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(54) DUAL-BIAS AIRBEAM

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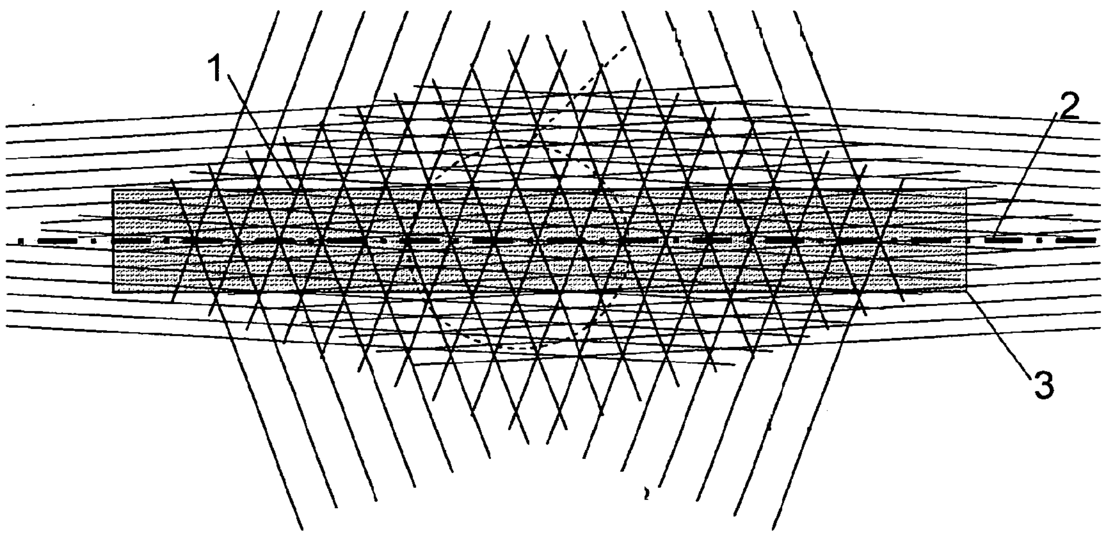
(57) **ABSTRACT**

An airbeam, inflated to create a structural member, has three functional layers in its wall: a flexible gas barrier and a braided reinforcing layer plus the novelty of an additional braided layer. Key design factors are the bias angles of the braids in the two braided layers: that of the inner one greater than 54.7 degrees bias angle and of the outer one less than 54.7 degrees bias angle. The two layers of braid being slipped over another allows the airbeam to be formed with bends for a wide variety of shapes.



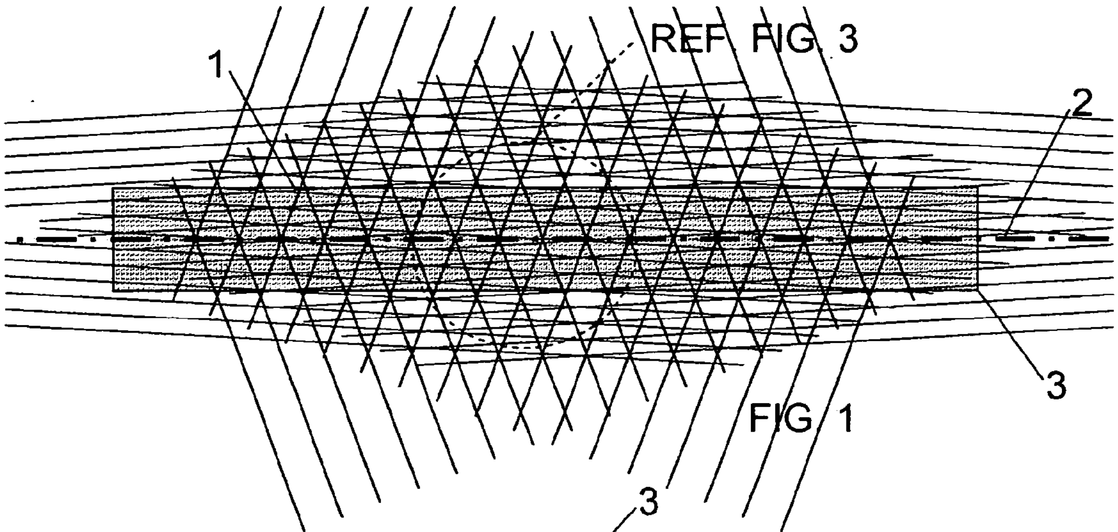


FIG. 1

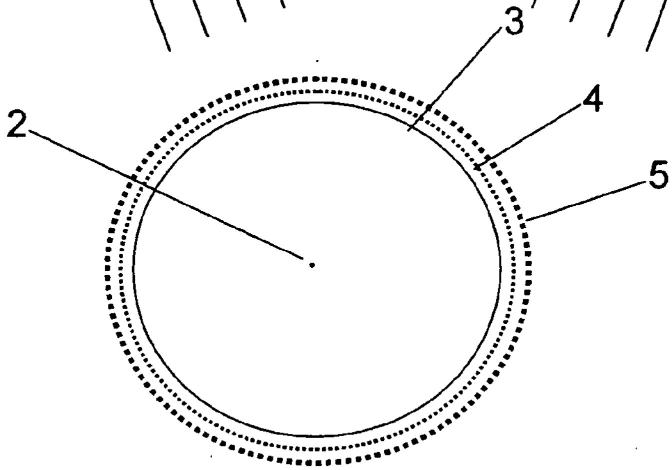


FIG. 2

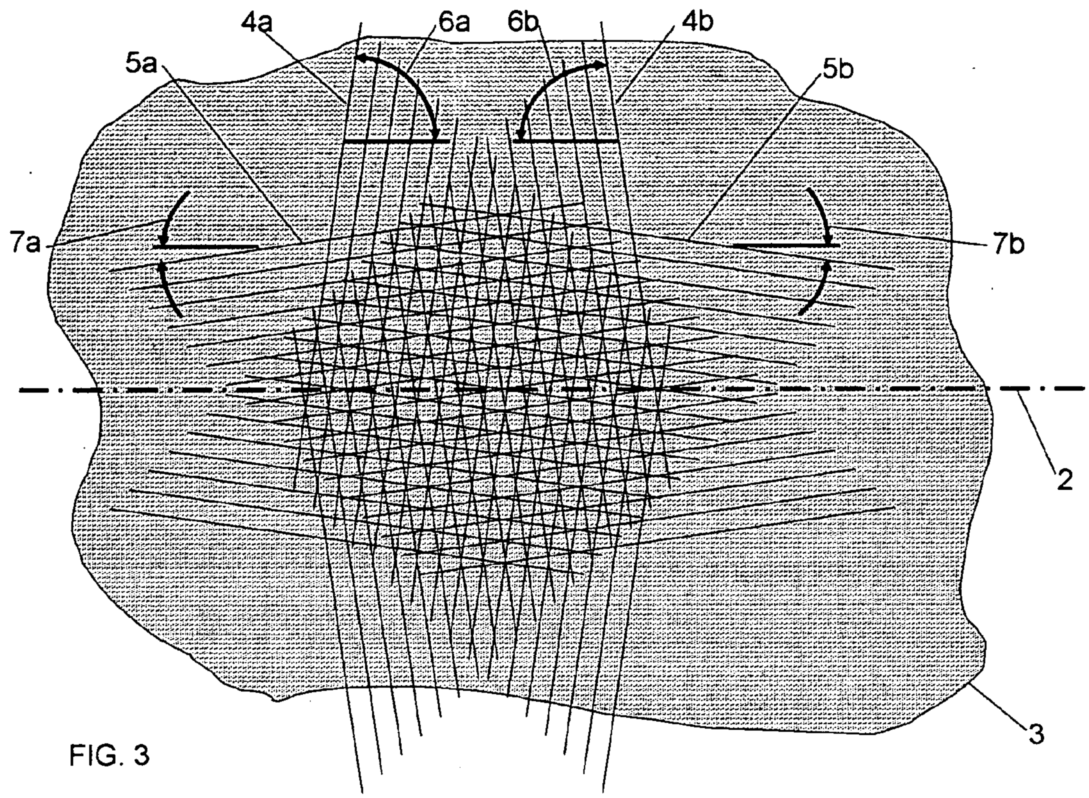


FIG. 3

DUAL-BIAS AIRBEAM

BACKGROUND OF THE INVENTION

[0001] The present invention is a braided airbeam intended to support a load. The otherwise collapsible airbeam structure derives its stiffness and strength from inflation by a gas under pressure and fiber reinforcement. Airbeams are tubular, having a circular cross-section, and may either be straight or manufactured with a shape, such as an arch. Arch-form airbeams are commonly used to support temporary or transportable shelters (tents).

[0002] Airbeams usually comprise an inner layer of flexible material that prevents leakage of the inflation gas. An outer layer of reinforcing fiber provides strength against burst and adds strength and stiffness in bending. Coated fabrics are also known.

[0003] Braided and woven designs of fiber are used for reinforcement, seamed or seamless. Braided reinforcement is always seamless with added axial fibers (parallel to the tube centerline) to provide bending strength and stiffness. Brown and Sharpless describe ways of including axial fibers in airbeam reinforcement design that are suitable for straight or curved airbeams (U.S. Pat. Nos. 5,421,128 and 5,735,083).

[0004] Braided airbeams have superior structural properties compared to woven airbeams, at least in part because a design with three fiber orientations instead of two as in woven types, has superior bending and shear strength and stiffness, and is more efficient at converting the tensile properties of the yarn used for reinforcement into high inflation pressure capability.

[0005] This invention has many of the advantages of previous braided airbeam designs, but can be manufactured at lower cost. This invention enables the manufacture of airbeams of almost any desired shape, including three-dimensional curved shapes that do not lie in a single plain. This invention provides a type of airbeam that is robust and damage tolerant by virtue of the multiple layers of high strength reinforcement.

SUMMARY OF THE INVENTION

[0006] The dual-bias airbeam has three functional layers. The inner two layers are the same as other braided airbeams: a flexible gas barrier and a braided reinforcing layer with a bias angle greater than 54.7 degrees. A third layer, also of braided yarn, is over the first braided layer and has a bias angle less than 54.7 degrees. With the two layers of braid slipped over one another, i.e., not interwoven during the manufacturing process, the airbeam can be bent into almost any desired shape. After the two layers are bonded to one another, the inflated airbeam becomes stiff in response to bending and/or shear loads. The outer layer with low bias angle performs much the same function as tri-axial fibers or bonded straps in other braided airbeams.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** shows a dual-bias airbeam with ends omitted to illustrate the elements of the cylindrical structure.

[0008] FIG. **2** is a cross-section view.

[0009] FIG. **3** is a partial side view in which each layer is cut and laid flat for illustration.

DETAILED DESCRIPTION

[0010] In FIG. **1** the cylinder is defined by its centerline **2**. The gas retention liner **3** lies inside the reinforcing fiber layers that are further illustrated in FIG. **2**, a section view in which the low-bias braid layer **4** is immediately over the liner **3**, the high bias braid layer being on the outside. Adhesive (not shown) is used to bind the three layers **3**, **4** and **5** together once the structure is complete as illustrated.

[0011] In FIG. **3** the centerline **2** is projected onto the view and is used as a reference for the bias angles **6***a*, **6***b*, **7***a* and **7***b*. The high-bias braid layer comprises fibers that are parallel to fiber **4***a* and interlaced with another set of fibers parallel to **4***b*. Fibers **4***a* and **4***b* are oriented with bias angles **6***a* and **6***b* respectively with **6***a* and **6***b* being equal and opposite angles, each greater than 54.7 degrees. The low-bias braid angle comprises fibers that are parallel to fiber **5***a* and are interlaced with another set of fibers parallel to **5***b*. Fibers **5***a* and **5***b* are oriented with bias angles **7***a* and **7***b* respectively, with **7***a* and **7***b* being equal and opposite angles, each less than 54.7 degrees.

[0012] The structure is stable dimensionally when inflated only when one layer has a high bias angle greater than 54.7 degrees and the other has a low bias angle less than 54.7 degrees. The choice of bias angles in the design of an inflatable structure determines the tension in each layer due to inflation pressure and to external loads, as well as determining the structural characteristics, e.g., bending stiffness of the pressurized inflatable structure.

[0013] The order of layers is described above in the preferred embodiment, although the airbeams of this invention can have the functional layers in any order. For example, the low bias angle layer **4** can reside inside the high bias angle layer **5**. Means for retaining the gas with other than the layer of elastic film **3** are available. One example is with coatings that fill the spaces between the fiber layers.

[0014] This invention also pertains to curved beams as well as straight. The beams are simply urged into the desired curved shape prior to the application of adhesive coating that binds the layers of fibers **4** and **5** together. Curvature involves a slight variation in bias angles **6***a*, **6***b*, **7***a* and **7***b*, compared to the straight preform, before curving.

[0015] Tapered, inflatable beams are a variation of this invention. The bias angles **6***a*, **6***b*, **7***a*, and **7***b* will vary as the diameter tapers if the braid is originally manufactured at constant diameter and bias angle. Tapered beams with constant bias angles **6***a*, **6***b*, **7***a*, and **7***b* can also be produced.

We claim:

1. An inflatable structure having tubular form, comprising:

a gas barrier layer, an inner fiber layer and an outer fiber layer, said gas barrier layer being a closed, gas-tight envelope constructed using flexible material and including valve means for introducing and removing inflation gas; said inner fiber layer having a tubular braided form with a bias angle measured from a reference line lying parallel to the centerline of the tubular form of greater than 54.7 degrees; said outer fiber layer having a tubular form with a braided bias angle measured from a reference line lying parallel to the centerline of the tubular form of less than 54.7 degrees, said inner fiber layer and said outer fiber layer being adhesively bonded together.

2. The inflatable structure of claim 1 in which said inner fiber layer has a bias angle of less than 54.7 degrees and said outer fiber layer has a bias angle greater than 54.7 degrees.

3. The inflatable structure of claim 1 with a curved shape.

4. The inflatable structure of claim 1 with a tapered shape.

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