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(71) Applicant (*for all designated States except US*): **GAASTRA KITEBOARDING INTERNATIONAL LTD.** [CN/CN]; Unit E-4, 10/F.,, Block E, Wah Lok Ind. Center, 31-35 Shan Met St, Fo Tan, Shatin, No. T, Hong Kong (CN).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **ROESELER, Corydon, C.** [US/US]; 1751 Markham Road, Hood River, OR 97031 (US). **RIBKOFF, Mark, Adam** [CA/US]; 5285 York Hill Drive, Hood River, OR 97031 (US).

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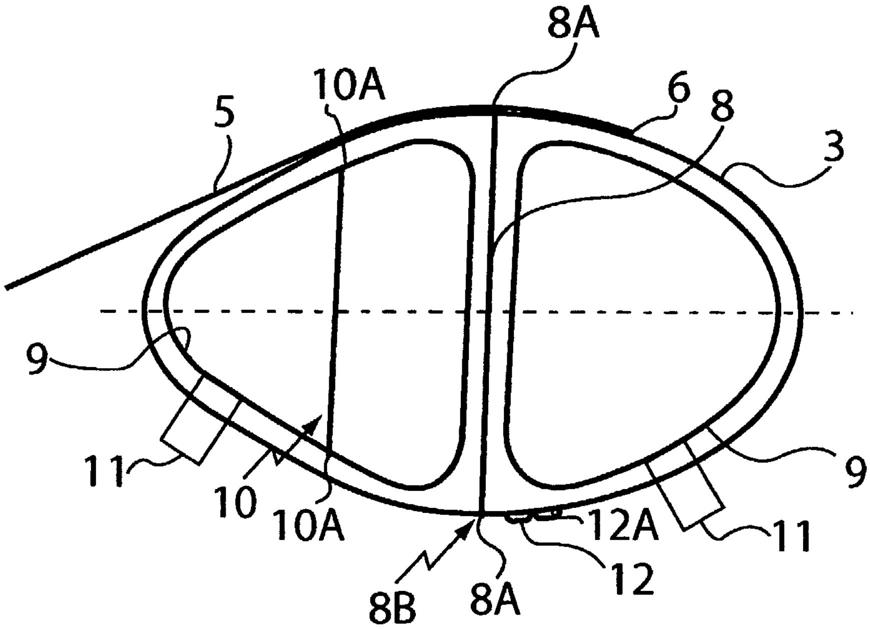
(54) Title: WING STRUCTURE



(57) Abstract: The invention relates to a wing structure comprising a single lifting skin (5) and an inflatable elongated spar (3) located at the leading edge thereof. According to the invention, the inflatable spar has a substantially oval, elliptic or teardrop shaped cross-section, the lifting skin being substantially secured to an upper surface of the spar (3) at a point near a minor axis of the spar. The cross-section shape is defined by at least one resilient internal web (8) or rib (13) substantially parallel to the minor axis, which is provided within the inflatable spar (3).

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A Wing Structure

FIELD OF THE INVENTION

The present invention relates to a wing structure having inflatable or inflated leading edge spars.

BACKGROUND OF THE INVENTION

Existing 'Tube kite' structures (i.e. inflated spars and battens) have a generally cylindrical shape when inflated and flown. These single-surfaced kites have a spar attached to their leading edge for span-wise support. Such spars are circular in cross-section and are oriented across the airflow. US-A-4 708 078 discloses an example of such an inflatable armature.

The cylindrical shape of the inflatable spar presents relatively large obstacles around which air must pass, resulting in a relatively high drag coefficient.

Furthermore, internal air pressure must be maintained at a sufficiently high level in the spar or tube kite, even under bending and compression loads, in order to prevent kinks from forming in the soft fabric envelope, which is not well suited for compression loads.

US-A-4 363 458 discloses a wing for kitesurf having two skins teardrop shaped in cross-section. This provides a ram air fillable structure requiring a rigid leading edge spar made of glass or carbon fibers.

US-A-3 412 963 discloses a parachute having a semi-rigid leading edge. Fgs 7-9 thereof show a two skin wing more or less in shape of a teardrop in cross-section of controllable volume without releasing gas.

SUMMARY OF THE INVENTION

Embodiments of the present invention are intended to provide strong inflatable wing structures with relatively low drag coefficient.

The invention relates to a wing structure comprising a single lifting skin and an inflatable elongated spar located at the leading edge thereof.

According to this invention, the inflatable spar has a substantially oval, elliptic or teardrop shaped cross-section, the lifting skin being substantially secured to an upper surface of the inflatable spar at a point near a minor axis of the spar. The cross-section shape is defined by at least one resilient internal web or rib substantially parallel to the minor axis, the at least one web or rib being provided within the inflatable spar.

Preferably, the at least one internal web or rib forms two or more compartments within the elongated spar.

Advantageously, the inflatable spar is constructed of gas impermeable fabric, such as vinyl, polyurethane , PVC and the combinations thereof.

At least one inflation port is connected to a compartment of the inflatable spar.

The pressure of the compressed gas inside said inflatable spar exceeds about 2 psi (1.1 x 10^5 Pascals).

The elongated spar may include one or more bladders formed of gas impermeable fabric.

Advantageously, the wing structure of the invention further includes external stiffening members fixed to an external surface of the spar. These external stiffening members include monofilament cord, tape and/or battens.

A direction of fibre weave forming the web may usefully be oriented at around 45 degrees to seams in the wing structure.

The wing structure of the invention may form a kite, one or more tethers being connected to each opposite end of the wing structure.

While the invention has been fastly described above, it extends to any inventive combination of the features set out above or in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood, and other objects, advantages and features thereof will become more obvious on reading the following disclosure of preferred embodiments given in a non limitative way and to which is joined a set of drawings in which :

Figure 1 is a perspective view of the wing structure of a typical traction kite ;

Figure 2 is a cross section of a single surface kite according to a first embodiment of the present invention;

Figure 3 is a perspective view of a wing structure for a kite according to a second embodiment of the invention ;

Figure 4 is a front view of another embodiment of the wing structure ;

Figures 5a and 5b illustrate diagrammatically airflow around a conventional cylindrical wing structure (Fg. 5a) and a wing structure according to an embodiment of the present invention (Fg. 5b) ;

Figure 6 is a cross section view of a single surface kite according to a further embodiment of the present invention having a generally elliptical shape ;

Figure 7 shows an ellipse for understanding of the structure of Figure 6 ;

Figure 8 is a cross-section view of another embodiment of the invention :

Figure 9 is an elevation view of the embodiment of Figure 8 ; and

Figure 10 diagrammatically shows, in cross-section, another embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring first to Figure 1, a flying wing structure is generally comprised of a spar 3 positioned along the leading edge of a sail 5. The inflatable spar 1 is secured to the sail 5 by means such as gluing or stitching. The spar 3 comprises an outer fabric envelope 3 with seam shaping to achieve the desired parabolic or arc of a circle wing profile as shown in Figure 1. Battens 4 (possibly also inflatable) provide lateral support for the sail 5. In the case of a traction kite, tether connections 7 may be connected to the wingtips, along the spar 3 or elsewhere on the wing. When tether connections 7 are located only at the wingtips, substantial bending loads are applied to the spar 3 due to dynamic pressure applied to the sail 5. Extreme loads may lead to buckling of the inflated spar structure, unless the spar is supported by stiffening means, e.g. shear webs, stiffening ribs, or a rigid batten housed in a pocket and sewn into the leading edge of the inflatable spar.

Referring to Figure 2, a wing structure according to a first embodiment of the present invention comprises an inflatable spar 3 at the leading edge of the structure, in the form of an elongate envelope having a generally oval, elliptic or teardrop shaped cross-section, having a minor and a major axis. Glue or stitching attaches the spar 3 to the leading edge of the lifting skin 5. The skin 5 is substantially secured to an upper surface of the spar 3 at a point 6 located near a minor axis of the spar, or forward this point, i.e. between the minor axis of the spar and the leading edge thereof.

A fabric web 8 is secured within the spar 3 by means of glue or stitching 8A. The web 8 extends from the bottom to the top of the inner surfaces near the middle of the width of the spar 3. The lower end of the web 8 is attached to a seam 8B of the envelope. The web 8 helps to form the shaped cross section of the spar and can also provide internal stiffening as sheer forces may be transmitted between the top and the bottom of the spar.

The inflatable spar 3 can either be formed from a gas impermeable fabric, such as vinyl, polyurethane, PVC or equivalent, and combinations thereof. As shown in the embodiment of Figure 2, the spar 3 may contain internal impermeable lining layers, such as polyurethane bladders 9. Generally, the bladder 9 relies on the spar 3 for its structure and the spar 3 relies on the bladder 9 to keep the compressed gas (typically air or helium) from leaking out.

Inflation ports 11 are strategically located along the spar 3, so that inflation and deflation thereof can be carried out as efficiently as possible. Preferably, the pressure of the compressed gas is higher than about 2 psi (about 1.1×10^5 Pascals).

A plurality of webs 8 may compartmentalize the spar 3 as desired, in which case multiple bladders may be needed. In Figure 2, two bladders 9 are shown, one near the leading edge of the wing structure and one near its trailing edge. A separate inflation port 11 is provided for each compartment.

All or some of the compartments may contain bladder webs 10 as an alternative or additional technique for achieving the desired cross-sectional shape of the spar 3. In Figure 2, one of the compartments is shown as having a web 10 extending from the bottom and top around halfway across its width. The bladder webs 10 are attached to the inner surface of the compartment by means of gluing or heat-sealing 10A.

Holes may be present in the bladder webs 10 so as not to generate impermeable compartments. It will be appreciated by those skilled in the art that combinations of fabric webs 8 and bladder webs 10 can be selected so that the spar can be formed according to virtually any desired shape, weight and/or manufacturing cost.

For additional stiffness under extreme bending loads, external stiffeners 12 formed of monofilament cord or tape may be sewn into the exterior of the envelope of the spar 3. One or more cords 12 extend along the length of the spar 3 and a fabric cover 12A is sewn over the cords. The stiffeners 12 can also reduce the possibility of kinks forming on the compression side of a highly loaded wing structure, such as in the case of a water-borne traction kite that has landed in the water.

The external stiffeners 12 can also help to keep the wing structure from folding in half.

Turning to Figure 3, there is shown an embodiment where a spar 30 has a generally teardrop shaped cross section. The wing is formed of a sail fixed to a single large elongate spar 30 that includes multiple teardrop shaped fabric ribs 13. Ribs are located at seam lines, and the teardrop shape is controlled at these joints between segments of the envelope. Each rib has a substantially teardrop shape and helps maintain the overall shape of the envelope.

Battens are found on many flying wing structures and in the case of water-borne traction kites, they are commonly constructed from the same material as the envelope 3. If the battens are inflated tubes they may be strategically mated to one or more spar compartments, so that a user may inflate multiple compartments through a single inflation port 11. Short lengths of hose 14 as shown in Figure 4 may be used to achieve this.

As illustrated by the arrows in Figures 5, there is less turbulence behind a wing structure 50 that has a spar of generally oval cross-section (Figure 5b) than a wing 52 that has a spar of conventional circular cross-section (Figure 5a), there being substantially less drag on the streamlined shape of the oval wing structure 50.

The spar 3 of the embodiment shown in Figure 6 has a generally elliptical or oval cross-section shape, rather than a teardrop shape. The dimensions of the ellipse shape used are best explained with reference to Figure 7, where the ratio of the radii X/Y is 1.2. In the embodiment of Figure 6, the elliptical envelope of the spar 3 is oriented so that, in use, the major axis of the ellipse runs parallel to the airflow at the leading edge of the wing structure. The web 8 extends from a new seam location 8C on the minor axis vertex on the lower surface of the spar 3 to the diametrically opposed vertex 8D on the upper inner surface. The width of the web 8 controls the major axis dimension at around 57 % of the width of the corresponding envelope panel 3. As shown schematically at 71 in Figure 7, the direction of the fibre weave of the web 8 is at around 45° to the direction of the seams 8B, 8C so that shear loads will most effectively be transmitted from the top surface to the bottom surface, or vice versa.

The lifting skin 5 is connected to the point 8D (i.e. on the minor axis vertex) on the outer surface of the spar 3.

The two bladders 9 extend from one tip of the envelope to the other. However, the bladder panels are about 78 % of the width of the corresponding spar panels, because one half of the perimeter of each compartment has an arc-length equal to 78 % of the corresponding panel width.

With reference to the embodiment of Figures 8 and 9, the web 8 may limit the width of the spar 3 at the minor axis thereof. In such a case, a local depression occurs at the lower surface of the spar 3, which becomes slightly concave in the minor axis vertex area. This results in an aerodynamic imperfection. In order to prevent such an imperfection, a fairing strip 20 is provided in front of this concave surface. Obviously, drain holes 22 are provided through the fairing strip 20.

While there has been shown and described what are at the present considered the preferred embodiments of the invention for decreasing the drag coefficient in wing structures, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

For instance, as diagrammatically shown in Figure 9, the inflatable spar 3 may be constructed by gluing or heat-sealing together tête-bêche two compartments 24, 24', each of half oval cross-section shape. In such a case, the web 8 is made of the two flat walls 26, 26' of the minor axis adhered together. Once more, an additional fairing strip (not shown in Figure 9) may reinforce the spar and prevent any local depressions.

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CLAIMS

1. A wing structure comprising a single lifting skin (5) and an inflatable elongated spar (3) located at the leading edge thereof, wherein said inflatable spar has a substantially oval, elliptic or teardrop shaped cross-section, the lifting skin being substantially secured to an upper surface of said spar (3) at a point near a minor axis of said spar, said cross-section shape being defined by at least one resilient internal web (8) or rib (13) substantially parallel to said minor axis, said at least one web (8) or rib (13) being provided within said inflatable spar (3).

2. A wing structure according to Claim 1, wherein said at least one internal web (8) or rib (13) forms at least two compartments within said elongated spar (3).

3. A wing structure according to Claim 1, wherein said inflatable spar (3) is constructed of gas impermeable fabric.

4. A wing structure according to claim 3, wherein said fabric is chosen among vinyl, polyurethane , PVC and the combinations thereof.

5. A wing structure according to Claim 1,

wherein said elongated spar (3) includes one or more bladders (9) formed of gas impermeable fabric.

6. A wing structure according to Claim 1, further including external stiffening members (12) fixed to an external surface of said spar (3).

7. A wing structure according to Claim 6, wherein said external stiffening members (12) include monofilament cord, tape and/or battens.

8. A wing structure according to Claim 1, wherein the narrow end of said spar (3) corresponds with the trailing edge or leading edge of the wing structure in use.

9. A wing structure according to Claim 1, further including at least one inflation port (11) connected to a compartment of said inflatable spar (3).

10. A wing structure according to claim 1, wherein a pressure of the compressed gas inside said inflatable spar exceeds about 2 psi (1.1×10^5 Pascals).

11. A wing structure according to Claim 1, wherein a direction (71) of fibre weave forming said web is oriented at around 45 degrees to seams (8B, 8C) in said wing structure.

12. A wing structure according to claim 1, wherein a fairing strip (20) is provided at the lower

surface of said spar (3) in the minor axis vertex area.

13. A wing structure according to claim 12, wherein draining holes (22) are provided through said fairing strip (20).

14. A wing structure according to Claim 1, wherein the wing structure forms a kite, one or more tethers (7) being connected to each opposite end of said wing structure.

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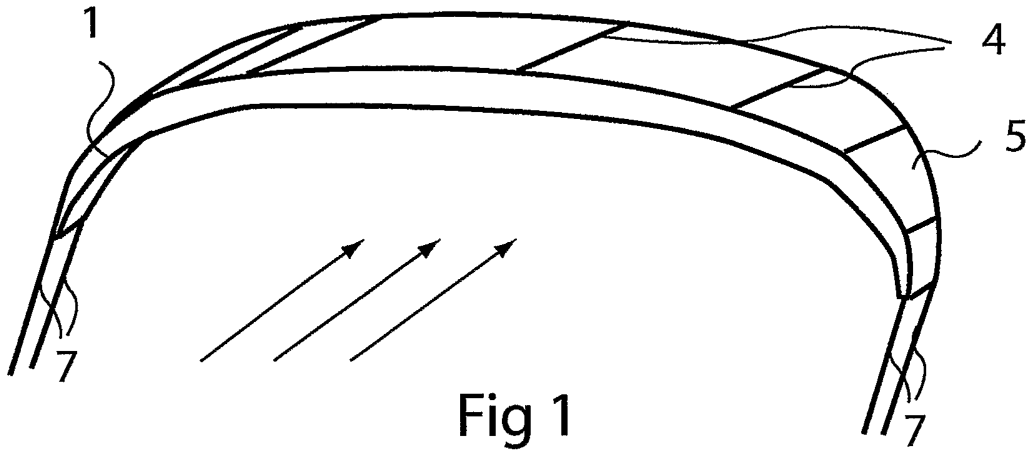

Fig 1

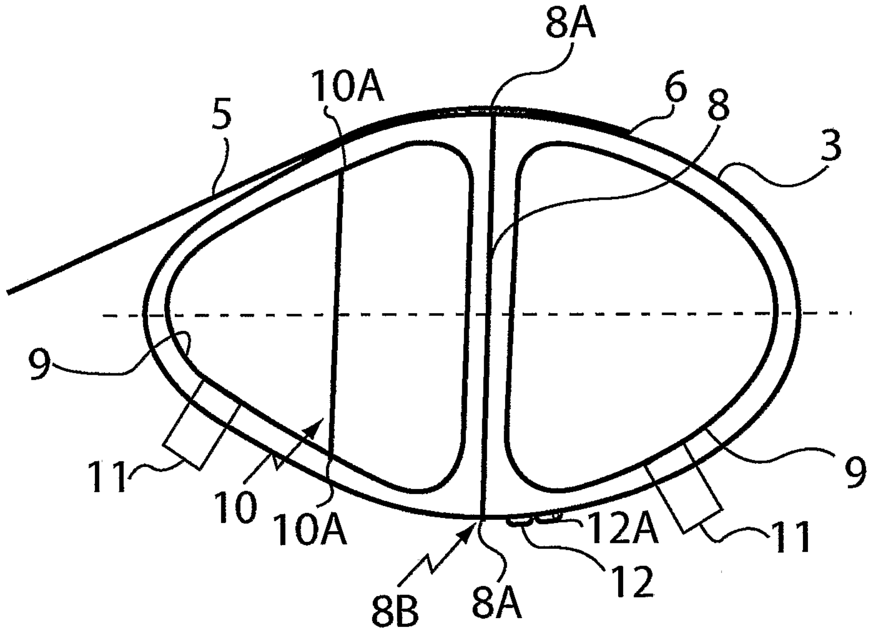

Fig 2

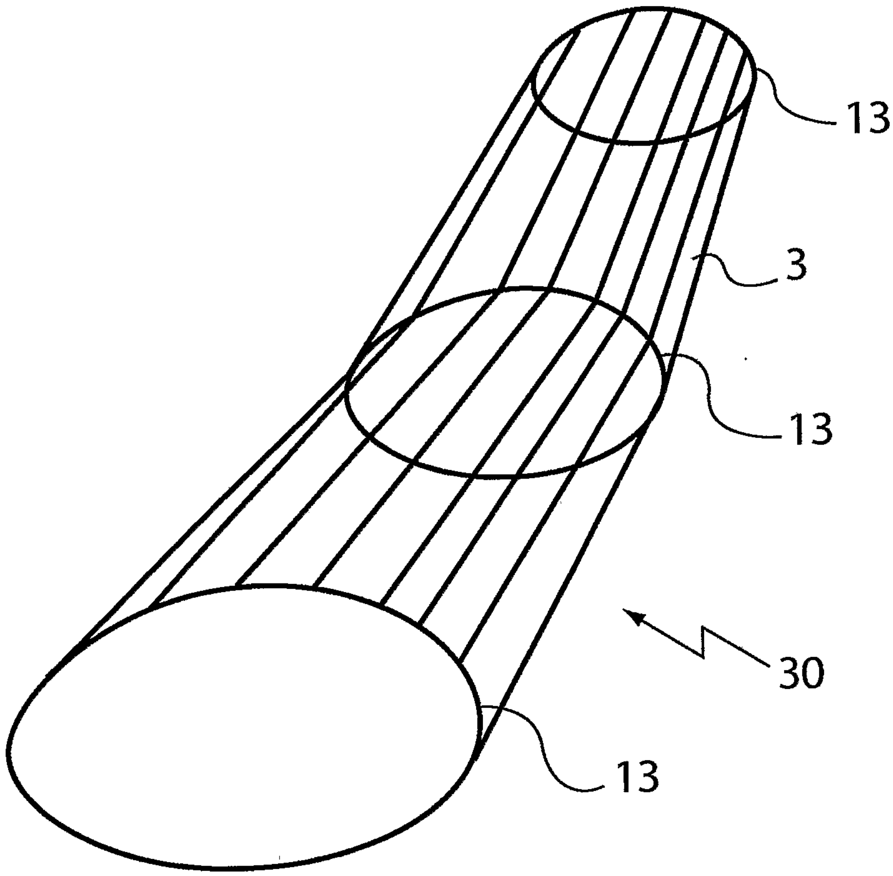

Fig 3

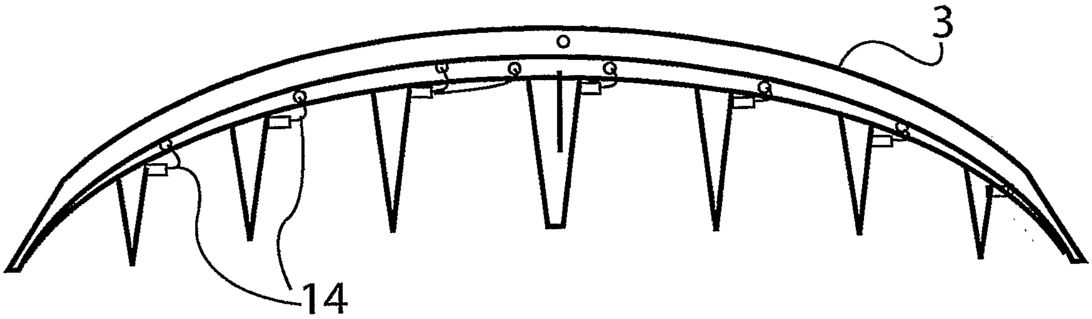

Fig 4

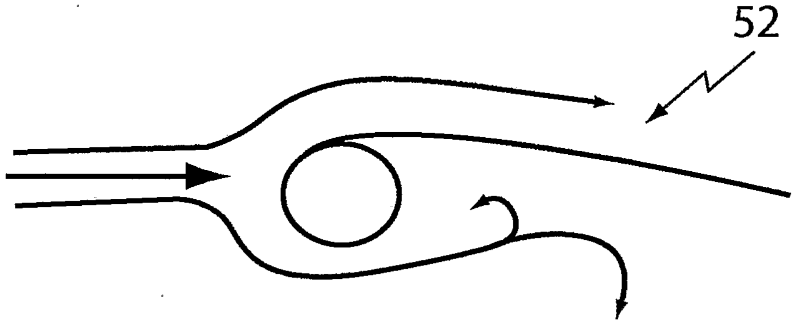

Fig 5a

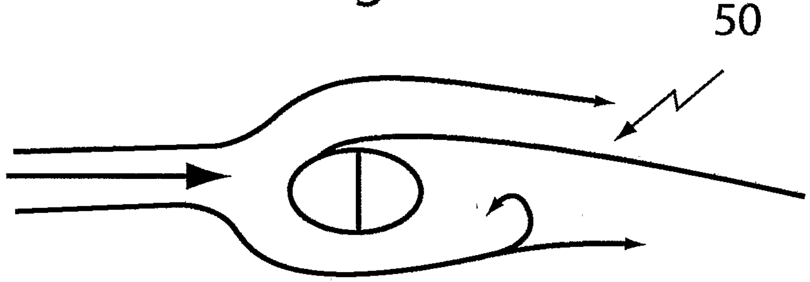

Fig 5b

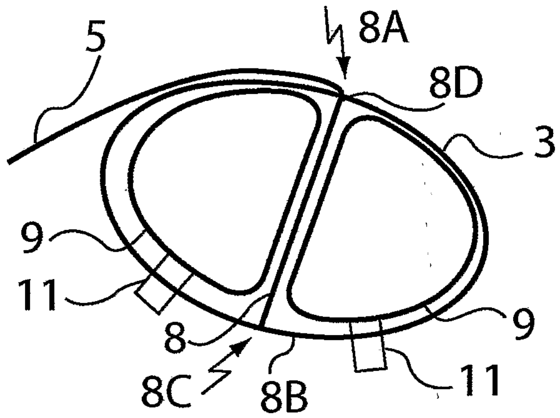

Fig 6

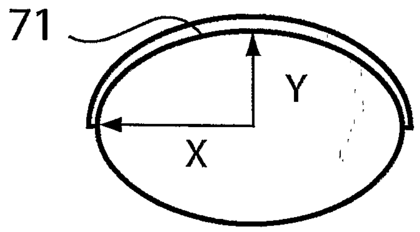

Fig 7

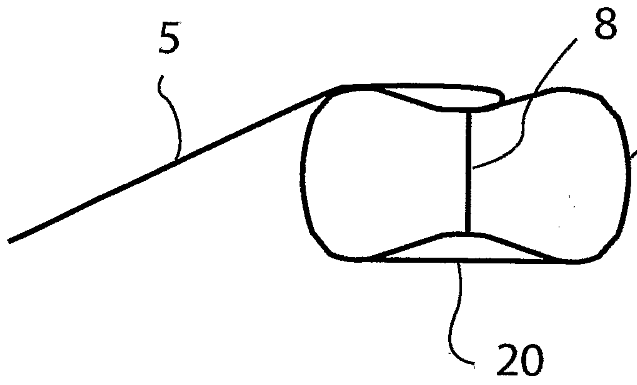

Fig 8

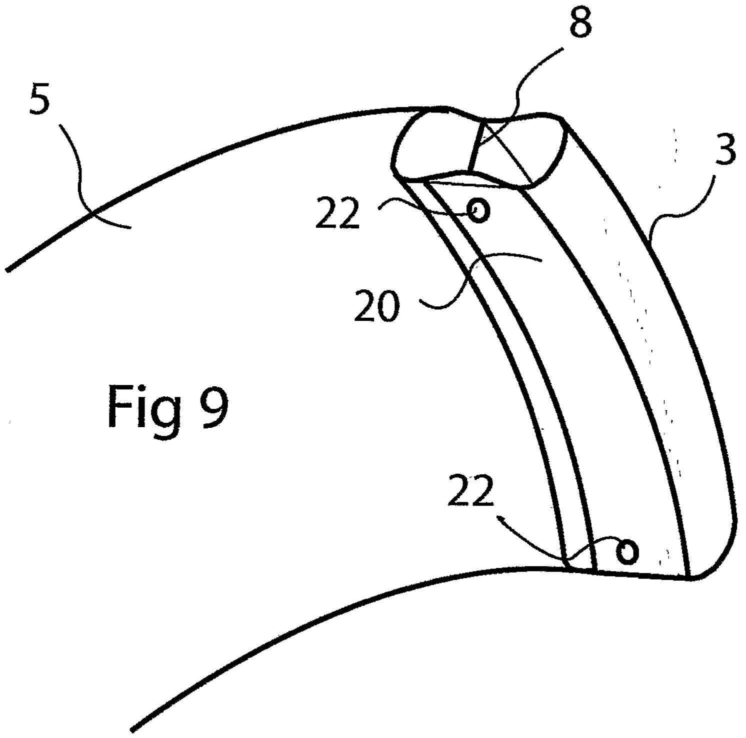

Fig 9

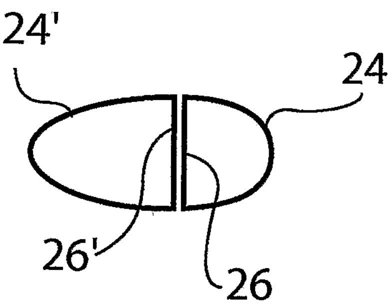

Fig 10