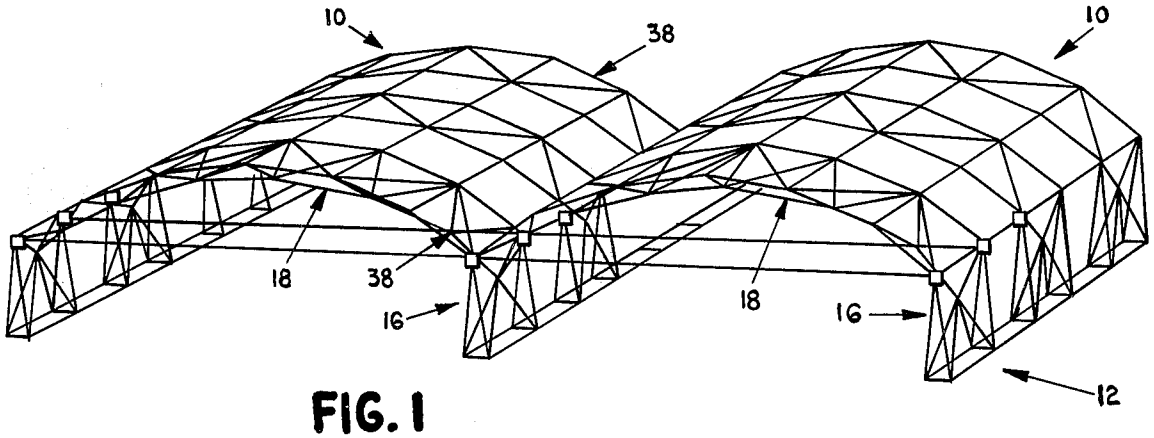


FIG. 1

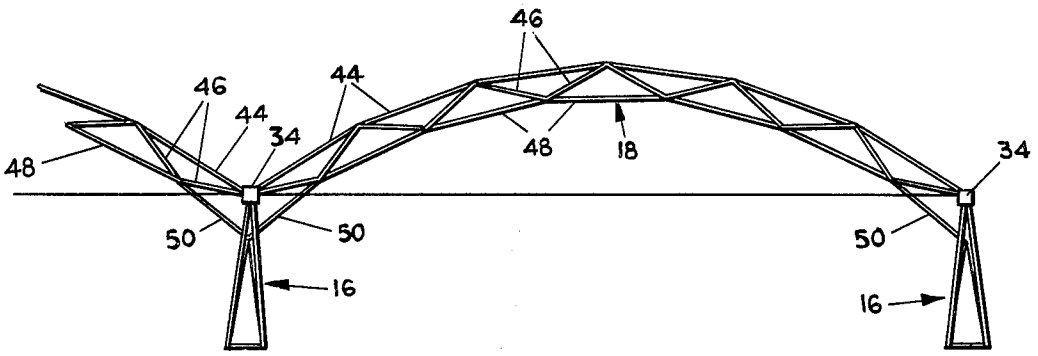


FIG. 2

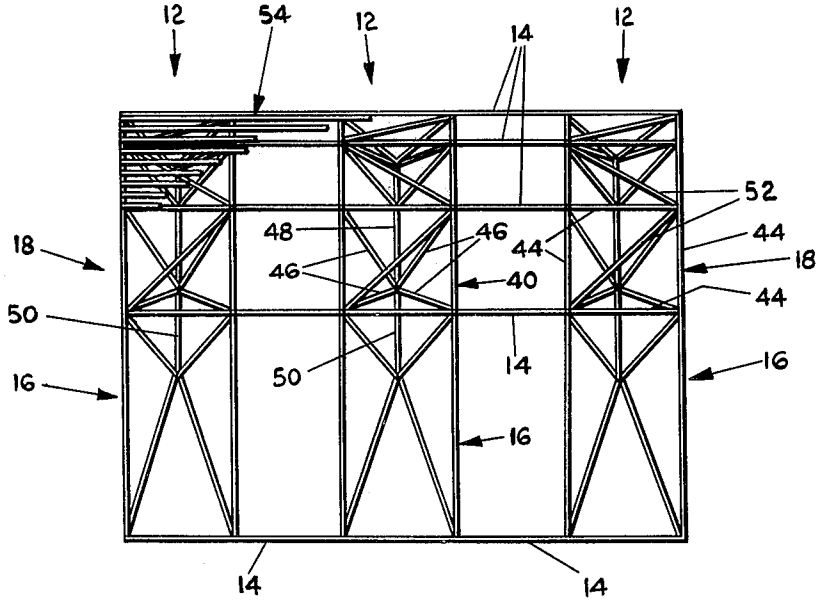


FIG. 3

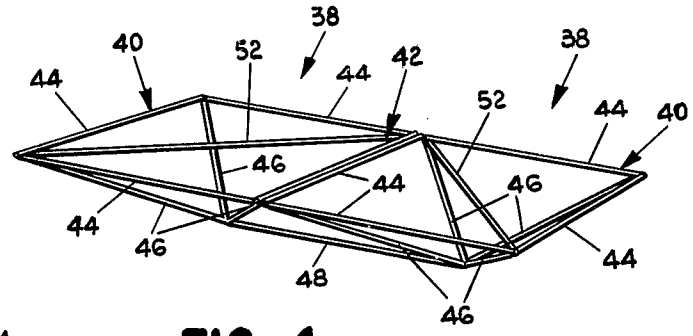


FIG. 4

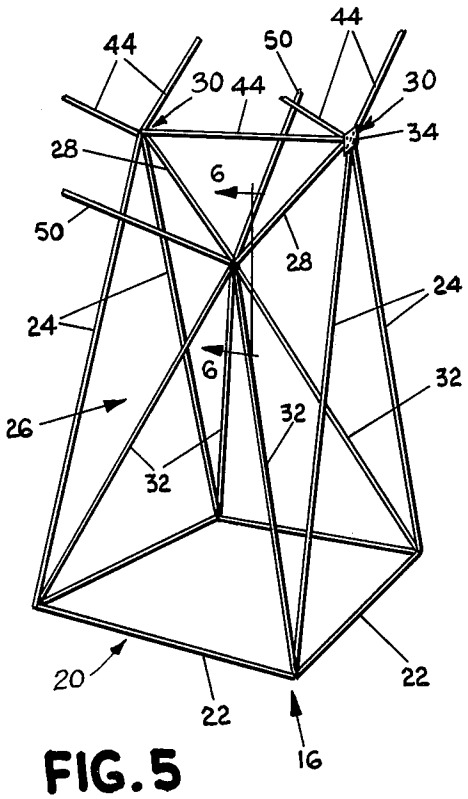


FIG. 5

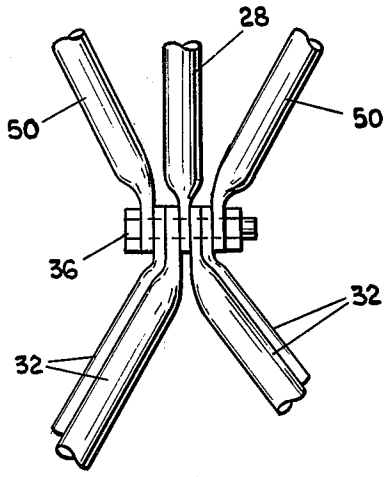


FIG. 6

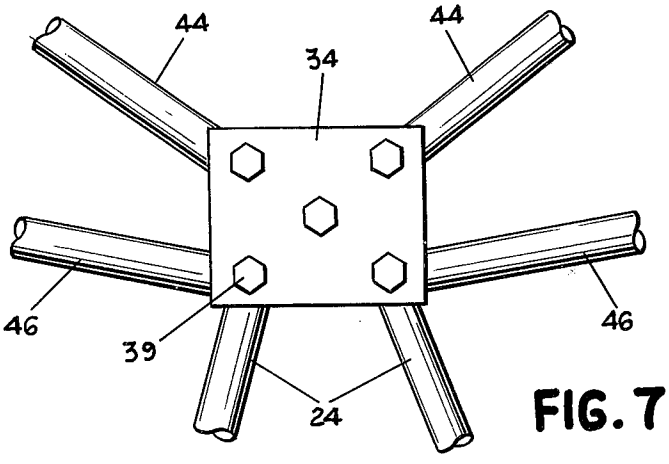


FIG. 7

MODULAR STRUCTURE FORMED OF INTERCONNECTED TUBULAR MEMBERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to modular structures and more particularly to an improved modular structure formed of interconnected tubular members.

2. Description of the Prior Art

Due to the high cost of labor and materials involved in erecting conventional types of building facilities, attempts have been made to decrease the cost of structural enclosures by making pre-fabricated structures that may be connected together in modules at the site of the construction. One type of modular structure involves the use of interconnected tubular members which form a domed type of framework which may then be covered by a suitable outer skin, such as a plastic material or the like.

One of the problems with such types of modular structures is that it is necessary to form the structure either in the form of a hemisphere or the form of a section of a hollow cylinder, much along the lines of the conventional Quonset hut design. In either type of structure, the domed roof and the walls present a continuous curved surface, and valuable space at ground level is lost along the edges of the structure, because the walls are sloped or converging at ground level. Also, in structures of this nature, the height of the structure is directly related to the ground area occupied by the structure in accordance with the geometry of a sphere or cylinder.

In previously existing modular structures formed of interconnected tubular members, the walls of such structures have typically been formed of a solid matrix of interconnected truss members, with reinforcing rods and struts being employed in all sections of the structure. This type of construction is suitable for many purposes but involves a significant expenditure on support frame work.

Another problem with certain previously existing modular structures formed of interconnected tubular members is that, to the extent that such structures have been constructed of a web of interconnected truss units formed in the shape of pyramids having rectangular bases, the points or tops of the pyramids generally have been positioned so as to be extending outwardly from the surfaces of the outer walls, thus presenting a non-uniform exterior surface to the structure, which detracts from the exterior appearance and militates against the use of certain types of coverings.

It is one of the objects of the present invention to provide a vertically oriented support tower formed of tubular members for use in connection with an elongated domed modular structure, such that the support tower serves as the vertical sidewall of the structure.

Another object of the present invention is to provide a stretched truss structure for an elongated domed modular structure, wherein rigid individual truss sections may be spaced apart and interconnected by spacer tubes.

Still another object of the present invention is to provide a reinforced truss structure that permits the use of a stretched truss design without impairing the structural rigidity of the overall modular structure.

Still another object of the present invention is to provide a modular structure formed of interconnected pyramidal truss units, wherein the truss structure has a smooth, even outer surface.

The foregoing deficiencies in previous modular structure designs and the foregoing objects, as well as other objects and advantages, are achieved by the modular structure of the present invention.

SUMMARY OF THE INVENTION

In accordance with the present invention, an improved modular structure formed entirely of interconnected tubular members comprises a pair of support towers spaced apart and defining the walls of the modular structure and a domed roof resting on and supported by the support towers. Each support tower comprises a rectangular base formed of tubular base members interconnected at right angles and support struts attached to and extending upwardly from each corner of the base, with the support struts on each side of the base being connected at the top ends thereof, thus forming a pair of upper corners on the support tower. Reinforcing means in the form of reinforcing tubes are employed to maintain the structural rigidity of the support tower. The reinforcing tubes extend from each of the corners of the base and from the upper corners of the tower and are connected together rigidly at a common point in the interior of the support tower by a nut and bolt connection.

The domed roof extends between the tops or upper corners of two opposed support towers and is connected to the upper corners of the towers by means of connecting plates. The domed roof comprises a plurality of pyramidal truss units having rectangular bases formed of tubular members connected together at right angles, with the truss units being interconnected end-to-end in a curved column along a common side of each base. The pyramidal portion of each truss unit is formed of tubular members extending from the corners of the base to a common point. The pyramid is inverted (i.e., extending toward the inside of the modular structure), so that the outside of the structure comprises a smooth outer surface formed by the adjacent adjoining base members.

The structural rigidity of this structure is increased by interconnecting the common points of the adjoining pyramidal truss units with truss unit reinforcing tubes and by providing diagonal reinforcement tubes across two opposing corners of the base of each truss unit. The diagonal reinforcement tubes are particularly important when this truss structure is used in fabricating a stretched truss modular structure.

In order to construct an elongated domed modular structure, the foregoing structures each constitute a truss section and are connected together end-to-end in accordance with the present invention. Due to the fact that the foregoing truss structure is extremely strong, it is not necessary to attach each section together directly in an end-to-end relationship, as has been the practice in the prior art. Rather, each truss section may be spaced apart in end-to-end alignment and interconnected with the adjacent truss sections by means of appropriate spacer tubes interconnecting the corners of each base in each truss section with the corner of the base in the truss section immediately adjacent thereto. Thus, it is possible with the structure of the present invention to create a "stretched" truss structure, which results in a considerable savings in both materials and in assembly time.

The tubular members employed in the structure of the present invention are preformed hollow tubular members having flattened ends with bolt openings therein. The structure is assembled simply by bolting these preformed members together.

The covering for the structure of the present invention may be any conventional covering, such as a flexible plastic material or the like. In one application, where the structure of the present application is used as a nursery to protect seedling trees, the structure is covered with a snow fence type of covering which if formed of closely spaced narrow wooden slats. This covering protects seedling trees from wind and temperature gradients until they are hearty enough to withstand the elements on their own.

These and other advantages and features of the present invention will hereinafter appear, and for purposes of illustration but not of limitation, a preferred embodiment of the subject invention is described below and shown in the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing two enclosures constructed in accordance with the present invention and interconnected in a twin dome enclosure.

FIG. **2** is an end view of the modular structure of the present invention.

FIG. **3** is a side view of the modular structure of the present invention.

FIG. **4** is a perspective view of two individual truss units connected together in accordance with the present invention.

FIG. **5** is a fragmentary perspective view showing a single support tower of the present invention.

FIG. **6** is a fragmentary view taken along line **6—6** of FIG. **5.**

FIG. **7** is a fragmentary end view showing the connection between the towers and twin dome roof structure of FIGS. **1** and **2.**

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, a pair of modular structures **10** constructed in accordance with the present invention are shown in FIG. **1** connected side-by-side in the form of a twin dome enclosure. Each individual structure comprises a plurality of truss sections **12** (shown in FIG. **3**) connected together end-to-end by means of spacer tubes **14.** For illustrative purposes, the structure shown in FIG. **3** comprises three interconnected truss sections. However, the present invention is not limited to any specific number of truss sections, and it would be possible to use any number of truss sections within the spirit and scope of the present invention. Indeed, a modular structure could conceivably consist of a single truss section alone for certain types of construction requirements.

The truss structure of the present invention is formed entirely of preformed hollow tubular members, with each tubular member having flattened ends and bolt openings therethrough. The structure is constructed simply by bolting the tubular members together with conventional fasteners and this operation can conveniently take place at the construction site, thus facilitating transportation of the structure. Disassembly, similarly, can be undertaken at the construction site simply by unbolting the tubular members.

Each truss section **12** comprises a pair of opposing support towers **16** and a domed roof **18** which extends between the tops of the support towers and encloses the modular structure. As shown in FIG. **2,** by using support towers as opposed to forming the structure of a single, continuous domed wall, it is not necessary to employ a domed roof having a substantially semicircular cross section in order to achieve substantially vertical side walls for the structure. Rather, vertical side walls are provided by the support towers and a flatter domed roof may be employed than would otherwise be possible. In addition, by varying the height of the support tower and the amount of dome on the roof, it is possible to achieve height to width ratios for the structure that are not obtainable with domed structures not employing support towers.

The construction of the support towers **16** is shown in detail in FIG. **5.** Support tower **16** is formed entirely of interconnected tubes, preferably tubular members formed of steel, aluminum or the like. Support tower **16** comprises a rectangular base **20** consisting of four equal tubular base members **22** interconnected together at the ends thereof at right angles to one another. The preferred structure employs a rectangular base, but it would be possible to employ a base having a configuration other than a rectangle. Extending upwardly from each of the corners of the base are four separate support struts **24.** The two support struts **24** on each side of the base are connected together so as to form a pair of corners **30** at the tops thereof, thus giving the support structure a generally triangular cross section. Corners **30** are joined by tubular member **44,** which, as discussed below, constitutes one of the base members in domed roof **18.**

For purposes of discussion, the triangular sides of the support tower will be referred to as the sides of the support tower and the planar faces of the support tower will be referred to as the inside and outside surfaces of the support tower, depending upon whether the surface faces toward the inside of the modular structure or the outside of the modular structure.

Reinforcement of the support tower structure is provided by connecting all six corners of the support tower together by means of a reinforcing structure **26.** This reinforcing structure provides sufficient structural rigidity so that the support tower can withstand the stresses that are placed upon it. Preferably, this reinforcing structure comprises upper reinforcing tubes **28,** which extend downwardly from upper corners **30** of the support towers, and lower refinforcing tubes **32,** which extend to a common point from each of the corners of the base **20.** In the preferred embodiment of the subject invention, the inner ends of both the upper and lower reinforcing tubes are connected together rigidly at a common point in the interior of the support tower by means of a bolt and nut fastener **36** which extends through mating openings in the overlapping ends of the reinforcing tubes. Other types of fasteners also would be suitable for this purpose.

The domed roof **18** of each truss section comprises a plurality of pyramidal truss units **38** having rectangular bases **40,** with the truss units **38** being connected together in a curved column along adjoining common sides **42** of adjoining truss units. As shown in detail in FIG. **4,** each truss unit comprises four tubular base members **44,** which are bolted together at right angles at the ends thereof. Preferably, these base members are all of equal length, but it is not necessary that this be

the case, as other rectangular forms may also be satisfactory.

The rectangular bases of each truss unit are braced by means of four tubular members **46** which extend to a common point from each corner of the truss unit, thus forming an inverted pyramid type of structure, with the exterior surface of the truss unit comprising a flat surface formed by tubular base members **44.** The inner ends of brace members **46** are all interconnected at the common point and form the point of the pyramid.

As shown in FIG. **4,** truss units **38** are interconnected along a common edge **42** of the bases **40** thereof, with a single tubular member **44** serving as the edge of the base in each pair of adjoining truss units. It would also be possible to construct completely separate truss units and connect them together with overlapping edges, but the additional material necessary for this type of construction is unnecessary for the structural rigidity of the unit.

The ends of each truss section are mounted on support towers **16** by means of flat steel connecting plate **34.** The ends of each tubular member **44** on the outside of each section are bolted to a connecting plate, and each connecting plate is in turn bolted to an upper corner **30** of the adjoining support tower **16.**

Reinforcement of adjacent truss units **38** is provided by truss unit spacer tubes **48** which interconnect the points of adjacent pyramids in each truss section. A separate truss unit spacer tube **50** is provided at the end of each section of roof to interconnect the point of the last pyramid with the support tower on which the domed roof is mounted at the common point where the tower reinforcing tubes are interconnected (see FIG. **6**).

Another type of reinforcement employed in the truss structure of the present invention is a diagonal reinforcing tube **52,** which extends across two opposing corners of the base of each truss unit. This diagonal reinforcing tube may not be necessary in a structure wherein adjacent truss sections are joined directly together, but these diagonal reinforcing tubes do provide significant additional structural rigidity when the stretched truss structure of the present invention is employed. As shown in FIG. **3,** diagonal reinforcing tubes **52** are connected together in a zig-zag fashion, with the ends of the reinforcing tubes in adjacent truss sections being connected to common corners of the adjacent truss units.

The stretched truss structure of the present invention is shown in detail in FIG. **3,** wherein each of the separate truss sections **18** are interconnected by means of spacer tubes **14** at the corners of the bases of each truss unit. Additional spacer tubes **14** are employed to connect the corners of the bases of each support tower to the corners of the adjacent support tower. Preferably, the open sections of the modular structure formed by spacer tubes **14** are approximately equal in width to one truss section of the modular structure. However, it would also be possible to provide greater or lesser separation of the truss sections, depending on the strength desired for the structure, the weight of the skin to be applied to the structure, or winds or other climatic conditions expected to be encountered by the structure.

Preferably, also, spacer tubes **14** are each horizontally disposed and extend from the corner of one truss unit to the immediately adjacent corner of the truss unit in the adjoining truss section. It is also contemplated that these spacer tubes could be connected in some other fashion, such as in a diagonal arrangement or the like, without adversely impairing the structural rigidity of the modular structure.

As discussed above, one important advantage of a support tower feature of the present invention is that the modular structure has generally vertical side walls and hence a greater useable area than a structure wherein the sidewalls and roof are formed by a continuous domed surface. Also, the use of a support tower **16** of the type described herein permits the construction of the twin dome type of structure shown in FIG. **1,** with a single support tower **16** serving as a common wall between two adjacent truss sections. The reinforced tubular structure of support tower **16** of the present invention provides adequate rigidity for the support of even this twin dome structure while minimizing the amount of materials and complexity of construction involved.

One of the important advantages achieved with the stretched truss structure of the present invention is that this structure substantially reduces the cost and complexity of a modular structure, without adversely affecting the structural rigidity of the module. The use of diagonal reinforcement tubes in the truss units of each truss section provides important additional support for this truss design.

Another advantage of the structure of the present invention is that the exterior surface of the domed roof of the structure is smooth and even, thus permitting the application of a smooth skin or covering to the modular structure. This also permits the application of flat materials to the structure, whereas such flat materials are not easily applicable to the outer surfaces of a modular structure wherein the points of the pyramids extend outwardly towards the exterior the structure.

When the structure of the present invention is used as an enclosure for a nursery for seedling evergreen trees ot the like, a preferred covering is a snow fence type of material consisting of a plurality of narrow wooden slats attached together in closely spaced relationship. A portion of a fence **54** constructed in this manner is shown schematically in FIG. **3.**

One of the problems encountered in growing seedling evergreen trees is that in late winter the warm sun present during the days causes the sprouts to start to grow, and then the cold nights and winds kill the new sprouts. By using the enclosure of the present invention and a snow fence type of covering, the seedlings are protected from the warm sun and other elements, so that the growth of the sprouts will be delayed until the weather is sufficiently warm to avoid damage to the sprouts.

It should be understood that the embodiments described herein are merely exemplary of the preferred practice of the present invention and that various changes, modifications, and variations may be made in the arrangements, operations, and details of construction of the elements disclosed herein without departing from the spirit and scope of the present invention, as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A modular structure comprising:

a pair of vertical support towers spaced apart and defining the sides of the modular structure, each support tower comprising a base formed of interconnected tubular members and support struts extend-

ing upwardly from the base so as to form a pair of upper corners spaced apart a pre-determined distance, each said tower further comprising reinforcing means that interconnect the base and the support struts so as to maintain the upper corners of the tower in a fixed position relative to the base of the tower; and

a section of a domed roof mounted on and extending between the support towers, said section of domed roof comprising a plurality of interconnected truss units formed in the shape of inverted pyramids having rectangular bases, said truss units being formed of tubular members connected together at the ends thereof, with the truss units being connected together along common sides of their bases, the truss units on each end of the domed roof section being mounted on the upper corners of the tower such that one side of the base of each such truss unit extends between the upper corners of the tower.

2. A modular structure as claimed in claim **1** wherein each pair of towers and attached section of domed roof comprise a single truss section and the modular structure comprises a plurality of truss sections connected together end-to-end.

3. A modular structure as claimed in claim **2** wherein the individual truss sections are spaced apart by truss section spacer tubes that extend between and connect adjacent truss sections so as to separate adjacent truss sections by a pre-determined distance.

4. A modular structure as claimed in claim **3** and further comprising diagonal reinforcing tubes extending between opposite corners of the bases of a sufficient number of truss units to adequately reinforce the modular structure.

5. A modular structure as claimed in claim **4** wherein the truss section spacer tubes extend from the corners of each truss unit in each truss section to the corners of each truss unit in the truss section adjacent thereto.

6. A modular structure as claimed in claim **4** and further comprising a plurality of truss unit spacer tubes interconnecting the inverted points of adjacent pyramidal truss units in each truss section, a truss unit spacer tube also extending from the inverted point on the truss unit at each end of each section of domed roof to the tower on which the truss unit is mounted.

7. A modular structure as claimed in claim **1** wherein:

the base of each tower is rectangular and is positioned such that two sides of the base are parallel to the axis of the domed roof and two sides of the base are perpendicular to the axis of the domed roof;

the tower comprises four support struts extending upwardly from the respective four corners of the base in vertical planes perpendicular to the axis of the domed roof, each pair of struts in a common plane being connected at upper ends thereof to form each upper corner of the tower; and

the reinforcing means comprise reinforcing tubes that extend from each corner of the base and each upper corner of the tower to a common point inside the tower, said reinforcing tubes being interconnected at said common point.

8. A modular structure as claimed in claim **7** wherein the domed roof is bolted to each upper corner of each tower by means of a connecting plate.

9. A modular structure comprising:

a pair of support towers spaced apart and defining the sides of the modular structure, said support towers each having inside surfaces that face each other, outside surfaces that face away from each other, and side surfaces that are perpendicular to the inside and outside surfaces, each support tower comprising:

a rectangular base formed of tubular base members interconnected at right angles at corners of the base;

support struts attached to and extending upwardly from each corner of the base, with the support struts on each side of the base being connected at upper ends thereof so as to make each side of the support tower a vertically disposed triangle, with the upper ends of the struts forming spaced upper corners of the support tower; and

reinforcing means adapted to maintain the structural rigidity of each support tower; and

a section of domed roof mounted on and extending between the upper corners of the two support towers, said domed roof comprising a plurality of pyramidal truss units having rectangular bases formed of tubular members connected together at right angles, with the truss units being interconnected end-to-end along a common side of each base, and with the sides of the bases on each end of the domed roof being connected at the ends thereof to the upper corners of the support tower.

10. A modular structure as claimed in claim **9** wherein the reinforcing means comprises a plurality of reinforcing tubes, one tube extending upwardly from each of the four corners of the base and one tube extending downwardly from each upper corner of the support tower, said reinforcing tubes all extending to a common point in the interior of the support tower and being rigidly fastened together at said point.

11. A modular structure as claimed in claim **10** wherein the reinforcing tubes of the truss tower are interconnected at said common point by means of a bolt and nut fastener.

12. A modular structure as claimed in claim **9** wherein:

each pair of towers and interconnecting section of domed roof comprises a single truss section and the modular structure comprises:

a plurality of identical truss sections, spaced apart a fixed distance and aligned end-to-end;

truss section spacer tubes interconnecting each corner of each base of each pyramidal truss unit with the corner of the base of the adjacent truss unit in the immediately adjacent truss section; and

diagonal reinforcing tubes extending diagonally across the base of each truss unit.

13. A modular structure as claimed in claim **12** wherein:

the pyramidal truss units are positioned so that the base of the pyramid forms the outer surface of the domed roof and the sides of the pyramid extend inwardly to a common point in the interior of the structure; and

truss unit spacer tubes interconnect the inwardly extending common points of adjacent pyramids in each truss section.

14. A modular structure as claimed in claim **13** wherein the modular structure is covered with snow fence material.

15. A modular structure comprising:

a plurality of identical domed truss sections spaced apart from each other a fixed distance and aligned end-to-end to form an elongated domed structure,

each truss section comprising:

a plurality of identical inverted pyramidal truss units connected together end-to-end in a curved column, each truss unit comprising a rectangular base formed of tubular members connected together at right angles and four tubular members extending from the respective four corners of the base to a common point, said truss units being connected together in said curved column along common sides of their bases;

truss unit spacer tubes interconnecting the common point of each truss unit with the common point of the adjoining truss unit in each truss section; and

diagonal reinforcing tubes extending between two opposing corners of each truss unit base; and

a plurality of truss section spacer tubes interconnecting the adjacent truss sections so as to produce a stretched truss structure, the truss section spacer tubes extending from the corners of the base of the truss units in each truss section to the adjacent corners of the base of the truss units in the adjacent truss section.

16. A modular structure as claimed in claim **15** wherein each domed truss section further comprises:

a vertically disposed support tower supporting each end of each domed truss section at a pre-determined distance above the ground, each tower being formed of tubular members that are interconnected at the ends thereof to form a rectangular base and a pair of upper corners on which the domed truss section is mounted.

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