United States Patent [19]

Danforth

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[54] **HYDROFOIL VESSEL**

[75] Inventor: **Leon J. Danforth,** Long Beach, Calif.

[73] Assignee: **Richard B. Markus, trustee,** San Francisco, Calif.

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[52] **U.S. Cl.** ..... **114/66.5 H**
[51] **Int. Cl.** **B63b 1/26**
[58] **Field of Search** ..... 114/66.5 H

[56] **References Cited**

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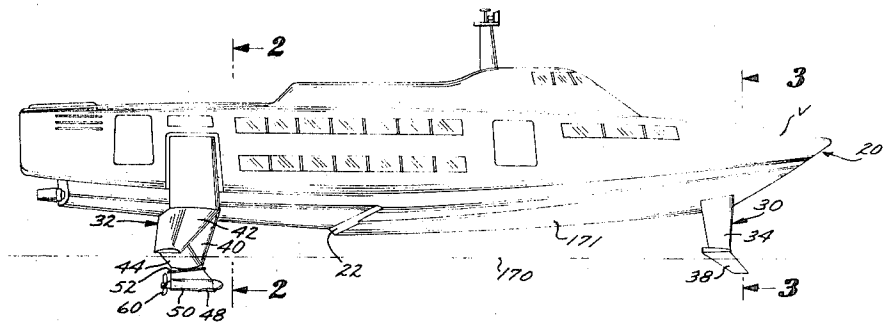
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Primary Examiner—George E. A. Halvosa
Assistant Examiner—Barry L. Kelmachter
Attorney—Fulwider, Patton, Rieber, Lee and Utecht

[57] **ABSTRACT**

A canard type hydrofoil vessel utilizing a lightly loaded bow foil unit to act as a pitch suppressor to oncoming waves in conjunction with dual main foil units. The bow foil unit supports approximately 15 to 25 percent of the weight of the vessel and the main foil units support approximately 75 to 85 percent of the weight of the vessel when the vessel is foilborne.

9 Claims, 13 Drawing Figures



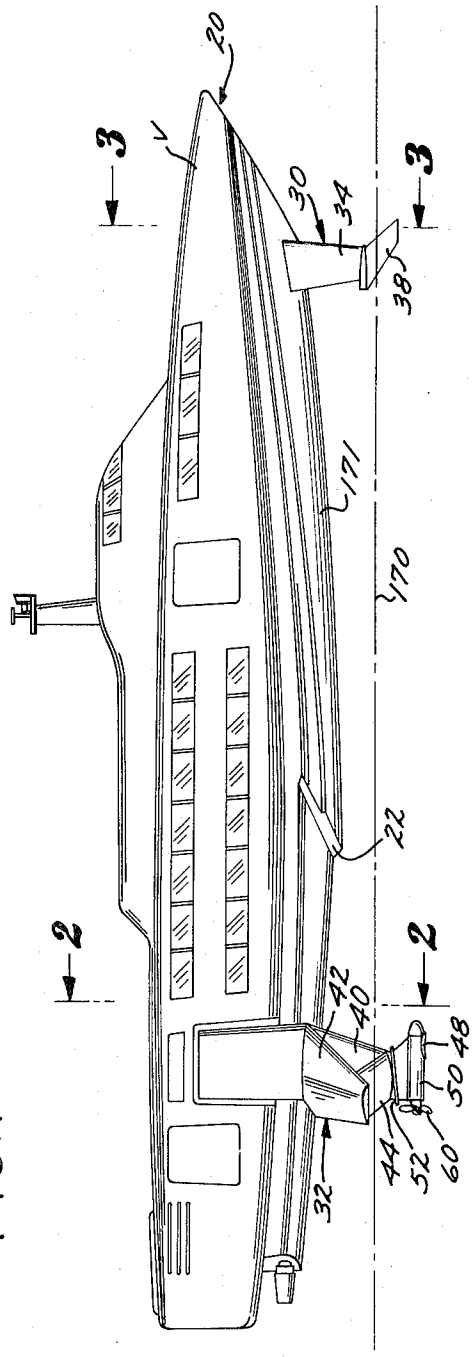


FIG. 1

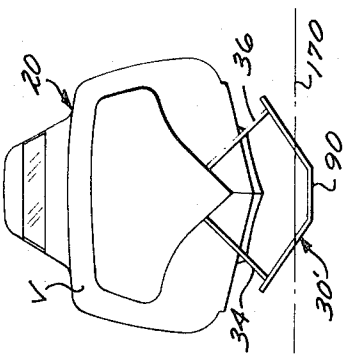


FIG. 4

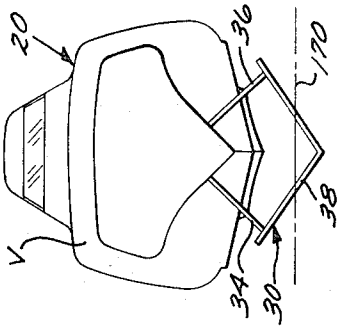


FIG. 3

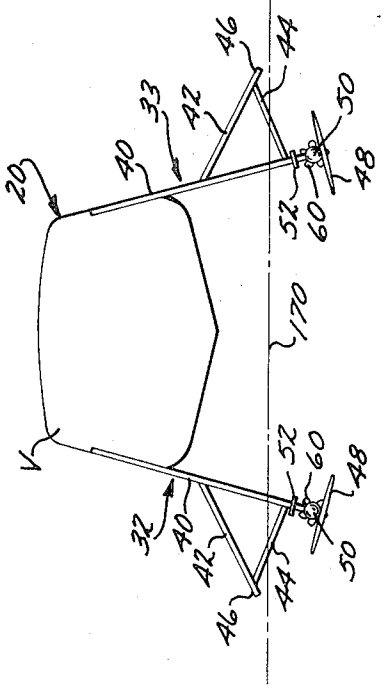


FIG. 2

INVENTOR.
LEON J. DANFORTH
BY
Fulwider, Patton, Rieber, Lee and Utecht
ATTORNEYS

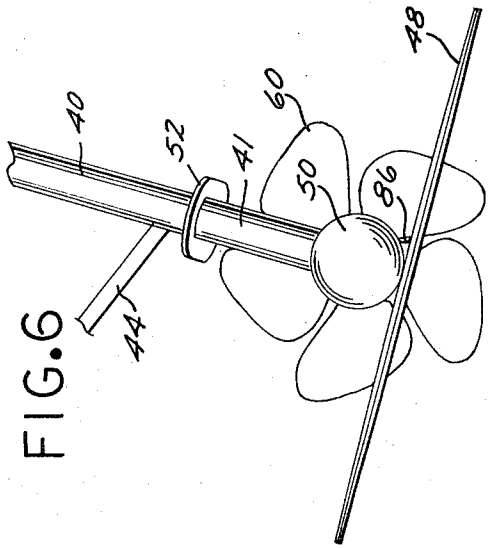


FIG.6

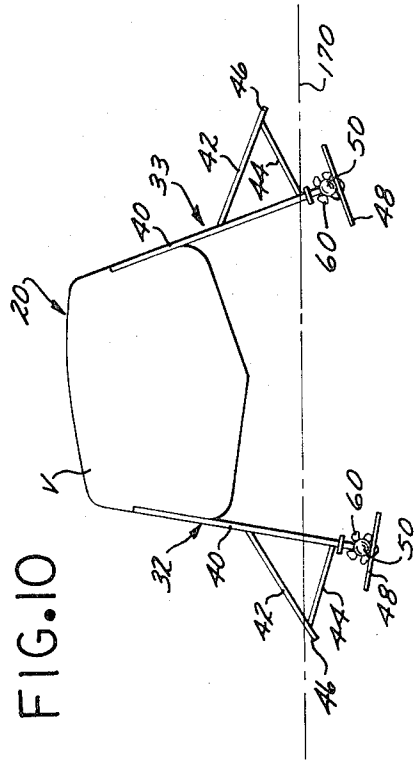


FIG.10

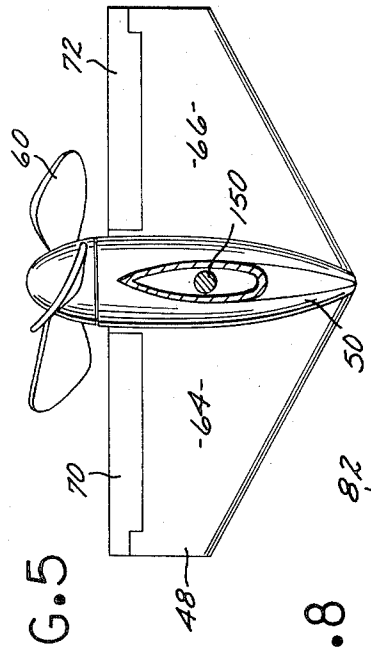


FIG.5

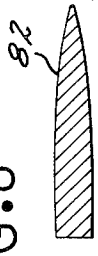


FIG.8

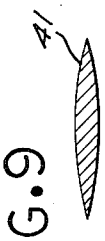


FIG.9

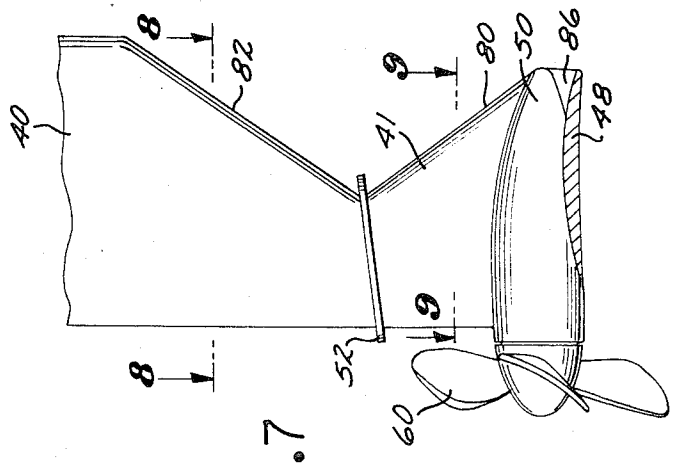


FIG.7

INVENTOR.
LEON J. DANFORTH
BY Fulwider, Patton, Rieber, Lee and Utecht
ATTORNEYS

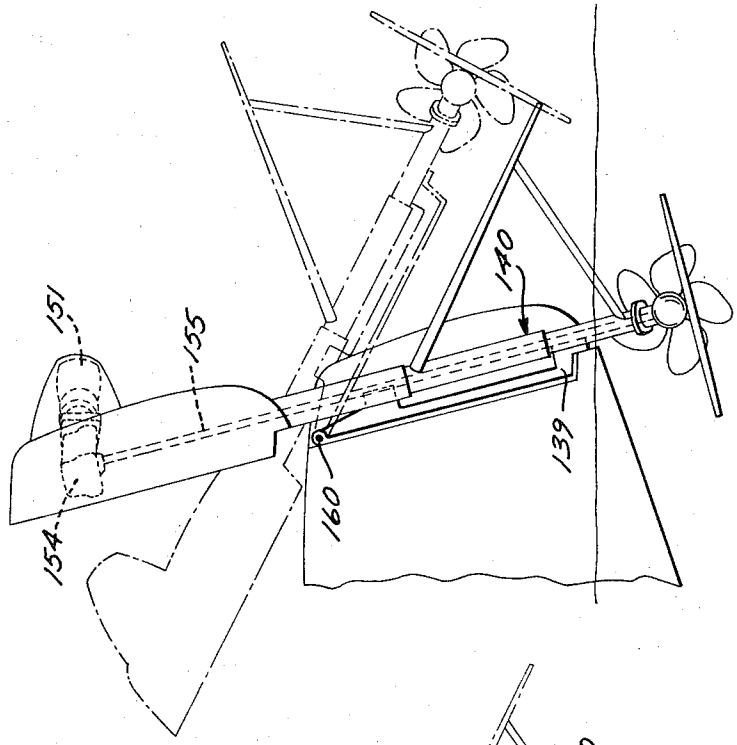


FIG. 13

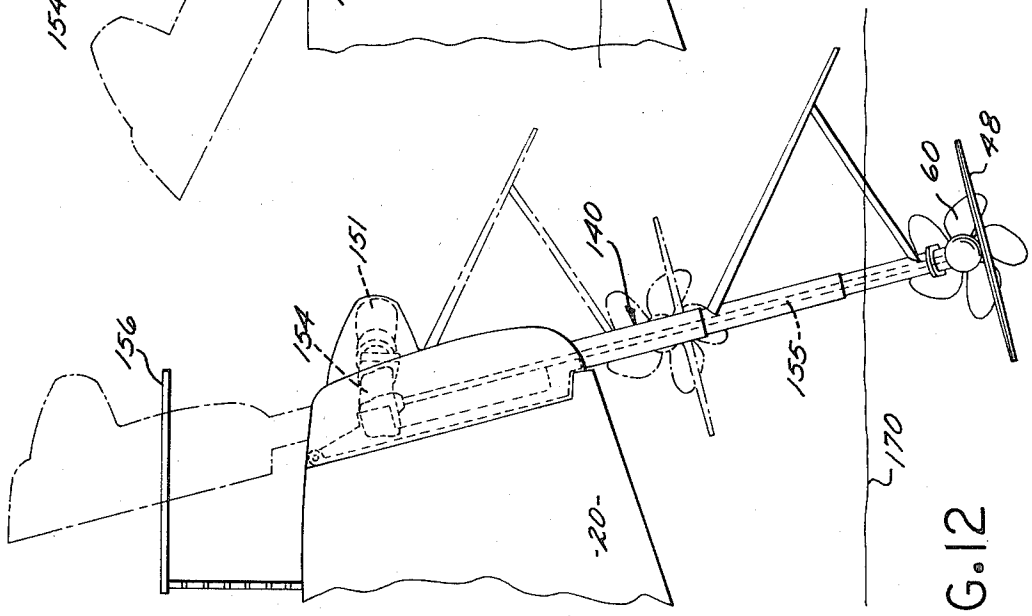


FIG. 12

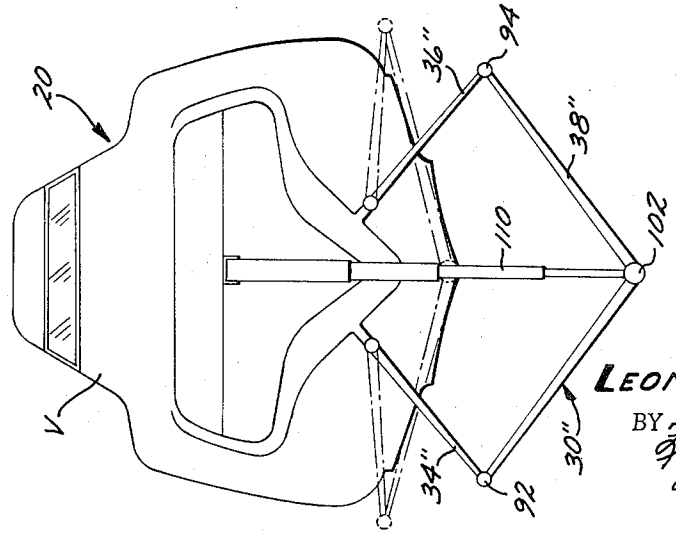


FIG. 11

INVENTOR.
LEON J. DANFORTH
BY Fulwider, Patton, Rieber, Lee and Utecht
ATTORNEYS

HYDROFOIL VESSEL

BACKGROUND OF THE INVENTION

The present invention relates to hydrofoil vessels and more particularly to a canard type hydrofoil vessel which will provide a stable high speed comfortable ride to its passengers even in rough seas without requiring automatic electronic or mechanical sensor control devices.

Various hydrofoil vessels have been developed generally utilizing either a fully surface-piercing or fully submerged lifting foil configuration. Surface-piercing foils when designed properly are self-stabilizing and provide a rapid lift off or short take-off distance to full foilborne flight. Such foils, however, operate in close proximity to the free surface of the ocean and are thereby subjected to large variations of the profiling sea; resulting in erratic pitching and heaving the vessel and therefore give a rough ride to its passengers in a choppy sea. Submerged lifting foils, on the other hand, are submerged deeper from the free surface than a surface piercing foil design and therefore are less influenced by large variations of the profiling sea. Drawbacks to this design is low lift at low speed requiring large take-off distances to foilborne flight, necessitating large power plants to propel the vessel. Further drawbacks are the vessels inherent destabilizing characteristics requiring automatic sensor controls for safe operation.

When provided with automatic controls, the submerged lifting foil design offers a smooth and stable ride even in choppy seas. The use of automatic controls greatly increases the cost, complexity and reliability of a fully submerged foil hydrofoil vessel, particularly since an electronic computer must generally be incorporated in such automatic controls.

SUMMARY OF THE INVENTION

The hydrofoil vessel of the present invention is of the canard type utilizing a lightly-loaded bow foil unit to act as a pitch stabilizer and as a suppressor to the oncoming waves or dampener to the vessel. The dual main foil units extending from opposite sides of the afterbody portion of the vessel are of a hybrid design embodying a combination of surface-piercing take-off foil, as surface piercing stabilizer depth sensor foil, and a fully submerged lifting foil. The take-off foils employ a high-lift, low speed hydrofoil cross-section so as to effect rapid take-off to a foilborne condition. The fully submerged foils employ a highly efficient, subcavitating cross-section providing efficient lift after the vessel is fully foilborne. The surface piercing stabilizer foil is a low lift depth sensor base ventilated foil designed to maintain the vessel on an even keel and to maintain the depth of the fully submerged foil. The foil arrangement of the present invention affords a stable ride with maximum efficiency without requiring expensive automatic sensor controls.

The hydrofoil vessel of the present invention also utilizes a pair of foil tip extensions attached to the outer extremities of the main lift take-off foil for the purpose of passively or automatically suppressing or limiting the degree of excess rolling or banking of the vessel possibly caused by upsetting conditions of an erratic or rough seaway or pilot error in pilot over-control when engaged in a turn.

This feature further prevents the fully submerged foil from ever leaving the water or dangerously ever coming in close proximity to the free surface tending to broach the vessel and further prevents the propeller from ever coming in close proximity to the free surface tending to broach the vessel and race (which could lead to a multiple of structural failures in the power drive train).

The present invention offers a further design advantage in being able to shed most ocean surface of semi-submerged debris that may be in way of the vessel's flight path with no or minimal damage to the foil structure and discomfort to its passengers or personnel. All foils and supporting struts are raked or swept rearward from the flight path direction of the vessel, offering a relieving path of least resistance to a debris object that might be captured by the foil system.

The split (one port and one starboard) main lift stern foils with separate propulsion at the base of each strut offers the vessel a further design feature in being able to maintain a safe foilborne flight at a reduced speed in the event of a power failure by either of the propulsion units.

The foil units of the hydrofoil vessel of the present invention are readily retractable vertically to control foil draft in hazardous shallow waters during forward movement of the vessel and so by doing permit safe foilborne operation in most channels, causeways and port facilities; facilitating docking at conventional dock sites, and immediate transition for open sea operations where greater vessel keel draft is necessary to clear the oncoming seaway. Lateral retraction to the main lift stern foils is also offered to facilitate dockside maintenance and repairs.

Various other objects and advantages of the hydrofoil vessel of the present invention will become apparent from the following detailed description and the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a hydrofoil vessel embodying the present invention;

FIG. 2 is a vertical sectional view taken along line 2—2 of FIG. 1 showing the main foil units of said vessel;

FIG. 3 is a vertical sectional view taken along line 3—3 of FIG. 1 showing the bow foil unit of said vessel;

FIG. 4 is a view similar to FIG. 3, but showing an alternate form of bow foil unit;

FIG. 5 is a top plan view of a main lift foil;

FIG. 6 is a front view of the lower portion of one of the main foil units;

FIG. 7 is a broken side elevational view of the lower portion of one of the main foil units;

FIG. 8 is a horizontal sectional view taken on line 8-8 of FIG. 7;

FIG. 9 is a horizontal sectional view taken on line 9—9 of FIG. 7;

FIG. 10 is a view similar to FIG. 2 showing the operation of the take-off foil tip extensions of said vessel;

FIG. 11 is a view similar to FIG. 3 (but in enlarged scale) showing a retractable bow foil unit which may be employed with said vessel;

FIG. 12 is a broken front view showing an arrangement for retracting the main foil unit of said vessel; and

FIG. 13 is a view similar to FIG. 12 showing how the main foil unit may be pivoted out of the water.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring particularly to FIGS. **1, 2** and **3,** there is shown a preferred form of hydrofoil vessel V embodying the present invention. The vessel V utilizes a hull, generally designated **20,** having a transverse swept **22** at its lower intermediate portion separating the forebody of the hull from the afterbody of hull. The forebody has a longitudinal step or strake **171** separating the keel planing bottom from the chine step planing bottom. The afterbody keel has a rise running aft to provide afterbody clearance during forebody planing just prior to take-off to foilborne flight. A bow foil unit, generally designated **30,** extends from the front portion or forebody of the hull **20.** A pair of main foil units, generally designated **32** and **33** extend from opposite sides of the stern portion or afterbody of the hull.

The bow foil unit includes a pair of outwardly and downwardly anhedral inclined take-off foil elements **34** and **36** of like construction which are connected at their lower ends to a dihedralled stabilizer lifting foil **38.** The take-off foil elements **34** and **36** preferably utilize a subcavitating high-lift, high in chamber cross-section to facilitate rapid low speed take-off.

The bow take-off foil **30** has both leading edge planform sweep running aft from the keel of vessel **20** and has either constant or decreasing chord or taper across its anhedral span. Furthermore, the take-off has decreasing angle-of-incidence across its span starting from the keel of the vessel **20.**

Foil **38** utilizes a high speed blunt base air ventilated cavity entrained cross-section and is of the surface-piercing type during normal foilborne operations running at water-line.

The stabilizer lifting foil **38** has both leading edge-planform sweep running forward from its juncture with the take-off foil running forward in depth and inturn has decreasing chord or taper across its dihedral span. Furthermore, the stabilizer lifting foil has a decreasing angle of incidence across its span starting from its junction intersection with the take-off foil.

The main foil units **32** and **33** are of like construction, but are mirror images of one another. Each includes a downwardly and outwardly anhedral strut **40** having its upper end secured to the afterbody of the hull **20.** A downwardly and outwardly extending anhedral take-off foil **42** has its upper portion affixed to the intermediate portion of strut **40.** A stabilizer foil **44** extends upwardly and outwardly in a dihedral fashion from the lower portion of the strut **40** and has its upper end connected to the lower portion of take-off foil **42,** allowing a portion of **42** to extend outward and downwardly beyond this junction. The tip extension of foil **42** extends beyond its junction with the stabilizer foil and forms a downwardly and outwardly continuation of take-off foil **42,** overhanging and extending below the upper end of the stabilizer foil **44.** A main lift foil **48** is affixed to the lower end of each strut **40.** A propulsion pod **50** is carried by the strut **40** immediately above the main lift foil **48** and a cavitation plate **52** which is a continuation of the stabilizer foil **44** is provided above the pod **50.**

A propeller **60** is mounted on the aft end of each propulsion pod **50.** Alternatively, however, a water jet intake scoop could be positioned at the forward end of pod **50** to injest water up the strut to supply a water pump jet system housed within the hull **20.** The take-off foils **42** utilize a high-lift, low speed sub-cavitating cross-section which is high in camber to permit rapid lift off for minimal angle of attack to the seaway and through planform sweep and taper, a high stall angle of attack is afforded so as to prevent fall-off tendency while the vessel is becoming foilborne. Preferably, the angle of incidence along the lateral inclined span of the take-off foil **42** decrease with depth to provide greater incidence at the top of the take-off foils than at the bottom so as to afford quicker and more efficient take-off of the vessel with minimal susceptability to cavitation as speed increases and water line changes down the span during lift off to a foilborne operation. It will be understood that as the speed of the vessel increases, less incidence is required to obtain lift. With lower incidence, the take-off foil **42** will be less responsive to an oncoming seaway as speed increases with a net effect of increased stability during take-off. Further, with respect to the take-off foils **42,** the leading edges thereof taper across the span from their inboard to their outboard ends. During take-off, such take-off foils **42** provide inherent stabilizing strength, as for example during take-off in an erratic quartering seaway. In this regard, in the event the vessel rolls, it will tend to roll about its longitudinal axis allowing the foil tip extremity **46** to recede into the water, as illustrated in FIG. **8,** thereby picking up greater planform area and greater incidence than the foil lifting out of the water so as to afford inherent roll restoration with a high rate of roll recovery.

As the vessel recovers from a destabilized banked condition back to an even keel up-right flight condition, other forces come into play from the opposite foil receding back into the water gaining lift from its increased wetted area and increased angle of incidence on the foil for full hull recovery. In this fashion the vessel does not lend itself to a roll oscillation condition, but in turn inherently dampens this motion rapidly. The design is such that frequency of encounter with a running seaway never matches the natural period of roll of the vessel.

The utilization of the overhang tip extension foil of the main take-off foil **46** provides important advantages. Each such overhang foils act as a suppressor or threshold stop in controlling submergence of one of the main foil units when the vessel V starts to roll or bank. It should be understood that the overhang foil **46** may either comprise an extension of the take-off foils **42** along the spanwise axis of the take-off foils.

The stabilizer foils **44** offer a large restoring moment arm with respect to the center of gravity of the vessel V in the event the vessel is disturbed in yaw or roll. When the vessel begins to roll, greater wetting outboard along the span of the stabilizer foil **44** as that foil recedes deep into the water offers positive wetted surface lift and outboard shifting of the hydrodynamic center-of-pressure lift thereby increasing the restoring moment arm relative to the vessel's center-of-gravity and increasing the lift force vector so as to righten vessel V to an even keel flight position. The angle of incidence of the stabilizer foils **44** decreases with draft so as to effect more rapid roll restoration at its upper ends near the free surface running water line. The chord of the stabilizer foils **44** increases or tapers from their inboard to their outboard ends and such foils are swept rearwardly.

Referring now to FIGS. 5 and 6, each main lift foil 48 includes a pair of integrally joined swept-back panels 64 and 66. The panels 64 and 66 may be provided with balanced hinged control flaps 70 and 72 respectively. By means of such controls flaps, more rapid foilborne take-off is possible, as well as an increase in the load-carrying capacity of such foils. Additionally, rapid turning of the vessel V may be facilitated by using the flaps to bank the vessel into a tighter turn. The use of such flaps also permit the accomodation of an autopilot roll dampener should it be necessary to minimize roll or heel oscillation while the vessel is transversing a beam or quartering following sea. The main lift foils 48 preferably utilize a highly efficient sub-cavitating foil cross-section. The hydrofoil planform has taper or decreasing chord across the span, decreasing from the root or juncture with 50 to its outer extremity tip. The taper is so designed to facilitate a balanced positive pressure lift distribution across the span and to facilitate leading edge planform sweep to an unswept trailing-edge. The foil has leading-edge planform sweep to control the inception of cavitation and to shed debris in the way of its flight path.

With continued reference to FIG. 2 and 6 and with additional reference to FIG. 7, each of the stabilizer foils 44 are of the high-speed, blunt base, air cavity ventilated type entraining air from the free surface interface to its junction with strut 40 where such air dissipates ovr the cavitation plate 52. Preferably, the section 41 of strut 40 below cavitation plate 52 utilizes a thin subcavitating cross-section, while the portion above the cavitation plate utilizes a blunt base, ventilated cross-section. As indicated in FIG. 7 raking the leading edge 80 prevents air from traveling down its face or tripping over the cavitating plate 52. In this manner, such air does not induce cavitation to the propeller 60. Debris will also be caused to be moved upwardly along the leading edge 80 and therefore away from the propeller 60 because of such sweep.

With continued reference to FIG. 7, the section of each strut 40 above the cavitation plate 50 sweeps forwardly and upwardly, as indicated at 82. This configuration serves to flatten out the spray to the side rather than to have such spray move upwardly along the strut. With reference again to FIG. 6, it will be noted that there are only two interference junctions 84 and 86 between each main lift foil 58 and the underside of pod 50 thereby minimizing drag at this point and controlling all adverse pressure gradients to the topmost region of panels 64 and 66. It further allows filleting in that juncture region 86 and 84 to alleviate the intensity of the adverse pressure gradient and preclude the inception of cavitation in that region.

Referring now to FIG. 4, there is shown an alternate form of bow foil unit 30'. Such alternate form includes a pair of take-off foil elements 34 and 36 which may be identical to those shown in FIGS. 1 and 3. The combination stabilizer and lifting foil 38'however, differs from that shown in FIGS. 1 and 3 in that the lower portion 90 thereof is flat so as to define a fully submerged highly efficient sub-cavitating foil cross-section for vessel speeds of about 60 knots or less. A cavitating foil cross-section may be utilized for vessel speeds greater than about 60 knots.

Referring now to FIG. 11, there is shown a retractable bow foil unit generally designated 30'' which may be utilized with the hydrofoil vessel V embodying the present invention. The bow foil unit 30'' is generally similar to that shown in FIGS. 1 and 3 except that it is provided with hinge points 92 and 94 at the junction of the take-off foil elements 34'' and 36'' with the upper end of the combination stabilizer and lifting foil 38''. From hinge point 102 a hydraulic cylinder and plunger unit 110 extends upwardly into the confines of the hull 20.

With this arrangement the bow foil unit 30'' may be retracted upwardly from its solid outline position of FIG. 9 into its planform outline position thereof. In the retracted position foils 34'' and 36'' may be easily inspected, serviced and replaced if necessary. Suitable conventional controls should be provided for the hydraulic cylinder and plunger unit 110 so as to permit the foils 34'', 36'' and 38'' to be securely but temporarily set at any position intermediate their fully extended and fully retracted positions. Partial retraction facilitates maintaining foilborne operations in shallow water areas where foil submergence draft is critical for a safe operation.

It should also be noted that the hinge point 102 provides a desirable location for an electronics surveillance device (not shown), such as a forward-looking Sonar. Such Sonar could be utilized to scan an area ahead of the vessel V for submerged and partially submerged objects and would have a range sufficiently great to allow a pilot to take evasive action in time to prevent a collision.

Referring now to FIG. 12, there is shown an arrangement for translational retracting the main foil units of the vessel V. Such arrangement utilizes a track 139 mounted on the side of the hull upon which to translate struts 140 rather than the fixed struts 40 shown in the preceeding figures. The struts are translated with the aid of conventional hydraulic cylinder and plunger units (not shown) with suitable controls being provided to permit such sections to be progressively raised from their extended position shown in solid outline in FIG. 11 to their raised retracted retracted positions shown in phantom outline in this figure.

A propeller 60 or water intake at the leading-edge of item 50 to facilitate water jet propulsion is used as the means of propulsion with this arrangement. Conveniently, the power for such propellers may take the form of a conventional gas turbine engine or other conventional readily available off-the-shelf combustion engines 151 rigidly mounted on the uppermost section 152 of struts 140. A suitable transmission 154 is interposed between the shaft of each such engine and the upper end of a telescoping propeller shaft 155 that extends through strut 140. With this arrangement, movement of the main foil units to their retracted position will lift the engine 151 and its transmission 154 above a service platform 156 formed on the hull 20 to facilitate inspection and repair thereof.

It will be understood that since the engines 151 are mounted outside the hull 20, little noise and vibration will be conducted into the cabin and there is maximum protection from engine fire. Preferably, as indicated in FIG. 13, each track 139 will be connected at its upper portion to the hull 20 by means of a horizontally extending pivot pin 160. With this arrangement, the retracted strut and the components carried thereby may be pivoted from the solid position shown in FIG. 12 to the plantom outline position shown therein. A suitable locking mechanism (not shown) is provided to main-

tain the strut **140** in its normal operating position. With the strut **140** rotated to its phantom outline position of FIG. **13** inspection of the foils and drive units can be readily conducted. Moreover, the strut **140** and elements supported thereby may be easily serviced in this position. The engine **151,** transmission **154,** or any of the other components, may be detached from the strut **140** for service. Additionally, the entire strut **140** may be easily replaced utilizing this arrangement.

In the operation of the afore-described hydrofoil vessel V, the high-lift characteristics of the lifting foils **42, 34** and **36** permit the vessel to be foilborne extremely rapidly. The vessel will normally be foilborne at the water line **170** indicated in FIGS. **1–4.** Referring to these figures, it will be noted that the main lifting foils **48** operate submerged for high lift efficiency. To properly distribute the longitudinal loading of the vessel V, a canard loading configuration is utilized wherein the bow foil unit **30** supports from about **15** to **25** percent of the vessel's total all-up weight, and the two main foil units **32** and **33** jointly support approximately 75 to 85 percent of the vessel's total all-up weight. By utilizing the canard loading configuration the vessel has the ability to reduce head sea accelerations and improved stability in following seas as compared to prior art hydrofoil vessels. The bow foil unit **30** takes the full impact of an oncoming seaway so that the motions of the bow foil unit control the natural frequency of the vessel in pitch and gives adequate separation between the vessel's own natural frequency and the dominant frequencies of encounter in head seas of the type which produce significant inputs of energy to the vessel. It should be noted that the relative innefficient lifting characteristics of the combination stabilizer and lifting foil **38,** while somewhat detrimental to the powering performance of the vessel V, achieves relatively small fluctuations in lift for relatively large angle of attack excursions imposed by the oncoming seaway. Accordingly, the sacrifice in drag is believed to be minimal considering that the bow foil unit **30** supports only 15–25 percent of the vessel's total weight whereby its lift-to-drag ratio may be relatively low so as to satisfy the criteria for minimal response to the seaway without contributing an unacceptably high drag. Moreover, the motion stiffness of the bow foil unit **30** in controlling bow heave introduces minimal pitch to the vessel which in turn results in relatively small angle of attack excursions by the main foil units **32** and **33.** Additionally, the downwash from the bow foil unit **30** tends to dampen the angularity of the seaway as the latter impinges on the main foil units **32** and **33.** For the above set-forth reasons the foil arrangement of the present invention affords maximum vessel stability with superior drag characteristics as compared with the prior art for surface piercing hydrofoil vessels and comparable drag characteristics as compared with the prior art for fully submerged hydrofoil vessels.

It is particularly important to observe that the foils utilized with the vessel V are swept back so as to assist in shedding any submerged or partially submerged debris encountered by such foils.

Referring now to FIG. **10,** the vessel V is shown during a turning maneuver. In curvilinear flight or when negotiating the vessel V into a turn, centrifugal inertia forces and changes in radius of gyration tend to destabilize the vessel by heeling it outward to restore equilibrium of the turn. This destabilizing outboard heeling condition is inherently overcome with the canard foil configuration described herein before since when the vessel engaged into a turn, the bow of the vessel is pointed into a turn allowing the stern of the vessel to side-slip and swing outboard of the turn. This sideslip phenomena accelerates the water particles over the outboard foil (port foil for a starboard turn, starboard foil for a port turn) and in turn reduces the outboard foil's lateral sweep influence to the free stream flow. This condition retards the lift on the inboard foil due to a masking effect of the inboard strut (starboard strut for a starboard turn or a port strut for a port turn) causing the vessel to heel, incline, or bank inboard to the turn while the vessel is traversing the turn. This effect is a result of the greater lift being generated by the outboard foil (outboard to the turn) overcoming the outward centrifugal inertia of the vessel and the inboard foil lift being retarded offering less lift than at its original even keel rectilinear flight water line. To put the vessel V in equilibrium while negotiating a turn, more wetted surface is incurred by the inboard foil and less wetted surface for the outboard foil. The required increased wetted surface of the inboard foil and required decrease in wetted surface of the outboard foil is obtained by heeling vessel V inboard to the turn so as to thereby submerge the inboard foil and decrease submergence of the outboard foil causing a stable banked turn to occur.

It should also be noted that a controlled bank can be assisted by proper actuation of the flaps **70** and **72.** The vessel then can be said to possess inherent self-stabilizing banking attributes which render comfortable riding tendencies to personnel and passengers on the vessel.

Referring again to FIG. **10,** it will be noted that the overhung foil **46** of the left-hand (more submerged) main foil unit **32** has been forced under the water-line **170.** As noted hereinbefore, this action serves to further depression of the main foil unit **32.** Accordingly, such arrangement automatically suppresses excess roll or banked conditions of the vessel V caused by rough seas or pilot error in over control.

Preferably, the hull **20** will employ a deep V construction utilizing high deadrise and the lateral step **22.** Such configuration offers cushioned entrance of the hull when the hull descends off the foils so as to be hull-borne. Also, the bow will preferably by heavily flared so as to minimize deck and superstructure wetting and to insure bow recovery in the event of a bow-in casualty.

It is an important feature of the form of the invention shown in FIGS. **11–13** that the bow foil unit **30''** and the main foil unit **34''** and **36''** may be retracted and also can be temporarily supported in any position between their fully extended and fully retracted positions. This arrangement makes it possible for the vessel V to be safely operated in a variety of sea and channel conditions. Thus, when the vessel enters shallow water, the bow foil units and the main foil units can be partially or fully retracted. When the vessel V is transversing a channel or the like of reduced depths, and the foils are partially retracted, foilborne flight can be maintained without the danger of collision with the channel sea floor. In a fully retracted manner as shown by the phantom outline in FIGS. **11** and **12,** the vessel operates in a partially foil-borne manner. When the vessel V enters the open sea, the foils will be fully extended and there-

after the hull will be lifted completely clear of the seaway environment to maintain a fully foilborne flight.

Various modifications and changes may be made with respect to the foregoing detailed description without departing from the spirit of the present invention.

I claim:

1. A canard type hydrofoil vessel, comprising:

a hull;

single bow foil means depending from the front portion of said hull and supporting approximately 15 to 25 percent of the weight of the vessel when said hull is foil-borne; dual main foil means depending from opposite sides of the afterbody portion of said hull, each main foil means including a strut, a main take-off foil on said strut and a fully submerged main lift foil below said take-off foil, with said main lift foils supporting approximately 75–85 percent of the weight of the vessel when said hull is foilborne; and

a propulsion unit disposed on the lower end of each of said struts immediately above the main lift foils.

2. A hydrofoil vessel as set forth in claim 1 wherein said struts extend downwardly and outboard of the sides of said hull, said main take-off foils extend downwardly and outboard of the upper portion of said struts, a stabilizer foil extends outwardly and upwardly relative to the lower portion of each strut and intersects the lower portion of each main take-off foil, and a main lift foil is secured to the lower end of each of said struts.

3. A hydrofoil vessel as set forth in claim 1 wherein said bow foil means includes an upper pair of outwardly and downwardly inclined sub-cavitating high-lift bow take-off foils that extend from the sides of said hull and are connected at their lower ends to a dihedral stabilizer and lifting foil, with the lower portion of said stabilizer and lifting foil being submerged during foilborne speeds of said vessel.

4. A hydrofoil vessel as set forth in claim 1 wherein a downwardly and outwardly extending stop foil is provided at the lower end of each of said main take-off foils to suppress roll of said hull.

5. A hydrofoil vessel as set forth in claim 1 wherein said main take-off foils are inclined downwardly and outwardly from their inner ends, with the angle of incidence of said take-off foils and said stabilizing foils decreasing with the draft thereof.

6. A hydrofoil vessel as set forth in claim 1 wherein a propulsion element is disposed on the lower end of each of said struts immediately above the main lift foils.

7. A hydrofoil vessel as set forth in claim 1 wherein flap means are provided on said main lift foils.

8. A hydrofoil vessel as set forth in claim 1 wherein said main take-off foils, stabilizing foils and main lift foils each embody rake, sweep and incline to assist in shedding of debris.

9. A hydrofoil vessel as set forth in claim 1 wherein a cavitation plate is positioned above each of said propulsion elements.

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