United States Patent [19]

Seaman

[11] **3,872,634**

[45] **Mar. 25, 1975**

[54] **RIGID FRAME, TENSIONED FABRIC STRUCTURE**

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[73] Assignee: **Seaman Corporation,** Millersburg, Ohio

[22] Filed: **June 20, 1973**

[21] Appl. No.: **370,028**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 276,899, July 31, 1972, abandoned.

[52] **U.S. Cl.** **52/222,** 52/80, 52/86, 52/63

[51] **Int. Cl.** **E04b 1/347,** E04b 1/32

[58] **Field of Search** 52/63, 86, 80, 83; 135/1

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Assistant Examiner—Henry Raduazo
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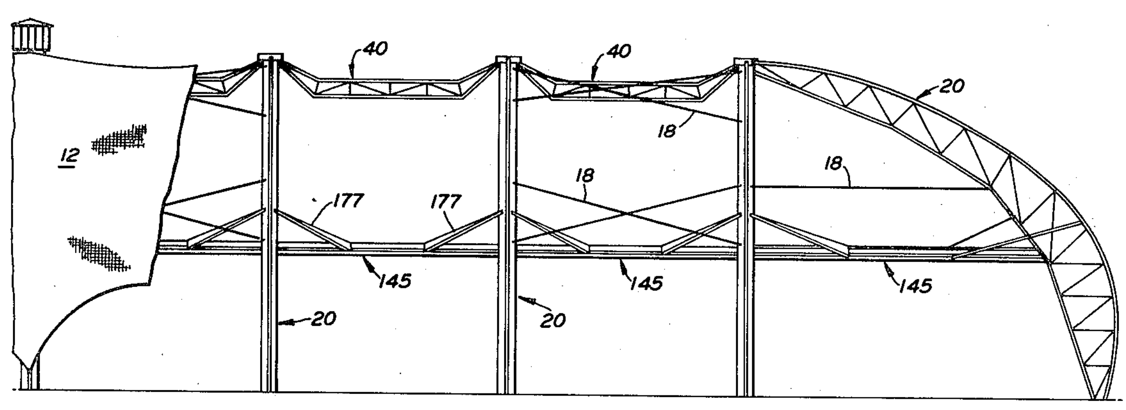
[57] **ABSTRACT**

A rigid frame structure having a plurality of curvilinear truss members of polygonal cross section which at their lower ends are connected to a foundation and at their upper ends are connected to at least one other truss member to form a framework. A fabric membrane covers the framework and is tensioned by cables extending between the truss members to form a stable rigid fabric covered structure.

38 Claims, 38 Drawing Figures



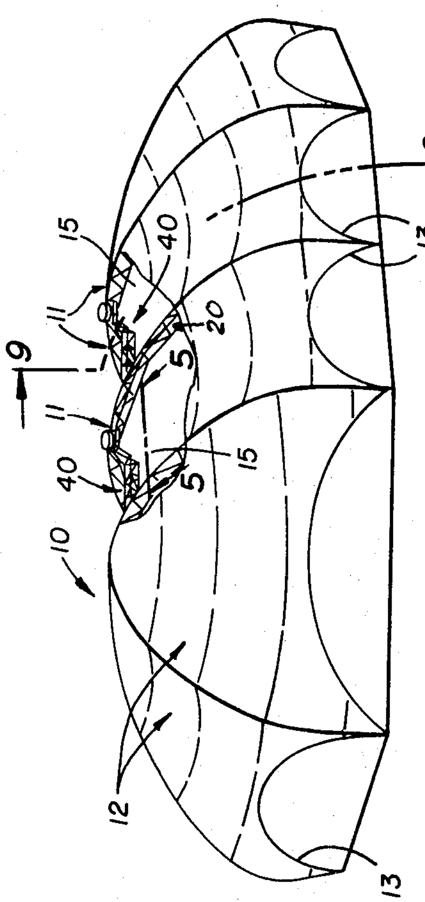


FIG. 1

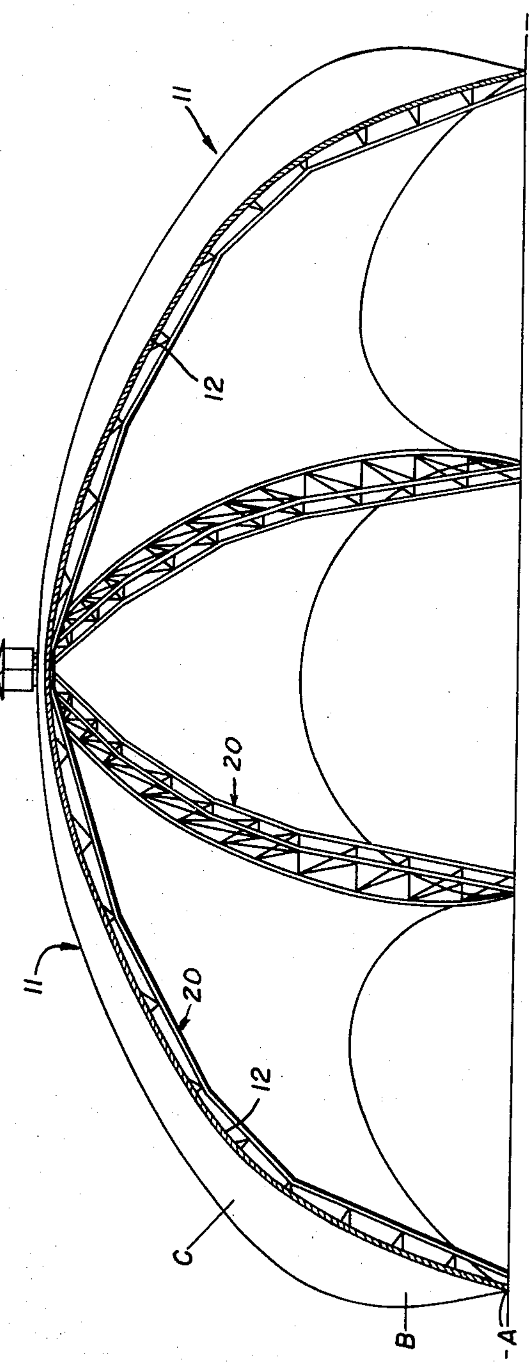
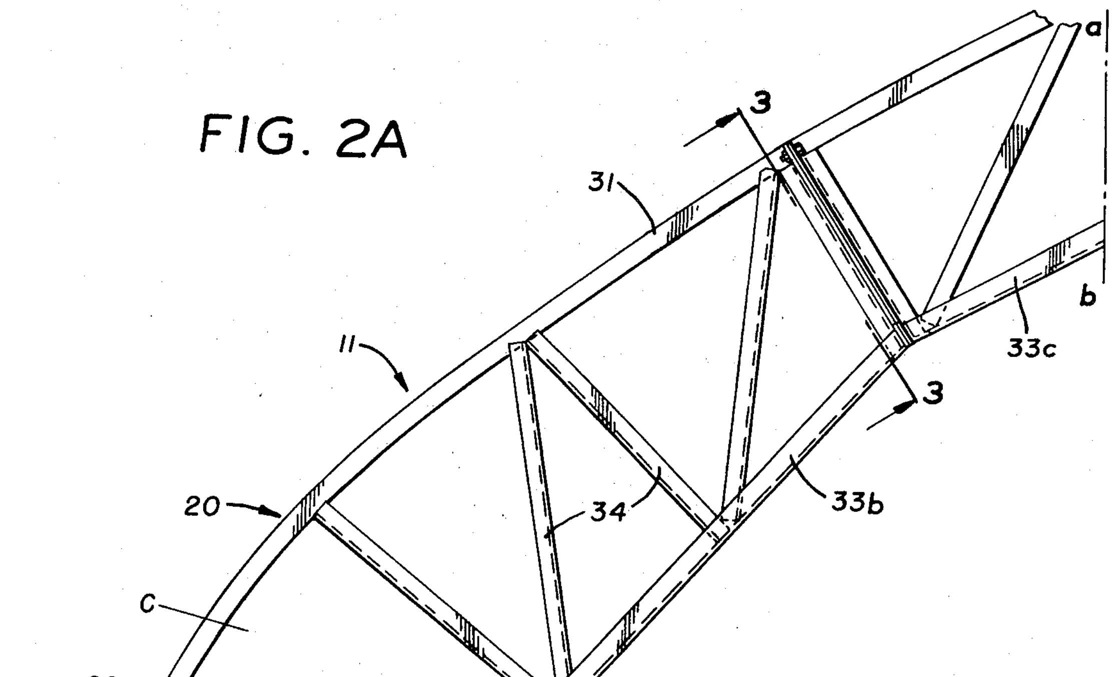


FIG. 9

FIG. 2A



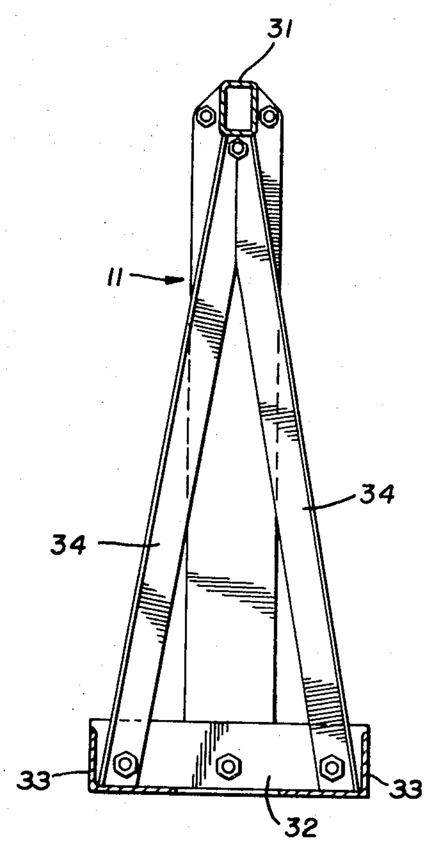


FIG. 3

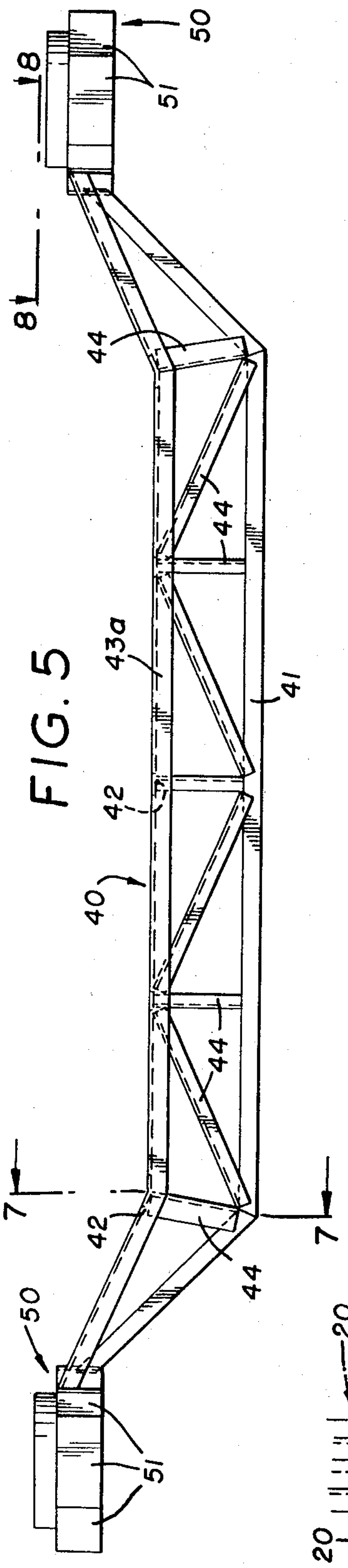


FIG. 5

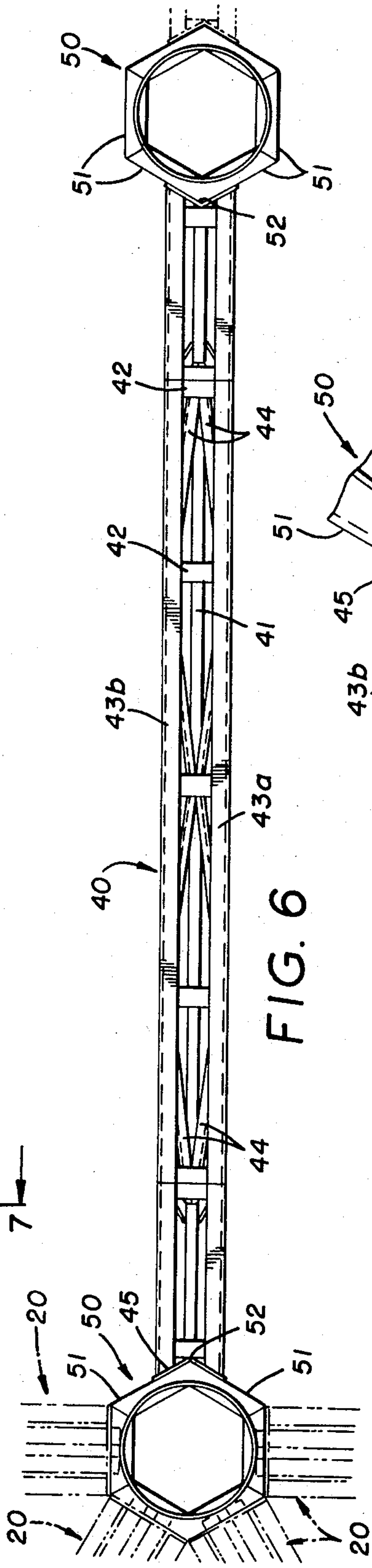
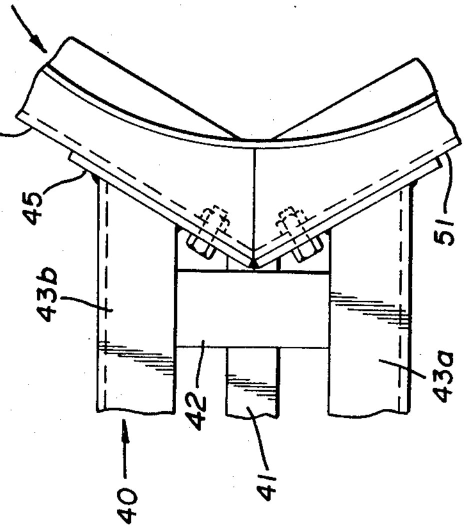


FIG. 6

FIG. 8



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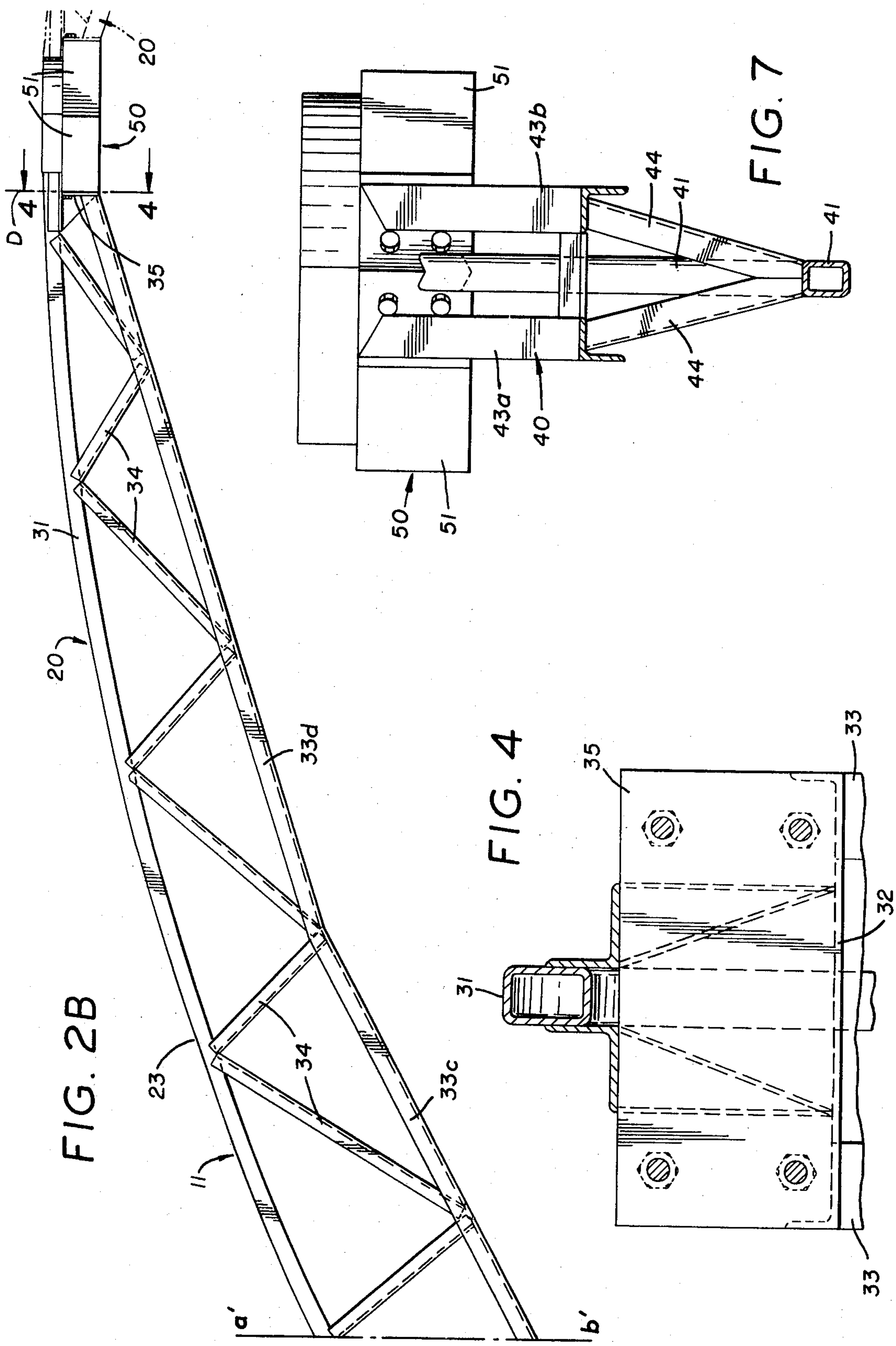

FIG. 2B

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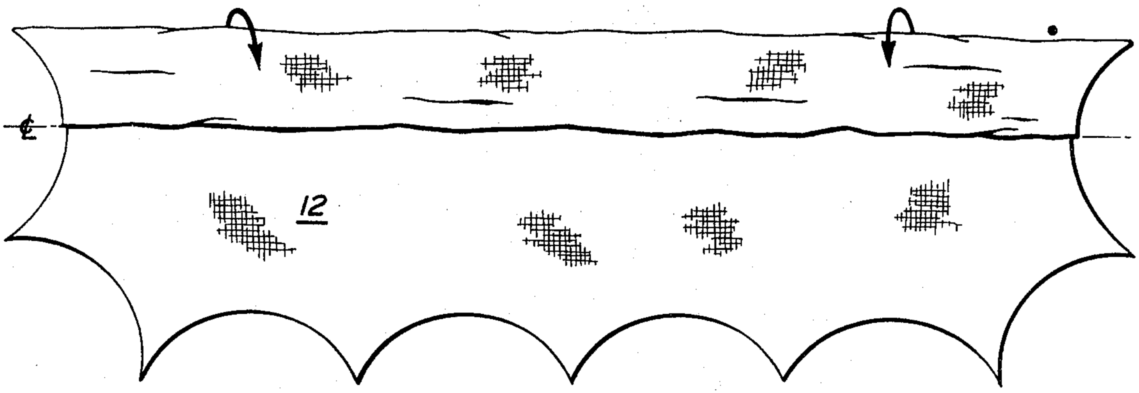


FIG. 10

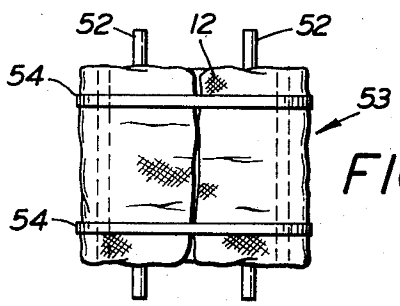
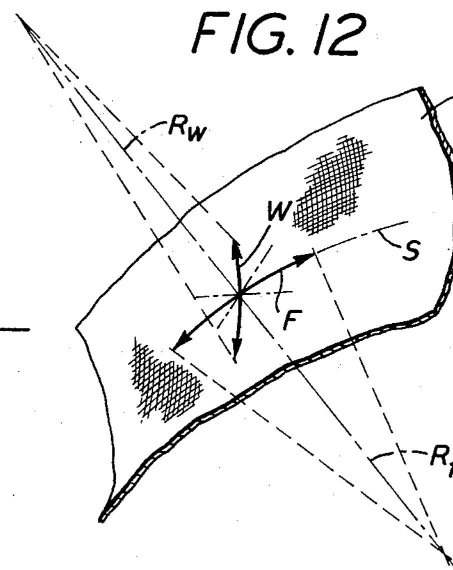


FIG. 11

FIG. 12



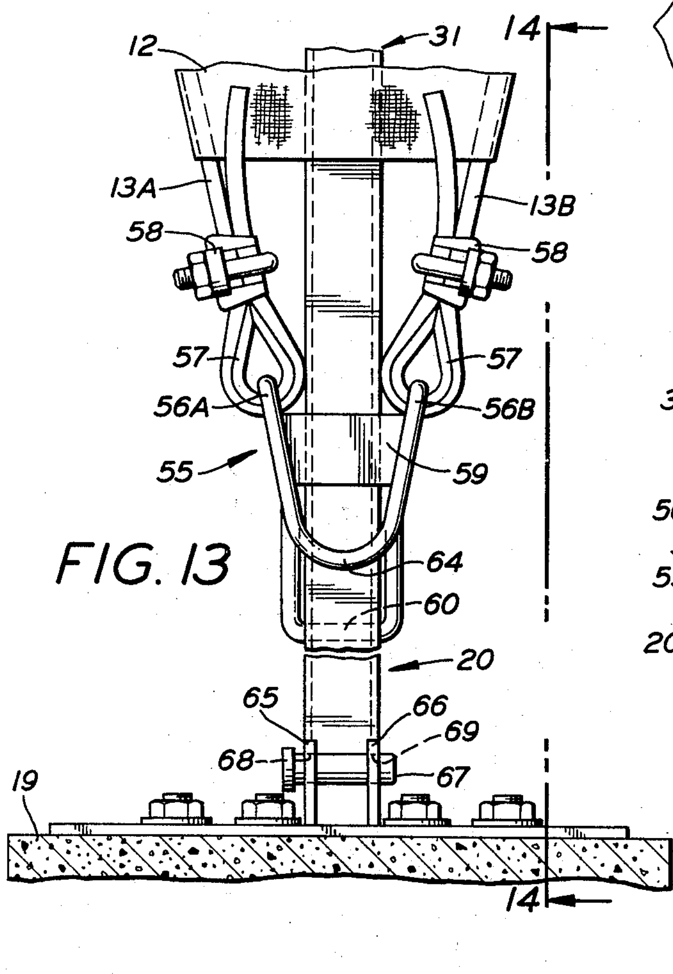
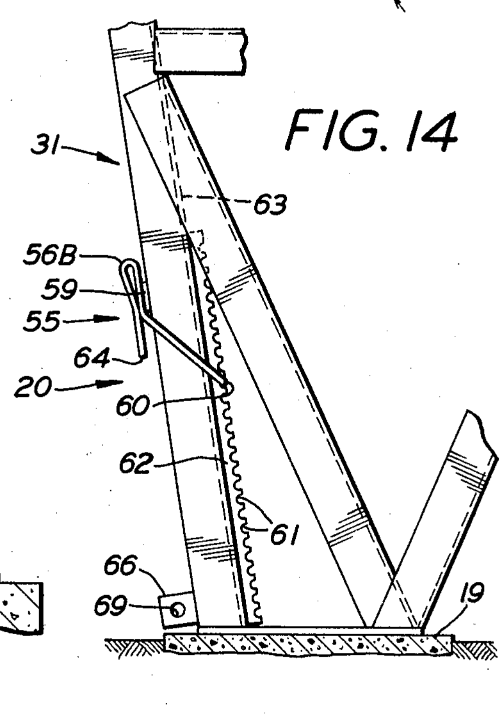


FIG. 13

FIG. 14



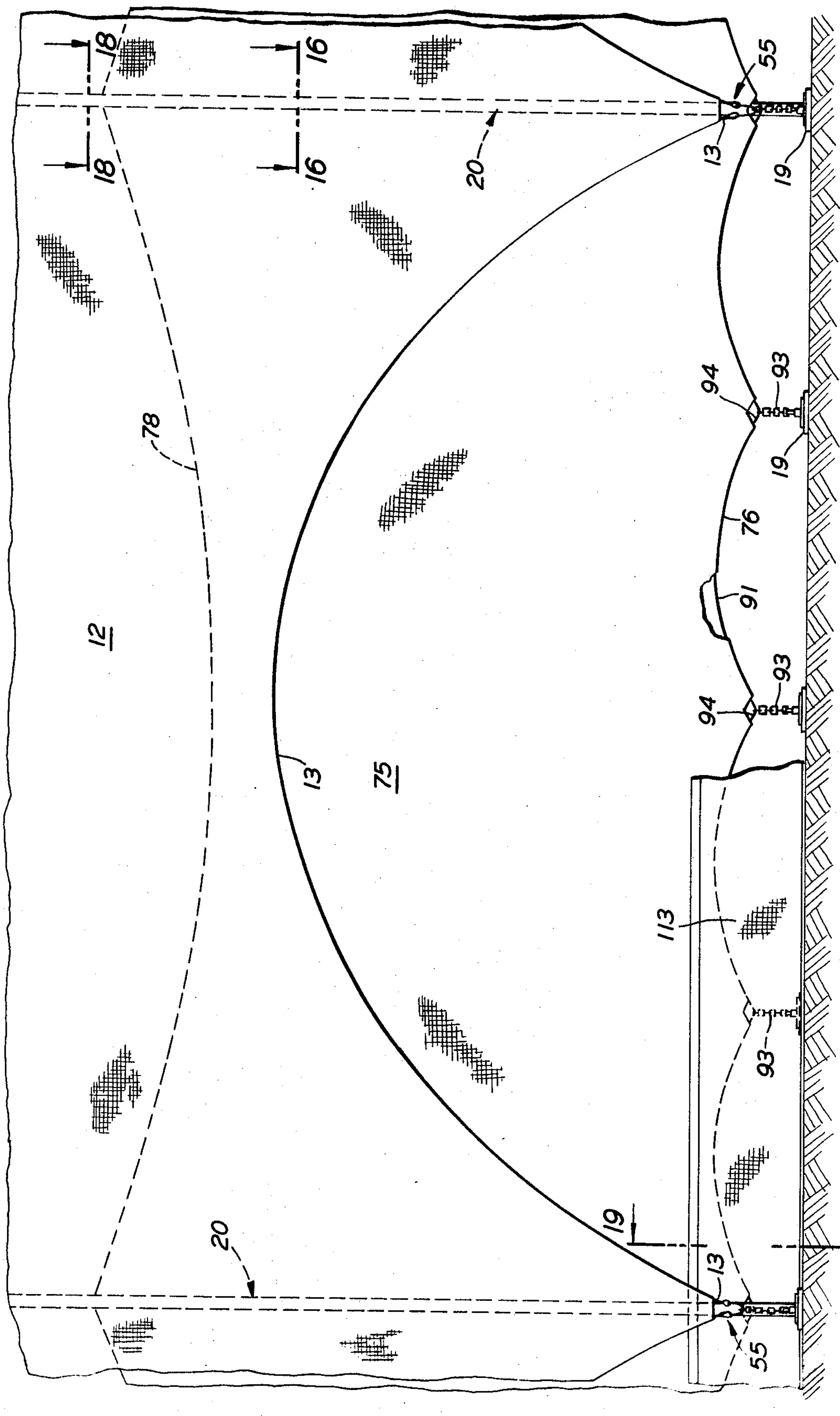

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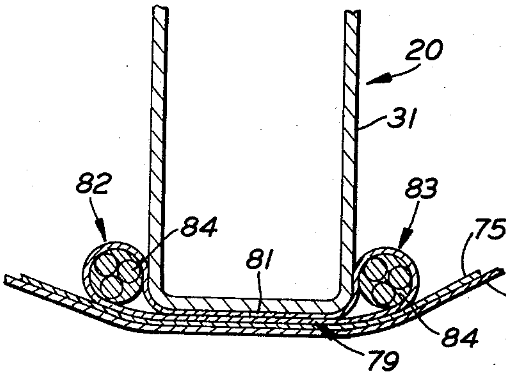
FIG. 15



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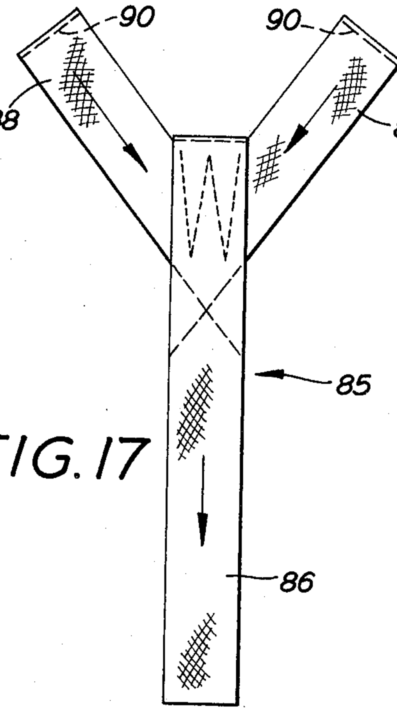

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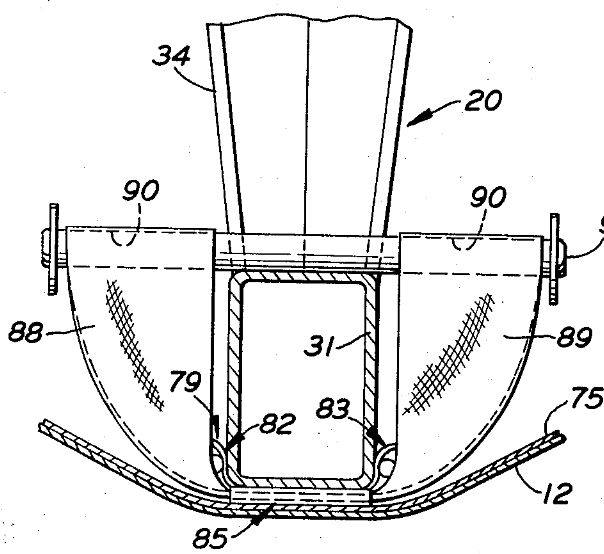

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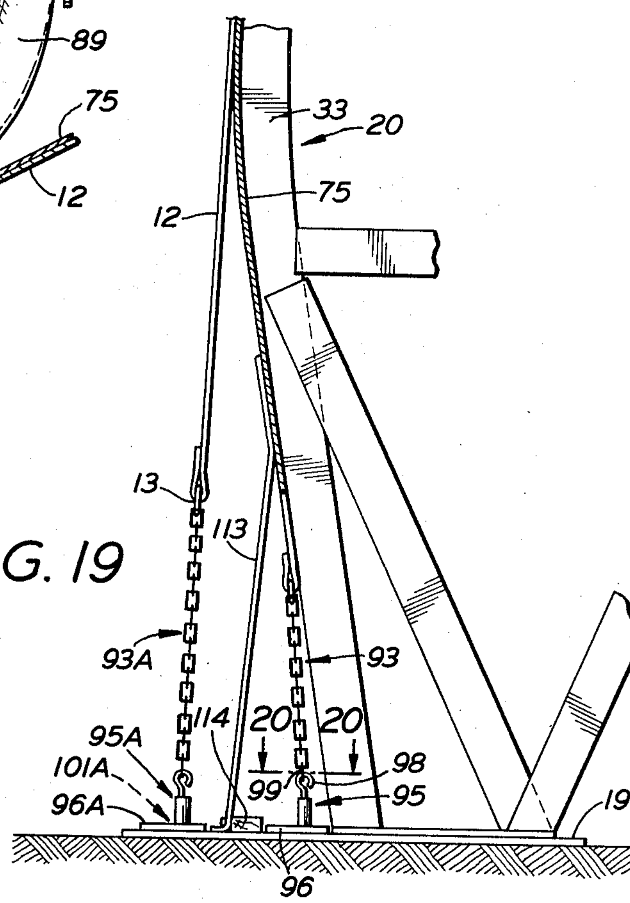

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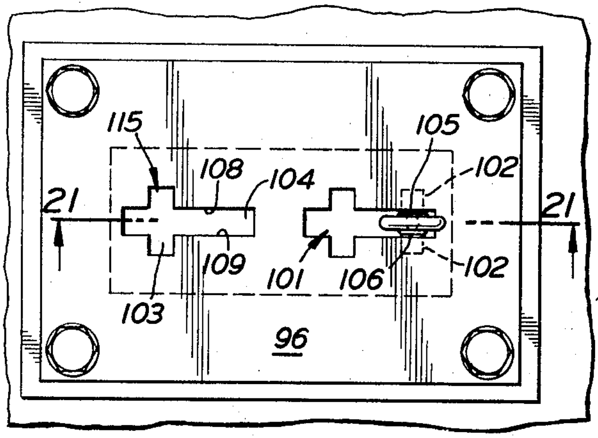

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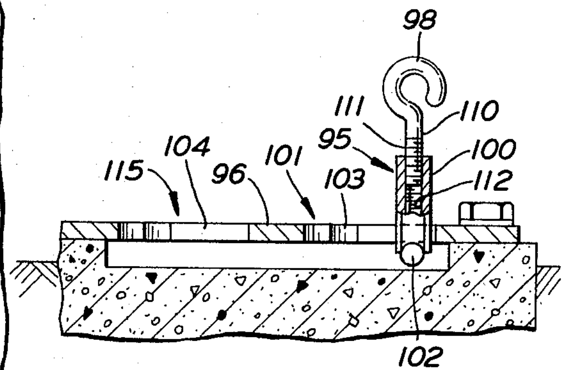


FIG. 21

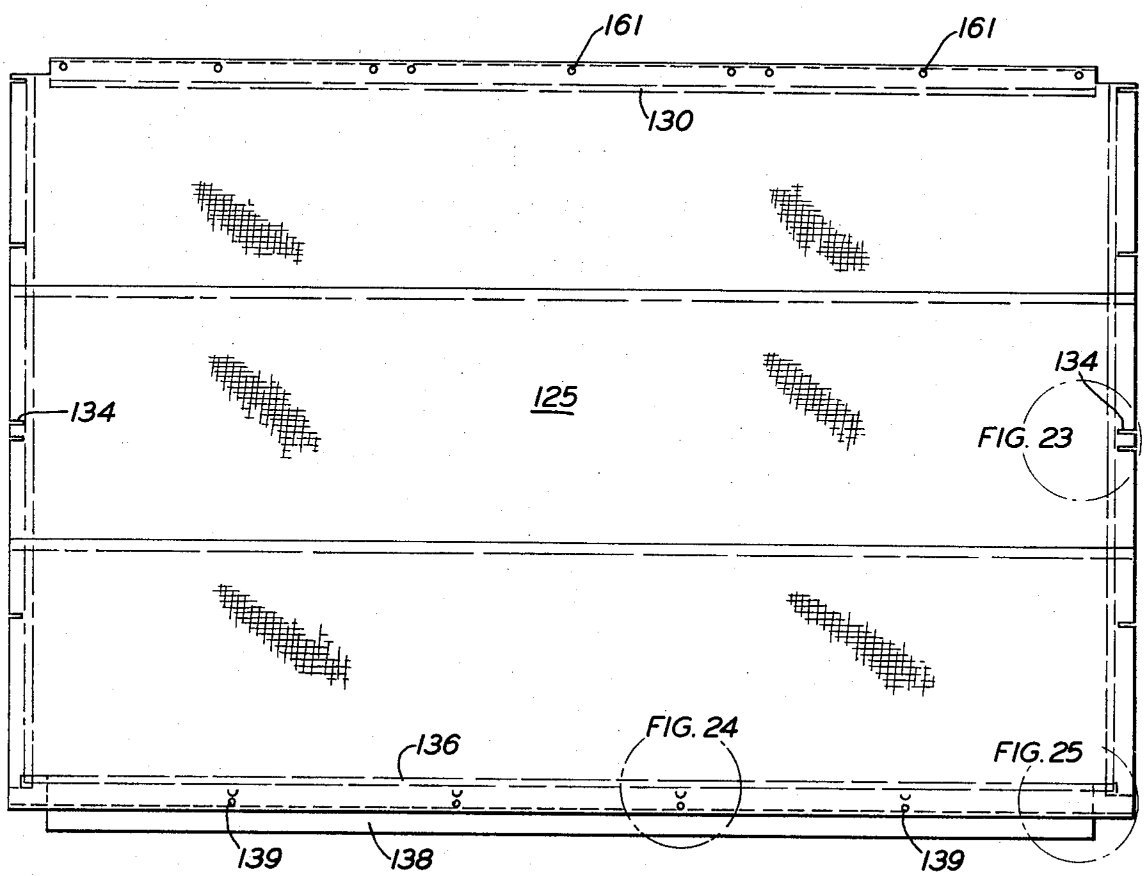


FIG. 22

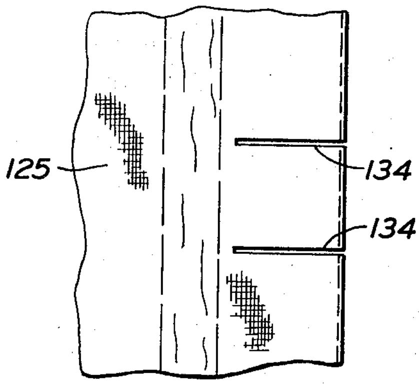


FIG. 23

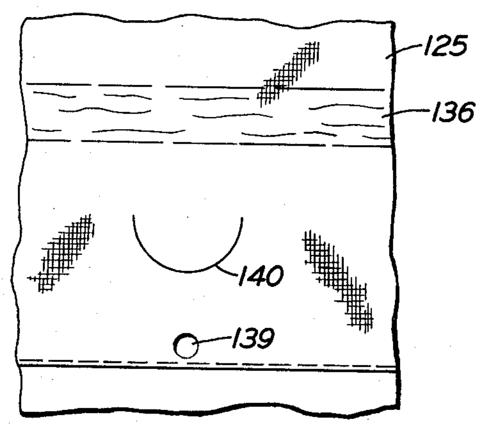
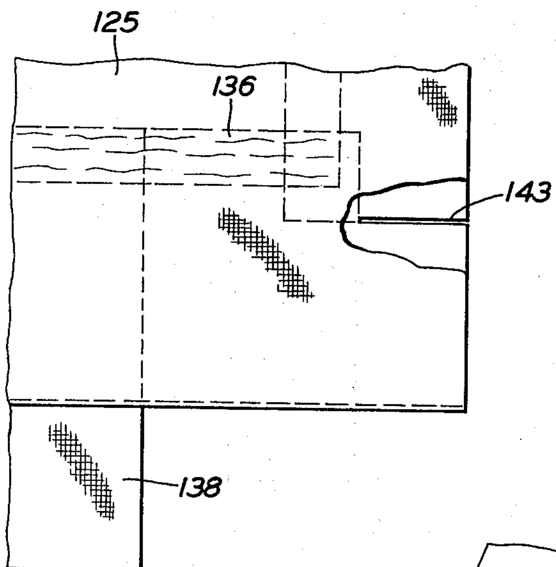


FIG. 24



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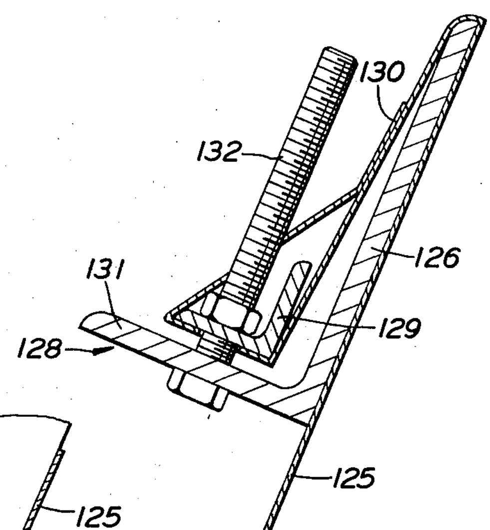

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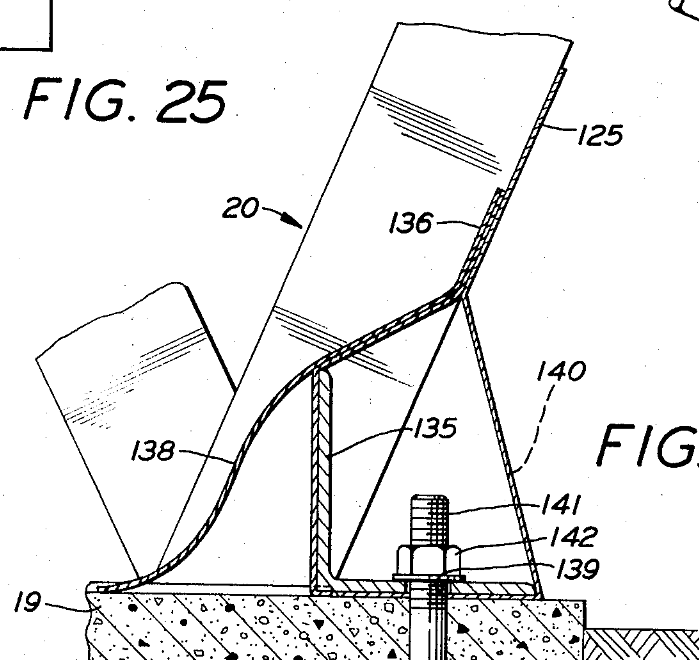

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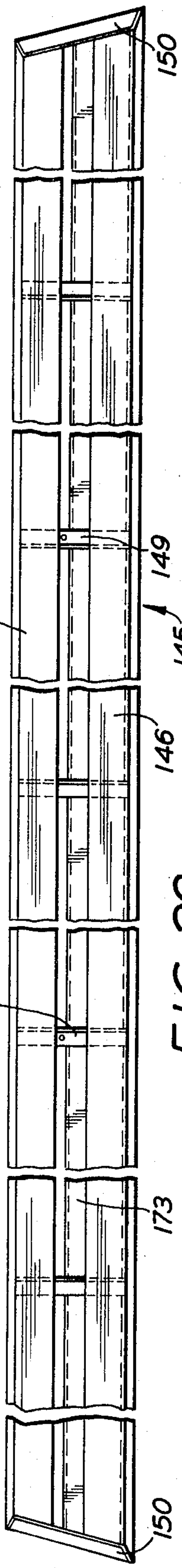
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FIG. 28

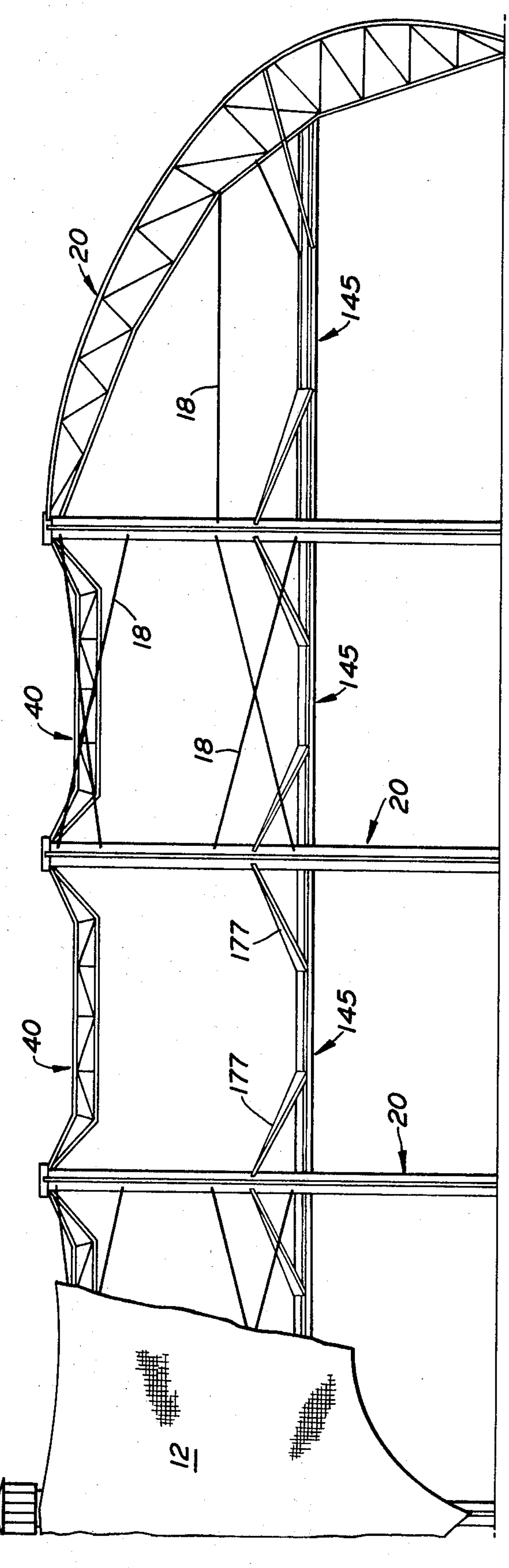
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FIG. 29

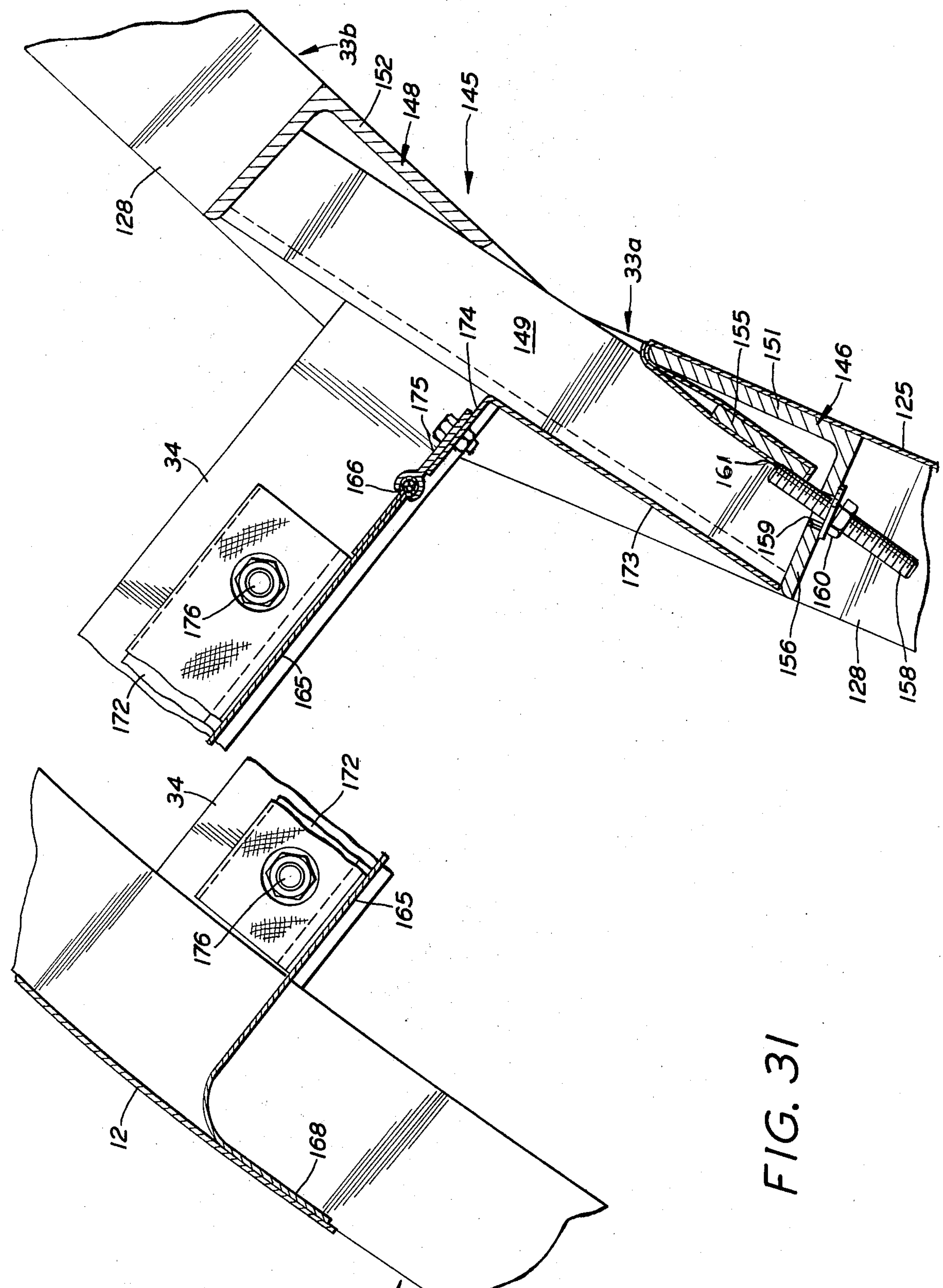
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FIG. 31

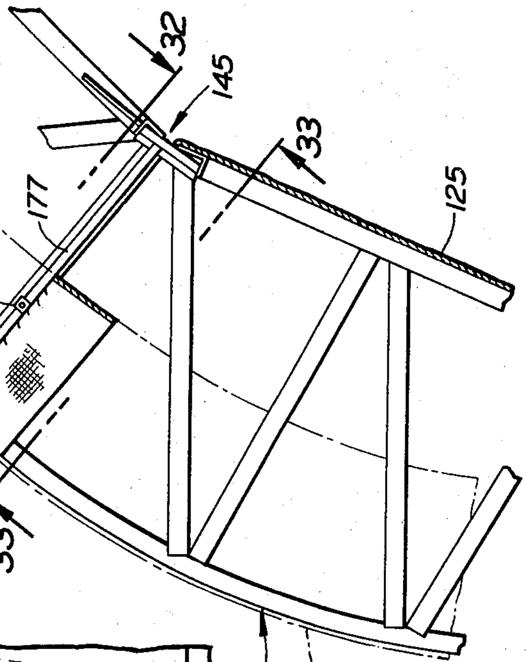

FIG. 30

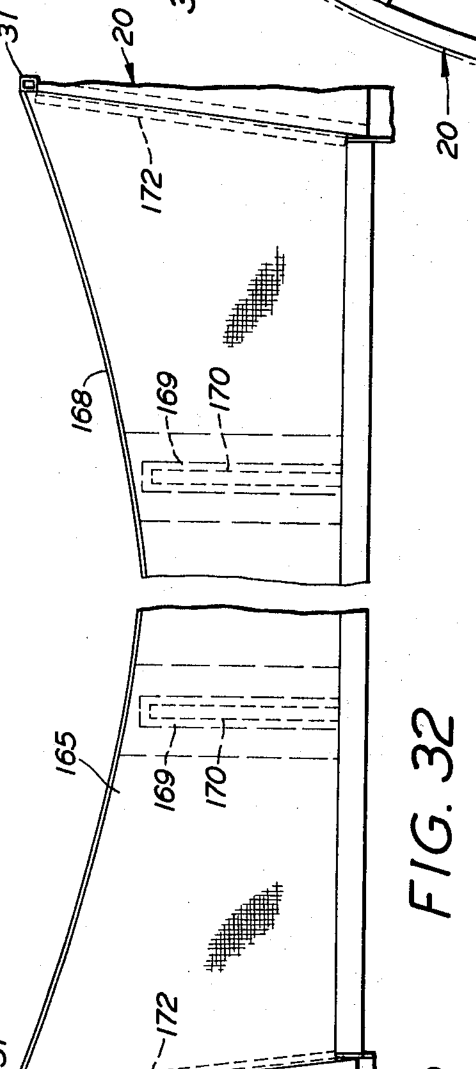

FIG. 32

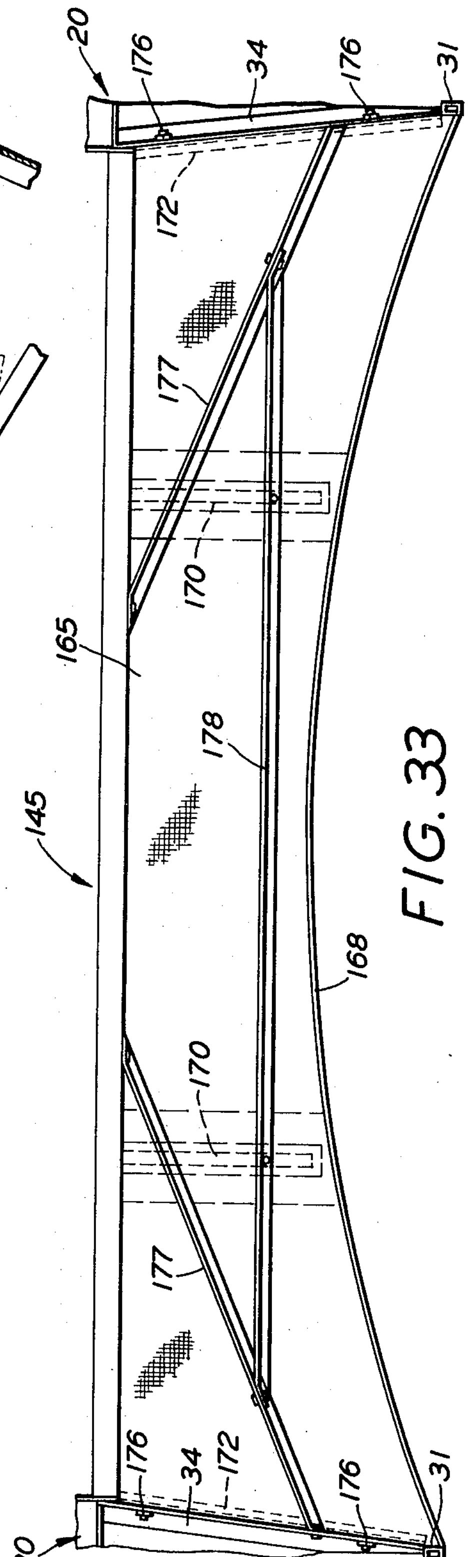

FIG. 33

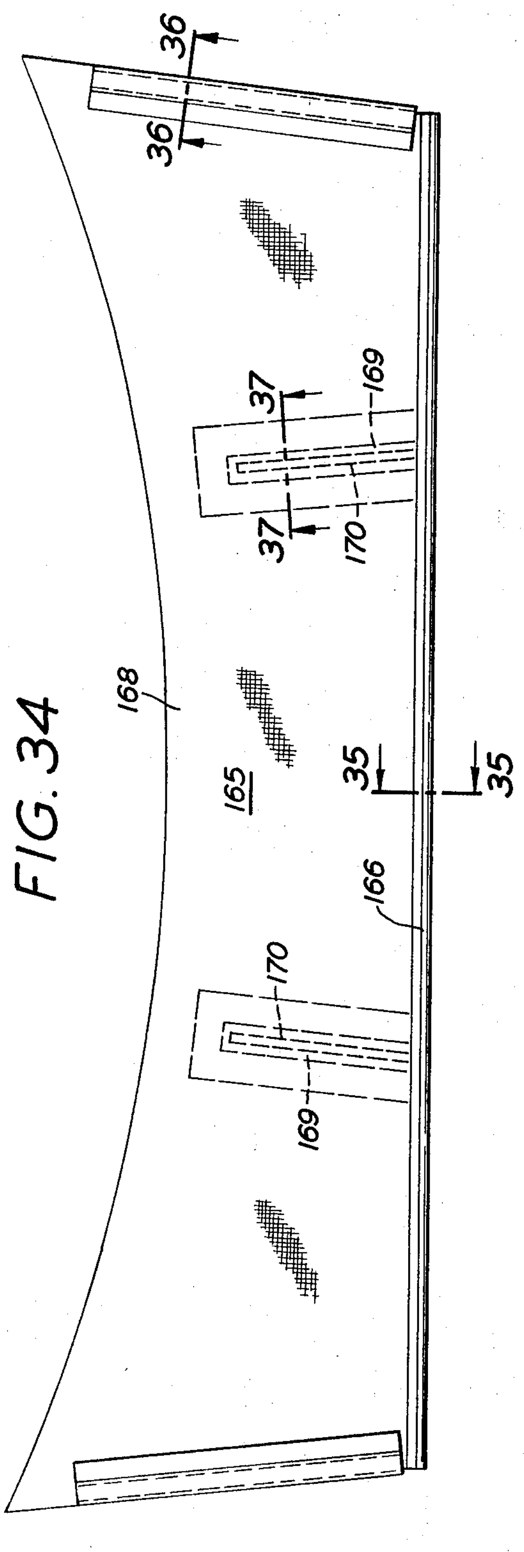

FIG. 34

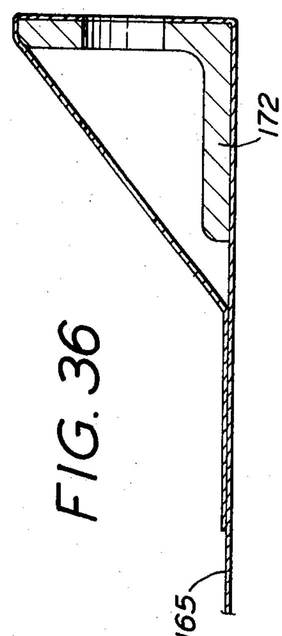

FIG. 36

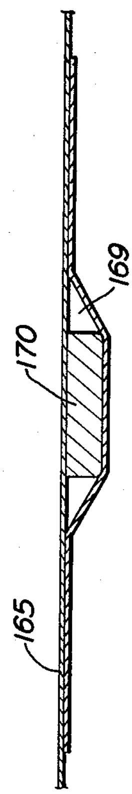

FIG. 37

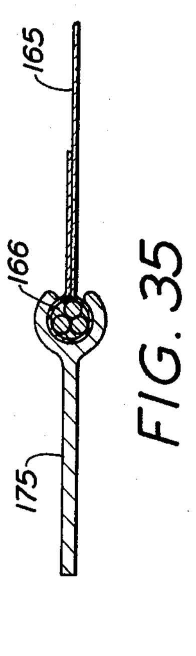

FIG. 35

RIGID FRAME, TENSIONED FABRIC STRUCTURE

RELATED APPLICATIONS

This application is a continuation-in-part of my prior, copending application, Ser. No. 276,899, filed July 31, 1972 and now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates generally to a curvilinear rigid frame structure having a tensioned fabric covering. More specifically, the present invention relates to a rigid frame structure in which the covering is designed most effectively to accept and distribute positive and negative loading to a plurality of truss members and also to reinforce, stabilize and stiffen the framework.

Heretofore, buildings usually have been rigid structures of wood, metal, stone, brick or concrete and generally have satisfactorily served their purpose. However, with the demands that are imposed by our constantly expanding mobile and transient society, an ever increasing need exists for portable buildings to accommodate the requirements of temporary structures. Furthermore, due to such items as exorbitant construction costs, the large amounts of capital currently required to construct a building has prompted the development of new building concepts which are intended to alleviate the financial burden.

One concept for a building that is both portable and relatively inexpensive to construct is an air supported fabric structure. Such structures generally utilize extremely strong synthetic fabrics and are inflated and tensioned by air pressure to withstand rain, wind and snow. The internal air pressure is usually maintained by a blower system consisting of one or more continuously operating fans and automatic controls. Often the structures are designed to provide a large span but with a low profile to minimize the effect of wind forces.

Although air supported structures have some advantages over standard rigid structures, they have several drawbacks. The blower and power accessories required to maintain the air pressure are subject to breakdown and power failures. The fabric cover, if not properly inflated or if subjected to high winds, may flutter and even tear. Another liability of the air supported structure is that the anchorage device must be designed to withstand the uplift created by the inflating air pressure as well as the uplift created by the flow of wind over the structure. Furthermore, although air supported structures are generally made of strong and durable fabrics, cuts and tears can occur which are difficult to repair and may even cause the structure to collapse. Another drawback is that the accumulation of localized or concentrated snow or ice is difficult to prevent and may consequently also cause collapse of the structure. Air conditioning and heating requirements tend to be difficult to satisfy because it is difficult, if not impossible, to insulate such structures so that heating and/or air conditioning of such structures becomes, therefore, quite costly. Additionally, the pendency of lights, electrical conduits, sprinkler systems, water pipes and the like from the fabric forming such a structure is not possible or allowable.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present invention to provide a stable, rigid frame, tensioned fabric building structure which is comparatively portable, inexpensive and safe under extreme weather conditions.

It is another object of the present invention to provide a rigid frame, fabric covered structure, as above, which is self-supporting and may be insulated.

It is a further object of the present invention to provide a rigid frame, fabric covered structure, as above, in which the fabric cover is not subjected to excessive tension or stress and yet is not subject to wind flutter.

It is a still further object of the present invention to provide a rigid frame, fabric covered structure, as above, in which various utility lines such as electrical and water can be suspended from the framework.

It is an even further object of the present invention to provide a rigid frame, fabric covered structure, as above, adapted for incremental increases in length by employing modular bays between end sections.

It is yet another object of the invention to provide a rigid frame, fabric covered structure, as above, which utilizes curvilinear truss members of polygonal cross section to form the framework and stringer trusses in combination with said curvilinear truss members to form the additional bays.

It is yet another object of the present invention to provide a rigid frame, fabric covered structure, as above, in which arched anchor cables are stretched between lower ends of the curvilinear truss members to apply tension to the fabric covering.

It is yet another object of the present invention to provide a rigid frame, fabric covered structure, as above, in which the shape of the truss members, the shape of the cables and the contour of the fabric between truss members is such that the static tension at any point on the fabric cover is substantially the same for both the warp and fill strands of the fabric.

It is yet another object of the present invention to provide a rigid frame, fabric covered structure, as above, in which the rigid frame is entirely self-supporting under all design loads and the fabric cover provides shelter as well as additional strength and safety to the structure.

It is yet another object of the present invention to provide a rigid frame, fabric covered structure, as above, in which the component parts are of such size, shape and weight as to make the structure comparatively easy to load, ship and erect.

These and other objects, together with the advantages thereof over existing and prior art forms, are accomplished by means hereinafter described and claimed.

One preferred embodiment of a structure incorporating the concept of the present invention is shown by way of example in the accompanying drawings and is described in detail without attempting to disclose all of the various forms and modifications in which the invention might be embodied, the invention being measured by the appended claims and not by the details of the specification.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a stable, rigid frame, tensioned fabric structure embodying the concept of the present invention, said Figure depicting a comparatively portable, modular building having two end sections and two intermediate bays with a portion of the fabric cover being cut away;

FIG. 2A is a side elevation of the lower portion of a truss member used to support the fabric cover of a structure embodying the concept of the present invention and depicting the substantially curvilinear shape of the lower portion of said truss member;

FIG. 2B is a side elevation of the upper portion of a truss member, the lower portion of which is depicted in FIG. 2A;

FIG. 3 is an enlarged cross section taken substantially on line 3—3 of FIG. 2A and appearing on the same sheet of drawings as FIG. 2A;

FIG. 4 is an enlarged cross section taken substantially on line 4—4 of FIG. 2B to depict the truss member center face plate and appearing on the same sheet of drawings as FIG. 2B;

FIG. 5 is an enlarged side elevation of a stringer truss and head member taken substantially on line 5—5 of FIG. 1 and showing the relationship of the stringer truss and the head members to form a bay;

FIG. 6 is a top plan view of the stringer truss and head members depicted in FIG. 5;

FIG. 7 is an enlarged cross section taken substantially on line 7—7 of FIG. 5 and appearing on the same sheet of drawings as FIG. 2B;

FIG. 8 is an enlarged top plan taken substantially on line 8—8 of FIG. 5 and depicting the stringer truss plate connection;

FIG. 9 is an enlarged cross section taken substantially on line 9—9 of FIG. 1 and depicting the fabric cover tensioned over the curvilinear truss;

FIG. 10 is a schematic top plan disclosing a sequential lateral folding prior to longitudinal rolling for bundling a fabric cover to facilitate its application to a structure embodying the concept of the present invention;

FIG. 11 is a top plan of the folded and rolled bundle;

FIG. 12 is a perspective view of a section of the cover removed from between successive truss members and depicting the double curved, convoluted saddle shape assumed in response to the pretensioning of the fabric;

FIG. 13 is an enlarged elevation of the assembly by which the anchor cable on the cover is adjustably tensioned;

FIG. 14 is a reduced side elevation taken substantially on line 14—14 of FIG. 13 with the anchor cable removed;

FIG. 15 is an enlarged elevation of that portion of the rigid frame, tensioned fabric structure relating to the open area between the anchor cable and ground level and depicting one form of a curtain that may be employed to close said open area;

FIG. 16 is an enlarged cross section taken substantially on line 16—16 of FIG. 15;

FIG. 17 is a plan view depicting the anchor yoke by which that form of curtain shown in FIG. 15 may be vertically secured to a truss member;

FIG. 18 is an enlarged cross section taken substantially on line 18—18 of FIG. 15 and depicting the yoke anchored to a truss member;

FIG. 19 is an enlarged further cross section taken substantially on line 19—19 of FIG. 15 and depicting, in side elevation, a means by which the curtain shown in FIG. 15 may be secured to the ground;

FIG. 20 is an enlarged cross section taken substantially on line 20—20 of FIG. 19 and depicting the anchor plate in top plan;

FIG. 21 is a cross section taken substantially on line 21—21 of FIG. 20;

FIG. 22 is an enlarged elevational view of an alternate form of closure curtain which may be located inside of the curved bottom openings in the main cover between the bays;

FIG. 23 is an enlarged elevation of a side marginal portion of said curtain;

FIG. 24 is an enlarged elevation of a bottom marginal portion of said curtain;

FIG. 25 is an enlarged elevation of a bottom corner portion of said curtain;

FIG. 26 is an enlarged sectional view through a side margin of the curtain showing how it is attached to the inner chords of adjacent trusses;

FIG. 27 is an enlarged sectional view showing how the bottom marginal edge of the curtain is attached to a base angle on the foundation;

FIG. 28 is a front elevation of one of the compression members extending between trusses to which the upper margin of the rectangular curtain is attached;

FIG. 29 is a partial elevation of the truss frame showing the location of the compression members, the truss structures being shown schematically;

FIG. 30 is a partial side elevation of one of the trusses showing a compression member attached thereto and the weatherseal filler panel extending between the compression member and the main cover;

FIG. 31 is an enlarged cross sectional view showing how the upper margin of the curtain is attached to the compression member and the filler panel;

FIG. 32 is a top plan sectional view on line 32—32 of FIG. 30 and appearing on the same sheet of drawings as FIG. 30;

FIG. 33 is a bottom plan sectional view taken substantially on line 33—33 of FIG. 30 and also appearing on the same sheet of drawings as FIG. 30;

FIG. 34 is a detached plan view of the filler panel;

FIG. 35 is an enlarged partial sectional view taken substantially on line 35—35 of FIG. 34;

FIG. 36 is an enlarged partial sectional view taken substantially on line 36—36 of FIG. 34; and,

FIG. 37 is an enlarged partial sectional view taken substantially on line 37—37 of FIG. 34.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, a rigid frame, tensioned fabric structure embodying the concepts of the present invention is designated generally by the numeral **10** in FIG. **1** and comprises a framework, generally indicated by the numeral **11**, which supports a fabric cover, or membrane, indicated generally by the numeral **12**. A static tensile stress is applied to the fabric of membrane **12** by cables **13**.

Framework **11** is formed from a plurality of truss members, designated generally by the numeral **20**, having a curvilinear outer, or upper, chord which supportingly engages the cover **12**. Each truss member **20** is conventionally connected at its lower end to a foundation **19** and is connected at its upper end to a plurality of similar, or identical, truss members to form a polygonal enclosure. If a longer structure is desired, incremental bays may be added by utilizing one or more pairs of intermediate truss members between end sections comprising one half of a polygon having an equal number of sides, as shown in FIg. **1**. The curvilinear truss members **20** are generally designed to give maximum space utilization. Therefore, as best shown in Figs. **2A** and **2B**, box channel, or rectangular tube, **31** forming the outer chord of truss member **20** preferably has an upright wall portion **21** which rises substantially vertically for a given distance to provide the desired wall height along the inner periphery of the structure **10.** A curved portion then extends toward the center of the structure. In order to transform a desired wall height into a generally flattened roof within a desired height range and to retain the advantages inherent in a curvilinearly shaped structure, the truss member preferably has two curved portions — haunch portion **22** and roof portion **23.** The haunch portion **22** generally has a shorter radius of curvature than roof portion **23** so that the truss member will provide the desired interior height and span with little, or no, wasted space.

It should be appreciated that the upright portion **21** and curved portions **22** and **23** can be varied in a great number of ways to provide structures incorporating any number of desired shapes. For example, if structure **10** is to serve as a church, wall portion **21** may be quite high and the haunch may define an extended curve of relatively long radius. If one desires to emulate a Gothic appearance, the roof portion **23** may be of relatively large radius, but if a Roman dome is to be emulated, the roof portion **23** may be of relatively short radius.

If an exhibit structure is desired, as might be used at a fair, upright portion **21** may be of moderate height and roof portion **23** may have a long span. Depending upon the type of displays to be exhibited, the haunch portion **22** may be fairly sharply curved to achieve only moderate roof height or the haunch portion may be gently curved so that tall displays may be housed within the structure **10.** It should be appreciated that portion **21** may also be curved to effect the desired interior configuration of structure **10.**

Although the truss member **20** is not limited to three portions, in order to achieve a desirable span and roof elevation the truss member **20** will generally have three portions with at least two — the haunch and roof portions — being curved. When so constructed the haunch portion **22** will generally have a sharper degree of curvature than roof portion **23.** Because the truss members **20** are substantially curvilinear, they may be parabolic, sinusoidal, arcual or any composite curvilinear shape. In the specific embodiment shown two portions are curved and both portions are arcual. That is, portion **22** extends approximately 12 feet along a chord from point B to point C (FIGS. **2A** and **9**) and has a radius of curvature of 12 feet (subtending a horizontal span of slightly more than 4 feet), and portion **23** extends approximately 32 feet along a chord from C to D (FIG. **9**) and has a radius of curvature of 49 feet (subtending a horizontal span of slightly more than 30 feet). Vertical portion **21,** which extends from point A to point B, is depicted as being approximately 6 feet in height.

Considering now the components of the truss member **20,** as aforementioned it has an outer, curvilinear box channel **31** comprising the upper, or outer, chord and a series of parallel, connected, straight structural components that may be fabricated from angle iron and which comprise the lower, or inner, chord sections ***33a***, ***33b***, ***33c*** and ***33d***. As best seen in FIGs. **2A** and **2B**, the lower chord sections follow the general outline of the curvilinear box channel **31** comprising the outer chord. Transverse spacer angles and plates **32** extend between the inner chord components **33** at intervals. According to conventional truss design, truss member **20** contains inclined reinforcing struts **34,** also which may be fabricated from angle irons and which connect box channel **31** to chord components **33** along the length of the truss member. Truss members **20** are interconnected to form framework **11.** These connections employ one or more variations of a face plate **35,** as is hereinafter more fully explained.

The cross section of truss member **20** generally is of any conventional polygonal shape or may simply be an I-beam. As shown in FIG. **3,** truss member **20** is preferably of triangular cross section, because this shape has been found to reduce the amount of steel required and to provide much greater transverse strength than an I-beam of equal weight, and thus is not only economical but also provides sufficient lateral stability so that the truss member will not bend laterally, or twist, as it is being handled during erection of structure **10.** Additionally, the triangular cross section provides sufficient resistance to torsional loads on the trusses assembled from truss members **20** that shear stresses may generally be fully balanced between consecutive trusses by means of light cross rod bracing **18** (FIG. **29**) in the plane of the lower chord components **33.** This position for the bracing allows ample room for the fabric cover to assume the hereinafter defined saddle shape, does not interfere with the head room within the structure and eliminates the necessity to puncture the fabric cover as would be necessary for normal cross bracing. Moreover, the cross rod bracing may be designed to support the fabric skin in the possible event of a complete skin failure. In the end sections of the building a single horizontal rod that extends between the intersections of chords ***33b*** and ***33c*** — i.e., the field joint — on adjacent truss members is generally all that is required to resist torsional stresses to the trusses.

To satisfy special environmental conditions and/or with particular embodiments it may well be required to provide additional cross bracing between adjacent truss members at one or more locations within the structure.

The base width of the truss member **20,** as with most trusses of polygonal cross section, is calculated by conventional methods to withstand the application of normal transverse loading forces. Excessive base widths are generally not used because they unnecessarily increase the weight and the cost of the truss.

Sizing of the structural components for the truss members is determined in accordance with conventional engineering techniques as known to one skilled in the art. Briefly, after the height of wall portion **21** and the lengths and radii of curvatures for the haunch portion **22** and roof portion **23** have been selected in a manner as described hereinbelow, the various loads, including wind load, are then determined. With these assumed loading conditions, stress analysis of the structure is conducted in order to determine the minimum size requirements, including a reasonable factor of safety, of each specific truss component.

The basic horizontal shape of framework **11** is a polygon. However, when additional space is desired, bays **15** may be added between the end sections of structure **10** by the incorporation of one or more pairs of opposed truss members **20** spaced laterally between end sections. In order to connect these pairs of bay truss members with each other and/or to the structural end sections, a stringer truss, generally indicated by the numeral **40**, is provided. For most installations only one stringer truss per bay section is needed, and it usually connects the mid-point of each pair of opposed truss members to the mid-point of another pair of laterally spaced, opposed truss members or to the convergence of the truss members in the end section.

The cross-sectional shape of the stringer truss, as with the curvilinear truss members, is generally polygonal to provide transverse stability and, as seen in FIG. **7**, is preferably triangular inasmuch as such a shape favorably satisfies considerations of weight, size, cost and strength. Stringer truss **40** is generally similar to curvilinear truss **20** in that it has a box channel or rectangular tube **41** vertically spaced from parallel chord members **43***a* and **43***b* that are themselves laterally spaced by bars **42.** Reinforcing struts **44** also interconnect the box channel **41** with the two chord members **43***a* and **43***b* throughout the length of the stringer truss **40.** Any type of structural components may be used, although angle iron is often preferred because that shape is relatively inexpensive and because that shape affords favorable strength and bending characteristics. As best seen in FIG. **5,** stringer truss **40,** unlike curvilinear truss **20,** is straight and inverted so that box channel **41** comprises the lower chord member. However, the ends of stringer truss **40** are inclined laterally so that the intermediate portion is offset from its ends in order to permit the tensioned fabric cover **12** to form a saddle between adjacent pairs of bay truss members and between the bay truss members in the end section of the framework. The amount of offset is preferably not much greater than the maximum depth desired for the saddle formed by the membrane of the fabric cover extending between the successive truss members in the framework inasmuch as an excessive offset would complicate the structure required to maintain the lateral stability desired for the stringer.

Sizing of the various stringer truss components will generally depend only upon the horizontal forces acting on structure **10.** In accordance with conventional practice as known to those skilled in the art, the various loads, including wind, are determined, and after applying a factor of safety the tensile or compressive stress resulting in each of the specific structural components is calculated. The type and size of each component is then selected.

In the assembled framework **11,** truss members **20** are preferably connected to one another at their upper ends in the manner depicted in FIGS. **1, 5, 6** and **8,** wherein the various truss members are bolted through face plates **35** to a polygonal head member, designated generally by the numeral **50.** Head member **50** is designed to transfer loads between truss members, to allow sufficient opening for gravity or forced air ventilation and to provide a weather seal.

Generally, head member **50** has six sides or faces **51** because a structure of regular hexagonal shape requiring six truss members has been found to provide a very stable structure and to permit the fabric cover **12** to be tensioned substantially equally along both the warp and fill strands. If the use of a greater number of truss members is desired, the head member may have eight, ten or more sides provided that there are preferably an even number of sides to facilitate the incorporation of bay sections. Head members **50** may also be used to connect the opposed bay truss members to each other and to the stringer trusses. For most structures the stringer trusses are desirably aligned across the head member **50** so that with the bay truss members connected to the opposed flat surfaces of a hexagonal head member **50,** the inclined ends of the stringer truss are provided with V-shaped face plates **45** in order to receive an apex **52** of the head member and effect a stable joinder therewith.

To erect the framework **11** a curvilinear truss member **20** is connected to a head member **50** and raised into position. Then the base of that truss member is anchored to a foundation according to any conventional manner. Thereafter three additional truss members are positioned and connected to that same head member **50,** and they too are anchored to appropriate foundation piers.

Even though only the structure of an end section is so formed, it is self-supporting and thereby greatly facilitates completion of the structural framework. If a structure does not have intermediate bays, the remaining truss members can similarly be positioned and connected to form a polygonal framework. If the structure is to contain intermediate bays, the desired number of pairs of truss members are positioned and connected by stringer trusses sequentially from the first head member **50** and then the truss members forming the remaining half polygonal end section are securely positioned to produce a rigid frame structure such as shown in FIG. **1.** As with other rigid frame structures, various items including utility lines, sprinkler lines and the like can be supported from the framework. Furthermore, the truss support chords **33** provide an ideal structural member to which insulation and/or a decorative interior surface can be attached.

Framework **11** supports a fabric membrane, or cover, **12** to complete the basic enclosed structure **10.** After the framework **11** is fully erected the cover **12** may be applied. To facilitate positioning of the cover it may be successively folded and rolled into a compact bundle, placed at the top center of the framework and successively unrolled and unfolded into position.

One convenient arrangement for bundling the cover, as shown in FIGS. **10** and **11**, is accomplished by folding the lateral sides to the longitudinal center line thereof (one side so folded is depicted in FIG. **10**) and then rolling each longitudinal end of the folded cover individually toward the center of the folded cover with a lading bar **52** centered within each rolled end. The resulting bundle **53** may then be strapped, as at **54,** to maintain its configuration. The ends of the lading bars **52** project laterally from the resulting bundle to provide a means for lifting the bundle from place to place and to the top centerline of the framework **11** in which position the strapping **54** may be removed and the lading bars **52** used to assist in unrolling the folded cover along the centerline of the framework. After being unrolled the sides may be unfolded outwardly and downwardly along the framework conveniently to effect an approximate positioning of the cover on the framework.

Cover **12** is so designed, as described below, that it can be statically prestressed in tension substantially equally along both the warp and fill strands at any given point and is preferably made from a fabric which maintains dimensional stability over a wide range of temperatures and humidity. Although several fabrics may be used, a polyester fabric such as Dupont's Dacron has been found to have these desirable properties. Additionally favorable properties of polyester over other types of fabric such as nylon include far superior ultraviolet light resistance, the ability to withstand weather exposure over long periods of time, and a high tear strength. In order to balance, as nearly as possible, the amount of initial stretch available in the warp and fill strands, a knitted fabric may be utilized to advantage. Preferably, the fabric is comprised of essentially straight warp and fill strands disposed at substantially right angles with respect to each other and knitted together by a third yarn system which allows both the warp and fill to remain relatively straight and does not impart the crimp to the fill yarns occasioned by nonknitting weave techniques. Such a fabric structure thereby tends to equalize the amount of stretch between the warp and fill yarns induced by crimping the fill strands during the weaving process.

Although the inequality in the amount of stretch between warp and fill strands occasioned by the crimp normally imparted to the fill strands during weaving is greatly minimized by knitting the base cloth, the lineal stretch characteristics are not altogether eliminated because even the handling of the fabric during the coating process applies a certain tension to the warp strands, thereby increasing, to a modest degree, the amount of stretch available to the fill strands as compared to the warp strands.

In order to prevent water from penetrating the fabric membrane, as well as to impart mildew, ultraviolet and abrasion resistance, the membrane is preferably coated with any high quality vinyl compound by techniques well known to those skilled in the art.

Considering now the special manner in which the membrane is applied to the structure so that substantially uniform tension exists throughout the membrane, it is of primary importance that fluttering due usually to windlift — i.e., the application of subatmospheric pressure to the exterior surface of the membrane — be minimized. To avoid flutter, the contour given to the fabric must not be essentially flat or located in a single curved plane. A saddle shape has been found to be effective in withstanding both positive and negative (windlift or minus pressure) loading. In order to achieve this contour, forces must be applied to the membrane; that is, the membrane must be pre-loaded in tension over the framework.

In orienting the fabric membrane it is desirable that the warp and fill strands be aligned respectively with the longitudinal and the generally vertical axes of the structure so that the warp strands (minimum stretch) will support positive loading (including loads of longer duration, such as snow and ice) and the fill strands will resist the negative loading (fluctuating wind lift). This orientation permits the positive live loads to be transferred to the trusses with the least deformation of the outer membrane.

As previously noted, the height and width of structural framework **11** is chosen to give the desired inside space. However, these parameters are chosen with a practical eye toward truss construction as understood by one skilled in the art so that the required depth of the truss member, particularly at haunch portion **22,** is not overly large or overly expensive. Moreover, the radius of curvature of the haunch portion must be kept within practical limits so that the tension of the fabric membrane between adjacent haunch portions is not so

great as to put undue stress on the fabric. For example, in the particular embodiment shown in FIG. **2,** the approximately 6 foot upright portion **21** of box channel **31** achieves a substantial wall height which then gives way to a haunch portion the outer curve of which is struck by a 12 foot radius and extends for approximately ten feet, as measured along the chord of the arc. From a practical standpoint this curvature has been found not to be sufficiently sharp as to necessitate overly heavy, or excessively expensive, truss components to support the roof portion. Moreover, undue stress on the covering fabric may be avoided because the haunch curvature is thus moderate.

Compatibly with the aforementioned haunch configuration the roof portion **23** may employ a radius of curvature of 49 feet and extend for approximately 30 feet, as measured along the chord of the arc. When two such truss members are opposedly connected to a head member **50,** the resulting structure provides a 68 foot clear span without interior supports. By locating one pair of opposed truss members medially of the end portions, as shown in FIG. **1,** and 20 feet from each end portion the resulting two bay structure provides over 6,300 square feet of unobstructed floor space. By adding one additional pair of opposed truss members that are also 20 feet on center from the adjacent truss members the resulting three bay structure provides approximately 7700 square feet of unobstructed floor space.

Having selected a fabric well suited for the cover and having determined the proper orientation for the warp and fill yarns, as well as the general height and width of the structure, the fabric cover is designed so that when stretched over the framework **11,** the warp and fill strands of the cover will be pretensioned to approximately equal tensile stress at all points along the curved surface thereof. Perfect uniformity in matching the tensile stresses in the warp strands with the tensile stresses in the fill strands throughout the cover is, however, substantially impossible to achieve because of the varying curvature of the cover **12.** It must be appreciated that the tensile stress in either a warp or fill strand at any given point on the cover equals the product of the load at that point multiplied by the radius of a curve along which the particular strand lies at that point.

As can be seen by reference to FIG. **12,** the fabric cover **12** assumes a double curved surface between any two consecutive truss members. This double curved, or convoluted, disposition of the fabric is designated as the saddle configuration, and the saddle seat S refers to a reference line on the fabric cover **12** which lies in a plane centered between any two consecutive truss members. The disposition of any warp strand W delineates the warp curve, and the warp curve constitutes that direction on the fabric cover which spans any two consecutive truss members and lies in a plane which passes through the intersection of that line and the saddle seat S and which plane is perpendicular to a line tangent to the saddle seat S at the point of intersection. The radius R_w of the warp curve lies within that plane.

The disposition of any fill strand F delineates the fill curve, and the fill curve constitutes that direction on the fabric cover **12** which lies between two consecutive truss members and also lies in a plane that is parallel to the plane which includes the saddle seat S. The radius R_f of the fill curve lies within the plane of the fill curve.

With respect to the structure **10**, the warp radius R_w lies exteriorly thereof, and the fill radius R_f lies interiorly thereof.

Briefly, the procedure for designing that portion of the fabric cover intended to span a bay section is as follows. Starting at the apex, or ridgerow of the structure, a trial fill radius R_f is selected which — in order that the saddle seat S will not be designed to lie radially outwardly of the curved outer chord defined by box channel **31** — is necessarily less than the greatest radius of the truss member. In order to design toward the desired stress balance between warp and fill strands the dimension of the trial fill radius R_f so selected is then considered as the dimension for the trial warp radius R_w, and in this context the dimension must be large enough so that the saddle seat S will clear the stringer truss **40** sufficiently to allow for stretch of the cover **12** due to snow or ice loads. As the next step in designing the fabric cover, a second trial radius is selected (for the portion of the cover lying between the centers of the haunch portions of adjacent trusses). The dimension of this second trial radius must be large enough so that when applied as the warp radius the resulting saddle seat will lie outside the planes of the lower truss chords **33**. This second trial radius must also be small enough so that when applied as a fill radius one end of the resulting saddle seat between the haunch portions of consecutive truss members will intersect the saddle seat defined by the first trial radius along a common tangent and the other end of the resulting saddle seat between the haunch portions will intersect the point of anchorage along a tangent to the saddle seat.

The entire saddle seat resulting from the two trial radii is somewhat similar to the outside member of the truss in that it consists of a short, straight section that extends upwardly from the point of anchorage and thereabove extends, by successive, merging arcs having two radii, to the apex, or ridgerow of structure **10**. However, the fill radii of the cover more nearly approach each other than the radii of the truss members **20**. In the particular embodiment depicted, the fill radii of the cover are about 45 feet and 22.5 feet, respectively. By interpolation, this trial saddle seat is modified to a somewhat parabolic curve such that the warp and fill radii at any point along the modified saddle seat are as nearly equal as possible.

The cover for a polygonal, or end, section is designed with radii similar to those used in designing the bay sections so as to maintain equal tensions on either side of a truss member at any point along the truss member. However, in an end section, the saddle seat actually extends to the apex rather than to a level below that of the apex, as in a bay.

According to expected field conditions, strength and stretch of the fabric under design loads, including both wind force (positive) and wind lift (negative as well as any snow loads, are calculated according to methods well known to one skilled in the art. Using these loads, and, of course, a factor of safety, the tension on the cover is calculated for that portion in proximity to the head member **50** as well as that portion adjacent the haunches to determine if the stresses in the cover resulting from the expected maximum loading is reasonably well below the fabric strength. If it is not, inasmuch as the load multiplied by the radius of curvature for either the warp or fill strands equals the tensile load in that strand, the radius of curvature may be reduced to reduce the tension.

By using test data which reveals the percent of stretch in the fabric under various loads along both the warp and fill directions (each react differently) the clearance between the fabric and the stringer trusses may be calculated for expected load conditions. If the calculations determine that contact may result, this condition may be obviated in any of a number of ways. For example, one may position the truss members delineating the bays slightly closer to each other, thus allowing a reduced fabric radius of curvature, or one may increase the dimension to which the stringer is offset. Using the particular embodiment shown in the drawings as an example, the fabric tension at maximum load conditions has been calculated to be approximately 115 pounds per inch at the head member portion and approximately 45 pounds per inch at the haunch portions. This is fully within the strength of available fabrics.

Having thus determined suitable radii and curves to be used in the cover design, and having determined that the fabric covering can withstand the maximum anticipated loading, it is a matter of geometry and trigonometry to develop patterns for the generally trapezoidal panel sections which, when sewed or welded together, should form a complete cover. However, because fabrics are not fully dimensionally stable, it is necessary to predetermine the amount of pre-loading and reduce the patterns by the amount of stretch that will be developed in both the warp and fill strands as a result of the pre-loading.

For the particular embodiment depicted herein, a maximum pre-loading tension of approximately 10.8 pounds per inch may be chosen. This maximum will occur in that portion of the cover located medially of the haunch portions in adjacent truss members and will develop a minimum tension of about 5.4 to about 6.3 pounds per inch in that portion of the cover located medially the apices of adjacent truss members -- i.e., in proximity to the head member **50**. These tensions are deemed to be substantially equal in view of the fact that the tear strength of the fabric is at least ten times the maximum pre-loading tension.

Because the application of positive loads relax negative pre-loads and because the application of negative loads relax positive pre-loads, in a building embodying the concept of the present invention, positive and negative loading need not be considered as being cumulative.

Actually, the maximum pre-load is limited by the stretch characteristics of the fabric. A fabric cover having a low stretch factor, after having been reduced by the stretch developed by a very light pre-load, thus would be very difficult to pull over the rigid frame.

Briefly, the manner by which the particular shape for the fabric panel sections is determined will now be described. The length of any fabric section is such that when placed on framework **11** longitudinally thereof and stretched to impart the desired pre-load tension, the negative radius of curvature -- i.e., the warp radius R_w -- will approximately equal the positive radius of curvature -- i.e., the fill radius R_f -- and thereby achieve the theoretically required material disposition -- the saddle shape. Because the fill radius of curvature changes in going from the level of the haunch portions to the level of the head portions, the negative warp radius of curvature must change accordingly. In order to achieve the proper overall contour in the cover fabric, the tension is calculated for the fill radius at the bottom and at the top of the section mid-point. From this the warp radius is calculated and the fabric section cut, compensating for the tension stretch, with the medial length varying approximately proportionally between the bottom and top lengths.

The dimension and disposition for the ends of the panel sections generally paralleling the fill curve and remaining in contact with the top chord box channel **31** of the truss members can be selected because of the fixed disposition of the truss members. From this known dimension, the dimension of the fill curve at the saddle seat can be approximately by knowing the selected pre-load tension to be applied to the fabric and the stretch to the fill strands normally associated with such a load. The intermediate dimensions vary generally proportionally between these two dimensions, but inasmuch as no precise formula exists by which one can accurately predetermine the dimensions for the panels along the fill curves, the design for a particular structure will often involve trial and error techniques.

Because the fabric is designed so that the pretensioned loads in the warp and fill strands are substantially equal, the disposition of the anchor cable **13** shall lie along the intersection of the convoluted saddle shape assumed by the fabric with a portion of the projected circumference of a vertical circle oriented parallel to the anchor points of the cable. The radius of the projected circle must be at least equal to one half the distance between those anchor points. In the particular embodiment depicted and described herein, the largest possible rectangular opening for ingress and egress under an anchor cable in a bay section would be 8 feet wide by 8 feet high, while that for the hexagonal end section would be 12 feet wide by 14 feet high. From a practical standpoint the highest point for the arc of the anchor cable in a bay section would seldom be less than 4 feet and, for the end section, would seldom be less than 8 feet in the embodiment depicted due to the size of the cable that would be required to carry the load as the ground level chord of the projected arc defined by the entire anchor cable is displaced from the diameter of that arc. It should also be noted that the relatively high arc of the pre-loading cable **13** shown in the preferred embodiment allows not only ingress and egress between any two trusses, but also permits a variety of methods for applying enclosing curtains, as is hereinafter more fully explained.

In the event a cover is designed wherein the loads applied to the warp and fill strands are not equal, the disposition of the anchor cable would be determined by the intersection of the convoluted saddle shape with the projected outline of an ellipse, the major axis of which would be located in a vertical plane parallel to the anchor points for that cable. The major axis itself would be parallel to the orientation of the strands bearing the greatest load.

After the skin has been fabricated and applied to framework **11**, it is pre-loaded in tension by the cables **13** enclosed within the hem of the fabric cover **12**.

As best shown in FIGS. **13** and **14**, the anchor cable **13** on each side of a truss member **20** may be adjustably secured to that truss member through a tensioning assembly **55**. The tensioning assembly **55** may well comprise a continuous rod that presents ear loops **56A** and **56B** to which the cables **13A** and **13B** may be respectively secured by the thimble **57** and crosby clip **58** arrangements depicted. A stabilizing plate **59** is secured to and extends between the ear loops **56A** and **56B** across the outer surface of the box channel **31**. From the stabilizing plate **59** the continuous rod extends inwardly along, and embraces, the side walls of the box channel **31** to form a transverse anchor bar **60** that extends behind the box channel **31** for engagement with selective notches **61** on the toothed plate **62** that is fixedly secured to the back wall **63** of the box channel **31**.

On the outer side of the box channel **31** the continuous rod presents a loop **64** which is spaced upwardly of the parallel lugs **65** and **66** that project outwardly from the truss member **20**. One end of a tightening means (not shown) may be temporarily secured to a pin **67** extending through the bores **68** and **69** in the respective lugs **65** and **66**, and the other end of the tightening means may be temporarily secured to the loop **64**. The tightening means is used to apply the necessary force to cables **13A** and **13B** and thereby draw the loop **64** downward toward the lugs **65** and **66**. When the desired load has been applied, the anchor bar **60** is engaged with the appropriate notch **61** on the toothed plate **62** and the tightening means may be removed for applying tension to the cables converging at the truss members **20** successively around the base of the structure **10**.

It has been found that the desired pretensioning of the fabric cover **12** cannot be accomplished at one time because of the tendency of the fabric to stretch under tension and because of even the modest frictional resistance between the fabric and the box channels **31** defining the upper chords of the truss members **20**. As a result, the cover **12** must be periodically retensioned in order to maintain the desired statically prestressed condition thereof.

As the force required to effect retensioning is applied to the anchor cable **13**, the lateral and vertical configuration of the three dimensional curve assumed thereby will change so that the portion of any fabric membrane attached to the cable and located between the cable and ground level will tend to wrinkle unless it can be tensioned independently of the remainder of the cover **12**.

One embodiment of an independent underlapping curtain **75** that may be employed to close the curved bottom openings between the anchor cable **13** and the ground is depicted in FIGS. **15** through **19**.

Referring to FIG. **15** it will be seen that the curtain **75** is presented by a continuous sheet of fabric positioned across a predetermined number of successive truss members **20**. The lower edge **76** of this fabric sheet lies in proximity to ground level, and the upper edge **78** is located at a height somewhat above the upper extent of the curved shape assumed by the anchor cable **13**.

The fabric curtain **75** is secured against lateral movement with respect to the truss members by a series of positioning brackets **79**, successive brackets being provided to embrace the box channels **31** comprising the upper chords on successive truss members **20**. As shown in FIG. **16** the bracket **79** may comprise a strip of fabric presenting a web portion **81** that is secured to the sheet of fabric forming curtain **75**. The side flanges **82** and **83** of the bracket **79** may comprise the lateral hems of the fabric strip which are each secured around a forming member **84.** In the preferred embodiment each forming member **84** may comprise a length of cable, or rope.

The positioning bracket **79** extends upwardly at least to a height level with the uppermost extent of the curve defined by anchor cable **13,** at which height the positioning bracket is preferably attached to an anchor yoke **85.**

The anchor yoke **85** (FIG. **17**) secures the curtain against vertical movement. The tab portion **86** on yoke **85** is fastened to the web portion **81** of the bracket **79.** The bifurcated arms **88** and **89** of the yoke **85** extend longitudinally outwardly from the tab portion **86** and laterally to opposite sides of the outer chord box channel **31** (FIG. **18**). The end of each arm **88** and **89** presents a loop **90** that receives a retainer pin **91** which extends through the truss member **20** and is positioned above the appropriate strut **34** in order vertically to secure the curtain **75.**

With the curtain **75** thus positioned before the outer cover **12** is applied, the convoluted configuration assumed by the cover as the anchor cables **13** are tightened will force the cover into sealing engagement with the curtain **75** along the full extent of each anchor cable **13** and thereby also impose the same convoluted configuration to the curtain **75** as is assumed by that portion of the cover **12** contacting the curtain **75.**

The lower edge **76** (FIG. **15**) of the curtain **75** is secured to the ground by virtue of a cable means through which the curtain **75** may be tensioned independently of the cover **12.**

According to the preferred configuration depicted herein, a cable **91** may extend continuously through the plurality of curves that define the lower edge **76** of the curtain **75** with a chain **93** attached to each end of the cable **91** and to each loop **94** that delineates the transition between successive curves.

An adjustable clamp **95** (FIGS. **19–21**) fastens each chain **93** to a plate **96** anchored in the ground. The clamp **95** has a hook **98** on one end adapted to engage an appropriate link **99** of the chain **93,** and a head **100** at the opposite end of the clamp **95** is adapted to interlock with the plate **96.** As best seen in FIGS. **20** and **21,** the plate **96** has at least one T-slot **101,** and head **100** has a stud **102** extending transversely outwardly therefrom and receivable through the lateral portion **103** of the T-slot **101** and positionable behind the stem portion **104** of the T-slot **101.** The head **100** is preferably provided with oppositely directed flats **105** and **106** adapted to engage the opposed side walls **108** and **109** of the stem portion **104** in order to preclude rotation of the head **100** while engaged with the plate **96.**

The hook **98** is presented from a shank **110** that is preferably externally threaded, as at **111,** to be adjustably positioned within an internally threaded bore **112** in the head **100.** The threaded engagement should allow the shank **110** to be adjusted axially with respect to the head **100** through a distance at least equal to the length of a link **99,** thereby permitting incremental adjustment of the hook **98** with respect to the chain **93** for precise tensioning of the curtain **75** independently of the cover **12.**

A flap **113** may be secured to the curtain **75** upwardly of the curve defined by the curtain cable **91** and extend to the ground. In order to preclude undesirable slatting of the flap **113** it may be nailed, or otherwise fastened, to a retainer bar **114** anchored to the ground, as depicted in FIG. **19.**

Because the preferred tensioning assembly **55** interferes with the disposition of the curtain **75** across the truss members **20** when such a curtain is employed, it is preferred that when a curtain **75** is utilized the anchor for the cover cable **13** be altered for positioning exteriorly of the curtain **75** and spaced outwardly of the truss member **20.** One convenient arrangement is to employ an adjustable clamp **95A** similar to clamp **95** in conjunction with a second plate **96A** with at least one T-slot **101A.** The clamp **95A** would be fastened between the plate **96A** and a chain **93A** secured to the cable **13,** as is also shown in FIG. **19.**

Plate **96A** may well duplicate plate **96** so that as shown in FIGS. **20** and **21** the plates may be provided with a second T-slot **115** to which the base of a tightening device (not shown) may be temporarily and removably anchored to impart tension to the cables anchored to such plates while the appropriate clamps **95** or **95A** are being adjusted to maintain the pretensioned load applied therethrough.

Curtain **75** may be provided with a vertical separating seam for easily opening the curtain for access to the interior of the building. The seam edges may be suitably provided with clamps or other tensioning means to pull the curtain taut laterally when rejoining at the seam.

As an alternative embodiment the lower curved opening in the fabric cover at each of the bays formed between successive trusses may be closed by means of rectangular curtains of fabric **125** (FIG. **22**) formed of seamed strips which extend laterally between the inner, or lower, chords of the trusses, and from a base angle across the bottom up to and over the bottom angle of a compression member extending horizontally between adjacent trusses. While the curtain **125** is preferably of fabric, it could be constructed of rigid material.

As shown on FIG. **26,** the side margins of the fabric curtain **125** are wrapped over the inner leg **126** of the adjacent angles **128** extending along and defining the lower or inner chords **33** of the truss members **20** and are then looped under and over a series of curtain angles **129** extending along and within the truss angles **128,** the marginal end of the fabric being welded to itself at **130.** The curtain angles **129** are spaced apart along the truss angles **128** to accommodate the joints between the angles **128** and the angularly oriented struts **34** of the truss. Each curtain angle **129** is adjustably secured to the other or outwardly directed leg **131** of the truss angle **128** by spaced adjusting bolts **132** which tension the fabric, and parallel slits **134,** as best seen in FIG. **23,** are provided between the ends of adjacent curtain angles **129** to span the joints between the truss angles **128** and the struts **34.**

The bottom marginal edge of the fabric curtain **125** is attached to a base angle **135** attached to the foundation **19,** or floor, of the building, and extending laterally between the inner surfaces of adjacent truss members **20** (FIG. **27**). The curtain is looped around the base angle **135** with the marginal edge of the curtain welded to itself at **136.** A protective ground flap **138** may extend outwardly from the weld over the base angle and curtain loop to ground level.

As shown in FIG. **24,** circular openings **139** and semicircular slits **140** are provided at the locations of the anchor bolts **141** tying down the base angle **135,** respectively, to permit the bolts **141** to extend through the fabric and to provide access for tightening nuts **142** onto the bolts **141.** As shown in FIG. **25,** the side edges of the curtain are slit at **143** and the ground flaps **138** are cut off, or notched, at their ends to fit the fabric curtain around the bases of the truss members **20.**

The compression members indicated as a whole at **145** to which the upper marginal edge of each curtain **125** is attached are best shown in FIGS. **28** and **31** and comprises two vertically spaced angles **146** and **148** extending horizontally between adjacent truss members **20.** The angles **146** and **148** are mitered at the ends to abut the upwardly extending inner angles **128** of adjacent truss member **20** and are connected in vertically spaced relation by laterally spaced angles **149** and end bars **150.** As shown in FIG. **31,** the inner legs **151** and **152** of the respective horizontal angles **146** and **148** are slightly inclined to each other to conform to the angular orientation between the consecutive inner chords **33***a* and **33***b* of the truss members at which the compression member is located.

As shown in FIG. **31,** the upper marginal portion of the curtain **125** is pulled up over the inner leg **151** of the lowermost angle **146** in compression member **145** and then looped under and around a horizontal curtain retainer bar **155** extending within the lowermost angle **146** throughout its length. The bar **155** is adjustably connected at intervals to the bottom leg **156** of angle **146** by adjusting studs **158** extending through holes **159** in said leg and having their upper ends welded to the bar **155** and adjusting nuts **160** on their lower ends by means of which the tension in the fabric can be adjusted. Suitable holes **161** are provided in the fabric loops to expose the locations where the studs **158** are welded to the retainer bar **155.**

To seal the gap between the compression member **145** to which the top marginal edge of the curtain panel **125** is anchored and the outer cover **12** of structure **10** a bias cut filler panel is used. The shape of this filler panel **165** is shown in FIG. **34** and it has a straight beaded inner edge **166** where it connects with the compression member **145,** as herein explained, and a curved flap **168** along the opposite outer edge for sealing against the inner surface of the main fabric cover **12.**

Referring to FIG. **37** it will be seen there are pockets **169** at intervals along panel **165** opening from the straight inner edge **166** for receiving stiffener bars **170** and as shown in FIG. **36,** there are end pockets to receive angle bars **172** for tensioning the fabric to curve the flap **168** into sealing conformity with the main fabric cover **12.**

Referring to FIG. **31,** the outer part of the compression member **145** is closed off by a metal plate **173** having a forwardly angled upper end **174** to which is fastened a retainer bar **175** which in turn is fastened to the straight inner edge bead **166** of filler panel **165** in pretensioned condition. At the outer edge of the filler panel **165** is the flap **168** which runs under and seals against the main outer fabric cover **12.** The ends of panel **165** abut the legs of angle struts **34** in each adjacent truss member **20** and the angle bars **172** are secured thereto by bolts **176.** As shown in FiGS. **29** and **33** bracing angles **177** extend angularly from intermediate portions of each compression member **145** out to the angles **34** of the trusses **20.**

A reinforcing angle **178** extends longitudinally of the filler panel above its upper surface and is connected at its ends to bracing angles **177.** Angle **178** is attached intermediate its ends to stiffener bars **170** in the panel. This angle **178** thus resists inordinate wind loads applied upwardly against the filler panel.

After the filler panel **165** is pre-tensioned to retainer bar **175,** the outer ends of the two tensioning angle bars **172** in the lateral ends of the panel are rotated about their inner ends as fulcrums to stretch or tension the outer curved panel edge as the tensioning bars **172** are swung laterally away from each other toward the angle struts **34** of the truss members **20.** The tensioning bars **172** are then bolted to the angle strus **34** by bolts **176** to maintain the panel **165** in fully tensioned condition.

Due to the bias condition of the filler panel **165,** when the free edge is thus tensioned the flap **168** will conform to and seal against the inner surface of the main fabric cover **12** which is tensioned over the steel truss members **20.**

If it is desired to provide an air space under the outer cover **12** for thermal insulation, the inner curtains **125** can be extended upwardly in spaced relation with the outer cover **12,** in which event the additional curtain panels could fit across and conform to the lower chords **33** of the truss members in similar fashion to the curtain panels **125.** Obviously, the curtain panels for the end sections would be tapered to follow the convergence of the end truss members from their bases toward the head member **50.**

The saddle shaped fabric cover **12** when designed as hereinbefore explained has at least three structural advantages over conventional buildings. First, the shape blends the roof and walls into a structurally cooperative arrangement which eliminates the necessity for cross bracing the truss members in two planes, as is normally required. Second, negative loading (wind lift) is resisted by the fill strands of the fabric which have the greater stretch when tensioned, thus allowing the fabric to absorb and release more energy and thereby alleviating shock loads to the rigid frame. Third, the negative loads due to wind lift are transferred to the truss members in such a manner and direction as to reverse the tension and compression stresses within the truss due to dead load and normal live loads. Thus, that component of the wind lift load which is transferred to the trusses would have to exceed the total dead weight of the trusses before loading them at all.

In addition to providing large areas of unobstructed floor space, a structure embodying the concept of the present invention has at least three additional advantages over conventional buildings. First, the present structure is generally less expensive to fabricate and erect than conventional buildings of comparable size. Second, conventional buildings are not readily, or inexpensively, moved. A new set of foundation footings and very modest labor and equipment is all that is required to move the subject structure. Third, if one desires, a field joint may be incorporated into the fabric cover which would allow one or both polygonal ends to be separated for the incorporation of additional bays.

It should now be apparent that the present invention provides a rigid frame, tensioned fabric structure that achieves the objects of the invention.

I claim:

1. A tensioned fabric structure having a rigid frame comprising, a plurality of curvilinear truss members forming a domed framework and each having a generally polygonal cross section, each said truss member being supported at its lower end on a foundation and connected at its upper end to at least one other of said truss members, each said truss member having a lower upright curved haunch portion connecting with a relatively flattened upper curved portion, a fabric membrane supported on and covering over said framework, said membrane having warp yarns running horizontally and fill yarns running vertically of said structure, and cable means extending between the bases of said truss members and attached to said membrane between said truss members for tensioning said membrane to form a stable structure.

2. A tensioned fabric structure as in claim **1,** in which the fabric membrane has a substantially saddle shape between truss members.

3. A tensioned fabric structure as in claim **1,** wherein the truss members are substantially triangular in cross section, said triangular cross section having an apex engaging said fabric membrane.

4. A tensioned fabric structure as in claim **1,** wherein a stringer truss is connected between the upper ends of spaced pairs of said curvilinear truss members to form a bay section.

5. A tensioned fabric structure as in claim **4,** in which the stringer truss has its intermediate portion bodily offset from its ends.

6. A tensioned fabric structure as in claim **4,** in which the stringer truss has a triangular shaped cross section, said triangular cross section having an apex directed toward the interior of said structure.

7. A tensioned fabric structure as in claim **6,** in which the stringer truss has its intermediate portion bodily offset from its ends.

8. A tensioned fabric structure as in claim **1,** wherein the truss members have inner and outer chords and each cable means tensioning said membrane defines an arcual path in a vertical plane forming a curved opening at the bottom of said membrane.

9. A tensioned fabric structure as in claim **8,** in which said fabric has a substantially saddle shape between truss members and said cable means conforms to said saddle shape.

10. A tensioned fabric structure as in claim **1,** wherein each cable means tensioning said membrane defines an arcual path projected in a vertical plane.

11. A tensioned fabric structure as in claim **4,** wherein said fabric membrane has a first radius of curvature at the apex in a vertical plane perpendicular to the curvilinear truss members delineating said bay sections, said radius being less than the largest radius of the truss members delineating said bay sections.

12. A tensioned fabric structure as in claim **4,** wherein said fabric membrane has a second radius of curvature in a plane perpendicular not only to the truss members but also to a second plane tangential to the center of the haunch curves, said radius being larger than the radius of curvature of the haunch portions of said truss members.

13. A tensioned fabric structure as in claim **8,** wherein the curved bottom openings formed in the fabric between truss members by each cable means are closed by a planar fabric curtain having an upper and lower margin and extending between the inner chords of adjacent truss members and upwardly from the foundation, the upper margin of said curtain being secured to a compression member extending between the inner chords of adjacent truss members.

14. A tensioned fabric structure as in claim **13,** in which a fabric filler panel extends outwardly from said compression member and seals against the inner surface of said fabric membrane covering.

15. A tensioned fabric structure as in claim **13,** in which tensioning means connect said curtain to the inner chords of adjacent truss members and to the compression member.

16. A tensioned fabric structure as in claim **14,** in which tensioning means connect said curtain to the inner chords of adjacent truss members and to the compression member.

17. A tensioned fabric structure as in claim **14,** in which said fabric filler panel is of bias cut fabric having its inner edge longitudinally pretensioned and its outer edge adapted to seal against said fabric membrane covering when longitudinally tensioned.

18. A tensioned fabric structure as in claim **17,** in which means is provided to attach the inner edge of the filler panel to said compression member, and means are provided at the ends of said filler panel to apply and maintain tension in its outer margin.

19. A tensioned fabric structure as in claim **17,** in which said filler panel has lateral stiffener bars encased therein.

20. A tensioned fabric structure as in claim **17,** in which the means to apply and maintain tension in the outer edge of said filler panel are bars encased in the ends of said panel and adapted to be secured to said adjacent truss members.

21. A tensioned fabric structure as in claim **8,** wherein the curved bottom openings formed in the fabric between truss members by each cable means are closed by an underlapping fabric curtain extending between at least two adjacent truss members and upwardly from the foundation beyond the upper extent of the curved bottom openings, said curtain having fabric channel brackets secured to said curtain and fitting over the outer chords of said truss members for holding said curtain against lateral movement, and fabric anchor yokes connecting said brackets to the truss members to hold the curtain against vertical movement.

22. A tensioned fabric structure as in claim **21,** in which an anchoring cable extends along the bottom edge of said curtain, and tensioning means is provided to connect said cable at intervals to the foundation.

23. A tensioned fabric structure as in claim **21,** in which said fabric anchor yoke has a tab secured to one of said fabric channel brackets and two arms having inner and outer ends extending laterally around the outer chord of a truss member, and a retainer pin securing the outer ends of said arms to said truss member.

24. A tensioned fabric structure as in claim **22,** in which said fabric anchor yoke has a tab secured to one of said fabric channel brackets and two arms extending laterally around the outer chord of a truss member, and a retainer pin securing the outer ends of said arms to said truss member.

25. A tensioned fabric structure as in claim **22,** wherein the tensioning means comprises a link chain secured to said cable means, an anchor means, a clamp means having a hook portion and a head portion, said head portion being selectively interconnected to said anchor means, said hook portion engaging a selected link in said chain.

26. A tensioned fabric structure as in claim **25,** wherein means are provided for adjustably positioning said hook portion with respect to said anchor means.

27. A tensioned fabric structure as in claim **25,** wherein a series of link chains are secured to the cable means attached to said membrane, a series of second anchor means are provided and second clamp means having a hook portion and head portion interconnect the chains in said series to said second anchor means, said hook portion in said second clamp means engaging a selected link in said series of chains and the head portion of said second clamp means being selectively interconnected to said second anchor means.

28. A tensioned fabric structure as in claim **25,** wherein said anchor means comprises a plate having at least one T-slot therein and said head portion presents a stud selectively insertable through said T-slot and engageable behind said plate.

29. A tensioned fabric structure as in claim **1,** wherein certain of said truss members form polygonal end sections viewed in plan.

30. A tensioned fabric structure as in claim **1,** wherein certain of said truss members form polygonal end sections viewed in plan and at least one bay having an upper end is formed between the end sections.

31. A tensioned fabric structure as in claim **29,** wherein a head member is connected to the upper ends of said truss members, said head member affording a vent opening.

32. A tensioned fabric structure as in claim **30,** wherein a stringer truss spans the upper end of the bay, and a head member is connected to one end of the stringer truss and to the upper ends of the truss members in the adjoining end section.

33. A tensioned fabric structure as in claim **1,** wherein said fabric membrane, when removed from the framework, may be bundled securely onto a pair of lading bars, said membrane having lateral sides, said lateral sides being folded to the longitudinal centerline of said membrane to present longitudinally opposed ends, the opposed ends of said folded cover being rolled about said lading bars, and strap means securing the resulting bundle.

34. A tensioned fabric structure as in claim **1,** wherein an adjustable tensioning assembly is provided to connect the cable means to said truss members.

35. A tensioned fabric structure as in claim **34,** wherein said tensioning assembly comprises ear means to which the cable means extending to the truss member at which said tensioning assembly is located are connected, a plurality of fixed notches presented from said truss member, an anchor bar secured to said ear means and receivable in selected notches.

36. A tensioned fabric structure as in claim **35,** wherein a loop is presented from said tensioning assembly and opposing lugs are presented from said truss members in spaced relation with respect to said loop.

37. A tensioned fabric structure having a rigid frame comprising, a plurality of curvilinear truss members forming a domed framework and each having a generally polygonal cross section, each said truss member being supported at its lower end on a foundation and connected at its upper end to at least one other of said truss members, each truss member having a lower upright haunch portion connecting with a relatively flattened upper portion, a fabric membrane supported on and covering over said framework and having a substantially saddle shape between truss members, cable means extending between the bases of said truss members and attached to said membrane between said truss members for tensioning said membrane, the saddle shape of the membrane being curved in directions longitudinally and laterally of said truss members, and the radii of said curvatures being so related to the radii of curvatures of the truss members that the applied tension at any point of said membrane is substantially equal in directions longitudinally and laterally of said truss members to form a stable structure.

38. A tensioned fabric structure as in claim **37,** wherein the lower portions of said truss members each extend substantially upright and then curve inwardly to form a haunch portion which connects with a relatively flattened curved upper portion.

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