Dec. 2, 1969 J. C. BELL 3,481,569

EXTENDABLE CONTOURED STRUCTURE

Filed May 16, 1968

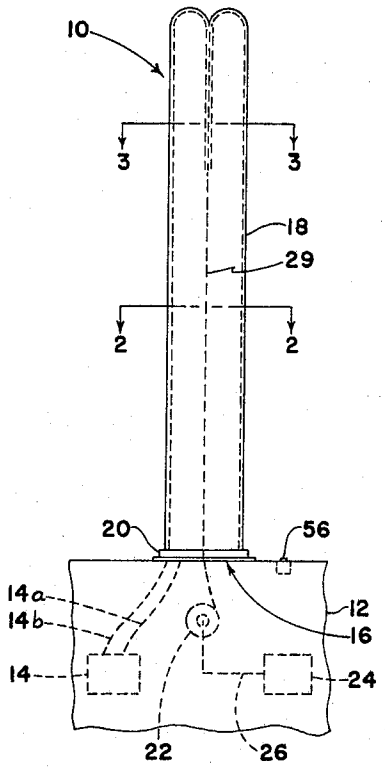


FIG.-1

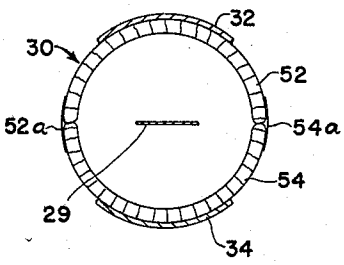


FIG.-2

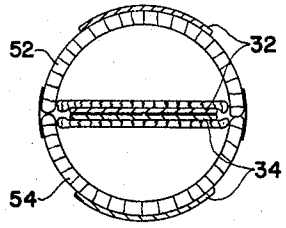


FIG.-3

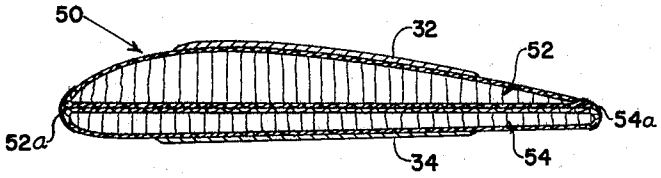


FIG.-4

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EXTENDABLE CONTOURED STRUCTURE

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U.S. Cl. 244—123 10 Claims

ABSTRACT OF THE DISCLOSURE

A structure capable of being erected, operated, retracted, and repacked for vehicular mounting. The concept in its preferred mode achieves deployment by inflation in the configuration of a fluid tight envelope shaped like a mast which is rigidized by adding stiffening reinforcing side panels in opposed relationship on opposite sides of the inflated envelope. The mast is made from contoured dual wall thread connected inflatable fabric, which when inflated forms a complex shape such as an airfoil. The structure extends substantially perpendicular from and retracts into a support base as the mast is inflated or deflated. The mast is pulled in from its outer end when the airfoil shape is deflated and wrapped around a carrying drum.

This invention represents an improvement over my prior patent application Ser. No. 592,497, filed Nov. 7, 1966, entitled "Inflatable Device For Antenna, Support and Lifting" which relates to an inflated mast or antenna. Particularly, improvement resides in being able to stiffen the device to withstand higher wind loading conditions, and provide a variable contour to an airfoil shape by using thread connected inflatable fabric.

Therefore, the general object of the invention is to provide an airfoil, normally inflated, which will be inexpensive to manufacture, highly reliable in operation, and yet represent a distinct improvement in the art by having greater stiffness in use, and hence greater reliability and longer life.

The object of the invention, as well as other objects, are achieved by providing an extendable airfoil which comprises a flexible fluid tight envelope with the walls thereof made from dual wall inflatable fabric, fuselage means with the base of said envelope secured to said fuselage, a pressure relief valve in the fuselage, means for introducing fluid pressure into said envelope to pressurize and extend said envelope, a reel rotatably mounted in said fuselage, drive means for said reel, band means, one end thereof attached to said reel, the other end thereof attached to the apex of the envelope so that said band means extends inside the structure the full length thereof when said envelope is fully inflated, but wherein when the reel is driven to wind in said band means, the apex of said envelope is pulled inside the outer periphery thereof forcing the excess fluid out of the pressure relief valve until substantially the entire envelope and band means are wrapped around said reel, and means to introduce fluid pressure into the walls of the envelope when inflated to pressurize the walls to define an airfoil shape.

For a better understanding of the invention, reference should be had to the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a preferred embodiment of the invention in a partially erected condition;

FIG. 2 is an enlarged cross-sectional view of the mast taken on line 2—2 of FIG. 1;

FIG. 3 is an enlarged cross-sectional view of the mast taken on line 3—3 of FIG. 1; and

FIG. 4 is an enlarged, cross-sectional illustration of the embodiment of FIGS. 1 to 3 with the dual wall thread connected inflatable fabric in an inflated condition to achieve an airfoil shape.

With reference to the form of the invention illustrated in FIG. 1 of the drawings, the numeral **10** indicates generally a mast or other protrusion which extends in an inflatable condition from a carrying structure **12**. The structure **12** in the embodiment illustrated is part of an aircraft fuselage, is fluid-tight, and incorporates an air compressor **14** or the like to achieve inflation through the open top **16** to which the mast indicated generally by numeral **18** is mounted as by clamps **20**. The exact details of the construction for inflating are much more clearly shown in my prior patent application Ser. No. 592,497 mentioned above. The mast **18** in the retracted condition is wrapped around a receiving shaft or drum **22** rotatably carried by base **12** and rotatably driven by a suitable motor **24** connected through appropriate mechanical connection as shown by dotted line **26**. The mast **18** has the end thereof indicated at dotted portion **28** connected through a retrieving band indicated by dotted line **29** to the shaft **22** to thus control erection and collapse of the mast, all in the manner shown in my prior application. The actual erecting mechanism, collapsing mechanism, and structure of base support **12** are not important to the fundamentals of the instant invention. The mast **18** is actually made from a dual wall thread connected inflatable fabric known as "Airmat" as made by Goodyear Aerospace Corporation, Akron, Ohio. Inflation of the "airmat" to provide a contoured configuration takes place after the mast is erected by means of internal inflation. The erecting inflation from compressor **14** is indicated by dotted line **14***a*, while the "airmat" inflation from compressor **14** is indicated by dotted line **14***b*.

FIG. 2 illustrates the structure of the mast itself which essentially comprises a flexible and fluid impervious envelope indicated generally by numeral **30** which actually represents the skins of the "airmat," and which normally will be made from some type of impregnated cloth. A feature of the invention is achieved by mounting strengthening ribs or stiffeners **32** and **34** on the outer skin of envelope **30** in opposed relationship thereof. FIG. 2 also illustrates the retrieval band **29** showing its position centrally of the inflated envelope **30**. The exact structural properties of stiffeners **32** and **34** will be described in more detail hereinafter.

FIG. 3 illustrates the non-completely deployed portion of the mast **18**, and particularly shows how the stiffeners **32** and **34** have been bent back on themselves in the retracted position which causes them to tend to flatten, as illustrated, so they can easily wrap around drum **22**.

The stiffeners are usually thin sheets of metal or high strength plastic films whose thicknesses are large enough for compressive stability but thin enough to be packaged into a relatively small volume and which will bend flat, but with resilience. The actual crippling stresses or collapsing loads can be computed to determine what arcuate length and thickness should be utilized. The reinforcing webs or stiffeners **32** and **34** are normally cemented to the envelope **30**, and preferably are preformed so that in their natural, unstrained shape will be of substantially circular cross-section. However, it should be understood, that a flat stiffener which can be bent towards the circular shape by the inflated characteristic of the "airmat" would also meet the objects of the invention.

The essence of the invention is achieved by use of contoured inflatable "airmat." As stated above, once the mast has been deployed, the fabric itself is inflated to provide the contoured airfoil configuration illustrated in FIG. 4 and indicated generally by numeral **50**. It should be noted

that the envelope **30** is comprised of two separate "airmat" sections **52** and **54** which are connected together at their ends by short splicing segments **52***a* and **54***a*, respectively. The sections **52** and **54** are formed with variable length drop threads connecting the walls thereof so that when inflated to their designed pressure they assure a contour which in combination takes an airfoil shape with the inner wall of each section in abutment to provide reinforcement. The contour is defined by the length of the drop yarns, and is preferably of a contour such that stiffeners **32** and **34** are under stress so as to further rigidize the structure. The retrieval band **29** will lie directly between the abutting inner walls of sections **52** and **54**. The splicing segments **52***a* and **54***a* are stretched taut to provide the leading and trailing edges respectively to the airfoil **50**. Upon pressurization of the sections **52** and **54** a relief valve **56** in the fuselage allows all air within the envelope to be expelled.

The stiffness capability of the inflated structure is dependent upon the pressurization of the envelope and the thickness of the airfoil at its widest portion. Quite obviously, the moment capability of the combination structure can be increased by inflating the envelope to the maximum pressure. When the structure is pressurized, it acts like a beam whose moments of inertia can be quite readily figured both in the direction normal to the stiffeners and in the direction substantially between the stiffeners. For example, if bending is applied about an axis between the stiffeners, the stiffeners carry both the shear and bending stresses. On the other hand, if this bending is applied normal to the stiffeners, the moment is carried by the stiffeners and the shear is carried by the fabric or envelope portions in diagonal tension as in a Wagner beam. A complete mathematical analyzation of the particular loading characteristics compared with the necessary length requirements is necessary to determine the dimensional relationships in each case. However, as a general guide line, the invention contemplates utilizing a sheet metal of some type of spring steel, for example, as the stiffener which will have thickness of between 0.003 inch to about 0.030 inch. Pressurization will be dictated by the structural requirements and materials used, but will normally fall within the range of between 1 to about 100 p.s.i.

Naturall, as in most airfoil designs, there should be a tapered relation of the sections **52** and **54** with a larger cross-section at the base and a smaller cross-section at the tip, and consequently the stiffeners **32** and **34** will also be tapered. The tapering also helps to eliminate frequency induction for a constant wind velocity into the airfoil during use.

Thus it is seen that the mechanical configuration of the airfoil lends itself to be in the form of a fabric cylinder for deployment with reinforcing skins of steel around the outside and "airmat" to obtain an airfoil design. Naturally, the reinforcing skins could be of some plastic material or otherwise reinforced resin impregnated fabric. The reinforcement by the opposed side members in combination with a pressure rigidized envelope enhances the stability of the airfoil.

While the description hereinabove has been limited to describing an airfoil configuration to the invention, it is to be understood that the invention is not limited thereto or thereby, but that the invention is applicable to any contoured shape for any use, structural or otherwise. Hence, for example, a square beam, a streamlined aerodynamic antenna, a cylindrical supporting post, etc., are well contemplated to be within the scope of the invention.

What is claimed is:

1. An extendable contoured structure which comprises
a flexible fluid-tight envelope with the walls thereof made from dual wall inflatable fabric,
base means secured to said fluid tight envelope,
a pressure relief valve to relieve pressure from the envelope,

means for introducing fluid pressure into said envelope to pressurize and extend said envelope,
a reel rotatably mounted in said base,
drive means for said reel,
band means, one end thereof attached to said reel, the other end thereof attached to the apex of the envelope so that said band means extends inside the envelope the full length thereof when said envelope is fully inflated, but wherein when the reel is driven to wind in said band means, the apex of said envelope is pulled inside the outer periphery thereof forcing the excess fluid out the pressure relief valve until substantially the entire envelope and band means are wrapped around said reel, and
means to introduce fluid pressure into the walls of the envelope when inflated to pressurize the walls to a predetermined shape.

2. A structure according to claim **1** which includes variable length connector means to control the spacing between the dual walls of the fabric when inflated, and which means are adjusted in length to provide the fabric with an aerodynamic configuration.

3. A structure according to claim **1** where the envelope is divided into two sections of dual wall inflatable fabric, where one section is contoured to have its outer surface provide the top of an airfoil configuration, and where the outer side of the other section is contoured to have its outer surface provide the bottom of an airfoil configuration and splicing segments connecting the ends of the sections to provide the leading and trailing edges of the airfoil.

4. A structure according to claim **3** which includes sheet metal stiffeners affixed to the outer surfaces of each section extending substantially the full length thereof to provide strength and rigidity to the airfoil configuration.

5. A structure according to claim **4** where the stiffeners are preformed to a curved shape, but are bendable, and conform to the airfoil shape of the inflated sections under stress, and which stiffeners are between 0.005 to 0.030 inch in thickness.

6. A structure according to claim **5** where the inner surfaces of the sections abut and reinforce each other when the sections are inflated.

7. An extendable air foil which comprises
a pair of sections of contoured dual wall thread connected inflatable fabric wherein the length of the threads is varied to provide the top surface configuration of an airfoil to one section, and the bottom surface of an airfoil to the other section, splicing segments connecting the adjacent edges of the sections to provide leading and trailing edges respectively, means to inflate the sections, a fuselage with one end of both sections connected to the fuselage, and means connecting to the inside of the other ends of the sections to pull such ends toward the fuselage collapsing the sections into an inverted relationship to retract the airfoil, and means to release the fluid pressure on the sections upon the collapse thereof.

8. An airfoil according to claim **7** where the inner surfaces of each section are in reinforcing abutment when the sections are inflated.

9. An airfoil according to claim **8** which includes sheet stiffeners adhered to the outer surfaces of each section and extending longitudinally thereof to provide strength and rigidity to the airfoil.

10. An extendable structure comprising
a fluid tight envelope with walls thereof made from dual wall inflatable fabric,
a base secured to said envelope,
a reel rotatably mounted in said base,
band means located inside the envelope and attached at one end to the apex of the envelope and at the other end to the reel,

means to pressurize said envelope to extend it to its limit and also to selectively pressurize said dual wall fabric to rigidize said envelope,

pressure relief means to relieve pressure from said envelope and said fabric,

means to drive said reel to wind up the band wherein the envelope is pulled inside itself until substantially the entire envelope and band means are wrapped on said reel, and

preformed thin sheet stiffeners affixed to the outer surface of the envelope substantially the full length thereof to provide strength and rigidity to the structure.

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U.S. Cl. X.R.

52—115; 343—915