Aug. 29, 1967 A. E. MOORE 3,338,203

SKIBOAT

Filed March 3, 1966 4 Sheets-Sheet 1

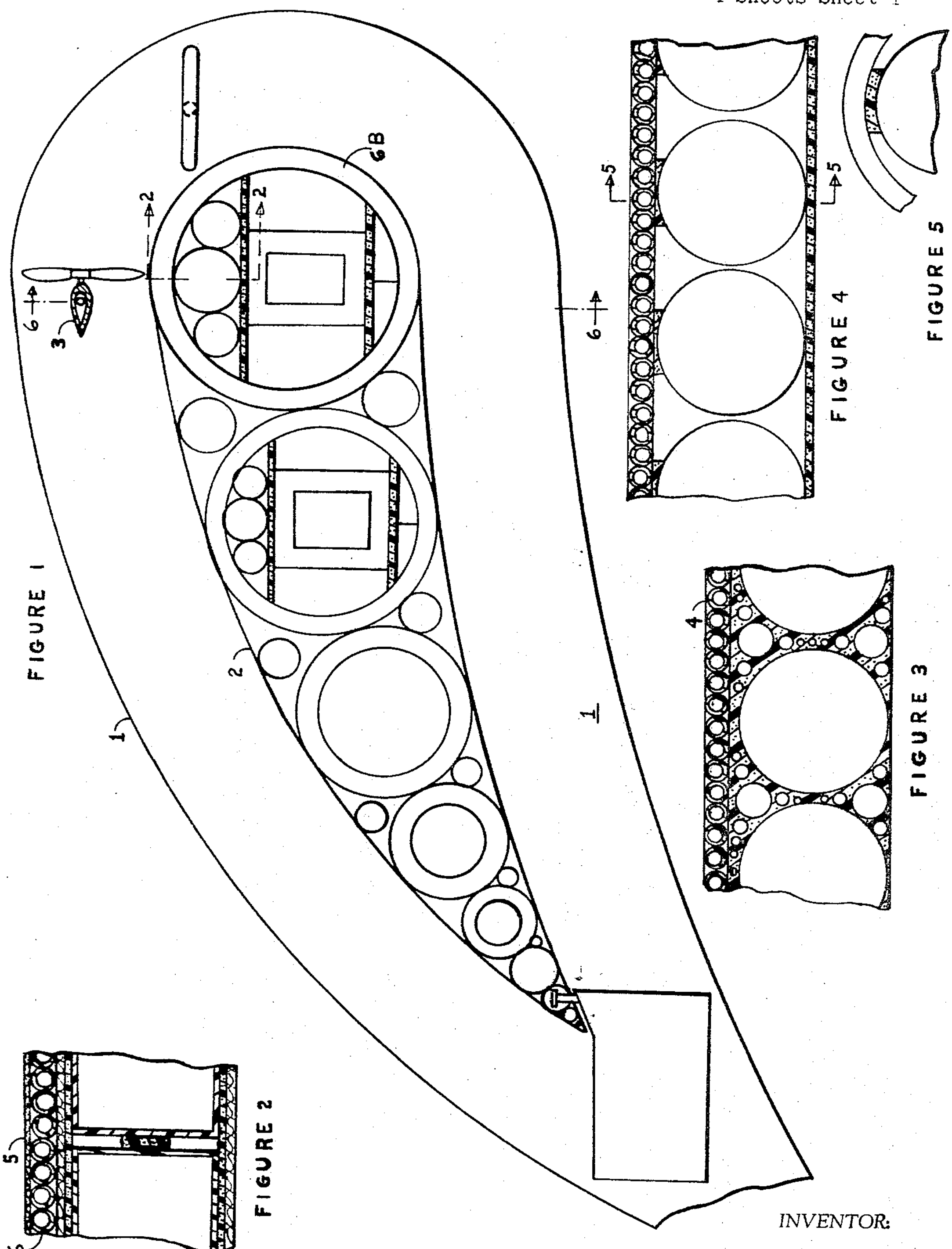


FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

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

Aug. 29, 1967 A. E. MOORE 3,338,203

SKIBOAT

Filed March 3, 1966 4 Sheets-Sheet 2

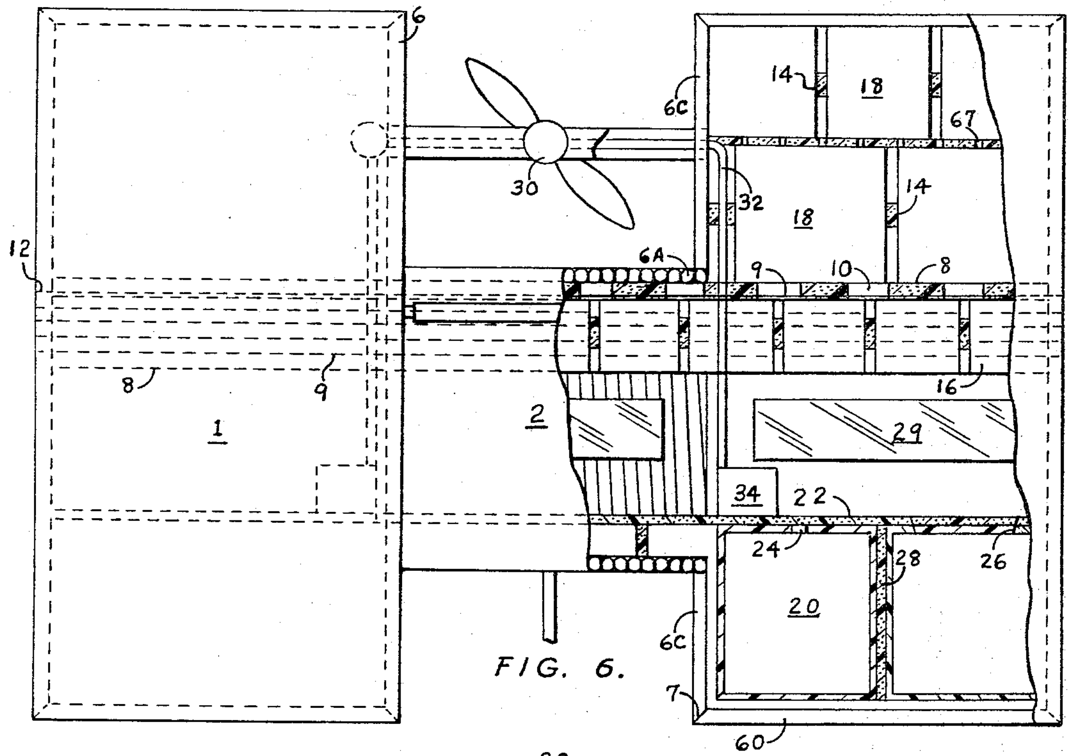


FIG. 6.

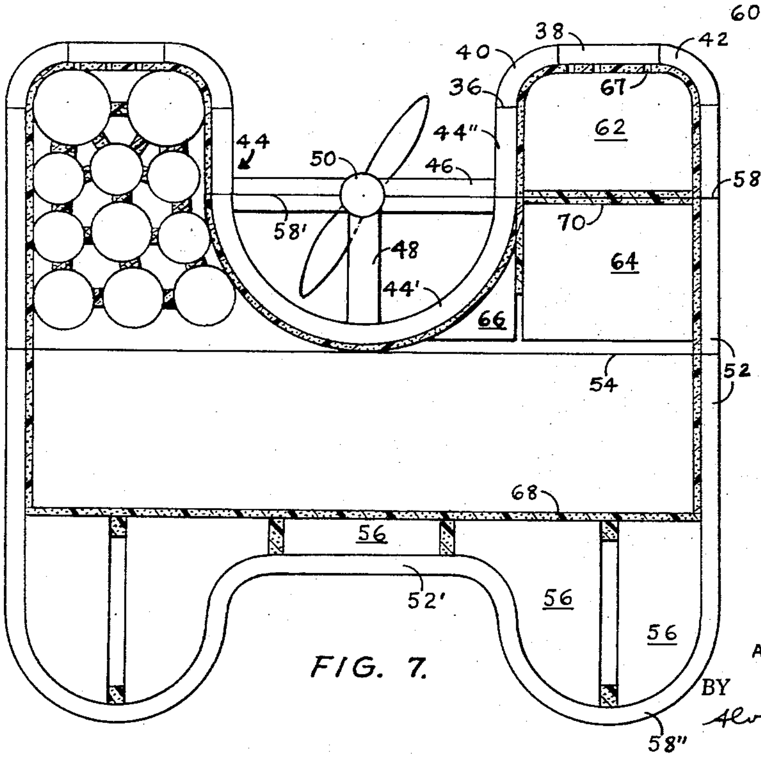


FIG. 7.

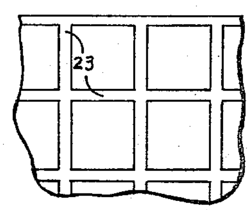


FIG. 8.

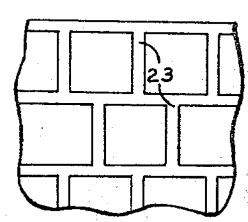


FIG. 9.

INVENTOR:
ALVIN EDWARD MOORE.

BY Alvin Edward Moore,
ATTORNEY.

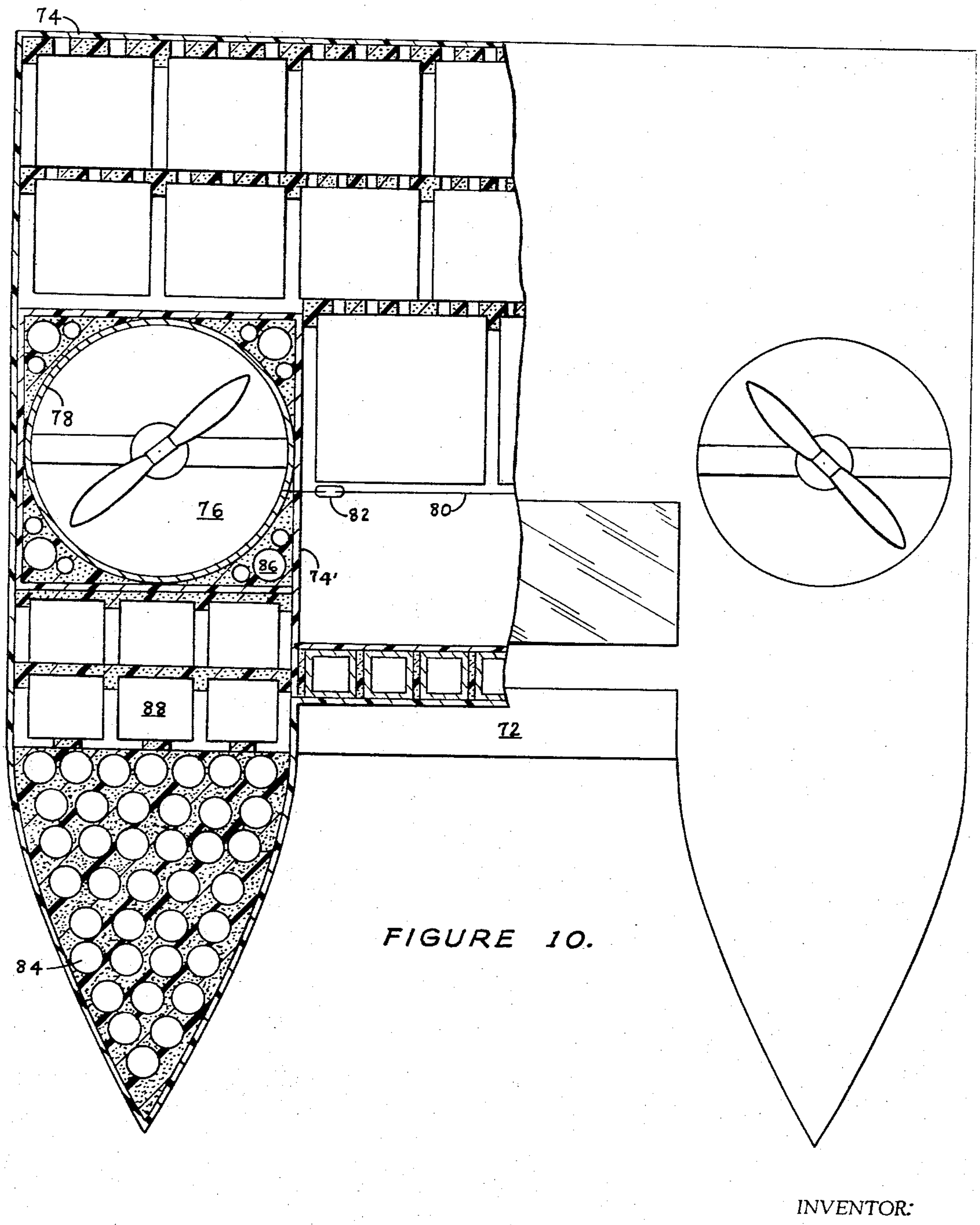



FIGURE 10.

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

Aug. 29, 1967 A. E. MOORE 3,338,203

SKIBOAT

Filed March 3, 1966 4 Sheets-Sheet 4

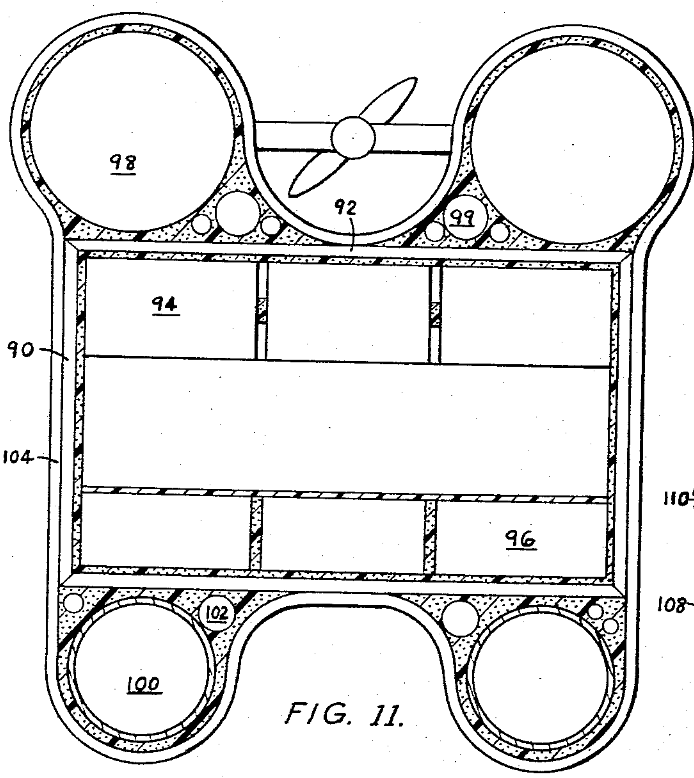
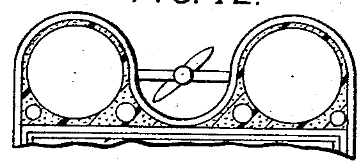



FIG. 11.

FIG. 12.



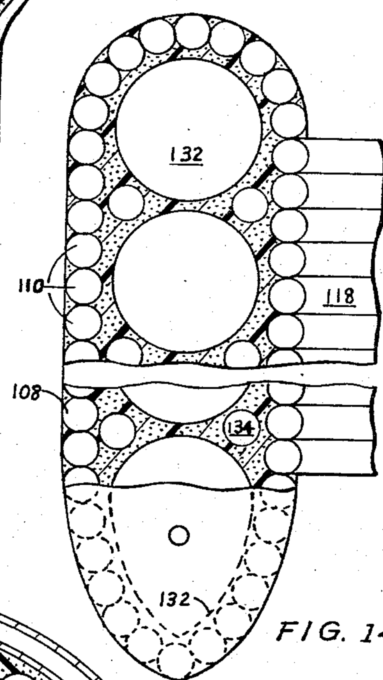



FIG. 14.

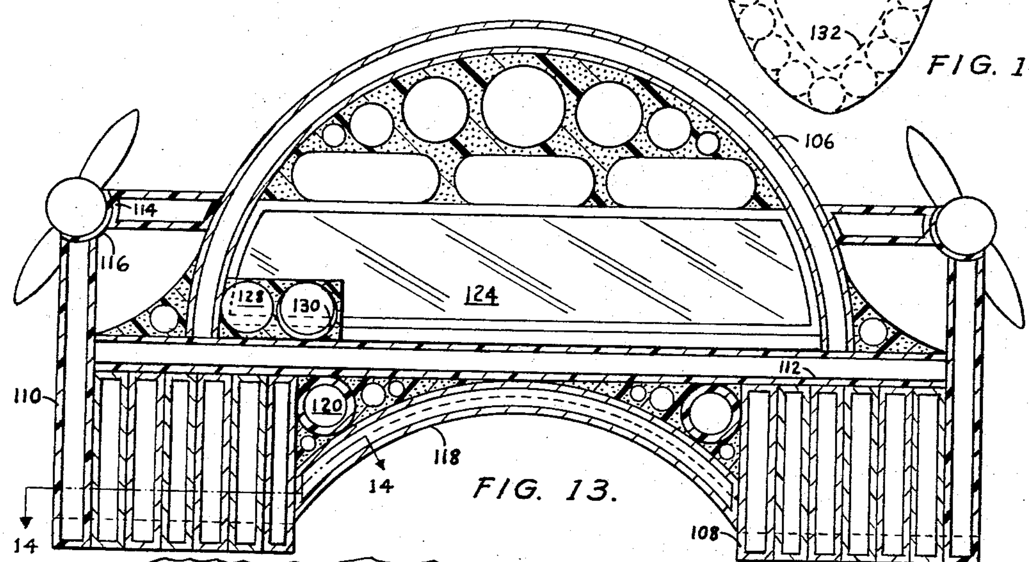



FIG. 13.

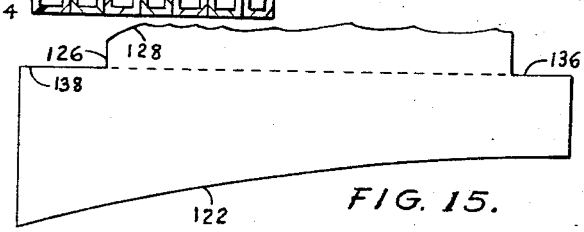



FIG. 15.

INVENTOR:
ALVIN EDWARD MOORE.

BY Alvin Edward Moore,
ATTORNEY.

United States Patent Office 3,338,203
Patented Aug. 29, 1967

1

# 3,338,203
# SKIBOAT

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

Filed Mar. 3, 1966, Ser. No. 531,566
19 Claims. (Cl. 114—66.5)

This invention pertains to a flexible, light-weight vehicle that is especially adapted for traveling on the surface of water and at low altitudes in the air and has little danger from capsizing or wreckage.

There is a present marked tendency of man to get away from crowded highways and return to much use of marine craft, and particularly to boats on streams, lakes and coastal waters. But three ancient dangers of marine travel remain—breakage from collision, wrecks on rocks and shoals, and sinking from capsizing; and these risks have been intensified by the great increase in users of boats, including some amateurs who are reckless. Also in the use of aerial and land vehicles these dangers of collision, hurtling against surface obstructions and capsizing are becoming intensified. The invention of craft that largely can avoid these disasters is thus urgently necessary.

Accordingly, one of the objects of the present invention is to provide a vehicle that has a flexible but strong framework and skin, capable of resisting minor shocks, but yielding under major shock and then returning to its former shape and strength.

Another object is to present a vehicle having a resilient outer structure, and within this structure a load-containing space and a plurality of lighter-than-air units that are capable, without distortion, of movement relative to said structure and to each other, when the structure bends under a major shock.

Another objective is to devise a vehicle which has a flexible and strong skin and framework, and which houses a plurality of lighter-than-air units that may move without distortion relative to each other and to the cabin.

A further object is to provide a vehicle cabin having a resilient outer structure, and within it a plurality of ballons exerting a lifting pressure on the upper part of the structure and a plurality of storage containers in the lower part of the structure, each of said balloons and containers being capable, without distortion, to move away from a point of major shock to said structure.

Another purpose is to provide a boat, adapted for use on water or in the air, comprising spaced flexible floats, and resilient structure bridging between the floats having a lower surface that slants downward from a forward to an after portion of the craft and in forward motion on the water provides a wedge of pressurized air or water between it and the floats, tending to lift the bridging structure out of the water.

Another objective is to provide resilient vehicle floats with lower surfaces shaped to lift the floats in the water or air.

Another object is to present a compactly and strongly integrated vehicle comprising aerostatic means to exert a lifting force on the vehicle at a center of lift that is above the craft's center of gravity, a cabin, and air-propulsion means located above the lower deck of the cabin.

A further purpose is to devise a craft that is very light in weight, but a little heavier than air, capable of rising in the water with increased speed, thus reducing its hydraulic drag and making a relatively high speed on the water, capable, with appropriate adjustment of an elevator and/or with still further increased speed, of taking off from the water, and capable of landing from the air with a short run in the water.

The foregoing and other objects of the invention will become more fully apparent from the following detailed

2

description of several forms of the invention and from the accompanying drawings. For clarity of illustration, the showing in these drawings of certain inflated tubes is hatched to indicate synthetic rubber or other plastic; but in practice the plastic of these tubes preferably is reinforced with fibrous or metallic fabric or mesh. Also for aid in illustration in some of the cross-sectional views the thickness of the vehicle's skin and the diameters of its inflated tubes have been considerably magnified above the actual sizes of the skin and tubes.

FIGURE 1 is a sectional view, partly broken away, of one form of the invented vehicle, taken from a vertical, median plane through the longitudinal axis of the craft.

FIGURE 2 is a sectional, detail view from the plane **2—2** of FIGURE 1, with the outer skin, the annular, inner lining of the inflated cabin-tubes, the containers of lighter-than-air gas and the cabin's ceiling or overhang being shown as enlarged.

FIGURE 3 is a sectional, detail view from plane **2—2**, showing an alternative type of aerostatic means.

FIGURE 4 is a sectional, detail view from plane **2—2**, showing another type of lighter-than-air unit.

FIGURE 5 is a sectional, detail view from plane **5—5** of FIGURE 4.

FIGURE 6 is a rear elevational view of the craft, with part of the rudder shown as broken away and with most of the right half of the view being in section from the plane **6—6** of FIGURE 1.

FIGURE 7 is a sectional view of a second form of the invented vehicle, taken from a transverse, vertical plane similar to plane **6—6** of FIGURE 1.

FIGURE 8 is a detail, plan view, partly broken away, of one type of deck surface material.

FIGURE 9 is a detail, plan view, partly broken away, of an alternative arrangement of the flexibly-jointed tiles of FIGURE 8.

FIGURE 10 is a front elevational view of a third form of the invention, with a major portion of the vehicle being shown in vertical section from a plane that is normal to the craft's longitudinal axis and is just forward of the propellers.

FIGURE 11 is a sectional, elevational view of a fourth form of the invented craft, taken from a vertical, transverse plane just abaft the propulsion unit.

FIGURE 12 is an elevational, sectional, detail view from a plane similar to the sectional plane of FIGURE 11, and on a scale reduced from that of FIGURE 11, showing an alternative type of upper construction of the vehicle of FIGURE 11.

FIGURE 13 is a sectional, elevational view of a fifth form of the invented craft, taken from a vertical, transverse plane just abaft the propellers.

FIGURE 14 is a sectional view, partly broken away, taken from a plane comparable to that indicated by lines **14—14** of FIGURE 13, showing the float-bridging tubes and the outer structure of the floats of FIGURE 13, but illustrating an alternative type of inner construction of the floats.

FIGURE 15 is a side elevational view, partly broken away and on a reduced scale, of the craft of FIGURE 13.

The vehicle of FIGURES 1 to 6 is generally shaped like a very large flying wing. It comprises two spaced, strongly resilient, buoyancy-providing, load-carrying side elements **1**, of relatively high elevation, that are securely joined at their middle parts by a bridging, resilient, buoyancy-providing, load-carrying central element **2**, and are further and securely joined, above element **2**, by another bridging and bracing, resilient, light-weight member **3**, which supports air-propulsion means.

The craft has an overall skin which is strong, flexible, and preferably resilient to a degree of strength determined by engineering calculations and the chosen nature of any other resilient frame structure that is within the skin. This skin **4**, optionally may comprise a strong, flexible plastic sheet **4**, or, as shown in FIGURE 2, a metallic or fibrous mesh (or other fabric) **5**, that is impregnated with flexible rubber or other plastic, or (preferably) with a composition comprising resilient rubber or other plastic mixed with plastic-reinforcing fibers of asbestos, metal, fiberglass, wood or cane, or with sawdust or sand.

Sanding the outer surface of at least part of the skin after it is in place on the craft is of value for reducing turbulence. This comprises sanding the flexible-glue joints between the cut sheets if they have been previously factory-made, or sanding the whole skin if the uncoated mesh or other fabric is first applied around the framework and then the plastic composition is troweled on the fabric.

When a resilient mesh or other fabric (or equivalent crossed, but not integrally-joined, set of resilient wires) is used it may be of spring metal (for example, spring steel or resilient Phosphor-bronze) or springy plastic (preferably of the thermosetting type). Such resilient material, imbedded in the plastic composition then serves two functions: (1) strengthening and stiffening the plastic composition of the skin, in the same general manner of fibrous-fabric reinforcement; and (2) adding to the resiliency of the skin plastic the additional resiliency of spring-steel, resilient Phosphor-bronze or spring-plastic wire or filaments. In this event—and especially if the reinforcing resilient material is in the form of wires, rods or narrow bands of sufficient diameter or rectangular dimensions to insure the necessary strength—the additional resilient outer framework of inflated tubes, shown in FIGURES 1 to 6, may be eliminated. Preferably, however, as a double protection against collapse from blows, the resilient framework comprises both the skin reinforcement of spring metal or the like and inside the skin the inflated tubes **6**.

This tubular framework may comprise numerous, long, juxtoposed, fore-and-aft extending tubes, each of which is bent around the semiannular nose or bow of the craft and brought aft (above, below and to the side of the interior structure) to the streamlined tail, where its two ends are cut on a slant and bonded together. But, as illustrated in FIGURE 6, the bridging element **2** has a tubular framework comprising a long, small-diameter, inflated tube, **6A**, that has been helically wound on a removable mandrel from one of the side members **1** to the other, with its juxtaposed convolutions flexibly glued together or, as illustrated in FIGURE 1, this framework optionally comprises a plurality of transversely-juxtaposed, inflated, annular tubes **6B**, with their sidewalls flexibly glued together. If these tubes are large in diameter they may contain, floating within their compressed gas, a plurality of small receptacles that hermetically contain a lighter-than-air gas. But preferably they, as well as the other framework tubes, have a very small diameter (for example of one-fourth to one-half of an inch). This small side enables the tubes to bend a great deal without undue distortion, and without possible rupture of the tube's material.

This material may be: flexible plastic (resilient or non-resilient); rubber or other flexible plastic that is reinforced with metallic or non-metallic mesh or other fabric; very thin metal (for example, copper of a thickness of .0012" to .006", soft iron, aluminum, aluminum alloy, resilient Phosphor-bronze or spring steel). If spring steel is used the tube is preferably inflated, and is helically wound on the mandrel while in an annealed state, and then it is tempered. The choice of material used in these tubes depends on the material used in the skin, and on engineering calculations, cost, and the environment of the intended craft's use. If the skin contains a tough, resilient reinforcing framework the material of the tubes may be either resilient or flexible without; but if the skin is non-resilient a resilient material is proferably used for the tubular framework. The tubes may be inflated with air or any other available gas. If their material is metal or high-density plastic that is substantially impermeable to gas they may be hermetically and permanently sealed, and the gas then is preferably helium, hydrogen or other lighter-than-air gas, but if their material is permeable to gas they are recurrently inflated thru valves in the tubes, preferably with air or some other economically-obtained, non-explosive gas.



Tubes 6A (or 6B) may be extended from one outer side of the craft to the other, but as shown they terminate at points that are inside and adjacent to the ends of the vertical, inner-sidewall tubes, **6C**. Straight tubes **6C** are arcuately cut to fit tubes **6A** and are bonded to **6A** and horizontal tubes **6D**. Tubes **6D** are also bonded to the outer vertical tubes of side elements **1**. All these straight tubes are cut diagonally at their ends and there bonded to imperforate pieces **7** of flexible, fabric-reinforced plastic or other suitable material and in bonding each pair of the tubes the pieces **7** are vulcanied or glued together. The inflating gas thus cannot pass from one of these tubes to another, and they are not bowed from their straight lines by such intercommunicating gas.

Optionally, and as illustrated in FIGURE 6, an arcuate pad, **8**, is glued or otherwise fixed to the lower surfaces of the upper portions of helical tube **6A**. Imbedded in this flexible, foam-plastic pad, are spring-plastic or spring-steel wires or slender rods or bars, **9**. For clarity of illustration, the upper one of these resilient elements is shown in FIGURE 6 as passing thru weight-lightening holes **10** in the pad, but in practice these holes of course are molded in or cut thru the foam plastic in places where there are no residient elements **9**.

The purpose of these elements is to securely hold together the two side members **1** and the bridging section **2** an dto stiffen the craft against undue transverse bending. These ties are securely fastened at **12** to the outer vertical tubes.

Another type of resilient pad or tie member that optionally may be used, in place of pad **8** and having the same arcuate shape, comprises a plurality of straight, small-diameter, inflated, juxtaposed and flexibily-glued-together tubes, extending between and bonded to the outside vertical sidewall tubes.

Members **1** and **2** house numerous lighter-than-air units which exert a lifting force on the craft. The smallness of these units and the buffering elements **14** which lie between the units and are numerous in directions both transverse and longitudinal of the craft insure that, when major shocks are transmitted to the thin material of the units, it will not buckle, while the affected unit as a whole moves away from the point of outside shock. The desired flexibility of the entire craft thus is not counteracted by large-diameter or unduly long balloons.

These lighter-than-air units preferably have thin walls of a high-density material that is substantially impermeable to gas. This material may be: high-density plastic; ductile metal; or resilient material (for example, spring-steel, Phosphor-bronze, or high-density resilient plastic); or rigid material (for example, rigid, high-density plastic, magnesium, magnalium with a high percentage of magnesium, or glass). Each unit or receptacle contains either lighter-than-air gas (such as helium, hydrogen, or hydrogen mixed with a small percentage of inert gas) or a vacuum. If vacuums are utilized their containers are round-ended cylinders or spheres and are of a rigid material, which advantageously may be dense plastic or glass (and, for example, may be similar to common electric-light bulbs, but without their necks and metal elements. Currently, lighter-than-air gas is preferred over the vacuums.

One transversely-arranged set of these units, **16**, extends from one side wall of the craft to the other, and floats upward and against reinformed pad **8**. Each of these units may be cylindrical, but preferably is in the shape of a half-cylinder, with a semi-cylindrical upper surface that conforms to the arc of pad 8, and a lower surface that lies in the horizontal plane of the lower edges of the pad. This combination of arcuate pad and semi-cylindrical containers constitutes a bridge across the craft which, optionally, may be placed either: lower than the bottoms of the other lighter-than-air units 18 (possibly requiring that a passenger stoop in walking under the bridge); or its lower, plane surface may be at the same height as lifting units (not shown) that are forward and aft of the bridge.

Each of the buffers 14 is glued only to one of the lifting units, thus providing extra freedom of the units to move relative to each other. If the containers are round-ended cylinders of flexible material and the lowermost units have clearances below them, allowing them and any units above them to move freely in any direction, the buffers 14 optionally may be eliminated; but such alternative is not currently preferred.

The lighter-than-air gas used in the lifting units preferably is hydrogen, hydrogen mixed with a small percentage of comparatively inert gas, or helium. Hydrogen, weighing .00562 pound per cubic foot, is only about half as heavy as helium.

It can be mixed with about ten percent of inert gas (as a safety factor) and still be very light in weight. The heaviest one of the inert gases contemplated in this invention is carbon dioxide, a very strongly effective inhibitor of combustion and explosion. It weighs .124 pound per cubic foot and thus is considerably heavier than air, but a very small amount of it that is mixed with hydrogen is effective in inhibiting combustion of the diffused mixture. Such a mixture which is 95 percent hydrogen and 5 percent carbon dioxide weighs only .011258 pound per cubic foot and thus has about the weight of helium. Even if the carbon dioxide is 8 percent of the hydrogenous mixture it still is only about a fifth of the weight of air. It thus may safely be used as a lifting agent not only in receptacles 16 and 18 but also in tubes 6.

Other comparatively inert gases that are suitable for use in the hydrogenous mixtures of this invention are nitrogen, helium and ammonia. Nitrogen, which is economically and plentifully obtained weighs .0782 pound per cubic foot. It chemically combines with hydrogen only when heated in the presence of a catalyst (usually finely divided iron mixed with aluminum or potassium oxide). These two gases thus may be safely diffused into an inert mixture in a closed container. An example of such a mixture comprises 92 percent of hydrogen and 8 percent of nitrogen; it weighs .0114264 pound per cubic foot, and thus has very nearly the lifting power of helium.

Ammonia, because of its lightness (weighing only .0482 pound per cubic foot) and its plentiful, low-cost supply, is an excellent safety factor in hydrogenous lifting gas. Except in the presence of a catalyst (usually platinum) it does not support combustion. An example of a safe hydrogen-and-ammonia gas consists of 90 percent hydrogen and 10 percent ammonia. It weighs only .009878 pound per cubic foot and thus is considerably lighter than the sometimes hard-to-obtain helium. Even when ammonia is 15% of this mixture it is still only slightly heavier than helium. It may be satisfactorily used in tubes 6 and lifting units 16 and 18 unless they are made of copper or copper alloy. Because ammonia vapor attacks copper or brass it should not be in contact with these materials.

If the thin walls of lighter-than-air units 16 and 18 are of flexible material they preferably are filled with lighter-than-air gas at atmospheric, or slightly above atmospheric, pressure. But if they are of either rigid or strongly flexible material (for example, resilient or rigid plastic, spring-metal, glass, or magnalium that contains a high precentage of magnesium) they may be filled with lift-gas at a sub-atmospheric pressure—for example at one-fourth to one-half of atmospheric pressure.



Such a low pressure inside the containers is of value in four ways: (1) it tends to insure that if any permeabity-to-gas at all exists in the dense materials of the thin walls air moves only in to the containers (in extremely small amounts), and the valuable lifting gas does not move out of the receptacles; (2) it decreases the amount and cost of the lifting gas; (3) it increases the lifting force from a given volume of the containers; and (4) if pure hydrogen is used as the lifting gas it almost eliminates any danger of its explosion. A given volume of hydrogen may be mixed with any amount of air without danger of explosion if the pressure of the mixture is one-fifth or less than one-fifth of an atmospheric pressure. At one-half atmospheric pressure the hydrogen content of the receptacles may be reduced by permeation of air to 65 percent without danger of explosion of the mixture even if a flame were in it; which of course is impossible within the sealed containers. Thus if hydrogen is sealed in these receptacles (which are free from buckling) at half-atmospheric pressure it will exert a strong lifting force on the vehicle and remain non-explosive for the life of the craft.

A vacuum in the container of course is theoretically preferable, but in practice the desired thinness of its walls may not be strong enough to withstand the difference of pressure between the vacuum and the cabin atmosphere. But such thin, light-weight walls may be amply strong enough to withstand the difference between half-atmospheric and atmospheric pressures.

Also inside the cabin there are storage containers, 20 made of reinforced plastic or sheet metal or of helically-wound small-diameter, inflated tubes. These receptacles additionally serve as supports for deck 22, which may be flexible or solid or foam plastic, or tiles of semi-rigid plastic or wood as shown in FIGURE 8 or FIGURE 9. These tiles are flexibly connected together by rubber or other flexible cement, 23.

Deck 22 is preferably horizontal both across and lengthwise of the craft. To secure its horizontal surface as well as provide for the desired fluid-wedging plane or camber of the bottom of the craft, the heights of the chambers 20 vary from the bow to the stern.

Each of these storage containers has either a small, sealable opening 24 (thru which liquids or finely divided solids may be moved) or a large opening, provided with a hinged, temporarily-sealable hatch, 26 (via which bulky objects may be stored). Between each pair of the chambers a flexible foam-plastic buffer 28 is placed; it is preferably glued or otherwise attached only to one of the pair; but alternatively the foam-plastic may be shredded and poured between containers. These pairs are sufficiently numerous, both athwart and lengthwise of the craft, to insure that when its bottom is subjected to a major shock (such as would damage the container walls if they were not divided and free to move relative to each other) the buffers 28 yield, and the containers are saved from breakage or damaging distortion.

Sealed to cut-out portions of the tubes at the bow are three transparent-plastic or glass windows, 29; and if desired such windows may be placed in the outer side walls.

The propulsion unit may be of a jet-propulsion type, but as shown it comprises a mechanical propeller, a propeller, a propeller-driving motor 30, and means for energizing the motor and controlling it from within the cabin. Element 32 optionally may be a fuel line (when 30 is an internal combustion engine), an electrical conduit (when 30 is an electric motor), or, and preferably, a flexible hydraulic line thru which hydraulic power fluid is supplied to hydraulic motor 30 from a source of energy 34, which in this instance comprises an engine and a pump.

FIGURE 7 illustrates a second form of the invention, in which the resilient framework within the craft's skin comprises a multiplicity of separately-inflated, small-diameter tubes that are integrally joined by imperforate disks **36**. These tubes and disks are optionally made of any of the above-named flexible materials.

The upper portion of this tubular framework comprises two straight tubes **38**, each of which is flexibly bonded, with interposition of disk **36**, at one end to an arcuate tube **40**, and at the other end to another arcuate tube, **42**. Each of these arcuate tubes is likewise imperforately bonded, at one of its ends, to tube **44**.

This inflated tube **44** also would be wholly arcuate except for the fact that its upper portions are forcibly held in straight lines. At the upper end of its semi-circular part **44′** it is flexibly and imperforately bonded to one of the horizontal inflated tubes (thin-walled, hollow metal tubes) of decreasing diameter from fore to aft) that are inside a streamlined skin and form the strength-providing framework of the strut **46**. This element and the similar vertical strut **48** securely support the propulsion motor **50**. They also hold the center and the ends of arcuate portion **44′** of unitarily-inflated tube **44** in a fixed position, holding this inflated portion in the arc of a circle, substantially centered at the axis of the motor. Since each of the straight parts **44″** of tube **44**, is fixed at one of its ends to strut **46** and at the other of its ends to one of the separately-inflated arcuate tubes **40**, it is thus held in a substantially vertical and straight line.

The lower part of the tubular framework comprises tubes **52**, each of which is imperforately bonded, with interposition of a disk **36**, to the lower end of an outer arcuate tube **42**. Tube **52** optionally may comprise curved and straight portions (similar to tubes **38**, **40** and **42**) that are bonded and separately inflated. But as illustrated it is one long tube, with sidewall portions and bottom part **52′** held in substantially straight lines and float portions **52″** held in semi-circular arcs. These tube portions are thus held in position by horizontal tie elements **54** and the glue and optional ties by which the lower portions are fastened to storage tanks **56**. The tanks are similar to but differently shaped from storage containers **20** of FIGURE 6. Optionally, the straight side portions of tube **52** also may be tied together by tie wires, ropes or rods **58** and **58′**, between these portions and motor **50**. Tie **58′** is shown as fastened only to tube **44** and the motor; but obviously (by slightly rearranging cylindrical or spherical lighter-than-air units **60**) it may extend all the way between the motor and the left-hand sidewall of the craft.

On the right side of FIGURE 7 multiple lifting units are indicated at **62**, **64** and **66**. Each is shaped to conform to a section of the tubular framework and preferably exerts its lifting force against the framework via an upper layer of flexible foam rubber or other foam plastic. Optionally, the lifting units may be short cylinders or spheres, as indicated at the left side of FIGURE 7.

Shock-absorbing and insulating, flexible, foam-plastic preferably lines all the cabin space that is above the storage tanks. For lessening the weight of any part of it holes **67** may be provided.

Optionally, the deck **68** may comprise tiles of the type shown in FIGURE 8 or FIGURE 9. These tiles may be either in lieu of or on top of the deck portion of the foam plastic shown in FIGURE 7.

Pads or pieces of foam plastic serve as side buffers between each pair of the lifting units; and a long pad of this material, **70**, serves to flexibly transmit the lifting force of lower units **64** to upper units **62** and the upper tubular framework. If ties **58** are utilized these are imbedded in (or extend thru holes or recesses in) pad **70**.

A third form of the invention is shown in FIGURE 10. Unlike FIGURES 6, 7 and 13, this is a front view and thus shows the bottom camber or inclined plane **72** in elevation. This element wedges the fluid (air and/or water) which moves beneath **72** and between the inner side surfaces of the floats. Although it may be parallel to the



longitudinal axis of the craft, it preferably is inclined to that axis in each of the disclosed species of this invention.

In FIGURE 10 the resilient framework of the craft's skin may be inflated tubes, but it is shown as comprising plastic **74**. Although this plastic may be strongly resilient enough to function satisfactorily without reinforcement, especially in areas where there is little turbulence of water and air, preferably it is inherently resilient and also has imbedded in it (or else glued to its inner surface) a strong spring-metal wire mesh.

The craft of FIGURE 10 is also different from the vehicles of FIGURES 6 and 7 in that its whole middle portion is bridged over by a portion of the resilient framework that, in every thwartship cross section, has an upper line that is parallel with the transverse axis of the craft. Thus the upper surface of the vehicle is uniformly streamlined from the bow to the stern, and its upper portion houses a larger total volume of the lighter-than-air units than exists for the same height and beam in the craft of FIGURES 6 and 7. This fact makes the vehicle of FIGURE 10 more compact and of a greater degree of stability due to the high centering of its aerostatic lift, well above the center of gravity. But it makes necessary the provision of tunnels, **76**, thru which the air of the propellers' slipstreams passes to the stern. This propelled air leaves the horizontal-axis tunnels at points considerably above and forward of the streamlined tail of the vehicle.

Tunnels **76** may be cylindrical throughout as shown; or optionally they may be made in venturi form, with the smallest diameter of the venturi tubes located at the propeller disks. Although only one inflated, resilient-tube motor-supporting strut is shown in each tunnel, another, similar to **48** may be provided. The two propeller tubes **78**, which may be of resilient plastic or spring-metal, and the adjacent portions **74′** of skin **74** are fastened together by tie rods or cables, **80**, which may comprise turnbuckles **82**, for adjustment of the tension of the ties.

In FIGURE 10 the upper lighter-than-air units are rectangular (preferably cube-shaped); and the lifting units in the floats also may be cubical and similar to elements **20** of FIGURE 6. But as shown the light-weight core of the sectioned left-hand float has a plurality of short, round-ended cylinders or hollow globes, **84**, which preferably are filled with explosion-free, lighter-than-air gas. Foam rubber or other flexible foam plastic surrounds these units. This porous flexible material, like that which surrounds lighter-than-air units **86** and like the other foam plastics in this invention, preferably are of the closed-cell type, and the sealed cells preferably contain lighter-than-air helium or nitrogen, which has been used as the foam-blowing agent.

The float core preferably is separately molded, and the skin **74** is then permanently placed over and glued to it. Then upper lifting elements **88** are placed over this core while the portion **74′** of the skin is bent or hinged upward to provide access to the float core from the cabin. If desired a long, rectangular, partially-cut-out part may be provided in **74′**, so that this part may be bent or hinged to facilitate exchange or reinflation of units **88**.

A fourth species of the invention is shown in FIGURES 11 and 12. Its cabin, streamlined in its top surface, is rectangular in transverse cross section and has a framework of straight, resilient, separtaely-inflated, vertical tubes **90** and horizontal tubes **92**. The sets of four tubes each are aligned along the craft's longitudinal axis and glued together in a flexible skin.

In the upper part of the inside space of the cabin float many rectangular, preferably cubical, lighter-than-air units **94**; and in the lower part there are multiple storage chambers, **96**, which support the deck. All these containers are assembled for free movement. They are flexibly connected both across and longitudinally of the craft, for example by foam rubber or other flexible plastic.

To the top surface of the cabin there are glued two long aerostatic, balloon-like elements, each of which comprises a plurality of lighter-than-air units or short balloons, **98**, which are aligned and spaced apart along a longitudinal axis that is parallel to the fore-and-aft upper surface of the cabin. These units may be made in the manner of any of the similar lifting units in FIGURES 1 to 7, and, together with lighter-than-air units **99**, are imbedded in foam plastic (preferably containing helium in its cells).

A pair of similar elongated elements is glued to the bottom of the cabin, but these are of smaller diameter, and because they are parts of the catamaran floats their lightweight units **100**, made of thin, resilient metal or the like, preferably contain lighter-than-air gas that is inflated to a pressure considerably above that of the atmosphere—for example, at twenty to thirty pounds per square inch. These units **100** are multiplied and spaced apart in a fore-and-aft direction, and, with smaller units **102**, are surrounded by flexible foam plastic, mold-shaped within a flexible, waterproof skin.

After the elongated upper and lower core elements (streamlined at the bow and stern) are glued in place the resilient-framework tube or tubes, **104**, are glued to the outer surfaces of the cabin and core elements. Although a plurality of inflated endless tubes may be aligned along the craft's axis, preferably a single long tubular element, comprising end-joined, separately-inflated tubes, is helically wound to form the outer framework. After the motor nacelle and its supporting struts are fastened to this framework the whole is smoothly covered with a flexible waterproof skin.

FIGURE 12 shows a simpler, more easily constructed form of the upper portion of this craft. In it the laterally outer surfaces of the upper core elements are vertically aligned with the sidewalls of the cabin skin.

The fifth disclosed species of the invention is shown in FIGURES 13 to 15. In this form, the upper part of the craft's resilient framework comprises inflated, resilient, semi-circular tubes, **106**, that are aligned, and flexibly glued together along the craft's axis; and the lower part is mainly composed of vertically arranged, straight, inflated tubes, **108**.

These lower tubes optionally may be made of any of the above-described tube material; but as shown all except the motor-supporting tubes, **110**, are of thin flexible metal, sheathed in very flexible, resilient foam rubber or other plastic. Optionally some of the lower tubes **108** may have thicker walls and be used for the storage of liquids (for example, fuel and water).

When all the vertical tubes comprise plastic those that do not support the motor may be extrusions of elastic plastic (for example, rubber), without fabric reinforcement. In this event, each of the floats (whose outer shape is shown in FIGURE 14) comprises an outer envelope of plastic-impregnated wire or fibrous mesh (or other fabric). This is glued to the sides and bottoms of all the vertical tubes and to the tops of all these tubes except those that support one of the motors. The motor tubes, **110**, numbering relatively few of the vertical tubes, as indicated in FIGURE 14, are taller than the others, and project upward thru holes cut in the waterproof fabric.

This gluing of the fabric to the elastic tubes (preferably with epoxy-resin cement), is effected while the tubes are only slightly inflated; and after the glue sets they are further inflated thru their valves until their sidewalls expand into full contact with each other, so that they are no longer circular but are closely nested, shutting out all of the air that was between their previously cylindrical outer surfaces. Thereafter the inflation is continued until the desired gaseous pressure (substantially above that of the atmosphere) is obtained.

The tops of these floats, excepting their streamlined bow and stern parts, are glued (and preferably also tied) to bottom surfaces of the aligned and glued-together deck tubes, **112**.

Tubes **112** optionally may be of thin, foam-rubber-sheathed, flexible metal or of reinforced plastic. They may be permanently inflated with lighter-than-air gas or used as storage chambers (with filling tubes that extend to the upper surface of the cabin deck). If they are used as storage receptacles their flexible material is strongly resilient.



The ends of motor-supporting tubes **110**, which may be bonded to and closed by concaved disks of the type shown at **114**, are shaped to fit and are glued to cylindrical motor tubes **110**.

On each side of the midships portion of the craft these motor tubes (preferably of reinforced plastic, and sheathed in a streamlined, flexible, plastic-impregnated fabric) are glued and tied at their upper ends to an arcuate, elongated, motor-supporting plate, **116**. It may be of reinforced plastic or of metal, and is fixed to a propeller-driving motor. The plate also is fastened to disk-like element, **114**, and thus, via their attached horizontal inflated tubes to cabin tubes, **106**.

The floats are further and strongly fastened together by inflated bracing tubes **118**, bonded and tied to the inner upright float surfaces. These bracing tubes, preferably of foam-rubber-sheathed, thin flexible metal, are glued and tied together and are covered by a smooth, strong, flexible skin, thus forming a flexible, bracing arch that is below and opposite the entire extent of the deck and cabin tubes along the vehicle's longitudinal axis.

The space between this arch and the deck tubes is filled with foam plastic. In this, on each side of the craft, there are imbedded a plurality of short, round-ended, plastic or metal storage cylinders, **120**, which have filling tubes that extend up to the cabin's deck surface. Preferably there are also imbedded in the foam plastic a plurality of lighter-than-air units.

The lower surface of each float is preferably shaped to provide a wedging and lifting reaction on it from the water or air thru which the craft advances. One form of this surface is shown in FIGURE 15 at **122**. It has the general shape of the lower camber of some airplane wings. Another, optional form is a plane surface that makes an acute angle with the direction of travel. And another, not preferred, is a normally horizontal plane, with reliance on rear elevators of the airplane type for providing an angle of attack of the surface which achieves the desired reaction and lifting force.

As illustrated, the bottom surface of the arch formed by tubes **118** and their skin is at the same distance below the normally horizontal deck tubes **112** throughout their length. But optionally the bracing tubes may successively be placed at lower elevations from the forward to the after portions of the arch, so that its skin also obtains a wedging and lifting reaction from the fluid that contacts and moves past it.

The cabin tubes **106** and their top skin have the same horizontal span throughout their extent from the transparent window or windshield, **124**, at the bow to a similar but lower window in the cabin's vertical, after portion, **126**. If desired, the upper edge of each of these windows may be arcuate, conforming to the arch of the tube **106** that is above it. The lengths and arcs of curvature of the tubes **106** vary from the bow to the stern, with their top skin thus providing a streamlined shape for the top of the cabin, indicated in FIGURE 15 at **128**.

Inside the upper part of the cabin lighter-than-air units, which may be of various sizes, exert a lifting force on the resilient framework. These units may have small foam-rubber buffers between them of the type shown in any of the other forms of the invention; but as illustrated in FIGURE 13 they are round-ended, hermetically-sealed cylinders that are imbedded in foam plastic, which preferably contains helium or nitrogen in its cells. All of the major axes of these short cylinders may extend in lines parallel to the craft's longitudinal axis, or optionally, and as shown, they may be staggered.

When the deck tubes **112** are inflated and not used as storage chambers, storage receptacles of the type shown in FIGURES 6, 7 and 10, are fixed to the bottom of the deck tubes and form or support the deck surface.

Seats or couches that are fastened to the deck inside the cabin may comprise lighter-than-air lifting units that are imbedded in foam rubber or other plastic that is sheathed with fabric. These lifting units, **128**, optionally may be directly in contact with the foam plastic, or they may float inside resilient outer envelopes **130**.

An optional type of inner structure of the floats is shown in FIGURE 14. Within the outer resilient, tubular float framework that is illustrated also in FIGURE 13, the alternative inner float structure comprises large, longitudinally-spaced storage chambers **132**, which have filling tubes that extend thru holes in the hermetically-sealed tubes **112** to the cabin deck surface. These containers may be made of plastic or metal. They are surrounded by foam plastic, in which lighter-than-air units **134** optionally may be imbedded.

In the form of the invention shown in FIGURES 13 to 15, there are two small outer decks, **136**—one above the semi-cylindrical nose of each float—and two other small decks, **138**, above the streamlined sterns of the floats. These decks may support persons outside the cabin—for example in mooring or anchoring the craft, or in recreation.

Within the scope of the following claims, various changes may be made in the specific disclosed structure.

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; the word "fabric" to mean any kind of woven material or of mesh, comprising fibers or metallic wire or filaments; the word "tube" or expression "tubular elements" to mean a hollow article, elongated and having ends, or curved and endless, circular or non-circular in cross section, and open or sealed; and the word "boat" to refer to a craft that traverses water and/or flies in the air.

I claim:

**1.** A vehicle comprising:

an upper structure, constructed and arranged to provide at least part of a load-confining space, comprising a flexible skin and within the skin a resiliently flexible, vehicle-strength-providing, framework; and

a lower, resiliently flexible structure, fixed to said upper structure, having at least one flexible, lift-producing surface that is exposed to the fluid which relatively moves beneath the vehicle when it is underway and that is shaped and arranged to provide an acute, lifting angle of fluid attack between said relatively moving fluid and at least a portion of said bottom surface;

said lower structure comprising: a middle portion having a bottom surface; and two side portions, joined to said middle portion, each of which has a bottom surface; each of said middle and side portions having a flexible skin and within the skin a framework of skin-bracing, strength-providing, resiliently flexible elements.

**2.** A vehicle as set forth in claim **1**, in which the said bottom surfaces of said side portions are lower than the bottom surface of said middle portion.

**3.** A device as set forth in claim **1**, in which said vehicle is a boat.

**4.** A vehicle as set forth in claim **1**, in which the majority of said resiliently flexible elements are tubes that are juxtaposed within said skins.

**5.** A vehicle as set forth in claim **4**, in which said tubes have sealed hollow spaces and compressed gas within said spaces.

**6.** A vehicle as set forth in claim **1**, in which said skins are of a material comprising plastic and fabric.



**7.** A vehicle as set forth in claim **6**, in which said fabric comprises metallic mesh.

**8.** A vehicle as set forth in claim **1**, in which said bottom surface of the said middle portion is a lift-producing surface, providing an angle of attack between it and relatively moving fluid in contact with it.

**9.** A vehicle as set forth in claim **1**, in which said bottom surfaces of the two side portions are lift-producing surfaces, providing angles of attack between them and relatively moving fluid in contact with them.

**10.** A vehicle as set forth in claim **1**, in which said bottom surfaces of said middle and side portions are lift-producing surfaces, providing angles of attack between them and relatively moving fluid in contact with them.

**11.** A vehicle as set forth in claim **1**, in which said upper structure has at least one flexible, lift-producing upper surface that is exposed to the fluid that relatively moves above said upper structure when the vehicle is moving forward and is shaped and arranged to provide a lifting vacuum above said upper surface during said motion.

**12.** A vehicle as set forth in claim **2**, in which the majority of said resiliently flexible elements are tubes.

**13.** A vehicle as set forth in claim **2**, in which said flexible skins are the surface portions of a material comprising flexible plastic.

**14.** A vehicle as set forth in claim **6**, in which said frameworks comprise resilient elements that are of springy material, have a maximum cross-sectional dimension of a fraction of an inch, and are coated with said material comprising plastic.

**15.** A vehicle as set forth in claim **6**, in which said frameworks comprise resilient elements that are tubular and adapted to be inflated with compressed gas.

**16.** A vehicle as set forth in claim **1**, in which said upper structure has two lateral parts that are above and joined to said lower side portions and has a middle part that is joined to said lower middle portion and is lower than said lateral parts.

**17.** A vehicle as set forth in claim **16**, in which said parts have upper surfaces that are contoured downward in a direction that is opposite to that of the vehicle's forward motion.

**18.** A vehicle as set forth in claim **16**, in which said upper structure further comprises a bridge that is fixed to each of said lateral parts and extends across a space above said lower middle part, and a propulsion device that is fixed to and supported by said bridge.

**19.** A vehicle as set forth in claim **1**, in which said upper structure further comprises lighter-than-air units, loosely positioned within a part of the vehicle and exerting a lifting force that is centered above the vehicle's center of gravity, said units having sufficient clearances between and below them and being sufficiently small in extent, both longitudinally and transversely of the vehicle, to move, without permanent deformation of their walls, relatively to each other and to said outer portion when it bends under a major shock.


**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,857,347 | 5/1932 | Beebe | 114—66.5 |
| 1,861,338 | 5/1932 | Faust | 114—61 |
| 2,381,583 | 8/1945 | Fechtenburg | 114—61 |
| 2,464,957 | 3/1949 | Wood | 114—61 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 446,807 | 3/1949 | Italy. |


MILTON BUCHLER, *Primary Examiner.*

A. H. FARRELL, *Assistant Examiner.*