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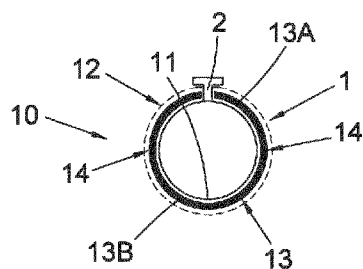


FIG. 4

(57) Abstract: An inflatable tube assembly (10) includes an inflatable tubular bladder (11) formed of flexible material, and at least one sheet (13) comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated.

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INFLATABLE TUBE ASSEMBLYTECHNICAL FIELD

The present invention relates to inflatable tube assembly
5 including an inflatable tubular bladder formed of flexible
material. The invention also relates to structures incorporating
such inflatable tube assemblies such as boats and marine
evacuation systems.

10 BACKGROUND TO THE INVENTION

Tubular inflatable structures are used in many applications to
support a load/force and it is beneficial if the degree of
longitudinal rigidity/stiffness is maintained. This is referred
to as Beam Strength. When a bending force is applied, the beam
15 will begin to bend. This is resisted by the supporting non
extensible material of the beam when it is under pressure. As
the pressure increases so the rigidity increases. However, the
amount of pressure the inflatable structure can withstand is
limited by the burst strength of the materials and seams.

20

Figures 1A and 1B show a known inflatable beam with limited Beam
Stiffness. When inflated the beam is generally straight in the
longitudinal direction, as shown in Figure 1A. When a force is
applied in the direction of arrow A the beam deforms so that it
25 is curved in the longitudinal direction.

Figure 2 shows a typical cross section of the beam along the
line X-X of Figure 1A. The inflation valve 2 and the tube wall
1 can be seen. The tube material may be a woven material
30 laminated with an air holding layer such as a polymer like PU.
Some such inflatable tubes used to support a load can also be
supported by being surrounded by a braid (e.g. as disclosed in
WO2018/078041) but such reinforcing braids are expensive and
even greater longitudinal rigidity would be desirable in some
35 applications.

SUMMARY OF THE INVENTION

In one aspect, the present invention provides an inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively
5 less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated.

The sheet may be semi-rigid. In some embodiments, the sheet is
10 generally planar in a rest (natural) state (i.e. when no force is applied to the sheet) but is resiliently deformable such that it follows the curvature of the surface of the bladder when the bladder is inflated due to forces applied to the sheet by the bladder. The curvature of the sheet around a longitudinal axis
15 of the bladder creates a structure that resists bending of the assembly in the longitudinal direction. However, when in the planar state, the sheet can be readily rolled or folded longitudinally, for easy transportation and storage.

20 In some embodiments the bladder and sheet lie generally flat when the bladder is uninflated.

In some embodiments the bladder and sheet are foldable when uninflated.

25 A plurality of the sheets may be provided. Adjacent ones of the sheets may be flexibly coupled together to facilitate folding of the sheets when the bladder is uninflated. The adjacent ones of the sheets may be coupled together by hinge means (or any
30 other form of suitable coupling). Alternatively, the sheet may include one or more lines along which the sheet is relatively highly flexible to facilitate folding of the sheet when the bladder is uninflated. These arrangements allow the assembly to lie flat when uninflated.

35 The sheet may be arranged along an internal surface of the bladder.

The sheet is arranged along an external surface of the bladder. Such an arrangement has an advantage that it may protect the bladder and reduce the likelihood a puncturing.

5

The present invention also provides a boat including at least one inflatable tube as defined above. At least one of a keel, main side tubes and a "speed tube" may comprises such an inflatable tube.

10

According to one embodiment of the invention a boat includes a deck; a central keel having an upper surface attached to the deck and a lower surface opposite the upper surface; and a hull comprising a flexible sheet of material having a central region attached to the central keel at the lower surface of the central keel, the sheet of material further having a first outer region attached to the deck at a first position spaced apart from the central keel and a second outer region attached to the deck at a second position spaced apart from the central keel, and on an opposite side of the central keel to the first outer region, such that the hull has a V shape. The central keel comprises an inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated. Two inflatable outer keels may be provided, one disposed to each side of the central keel, and each having an upper surface attached to the deck at a position spaced apart from the central keel, wherein the outer keels (28) each comprise an inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated. One of the outer keels may be attached to the deck at said first position and another of the outer

keels may be attached to the deck at said second position. The deck may comprise an inflatable drop-stitch panel. The boat may advantageously be readily folded when uninflated but rigid when inflated.

5

The present invention further provides a marine evacuation system including at least one inflatable tube as defined above. A slide supporting tube may comprise such an inflatable tube.

10 The inflatable tube may be used in many other applications where longitudinal rigidity is required, but also a compact form when the tube is deflated.

Embodiments of the invention relate to how an inflatable tube
15 can have increased Beam Strength by incorporating a "semi-rigid" sheet element (e.g. a plastic panel) into the structure.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention embodiments
20 will now be described by way of example, with reference to the accompanying drawings, in which:

Figures 1A and 1B show a side elevational view of a known inflatable beam;

25

Figure 2 is a cross-section taken along line X-X of figure 1A;

Figure 3 is a side elevational view of an inflatable tube assembly in accordance with an embodiment of the invention;

30

Figure 4 is a cross-section of Figure 3 taken along line X-X with the tube in an inflated state;

Figure 5 is a cross-section of Figure 3 taken along line X-X
35 with the tube in a deflated state;

Figure 6 is a transverse cross section of the tube of Figure 5

rolled up longitudinally;

Figure 7 is a cross-section of Figure 3 taken along line X-X with the tube in an inflated state in accordance with a second
5 embodiment of the invention;

Figure 8 is a cross-section of Figure 3 taken along line X-X with the tube in a deflated state in accordance with a second
10 embodiment of the invention;

Figures 9 and 10 show an example application of the inflatable tube assembly to increase the performance of a boat; and

Figures 11 and 12 show an example application of the inflatable
15 tube assembly to increase the performance of an escape slide.

In the drawings like elements are generally designated with the same reference signs.

20 DETAILED DESCRIPTION OF EMBODIMENT OF THE INVENTION

Figures 3 to 6 show an inflatable tube assembly 10 in accordance with an embodiment of the invention.

An inflation valve 2 and the tube wall 1 of the inflatable tube
25 assembly 10 can be seen. The inflation valve 2 allows fluid to be applied to the interior of the assembly 10 allow inflation. When inflated, the bladder may have a generally cylindrical shape.

30 Figure 4 is a cross-section of Figure 3 taken along line X-X. The tube assembly 10 includes an inflatable tubular bladder 11 formed of flexible material, and a sheet 13 comprising relatively less flexible material arranged along a surface of the bladder 11 such that it conforms to a non-planar shape of
35 the bladder 11 when inflated.

The sheet 13 may be a plastic support/plastic stiffener incorporated into the structure of the inflatable tube assembly 10. Instead of plastics, other resiliently deformable materials may be used for the sheet 13. The inflatable tubular bladder 11
5 is fully or partially surrounded by the sheet 13. The sheet 13 may extend along the entire length of the bladder 11 or along a portion of the length of the bladder 11. The sheet 13 is generally planar in a rest (natural) state (i.e. when no force is applied to the sheet) but is resiliently deformable such that
10 it follows the curvature of the surface of the bladder 11 when the bladder is inflated due to forces applied to the sheet by the bladder.

When inflated the bladder 11 has a generally circular cross-section, although other shapes, such as rectangular or ellipse
15 may also be used.

When the bladder 11 is uninflated, opposite surfaces of the bladder may generally lie flat one on top of the other, with
20 each flat surface corresponding to approximately half the circumference of the inflated bladder 11. The sheet 13 may extend around half or less of the circumference of the inflated bladder 11, in which case the generally planar (natural) state of the sheet 13 may lie flat above or below the uninflated opposite
25 surfaces of the bladder, so that the assembly 10 as a whole lies flat.

If the sheet extends around more than half of the circumference of the inflated bladder 11, as shown in Figure 4 and 5, where
30 the bladder 11 extends around the entire circumference of the inflated bladder 11, the sheet 13 might inhibit uninflated opposite surfaces of the bladder generally lying flat one on top of the other, with each flat surface corresponding to approximately half the circumference of the inflated bladder 11.
35 To address this, the stiffening may be provided by two sheets 13A, 13B (two panels), each sheet 13A, 13B extending around half the circumference of the bladder 11. The sheets 13A, 13B may be

attached together in some way such that they lie flat, one on top of the other, when the bladder 11 is deflated, and can then be rolled as shown in Figure 6 (described in more detail below). The sheets 13A, 13B may be flexibly coupled together at points 5 14 to facilitate folding of the sheets when the bladder 11 is uninflated. The sheets 13A, 13B may be coupled together by a hinge or hinge-type connection. More than two sheets may be provided, with adjacent ones of the sheets being flexibly coupled together. Alternatively, a single sheet 13 may include 10 one or more lines along which the sheet is relatively highly flexible to facilitate folding of the sheet 13 when the bladder 11 is uninflated. In another arrangement, the sheets 13A and 13B may be separate from one another (not coupled together).

15 The uninflated tube assembly 10 may be rolled up along its longitudinal axis, as shown in Figure 6. Figure 6 is a transverse cross section of the assembly 10 and shows how the bladder 11 and the sheet 13 can be rolled up longitudinally. It is very advantageous that the assembly 10 can be compacted down in size, 20 particularly in applications like inflatable boats where the deflated boat may need to be passed through or stored in a confined space (such as a submarine hatch).

The bladder 11 can further be fitted with an outer cover 12 25 which protects the sheet 13 around the tube and also can be colour matched to the other materials etc.

The sheet 13 advantageously can also provide additional protection against abrasion and puncture to the bladder 11; this 30 is particularly advantageous in for example a boat where the keel tube 22 and "speed tubes" 28 (see Figures 9 and 10) are susceptible to damage when the boat is dragged over rough ground on landing etc.

35 The sheet(s) 13 may fit over the bladder 11 but may not be attached to the bladder 11. Alternatively, the sheet(s) 13 may be attached to the bladder 11 at selected points or regions.

Figures 7 and 8 show another embodiment of the invention. Figures 7 and 8 show the stiffening sheet 13 fitted inside the bladder 11. The sheet 13 may fully or partially surround the inflatable tubular bladder 11. The sheet 13 may extend along the entire length of the bladder 11 or along a portion of the length of the bladder 11. As in the first embodiment two sheets 13A, 13B may be flexibly coupled together at points 14 to facilitate folding of the sheets when the bladder 11 is uninflated. The points of attachment 15 of the sheets 13A, 13B to the inside of the bladder 11 may be at the points 14 where the sheets 13A, 13B are hingedly attached. In another arrangement, the sheets 13A and 13B may be separate from one another (not coupled together).

Figures 9 and 10 show an example application of the inflatable tube assembly 10, according to another embodiment of the invention. Figures 9 and 10 show how the inflatable tube assembly 10 can be used in an inflatable boat to increase the performance of the boat.

The boat 20 is shown in side-view in Figure 9. The main side tubes 24 provide the main support and buoyancy of the boat 20. An engine 25 is typically fitted to the transom of the boat 20 to drive it forward.

Figure 10 shows a cross section at A-A and shows an inflatable central keel 22 positioned between the deck 27 and the fabric hull 26 of the boat 10 which gives the boat 10 a pronounced "V" shape of the hull. The deck 27 is typically of either a rigidised panel or panels or can be an inflatable structure such as made from "drop thread" material (as shown in Figure 13). Additionally, under the main side tubes 24 of the boat 10 an additional tube 28 can be fitted, called "speed tubes". The additional tubes 28 can be considered to be outer keels, extending along the periphery of the deck either side of the central keel 22. The additional tubes 28 may have a smaller diameter than the central keel 22.

When the boat 10 is driven forward by the engine 25, as the boat 10 is propelled forward by force "Y", then the resistance of the water exerts a bending force "Z" on the hull of the boat 10, potentially causing it to distort and bend which results the boat losing speed as it cannot "plane", that is ride up, on its own bow wave. As a result, the speed may be reduced.

In accordance with this embodiment of the invention, in order to maintain speed, the keel 22 is adapted to maintain longitudinal stiffness and does not bend significantly. It is also helpful to the performance of the boat if the main side tubes 24 of the boat 20 are also stiffened. The "speed tubes" 28 also provide a beneficial "lift" and stiffness to the boat and again these can benefit from the additional stiffness. In accordance with this embodiment of the invention, any or all of the keel 22, the main side tubes 24 and the "speed tubes" 28 may comprise an inflatable tube assembly 10 as described above in relation to any one of Figures 3 to 8.

20

In Figure 10 the sheets 13 are shown on the outside of the bladders 11, but the sheets 13 may alternatively be on the outside of the bladders 11 (as in Figures 7 and 8).

25 The hull 26 may be formed of any suitable material, of which fabric is one example. Other flexible sheet materials may be used for the hull 26.

Figures 11 and 12 show an additional application of the use the novel inflatable tube assembly 10 in a marine evacuation system (MES). A typical example of an MES is a lateral inflatable slide (see, for example the slide in WO2018/078041). Figure 12 is a cross-section taken along line B-B of Figure 11.

35 In the example in Figures 11 and 12, the inflatable slide 39 forms a connecting passageway between a disembarkation point 36 on a vessel that needs to evacuate its passengers in an emergency

onto Life Saving Appliances 37 such as inflatable liferafts which are on the water surface. Passengers travel down the slide 39 and as they do so a force "Z" is exerted onto the slide 39 which potentially causes it to bend, which is
5 undesirable as the bending effect causes the slide 39 to not have a uniform angle and can be dangerous to the descending passengers.

A slide 39 can typically be designed with a number of supporting
10 tubes 40 which resist the bending effect of the slide. The passengers can slide or walk down the slide 39 on a surface 41 which can be made of a number of alternative materials but typically could be a "drop thread" construction (as shown in Figure 13).

15 In accordance with an embodiment of the invention, the supporting tubes 40 of the evacuation slide 39 comprise an inflatable tube assembly 10 as described above in relation to any one of Figures 3 to 8.

20 In Figure 12 the sheets 13 are shown on the outside of the bladders 11, but the sheets 13 may alternatively be on the outside of the bladders 11 (as in Figures 7 and 8).

25 The use of the stiffener sheets 13 can benefit the longitudinal rigidity of the slide 39, but at the same time can allow the slide 39 to be rolled up (e.g. as in Figure 6) to be stowed on the vessel when not in use.

30 There are many other applications of the inflatable tube assembly 10 described above. Other applications of the inflatable tube assembly 10 include inflatable masts and aerials, inflatable surf boards, wind surf boards, inflatable wings, inflatable "walkways" etc. The stiffening sheets 13 may
35 stiffen an inflatable tubes whilst still allowing the deflated items to be folded or rolled up for storage.

The sheet 13 may be formed of low-density polypropylene. The sheet 13 may be air-permeable.

5 The bladder 11 material may be a woven material laminated with an air holding layer such as a polymer like PU.

Drop stitch (or drop thread) material has the general form shown in Figure 13. In such a material, thousands of (e.g. nylon) threads connect the two opposite faces to keep side panels in
10 the desired shape when inflated and to provide rigidity.

CLAIMS

1. An inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated.
2. The inflatable tube assembly of claim 1, wherein the bladder and sheet lie generally flat when the bladder is uninflated.
3. The inflatable tube assembly of claim 1 or 2, wherein the bladder and sheet are foldable when uninflated.
4. The inflatable tube assembly of claim 1, 2 or 3, including a plurality of said sheets, adjacent ones of said sheets being flexibly coupled together to facilitate folding of the sheets when the bladder is uninflated.
5. The inflatable tube assembly of claim 4, wherein adjacent ones of said sheets are coupled together by hinge means.
6. The inflatable tube assembly of claim 1, 2 or 3, wherein the sheet includes one or more lines along which the sheet is relatively highly flexible to facilitate folding of the sheet when the bladder is uninflated.
7. The inflatable tube assembly of any one of claims 1 to 6, wherein the sheet is arranged along an external surface of the bladder.
8. The inflatable tube assembly of any one of claims 1 to 6, wherein the sheet is arranged along an internal surface of the bladder.
9. The inflatable tube assembly of 8, wherein the sheet is attached to the bladder at points of attachment along the

length of the bladder, the points of attachment being at opposite sides of the bladder.

10. The inflatable tube assembly of 8, wherein the sheet is
5 foldable at the points of attachment.
11. An inflatable tube assembly including an inflatable bladder
which is generally cylindrical when inflated, and at least
one resiliently deformable flat sheet of material arranged
10 longitudinally along a surface of the bladder, the sheet
changing from a flat state to a curved state in which
follows the curvature of the generally cylindrical bladder
when the bladder is inflated, the arrangement being such
that the inflatable tube assembly can be readily rolled or
15 folded when deflated but is rigid when inflated due to the
change in shape of the sheet.
12. A boat including at least one inflatable tube according to
any one of claims 1 to 11.
20
13. The boat of claim 12, wherein at least one of a keel, main
side tubes and a "speed tube" comprises an inflatable tube
according to any one of claims 1 to 12.
- 25 14. A marine evacuation system including at least one
inflatable tube according to any one of claims 1 to 11.
15. The marine evacuation system of claim 14, wherein a slide
supporting tube comprises an inflatable tube according to
30 any one of claims 1 to 11.
16. A boat including:
a deck (27);
a central keel (22) having an upper surface attached
35 to the deck (27) and a lower surface opposite the upper
surface; and
a hull (26) comprising a flexible sheet of material
having a central region attached to the central keel (22)
at the lower surface of the central keel (22), the sheet
40 of material further having a first outer region attached

to the deck (27) at a first position spaced apart from the central keel (22) and a second outer region attached to the deck (27) at a second position spaced apart from the central keel (22), and on an opposite side of the central keel (22) to the first outer region, such that the hull has a V shape;

wherein the central keel (22) comprises an inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated.

17. The boat of claim 16, including two inflatable outer keels (28), one disposed to each side of the central keel (22), and each having an upper surface attached to the deck (27) at a position spaced apart from the central keel (22), wherein the outer keels (28) each comprise an inflatable tube assembly including an inflatable tubular bladder formed of flexible material, and at least one sheet comprising relatively less flexible material which is generally planar in a rest state and arranged along a surface of the bladder such that it conforms to a non-planar shape of the bladder when inflated.

18. The boat of claim 17, wherein one of the outer keels (28) is attached to the deck at said first position and another of the outer keels (28) is attached to the deck at said second position.

19. The boat of claim 16, 17 or 18, wherein the deck comprises an inflatable drop-stitch panel which is rigid when inflated.

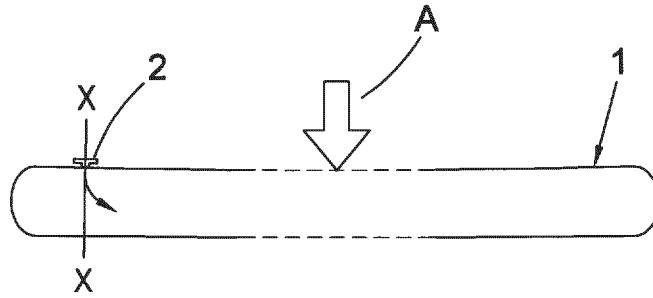


FIG. 1A

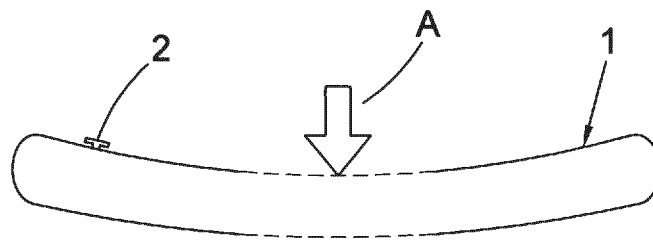


FIG. 1B

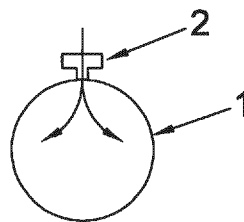


FIG. 2

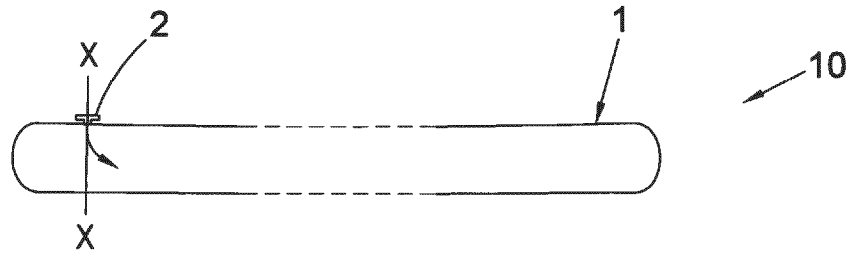


FIG. 3

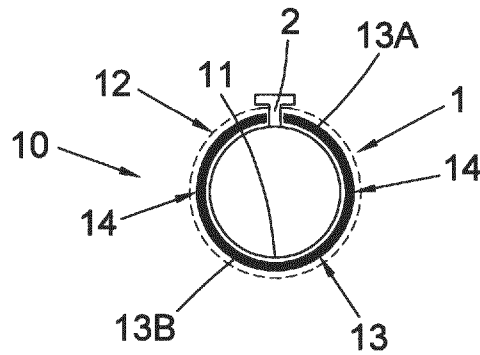


FIG. 4

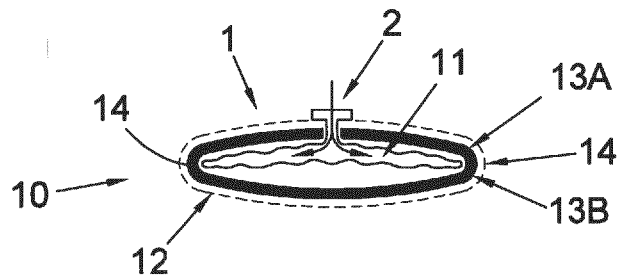


FIG. 5

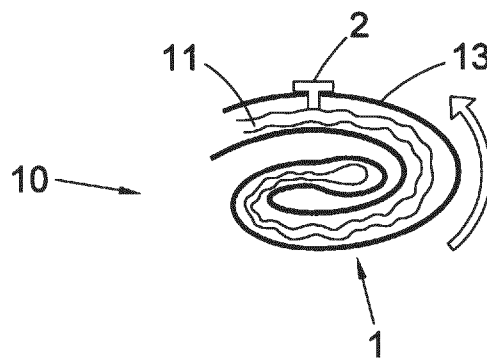


FIG. 6

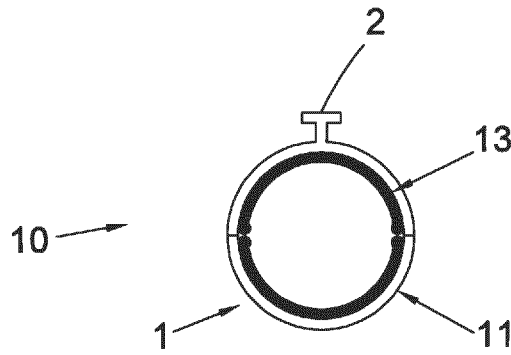


FIG. 7

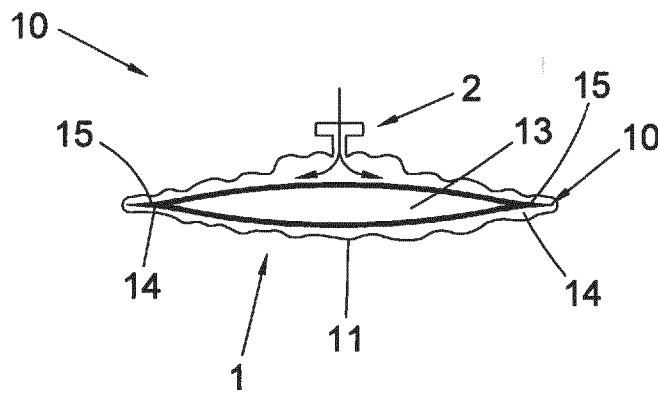


FIG. 8

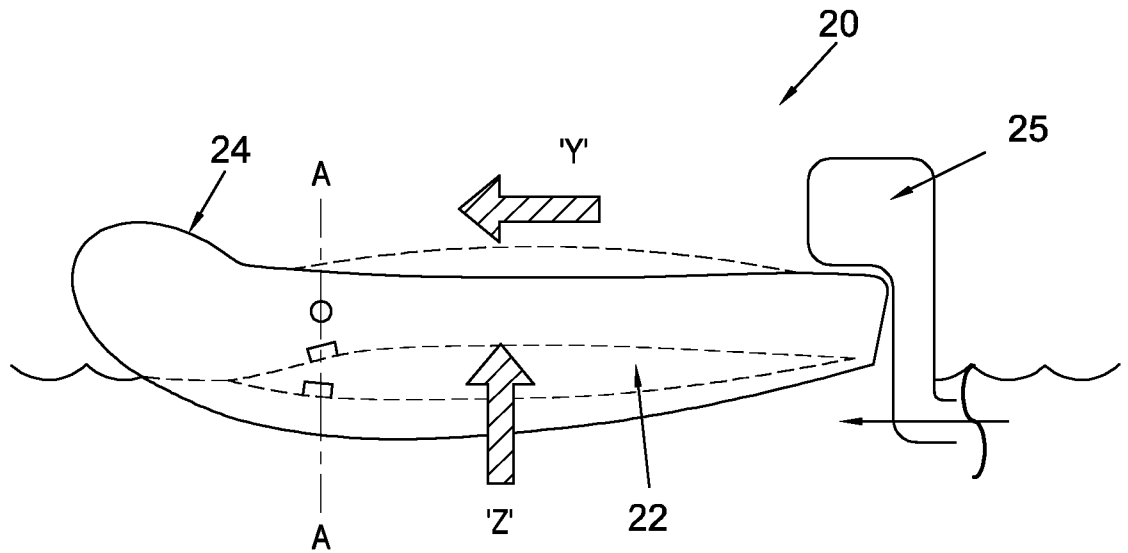


FIG. 9

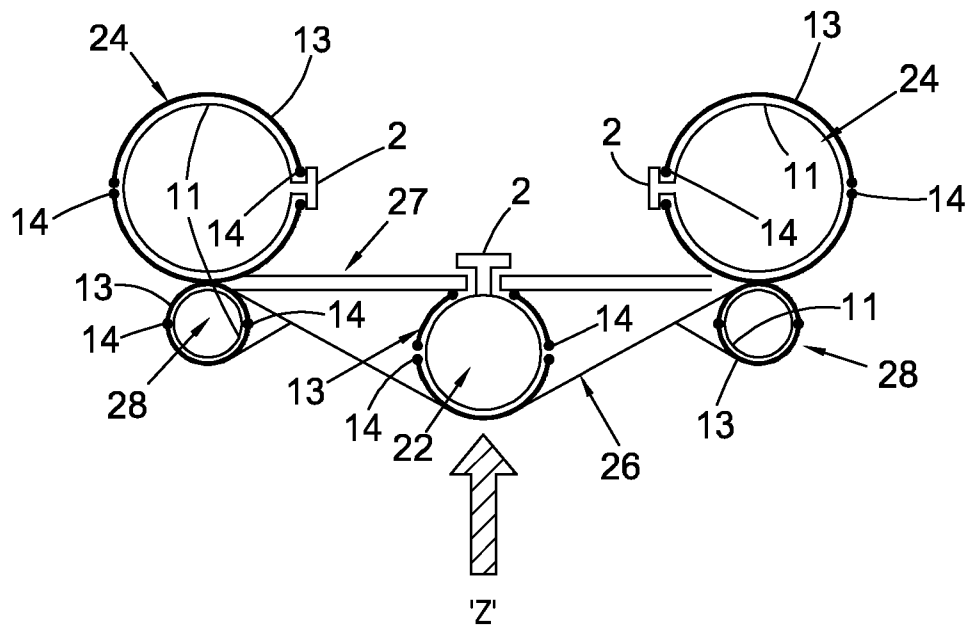


FIG. 10

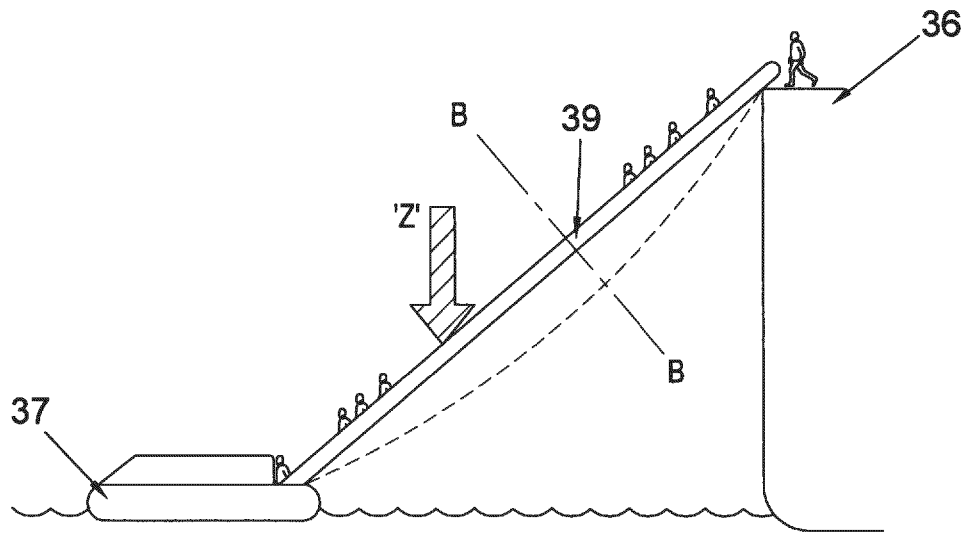


FIG. 11

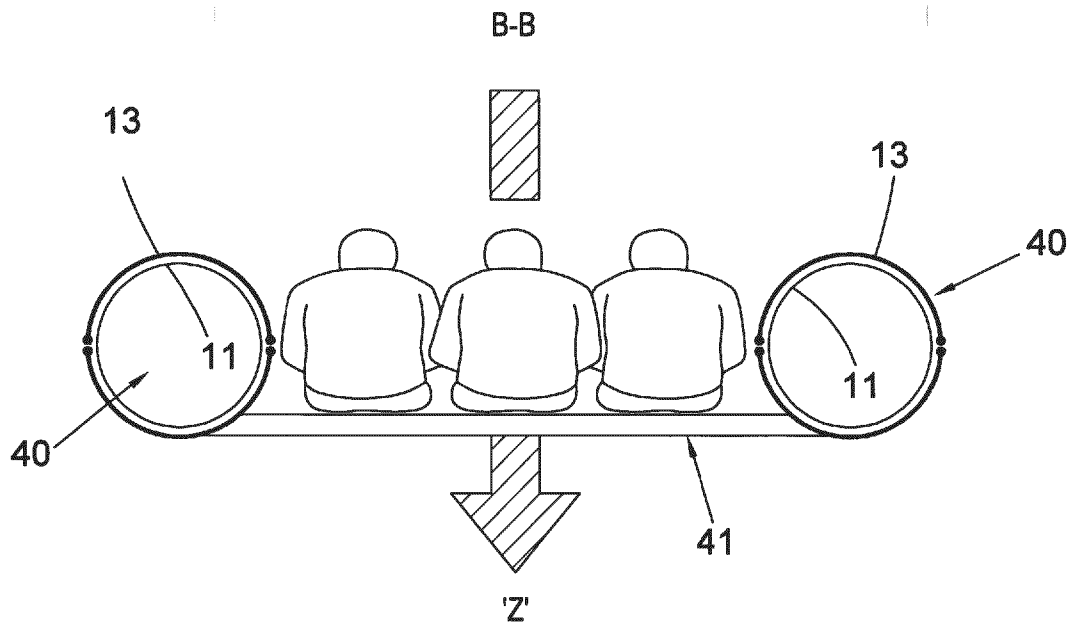


FIG. 12

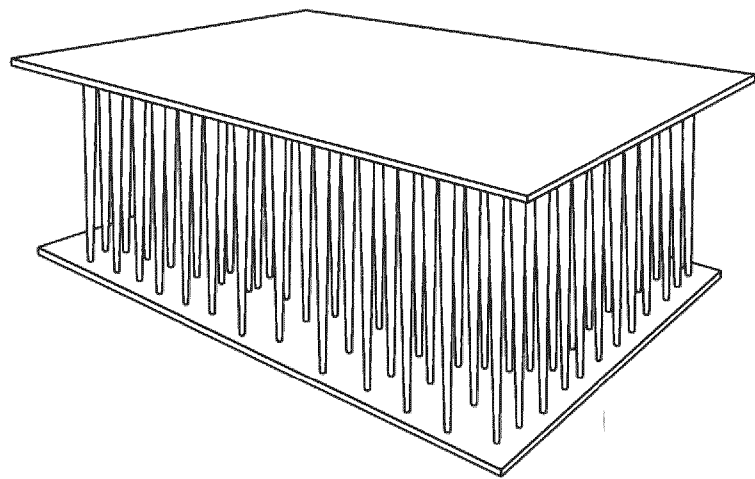


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/058621

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B7/08 E04H15/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
 Minimum documentation searched (classification system followed by classification symbols)
B63B E04H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 364 632 A (PETER ISAAC) 23 January 1968 (1968-01-23)	1-5, 7, 8, 11
Y	column 3, line 11 - line 21; figures 1-10	12, 13,
A	page 4, line 49 - line 55	16-18
	-----	6
X	WO 2004/083568 A1 (PROSPECTIVE CONCEPTS AG [CH]; PEDRETTI MAURO [CH]) 30 September 2004 (2004-09-30)	1-4, 7, 8, 11
A	page 6, line 31 - page 7, line 4; figures 1-9	5

X	WO 95/15787 A1 (STEFENSON PER [SE]) 15 June 1995 (1995-06-15)	1-4, 11, 14, 15
	page 4, line 1 - line 29; figures 1-4, 7, 8 page 6, line 9 - line 28	

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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search 25 August 2022	Date of mailing of the international search report 05/09/2022
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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/058621

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