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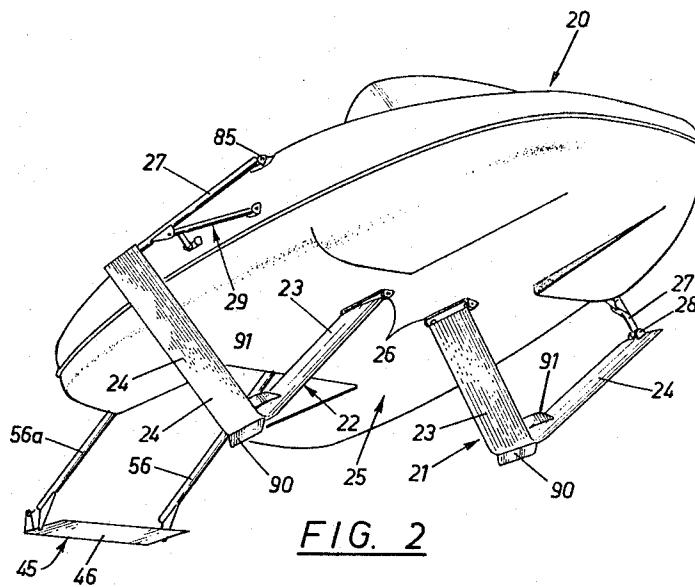
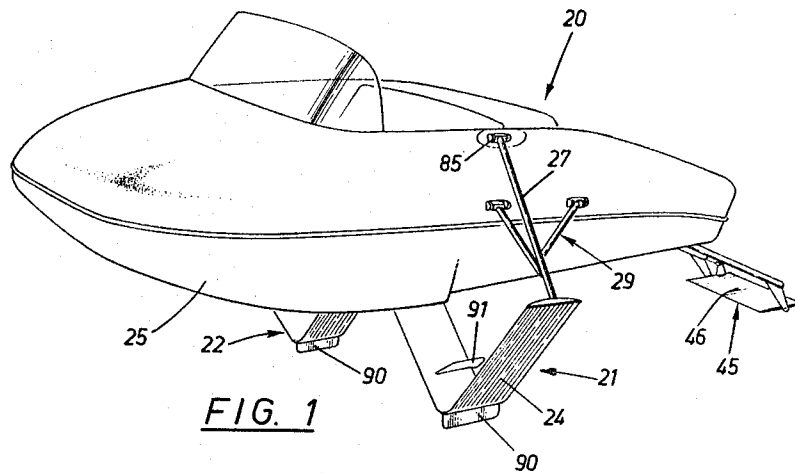
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3,380,421

HYDROFOIL CRAFT

Filed July 11, 1966

2 Sheets-Sheet 1



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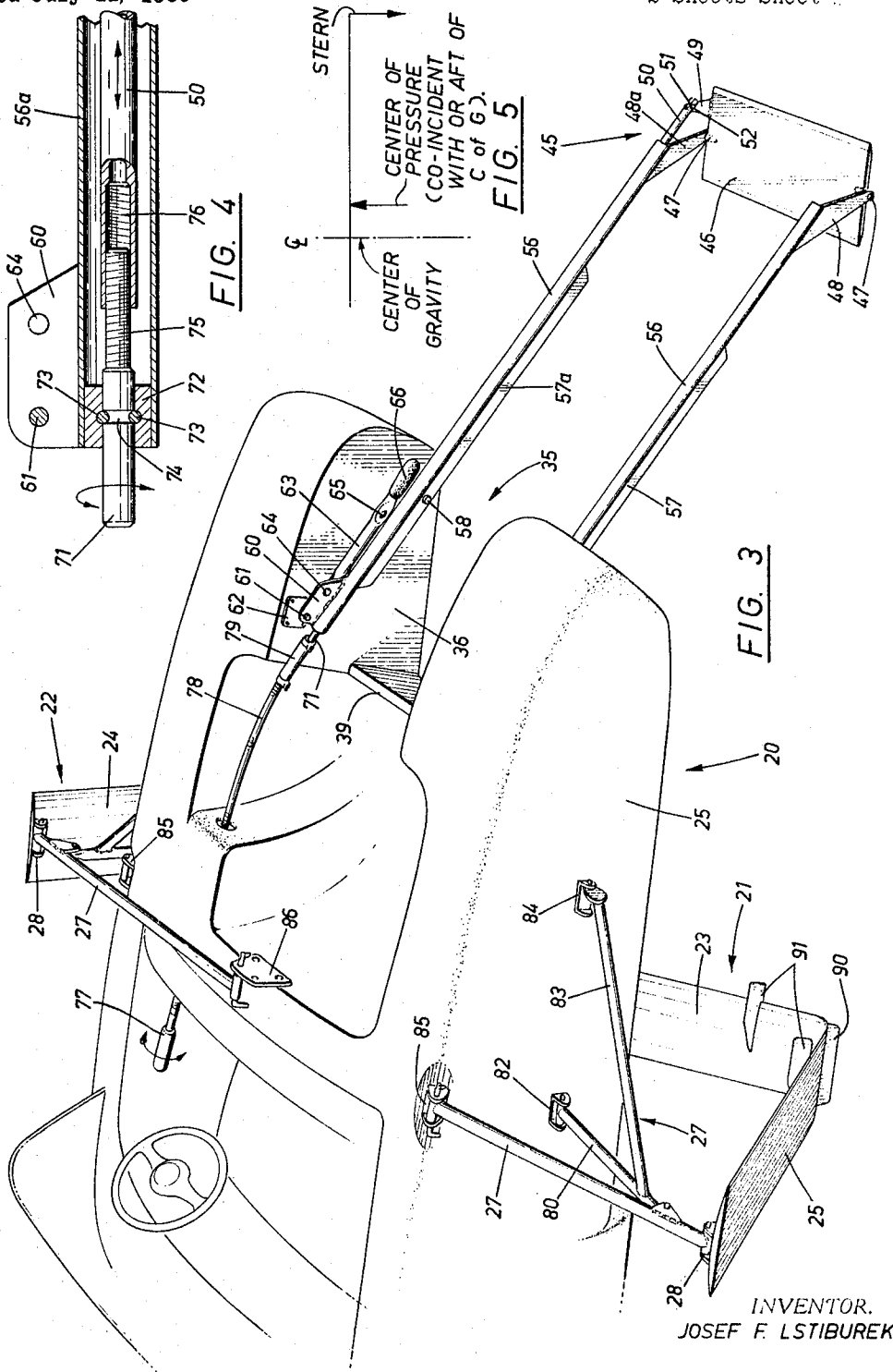
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HYDROFOIL CRAFT

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ABSTRACT OF THE DISCLOSURE

A small watercraft hydrofoil system including a fixed incidence hydrofoil means positioned at a single longitudinal station on the craft hull in a position substantially beneath the centre of gravity of the loaded craft and such that when the craft is foil-borne, the weight of the craft is fully supported by the single hydrofoil means and the centre of pressure of the hydrofoil means is coincident with or slightly aft of the centre of gravity of the craft. A variable incidence stabilizer plate means extending beneath the craft aft of the hydrofoil means and adjustable in horizontal angle relative to the longitudinal axis of the craft permits the attitude of the craft and the angle of attack of the hydrofoil means to be readily controlled. The hydrofoil means and the variable incidence plate means are adapted for retraction upwardly, thus facilitating land transportation, launching and beaching of the craft.

This invention relates to a hydrofoil system for use with a boat, and in particular it is directed to a small watercraft embodying the hydrofoil system.

Hydrofoil systems for use with boats for over the water propulsion are well known. A hydrofoil, comprising an arrangement of hydrodynamically shaped foil sections depending downwardly in supporting relation with the hull of a vessel, provides lift to the vessel to raise the vessel hull clear of the water surface upon the attainment of a sufficient forward speed, thereby ridding the vessel of the parasitic hull drag of the water which, in conventional craft, presents an obstacle to the achievement of higher speeds.

A major problem encountered by prior hydrofoil arrangements has been the achievement of longitudinal stability of the vessel. This problem arises owing to the fact that variation in the longitudinal attitude of the vessel relative to its direction of motion changes the effective angle of attack of the hydrofoil elements, thereby varying the effective lift of the elements, so causing an unstable condition which can result in violent raising and lowering of the hydrofoil members and hull therewith, together with a violent porpoising effect if an unstable condition is reached.

In the main, prior arrangements have been characterized by a multiplicity of hydrofoil members arranged at different positions along the length of the vessel with each providing a part of the lifting force required to raise the hull above the water surface in operation. Many of the prior systems incorporate a sensing device to provide automatic variations in the angle of attack of at least one hydrofoil member in an effort to provide automatic stabilizing of the vessel in its progress over rough water.

Although a number of generally satisfactory hydrofoil systems have been developed for large, relatively high length-to-beam ratio watercraft, none of the prior art systems has been successfully adapted for use with small pleasure craft of relatively low length-to-beam ratio. The present invention provides such a craft. In accordance with the invention, a fixed incidence hydrofoil means is located at a single longitudinal station on the vessel in a position substantially beneath the centre of gravity of

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the loaded craft and such that when the craft is foil-borne, the weight of the craft is fully supported by the single hydrofoil means and the centre of pressure of the hydrofoil means is coincident with or slightly aft of the centre of gravity of the craft. A variable incidence stabilizer plate means extending beneath the vessel aft of the hydrofoil means and adjustable in horizontal angle relative to the longitudinal axis of the vessel permits the attitude of the vessel and the angle of attack of the hydrofoil means to be readily controlled. During foil-borne operations, the stabilizer plate means does not function to provide lift at the stern. In functions to provide either an essentially "neutral" stabilizing effect when the centre of pressure of the hydrofoil is coincident with the centre of gravity; or, when the centre of pressure of the hydrofoil means is aft of the centre of gravity of the craft, the plate provides a downward force to compensate for the lifting moment at the stern. This arrangement has been found to provide exceptional longitudinal stability of the craft in operation.

Transverse stability of the arrangement is provided by the use of a pair of V-form hydrofoils. Each of the hydrofoil pair includes subsidiary barrier fins extending normally inwardly at a point slightly above the apex of the V of the foil to minimize the entrainment of air along the surface of the foil. Also, a downwardly extending keel means located at the apex of each of the foil pair provides lateral resistance against sideways skidding of the craft during turns.

The stern of the craft is recessed forwardly to receive an outboard motor suspended in propulsive arrangement from a transverse transom portion of the recessed well. The variable incidence plate means extends rearwardly from the stern, preferably being positioned substantially in line with the axis of the propeller of the motor in order to increase its deflective effectiveness, particularly at lower speeds.

In order to facilitate handling of the vessel, the hydrofoil and the variable incidence plate, together with the propulsive motor are adapted for retraction upwardly, thus facilitating land transportation, launching and beaching of the vessel.

While the preferred embodiment is for relatively low length-to-beam ratio personal runabouts holding up to six passengers, it is contemplated that larger versions of the arrangement may be utilized.

Broadly, the water borne hydrofoil craft of the invention comprises a hull portion for floating on water adapted to receive fluid reaction means in attached propulsive relation therewith; hydrofoil means attached to the craft and adapted to fully support the hull above the water at speed, the longitudinal position of said hydrofoil means being selected such that the centre of pressure thereof when the hull is foil-borne coincides with or is aft of the centre of gravity of the loaded craft; variable incidence stabilizer plate means extensible below the hull of the craft, located longitudinally from the hydrofoil means to control the angle of incidence of the craft together with the angle of attack of the hydrofoil means, and control means for selectively varying the angle of incidence of the plate means to provide a neutral or negative lift at the stern when the craft is foil-borne.

Certain embodiments of the present invention are described by way of example, reference being had to the accompanying drawings wherein:

FIGURE 1 is a general perspective view of the craft in the operative condition;

FIGURE 2 is a perspective view showing the underside of the craft;

FIGURE 3 is a partial perspective view showing details of the stabilizer plate mounting and control means;

FIGURE 4 is a partly sectional detail of the incidence control of the variable plate means; and

FIGURE 5 is a schematic illustration showing the relative positioning of the centre of gravity of the craft and the centre of pressure of the hydrofoil in foil-borne operation.

Referring first to FIGURES 1, 2 and 3, the hydrofoil craft 20 includes a streamlined hull 25 formed of glass fibre, reinforced plastic or the like and having a pair of hydrofoil assemblies 21, 22 attached thereto. Each assembly 21, 22 is of V-form and comprises an inner foil member 23 and an outer foil member 24. Foil members 24 are pivotally attached to the underside of hull 25 at their inner ends by means of pivotal mountings 26 fixed to the bottom of hull 25 adjacent the centre line thereof. The outer foil members 24, in fixed angular relation with the inner foil members 23, are secured to the hull 25 by support arms 27, attached by foil pivot brackets 28 and brace frames 29 arranged in triangulated, braced relation therewith.

As shown particularly in FIGURE 3, the hull 25 of the craft is formed with a stern well 35 including vertical sidewalls 36 and a lateral transom 39 at the forward end thereof adapted to permit rigid attachment of an outboard motor or propulsive means (not shown) thereto. It is also contemplated that the present invention may be adapted for use with an aircraft type propeller drive upon suitable adjustment of the relative longitudinal position of the hydrofoil means to compensate for the changed eccentricity of thrust.

The rear stabilizer assembly 45 comprises a substantially flat stabilizer plate 46 having leading and trailing sharp edges. The plate 46 is mounted on pivot pins 47 secured to a pair of support brackets 48, 48a. A control bracket 49 extends upwardly from the plate 46 and is connected to a control rod 50 by means of a clevis end 51 and a pin 52 extending through the clevis end 51 and rod 50.

The stabilizer assembly 45 is secured to the hull 25 of the craft by means of a pair of tubular suspension struts 56, 56a to which the support brackets 48, 48a are secured. Struts 56, 56a each have a stiffening member 57 secured to the underside thereof and pivotally mounted on stern well sidewalls 36 by pivot mountings 58.

Each of the stabilizer support struts 56, 56a has a holding plate 60 secured to the upper end thereof adapted to releasably engage a strut securing pin 61 attached to each side 36 of stern well 35 by a bracket 62. A strut retracting bar 63 is pivotally connected to plate 60 by transverse pin 64 and has a hole 65 formed therethrough at a point intermediate pin 64 and its free end, which is provided with hand grip 66 to facilitate manual manipulation thereof. It will be seen that the arrangement just described enables the stabilizer assembly 45 to be secured in a fixed, operative position as shown in FIGURES 1-3 or to be moved and secured in a retracted position by raising bars 63, disengaging plates 60 from pins 61, pushing the inner ends of struts 56, 56a downward and engaging holes 65 in bars 63 with pins 61.

Referring particularly to FIGURE 4, the means for controlling the angle of incidence of the variable plate 46 relative to the horizontal comprises a rotatable shaft 71 mounted in a thrust plug 72 within the upper end of the stabilizer support arm 56a by means of a pair of transverse pins 73 which engage a groove 74 in shaft 71. The inner end of the shaft 71 has a threaded portion 75 in threaded engagement with a threaded recess 76 of the control rod 50. As shown in FIGURE 3, a stabilizer control handle 77 conveniently positioned near the operator's position in the craft cockpit is connected to shaft 71 by torque tube 78 and flexible coupler 79. Rotation of the shaft 71 by means of control handle 77 produces an extension or shortening of the control rod 50, thus enabling precise control of the angle of plate 46 from the cockpit. Rotation of the rod 50 is prevented by virtue of the clevis

joint 51 at the outer end thereof engaging the control bracket 49.

Referring now to the details of the hydrofoil pivotal mounting arrangement illustrated in FIGURES 1, 2 and 3, the brace frames 29 include a first bracing strut 80 pivotally connected to support arms 27 adjacent the outer ends thereof by support arm pivot brackets 81 and pivotally secured to the side of hull 25 by forward hull brackets 82. A second bracing strut 83 is fixed such as by welding to each first strut 80 at its outer end and is pivotally secured to hull 25 by aft hull brackets 84. The inner ends of the support arms 27 are detachably, pivotally secured to boat hull 25 at a first outboard position indicated by the numeral 85 (the position of the left arm 27 in FIGURE 3) and may be resecured to a position adjacent the centre line of the boat at the top of the hull to a holding bracket 86 to secure foil assemblies 21, 22 in a retracted position (the position of the right-hand arm in FIGURE 3).

An important feature of the hydrofoil boat arrangement of this invention is the location of the hydrofoil assemblies 21, 22 at a longitudinal position on the boat hull substantially beneath the centre of gravity such that the weight of the boat is fully supported by the hydrofoil means 21, 22 when the craft is foil-borne. That is, the positioning of the foil means 21, 22 must be such that when the loaded craft is in foil-borne operation, the centre of pressure of foils is coincident with or slightly aft of the centre of gravity of the craft. The stabilizer assembly 45 does not function as a hydrofoil element. In normal operation it exerts either a neutral or a negative lifting force at the stern of the craft. Any negative force must be sufficient only to compensate for the lifting moment at the stern resulting from the positioning of the hydrofoil means such that the centre of pressure is aft of the centre of gravity of the craft as shown schematically in FIGURE 5. Preferably, the centre of pressure is coincident with the centre of gravity or aft thereof a distance less than 10% of the hull length. This arrangement provides excellent longitudinal stability in the foil-borne operation of the craft. Also, by selecting a hull configuration in which the variation of the centre of gravity of the craft due to passenger movement is substantially controlled in the longitudinal sense by the utilization of a single transverse seat arrangement, a particularly stable and readily controlled vessel is provided.

Also, in the matter of stability, the provision of a downwardly extending keel portion 90 at the apex of the foil members 23, 24 prevents undue sideways skidding motion of the craft during high speed turns, while anti-ventilation barriers 91 comprising plate portions extending normally from each of the foil members 23, 24 at a point above the apexes prevent the access of air along the top surface of the foil in the low pressure lift region so that cavitation flow is avoided and separation which may occur with the presence of air bubbles at this point, is substantially eliminated.

A particular advantage afforded by the present arrangement as illustrated is the arrangement of the stabilizer plate 46 below the bottom of the craft and behind the propulsive means which ensures effective stabilizing operation of the plate 46 even at relatively low speeds, owing to the motion of water therepast due to the action of the propeller.

It will be understood that the vessel can be operated in a relatively unrestricted fashion as an orthodox boat when the foils 21, 22 and stabilizer assembly 45 respectively are retracted. Retraction of the stabilizer plate 46 need not be effected for hydrodynamic reasons but is carried out principally to facilitate operation in shallow waters with the hull in the immersed position for carrying out operations such as beaching and launching.

It is to be understood that the form of the invention herein shown and described is to be taken as a preferred example of the same and that various changes in the

shape, size and arrangement of the parts may be resorted to without departing from the spirit of the invention or the scope of the appended claims.

What I claim as new and desire to protect by Letters Patent of the United States is:

1. A water borne hydrofoil craft comprising: a hull portion for floating on water adapted to receive fluid reaction means in attached propulsive arrangement therewith; hydrofoil means attached to the craft adapted to support the full weight of the craft above water at operational speeds, said hydrofoil means being located at a longitudinal position such that in foil-borne operation, the centre of pressure of the hydrofoil means is between the centre of gravity of the loaded craft and a point slightly aft of said centre of gravity; said hydrofoil means comprising a pair of independent V-shaped groups of foils suspended side-by-side from said hull portion with each pivotally connected at the inner end thereof to the bottom of the craft, a pair of support arms pivotally connected with the outer ends of said foils extending inwardly and detachably pivotally secured to the upper outboard edge of the hull, bracing struts pivotally attached to said support arms adjacent their outer ends extending inwardly in a triangulated arrangement and pivotally attached to the side of the hull, said foils, support arms and bracing struts adapted for upward retractive movement; variable incidence plate means extensible below the hull of the craft, located longitudinally from said hydrofoil means to control the angle of incidence of the craft together with the angle of attack of the hydrofoil means, and control means for selectively varying the angle of incidence of the said plate means.

2. A hydrofoil craft as claimed in claim 1 wherein said variable incidence plate means comprises a substantially flat rigid plate with sharp leading and trailing edges and connected by pivot mounting means to a support structure extending downwardly and rearwardly from said hull.

3. A hydrofoil craft as claimed in claim 2 wherein said variable incidence plate means is operatively connected with a control means extending from the craft cockpit

whereby the angle of incidence of said plate means can be varied by the operation when the craft is in motion.

4. A water borne hydrofoil craft comprising: a hull portion for floating on water adapted to receive fluid reaction means in attached propulsive arrangement therewith; hydrofoil means attached to the craft adapted to support the full weight of the craft above the water at operational speeds, said hydrofoil means being located at a longitudinal position such that in foil-borne operation, the centre of pressure of the hydrofoil means is between the centre of gravity of the loaded craft and a point slightly aft of said centre of gravity; variable incidence plate means extensible below the hull of the craft, located longitudinally from said hydrofoil means to control the angle of incidence of the craft together with the angle of attack of the hydrofoil means, and control means for selectively varying the angle of incidence of said plate means including an upright bracket fixed at one side of the plate means, a non-rotatable control rod pivotally connected to said bracket and extending forwardly towards the craft cockpit, a rotatable torque member extending rearwardly from the craft cockpit, means connecting said torque member and control rod such that rotational movement of the torque member effects controlled reciprocatory movement of said control rod.

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ANDREW H. FARRELL, *Primary Examiner*.