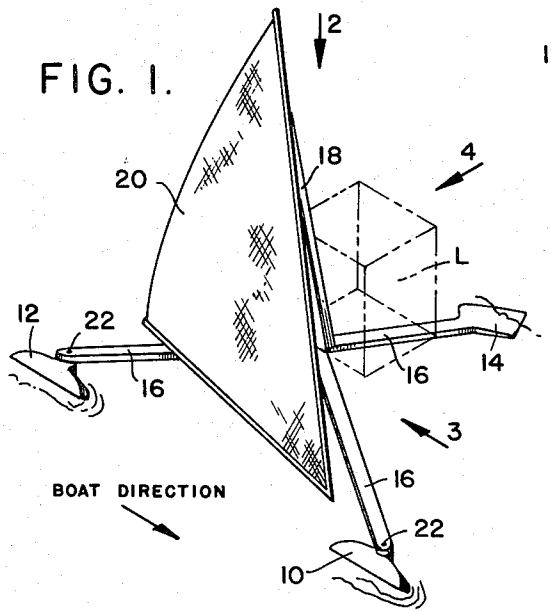
June 25, 1963 B. SMITH 3,094,961

HYDROFOIL SAILBOAT

Filed June 13, 1961

FIG. 1.



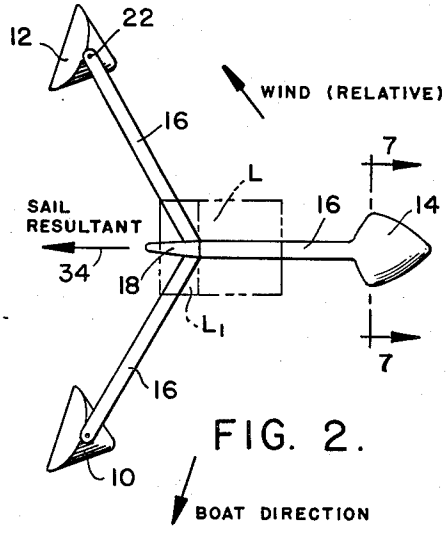


FIG. 2.

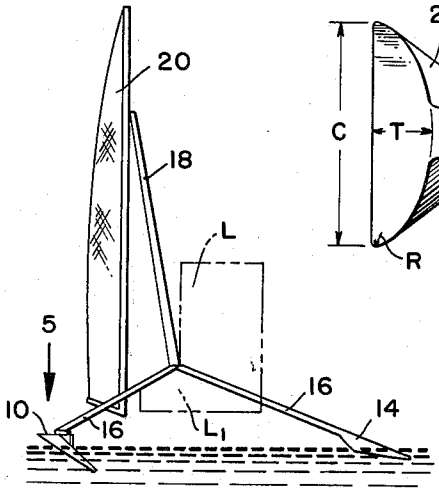


FIG. 3.

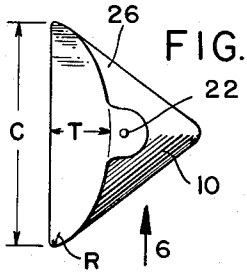


FIG. 5.

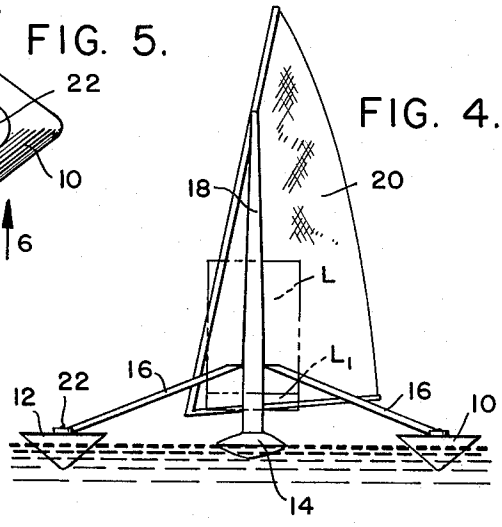


FIG. 4.

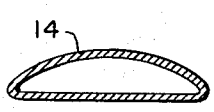


FIG. 7.

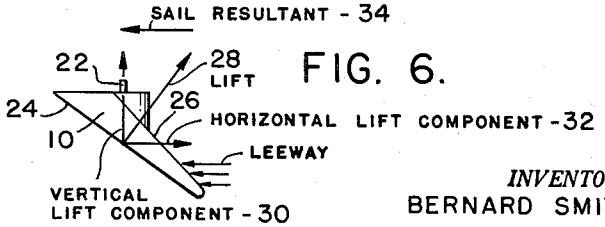


FIG. 6.

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HYDROFOIL SAILBOAT

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6 Claims. (Cl. 114—66.5)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to hydrofoil type water craft and more particularly to hull less water craft supported while both static and in motion solely by hydrofoils.

Until the relatively recent advent of the hydrofoil, the design of boat hulls has gradually improved over many centuries, reaching a near optimum design at which it remained relatively stagnant for quite some time. With the desire for greater speeds, efficiencies and comfort the hydrofoil opened a new era for advancement in the boat art by providing means for supporting the boat hull above the water while in motion where it is substantially free of pitch and roll. The frictional water drag on the hull having thus been reduced has permitted increased speeds with comparable propulsion power and hence greater efficiency as well as comfort. While such combination is relatively new, its novelty resides mainly in the application of lifting hydrofoils to otherwise conventional hulls and each serves its separate purpose, the hull for buoyancy while at rest and the hydrofoil for lift while in motion, each being redundant while the other is performing its function. Thus, while at rest, the boat remains buoyant irrespective of the presence or absence of hydrofoils and when in motion above the water the hydrofoils support a load which does not necessarily require buoyancy. At intermediate speeds, prior to lift of the hull completely above the water the forces of buoyancy and lift are cooperative. This, however, is a necessity imposed upon such system since it cannot change from a condition of rest to operative speed without passing through intermediate speed. It should thus become apparent that the boat hull, while operating above the water, represents dead weight and unnecessary frontal area which could either be eliminated to attain greater speeds or replaced with cargo weight for increased carrying efficiency were it not for the requirement that the hull provide buoyancy during the periods of rest. Conceivable, the hull could be jettisoned, the system retaining only the pay load, after the hull has been supported above the water by the hydrofoils. Conceivable, also, the system could be constructed and supported in some way without a hull and brought to operative speed without requiring hull buoyancy in which case the conventional hydrofoils could serve their intended purpose. The present invention, while somewhat related to this latter general concept provides a specific solution to the problem by providing a unique arrangement of hydrofoils which depart from the conventional hydrofoils referred to in that they serve not only as lifting hydrofoils but provide, also, the necessary buoyancy of the system formerly contributed by the hull. It is, accordingly, the principal object of this invention to provide a hull less hydrofoil watercraft in which the hydrofoils serve the purpose of providing hydrodynamic lift and also displace sufficient water to supply buoyancy forces required while the craft is at rest.

Another object is to provide a hull less hydrofoil watercraft having a novel arrangement of buoyant hydrofoils which permit high stability and improved maneuverability.

A further object is to provide a hull less hydrofoil watercraft in which directional stability is maintained by the relative orientation of the various hydrofoils.

A further object is to provide a sail boat constructed in accordance with any of the preceding objects.

A further object is to provide a hull less watercraft to which a buoyant hull and its cargo may be floated, transported and released for delivery.

A further object is to provide a buoyant hydrofoil for use with watercraft.

Still further objects, advantages and salient features will become more apparent from the description to follow, the appended claims, and the accompanying drawing, in which:

FIG. 1 is a perspective of a sail boat employing the subject of the invention;

FIG. 2 is a top plan as viewed in the direction of arrow 2, FIG. 1, the sail being emitted;

FIG. 3 is a front elevation as viewed in the direction of arrow 3, FIG. 1;

FIG. 4 is a side elevation as viewed in the direction of arrow 4, FIG. 1;

FIG. 5 is a top plan of one of the hydrofoils;

FIG. 6 is a front elevation as viewed in the direction of arrow 6, FIG. 5; and

FIG. 7 is a cross section taken on line 7—7, FIG. 2.

Referring in detail to the drawing, in which the invention is illustrated in highly simplified form, essentials comprise hydrofoils 10, 12, 14 constructed and oriented to produce certain desired forces, a rigid frame 16 for maintaining the hydrofoils in special relationship, and means for applying a propelling force to the frame and its attached hydrofoils, such as a mast 18 secured to the frame and a sail 20 secured to the mast. The hydrofoils differ from those employed with hydrofoil boats having buoyant hulls in that they provide the entire buoyant supporting forces for the craft when it is at rest. When in motion, however, they produce lift forces, analogous to the lift forces produced by the hydrofoil of a hull type hydrofoil boat, and other stabilizing and steering forces as will subsequently appear.

Each of hydrofoils 10, 12 and 14 is considerably thickened, as compared with a hydrofoil designed solely for lift, so that it displaces a relatively large volume of water compared to its mass and hence is buoyant and effective to produce an upward force. This force is analogous to the buoyant force produced by the hull in the conventional type boat provided with hydrofoils. The hydrofoils may be hollow, constructed of sheet material, or solid if constructed of any material which is buoyant, the only essential requirement being that they be sufficiently buoyant to support the desired load which consists of all parts of the craft which are disposed above the water.

Hydrofoils 10, 12 are each pivotally connected to the frame by a shaft 22 for rotation about parallel vertical axes and may be rotated either separately or conjointly to desired positions by any means such as pulleys, tiller ropes, gears, linkages, motors, etc. (not shown) as will be apparent to those skilled in the art. Hydrofoil 14 may also be pivotally mounted in the same manner; however, in the most simplified form this is unnecessary, this hydrofoil thus being illustrated as fixedly mounted to the frame. The pivotal axis of each of hydrofoils 10, 12 is disposed at the midpoint of the chord and the cross sectional shape is symmetrical fore and aft of the axis. These foils may thus move in either of opposite directions and produce the same lift. Hydrofoil 14 is also formed symmetrical on both sides of the center of the chord, as best shown in FIGS. 4 and 7, and similarly provides the same lift irrespective of opposite directions of motion.

The forces acting upon the craft will now be described, it being assumed that it is beating to windward, foils 10, 12 being the leeward foils and foil 14 being the windward foil. The wind vector or relative wind and boat direc-

tions are indicated by arrows. The force vector developed by the sail is perpendicular to a line extending between the fore and aft leeward foils. As best illustrated in FIGS. 5 and 6, foils 10, 12 each comprise a flat or pressure side 24 angularly disposed to the horizontal, illustrated as a 30° angle, and a cambered or suction side 26 which, when moving in the plane of the flat side produce a lift force 28. Force 28 may be resolved into a vertical lift component 30 and a horizontal lift component 32. If leeway were not resisted by component 32, this would become one of the components of direction of movement of the craft. The fore and aft or longitudinal cross section of the foil resists this movement, in part, however, which is analogous to the broadside or leeway resistance of a boat or other body in water. The remainder of the resistance is furnished by the sail force resultant 34, which as previously described, is perpendicular to a line extending between the two leeward foils. The direction of the craft is thus in the plane containing the flat or pressure sides of fore and aft leeward foils 10, 12. As will now be apparent, pivotal movement of one or the other or both of those foils away from this plane provides a steering force, analogous to a boat rudder, for steering the craft. These hydrofoils thus serve a third function, in addition to buoyancy and lift, of steering control. The fixed windward foil 14 similarly produces lift and also a smaller horizontal component like component 32. The latter may be minimized by disposing the windward foil at a relatively low angle to the horizontal which component will be balanced by the leeward foils and said force resultant.

By constructing the foils symmetrical about their midpoints the craft may sail in either of opposite directions. Thus with suitable reorientation of the sail with respect to the frame what was formerly the front leeward foil becomes the rear leeward foil.

All foils decrease in cross section in a direction toward their lower ends, a generally triangular shape being illustrated with the apex at the bottom. Thus, a horizontal sectional increment at the lower end produces less lift than a similar increment thereabove. Due to its lesser wetted surface, however, it also produces less drag. Thus, when the craft is at rest and buoyancy is its sole support the upper portions of the foils which provide the greater buoyancy are utilized. When in motion, however, such portions would produce considerable drag. Lift forces, however, are a function of speed and as speed increases the upper portions emerge from the water thus eliminating their drag. The triangular shape thus provides means for decreasing wetted surface or drag area in definite proportion to increase in speed. Thus, the lower portions approach the optimum type of hydrofoil section which would be employed with the hull type hydrofoil boat which produces only hydrodynamic lift forces. The upper portions, while less efficient than the optimum type just referred to, contribute increased buoyancy with decrease in speed, as needed, and when increased speeds are attained emerge from the water since they are not needed for buoyancy. A reasonable compromise of shape of the hydrofoils are circular arcs wherein the leading and trailing edges radii R are 1% of the chord C, thickness T is 16% C at its upper or thickest section, tapering to 8% of the chord at the lower tip. Leading and trailing edges are swept 30° from the vertical.

Since the load which may be carried by the craft may assume many different forms, this has been illustrated generically in dotted lines as a load L. In smaller versions of the craft this would comprise any suitable quarters to accommodate the operator or a crew. In larger versions, designed for transport, it would also include cargo space. In another application the cargo space would be provided by a boat L' which would be towed or otherwise moved to the craft and then raised above the water and supported by the craft frame. At destination it would be lowered and floated to a pier or the like for unloading or other disposition.

While the propulsion means has been illustrated as a sail it is to be understood that the hydrofoils have utility with other forms of propulsion such as a motor driven wind propeller, such as is used with ice boats, or a motor driven water propeller, such as used with conventional boats, and outboard motors.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A hull-less boat comprising;
   (*a*) a portion disposed in a position above and out of contact with the water and adapted to carry a load
   (*b*) said portion being supported in said position, when the boat is at rest in the water, solely by a triangular arrangement of three submerged hydrofoils having the requisite total displacement and buoyancy, which displacement is considerably in excess of the displacement and buoyancy of conventional hydrofoils designed solely for produced maximum lift with minimum drag,
   (*c*) two of said hydrofoils each having a substantially flat pressure side and a cambered suction side providing leading and trailing edges at their intersections and constructed symmetrically about its mid-section to produce equal lift forces while in motion in either of opposite directions in the plane of said flat side,
   (*d*) at least one of said two hydrofoils being secured to the boat for pivotal movement about a substantially vertical axis and each disposed with said flat side in substantially the same plane, which plane is disposed at an angle to the vertical
   (*e*) the third hydrofoil being rigidly affixed to the boat and symmetrically constructed about its mid-section to also produce equal lift forces while in motion in either of opposite directions of motion of the boat
   (*f*) and means carried by the boat for propelling it in said directions and for applying a force equal and in opposition to the horizontal components of force produced by all hydrofoils.

2. A boat in accordance with claim 1 wherein said means for propelling the boat comprises a sail.

3. A boat in accordance with claim 1 wherein each of said two hydrofoils is constructed with downward horizontal sections of decreasing cord length between leading and trailing edges and also of decreasing displacement, a lower submerged portion adapted to produce sufficient lift when in motion to maintain an upper portion out of the water, thereby obviating water drag of said upper portion.

4. A hydrofoil,
   (*a*) the outer surface of which encloses a volume which displaces a sufficient amount of water, when submerged at rest therein, to support a substantial load disposed above the water,
   (*b*) the displacement being considerably in excess of that of a conventional hydrofoil constructed solely to produce maximum lift with minimum drag and also having greater drag than said conventional hydrofoil,
   (*c*) said hydrofoil having a substantially flat side and a cambered side,
   (*d*) their intersections forming leading and trailing edges,
   (*e*) said cambered side being symmetrical on each side of its central section, whereby it may produce equal lift in either of opposite directions of movement in the plane of said flat side,
   (*f*) means for moving said hydrofoil through water

with said flat side disposed at an angle to the vertical, said means adapted to also produce a force equal and in opposition to the horizontal component of force produced by said hydrofoil,

(*g*) and means for rotating the hydrofoil about a substantially vertical axis for steering it along a desired course.

5. A hydrofoil in accordance with claim 4 wherein

(*a*) its chord lines are of decreasing length across downward horizontal sections and

(*b*) said sections are of decreasing displacement, a lower submerged portion of the hydrofoil adapted to produce sufficient lift when in motion to maintain an upper portion out of water, whereby the water drag of the upper portion is obviated.

6. A hydrofoil in accordance with claim 5 wherein the leading and trailing edges are substantially straight.

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