United States Patent [19]

Lang

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[54] **SEMI-SUBMERGED VESSEL ADAPTABLE TO SAILING**

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[51] **Int. Cl.** **B63b 1/12**

[58] **Field of Search** ..... 114/61, 77, 39, 62, 235 B, 114/16 F, 16 E, 16 B, 16 A, 16 R, .5 D, 43.5; 115/26; 9/11 A, 2 A, 2 R, 2 S, 2 C

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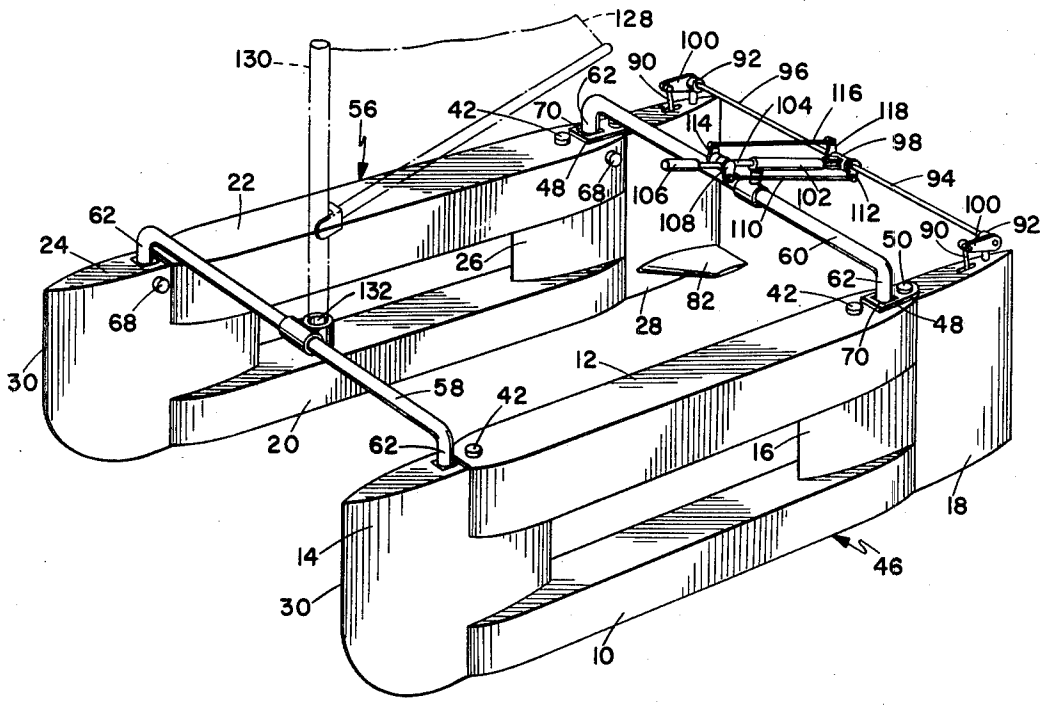
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Assistant Examiner—Donald W. Underwood
Attorney, Agent, or Firm—Brown & Martin

[57] **ABSTRACT**

A vessel having a superstructure supported above water on streamlined struts extending from fully submerged hulls. Portions of the struts are hinged to act as rudders and submerged vanes provide stability in pitch, and control pitch and roll. The form of structure illustrated is particularly suitable for small sail boats and is easily disassembled for transportation. In one form the superstructure is composed of buoyant hulls differing in size from the submerged hulls, the hulls being readily made interchangeable to adjust the buoyancy of the vessel to different loads.

11 Claims, 14 Drawing Figures



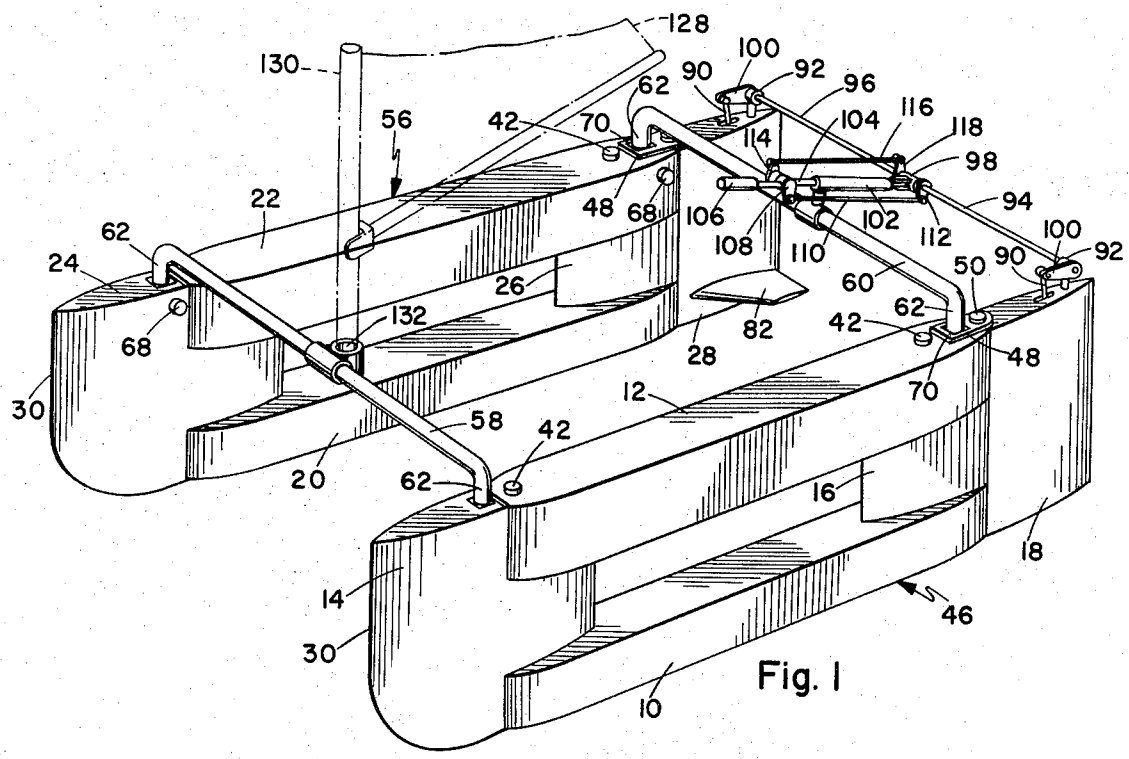


Fig. 1

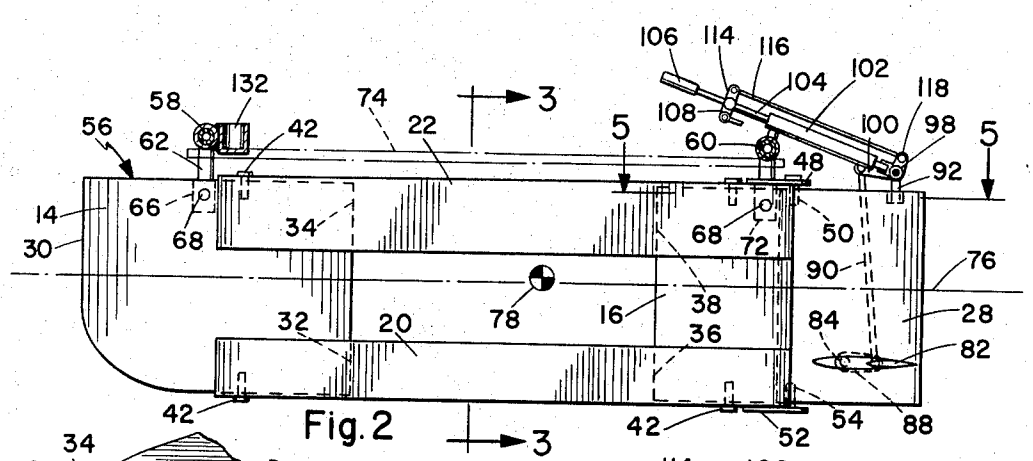


Fig. 2

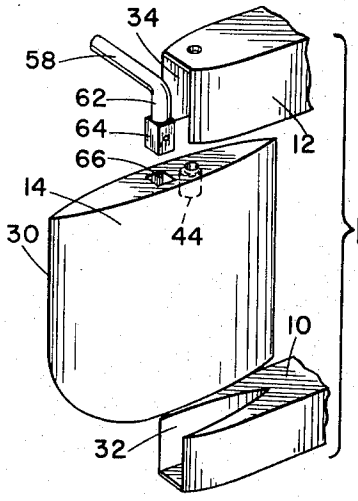


Fig. 4

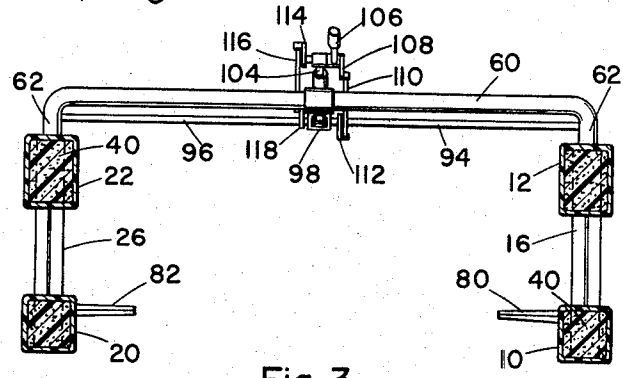


Fig. 3

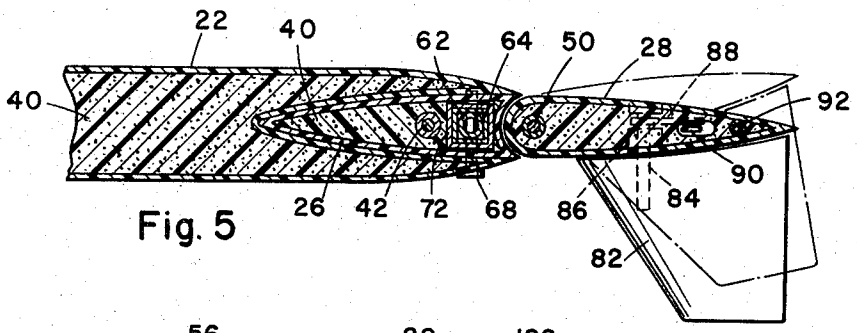


Fig. 5

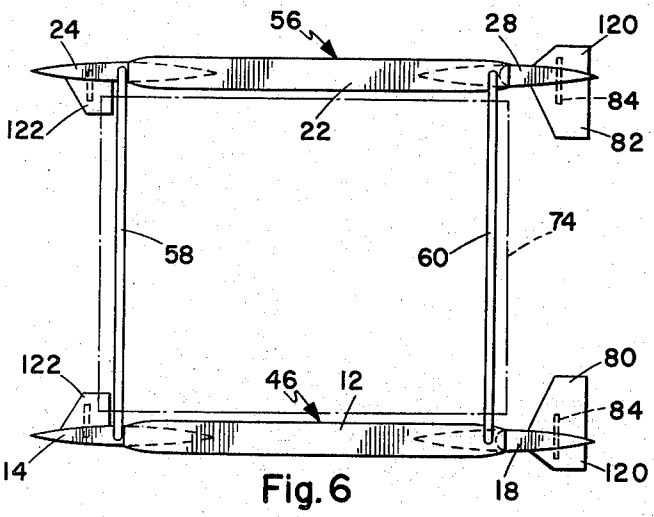


Fig. 6

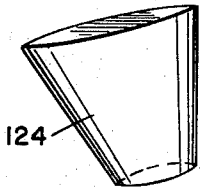


Fig. 7a

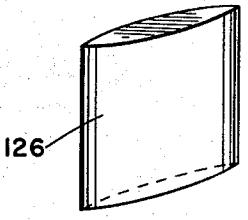


Fig. 7b

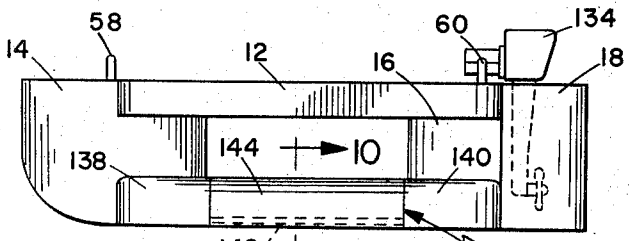


Fig. 9

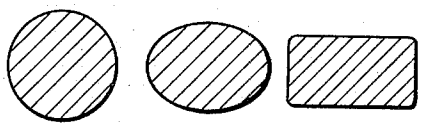


Fig. 8a Fig. 8b Fig. 8c

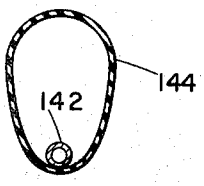


Fig. 10

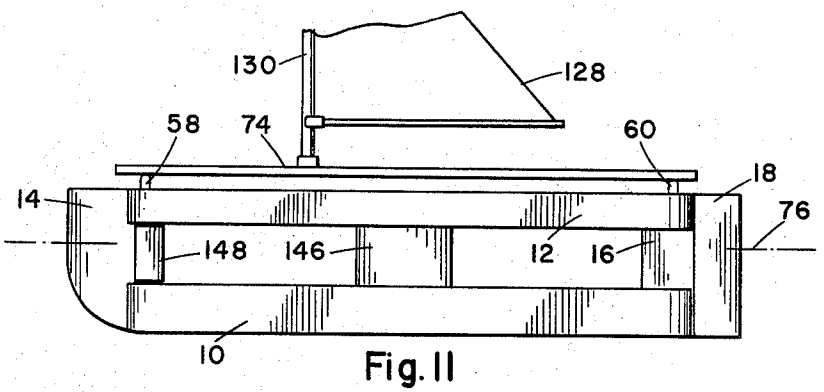


Fig. 11

SEMI-SUBMERGED VESSEL ADAPTABLE TO SAILING

BACKGROUND OF THE INVENTION

Conventional types of ships are limited in speed by wave and surface drag on the considerable hull surface necessary for support. In heavy seas, conventional vessels are subject to all motions of the water, and their stability and performance is reduced. To overcome this, various means have been devised to lift the bulk of the vessel clear of the water as much as possible.

High performance vessels using hydrofoils are efficient at high speeds, but their hulls rest in the water at speeds below the lifting speed of the foils. Air cushion supported vessels are completely clear of the water when the air cushion is operating, but are very bulky for their load capacity and are not particularly seaworthy when the air cushion is inoperative.

Another type of vessel utilizes one or more submerged buoyant hulls to support a superstructure above the water line. In one form the submerged hull is large and comprises the payload section, with only a small control structure above water. In another form, typified in U.S. Pat. No. 3,623,444, the bulk of the vessel is above the water, supported well clear of the surface by submerged hulls, the configurations shown being primarily adaptable to large vessels.

SUMMARY OF THE INVENTION

The vessel structure described herein, while adaptable to a wide range of sizes, is particularly suitable for small craft such as powered by sails, outboard motors or manual means. The structure comprises a pair of submerged hulls in spaced parallel relation, each having upwardly extending streamlined struts at opposite ends to support a superstructure above the water line. In the form illustrated, the superstructure includes a pair of hull members, each mounted on and being parallel to one of the submerged hulls, the hull members being connected at opposite ends by cross bars which set the width of the vessel. Any suitable deck or supporting surface may be attached to the hull members and cross bars, depending on the intended use of the vessel. The hulls are detachably secured to the struts and the cross bars plug into the struts, making the structure easy to disassemble for storage and transportation.

Portions of the rear struts, at least, are hinged to serve as rudders, and vanes are mounted on the submerged structure for roll and pitch stabilization and control. A simple control system operates the movable surfaces.

With the knock-down type of structure, it is practical to make the upper and lower hull units interchangeable and of different sizes. Thus either size may be used for the submerged hulls, providing a variable buoyancy to suit the load to be carried by the vessel.

The struts extend forwardly and rearwardly beyond the hulls to provide maximum length with minimum hull structure, the center of gravity being generally near the center of the vessel between the struts. The hulls are streamlined longitudinally between the struts to reduce drag and the struts provide an "area ruling" effect at high speeds to minimize wave drag. In larger sizes of the vessel, it may be desirable to use a third strut on each side, between the front and rear struts.

Various materials may be used for the structure, such as metal, fiberglass, or plastics, with parts or all of the components filled with buoyant foam material for safety and rigidity. For maximum portability, portions of the hulls may be inflatable.

The hulls are preferably spaced at least two hull widths apart, the vessel being a wide stable platform in any reasonable sea state. Only the sides of the struts are exposed to the immediate surface wave action, the supporting hulls being below the surface and the bulk of the superstructure generally clear of the water, at rest or at any speed of the vessel. By making the upper hulls buoyant, additional support is provided when the upper hulls are partially in the water, as when rolling under sail, or under heavy load conditions.

The primary object of this invention, therefore, is to provide a new and improved semi-submerged vessel.

Another object of this invention is to provide a new and improved semi-submerged vessel having submerged hulls which support an above water superstructure on streamlined struts.

Another object of this vessel is to provide a new and improved semi-submerged vessel structure which is particularly adaptable to small craft use and is readily assembled and disassembled.

A further object of this invention is to provide a new and improved semi-submerged vessel capable of high performance with low power and having high stability in a wide range of sea states.

Other objects and advantages of the invention will become more apparent upon reading the following description together with the drawings, in which like reference numerals refer to like parts throughout, and in which:

FIG. **1** is a perspective view of the complete basic structure of the vessel, the deck being omitted for clarity.

FIG. **2** is a longitudinal center line sectional view of the vessel.

FIG. **3** is a sectional view taken on line **3—3** of FIG. **2.**

FIG. **4** is an exploded perspective view of a typical hull and strut connection.

FIG. **5** is an enlarged sectional view taken on line **5—5** of FIG. **2.**

FIG. **6** is a top plan view of the vessel with a modified stabilizing surface arrangement.

FIGS. **7***a* and **7***b* are perspective views of an alternative strut configuration.

FIGS. **8***a* and **8***b* and **8***c* are cross sections of alternative hull shapes.

FIG. **9** is a side elevation view of a form of the vessel with an inflatable hull section.

FIG. **10** is an enlarged sectional view taken on line **10—10** of FIG. **9.**

FIG. **11** is a side elevation view of a vessel with an added center strut.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the basic configuration of the vessel, illustrated in FIGS. **1–5,** the structure includes a pair of elongated lower hulls **10** and **20,** a pair of upper hulls **12** and **22,** front struts **14** and **24,** rear struts **16** and **26,** and rudders **18** and **28.** Front strut **14** is streamlined in cross section from front to rear, with a reasonably sharp water penetrating leading edge **30.** The forward end of

lower hull **10** has a cavity **32** shaped to receive the lower rear portion of front strut **14** with a close fit. The forward end of upper hull **12** has a similar cavity **34** to fit the upper rear portion of the front strut. At the rear end of the lower and upper hulls **10** and **12** are similar cavities **36** and **38,** respectively, to fit the forward portions of rear strut **16.** As illustrated, the main structural components are of plastic material filled with buoyant foam **40,** but other types of construction may be used.

The upper and lower hulls are secured to the struts by fasteners **42,** which may be screws or quick release pins passing through the hull walls and seating into suitable receiving sockets **44** in the struts. More than one fastener may be used at each joint if required. The hulls **10** and **12** and struts **14** and **16** are thus joined to form a rigid left hull assembly **46.**

Fixed to the rear top portion of upper hull **12** is a top hinge plate **48,** which extends rearwardly and has a downwardly projecting hinge pin **50.** Fixed to the lower rear portion of lower hull **10** is a rearwardly extending bottom hinge plate **52,** with an upwardly projecting hinge pin **54.** Rudder **18** is pivotally mounted between hinge pins **50** and **54** when the structure is assembled and forms the streamlined rear portion of rear strut **16.**

The left hull assembly **56,** comprising hulls **20** and **22** and struts **24** and **26,** is identical in structure and has the same hinge arrangement for its rudder **28.**

The two hull assemblies are connected in spaced parallel relation by a front cross bar **58** and a rear cross bar **60.** Each cross bar has downwardly turned ends **62,** each fitted with a non-circular plug **64.** As illustrated, the plug portion is a square tube element, welded or otherwise secured to the cross bar. The ends of the front cross bar **58** plug into sockets **66** in the top portions of front struts **14** and **24,** forward of the upper hulls, and are held by removable fasteners **68.** The ends of rear cross bar **60** pass through openings **70** in top hinge plates **48** and into sockets **72** in rear struts **16** and **26,** and are also held by fasteners **68.** By making the plug and socket connections square or otherwise noncircular, the structure is prevented from twisting. For heavy load conditions, auxiliary struts or bracing wires can be used, or rigidity provided by deck structure secured between the cross bars. The deck structure, indicated in broken line at **74,** may be of any suitable type to suit the specific use of the vessel. If the upper and lower hulls are to be interchangeable, bottom hinge plates **52** would also have openings **70** for the cross bar ends.

The vessel rides in the water with the lower hulls and approximately one half of the height of the struts submerged, depending on the load. A typical waterline is indicated at **76** in FIG. **2.** The center of gravity **78** of the vessel is preferably slightly above the water line and longitudinally near the center of the vessel, between the front and rear struts. This configuration is extremely stable as long as the metacentric height of the vessel is positive, the metacenter being above the center of gravity. It has been found that the metacentric height should be at least 10 percent of the vessel beam width in roll and about 10 percent of the vessel length in pitch, but any positive value makes the vessel statically stable. When heavily loaded, or when rolling under sail, portions of one or both upper hulls may be in the water at times. It is thus an advantage to have the upper hulls water tight and buoyant to provide additional support when required.

To provide for control and stabilization in pitch and roll, horizontal control vanes **80** and **82** are mounted on the inside of rubbers **18** and **28,** respectively, well below the water line. The mounting is illustrated in FIG. **5,** wherein vane **82** is fixed on a pitch shaft **84** which is pivotal in a bearing **86** in the rudder. Pitch shaft **84** has a radial arm **88** from which a link rod **90** extends upwardly through the top of the rudder. Vane **80** is mounted in a similar manner. To reduce cost in a simple sail boat, the vanes could be fixed, or have means for limited adjustment to a preset pitch angle to suit the particular conditions and performance of the vessel.

Various types of controls may be used to operate the movable surfaces. The system illustrated is an example adapted to the simple structure of the vessel and should not be considered limiting. On the top rear portion of each rudder is a hinge fitting **92,** the hinge fittings being connected by tie rods **94** and **96** to a central coupling sleeve **98.** The tie rods are secured in any suitable manner to maintain a fixed length and thus parallelism of the rudders, but are free to rotate individually on their axes. Tie rod **94** has an arm **100** connected to the link rod **90** of vane **80** and tie rod **96** has a similar arm connected to the link rod of vane **82.** On the central portion of rear cross bar **60** is a tiller bar **102** pivoted to swing about a generally vertical axis, and attached to coupling sleeve **98** to move both rudders by tiller action. Telescopically mounted in the forward end of the tiller bar is a control rod **104** with control hangle **106** pivoted to swing vertically. On one side of handle **106** is a downwardly extending arm **108,** coupled by a link rod **110** to an arm **112** fixed below the tie rod **94.** On the other side of handle **106** is an upwardly extending arm **114,** coupled by a link rod **116** to an arm **118** fixed above tie rod **96.**

An upward motion of handle **106** causes link rod **110** to be pulled forwardly and link rod **116** to be pushed rearwardly, both actions causing arms **100** to be lifted and vanes **80** and **82** to be moved to a negative pitch angle. A downward motion of handle **106** produces a corresponding positive pitch motion of vanes **80** and **82.** Thus lifting the control handle tends to raise the bow, providing a natural pitch control. If roll control is required, the control rod **104** can be slid forward or backward in tiller bar **102** to produce opposite twisting action on tie rods **94** and **96,** and corresponding opposite pitch motion of the vanes.

For some conditions it may be desirable to minimize torque on the structure caused by operation of the vanes. This can be accomplished by extending pitch shafts **84** through the rudders and attaching external vanes **120,** as in FIG. **6.** The external vanes should be kept as short as possible to avoid damage against a dock or other structure. Additional control in heave and pitch may be provided by forward control vanes **122** mounted on front struts **14** and **24,** and suitably coupled to the control system, or set at a predetermined pitch angle.

When interchangeability of the hulls is not required, the drag of the vessel can be reduced by reducing the cross sectional area of the struts below the water line. This can be accomplished as in FIG. **7***a* by tapering the strut **124** in width while retaining a constant thickness for strength. In FIG. **7***b*, the strut **126** is of constant width but is reduced in thickness.

The hulls are shown as having a square or rectangular cross section for simplicity. However, they could be circular as in FIG. 8*a*, or elliptical as in FIG. 8*b*. FIG. 8*c* shows a rectangular cross section with the large dimension horizontal, to obtain maximum volume of the hull with minimum draft clearance. It should be noted that the left and right hull assemblies could be permanently secured as units, with the knock-down limited to the interconnection of the hull asssemblies by the superstructure.

The vessel can be powered by a sail **128** supported by a mast **130**, which is held in a socket **132** on the front cross bar **58**, as in FIG. **1**. Other mountings for the sail may be used, such as on the deck structure **74** in FIG. **11**. Alternatively, an outboard motor **134** may be attached to rear cross bar **60**, as in FIG. **9**, or to any other suitable portion of the structure. With the flat bottomed lower hulls as shown, the vessel will be capable of planing on the lower hulls at high speed with sufficient power.

In FIG. **9**, a modified lower hull **136** is illustrated, all other structure being as described above. The hull **136** has front and rear rigid portions **138** and **140** for attachment to the respective struts, the rigid portions being joined by a lower connecting bar **142**. The body of the hull between the rigid portions is formed by an inflatable bag **144** of suitable material.

The configuration illustrated in FIG. **11** is suitable for larger sizes of vessels and incorporates the same arrangement of upper and lower hulls and front and rear struts, but includes a central strut **146** between the hulls for added support. With widely spaced front and rear struts, the streamlined center strut also reduces wave drag. If additional directional control is required, a rear portion of each front strut may be hinged to form a rudder **148**.

In all forms described the vessel is stable, capable of high speed with low power due to low drag, and has been found to ride waves of considerably size with a minimum of disturbance. With the major portion of the buoyancy provided by submerged hulls, the vessel ha good damping characteristics in heave, pitch and roll.

Having described my invention, I now claim:

1. A semi-submerged vessel, comprising,

a pair of spaced elongated lower hulls disposed completely below the water line of the vessel,

forward and rearward streamlined struts extending upwardly from opposite ends of said hulls and extending above the water line, said forward streamlined struts having water penetrating tapered leading edge portions projecting forwardly of the forewardmost portion of the hulls and said rearward streamlined struts having tapered trailing edge portions projecting rearwardly of the rearwardmost portion of the hulls, and an open space between the struts, and a superstructure supported on said struts above the water line.

2. A semi-submerged vessel according to claim **1**, wherein the major portions of said rear struts rearward of the hulls are hinged between the lower hulls and the superstructure and comprise rudders.

3. A semi-submerged vessel according to claim **2**, and including control vanes pivotally mounted on the lower portions of said rudders and extending substantially horizontally inboard therefrom toward the center of the boat,

and means for varying the pitch angle of said vanes.

4. A semi-submerged vessel according to claim **1**, wherein said superstructure includes a pair of elongated upper hulls secured to said struts in spaced parallel relation to said lower hulls.

5. A semi-submerged vessel according to claim **4**, and including releasable fastener means securing said upper and lower hulls to said struts.

6. A semi-submerged vessel according to claim **4**, and including a front cross bar detachably secured between said front struts, and a rear cross bar detachably secured between said rear struts with releasable fastener means securing said cross bars to said struts.

7. A semi-submerged vessel according to claim **4**, wherein said upper and lower hulls are of different cross sectional sizes and are interchangeable with each other.

8. A semi-submerged vessel according to claim **1**, wherein said lower hulls have rigid portions secured to said struts, a bar member interconnecting the lower ends of said rigid portions, and an inflatable body supported by said bar member and extending between said rigid portions.

9. A semi-submerged vessel according to claim **1**, wherein certain of said struts are tapered vertically, with the narrower portions at the lower ends thereof.

10. A semi-submerged vessel, comprising,

a pair of spaced elongated lower hulls disposed completely below the water line of the vessel,

streamlined struts extending upwardly from opposite ends of said lower hulls and extending above the water line, with water penetrating tapered leading edge portions projecting forward of the hulls and tapered trailing edge portions projecting rearward of the hulls, and an open space between the stuts,

superstructure supported on said struts above the water line, the superstructure including a pair of elongated upper hulls in spaced parallel relation to the lower hulls,

said upper and lower hulls having cavities in the forward ends thereof to receive the rear portions of said front struts, and cavities in the rear ends thereof to receive the forward portions of said rear struts,

and releasable fastener means for securing each of the hull and strut connections.

11. A semi-submerged vessel according to claim **10**, and including a front cross bar interconnecting said front struts, and a rear cross bar interconnecting said rear struts,

said cross bars having non-circular end plug portions,

said struts having correspondingly non-circular sockets for receiving said plug portions,

and releasable fastener means for securing said plug portions in said sockets.

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