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[54] **TILTABLE HYDROFOIL ARRANGEMENT**
 6 Claims, 9 Drawing Figs.

[52] U.S. Cl. 114/66.5 H
 [51] Int. Cl. B63b 1/18
 [50] Field of Search 114/66.5 H

[56] **References Cited**

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ABSTRACT: A tilting arrangement is disclosed for watercraft having a pair of hydrofoils mounted on opposite sides of the hull by means of struts. Such tilting arrangement allows the hydrofoils to be lifted into a position adjacent the deck of the hull or the superstructure of the watercraft. The tilting arrangement comprises for each of the hydrofoils a tilt bearing, the axis of which is angled relative to the centerline of the associated strut. Additionally, each hydrofoil may be pivotally connected to the lower end of the strut. By such pivotal connection, the hydrofoil may be rotated into a position adjacent the strut when the latter is tilted into its elevated position.

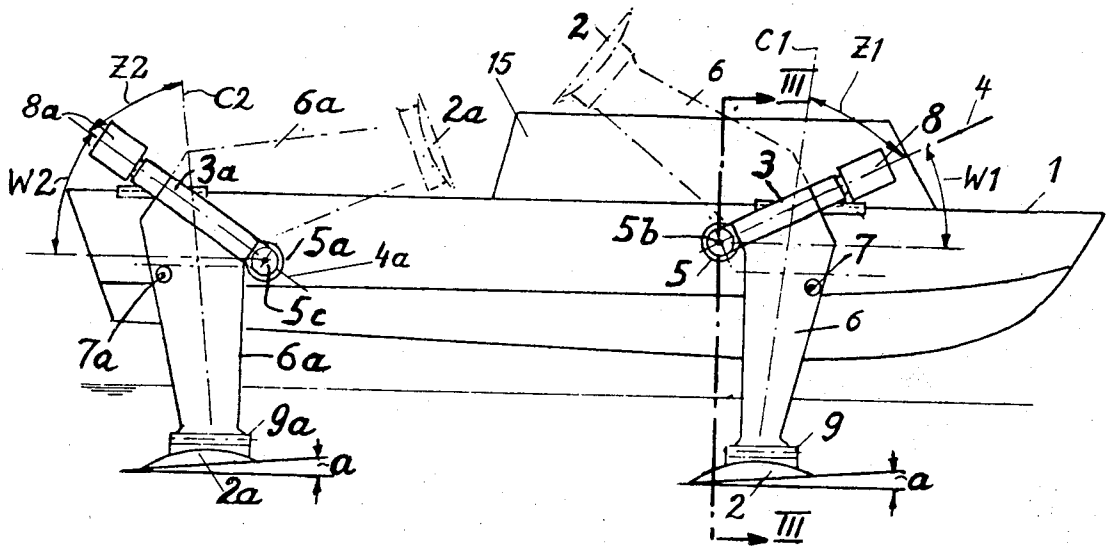


FIG. 1

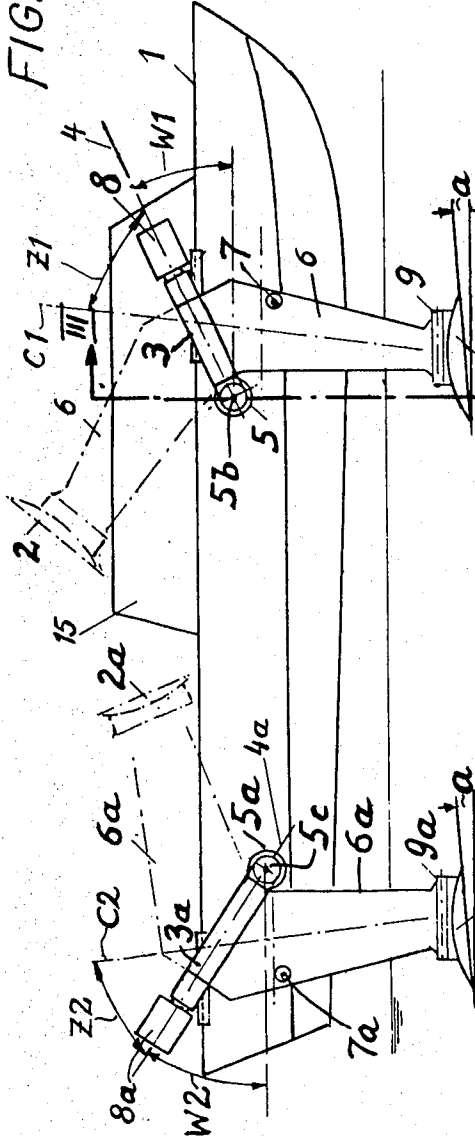
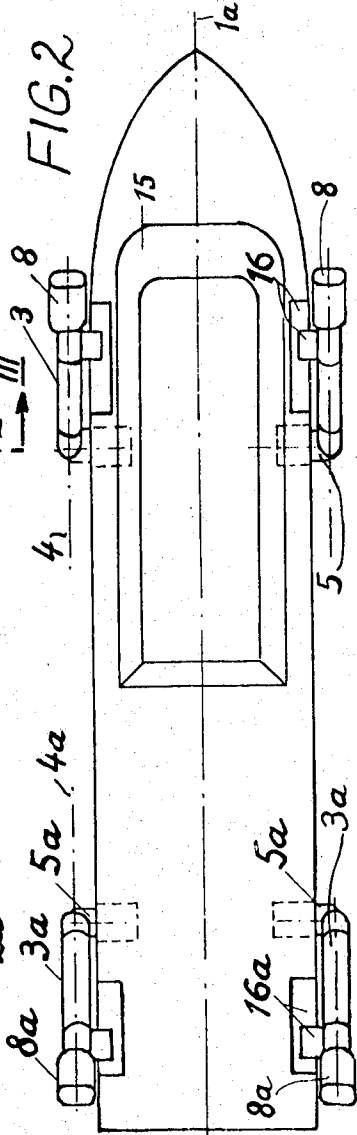


FIG. 2



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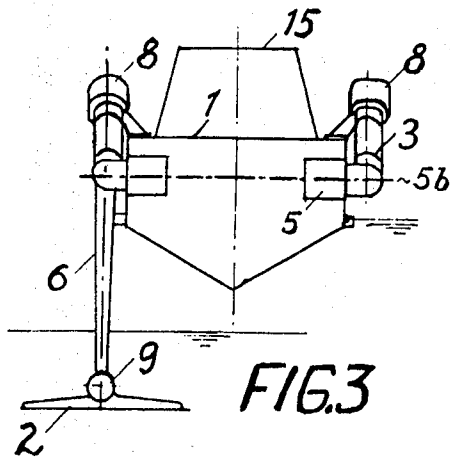


FIG. 3

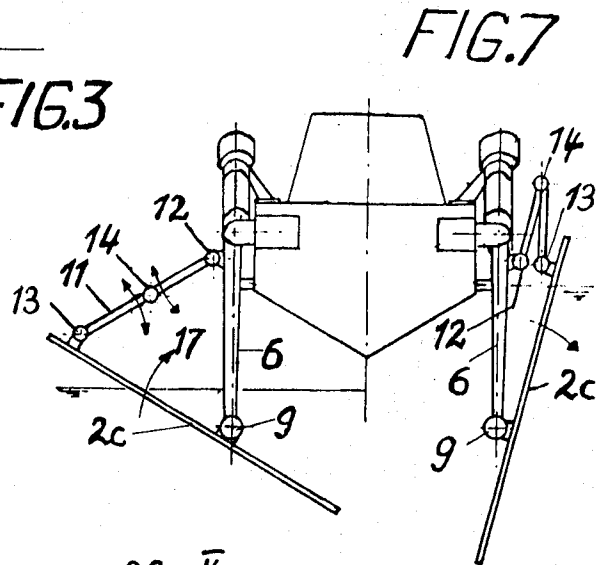


FIG. 7

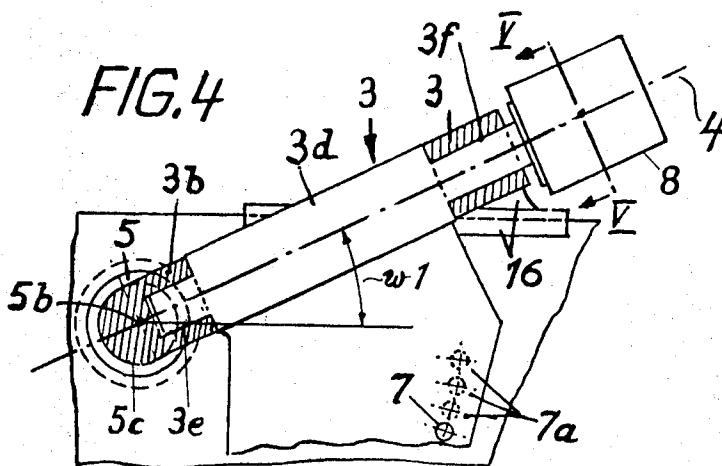


FIG. 4

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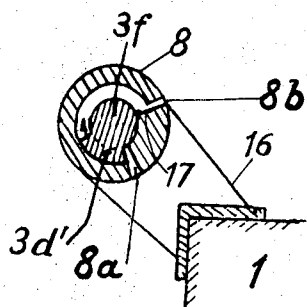


FIG. 5

FIG. 6

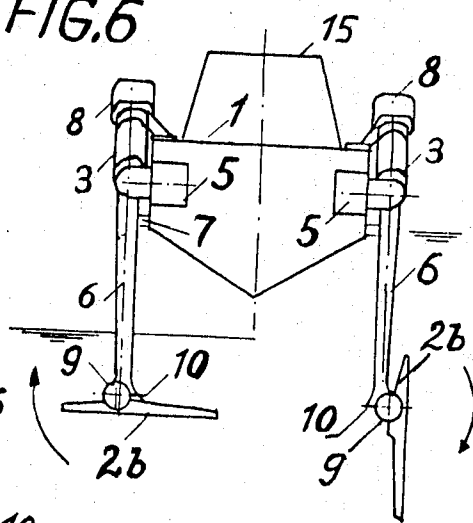


FIG. 6a

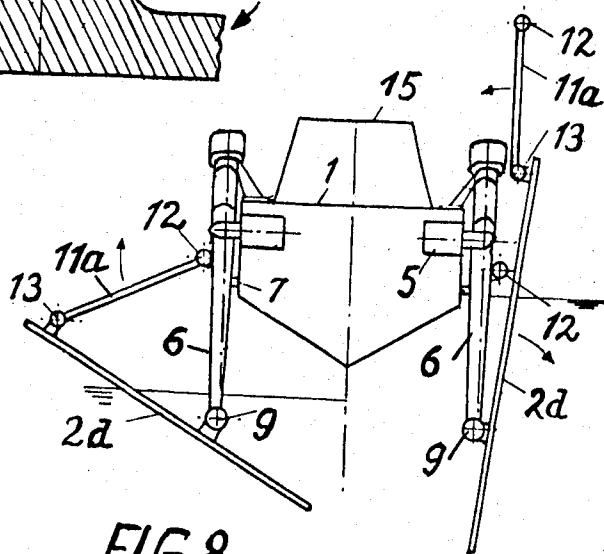
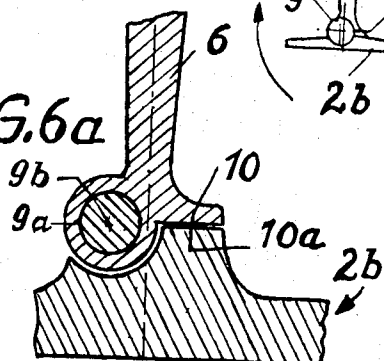


FIG. 8

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TILTABLE HYDROFOIL ARRANGEMENT

BACKGROUND OF THE INVENTION

The present invention relates to an improved tiltable hydrofoil arrangement on watercraft wherein the hydrofoils can be lifted by tilting them upwards on the resting or floating watercraft.

In the latest development of hydrofoil watercraft there is frequently a demand for tilting or raising the hydrofoils. As a consequence thereof, the draught of the floating craft, particularly for coming alongside the shore, or in shallow water, is reduced and, moreover, the hydrofoils can be cleaned or repaired without need for docking or putting the watercraft ashore.

Prior structures of that kind have the drawback that the hydrofoils may be lifted in a vertical direction only. In this case, the hydrofoils are raised close to the bottom of the hull so that the draught of the watercraft is reduced. Moreover, they remain under the water level and are not accessible since they are beneath the bottom of the hull. On a known hydrofoil craft, each hydrofoil is tiltable about an inclined axis which is essentially perpendicular to the centerline of the strut of the craft, and the hydrofoils when placed into their uppermost positions are so high above their tilt axes that when mounted on large watercraft they can be reached only by means of special devices, or high stages for cleaning purposes. Moreover, with such a position of the foils the center of gravity is so much lifted that the stability of the craft may become insufficient, particularly with motion of the sea, winds can become risky. Finally it is to be noticed that for the tilting of such a hydrofoil a very high torque must be overcome and a large power must be provided, contrary to the demand for small lifting devices.

The present invention provides a tiltable hydrofoil arrangement on watercraft comprising at least one pair of hydrofoils, one hydrofoil of the or each pair being mounted on opposite sides of the hull, each hydrofoil being connected to the hull through a strut which is mounted at its upper end to the hull by means of a tilt bearing, the axis of the tilt bearing being angled relative to the centerline of the strut such that the acute angle between said axis and said centerline is in a range from 30° to 70° and being disposed in a vertical plane which is essentially parallel to the longitudinal axis of the hull.

In a preferred embodiment of the invention, a tilting device is provided which comprises a hingelike structure one wing of which is represented by the strut to which the hydrofoil is mounted. Both ends of the pivot axis of that hingelike structure are attached to, or supported by the hull. The hinge may be mounted to the hull in such a way that the whole hydrofoil arrangement is rotatable about an axis transverse to the hull. With such an arrangement, the angle of attack of the hydrofoils can be varied on the floating or travelling watercraft.

In the preferred embodiment of the invention, stop members are provided to receive transverse forces acting upon the hydrofoils in their lowered position and to prevent undesired loosening or rocking of the hydrofoil arrangement about the above-mentioned transverse axis.

The hydrofoil arrangement of the invention may be constructed in such a manner that each hydrofoil when placed in the uppermost position, located close above the hull. Thus, the hydrofoils can easily be cleaned or repaired from the deck or superstructure of the watercraft. Moreover, the hydrofoil structure may be designed to keep the center of gravity of the lifted structure on a low level so that the stability of the craft will not be substantially reduced. Finally, with that embodiment the power required for lifting the hydrofoils may be reduced relative to prior arrangements.

The new hydrofoil structure can be used for fully immersed or partially immersed hydrofoils. In order to prevent damage which may be caused by impact of the hydrofoils with the superstructure of the craft, when the hydrofoils are moved into their raised position, each hydrofoil may be pivotally mounted about a longitudinal axis to the lower end of its associated

strut so that the hydrofoil can be rotated in to a position adjacent and parallel to the strut. Such a pivotal mounting is particularly desirable in the case of partially immersed hydrofoils.

In the case of hydrofoils which are partially immersed when the watercraft is travelling, it is in most cases necessary to provide, for reasons of stability, a transversally inclined fin connected between each strut and the outer end of its associated hydrofoil. To permit the just mentioned rotational movement of the hydrofoil, the inner and outer ends of that fin may be connected to the strut, and hydrofoil, respectively, by joints, and the fin may be made foldable by means of a joint which is arranged in the longitudinal middle axis of the fin. With those joints, the fin folds up when the hydrofoil is rotated upwards about its longitudinal pivot axis.

The tilting or lifting of the whole hydrofoil arrangement may be performed with the aid of conventional devices, e.g. hydraulic, electrical or mechanical lifting devices, such as hydraulic torque rams, electrical motors or hoists.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in detail by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a side elevational view of a watercraft provided with two pairs of laterally and tiltably arranged hydrofoils;

FIG. 2 is a plan view of the watercraft of FIG. 1; FIG. 3 is a cross-sectional view taken along the line III—III in FIG. 1;

FIG. 4 is a side elevation of the tilt bearing of FIG. 1 on a larger scale, partially in cross section;

FIG. 5 is a cross-sectional view taken along the line V—V in FIG. 4;

FIG. 6 is a cross-sectional view, similar to that of FIG. 3 showing one of the hydrofoils in an upwardly rotated position adjacent its associated strut;

FIG. 6a shows a detail in FIG. 6 in cross-sectional view and on a larger scale;

FIG. 7 shows, in similar view as FIG. 6, a second embodiment of rotatably mounted hydrofoils; and

FIG. 8 is a similar view of a third such embodiment.

DETAILED DESCRIPTION OF THE INVENTION

At the outset, it is here mentioned that similar components are designated throughout by like reference numerals or characters. Turning now specifically to FIGS. 1 and 2, there will be seen to be provided a pair of front hydrofoils 2 and a pair of aft hydrofoils 2a which are mounted on the hull 1 of a watercraft by means of tilt bearings 3 and 3a, respectively. The struts 6, 6a and with them the hydrofoils 2, 2a may be tilted about the axes 4, 4a of their associated tilt bearings 3, 3a respectively, into their upper end positions depicted in dash-dotted lines in FIG. 1. The tilt bearings 3, 3a are mounted with their axes 4 and 4a, respectively, in vertical planes essentially parallel to the longitudinal axis 1a of the hull (FIG. 2). As shown in FIG. 1, the axes 4 and 4a are inclined to the horizontal at angles W1 and W2, respectively, which are of the order of 25° to 35°, respectively.

The centerlines C1 and C2 of the struts 6 and 6a respectively, include, by way of example, small angles of about 7° with the vertical, but those centerlines may be exactly vertical as well or inclined at greater angles to the vertical. The acute angles Z1 and Z2 formed between said centerlines and the axis 4 and 4a are about 60° and 50°, respectively.

Depending upon the magnitude of the angles which the centerlines of the struts 6, 6a form with the vertical, and the position of the tilt bearing with respect to the level of the deck of the hull 1, or superstructure 15 of the watercraft, the angles Z1 and Z2 may be chosen in such a way that the hydrofoils 2 and 2a in their upper end positions assume the desired positioning and small spacing relative to the deck of the hull 1, or superstructure 15. In order to arrange that the hydrofoils 2 and 2a assume the desired positioning and spacing when stern, are raised, it is essential to angle the axes 4, 4a approximately

relative to the centerlines of the struts 6, 6a. It will be appreciated that the struts 6, 6a are shown in FIG. 1 as having their centerlines approximately vertical when the foils are in their lowered positions, and it will further be appreciated that the centerlines are themselves angled relative to the axes 4, 4a. The angles Z1, Z2 between each center line and the relevant axis may be in the range of 30° to 70°.

In FIGS. 1 and 2, the axes 4 and 4a of the tilt bearings are directed to the bow and stern of the watercraft, respectively. Of course, both axes may be directed in the same sense, e.g. both to the bow or both to the stern, if desired.

The tilt bearings 3 and 3a are mounted to the hull 1 by means of transverse bearings 5 and 5a, respectively so that the hydrofoil arrangements each comprising a hydrofoil 2 or 2a, a strut 6 or 6a, respectively, and a tilt bearing 3 or 3a, respectively, may be rotated about a horizontal axis 5b (FIG. 3) or 5c, respectively, extending through a pair of associated transverse bearings 5 or 5a. In this way it is possible to vary the angle of attack α of the hydrofoils. In order to lock the hydrofoil arrangements in their lowered position, or positions, there is provided a locking stud 7 or 7a for each hydrofoil arrangement which will be described in detail in connection with FIG. 4.

A motor 8 is provided at the outer end of each tilt bearing for tilting the struts upwards into the dash-dotted positions of FIG. 1 as will be outlined in detail with reference to FIGS. 4 and 5.

As shown schematically in FIGS. 1 and 3, the hydrofoils, e.g. the front foils 2, are mounted to the lower ends of their associated struts 6 by means of pivot bearings 9 the pivot axes of which are, in the normal lowered positions of the foils 2, horizontal and parallel to the longitudinal axis 1a of the hull. A detailed description of those pivot bearings will be given in connection with FIG. 6 and 6a.

According to FIG. 4, the hingelike tilt bearing 3 comprises two bushings 3b and 3c and a shaft 3d having reduced end studs 3e and 3f which are rotatably supported by said bushings. The lower bushings 3b is integral with a transverse trunnion 5c which is rotatably mounted to the hull 1 of the craft. The upper bushing 3c is secured to the hull by means of a bracket 16. Also fixed to the upper bushing 3c is the housing of a hydraulic motor 8.

FIG. 5 shows a cross-sectional view of the motor 8 which is constructed as a hydraulic torque ram. There are provided two ducts 8a and 8b in the housing of the ram to admit or remove hydraulic fluid for operating the ram. The end stud 3f extends into the housing of the ram 8 in which a segment 3d' is provided on the end stud 3f. When hydraulic fluid is forced into the housing through duct 8a, the segment 3d' and therewith the shaft 3d is rotated clockwise, and the strut 6 is tilted upwards until the segment 3d' reaches its other end position adjacent a stop 17 which is integral with the housing of the ram. On releasing the hydraulic pressure introduced through the duct 8a, the strut 6 can be returned to its lower end position, aided by the weight of the strut and its associated hydrofoil.

The locking stud 7 provided to lock the strut 6 in different angular positions relative to the transverse axis 5b is threaded and a number of threaded bores 7a are provided in the strut 6 so that the strut 6 may be bolted to the hull in various positions. In order to change the angular position of the hydrofoil arrangement, the bracket 16 must be removed and replaced by another bracket to furnish the desired angle of attack to the associated hydrofoil.

Of course, it is also possible to provide for a bracket which is adjustable so that the angle of attack α (FIG. 1) may be changed or controlled without removing the bracket, or even when the watercraft is travelling.

FIG. 6 illustrates another embodiment in which the

hydrofoils 2b may be rotated into a position as shown on the right side of the FIG. The pivot bearing 9 by which each hydrofoil 2b is attached to its strut 6 is depicted in cross-sectional view in FIG. 6a. The pivot bearing is constructed in the form of a hinge. The hydrofoil 2b and the strut 6 are connected by means of a shaft 9a, the axis 9b of which, in the normal or lowered position of the hydrofoil, is substantially horizontal and parallel to the longitudinal axis 1a of the hull. At the lower end of the strut 6 there is provided a stop edge 10 to which a counterface 10a on the hydrofoil is forced on the travelling watercraft. Securing elements (not shown), such as bolts, are provided to keep the hydrofoil in its normal, horizontal position when the watercraft is floating or at rest.

FIG. 7 shows another embodiment adapted for use with partially immersed hydrofoils. There is provided a foldable fin 11 which is mounted at its inner end on the strut 6 by a first joint 12, and at its other end on the outer end of the hydrofoil 2c by a second joint 13. A third joint 14 arranged along the longitudinal middle axis of the fin 11 connects both halves of same. By this construction it is possible to fold the hydrofoil 2c from its lowered position shown on the left side in the direction of the arrow 17 to a position adjacent the outer side of the strut 6, whereby the fin 11 is folded up between the hydrofoil and strut. The folded position is shown at the right side of FIG. 7.

FIG. 8 illustrates another embodiment usable for partly immersed hydrofoils. In this case, the inner joint 12 of an integral fin 11a may be disconnected so that the hydrofoil may be hoisted together with the fin to its upper end position as shown on the right side of FIG. 8.

While there is shown and described present preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto, but may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. A tiltable hydrofoil arrangement on watercraft having a hull comprising at least one pair of hydrofoils, one hydrofoil of each said at least one pair being mounted on opposite sides of the hull, each hydrofoil being connected to the hull through a strut mounted at its upper end to the hull by means of a tilt bearing, the axis of a said tilt bearing being angled relative to the centerline of the strut such that acute angle between said axis and said centerline is in the range from 30° to 70° and being disposed in a vertical plane which is essentially parallel to the longitudinal axis of the hull.

2. The hydrofoil arrangement according to claim 1, wherein the angle between the axis of the tilt bearing and the centerline of the associated strut is chosen such that, with the hydrofoil in its uppermost position, the hydrofoil possesses a small spacing relative to the deck of the hull or superstructure of the watercraft.

3. The hydrofoil arrangement according to claim 1, wherein a motor is provided at the outer end of each tilt bearing for tilting the associated strut into the elevated position.

4. The hydrofoil arrangement according to claim 1, wherein each hydrofoil is pivotally connected to the lower end of its associated strut so as to be pivotable about an axis which is substantially parallel to the longitudinal axis of the hull.

5. The hydrofoil arrangement according to claim 2, wherein each hydrofoil and its associated strut are additionally connected by foldable fin means comprised of two portions connected to each other by a middle joint and to the hydrofoil and fin, respectively, by means of outer joints.

6. They hydrofoil arrangement according to claim 1, wherein each tilt bearing is mounted on a member transverse to the longitudinal axis of the hull, each said tilt bearing being rotatable about a transverse axis for changing the angle of attack of the hydrofoils.