March 11, 1969 A. E. MOORE 3,431,878

FLUIDFOIL RINGCRAFT

Filed March 3, 1966 Sheet 1 of 6

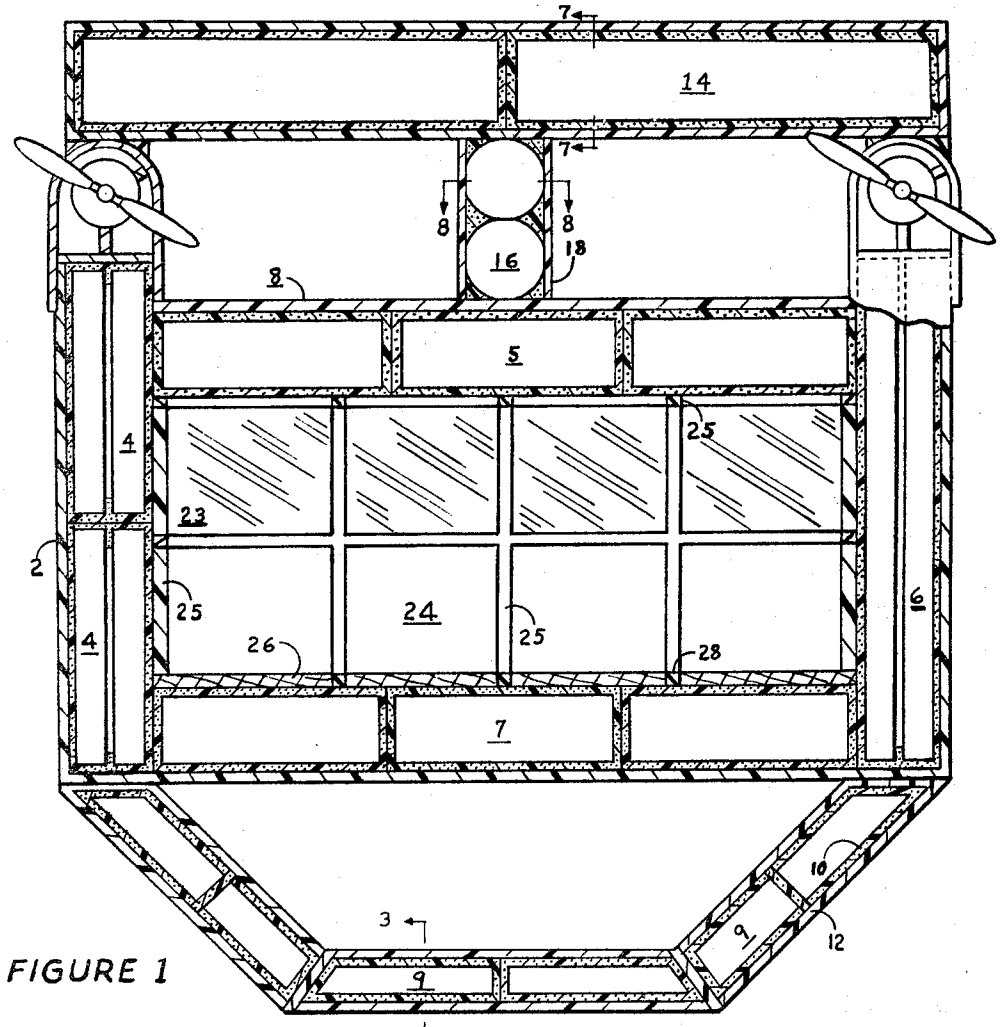


FIGURE 1

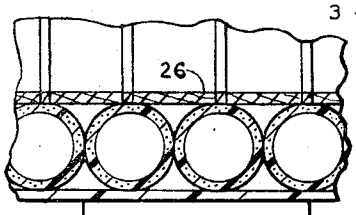
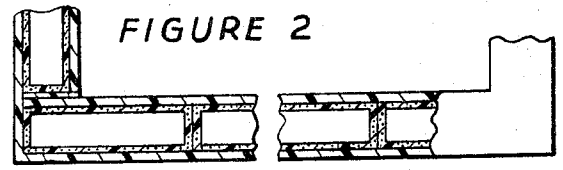


FIGURE 2



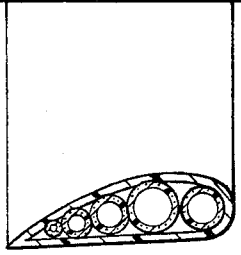
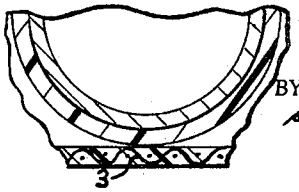


FIGURE 3

FIGURE 4



ALVIN E. MOORE,
INVENTOR.

BY Alvin Edward Moore,
ATTORNEY.

FIGURE 5

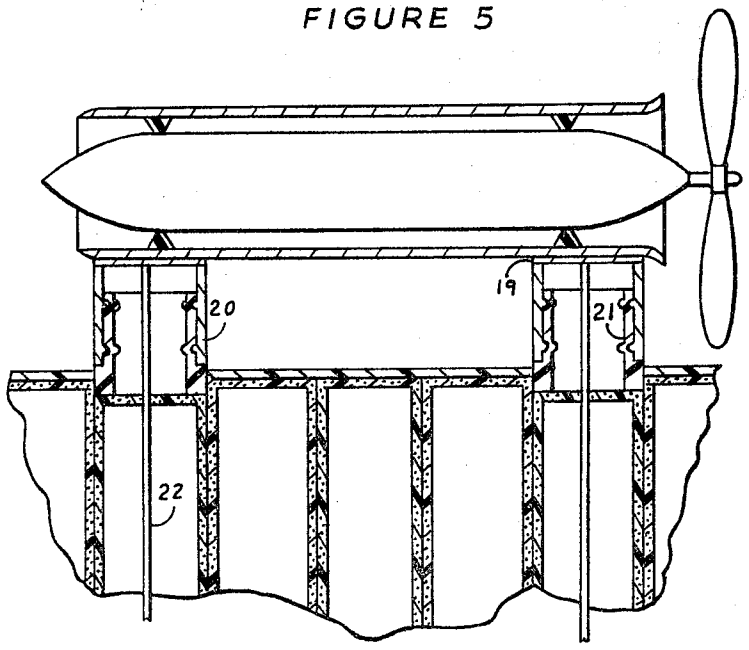
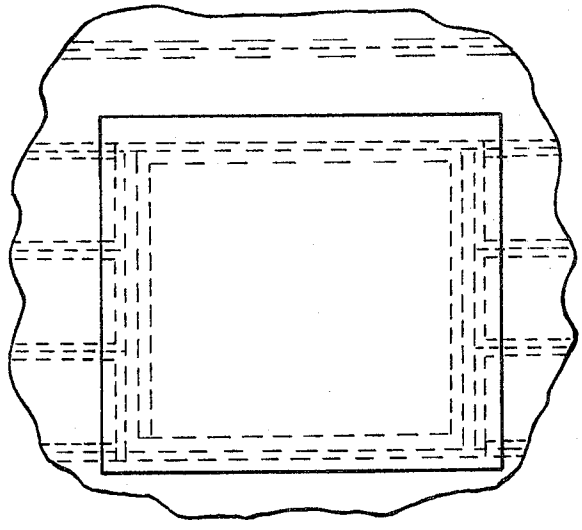


FIGURE 6



INVENTOR:
ALVIN EDWARD MOORE,
BY
Alvin Edward Moore,
ATTORNEY

March 11, 1969 A. E. MOORE 3,431,878

FLUIDFOIL RINGCRAFT

Filed March 3, 1966 Sheet 3 of 6

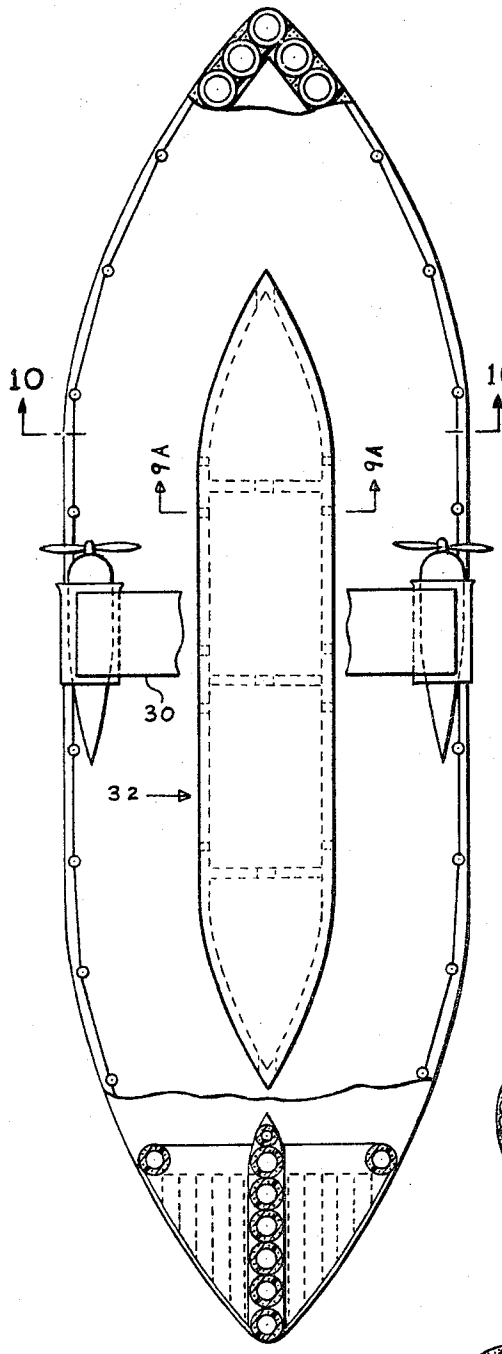


FIGURE 9

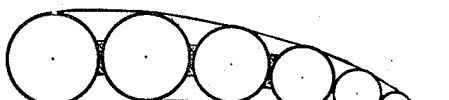


FIGURE 7

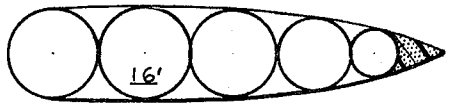


FIGURE 8

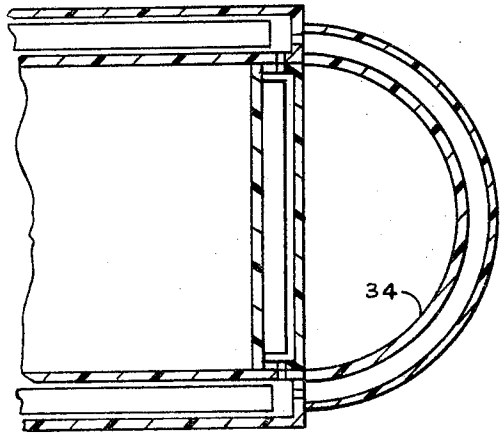


FIGURE 10

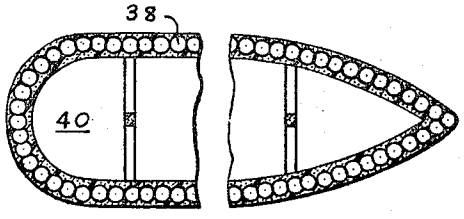


FIGURE 11

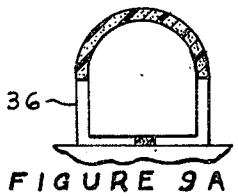


FIGURE 9A

ALVIN E. MOORE,
INVENTOR.

BY Alvin Edward Moore,
ATTORNEY

March 11, 1969 A. E. MOORE 3,431,878

FLUIDFOIL RINGCRAFT

Filed March 3, 1966 Sheet 4 of 6

FIGURE 12

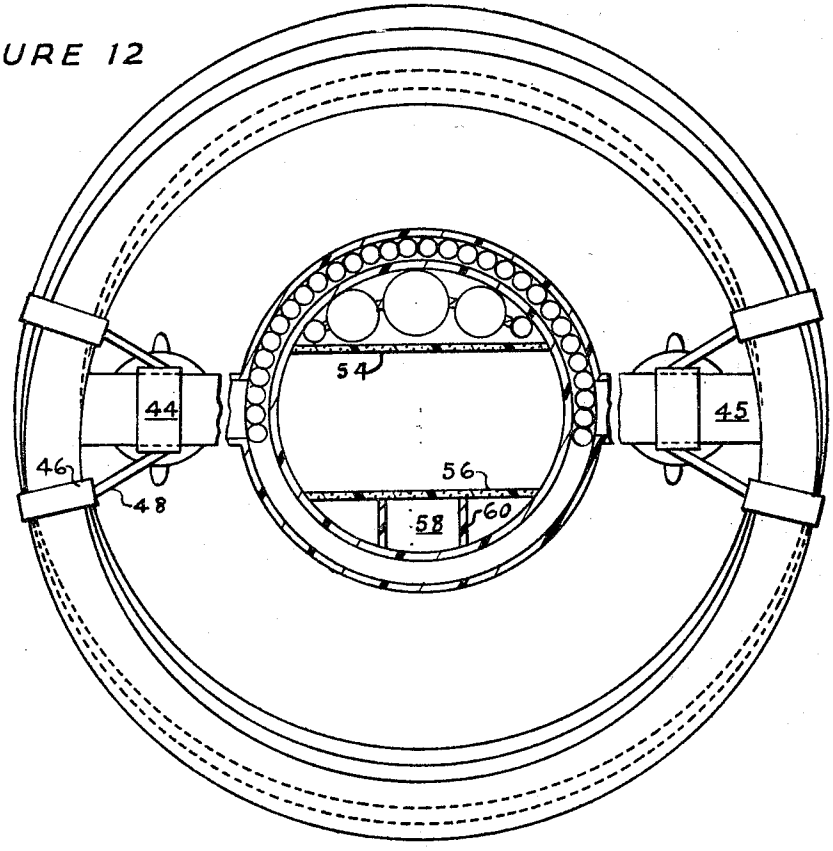
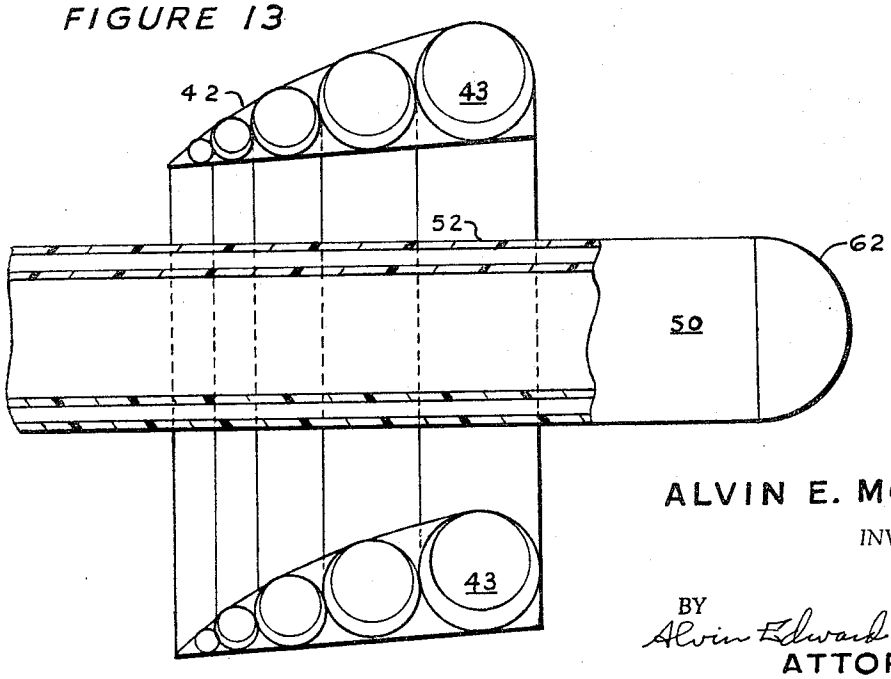


FIGURE 13



ALVIN E. MOORE,
INVENTOR.

BY Alvin Edward Moore,
ATTORNEY

March 11, 1969 A. E. MOORE 3,431,878

FLUIDFOIL RINGCRAFT

Filed March 3, 1966 Sheet 5 of 6

FIG. 14.

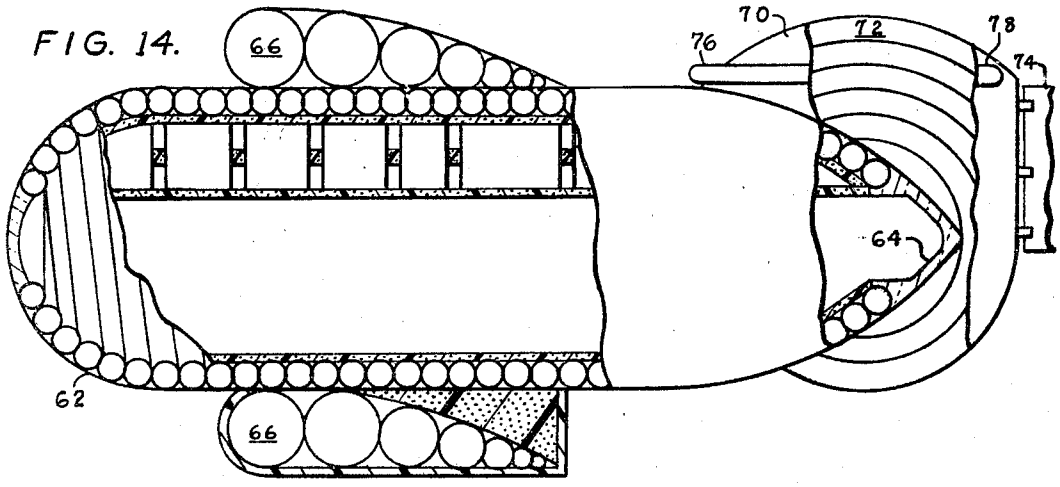


FIG. 16.

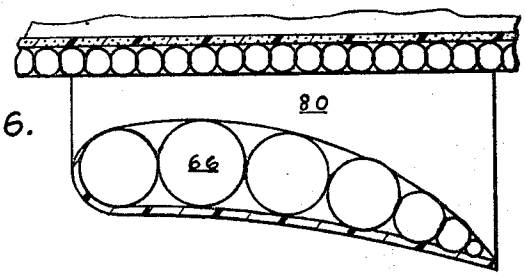


FIG. 15.

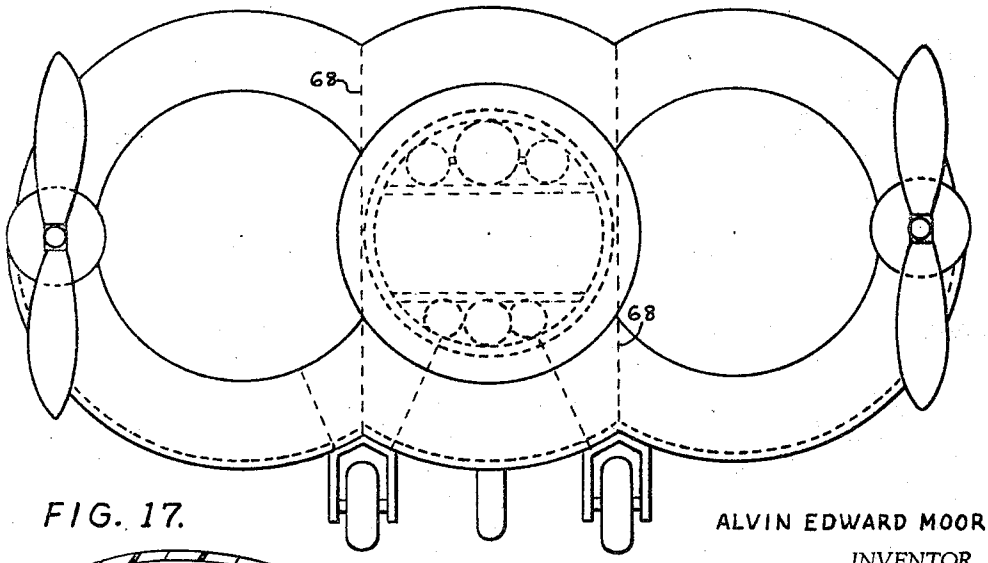
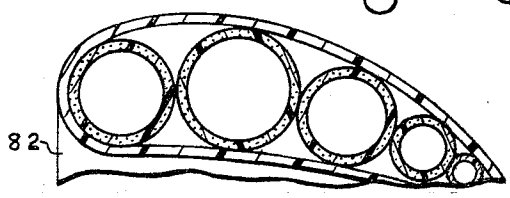


FIG. 17.



ALVIN EDWARD MOORE,
INVENTOR.

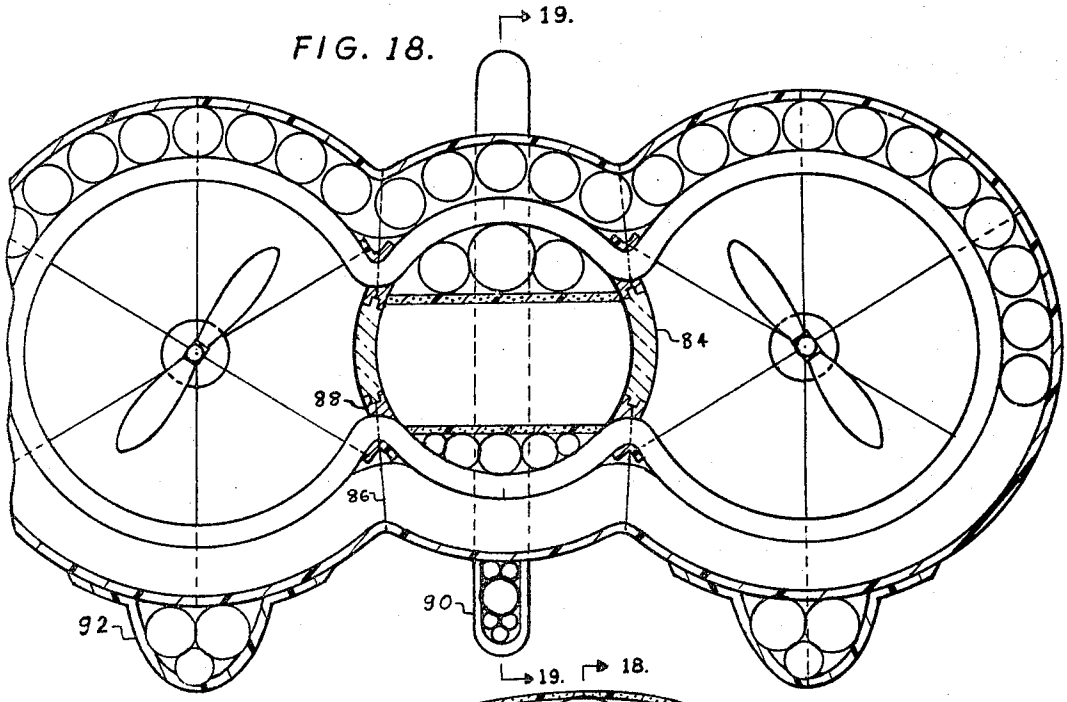
BY
Alvin Edward Moore,
ATTORNEY.

March 11, 1969 A. E. MOORE 3,431,878

FLUIDFOIL RINGCRAFT

Filed March 3, 1966 Sheet 6 of 6

FIG. 18.



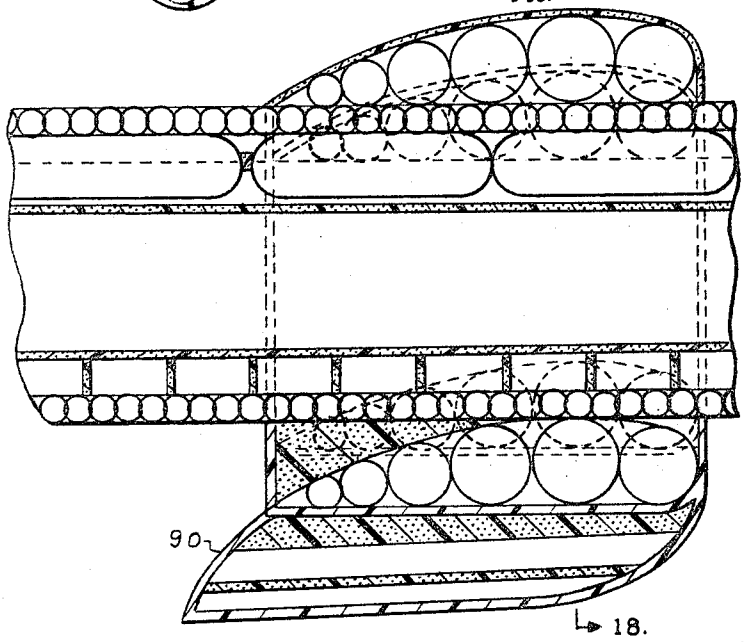


FIG. 19.

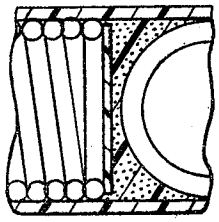


FIG. 20.

ALVIN EDWARD MOORE,
INVENTOR.

BY Alvin E. Moore,
ATTORNEY.

United States Patent Office 3,431,878
Patented Mar. 11, 1969

3,431,878

FLUIDFOIL RINGCRAFT

Alvin Edward Moore, 916 Beach Blvd.,
Waveland, Miss. 39576

Filed Mar. 3, 1966, Ser. No. 531,565
U.S. Cl. 114—66.5 55 Claims
Int. Cl. B63b 1/18

ABSTRACT OF THE DISCLOSURE

A lightweight, slightly heavier-than-air vehicle (such as an aircraft or boat), yieldable without fracture under major shocks, having fluid-dynamic and aerostatic lifting means. It comprises: flexible skin means; strength-providing, shock-resisting elements of flexible material within the skin; flexible (optionally foam) plastic surrounding said elements and between them and the skin; and optional lighter-than-air balloons in the plastic. To a cabin or fuselage there are attached upper and lower fluidfoils, each of which has a flexible skin comprising plastic and, within the skin, strength-providing elements, which may be inflated tubes, or spring-steel mesh or the like imbedded in the skin plastic. When the vehicle is in water the lower fluidfoil is a hydrofoil. Optional means to provide aerostatic lift, centered above the vehicle's center of gravity, may be in flexible foam plastic that substantially fills a fluidfoil skin, or may be an elongated balloon.

This invention pertains to a boat, aircraft or other vehicle that has a flexible skin and within it a strength-providing framework of resilient elements, the lower part of the framework comprising such elements (that may be tubes) and a flexible skin that has fluid-dynamic surfaces. As used in this specification and the appended claims, the term fluid-dynamic surface is defined as a surface which moves through or relative to a fluid (water or air) and which has a lifting dynamic force exerted on it by the fluid; and the term fluidfoil is defined as a vehicle element which has an upper, lifting, vacuum-forming, fluid-dynamic surface. In a vehicle designed as a boat the lower fluidfoil of this invention is a hydrofoil; and the upper fluidfoil is an aerodynamic wing; in a vehicle designed as an aircraft capable of taking-off from water the lower fluidfoil serves as a hydrofoil while it is in the water and as an airfoil while it is in the air; and in a vehicle having wheels that extend below the lower fluidfoil (or fluidfoils) both fluid-dynamic surfaces when underway obtain reaction from the air thru which they move.

The lower fluidfoils of the present invention preferably are used on a water-traversing or flying boat. As such, these lower foils in a considerable part of their use thus are hydrofoils.

In boats and aircraft—and especially in hydrofoil craft—there is a great need for flexibility of construction and safety—both from breaking-up and from capsizing, in the water or in the air. Most of the wrecks of such craft are caused by the breaking of rigid structure; and another major cause of disaster in boats is capsizing.

In the past hydrofoil boats have been subject to very harmful vibration. In moderately rough water such boats are usually and necessarily throttled down until their hydrofoils sink back into a lower part of the water, and the craft then moves slowly ahead, with the lower part of its hull as well as its hydrofoils submerged. This increase in area of wetted surface further slows the boat; for, as William Froude discovered nearly a century ago in investigations in an experimental tank in England, at low speeds surface or skin friction is the cause of nearly all the resistance to marine propulsion; and at a given speed this

drag is proportional to the area of the wet surface. Therefore this area should be reduced to a minimum.

On the other hand, if a boat of ordinary construction rises too high in the water it is subject to difficulty of control and of marine-propulsion and to danger of capsizing.

A good way both to decrease the area of wet surface and practically eliminate the danger of capsizing is to provide a source of aerostatic, lighter-than-air lift which is centered above the boat's center of gravity.

In view of the above facts, one of the objects of the present invention is to provide a shock-resisting vehicular structure, comprising strength-providing elements of flexible material, a flexible skin, and plastic between the flexible elements and skin.

Another object is to decrease the drag and vibration of a boat of the hydrofoil type.

A further object is to prevent capsizing of a boat by provision in it of an aerostatic lifting force that is centered above the craft's center of gravity.

Another object is to provide a flexible vehicle with a lifting fluidfoil at its base, at least one other source of lift exerted at a point above the craft's center of gravity, and a pair of widely-spaced, controllable propulsion means by which the craft may be steered.

A further object is to provide a vehicle having: flexible, resilient upper and lower wings; a flexible, resilient inflatable cabin framework; and, mounted in the upper part of the cabin, a plurality of hermetically-sealed balloons that are inflated with lighter-than-air gas.

Another object is to build a flexible boat, capable of low-flying, having lifting and stabilizing means comprising flexibly-jointed, hermetically-sealed balloons, permanently inflated with lighter-than-air gas.

The foregoing and other objects of the invention will become more fully apparent from the following detailed description of several forms of the invention and from the accmpanying drawings. For ease and clarity of illustration, the showing of the inflated tubes in these drawings is hatched to indicate synthetic rubber or other plastic, but in practice some of the elements thus shown preferably are reinforced with nylon or wire-mesh or other fabric, and some of the rubber or other plastic is mixed with fibers (asbestos, wood or cotton or other natural fiber, aluminum flakes, sand, or the like).

FIGURE 1 is a front elevational view of one form of the craft, mostly in section thru a transverse median plane in the midships portion of the vehicle.

FIGURE 2 is a detail, elevational view, mostly in section, on a reduced scale, of an alternative construction of the inflatable lower fluidfoil. It is a view from a plane comparable to that indicated by the line 3—3 of FIGURE 1.

FIGURE 3 is a detail, sectional view from the plane 3—3 of FIGURE 1.

FIGURE 4 is a detail, cross sectional view on an enlarged scale from a vertical plane parallel to the longitudinal axis of the craft, partly broken away, showing one form of structure of the wing, lower fluidfoil or lower half of the lower, cabin-interior deck.

FIGURE 5 is a detail, sectional view thru a propulsion unit, from a vertical plane thru the propeller axis. For ease of illustration, this unit is here shown before the upper fluidfoil is fastened to the upper parts of the motor nacelles.

FIGURE 6 is a detail view of one of the hatches or doors, which optionally may be placed in the side walls and/or the upper, exterior deck of the craft.

FIGURE 7 is a sectional view of the upper wing, from the plane 7—7 of FIGURE 1, showing one form of assembly of the inflated tubes.

FIGURE 8 is a sectional view from the plane **8—8** of FIGURE 1, but showing some alternative details of construction of the wing-bracing, streamlined strut.

FIGURE 9 is a plan view of another form of the vehicle of the invention, partly broken away amidships, and at the bow (to illustrate a cross section of the construction of the hull), and partly shown in horizontal section above the hull's stern to illustrate one form of construction of vertical and horizontal stabilizers at the tail of the craft. The after sectional plane is thru the vertical stabilizer and support for the horizontal stabilizer, but above the horizontal stabilizer.

FIGURE 9A is a detail, sectional view on plane 9A–9A of FIGURE 9.

FIGURE 10 is a sectional view from the plane **10—10** of FIGURE 9, its left-hand (upper) part being broken away.

FIGURE 11 is a sectional view on a horizontal plane thru the longitudinal axis of an alternative type of the jointed balloon on the upper deck of the craft of FIGURE 9.

FIGURE 12 is an elevational view, partly broken away in section, of a third form of the invention. The broken-away, sectional part of this view is forward from a plane through the cabin or fuselage that is just abaft the propulsion unit and that extends thru the supports from the fluidfoils for the propulsion unit and cabin; and the outer inflated rings are shown before they are enveloped in an outer skin.

FIGURE 13 is a side elevational view, partly broken away, of the craft of FIGURE 12, showing the outer skin as now being on the outer rings of FIGURE 12, the after, major portion of FIGURE 13 being in vertical section thru the longitudinal axis of the cabin and fluidfoils.

FIGURE 14 is a side elevational view, partly broken away, of a fourth form of the invention, with the major portion of the cabin, wings and tail structure being shown in section from a vertical plane thru the longitudinal axis of the craft.

FIGURE 15 is a front elevational view of the vehicle of FIGURE 14, with wheels added to illustrate the general manner in which this or any other of the disclosed invention forms may have wheels attached to the lower fluidfoil.

FIGURE 16 is a sectional side from the vertical, sectional, longitudinal-axis plane of FIGURE 14, showing an alternative way of connecting the lower fluidfoil to the bottom of the cabin.

FIGURE 17 is a detail sectional view from the vertical sectional plane of FIGURES 14 and 16, showing an alternative way of connecting the upper fluidfoil to the upper part of the cabin.

FIGURE 18 is a vertical, transverse, sectional view of a fifth form of the invention, from a plane normal to the longitudinal axis of the craft, just forward of the propulsion units, indicated by the lines **18—18** of FIGURE 19.

FIGURE 19 is a sectional view of the craft from plane **19—19** of FIGURE 18.

FIGURE 20 is a detail sectional view, from a vertical plane thru the transverse axis of the craft of FIGURE **18**, showing one way of constructing the flexibly-jointed, below-deck storage containers.

In the disclosed forms of the invention the framework of nearly all the structural elements comprises straight, annular, or helically wound inflated tubes, and the outer skin of the craft comprises waterproofed, metal or fibrous fabric or mesh. The tubes are flexible, preferably resilient, and preferably have walls that comprise means for limiting their distention by high-pressure inflation substantially to a predetermined size. If the craft's outer skin or envelope comprises either resilient, spring-metal mesh (impregnated with rubber) or resilient plastic, the flexible framework tubes optionally may be nonresilient.

All the disclosed forms preferably comprise balloon or other means for exerting a stabilizing and water-drag-reducing aerostatic lift, centered above the craft's center of gravity. At least a major part of this aerostatic lift preferably comes from a plurality of balloons or the like within the top part of the cabin, exerting a lift against the cabin's overhang, and preferably free to move, when the outer skin is subjected to a major fluid shock, relative to the overhang and to each other.

In FIGURE 1, the numeral **2** indicates the outer skin of the craft. Made of resilient or nonexpandable rubber-and-fabric or other plastic material, it extends entirely around the sides, top and bottom of the cabin. One example of a good material for this skin is metallic (for example, copper, iron or aluminum) wire mesh or fabric (indicated at **3** in FIGURE 4), impregnated and coated with a composition comprising synthetic or natural rubber or other plastic. This plastic preferably is reinforced by adding to it fibers (of asbestos—preferably short fibers), shredded wood, cotton or the like) or sawdust or sand. If a mesh of spring steel is used, preferably the wire fabric in annealed condition is first shaped to fit the hull or part of the hull, and then is tempered before applying it to the hull. The impregnation of the mesh with plastic composition may be done before or after wrapping the fabric material around the hull. If the mesh has been tempered and rubber is the plastic used it is cold-vulcanized by exposing it to a vapor or solution of sulfur chloride; or, alternatively, rubber-liquid cement (which sets into normal rubber as it dries) may be utilized.

When the plastic composition of the skin, containing fibers, is applied with a trowel or taping knife, the skin may be sanded smooth.

The stiffening, insulating and buoyancy-providing cabin frame work comprises a plurality of hermetically and permanently sealed containers **4**, **5**, **6** and **7**. As indicated in the side containers **4** and **6**, the sizes of the receptacles may be varied, according to engineering calculations. As shown in FIGURE 1, these comprise thin-walled cylindrical bags or cans of helium, hydrogen or other lighter-than-air gas, with thin buffering elements of foam plastic (for example, foam rubber) between each adjoining pair and between them and the skin. These buffering elements may envelop all or part of each container, or they may be small pieces of foam plastic glued to the containers where they are apt to strike the outer skin or each other.

The thin-wall material of the containers optionally is resilient, strong, rather dense plastic. If helium is used in them, it may be blown into a mass of the plastic while it is soft and in a mold, forcing the plastic while it is hot against the mold and into thin walls, and then withdrawing the helium-injection nozzle through a tight opening in the mold, which is closed while the plastic is still warm, preventing the escape of plastic or helium.

Preferably, at least the side and bottom containers **4**, **6** and **7** contain lighter-than-air gas at a pressure sufficient to cause the containers, when subjected to major shock through the vehicle's skin, to move relatively to the skin and each other without distortion of their walls. In other words, the containers are inflated to a pressure sufficiently high to insure that the foam plastic between the containers and the skin and between each pair will yield before the container walls yield. This pressure, for example, may be 10 to 30 pounds per square inch.

When the vehicle is mainly used as a boat the upper surface **8** preferably is designed for at least occasional use as an upper deck. In this event, this top of the cabin is preferably strengthened against bending under foot by inflating containers **5** also to a relatively high pressure—for example, of 15 to 30 pounds per square inch.

Any or all of the cabin containers **4** to **7**, as well as those of the fluidfoils and of the other four disclosed forms of the invention, may be made in the above-disclosed manner; or, alternatively, the material of their walls may be thin metal (for example, soft iron, spring

steel, copper, aluminum, magnesium, or an alloy of aluminum and magnesium), or it may be of glass.

The lower fluidfoil, which serves as a hydrofoil when the craft is moving in the water, comprises a plurality of flexibly-jointed containers **9** of lighter-than-air gas, sheathed or embedded in readily yieldable, resilient foam plastic **10**.

This foam plastic preferably fills all the spaces between the gas containers and the resiilent skin **12** of the fluidfoil.

Preferably, this skin comprises a mesh or fabric of spring metal, impregnated and coated with plastic-and-fiber composition. This fluidfoil skin may be integral throughout, or, as shown, may be of integrally-joined parts. If desired, the tubes it incloses may be inflated with air instead of lighter-than-air gas.

The upper fluidfoil or wing, which serves as an airfoil at all times of movement of the vehicle when it is an aircraft, comprises an outer skin and inflated, foam-plastic-encased containers **14**. It may be made in the same general manner as the lower fluidfoil. The volume of its containers **14** is calculatedly sufficient to insure that the center of aerostatic lifting force on the vehicle is above its center of gravity at all times. Stability in the water (or in the air or on the land) is thus obtained.

This upper wing is joined at its middle portion to the cabin by a thick, buoyant, streamlined, aerostatic strut. This comprises spherical or cylindrical containers **16**, filled with lighter-than-air gas, and imbedded in readily yieldable, resilient foam plastic, which occupies all the space between the lighter-than-air units and the strut skin, **18**. This skin is constructed in the manner of the skin of the fluidfoils.

FIGURE 8 illustrates the streamlining of this strut. Although the elements **16'** shown here may be spherical, preferably they are in the form of upright, closed-ended cylinders, which extend from the cabin top **8** to the wing and are securely fixed (as by tying and gluing) to the wing and cabin. In FIGURE 8 the lighter-than-air units are shown as comprising abutting metal or plastic containers, which decrease in diameter from the forward part of the wing to its trailing edge. The walls of the containers preferably are flexible and/or resilient metal or strong plastic.

The two, laterally spaced propulsion units may be of any known type. Although they may be jet-propulsion units, preferably each comprises a screw propeller and either an internal combustion engine or a motor which receives energy from a power plant placed on the lower deck. Preferably, hydraulic motors, driven by liquid under pressure from flexible, strong hydraulic hose and an engine-and-pump unit on the lower deck are utilized. Alternatively, the motors may be electrical and receive current from a generator on the lower deck. In either of these two arrangements, the center of gravity of the craft is placed lower than if upper engines were utilized.

In FIGURE 5 some details of construction are shown of one form of motor or engine that drives a propeller. The metallic motor nacelle is welded or otherwise fixed to metal plates **19**, which are secured to metal tubes **20** (streamlined in fore-and-aft direction); and tubes **20** are fixed to resilient plastic tubes **21**, which are integrally bonded to the skin. The motors are held strongly in position, preferably by means of cables or flexible rods **22**, fixed to plates **19**, and extending between pairs of the lighter-than-air containers down to the bottom skin, where they are anchored by means of plates similar to **19**.

The bow or nose of the cabin is not of less width than its midships and after portions, but it is streamlined. In this nose there is securely fixed, by means of a frame and rubber mounting, a plurality of windows, **23** which may be of strong glass or transparent plastic. Below these windows, and inside the inflated tubes and skin of the lower part of the bow there is optionally placed a plurality of tiles **24**, which may be of wood, but preferably are of porous, insulating plastic. Preferably this plastic is semirigid; and the tiles are joined to each other by means of rubber cement **25**. Tiles or boards of this type also bridge over the framework tubes at the sides and top of the cabin. And they may be used for the deck, but as shown the deck preferably comprises tiles **26** of cedar, balsa or other lightweight wood, dipped in rubber cement and joined together by rubber cement **28**.

The top of the cabin is streamlined downward to a line that is a sufficient distance above the deck at the stern to provide space there for a rear-view window or windows.

In the form of the invention shown in FIGURES 9 to 11 a long balloon is fixed to the open upper deck. An upper fluidfoil of the general type indicated in FIGURE 1 is shown, partly broken away, at **30**. It is fastened to and bridges between the upper parts of the motor nacelles, and passes over and is fixed to the top of balloon **32**. In both the vehicles of FIGURES 1 and 9 the motor nacelle supports (**20–21** in FIGURE 5) are sufficiently high to allow clearance above the top of the cabin for the tips of propellers of the diameter that is required for the desired power and speed, and if either of these craft is intended for considerable use as a boat, the supports will be high enough above the upper deck to allow walking, without uncomfortable stooping beneath the upper fluidfoil, from the bow to the stern. Alternatively, these supports may be made of metal-mesh-reinforced, inflated plastic tubes, similar to those of the strut of FIGURE 8.

The lower fluidfoil of the form of FIGURE 9 may be like that shown in FIGURE 1 or FIGURE 2. But optionally it may be made of arcuate, inflated, metal-reinforced plastic tubes of the type shown at **34** in FIGURE 10. In any event, it is of the streamlined type of construction shown in FIGURE 3.

Balloon **32** is built so as to be able to flex under major wind shocks or, while the craft is in the water, under bending force from strong waves, transmitted to the balloon through the lower, tubular framework of the vehicle. The balloon's skin is of flexible, resilient material. Preferably it is of resilient plastic, and optionally it is reinforced by a mesh of very fine, lightweight, spring-steel or resilient Phosphor bronze wire, imbedded in the plastic. Preferably, the skin's weight is kept low by placing such a spring-metal mesh only in the upper semicylindrical half of the skin; and, below the upper curvature, the skin **36** extends vertically downward, as illustrated in FIGURE 9A, to its attaching junction with the deck, and this lower part of the skin is reinforced with nylon, rayon or fiber glass mesh.

Resilience of the skin thus is provided by the very-small-diameter spring-metal wires and transmission of the lifting force of the balloon is effected mainly by the lightweight, but nonresilient fibrous mesh, which is securely attached to the spring-metal fabric. A secondary support for the balloon, at its middle, is effected by means of the bracing and bridging fluid foil **30**.

An alternative way of constructing balloon **32** is shown in FIGURE 11. In this figure the outer framework of the balloon may comprise a multiplicity of annular, doughnut-shaped, inflated tubes; but preferably long, extruded-plastic tubes **38**, of very small diameter (for example of one-fourth to three-eighths of an inch), are helically wound around a core of properly-shaped, flexibly-jointed foam-plastic-sheathed containers **40** of lighter-than-air gas, such as helium or hydrogen. The walls of the tubes are thin, and may be made, for example, of high-density polyethylene; and they may be sheathed by an outer skin of thin plastic or balloon silk or other cloth. Optionally, there may be a very thin layer of flexible foam plastic around the tubes, and this plastic may be coated with a solid film of plastic for a waterproof, smooth outer surface. Optionally, the convolutions of the tubes may be flexibly glued together, for example, by rubber cement. The inner containers **40** are of very thin plastic, and may be made of high-density polyethylene. The balloon is securely tied and glued to

the deck. Its lifting force optionally may include lighter-than-air inflating gas in tubes **38**.

FIGURES 12 and 13 show a third species of the invention. In this form the inflated tubes of the upper and lower fluidfoils (shown with their enveloping skin in FIGURE 13 and without the skin in FIGURE 12) are annular and are so placed as to consitute the framework of an upper airfoil that obtains dynamic reaction on its surfaces from the air through which it moves, and a lower fluidfoil (hydrofoil and/or airfoil) which obtains such reaction from movement through water or air. This dual lifting reaction is achieved from annular, and therefore very strong, inflated rings due to the fact that, considering the foils from their leading edges to their trailing edges, the rings successively are on centers of curvature that are lowered. At their horizontal median plane the rings nearly come together in a roughly streamlined shape, which may be improved by fairing this portion with foam plastic between the rings and their outer skin, **42**. Each ring may be inflated with air or nitrogen and have within it a floating lighter-than-air ring **43**. As illustrated in FIGURE 13, the inner inflated ring has major and minor diameters that are smaller than those of its enveloping outer tube, so that as an entirety the inner tube floats upward and exerts a lift on the outer ring, and thus on skin **42**.

The propulsion units are supported from the outer rings by metal bands **44** that are clamped on strong, streamlined, inflated struts **45** that extend between and are attached to the outer rings and the fuselage or cabin. Bands **44** are also connected and braced to the outer rings by means of bands **46** that are clamped to the rings and braces **48** that are fixed to bands **44** and **46**.

The streamlined fuselage **50** may be constructed, as illustrated in FIGURES 11 and 12, of a helically-wound, flexible, inflated, small-diameter tube (or two end-to-end-joined, separately-inflated tubes); but in FIGURE 13 an alternative type of cabin framework is shown. In this figure the lighter-than-air units, deck and other internal structure have not yet been installed. The cabin comprises a plurality of extruded tubes **52**, which extend from the separately-formed, partially-transparent cabin nose to the separately-formed, streamlined, partially-transparent cabin's stern. These tubes are flexibly glued together (for example, with rubber cement) and are tightly enveloped in the waterproofed skin of the cabin.

Inside the fuselage of FIGURES 12 and 13 there are upper and lower sheets **54** and **56** of semirigid but flexible foam plastic, glued to the annular inner tube walls, demarcating between them, a space for the pilot, passengers and, if necessary, machinery. Above sheet **54** numerous round-ended cylinders or global containers of lighter-than-air gas float, with freedom to move away from the inflated tubes when they are under major shock. And below deck covering **56** there are numerous thin-metal storage tanks and deck supports **58**. Each adjoining pair of these tanks are connected by a sheet of flexible plastic **60** (which optionally may be foam rubber).

A fourth species of the invention is shown in FIGURES 14 to 17. The illustrated vehicle comprises interconnected upper and lower fluidfoils which have middle portions that are securely and tightly clamped to a cabin and looped outer portions that support propulsion units and provide passageways for the slipstreams from the propellers. The cabin or fuselage is round in cross section. Its basic framework may be of numerous, juxtaposed, inflated rings, but preferably, and as shown in FIGURE 14, it is made of one or more helically wound long tubular elements of very small diameter. In FIGURE 14 this size is shown as considerably larger than the preferred tube, which is of about one-fourth to three-eighths of an inch in outside diameter. This small size insures considerable flexibility under major shock without much distortion of the tubular element's walls. These tubular elements preferably are provided with inflation valves for the supply of compressed air or lighter-than-air gas.

Their material may be very thin iron, steel or copper (for example, of a thickness of .0012" to .006"). Pure aluminum also may be used, but due to the tendency to crystallize when bent it is not preferred. Some aluminum alloys—for example, duralumin or magnalium—are satisfactory; magnalium containing about six percent of magnesium, being light in weight, very strong, ductile and easily worked is one of the preferred materials. Other preferred materials are: thin copper (which greatly resists corrosion and is exceptionally ductile); soft or wrought iron (very ductile and economical in cost); steel (which may be helically wound when in annealed condition and then converted into spring steel by tempering); rubber- and fabric (similar to rubber water hose but smaller in diameter, and preferably containing only one ply of fabric, which may be fibrous or metal fabric or mesh); plastic other than rubber, reinforced with fabric, which may be fibrous or metal mesh; resilient plastic (for example, polyethylene) which resists buckling except under unusual bending stress. If steel, resilient plastic or fabric-reinforced plastic is used it does not require an outer thin layer of flexible foam plastic (between it and the cabin's skin) of the type shown in FIGURE 11; but when one of the other, ductile materials which have a tendency to buckle slightly under major bending stress is used the foam-plastic outer layer is preferred. Although not necessary for safe functioning of the craft, this layer of readily yieldable material within the tight outer skin insures that this streamlined skin will remain smooth and cause little turbulence.

Although such is not clearly shown in FIGURE 14, the cabin, as in FIGURE 13, has a separable semispherical nose portion **62**. This part has a transparent, preferably plastic window and is preferably hinged, so that it serves both as window and door. The frames of other windows and/or doors, of the general type illustrated in FIGURE 6, may be sealingly bonded to cut ends of the wound tube—cut after winding and flexibility gluing together the convolutions of the long tubular element, which extends from the nose portion **62** to the transparent-plastic tail window and tube support, **64**. If windows or doors are built into the sides of the craft, the separately inflated tubular elements, if of ductile material, are sufficiently numerous to insure safety and comfortable traveling to a point of repair, but if the tubes are of resilient metal or plastic they will not permit the vehicle to become too limp in such seeking of repair, even in the unlikely event that all of them are punctured. If the tubes are of very ductile material and no windows at the sides break their length, preferably two of the tubes are sealingly joined, end-to-end, into one wound tubular element that has two inflation valves.

The doorway in the nose, being as large as the interior diameter of the fuselage, permits use of a rigid, lightweight mandrel, around which the tubular elements are snugly and helically wound. After this operation is completed, the convolutions of the tubes preferably are glued together with flexible cement (for example, rubber cement that sets into rubber when it dries). Then the mandrel is withdrawn, and if windowed doors are to be installed in the sides holes for them are cut through the glued tubular elements, and the door frame is then sealingly bonded to the cut edges.

Alternatively, the holes may be cut while the rigid mandrel is in place. Also, if desired, an inflatable mandrel, withdrawn when it is deflated, may be used.

The fluidfoils provide lifting force; and they support the propulsion units and fuselage above water, or (as shown in FIGURE 15) above either water or land, and on wheels. These foils comprise looped, inflated tubes, **66**, having valves that are accessible from their outer air-exposed surfaces, and preferably are of flexible plastic of limited expansion (for example, of rubber and fabric).

The tubes, of decreasing diameter in a forward-to-after direction, may be molded into the general shape shown in FIGURES 14 and 15; but preferably they are first and separately formed in annular or oblong shape and then are clamped and glued about the cabin. Also, their middle parts are tied to the cabin and to each other by cords or wire elements **68**.

At the stern there is a vertical stabilizing fin **70**, bonded and tied to the fuselage, comprising concentric, arcuate, inflated tubes of the same diameter, **72**, tightly encased in a waterproofed skin, and bonded at their vertical trailing edge portions to a bar of metal, to which is hinged rudder **74**. A horizontal stabilizing fin, **76**, also of arcuate, inflated tubes in a waterproofed skin, is bonded and tied to fin **70**, and hinged to its two vertical after surfaces (which are perpendicular to the skin of **70**) th re is an elevator **78**. The rudder and elevator are controlled by levers and cables from the inside of the cabin.

FIGURE 16 shows a variant of the manner in which the middle part of the lower fluidfoil is attached to the fuselage. Between the foil and the cabin there are interposed two streamlined vertical struts, **80**, which preferably are made of vertical, juxtaposed, resilient, inflated tubes. This construction permits the middle part of the lower fluidfoil (as well as the side-loop part) to provide lift, from streams of fluid that pass both above and below this middle portion. FIGURE 17 indicates a similar construction which permits extra lift from the upper fluidfoil. In this figure the numeral **82** indicates one of the parallel pairs of inflated, streamlined struts which support the upper fluidfoil (or wing) above and out of direct contact with the fuselage.

In the species of the invention illustrated in FIGURES 18 and 19 plastic or glass windows are shown at **84**. These windows, in outline, are substantially square or rectangular, and the looped, endless, inflated tubes or rings are tightly and resiliently fastened by tie elements **86** to the window frames **88**. These frames are shown as of metal, but optionally they may be of plastic. Where there is no window space opposite the fluidfoils tie elements similar to **68** extend from the upper wing to the lower fluidfoil, through the fuselage skin and between outer surfaces of the helically-wound, inflated tubular elements (or alternatively between juxtaposed inflated annular rings).

FIGURES 18 and 19 also show optional floats **90** and **92**, which preferably comprise inflated tubes housed in resilient foam rubber. Float **90** may be secured only to the lower fluidfoil, as shown in FIGURE 19; or, as shown in FIGURE 18, it may be part of a looped set of inflated tubes, shaped to snugly fit over the fluidfoils and the cabin, and extending from the nose of the craft to its stern. If stern steering and elevating controls are utilized in the latter construction the rudder is hinged to the trailing edge of this set of tubes, the horizontal stabilizer is fixed to the set, and the elevator is hinged to the stabilizer.

FIGURE 20 illustrates an optional construction of the below-deck storage containers of water, fuel, or other material that optionally may be parts of some of the forms of the invention. As here shown, the two cylindrical storage tanks, housed in flexible foam plastic, have perpendicular longitudinal axes, so that they are staggered. Each tank comprises a helically-wound inflated tube of the above-described type, and at each end of the tank there is a plastic or metal closure plate **94**, bonded to the tube. The convolutions of this tube are flexibly and sealingly joined with glue in the manner, indicated above, of the gluing of the convolutions of the tube **38** of FIGURE 11 and of the fuselage tube of FIGURE 14. When the flexible storage tanks are used to store liquid they are thus sealed against its leakage. They may be positioned below the surface of the main deck—for example, replacing some of the containers **7** in the vehicle of FIGURE 1, or the cylindrical lighter-than-air units shown in the deck of FIGURE 10, or the storage tanks **58** of FIGURE 12. As indicated in FIGURE 20, showing in vertical cross section two of these flexible storage containers (as partly broken away), preferably the tanks in the deck structure are staggered relative to each other, in a way similar to the staggering of bricks in a wall. Since the longitudinal axis of one tank is perpendicular to the longitudinal axis of each adjacent tank, extra stiffness and strength of the deck is achieved, but some flexibility under major shocks is maintained.

In this position the tanks serve best for the storage of liquids, which may be pumped in or out through hose connections to the surface of the deck. If solid materials are to be stored in the tanks their longitudinal axes preferably are perpendicular to the surface of the deck, and plate **94** (or part of it) is hinged for placing the stored objects in the containers.

In the claims the word "plastic" is used to signify any type of natural or synthetic rubber or other plastic; the word "gas" to signify any pure gas or gaseous mixture; and the word "fabric" to signify any kind of woven material or of mesh, comprising fibers or metallic wire or filaments; the word "tube" or expression "tubular element" to mean an elongated article, having spaced wall portions, that is circular or noncircular in cross section, and is open or sealed; fluidfoil and the word "boat" to refer to a water-traversing and/or flying boat.

I claim:

Add the following claims:

1. A boat having a load-supporting body and a fluidfoil located below the boat's center of gravity which functions as a hydrofoil when the boat is traversing water, said fluidfoil comprising

flexible skin means having upper and lower fluid-dynamic surfaces, said skin means during forward motion of the boat having a substantially invariable extent of surface that is continually exposed to, and provides smoothly flowing contact with, streams of fluid over the skin means; and

shock-resisting, strength-providing means holding said skin means in continual smooth contact with said streams, comprising resilient framework within the skin means.

2. A device as set forth in claim **1**, in which said resilient framework comprises a plurality of tubes of resilient metal.

3. A device as set forth in claim **1**, in which said resilient framework comprises a plurality of sealed tubular elements of resilient material, and gas under pressure above that of the atmosphere in said tubular elements.

4. A device as set forth in claim **3**, in which said gas is lighter than air.

5. A device as set forth in claim **1**, which further comprises elongated, lighter-than-air balloon means, exerting an aerostatic lift on said body that is centered above the center of gravity of the vehicle.

6. A vehicle as set forth in claim **1**, in which said shock-resisting means comprises tubular elements.

7. A vehicle as set forth in claim **1**, which further comprises an upper fluidfoil, exerting, when the vehicle is underway, a fluid-dynamic lift on said body.

8. A vehicle as set forth in claim **1**, in which said fluidfoil comprises: a middle part that is spaced below the bottom of said body; and two side parts, each of which extends generally upward and is connected to said body.

9. A device as set forth in claim **1**, in which said shock-resisting means comprises flexible plastic between said resilient framework and skin means.

10. A vehicle as set forth in claim **1**, in which said resilient framework comprises at least three elongated tubes of varying cross sectional areas, arranged in tandem, with their major axes athwart the relative direction of said fluid, when the vehicle is underway, with the cross section of at least one after tube being smaller in area than that of the adjacent tube that is forward of it.

11. In a vehicle, a vehicular structure comprising fluidfoil means having:

an outer network of strong, resilient elements and flexible, compact plastic, impregnating said network;

a skin layer of flexible, compact plastic over and contiguous to said network and first-named plastic, said layer having upper and lower portions with streamlined surfaces that are exposed to fluid current when the vehicle is underway, said upper surface being fluid-dynamically contoured to exert a vacuum-caused lift on the vehicle, said lower surface being located well below the center of gravity of the vehicle and constructed and arranged to exert a pressure-caused lift on it; and

strength-providing means between said streamlined surfaces.

12. A device as set forth in claim 11, adapted to float in water, in which said fluid current is of water and in which said fluidfoil is adapted to coact with said water in exerting hydrodynamic lifting force on said body.

13. A device as set forth in claim 11, in which said strength-providing means comprises tubular elements of spring metal.

14. A device as set forth in claim 13, in which said tubular elements are sealed and contain gas.

15. A device as set forth in claim 14, in which said gas is under pressure above that of the atmosphere.

16. A structure as set forth in claim 11, comprising a load-supporting body, in which said network, skin layer of plastic and strength-providing means constitute a fluidfoil below said body that acts as a hydrofoil when the vehicle is traversing water, said structure further comprising means connecting the ends of said fluidfoil to laterally spaced edge portions of the bottom of said body.

17. In a vehicle:

a body having a load-supporting part;

resilient fluidfoil means for exerting substantial fluid-dynamic lifting force on said body, constructed and arranged to yield without fracture under major shocks and to return to its former configuration after a shock is over, having: skin means, comprising resilient plastic and resilient mesh, having a surface extent that, during forward travel of the vehicle, is in continual fluid-dynamic contact with fluid flowing over the fluidfoil means; and stiffly flexible means within and normally holding said skin means in smooth, fluid-dynamic condition, comprising resilient, strength-providing elements having substantially permanent shapes; and

means permanently connecting certain portions of said resilient elements to said body, holding during forward travel of the vehicle said surface extent constantly in fluid-dynamic contact with said fluid.

18. A device as set forth in claim 17, in which said plastic impregnates and coats said mesh.

19. A device as set forth in claim 17, which comprises containers of gas within said resilient plastic and mesh.

20. A device as set forth in claim 17, which comprises containers of gas within said plastic and mesh, and gas-cell-containing skin means.

21. A device as set forth in claim 17, in which said resilient mesh is of spring metal.

22. A device as set forth in claim 17, in which said connecting means comprises at least one strut having strut skin means, and resilient, substantially upright, strength-providing members, said strut skin means having surfaces that are shaped to cause smooth flow of fluid over the strut.

23. A device as set forth in claim 17, in which said connecting means comprises at least one streamlined strut having a streamlined skin and a plurality of resilient, strength-providing tubes of several cross-sectional areas within said skin.

24. A device as set forth in claim 17, in which at least a major portion of said fluidfoil means is located below the bottom of said body.

25. A device as set forth in claim 17, in which said fluidfoil means comprises upper and lower fluidfoils and said connecting means comprises attachment elements joining said fluidfoils, and in which said upper and lower fluidfoils and connecting means encompass portions of said body.

26. A device as set forth in claim 25, in which portions of said skin means of the fluidfoils are joined in a continuous skin around said body, and at least some of said resilient, strength-providing elements are connected in substantially resilient structures that encompass the body.

27. A device as set forth in claim 17, in which said fluidfoil means comprises an upper fluidfoil, and a lower fluidfoil that is of less width than said body; and in which part of said connecting means, having outer surfaces adapted for smooth flow of fluid over them, extends in an inclined, upward direction to a junction with a portion of said body.

28. A device as set forth in claim 17, which further comprises propelling means, located above the vehicle's center of gravity, comprising at least one motor and at least one motor-driven propeller; and a source of power, located in said body, below said center of gravity.

29. A device as set forth in claim 26, in which said continuous skin and some of said strength-providing elements are constructed and arranged to form a plurality of fluidfoil arches that add strength against collapse to said fluidfoil means.

30. A device as set forth in claim 29, in which at least some of said strength-providing elements are tubular, continuous loops arranged in tandem along a fore-and-aft plane, each of which has an upwardly convex portion that substantially conforms to the arch of the upper fluidfoil and a downwardly convex portion that substantially conforms to the arch of the lower fluidfoil, and in which the central point between upper and lower arches of a loop, equidistant from its upper and lower convex portions, is successively lower in progressing along said plane from a forward loop to a loop that is adjacent to the trailing edge of the fluidfoil means.

31. A vehicle, with a shock-absorbing outer part that is strongly resistant to minor shocks but resiliently yields under major shocks, having a body providing a load confining space, and a passage into said space large enough for entry of a person, said vehicle comprising:

skin means comprising a thin layer of resilient plastic, and within said layer skin-strength-providing means comprising metallic mesh;

vehicle-strengthening members within said skin means comprising curved, hollow, sealed, tubular elements that are round in cross section;

gas within said elements;

anr resilient, shock-absorbing foam plasttic between said skin means and elements.

32. A device as set forth in claim 31, in which said vehicle is a boat.

33. A device as set forth in claim 31, in which said resilient foam plastic is synthetic rubber polymer.

34. A device as set forth in claim 31, in which the metal of said mesh is resilient.

35. A device as set forth in claim 34, in which said metal is spring steel.

36. A device as set forth in claim 31, in which said first-named resilient plastic impregnates and coats said mesh.

37. A device as set forth in claim 36, in which said plastic impregnating said mesh is integrally joined with said thin layer of plastic.

38. A vehicle, having a body, providing a load-confining space and a passage into said space large enough for entry of a person, said vehicle having:

skin means comprising a thin layer of flexible plastic, and within said layer skin-strength-providing means

comprising numerous spaced, slender elements of metal that are joined at points;

stiffly flexible vehicle-strengthening members within said skin means comprising hollow, thin-walled tubes and tube-stiffening means within said tubes; and

flexible plastic within and in contact with said skin means and said tubes.

39. A device as set forth in claim **38**, in which said tube-stiffening means comprises gas under pressure greater than that of the atmosphere.

40. A device as set forth in claim **38**, in which said vehicle-strengthening members comprise spirally wound tubular convolutions.

41. A device as set forth in claim **38**, in which said tubes comprise joined spiral convolutions of at least one helically wound tubular element that encompasses said load-confining space, and said tube-stiffening means comprises reinforcing means in said helically wound tubular element.

42. A device as set forth in claim **41**, in which said helically wound tubular element is sealed and said reinforcing means is gas within the said tubular element under pressure greater than that of the atmosphere.

43. A device as set forth in claim **42**, in which said helically wound tubular element is of metal.

44. A device as set forth in claim **42**, in which said gas is lighter than air.

45. A device as set forth in claim **38**, in which said tubes are of thin steel.

46. A device as set forth in claim **38**, in which said tubes are endless and in juxtaposition.

47. A device as set forth in claim **38**, in which said vehicle-strengthening members are of spring metal, and in which said last-named flexible plastic has in it a multiplicity of minute gas cells.

48. A device as set forth in claim **47**, in which said spring metal is steel, and said slender elements are interconnected in a mesh.

49. A vehicle as set forth in claim **38**, in which parts of said skin means, vehicle-strengthening members and flexible plastic are constructed and arranged to form a streamlined strut, connected to said body.

50. A device as set forth in claim **38**, in which said last-named plastic comprises a jacket of shock-absorbing foam plastic around each of said sealed cylinders.

51. A devce as set forth n clam **38**, n whch sad

51. A device as set forth in claim **38**, in which said tubes contain gas that is lighter than air.

52. A device as set forth in claim **38**, in which said vehicle comprises a balloon, connected to said body, said balloon comprising at least portions of said skin means, vehicle-strengthening members and flexible plastic.

53. A vehicle as set forth in claim **38**, having a propulsion means which comprises: a relatively heavy source of energy, located in a lower portion of said body; and at least one relatively lightweight propulsive device, utilizing said energy, located above the center of gravity of said body.

54. A device as set forth in claim **38**, in which said tubes comprise cylindrical tubular elements, each of which has a length that is at least three times its diameter.

55. A device as set forth in claim **54**, in which said tubular elements are hermetically sealed cylinders, containing gas under pressure above that of the atmosphere.

References Cited

UNITED STATES PATENTS

1,697,770	1/1929	Kreikenbohm	244—34
1,851,279	3/1932	Hitt	114—66.5
1,857,347	5/1932	Beebe	114—66.5
2,349,584	5/1944	Arnstein et al.	114—66.5
2,875,720	3/1959	Hupp	114—66.5
2,933,266	4/1960	Von Zborowski	244—117
3,106,373	10/1963	Bain et al.	114—66.5
3,184,187	5/1965	Isaac.	
2,382,817	8/1945	Reiss	244—5
3,067,712	12/1962	Doerpinghaus	114—74.1
3,179,077	4/1965	Wai Po Loo.	
3,237,218	3/1966	Moore	9—2

FOREIGN PATENTS

28,704	1911	Great Britain.

ANDREW H. FARRELL, *Primary Examiner.*