United States Patent [19]

Moore

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[45] **Feb. 20, 1973**

[54] **LIGHT-WEIGHT, CRASHPROOF, TUBULAR STRUCTURE**

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

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

[58] **Field of Search** 52/2; 156/253; 206/DIG. 30

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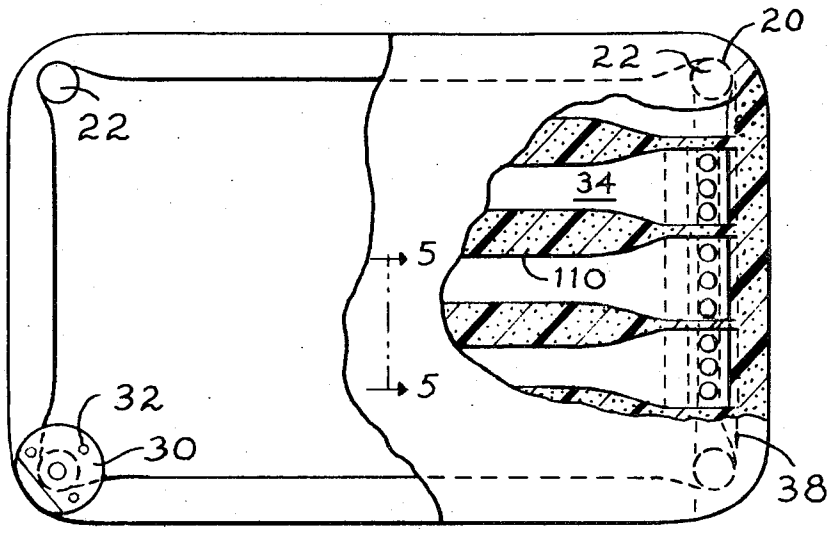
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Attorney—Alvin Edward Moore

[57] **ABSTRACT**

An elongated tubular structure, of non-stretchable material — preferably comprising impermeable-to-gas thin metal having: flat, wider, sealed ends; and intermediate, elongated links, each of which has a hollow portion, inflated with gas at a pressure well above that of the atmosphere, and a wider, bonded, flattened-tube band at each link end. Each flat, tubular-structure end comprises a welded, vulcanized or otherwise bonded, sealed joint between two flat sides of the structure and an outer-end means for attachment of this end to a similar portion at the other end and/or to adjoining structure (an end flange, optionally having bolt or rivet holes). Adjacent inflated links are preferably joined by a flatter, wider portion that preferably allows passage of gas between links and inflation of all the links from a single gas inlet, permanently sealed after inflation. The disclosure also comprises a strongly rigid or very stiffly resilient vehicular body (strongly protecting a load in a crash) and stiffly resilient shock-taking means, yieldable without fracture under major shock, comprising tubular structure of the above type.

14 Claims, 19 Drawing Figures



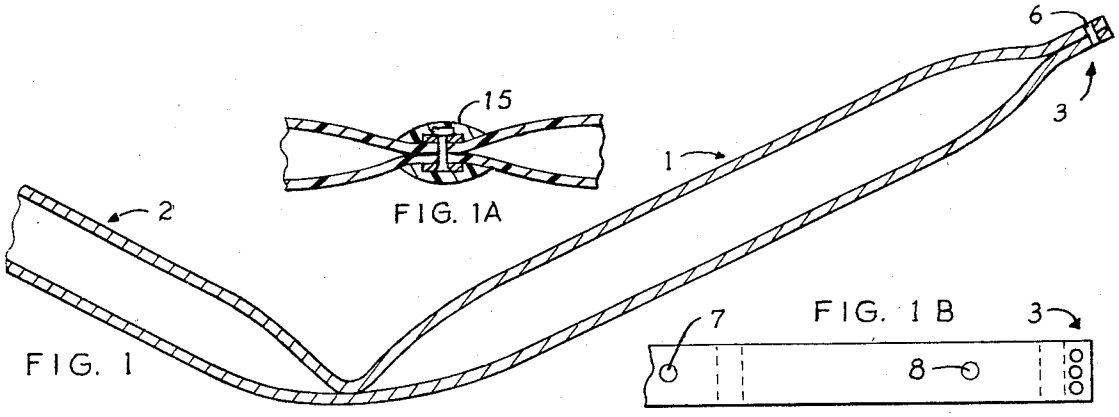


FIG. 1A

FIG. 1

FIG. 1B

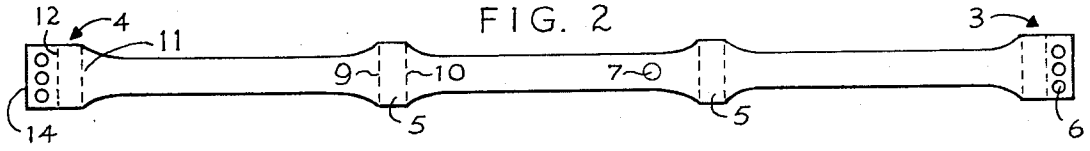


FIG. 2

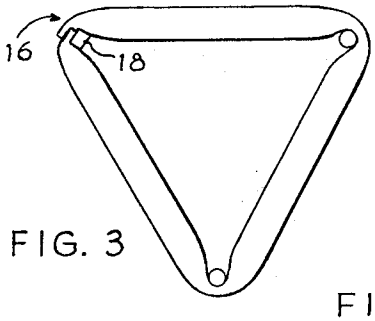


FIG. 3

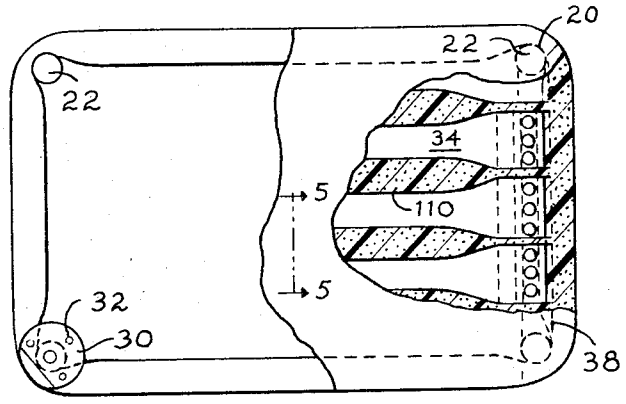
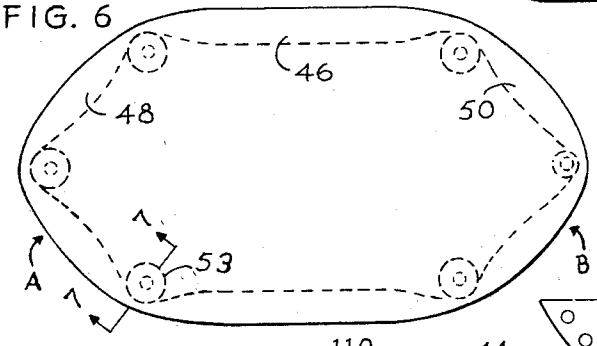


FIG. 4

FIG. 6



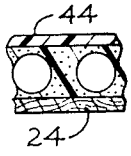
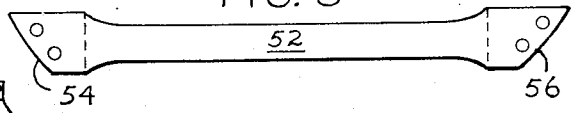


FIG. 5

FIG. 8



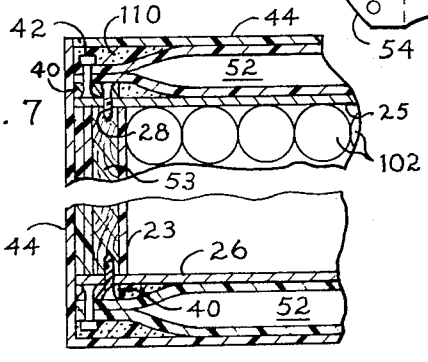


FIG. 7

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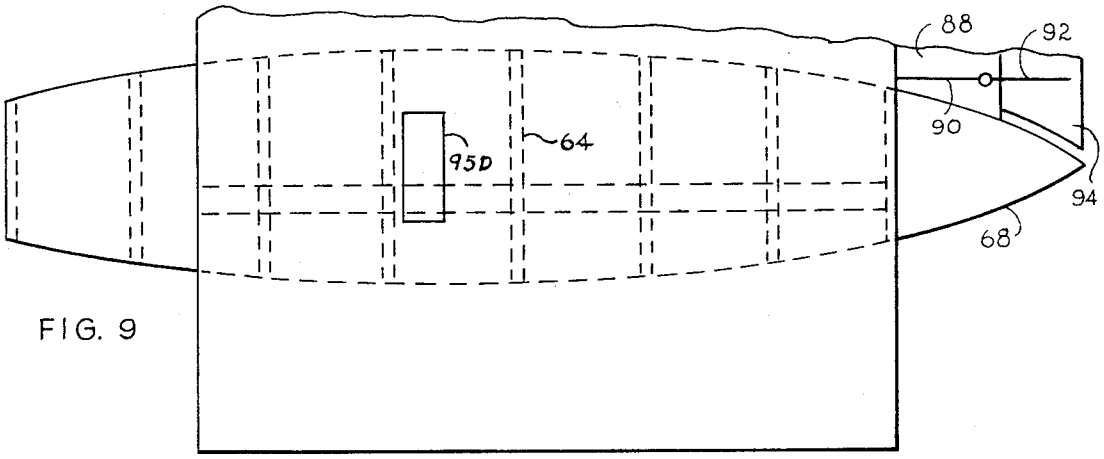


FIG. 9

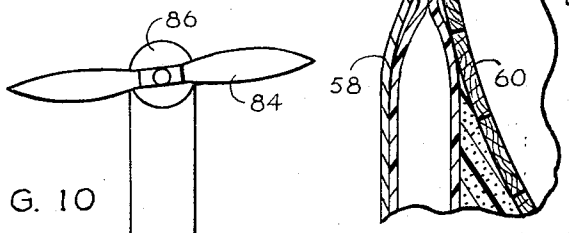


FIG. 10

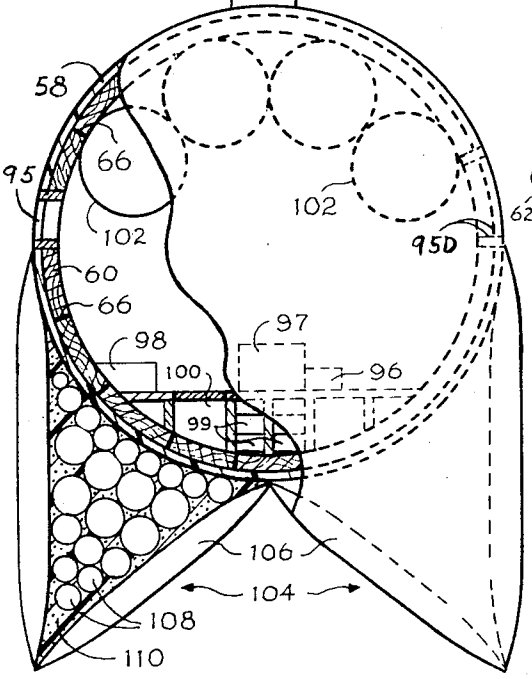


FIG. 11

FIG. 12

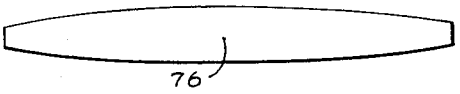


FIG. 13

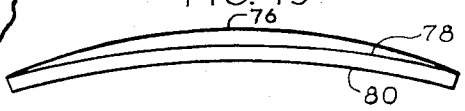


FIG. 14

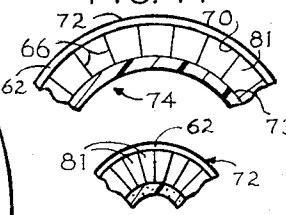
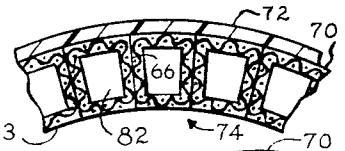


FIG. 15

FIG. 16



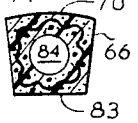


FIG. 17

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LIGHT-WEIGHT, CRASHPROOF, TUBULAR STRUCTURE

This invention pertains to: light-weight, strong, unbreakable tubular structures, easily and hermetically inflatable with lighter-than-air gas, air or other gas, usable in the construction of various types of devices, but especially designed for vehicular construction; and the combination of such structures, as shock-taking means, with a strong, rigid or nearly rigid cabin of a water-surface or flying boat, life raft, automobile, aircraft, space vehicle, or other vehicle. Some of the basic principles of the invention are: (1) if a sealed tube inflated with gas at above-atmospheric pressure has ends free to move (is not endless) it tends to assume and hold a position in which its longitudinal axis is in a straight line. (2) If a sealed tube inflated with gas at above-atmospheric pressure is endless, with gaseous communication throughout its length, it tends to assume and hold an annular (at least roughly circular) shape. (3) A tube flattened throughout its length and sealed at its flat ends may be inflated with helium or non-aerial gas (without wrinkling of the tube material, without inefficient use of a vacuum pump, and without intermixture of the gas with air). After inflation the tube has an annular middle portion, tapering to wider, sealed, flatted ends; and if made of sealed flexible material it may be repeatedly inflated or bent under shock without permanent wrinkling of the material. (4) Certain materials may be repeatedly bent a long time without fracturing; among these are resilient, synthetic or natural rubber; dense, flexible or resilient plastic; copper (which in this invention may be very thin and therefore light and inexpensive sheet copper); flexible spring steel sheet; soft iron. (5) An elongated, sealed, flat-ended tube of the above type may be further flattened and bonded by welding, epoxy resin or the like in one or more narrow bands or lines of contact between flattened tube walls at one or more places between the flat tube ends; and these intermediate flattened areas may easily be bent into strong angular joints between adjacent, inflated-tube portions that have any desired angle between them, and the narrow bands or areas further and optionally may serve as: means sealing the adjacent tubular portions from gaseous flow between them; alternatively, means (for example provided by bolt or spot welding) that allows only very limited flow of gas between these portions; means for attachment to a portion of a vehicular cabin or other support. (6) A barrel-curved vehicular wall is the strongest kind of form per unit of weight for the load-containing cabin of a boat, aircraft, car or other vehicle. (7) The combination of a strong, rigid or nearly rigid cabin with outer tubular structures of the above type in a shock-taking float, wheel support, propeller support or the like forms a nearly crashproof vehicle of a type that is badly needed in our present wreck-prone civilization.

An object of this invention is to provide an elongated, flat-ended, inflatable tubular structure of the above-mentioned type, having, bendable, flattened and widened portions between its flat ends. Another object is to provide such a structure having wall material or combination of materials that is capable of long-repeated bending under shock without fracturing. A further purpose is to present the combination of such tubular structures, as shock-taking means, with a strong, rigid or nearly rigid, load-protecting vehicular wall. Some other objectives are to provide: a tubular article of the above type that is inflated with lighter-than-air or other gas at a pressure well above that of the atmosphere (sufficient to cause the tube not to yield under minor shocks, for example under normal wave or wind action, but to allow the tube safely to yield under major shock, as in a collision, and then to return to its former shape); the combination of such tubular structures, as a shock-taking means, with a barrel-curved vehicular cabin mainly made of staves or stave-like panels, held together inside hoops or equivalent looped means and optionally bonded at their contacting edges with epoxy cement (or welding), having a strong, barrel-curved exterior surface.

Other objects of the invention will be apparent in the following specification and the accompanying drawings.

FIG. 1 is a view in section from a plane containing the longitudinal axis of a bent, flat-ended, inflated tubular structure, this plane being normal to the flattened portions of the structure, and the structure being shown as partly broken away.

FIG. 1A is a detail, sectional view, showing a bolted or riveted joint between links of a tubular structure.

FIG. 1B is a reduced-scale plan view, partly broken away, of a structure of the invention in its uninflated form.

FIG. 2 is a plan view of the tubular structure of FIG. 1, illustrating it in three inflated links, with the intermediate wall constrictions between links not bent.

FIG. 3 is a plan (or side) view of the structure of FIG. 2, bent into a triangular object, having bracing elements at its three corners.

FIG. 4 is a plan view of a structure of the type of FIG. 1, having four inflated links, joined and fastened to braces and skin means in a device which may be the cabin or body of a life raft, other boat, aircraft or other vehicle, shown as having its top skin broken away at part of one end to expose portions of the vehicle-cushioning means, and as having at its other end its cushioning means and skin means broken away to expose the tubular wall constriction.

FIG. 5 is a detail sectional view from the plan indicated by the arrows 5—5 of FIG. 4.

FIG. 6 is a plan view of the body or other vehicle, having walls comprising the invented type of tubular structures.

FIG. 7 is a detail, sectional view from the plane 7—7 of FIG. 6.

FIG. 8 is a detail plan view of one of the top (or alternatively bottom) tubular members of the cushioning part of the vehicle's top (or bottom wall); when showing one of the top members it is designed to extend between the areas indicated by the arrows A and B in FIG. 6.

FIG. 9 is a side, elevational view, partly broken away, of a surface-traversing vehicle and/or flying boat, comprising a barrel-curved cabin and shock-taking means of the tubular-structure type.

FIG. 10 is an end elevational view of the vehicle of FIG. 9, with its left-hand part broken away to illustrate details of the body and float means in cross section.

FIG. 11 is an enlarged, detail, sectional view of the junction of the vehicular body and a flat-ended tubular element, showing the upper edge of its flattened end as

in its preferred position, a little below the median horizontal plane of the body.

FIG. 12 is a plan view of a solid-material, stave-like panel of the barrel-curved body.

FIG. 13 is a side elevational view of the panel of FIG. 12.

FIG. 14, showing an optional form of the stave-like panels, is a reduced-scale, sectional, detail view from a plane across the longitudinal axis of the barrel-curved body that is at one of its larger-diameter portions.

FIG. 15 is a similar view from a plane that is spaced from that of FIG. 14, toward one end of the body's load-carrying space.

FIG. 16 is a sectional, detail view from a plane normal to the longitudinal axis of a barrel-curved cabin, showing an optional form of the barrel-curved, stave-like panels.

FIG. 17 is a detail, cross-sectional view of another optional type of the barrel-curved, stave-like panels, having an inner surface that is straight in section normal to its longitudinal axis.

The basic tubular structure of this invention is illustrated in FIGS. 1, 1A, 1B and 2. It comprises a plurality of links, of which only one complete link, 1, is here shown, and a second link, partly broken away is indicated at 2. The wall material of the structure is illustrated in FIG. 1 as preferably comprising metal, but in it and in each of the other illustrated forms of the invention this material optionally may be of: resilient rubber or other resilient plastic, preferably reinforced with metal or fibrous mesh or other fabric, or of thin copper, aluminum or iron sheet or extruded material.

The elongated tubular structure has a pair of flat end parts (3 in FIGS. 1 and 1B; 3 and 4 in FIG. 2) and one or a plurality of intermediate flat bands, 5. The flat ends optionally may have holes 6, for aid in fastening the ends together and/or to bracing or supporting means that supports the tubular structure or structures. The tubular structure may be made from thin sheets of one of these materials, bonded at their edges, or by extrusion.

When from an extrusion it may be made in accordance with the following method: (1) the extruded tube is flattened into a planar rectangle throughout its length. (2) Means for inflating the tubular structure is fixed to at least one side of the rectangular article. This means 7, 8 optionally may be either a gas-inflation valve (nearly always used if the structure (for example of rubber) is to be repeatedly inflated) or a small gas-inlet tube (optionally usable when the structure is of dense, practically impermeable material, such as metal). (3) The two flat planar folds are united by fastening means, for example bonding material (welding, brazing, vulcanizing material or epoxy resin) in the flatter intermediate constrictions or bands 5, indicated as between lines 9 and 10, and are hermetically bonded at their ends 3 and 4. In some uses of the structure the sealing and bonding material at one (or each) of these ends is restricted to the band between lines 11 and 12; and the end portions between lines 12 and 14 then are bifurcated, with the upper and lower parts capable of being temporarily spread apart, for aid in welding or otherwise fastening the two ends of the structure together and/or to braces or the like. In an optional form of the structure the bonding material (for example spot welding) along and optionally between lines 9 and 10 is not an hermetic, continuous weld or other bond, but instead has gaps between portions of it that allow a slow seepage or gaseous-flow communication between the adjoining pair of tubular links. In this event: as illustrated in FIG. 2, only one gas-inlet means 7 is sufficient for inflating the links; and if the tubular structure is bent (as in FIGS. 1 and 3 to 6) each pair of the inflated links is held in fixed angular relation by a brace or angle iron or the like. But when the bonding material of the constrictions 5 hermetically seals the links from gaseous-flow communication a gas-inlet means 7 or 8 is necessary for each link, at least before the structure is inflated. In some instances the flat article illustrated in FIG. 1B may enter commerce in this rectangular, uninflated, easily transportable form, and then be inflated at the place of its first use. Whether the gas-inlet means comprises a simple, small tube or such a tube with a valve in it, the small tube is preferably permanently sealed when the tubular wall material is of metal or dense plastic that is substantially impermeable to gas. This permanent sealing is by bonding material which may be epoxy glue, but if the structure is of metal is preferably welding, brazing or soldering material.

An optional type of the fastening means which holds together the flat areas of the constriction between links is shown in FIG. 1A. This comprises rivets or bolts thru constriction holes (providing gas-passage clearances on the sides of these rod-like elements) and bonding material, 15, sealing over the rivets or bolts and holes.

An optionally alternative method of making the tubular structure comprises the following steps: (1) cutting or otherwise forming two equal, rectangular, elongated strips (narrow pieces) of the tubular-structure material; (2) fixing to one of these sheets the gas-inlet means in the above-described manner: (3) placing the strips or layers in contact, one above the other; (4) hermetically bonding (with welding, brazing, soldering, vulcanizing or epoxy bonding material) each adjoining (aligned) pair of the side and end-edge portions of the two layers; (5) forming the bonded intermediate constrictions 5 in the above-described manner.

After the uninflated structure is made by one of the above-described methods, it is inflated with gas. This may be air, but preferably is lighter-than-air gas (preferably helium; or nitrogen; or hydrogen, preferably mixed with gas that inhibits combustion). The originally flat nature of the structure efficiently provides for its inflation with non-aerial gas, without the troublesome use of a vacuum pump, because little or no air is present between the contacting flat sides of the structure in its uninflated condition.

When the tubular-structure material is metal or other substantially impermeable-to-gas material, the structure is initially inflated with gas at a pressure well above that of the atmosphere - for example in the range of 10 to 30 pounds per square inch; and the gas-inlet means then is preferably permanently sealed. But when the material is stretchable (for example resilient rubber, not reinforced with fabric) it is first only moderately inflated (for example at a pressure of 1 to 2 pounds) and then incased in a restricting outer envelope (thus forming a composite, non-stretchable tube material) and inflated at a pressure well above that of the atmosphere.

This envelope may be: densely woven fabric; or molded, stiffly resilient material - such as semi-rigid foamed plastic, within a strength-providing vehicular skin means (for example woven or metallic fabric, plywood, sheet metal, or dense-plastic sheet).

FIGS. 3, 4 and 6 show devices of several of the numerous configurations possible with the angularly bent constrictions 5. In FIG. 3, the triangularly arranged tubular structure has its ends joined by overlapping the end portions 3 and 4 and fastening them together. The joint 16 may be made detachable by using bolts in the holes 6; but preferably it is permanent, with the use of rivets, bolts, glue and the bracing element 18. This bracing element preferably has its outer surface shaped to conform to the inside surface of the inner bent-end flange.

In FIG. 4, illustrating a quadrilateral device, (preferably the body of a vehicle), the joint between the ends of the tubular structure comprises bonding material 20 of one of the above-described optional types. The device of this figure comprises upright braces or posts, 22, of wood or metallic pipe, which are shaped to approximately conform to the bent curve of the constrictions 5 and of the joined ends of the tubular structure. These posts (braces) are strength-providing elements of the vehicular body, to which are bolted, screwed, riveted or bonded the bent curves of the constricted junctions between links and which serve for attachment of the top, bottom and the optional interior skin or wall element of the cabin, which is similar to the sheet plastic 23 of FIG. 7, and may be of fabric-reinforced plastic, preferably rigid or semi-rigid, or of plywood, or metal.

The top and bottom are attached to the posts in a similar manner. A sheet 24 of plywood or metal (like 25 or 26 in FIG. 7), for example, of aluminum alloy, thin steel, plywood, or dense, strong plastic (preferably reinforced with fabric), is fixed (for instance with screws 28 and/or bonding material of the above-described type) to an end of each of the posts. Optionally each junction may be strengthened by a flanged, metallic element, 30, having holes 32 for attachment of bolts or rivets.

The top and bottom of the vehicular body (outside the interior skin elements 25 and 26) mostly comprise cushioning, shock-taking, stiffly resilient tubular structures. Each of these structures, 34, is similar to the tubular structures 52 of FIG. 7, and like 52 is fastened at its end to a pair of bars 38 (similar to bars 40 of FIG. 7). These bars are fixed to upper and lower ends of the posts by the screws 28 and cement, welding or other bonding material; and to the bars the flat, wider ends of the tubular structures are fastened by such bonding means and bolts or the like, 42.

The outer part of the vehicular body has an exterior skin means. This comprises yieldable sheet material 44, which is preferably metallic or fibrous mesh or other fabric impregnated and coated with stiffly resilient rubber or other stiffly resilient plastic.

The vehicular body of FIG. 6 is generally similar in construction to the cabin of FIG. 4, but has a different, more streamlined outer configuration. Its cushioning, stiffly resilient side walls comprise inflated, vertically stacked tubular structures 46, 48, 50, of the above-described type, whose flat, wider parts are bent around and fixed in the above-described manner to six upright posts, 53. The shorter structures 48 form the main, shock-taking part of the bow of the vehicle; and the somewhat longer structures 50 form that of the streamlined stern. The shock-taking side-wall structures 46 are preferably longer than the structures 48 or 50. Due to the number of these structures (exceeding four) and the fact that their flat portions are conducive to curving and conforming to the curved sidewall skin or skins, the exterior, sidewall skin means and the cabin are smoothly streamlined. The bars 40, to which the skin means is attached, are preferably curved to conform with and be closely juxtapositioned with the sidewall skin. Each of the elongated, single-link tubular structures 52 of the top and bottom cushions has a flat portion that is curved at 54 to fit a curved portion of one of the forward bars 40, and an after flat portion that is curved at 56 to similarly fit a curved portion of an after bar.

FIGS. 9 to 11 illustrate a shock-taking vehicular cushioning means, comprising inflated tubular structures of the above-described type, in combination with a rigid (or nearly rigid), barrel-curved vehicular body. This cabin comprises:

a streamlined exterior skin means, 58, of flexible or resilient metal or any of the other, above-described skin materials; and, within this skin means and the lower cushioning structure, numerous stave-like panels, 60. These panels optionally may be barrel-curved wooden staves, as shown in FIGS. 10 and 11, or stave-like panels of the below-described general type that is shown in FIGS. 14 to 17. They are surrounded and held with their side edges in tight juxtaposition by looped means, 62, which may be bent, round-in-cross-section rods, or the barrel-like metal hoops or rings 64 shown in FIG. 9 (nailed and/or epoxy-glued to the stave-like panels) or, alternatively and optionally, a spirally wound strip of thin steel or wire mesh - tightly wound around and preferably nailed and epoxy-glued to the panels.

The panels have planar sides, 66, lying in planes that contain and converge at the longitudinal axes of the barrel-curved body. Each juxtaposed pair of these sides or side edges are waterproofedly united with bonding material of one of the above-described types, preferably epoxy resin. This is applied to the planar sides (which are edges in the case of wooden panels) just before the panels are clamped into tight contact by the panel-holding looped means. The currently preferred form of this looped means comprises a thin steel or aluminum-alloy hoop (ring or band). Each is of a size to fit the approximate curvature of the barrel-curved wall where it is to be fastened, and it is hammered or otherwise forced upward on the barrel-shaped curve, jamming the glued planar sides of the panels into tight, clamped contact. After all the hoops are in place, optionally and preferably other looped means, comprising a metallic mesh (of aluminum alloy or steel wire or expanded metal) is stretched tautly over and bonded to the curved wall and hoops, and this mesh is impregnated and coated with plastic, stucco or the like. Thus the panels are preferably strongly held together to form the barrel-like exterior curve by four holding means: epoxy resin; thin metal hoops; metallic mesh, and the coating material.

Optionally, the barrel-like cabin may be made without use of narrow, stave-like panels. It may be of relatively wide curved staves (panels or gores) of thin iron, steel or spring steel - by die-forming them with shallow flanges at their edges, bonding the flanges together with welding, brazing, solder or epoxy-resin glue, and stretching and bonding a strength-providing looped means (mesh of the above type) over the whole. Or the barrel-curved wall may be of laminated plywood - of built-up, staggered layers of relatively wide plywood gores, epoxy-glued together, on a temporarily placed, removable, barrel-shaped, inflatable bag. This mold-core bag preferably is of slightly stretchable fabric impregnated with resilient rubber.

Although each of the stave-like panels may be pointed at one end, to form the pointed, streamlined stern portion, **68**, preferably this portion comprises expanded metal (optionally integral with the preferred metallic mesh that covers the stave-like panels - or else separate mesh, nailed, bolted or riveted to after ends of the panels, and preferably bonded to these ends by selected bonding material of one of the above-described types). The mesh is impregnated and coated with plastic or stucco.

The currently preferred shape of the panels is indicated in FIGS. **12** to **16**. From the cabin's barrel-like bulge of largest diameter it and each of the barrel-curved panels slopes, with decreasing radii of curvature of the curved surfaces, to at least one of the ends of each stave-like panel; and preferably, as illustrated in FIGS. **12** and **13**, the greatest-diameter bulge is in the middle part of the cabin, and its barrel-curved surfaces slope, with decreasing radii of curvature to both ends of each panel. This lessening of radii is illustrated in FIGS. **14** to **16**. FIG. **14** (or FIG. **16**) is a sectional detail view across the axis of the cabin at one of its larger-diameter portions, and FIG. **15** is a similar view from a plane spaced from this larger portion, toward one end of the load-carrying space. The radii of the exterior panel arcs (or covering) **70** (as well as the radii of the circumference of the skin **72** (of the skin means around the panels), progressively decrease from the cabin's largest diameter to at least one of its ends; and in a similar manner the smaller radii of the interior arcs **73** of the panels and the arcs **74** of the inner skin decrease toward the same end (or ends) of the cabin.

These decreasing radii are also indicated in the panel of solid material (wood or metal) shown in FIGS. **12** and **13**. The area of the cabin's largest diameter is indicated at **76**; and from this area the radii of curvature of the panel decrease to each of its ends. The outer and inner curved lines of each of the planar sides are respectively indicated at **78** and **80**.

FIGS. **14** and **16** illustrate, at **81** and **82**, two optional, hollow forms of the stave-like panels. In FIG. **14** they may be of die-formed wire mesh, impregnated and coated in a mold with dense plastic, mortar or glass; but preferably each panel of FIG. **14** comprises an elongated exteriorly open channel, having planar sides **66** and an inner curved wall portion having the interior arc **73**. Optionally, the panel also may comprise a narrow outer curved wall portion **70**, but preferably the element **70** is annular and surrounds all the channels or stave-like panels. It may be of sheet metal, or wire mesh, impregnated and coated with plastic or stucco.

In FIG. **16** the stave-like panels are separately formed, gas-contained, hollow elements, comprising wire or other fabric mesh, imbedded in plastic, or glass. They may be formed on a removable core within the wire mesh in a mold, or may be extruded from plastic or glass and later wrapped with the mesh, and glue, plastic or stucco then applied to the mesh. The plastic or the like is not shown in small-scale FIG. **16**, but plastic of the type that optionally may be used is indicated in FIG. **17**.

In FIG. **17** an alternative and optional type of interior surface of the stave-like panels is shown. Here the internal surface, **83**, has a straight line in each cross section normal to the elongated axis of the panel, but as in FIGS. **14** to **16**, this internal surface is arched for extra strength in a fore-and-aft plane containing the longitudinal axes of the panel and the cabin; but it is not curved in cross-sectional planes that are perpendicular to this fore-and-aft plane. Its planar sides **66**, like those of the other forms of panels, interiorly slant toward each other, and their planes converge at or toward the cabin's longitudinal axis, thus adding to the vehicle the strength of wedging tendencies of these preferably glue-bonded planar sides when the panels are subjected to external force.

The numeral **84** may indicate a hollow space in a molded or extruded panel, but preferably it indicates a sealed tubular element of one of the above-described tubular materials, preferably inflated with air or lighter-than-air gas at a pressure well above that of the atmosphere; and optionally it comprises a flat-ended tubular structure of the above-described type, having one or more links. The hollow spaces of FIGS. **14** to **16** likewise optionally may be filled with well-pressurized gas.

The device of FIG. **4** or FIG. **6** may be used as a very light-weight but strong life raft or lifeboat, propelled by a paddle or oars; or it may be equipped with a motor and propeller. Any known type of such propulsion assembly may be used with the vehicular body of FIG. **4**, **6** or **9**. A pair of marine propellers may be installed in spaces (not shown) in the V-shaped lower floats of FIG. **10**; but preferably an aerial propeller, **84**, and an engine or other motor, **86**, are utilized, together with the airplane-type vertical and horizontal stabilizers **88** and **90**, elevator **92**, and rudder **94**. The vehicle of FIG. **4**, **6** or **9** comprises window and door means (**95** and **95D** in FIGS. **9** and **10**).

The motor **86** optionally may be an electric motor; but preferably it is an hydraulic motor, receiving fluid from a pump, **96**, driven by the engine **96**, located on the lower deck, amidships. If the motor **86** is an engine, the element **97** may be an electric generator; and in any event the engine **97** drives a generator; and the major portion of the weight of these parts, the air-conditioning unit **98**, the batteries **99**, and the rest of the equipment and other load is located below the center of buoyancy of the vehicle. The element **100** is a storage chamber, having a hinged top.

The location of the center of gravity below the center of buoyancy helps stabilize the craft. Also optional balloons in the upper part of the vehicular body **102** in FIGS. **7** and **10** provide lift, aiding in stabilization and reduction of water or aerial friction on the floats or on the landing gear which may be attached to the bottom

of the vehicular structure of FIG. 4, 6 or 9. When, as is preferable, the floats 104, comprising aligned, connected, stiffly resilient, four-link tubular structures (having constrictions) of the above-described type, 106, do not house propulsion devices, they preferably comprise balloons, 108 (for example of thin rubber), imbedded in stiffly resilient foamed plastic, 110. As indicated in FIGS. 4 and 7, such foamed plastic also preferably surrounds the inflated links and constrictions of the tubular structures.

In summation: the vehicular body in any of the forms illustrated in FIGS. 4, 6, 9 and 10, comprises: a strong vehicular framework, having vehicular-body elements of firm, strength-providing material (23, 25 and 26 in FIG. 7: member 24 and elements like 23 and 26 in FIGS. 4 and 5; 58 and 60 in FIGS. 9 and 10); means strongly holding the body elements together (the posts or braces and/or screws or the like in FIGS. 4 and 6; the hoops or other looped means in FIGS. 9 and 10); and sealing or bonding material between the contacting joints of the above-mentioned body elements.

I claim:

1. An elongated, angularly bendable structure, having an integral plurality of inflated curved, end-joined links, and an integral plurality of wider, flatter portions, said links and flatter portions being surroundable by ambient air, comprising:

a plurality of said inflated, curved links, each comprising an impermeable-to-gas, thin, solid-metal envelope that is arcuate in cross section and comprises impermeable-to-gas metal that has a thickness of over 3 mils;

a said wider, flatter, interconnecting portion between each pair of said links, comprising opposite walls of solid, impermeable-to-gas metal that is integral with said metal of the links, the said opposite walls being closer together than the maximum distance across the space between the link walls and having clearance between them, allowing passage of gas between adjacent links;

means, associated with each of said interconnecting portions, forcing said opposite walls toward each other against expansive force of inflation gas;

a pair of hermetically sealed flat ends of said structure, comprising a said integral flatter portion at each end of the structure, each of said ends comprising solid-metal layers of impermeable-to-gas metal, integral with the metal of said links and interconnecting portions, being wider in the planes of their flat sides than said maximum distance, and having holes for attachment to other structure;

gas inside the said links and interconnecting wider portions under a permanent pressure well above that of the atmosphere;

a single inflation-gas inlet, comprising a relatively small gas-conveying element, between end edges of said structure, having a cross-sectional area well below the maximum cross-sectional area of said links, forming a permanent part of said structure, supplying inflation gas to all of said links and interconnecting portions; and

means sealing said inlet after inflation of the structure.

2. Structure as set forth in claim 1, in which the pressure of said gas is at least five pounds per square inch.

3. Structure as set forth in claim 1, in which said gas is lighter than air.

4. Structure as set forth in claim 1, in which said gas-conveying element is attained to a curved side wall of one of said inflated links.

5. Structure as set forth in claim 1, in which each of said sealed flat ends comprises: a band of sealing, bonding material joining portions of said layers; forked attachment tabs, between said band and an end edge of said structure, adapted to straddle another object in assembly; and attachment holes in said tabs for rod-like attachment elements.

6. Structure as set forth in claim 1, comprising bonding material, permanently sealing said gas-conveying element after inflation of the structure.

7. Structure as set forth in claim 1, in which said means forcing said walls toward each other comprises rod-like elements.

8. Structure as set forth in claim 7, in which said rod-like elements comprise bolts.

9. Structure as set forth in claim 1, in which said means forcing said walls toward each other, at each said interconnecting portion, comprises a rod-like element and bonding material.

10. Structure, surroundable by ambient air, adapted to be inflated and to serve as a substantially non-stretchable construction unit, having parallel side edges exposed to ambient air, and having a plurality of elongated, planar, inflatable, end-to-end-joined links, each extending from one of said side edges to the other, with oppositely arranged inflatable parts of the walls of each link free to expand under subsequent inflation from planar condition, outwardly from each other and into arcuately curved walls; said structure having at least one bendable constriction between each two adjacent, end-to-end-joined inflatable parts, extending from one of said side edges to the other; the said structure comprising:

a pair of equal-size, planar, rectangular layers of solid metal having a thickness of at least 3 mils, one layer located above the other, having opposite, juxtaposed inner faces and the said side edges;

bonding means sealingly connecting the two end portions of said layers, hermetically joining said end portions in sealed bands, extending from one of said side edges to the other;

at least one intermediate fastening means, between said end portions, and between a pair of said links, substantially forcing opposite portions of said layers toward each other in a said bendable constriction, against expansion when under inflation, providing restricted passage of inflation gas;

portions of said opposite inner face on each side of said intermediate fastening means and between the two united pairs of said side edges being free from attachment to each other, and movable outwardly apart into curved walls when under pressurized inflation, into curved, elongated, inflated links, each of which curvingly and smoothly slopes from a middle link portion to a wider portion at each end of the link; and

a single inflation-gas inlet, permanently and sealingly connected to one of said layers, between said sealed bands at the end portions of said structure,

comprising a gas-conveying duct, for supplying pressurized inflation gas into all of said links and constrictions.

11. Structure as set forth in claim **10**, in which each said intermediate fastening means comprises a rod-like element.

12. Structure as set forth in claim **11**, in which said rod-like element is a bolt.

13. Structure as set forth in claim **10**, in which each of said sealed bands is spaced from an end edge of the structure, and the said structure, further comprises: between each said band and end edge, two bifurcated attachment parts adapted to straddle another object in assembly; and attachment holes in said tabs for rod-like attachment elements.

14. Structure as set forth in claim **10**, in which said intermediate fastening means comprises spot welds.

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