United States Patent

Bird

[15] **3,651,609**

[45] **Mar. 28, 1972**

[54] AIR INFLATED STRUCTURE

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[52] **U.S. Cl.** **52/2**

[51] **Int. Cl.** **E04b 1/345**

[58] **Field of Search** ..... 52/2; 25/128 D; 249/65; 135/1

[56] **References Cited**

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1,302,182	4/1919	Lanchester	52/2
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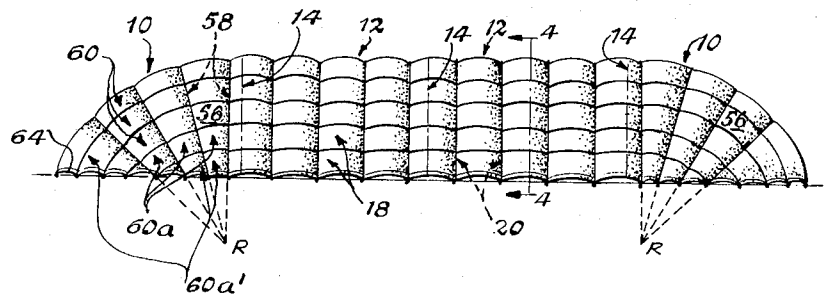
Primary Examiner—John E. Murtagh

Attorney—Bean & Bean

[57] **ABSTRACT**

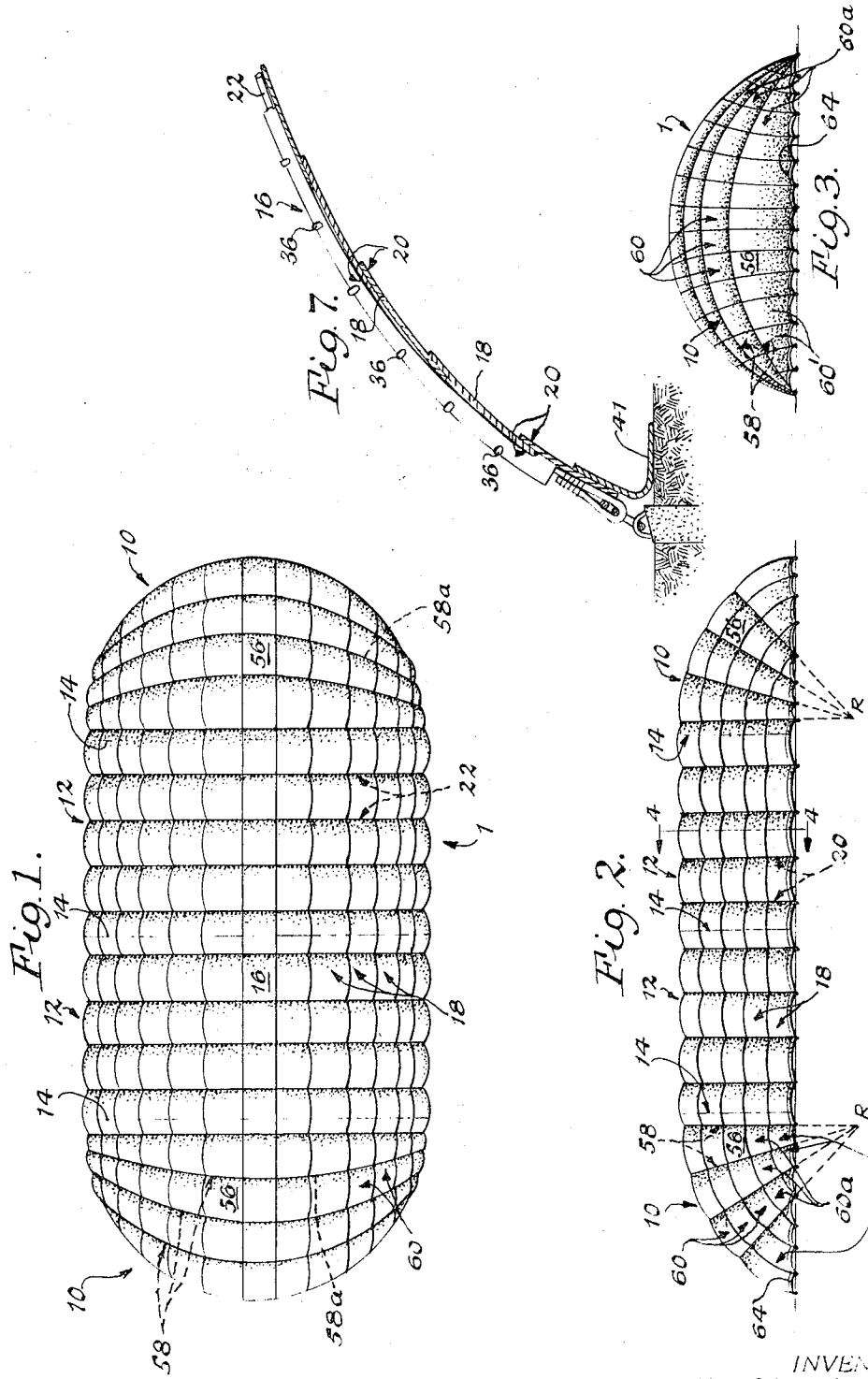
An air inflated structure including an air inflated envelope formed by a plurality of relatively narrow, horizontally elongated panels having horizontally extending adjacent edge portions joined together, and a cable system having a series of widely spaced parallel flexible tension devices anchored to their opposite ends to the ground or other suitable structure base. The tension devices extend transversely of and are fixed relative to the envelope panels. The arrangement reduces the maximum fabric stresses in the envelope material, and permits substantially all loads to be transferred from the envelope panels horizontally into the tension devices and be carried thereby to the ground, thereby limiting propagation of rips or tears occurring in the envelope panels.

12 Claims, 11 Drawing Figures



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3 Sheets-Sheet 1



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Fig. 5b.

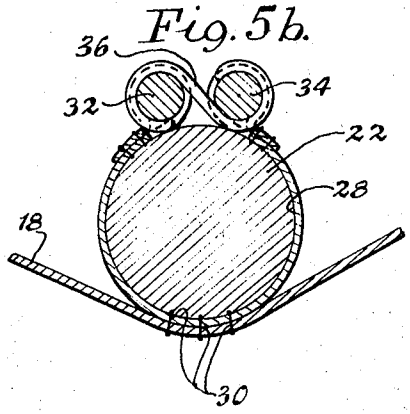


Fig. 6.

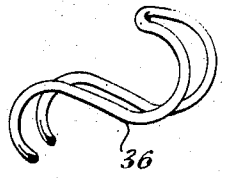
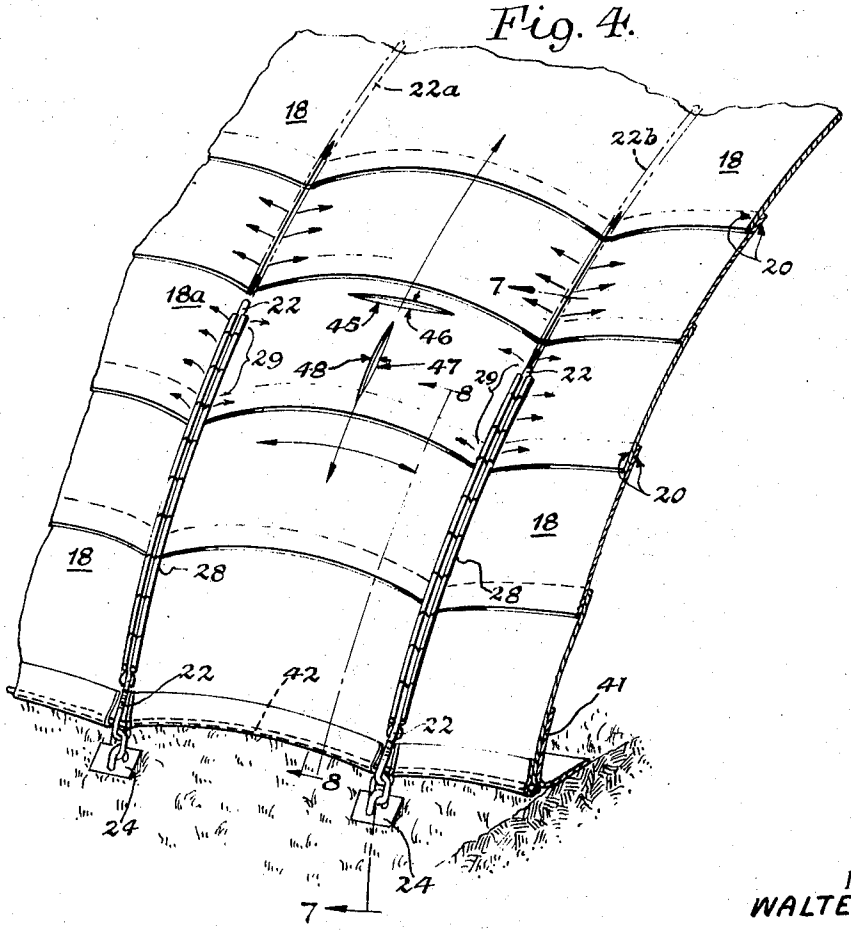


Fig. 4.



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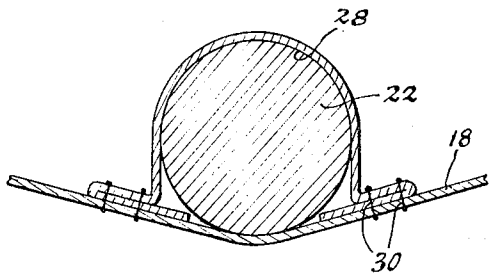


Fig. 5a.

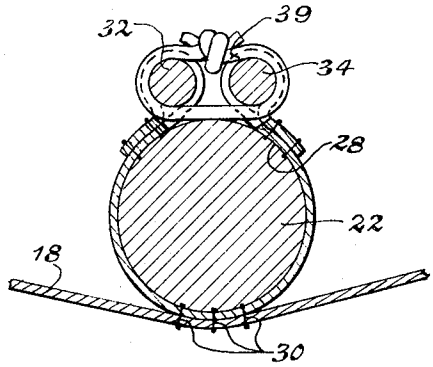


Fig. 5c.

Fig. 5d.

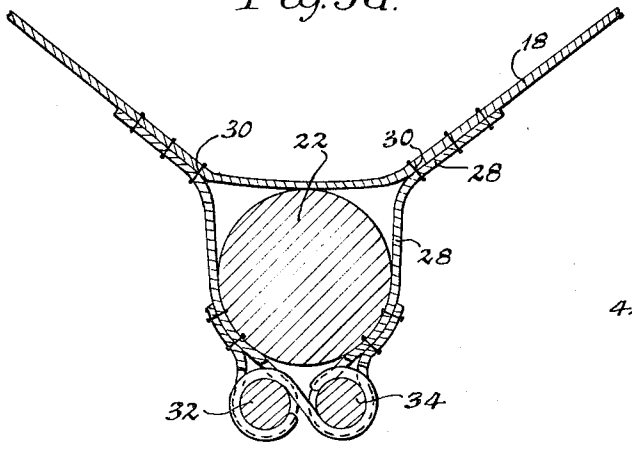
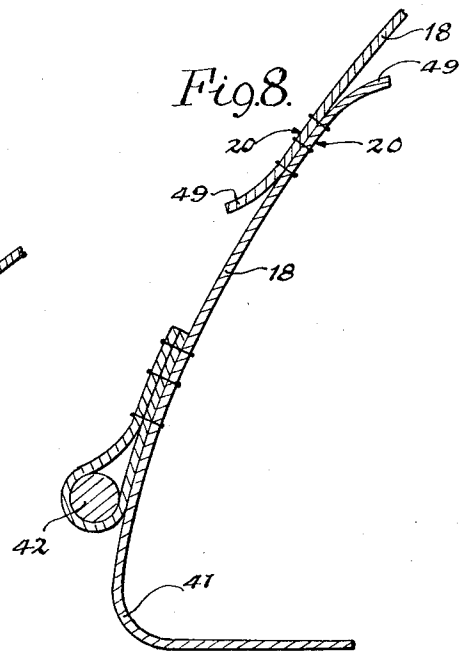


Fig. 8.



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AIR INFLATED STRUCTURE

BACKGROUND OF THE INVENTION

The majority of air supported structures used to date are simple air inflated envelopes, which are fabricated from high strength, coated fabric. These structure have been provided at low cost and have proven serviceable where they were of a size that could be fabricated from material currently available, where used for portable or semi-permanent applications and where temporary collapse, due to accidental damage or vandalism, would not be of serious consequence. However, with the growing interest in air supported structures of larger size and the need for more permanent installations, there is required a design which will result in low fabric stresses, a longer service life, greater reliability, less vulnerability to damage, and easier maintenance and repair.

Air supported structures have conventionally been shaped from generally spherical and cylindrical elements to form an enclosure of the desired size and shape. Normally, stresses in the envelope vary with the shape of the structure and in direct relation to the size of the structure and inflation pressure used to maintain stability. Aerodynamic and snow loads result in non-uniform loading in the envelope. The aerodynamic loading varies as the square of the wind velocity and is proportionately much larger than the normal stresses due to inflation pressure alone. Under non-uniform loading, equilibrium conditions in an air structure are achieved by redistribution of load, or by distortion of the envelope. With spherical elements or elements having a double curvature, loads can be redistributed between the intersecting circular elements. In effect, compressive loads are resisted as a relaxation of tension loads imposed by the initial inflation pressure. The spherical shape is therefore quite stable. However, with cylindrical sections, all stresses resulting from pressure differential must be carried by the circular elements, that is, as hoop tension. Longitudinal stresses in the envelope, that is in the straight elements, result from pressure of aerodynamic loads on the end sections, but are not effected nor have any influence on the local loading. Therefore, if the pressure varies along the circular element, distortion or a change in radius along the length of the element is required in order to result in approximately equal tension in the element from anchor point to anchor point, as is required for an equilibrium condition.

One obvious way to reduce the stress levels in the basic envelope would be to enclose it within a network of intersecting cables capable of carrying the entire aerodynamic of pressure loading. The envelope itself would thus be required only to distribute the pressure loading to the cable system. Uniform distribution of load can be achieved only if the cables are relatively closely spaced on approximately a uniform pattern over the entire surface, including the end sections of the structure.

As an alternate to the cable network, the envelope can be reinforced by running cables hoopwise across the cylindrical center section and radially from the crown of the spherical end sections in the manner illustrated in Lanchester's Pat. No. 1,302,182, Where such a cable system has been used, in combination with conventional envelope patterning wherein relatively inextensible coated fabric panels run vertically so as to form the circular elements of the structure, it has proven to be of limited effectiveness unless the cables are spaced very closely together. Otherwise, the cables relieve the stress only in the small area of the panels immediately adjacent to the cables, with the result that the remaining or mid-portions of the panels must still carry essentially the full load down to the structure base or support to which the cables are attached. Thus, the cabling system is not fully utilized, the distribution of load in the panels is indeterminate and thus difficult to design for, and the stress distribution under high wind conditions could result in severe propagation of any cut or tear in the panels resulting from accidental damage or vandalism. If the cables are shortened to press in on the envelope sufficient to allow for the required outward bulging of the envelope between the cables, then the envelope becomes very wrinkled, resulting in an unsightly appearance and poor distribution of load.

Another difficulty encountered with conventional construction is that the growth and elastic characteristics of the materials in conventionally patterned structures results in a growth and resulting distortion of the envelope. Large variations occur primarily in the fill direction of the material which, with conventional patterning, is parallel to the longitudinal axis of the structure. While this high elasticity can normally be compensated for in the patterning of small structures, this is extremely difficult to do in large structures, particularly those with a high length-to-width ratio, as the greater stretch and changes in elongation under varying conditions of load, temperature, and humidity result in a possible variation of several feet in the location of attachments to the base of related equipment near the ends of the structure.

These difficulties can be overcome and a much more reliable structure having less vulnerability to damage and a much longer service life can be provided by using a cabling system and a method of patterning which will result in essentially toroidal-shaped panels, as proposed in my prior U.S. Pat No. 3,225,413. However, in this patent the individual panels were patterned so as to develop the toroidal shape and achieve approximately a uniform distribution of load in both hoop-wise and horizontal directions in order to assure minimum distortion under locally applied loads (such as the weight of concrete when applied to the air form).

SUMMARY OF THE INVENTION

The present invention relates to air supported structures, and more particularly to a patterning arrangement for air inflated structure having a generally cylindrical configuration.

It is a primary object of the present invention to fabricate an envelope for use in a generally cylindrical air inflated structure in such a manner that tears or rips occuring in any circular element of the envelope will be largely prevented from propagating themselves throughout more than a small predetermined surface area of the envelope.

It is another particularly important object of the present invention to provide a novel envelope paneling arrangement which will limit deformation of the circular elements of a cylindrical envelope under non-uniform loading and result in transfer of essentially all of the load-induced tension forces directly into the cable system.

In accordance with the preferred embodiment of the present invention a generally cylindrical envelope is formed by a plurality of relatively narrow, horizontally extending panels, which are joined along horizontally disposed edges thereof with vertically adjacent panels; the individual panels being fabricated from a material which is characterized by being appreciably more elastic or extensible in the fill or transverse direction than in the warp of machine direction. This is exactly opposite from the uniform elongation characteristic desired of materials used in conventional air supported structures or in my prior U.S. Pat No. 3,225,413 wherein major loads are to be distributed between both the warp and fill directions of the material, or in both hoop-wise and horizontal directions of the envelope. Where special procedures are not used to control or limit the fill-wise extensibility of the envelope material in conventional structures, severe distortion of the structures under normal loading generally occurs, resulting in not only poor appearance, but severe stress concentrations. An important advantage of the present novel method of patterning is that it eliminates the need for costly weaving, heat setting and coating procedures normally required to prevent high elongation in the fill direction of conventional envelope materials, thus making it possible to provide materials with improved properties at lower cost and to greatly enhance the performance and serviceability of the air structure.

When envelope panels of the type described are assembled, they cooperate to produce circular envelope elements having

a degree of elasticity in the direction of curvature of the cylindrical envelope surface sufficient to permit such circular envelope elements when inflated to assume a toroidal shaped configuration. Thus, the panels forming the circular envelope element will transfer substantially all of the load induced by the pressure differential horizontally across the surface of the envelope directly to the cable system with a minimum load being carried by the circular elements in a hoopwise or vertical direction without need for excessively contouring the individual panels.

The assembled panels are each joined to a cable system including a series of relatively widely spaced parallel flexible tension devices anchored at their opposite ends to the ground or other supporting base. By this arrangement, a tear or rip occuring in any panel cannot propagate itself beyond a limited envelope surface area defined by a pair of adjacent hoopwise extending tension devices and the horizontally extending side marginal edges of the damaged pane.

As the method of assembling the panels in accordance with the present invention results in a very low fabric stress in the vertical or hoopwise direction of the structure, there will be little concentration of stress on the ends of any horizontal tear or cut to cause propagation. Thus, even if a panel is cut by a vandal, the stresses in the fabric would be essentially parallel to the cut and little gap would result, thus greatly limiting air loss through the opening. If the damaged panel was cut in a vertical direction or across the loaded direction of the material, the concentration of load at the ends of the cut would be limited, as the load in the damaged panel would be transferred into the vertical cables or tension devices to which the panel is attached, rather than into an adjacent panel, such as would result under normal construction methods. Thus, the severe buildup of loads and concentration of stress in an adjacent panel, which could result in catastrophic failure of the entire envelope, is prevented. Propagation of a cut in the vertical direction would also be limited by the overlapping horizontal seams of vertically adjacent panels, which serve as a rip or tear stop. Where desirable, additional rip stop characteristics could be readily incorporated into the seams during assembly by incorporating strong cords, or by forming the seam with extending edges so as to effectively limit propagation of a tear thereacross.

In the preferred embodiment of the present invention, end sections of semi-spherical configuration are connected to the respective ends of the cylindrical or intermediate section of the air inflated structure, and the horizontally arranged panels defining the envelope of the cylindrical section extended into the end sections and patterned so as to provide for uniform loading thereof. The cabling system employed for the end sections includes base anchored tension devices, which lie along generally great circles through a common center. Because the circular elements between pairs of adjacent cables on the end sections are tapered, normal pressure loading varies along the cables or tension devices. This requires that the length of the horizontally disposed panels within each circular elements be varied hoopwise of the end section, such that in their inflated position, shorter panels approaching the ground have a greater radius of curvature than the upper panels of the same circular element. This minimized displacement of the adjacent cables from their normal plane and results in a stable shape. However, because of the tapered circular elements, the radius of curvature of the tension devices within their planes is not uniform, but can be blended into the cylindrical section by arbitrarily spreading the base anchors in order to achieve a smooth, undistorted transition between the end and cylindrical sections.

DRAWINGS

The present invention will now be more fully described with reference to the accompanying drawings wherein:

FIG. **1** is a top plan view of an air inflated structure formed in accordance with the present invention;

FIG. **2** is a side elevational view of the air inflated structure shown in FIG. **1**;

FIG. **3** is an end elevational view of the air inflated structure shown in FIG. **1**;

FIG. **4** is a fragmentary perspective view indicating the manner in which the respective envelope forming panels deform for the purpose of transferring a load to the cable system when the envelope is inflated;

FIGS. *5a–5b* are sectional views taken generally along the line **5—5** in FIG. **2**;

FIG. **6** is a perspective view of the cable system attaching clip shown in FIG. *5b*;

FIG. **7** is a sectional view taken generally along the line **7—7** in FIG. **4**; and

FIG. **8** is a sectional view taken along line **8—8** in FIG. **4**, but showing a modified panel joining arrangement.

DETAILED DESCRIPTION

Now referring to FIG. **1**, it will be seen that the air supported structure according to the preferred embodiment of the present invention is generally designated as **1** and includes a pair of rounded or semi-spherical end sections **10**, which are bonded to or separably joined to one or more generally cylindrical intermediate sections **12**, as by suitable joiners **14**. While joiners **14** may be of any desired design, it is preferable to employ joiners of the types disclosed in U.S. Pat. No. 3,116,746 and 3,103,050. It will be understood, however, that one or both of end sections **10** may be dispensed with if the cylindrical section is otherwise attached in a manner capable of carrying imposed loads without excessive distortion. For instance, section **12** may be employed as an extension of a rigid building structure or to interconnect a pair of such building structures. Also, end section **10** may be replaced, if desired, by vertically extending end closures of the types disclosed by my U.S. Pat. Nos. 3,139,464 or 3,240,217.

More specifically, sections **12** are defined by an air inflatable envelope **16** formed by a plurality of relatively narrow, horizontally elongated panels **18** having their horizontally extending edge portions **20** joined together. Preferably, edge portions **20** of each panel are arranged in overlapping relationship with those of vertically adjacent panels, as best shown in FIG. **7**. Sections **12** also include a cable system defined by a plurality of parallel, relatively widely spaced, flexible tension devices, such as cables **22**, which are connected at their respective ends to ground anchors **24** of any suitable design, as best shown in FIG. **4**. The overlapping edge portions **20** of the panels are interconnected by suitable means, such as stitching or adhesive.

As by way of example, panels **18** may be on the order of four feet wide and the spacing between adjacent cables **22** may be on the order of twenty feet.

Referring to FIGS. **4** and *5a–5d*, it will be understood that each of sections **12** is provided with a plurality of transversely extending attaching sleeves in the form of fabric strips **28**, which are suitably affixed across panels **18** at spaced points, lengthwise thereof, as by stitching **30**. Strips **28** may be sewn directly to the panels so as to provide a sleeve about a previously arranged cable, as indicated in FIG. *5a*, or may be formed with roped or cabled edges **32**, **34**, as shown in FIGS. *5b–5d* in order to facilitate subsequent attachment of the cables. Further, it will be understood that strips **28** may, as desired, be of one piece construction, as shown in FIGS. *5a–5c*, or of plural piece construction, as indicated in FIG. *5d*.

Strips **28** are preferably continuous lengthwise of cables **22** and attached to the envelope after panels **18** are assembled. However, strips **28** may be formed in a plurality of segments, which are aligned end to end when the panels are joined together.

The preferred arrangement for attaching cables **22** to attachment strips **28** is best shown in FIG. **5b**, wherein a generally S-shaped clip **36** of the type shown in FIG. **6**, is deformed around rope edge **32** with its opposite end hooked

about roped edge **34** through a slot cut in the panel material in order to hold the roped edging together and thus frictionally retain cable **22** within strip **28**. Any suitable tool, not shown, may be provided for deforming clips **35** for attachment. Alternatively, the marginal edges of strips **28** may be drawn together by rope lacing **39**, as illustrated in FIG. **5***c*.

Where it is desirable to have the cable system located on the inside of the structure, rather than on the outside, in order to protect it from the weather, and permit attachment thereto of internal equipment, curtains, etc. attaching strip **28** could be mounted to the inside of the structure, as illustrated in FIG. **5***d*.

It should be understood that a wide variety of different types of sleeve designs and attachment devices could be used to secure cables either on the inside or outside of the structure of the present invention, provided that attachment was adequate to assure transfer of the load from the panels into the cables.

It will be understood that strips **28** are spaced lengthwise of panels **18** a distance in excess of the final spacing between cables **22** when structure **1** is inflated. This arrangement, together with the special patterning to be described, permits a circular element of the envelope, i.e. the segment of the envelope between a pair of adjacent cables **22***a*, **22***b* shown in FIG. **4**, to assume a desired toroidal shaped configuration, while permitting cables **22** to be maintained in a parallel relationship.

Referring to FIGS. **4**, **7** and **8**, it will be understood that a flap seal device **41** is preferably attached to the lowermost panel on each side of section **12** for the purpose of forming an air seal between envelope **16** and the ground. Also, it is preferable to secure the bottommost panels by means of a cable **42** in order to control the position and shape of the several circular elements of the envelope. Alternatively, flap seal device **41** may be dispensed with and the lowermost panels merely folded inwardly to provide an air seal.

In accordance with the preferred embodiment of the present invention, panels **18** are fabricated from a low cost coated fabric, characterized as being substantially more elastic or extensible in the fill or in the direction transverse to the machine or warp direction of the panels.

The radius of curvature of the envelope between adjacent cables would normally depend on the elastic properties of the material in both warp and fill directions. However, by employing horizontal panels and a panel material with relatively high extensibility in the fill direction as compared to the warp direction, loads through the material hoopwise of the envelope from base anchorage to base anchorage may be kept to a minimum, and essentially all loads are carried horizontally into the cables and thereby to the ground. In many applications this permits a desired toroidal shape to be achieved with no contouring of the panels and thus greatly simplifies the envelope construction. Where the elasticity of the envelope fabric in the fill direction cannot be made sufficient to fully accommodate the desired toroidal shape, such as for very large structures where a deep fluted effect is desired, then some contouring of the joining edges of adjacent panels may be necessary in order to keep the stress levels low when the envelope is inflated.

The beneficial result of this special horizontal patterning is to reduce vertical or hoopwise loads on the panels, thus minimizing possible propagation of cuts of tears in the horizontal direction. A further benefit is to prevent undesirable transfer of aerodynamic load through the panel to the anchorage, thus eliminating the need for costly attachment method. Thus, in the present construction all that is required is that bottom edges of the envelope be clamped to provide a seal or otherwise secured to control position and shape, as indicated above.

Again referring to Fig. **4**, it would be understood that, as a result of the above-mentioned design, if a horizontal tear or rip **45** should occur in panel **18***a* between a pair of adjacent cables **22***a*, **22***b*, the vertical or hoopwise stresses would be so low that there would be little tendency for the tear to propagate. However, if a tear should start, the cables and strips **28** would effectively prevent propagation of the tear lengthwise of panel **18***a*, and the size or width of any resulting gap **46** would be very small, so as to keep air losses to a minimum. Also, it will be apparent that if a vertical tear **47** should develop, the fabric stresses **29** in panel **18***a* on the other sides of cables **22***a*, **22***b* would be picked up by these cables through the attachment strip **28**, thus effectively limiting the load causing propagation of such tear and/or opening of resulting gap **48**. Also, the double fabric thickness provided by bonding together overlapping edges **20** of panel **18**a with vertically adjacent panels **18** would effectively act to prevent the propagation of tear **47** into such vertically adjacent panels.

The possibility of vertically adjacent panels being torn may be even more effectively prevented in cases where they are bonded together, as by heat sealing or cement, by joining the overlapping edges of such panels so as to form unattached projecting edges **49**, as generally illustrated in Fig. **8**. This construction prevents transfer of the load into a cut edge of the panel material, where a tear is most likely to be initiated. Alternatively, reinforcing cords may be incorporated into the bond to reinforce against tear.

Referring to Figs. **1** and **2**, end sections **10** are shown as having envelope portions **56** and a cabling system, including cables **58**, which lie substantially along great circles drawn through an imaginary center R, such that the curvature of cables **58** corresponds generally to the radius of curvature of cables **22**.

Envelope portions **56** are formed of panels **60**, which are preferable end aligned with panels **18**. As previously described in detail with reference to panels **18**, end panels **60** are preferably edge joined in overlapping relationship with vertically adjacent end panels in a manner providing for rip or tear stop characteristics. Further, attaching sleeves of the type described above are employed to attach end cables **58** across end panels **60**, such that the cables extend transversely of the joining edges of such panels at their points of intersection.

To facilitate fabrication of end section envelope portions **56**, panels **60** are preferable formed by a plurality of end joined panel segments **60**a, which extend between adjacent pairs of cables **58** and have their respective ends tapered so as to permit panels **60** to assume a generally arcuate shaped configuration, illustrated in Fig. **2**, and the circular elements between adjacent cables **58** to be of generally toroidal shaped configuration.

Preferably, panel segments **60** are formed from conventional coated fabric having a greater degree of elasticity of extensibility in its fill, as compared to its warp direction, so that panel segments **60***a* are relatively inextensible in their lengthwise direction, that is, between adjacent cables **58**.

Because the circular elements between pairs of adjacent cables **58** are tapered, normal pressure loading varies along the cables from anchor point to anchor point. This requires that the length of panel segments **60***a* within each circular element be varied in a hoopwise direction, such that in their inflated position panel segments approaching the ground have a greater radius of curvature than relatively upper panel segments of the same circular element. This variance in panel segment curvature tends to equalize pressure loading along the cables and thus minimizes displacement of adjacent cables from their normal plane and results in a stable end section shape. However, because of the tapered circular elements, the radius of curvature of the cables within their planes on the essentially spherical end sections is not uniform, but can be blended into the uniform curvature of cylindrical section **12** by arbitrarily spreading the base anchors to which cables **58** are attached. In other words, the base anchors of one or more of cables **58** immediately adjacent cylindrical section **12** are arranged more or less in alignment with the base anchors of the cylindrical section, as indicated in the case of cables **58***a* in FIG. **1**; the base anchors of the remaining cables being arranged substantially along a circular arc. This results in a smooth, undistorted transition between end and cylindrical sections of the structure.

The above described arrangement provides for uniform end section loading conditions in order to maintain equilibrium conditions with a minimum of distortion.

In order to insure proper transfer of the loads from peripheral panel segments **60***a'*, that is, those having edges disposed adjacent the ground, such panel segments are ground anchored by a conventional catenary cabling system **64** or by clamping or otherwise attaching such panel segments to the base. Further, end sections **10** are air sealed relative to the ground, as for example by inturning the lower edges of peripheral panel end segments **60***a'*.

From the foregoing, it will be understood that the present invention provides for a stable, relatively low cost air supported structure which has minimum vulnerability to damage. Further, due to the provision of generally toroidal shaped envelope elements in both the end and intermediate section, improved acoustical characteristics are achieved when compared to conventional smooth surfaced envelope construction.

Various possible changes in and modification of the preferred embodiment of the present invention will likely become apparent to those skilled in the art in view of the foregoing description. Exemplary thereof, would be to form the horizontally arranged panels from material having like warp and fill extensibility characteristics, and to achieve the desired toroidal shaped configuration of and load distribution in the envelope elements by contouring the horizontally extending marginal edges of the panels. However, reliance on patterning alone to achieve the desired characteristics mentioned above is, as a practical matter, undesirable from the standpoint of envelope material and fabrication cost.

I claim:

1. An air inflated structure comprising in combination:

a generally cylindrical section and end means to air seal opposite ends of said cylindrical section, said cylindrical section including a generally cylindrical air inflated envelope, a series of generally parallel flexible tension devices and attaching means for attaching said tension devices to said envelope, said envelope arching over a supporting surface and having lengthwise extending marginal edge portions thereof air sealed relative to said supporting surface and having hoopwise extending marginal edge portions thereof air sealed relative to said end means, said envelope comprising a plurality of relatively narrow horizontally elongated envelope panels extending lengthwise of said cylindrical section, said envelope panels being joined to vertically adjacent envelope panels,

said flexible tension devices being anchored at their opposite ends to said supporting surface, said tension devices being relatively widely spaced apart lengthwise of said envelope so as to extend hoopwise of said envelope and transversely of said envelope panels,

said panels cooperating to define between each pair of adjacent tension devices a generally toroidal shaped envelope element extending hoopwise of said envelope, said panels forming each of said envelope elements being characterized as being extensible transversely thereof thereby permitting transfer of essentially all loads imposed on said envelope lengthwise thereof into said tension devices, the joining of said vertically adjacent panels and attaching of said tension devices to said panels limiting propagation of rips or tears occurring in said panels.

2. An air inflated structure according to claim **1**, wherein said panels are characterized as possessing a substantially greater degree of extensibility in a direction transversely thereof than in a direction lengthwise thereof, and said panels forming each of said envelope elements being further characterized as having a lengthwise dimension in excess of the spacing between said pair of adjacent tension devices.

3. An air inflated structure according to claim **1**, wherein said panels are characterized as possessing a substantially greater degree of extensibility in a direction transversely thereof than in a direction lengthwise thereof, said panels forming each of said envelope elements being further characterized as having a lengthwise dimension in excess of the spacing between said pair of adjacent tension devices, said tension devices lie along the outer surface of said envelope, and said attaching means includes sleeve devices fixed to and extending transversely of the outer surface of said panels, said tension devices being received within said sleeve devices.

4. An air inflated structure comprising in combination:

a generally cylindrical section and end means to air seal opposite ends of said cylindrical section, said cylindrical section including a generally cylindrical air inflated envelope, a series of generally parallel tension devices and attaching means for attaching said tension devices to said envelope, said envelope arching over a supporting surface and having lengthwise extending marginal edge portions thereof air sealed relative to said supporting surface and having hoopwise extending marginal edge portions thereof air sealed relative to said end means, said envelope comprising a plurality of relatively narrow horizontally elongated envelope panels extending lengthwise of said cylindrical section, said panels being disposed in overlapping relationship with vertically adjacent panels and joined thereto within the area which said panels overlap in a spaced relationship to marginal edges thereof whereby said marginal edges of adjacent panels are unattached, said flexible tension devices being anchored at their opposite ends to said supporting surface, said tension devices being relatively widely spaced apart lengthwise of said envelope so as to extend hoopwise of said envelope and transversely of said envelope panels, said panels cooperating to define between each pair of adjacent tension devices a generally toroidal shaped envelope element extending hoopwise of said envelope, said panels forming each of said envelope elements being characterized as transferring essentially all loads imposed on said envelope lengthwise thereof into said tension devices, the joining of said vertically adjacent panels and attaching of said tension devices to said panels limiting propagation of rips or tears occurring in said panels.

5. An air inflated structure comprising in combination:

a generally cylindrical section and end means to air seal opposite ends of said cylindrical section, said cylindrical section including a generally cylindrical air inflated envelope, a series of generally parallel tension devices and attaching means for attaching said tension devices to said envelope, said envelope arching over a supporting surface and having lengthwise extending marginal edge portions thereof air sealed relative to said supporting surface and having hoopwise extending marginal edge portions thereof air sealed relative to said end means, said flexible tension devices being anchored at their opposite ends to said supporting surface so as to extend hoopwise of said envelope, at least one of said end means is in the form of a generally spherically shaped end section, said one end section including:

an air inflated envelope end portion attached to the first said envelope so as to close one end of said cylindrical section, said envelope end portion comprising a plurality of end panels;

a series of flexible end tension devices anchored at their opposite ends to said supporting surface at points spaced in a direction transversely of the first said envelope, said end tension devices lying substantially along great circles passing through a common center and having a curvature corresponding substantially to the radii of curvature of the first said tension devices, said end panels being arranged such that said end tension devices extend transversely thereof; and

means for attaching said end tension devices to said end panels, adjacent end tension devices bounding a circular element of said envelope end portion extending between and tapering towards said opposite ends of said end ten-

sion devices, each said end portion circular element being characterized as being of toroidal shaped configuration and as having essentially all loads imposed thereon transferred transversely thereof into end portion tension devices bounding same.

6. An air inflated structure according to claim 5, wherein said end panels are characterized as possessing a substantially greater degree of extensibility in a direction transversely thereof then in a direction lengthwise thereof, and said panels forming each of said envelope elements being further characterized as having a lengthwise dimension in excess of the spacing between said pair of adjacent tension devices.

7. An air inflated structure comprising in combination:

a generally cylindrical section and end means to air seal opposite ends of said cylindrical section, said cylindrical section including a generally cylindrical air inflated envelope, a series of generally parallel tension devices and attaching means for attaching said tension devices to said envelope, said envelope arching over a supporting surface and having lengthwise extending marginal edge portions thereof air sealed relative to said supporting surface and having hoopwise extending marginal edge portions thereof air sealed relative to said end means, said envelope comprising a plurality of relatively narrow horizontally elongated envelope panels extending lengthwise of said cylindrical section, said envelope panels being joined to vertically adjacent envelope panels, said flexible tension devices being anchored at their opposite ends to said supporting surface, said tension devices being relatively widely spaced apart lengthwise of said envelope so as to extend hoopwise of said envelope and transversely of said envelope panels, said panels cooperating to define between each pair of adjacent tension devices a generally toroidal shaped envelope element extending hoopwise of said envelope, said panels forming each of said envelope elements being characterized as transferring essentially all loads imposed on said envelope lengthwise thereof into said tension devices, at least one of said end means is in the form of a generally spherically shaped end section, said one end section including:

an air inflated envelope end portion attached to the first said envelope so as to close one end of said cylindrical section, said envelope end portion comprising a plurality of end panels;

a series of flexible end tension devices anchored at their opposite ends to said supporting surface at points spaced in a direction transversely of the first said envelope, said end tension devices lying substantially along great circles passing through a common center and having a curvature corresponding substantially to the radii of curvature of the first said tension devices such that adjacent end tension devices bound circular end section envelope elements extending between and tapering towards said opposite ends of said end tension devices, said end panels being arranged so as to extend transversely of said end section circular elements and joined to adjacent end panels within said circular elements each said end section envelope element being characterized as having a generally toroidal shaped configuration, and said end panels of each said end section envelope element being characterized as transferring essentially all loads imposed on their associated end section envelope element into end tension devices bounding same; and

means for attaching said end tension devices to said end panels.

8. An air inflated structure according to claim 7, wherein said end panels are characterized as possessing a substantially greater degree of extensibility in a direction transversely thereof than in a direction lengthwise thereof, and said end panels of each said end section envelope element being characterized as having a lengthwise dimension in excess of the spacing between bounding end tension devices in an area of attachment thereto, whereby to permit said end envelope circular element to assume said configuration.

9. An air inflated structure according to claim 8, wherein at least some of said end panels are formed by end joined end panel segments extending between adjacent end tension devices.

10. An air inflated structure according to claim 7, wherein said end section envelope elements are characterized as having an increasing radius of curvature transversely thereof in directions towards said opposite ends of said adjacent end tension devices.

11. An air inflated structure according to claim 10, wherein at least some of said end panels are formed by end joined end panel segments extending between adjacent end tension devices.

12. An air inflated structure according to claim 11, wherein said end panels are characterized as possessing a substantially greater degree of extensibility in a direction transversely thereof than in a direction lengthwise thereof, and said end panels of each said end section envelope element being characterized as having a lengthwise dimension in excess of the spacing between bounding end tension devices in an area of attachment thereto, whereby to permit said end envelope circular element to assume said configuration.

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