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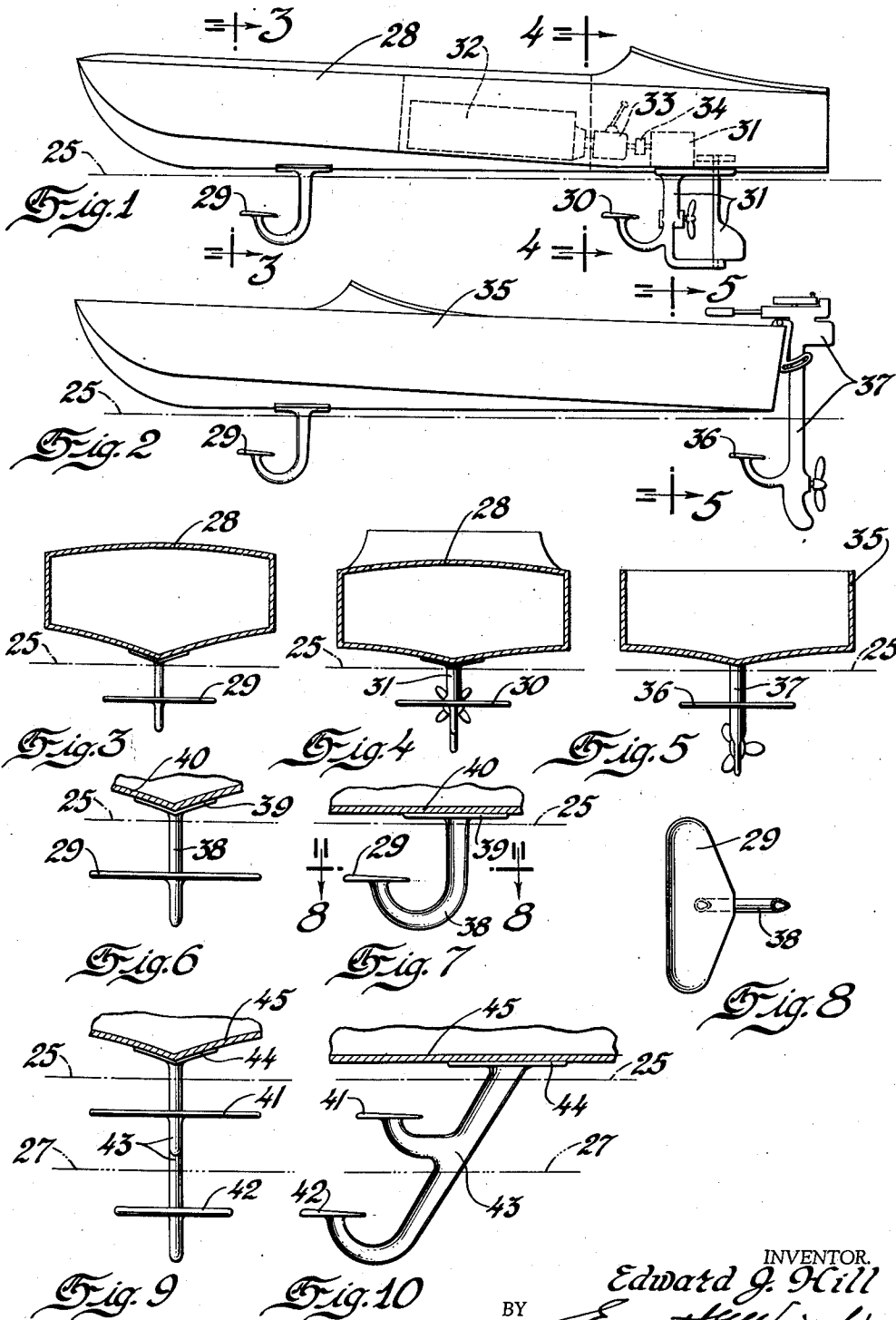
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2,274,200

ANTICAVITATION HYDROFOILS

Filed Nov. 5, 1938

3 Sheets-Sheet 1



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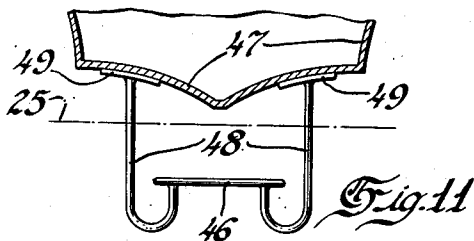
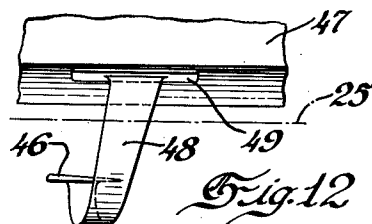
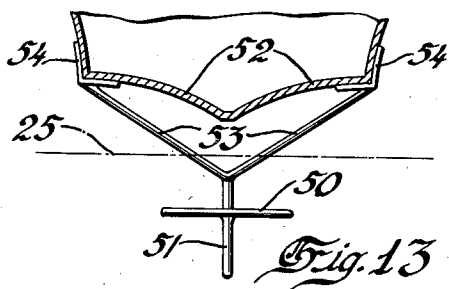
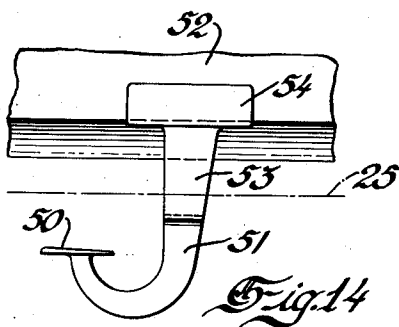
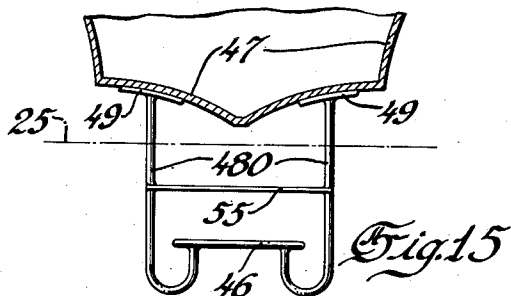
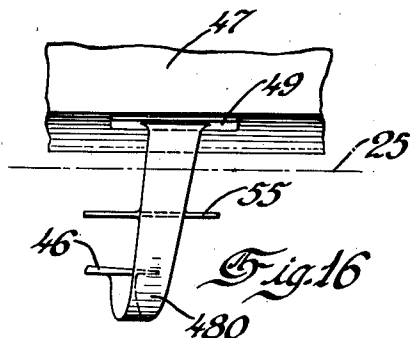
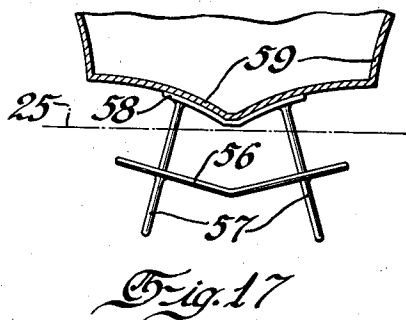
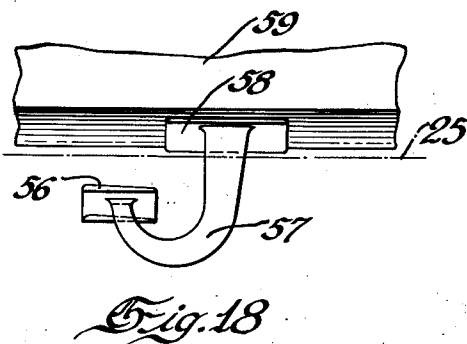
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ANTICAVITATION HYDROFOILS

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3 Sheets-Sheet 2



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ANTICAVITATION HYDROFOILS

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3 Sheets-Sheet 3

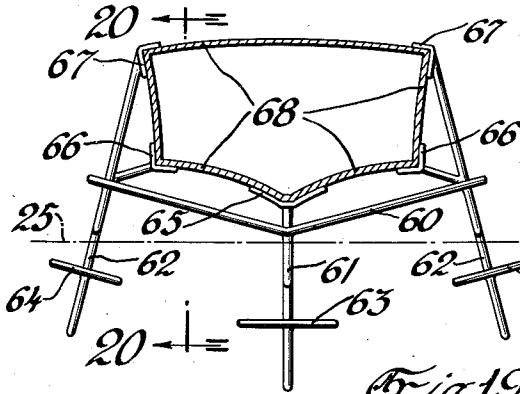


Fig. 19

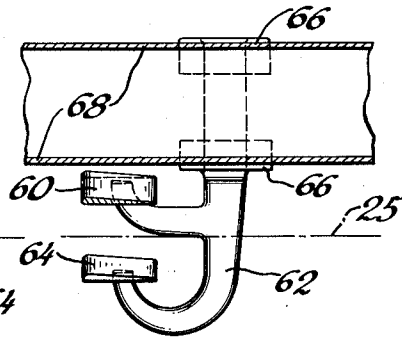


Fig. 20

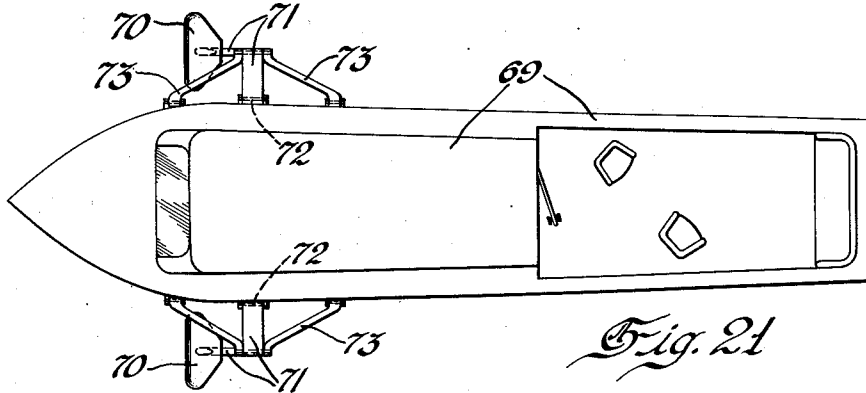


Fig. 21

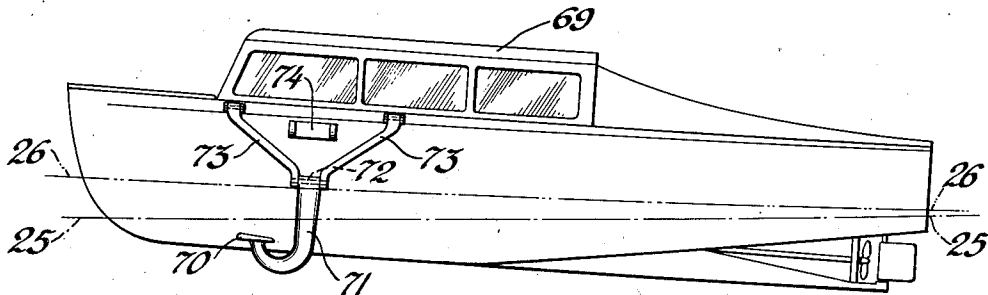


Fig. 22

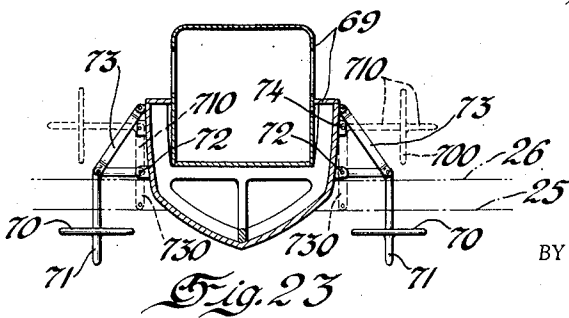


Fig. 23

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## UNITED STATES PATENT OFFICE

2,274,200

## ANTICAVITATION HYDROFOIL

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Application November 5, 1938, Serial No. 238,943

7 Claims. (Cl. 114—66.5)

This invention relates to anti-cavitation hydrofoils adapted for use on various types of water craft and on the hulls and pontoons of flying boats and the like.

Many and various types of water craft with and without hydrofoils have been devised to develop high speeds and reduce the horsepower required to propel the craft through the water at high speeds. The most desirable results have been attained through the use of submerged cambered hydrofoils which lift the craft with respect to the water, and, under extremely high speeds sometimes lift the entire craft out of the water, thus reducing to a more or less degree the resistance of the water to the propulsion of the craft therethrough.

The major difficulty encountered in the use of hydrofoils is cavitation, that is, the presence of air above the hydrofoil which destroys the suction lift created on the top surface of a submerged cambered hydrofoil.

It is recognized that when hydrofoils are supported below a hull at an angle dihedral to the water line and the said hydrofoils raise in respect to the water line "reefing" occurs, that is, the outward ends of the hydrofoils break through the surface of the water and expose the ends thereof to the air. As reefing occurs air is admitted to the suction surface of the hydrofoil causing cavitation along the top thereof which almost entirely destroys its suction lift.

It is also recognized that reefing is not the only cause of cavitation. The struts between the top of the hydrofoils and the craft to which they are secured create a cavity at their trailing edge which communicates with the top preferably cambered surface of the hydrofoil and admits air thereto forming one or more cavitation bubbles thereon which destroys the suction lift thereof.

In order to avoid cavitation of hydrofoils via the supporting struts thereof, the hydrofoils must be deeply submerged. However, as soon as a craft having deeply submerged hydrofoils therein is propelled through the water at high speeds, the craft and hydrofoils are lifted with respect to the surface of the water, which lifting during propulsion is termed "planing." As soon as the distance from the top of the hydrofoils to the surface of the water is materially reduced, cavitation via the struts occurs and the craft settles with respect to the surface of the water only to be lifted again as soon as the suction lift of the hydrofoils is built up at the deeper submergence thereof. This alternate raising and lowering of the craft in respect to the surface of the water

which may be termed "porpoising" is highly undesirable and reduces the speed of the craft to such an extent that any advantage derived from the use of hydrofoils is lost in many instances.

5 In order to overcome the undesirable effects of cavitation some craft have been built having a multiplicity of vertically spaced hydrofoils upon the theory that when upper hydrofoils become ineffective because of cavitation the lower hydrofoils remaining some distance below the surface of the water will maintain their suction lift. Such construction is not only freakish but impractical because of the danger that the multiplicity of hydrofoils in sets or tiers will foul the slightest obstruction at or below the surface of the water. Also, a multiplicity of hydrofoils cause a great resistance to propulsion through the water requiring a tremendous amount of power to propel the craft at a sufficient speed to permit planing.

20 An attempt to overcome cavitation via supporting struts has been made which comprised the use of small baffles on the strut between the hull of a water craft and the top of the hydrofoil. Such baffles have been found to be ineffective inasmuch as when the craft planes the baffles become located so near the surface of the water that cavitation around the baffles and down the struts occurs which admits air to the cambered surface of the hydrofoil forming one or more cavitation bubbles thereon which destroys the suction lift thereof. The above is especially true in choppy water.

35 Dihedrally disposed hydrofoils have been baffled with small baffles disposed normal thereto spaced along the top thereof to prevent cavitation during reefing, however, such baffling is ineffective inasmuch as air bubbles can travel vertically down both sides of the vertical baffles and destroy the suction lift of the said dihedrally disposed hydrofoils which is especially true in choppy water.

40 With the foregoing in view, the main object of this invention is to provide anti-cavitation hydrofoils for various types of craft including a novel arrangement of the supporting struts of the hydrofoils.

45 Another object of this invention is to provide hydrofoils in combination with various types of craft supported therefrom in such a manner as to eliminate cavitation via the supporting struts of the hydrofoils.

50 Other objects of this invention will become apparent by reference to the following detailed de-

scription, taken in connection with the accompanying drawings, in which:

Fig. 1 is a side elevational view of a speed boat equipped with anti-cavitation hydrofoils.

Fig. 2 is a side elevational view of an outboard motor boat equipped with anti-cavitation hydrofoils.

Fig. 3 is a cross sectional view taken on the line 3—3 of Fig. 1 showing in front elevation the embodiment of the forward anti-cavitation hydrofoil disclosed therein.

Fig. 4 is a cross sectional view taken on the line 4—4 of Fig. 1 showing in front elevation the embodiment of the rear anti-cavitation hydrofoil disclosed therein in combination with inboard propelling means.

Fig. 5 is a cross sectional view taken on the line 5—5 of Fig. 2 showing in front elevation the embodiment of the rear anti-cavitation hydrofoil disclosed therein in combination with outboard propelling means.

Figs. 6 and 7 are enlarged front and side elevational views respectively of the forward anti-cavitation hydrofoil disclosed in Figs. 1 and 2.

Fig. 8 is a vertical sectional view taken on the line 8—8 of Fig. 7.

Figs. 9 and 10 are front and side elevational views respectively of a set of anti-cavitation hydrofoils arranged in vertically spaced relationship to each other and supported on a common forwardly sloping strut.

Figs. 11 and 12 are front and side elevational views respectively of a single anti-cavitation hydrofoil supported between a pair of forwardly sloping struts.

Figs. 13 and 14 are front and side elevational views respectively of a single anti-cavitation hydrofoil supported from the hull of a boat by dihedrally disposed hydrofoils.

Figs. 15 and 16 are front and side elevational views respectively of a single anti-cavitation hydrofoil supported between a pair of forwardly sloping struts with a ceiling plate therebetween.

Figs. 17 and 18 are front and side elevational views respectively of a pair of dihedrally disposed anti-cavitation hydrofoils.

Fig. 19 is a front elevational view of the combination of a lower central vertically disposed anti-cavitation hydrofoil and two lower dihedrally disposed anti-cavitation hydrofoils, one laterally spaced on each side of said central anti-cavitation hydrofoil, and a single dihedrally disposed anti-cavitation hydrofoil located in spaced relationship above the three lower anti-cavitation hydrofoils.

Fig. 20 is a view part in section and part in elevation taken on the line 20—20 of Fig. 19.

Fig. 21 is a plan view of a cruiser equipped with retractable anti-cavitation hydrofoils.

Fig. 22 is a side elevational view of the cruiser shown in Fig. 21.

Fig. 23 is a more or less diagrammatic cross sectional view of the cruiser disclosed in Figs. 21 and 22 showing the anti-cavitation hydrofoils in both their operating and retracted positions.

Referring now to the drawings wherein like numerals refer to like and corresponding parts throughout the several views, the dash and single dot lines 25 throughout the drawings indicate the water line when a craft equipped with anti-cavitation hydrofoils is planing at high speeds. In Figs. 22 and 23 the dash and two dot line 26 indicates the normal water line of the cruiser shown therein. In Figs. 9 and 10 the dash and three dot line 27 indicates the water line when a

craft equipped with a set of anti-cavitation hydrofoils planes at sufficiently high speed to utilize only the lower hydrofoil of the set.

Anti-cavitation hydrofoils may be used singly or in longitudinal, vertical and transverse multiples and in combination with drive and rudder units, they may be of various size and configuration, and may be either horizontally or dihedrally disposed; all according to the design of the craft upon which they are mounted, the service for which the craft is intended, and the means employed to drive the craft through the water.

By supporting hydrofoils at their bottom and forward of their supporting strut or struts, cavitation via the supporting struts is eliminated inasmuch as the hydrofoil is permitted to do its work forward of its supporting strut or struts and is not affected by the cavity formed at the trailing edge of the said supporting strut. Likewise, when hydrofoils are supported at their bottom lateral of their supporting struts with the sides thereof adequately laterally spaced from their said supporting struts, cavitation via the supporting struts is eliminated. Hydrofoils so supported as to eliminate cavitation via their supporting struts are termed "anti-cavitation hydrofoils" herein.

Referring now particularly to Fig. 1, the speed boat 28 shown therein is equipped with a forward anti-cavitation hydrofoil 29 and an aft anti-cavitation hydrofoil 30 supported from and forward of a drive-rudder unit 31 coupled in the usual manner to a marine engine 32 by a selective transmission 33 and a flexible coupling 34. Cross sectional views shown in Figs. 3 and 4 show the central disposition of the forward and aft anti-cavitation hydrofoils 29 and 30 respectively.

Fig. 2 discloses a motor boat 35 equipped with a forward anti-cavitation hydrofoil 29 and an aft anti-cavitation hydrofoil 36 combined with and supported from an outboard motor unit 37 which also serves as a rudder for the said boat. The cross sectional view shown in Fig. 5 shows the central disposition of the anti-cavitation hydrofoil 36 in respect to the outboard motor unit 37.

The forward hydrofoil 29 of the motor boat 35 shown in Fig. 2 may be omitted and the anti-cavitation hydrofoil 36 combined with and supported from the outboard motor unit 37 may be utilized to lift the stern of the boat 35 with respect to the water, thus eliminating the undesirable drag of the stern of an outboard motor boat caused by the concentration of the weight of the outboard motor unit and the operator thereof at the stern of the boat.

The forward anti-cavitation hydrofoil 29 as applied to the speed boat 28 and motor boat 35 in Figs. 1 and 2 respectively is shown in detail in Figs. 6, 7 and 8 and comprises a substantially horizontal hydrofoil 29 supported at its lower surface forward of and from a rearwardly spaced strut 38 having a suitable gusset 39 integral with or welded thereto by means of which the hydrofoil is bolted or otherwise secured to the hull 40. The strut 38 is preferably streamlined as best shown in Fig. 8. The hydrofoil 29 may be of any desired hydrofoil section and set at any desired angle in relation to the keel of the boat.

Figs. 9 and 10 show upper and lower anti-cavitation hydrofoils 41 and 42 respectively arranged in vertically spaced relation to each other and supported at their bottom from a common forwardly sloping strut 43 spaced rearwardly from the trailing edge of the said hydrofoils 41 and 42.

A gusset 44 preferably integral with or welded to the strut 43 is bolted or otherwise secured to the hull 45. At moderately high speeds the hull 45 planes to the position shown with respect to the water line 25, however, at extremely high speeds the upper hydrofoil 41 "breaks" the water and the hull 45 planes to the position shown with respect to the water line 27. The lower hydrofoil, of course, may be of a greater area or lift than the upper hydrofoil.

The anti-cavitation hydrofoil 46 in Figs. 11 and 12 is centrally disposed in respect to the hull 47 and is supported at its bottom from two laterally spaced struts 48 which are provided with gussets 49 preferably integral with or welded to the said struts 48. The gussets 49 are bolted or otherwise secured to the hull 47.

The anti-cavitation hydrofoil 50 disclosed in Figs. 13 and 14 is similar to the hydrofoil 29 shown in Figs. 1, 2, 3, 6, 7 and 8 except that it is supported at its bottom forward of and from a rearwardly spaced strut 51 which is in turn supported from the hull 52 by dihedrally disposed struts 53 preferably of a suitable hydrofoil section to permit the said struts 53 to assist in lifting the hull 52 with respect to the water line 25 at comparatively low speeds and before the said hull planes on the anti-cavitation hydrofoil 50. The said struts 53 are provided with angular gussets 54 by means of which the said struts are bolted or otherwise secured to the said hull 52.

The construction shown in Figs. 15 and 16 is substantially the same as the disclosure in Figs. 11 and 12 except that the struts 480 in Figs. 15 and 16 are longer than the struts 48 in Figs. 11 and 12, and a ceiling plate 55 is secured across the struts 480 spaced above the hydrofoil 46 and below the hull 47. The ceiling plate 55 prevents cavitation at the top of the said hydrofoil 46 when a craft equipped with the same is propelled at high speed through choppy waters.

The dihedrally disposed anti-cavitation hydrofoil 56 disclosed in Figs. 17 and 18 is supported at its bottom forward of and from two rearwardly spaced struts 57 which are preferably welded to a common gusset 58 which in turn is bolted or otherwise secured to the hull 59. The struts 57 are laterally spaced with respect to each other and may be disposed normal to the dihedral hydrofoil 56 as shown or on a vertical axis in respect to the hull 59 as desired.

Figs. 19 and 20 indicate one of many possible combinations of hydrofoils embodying this invention, the construction shown therein comprises the combination of a single upper dihedrally disposed anti-cavitation hydrofoil 60 supported at its bottom by a central strut 61 and two side struts 62, the strut 61 and each strut 62 supporting lower anti-cavitation hydrofoils 63 and 64 respectively at their bottom, the struts 61 and 62 being located in spaced relation to the trailing edge of said hydrofoils 60, 63, and 64. The strut 61 is provided with a suitable gusset 65 and each strut 62 is provided with suitable gussets 66 and 67 by means of which the anti-cavitation hydrofoils are bolted or otherwise secured to the hull 68.

The cabin cruiser 69 shown in Figs. 21, 22 and 23 is equipped with anti-cavitation hydrofoils 70 supported at their bottom from a strut 71 rearwardly spaced from the trailing edge of the hydrofoil 70. Instead of being rigidly secured to the bottom of the cruiser 69, the hydrofoil struts 71 may be formed angular in shape and hinged to the cruiser 69 by hinge pins 72 and held in their normal position by diagonal braces

73. The hydrofoils 70 and their struts 71 are indicated in a retracted position by the dotted lines 700 and 710, the diagonal braces 73 being shown in a depending position by the dotted lines 730. Suitable anchorages 74 engage the struts 71 when the hydrofoils are in their retracted position as indicated by the dotted lines in Fig. 23.

In Figs. 22 and 23, the dash and two dot line 26 indicates the normal water line of the cruiser 69 when the anti-cavitation hydrofoils 70 are retracted or when the hydrofoils 70 are lowered and the cruiser travels at low speed. The dash and single dot line 25 indicates the water line of the cruiser 69 when the anti-cavitation hydrofoils 70 are lowered and the cruiser is being propelled through the water at high speeds.

Although numerous applications of the invention to various types of water craft and drive units have been disclosed and described herein, it will be understood that many changes in the size, shape, arrangement and details of the various parts of the invention may be made without departing from the spirit thereof, and it is not intended to limit the scope hereof other than by the terms of the appended claims.

#### I claim:

1. An anti-cavitation hydrofoil of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when the said hydrofoil is moved forwardly through the water comprising, in combination, a hydrofoil, a plurality of struts extending from the bottom of the said hydrofoil to a point thereabove passing an edge other than the leading edge of the said hydrofoil in sufficiently spaced relationship to prevent air from the surface of the water from following the strut to the upper surface of the said hydrofoil, and means for securing the said struts in rigid depending relationship to the hull of a boat.

2. Anti-cavitation hydrofoil of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when the said hydrofoil is moved forwardly through the water comprising, in combination, a hydrofoil, a strut extending from the bottom of the said hydrofoil to a point thereabove passing the trailing edge of the said hydrofoil in sufficiently spaced relationship to prevent air from the surface of the water from following the strut to the upper surface of the said hydrofoil, and means for securing the said strut in rigid depending relationship to the hull of a boat.

3. An anti-cavitation hydrofoil of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when the said hydrofoil is moved forwardly through the water comprising, in combination, a hydrofoil, a plurality of struts extending from the bottom of the said hydrofoil to a point thereabove passing the said hydrofoil in sufficiently lateral spaced relationship to prevent air from following said strut to the upper surface of the said hydrofoil, and means for securing the said strut in rigidly depending relationship to the hull of a boat.

4. An anti-cavitation hydrofoil of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when the said hydrofoil is moved forwardly through the water comprising, in combination, a dihedral hydrofoil with said dihedral upwardly disposed with respect to the central plane of symmetry of the boat to which it is attached, a pair of struts extending from the bottom of the said dihedral

hydrofoil at a point lateral of the center thereof to a point thereabove passing the trailing edge of the said hydrofoil in sufficiently spaced relationship to prevent air from the surface of the water from following the strut to the upper surface of the said hydrofoil, and means for securing said struts to the bottom of the hull of the said boat.

5. In a hydrofoil structure of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when moving through water, one or more generally vertically disposed struts rigidly secured to the bottom of the hydrofoil capable of supporting the said hydrofoil in vertical spaced relationship rigidly below the hull of a boat, the said struts extending past the said hydrofoil in sufficiently spaced relationship to prevent air from the surface of the water from following said struts to the upper surface of the said hydrofoil, and means for attaching the said struts to the boat hull.

6. In a hydrofoil structure of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when moving through water, one or more generally vertically disposed struts rigidly secured to the bot-

tom of the said hydrofoil at a point forward of the trailing edge thereof capable of supporting the said hydrofoil rigidly from the hull of a boat, the said struts extending past the said hydrofoil at a point other than the leading edge thereof in sufficiently spaced relationship thereto to prevent air from the surface of the water from following the said struts to the upper surface of the said hydrofoil, and means for attaching the said struts to the boat hull.

7. In a hydrofoil structure of the type wherein the greater portion of its lift is obtained by the suction lift of its upper surface when moving through water, one or more generally vertically disposed struts capable of supporting the hydrofoil in spaced relationship below the hull of a boat rigidly supporting the said hydrofoil from the bottom thereof at a point inward of its peripheral edge, the said strut or struts extending past an edge of said hydrofoil other than the leading edge thereof in sufficiently spaced relationship to prevent air from the surface of the water from following the said struts to the upper surface of the said hydrofoil, and means for attaching the said struts to the boat hull.

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