

[54] **HYDROFOIL WATERCRAFT STEERING AND STABILIZING MECHANISM**

2,387,907 10/1945 Hook 114/66.5 H
3,237,582 3/1966 Sturgeon et al. 114/66.5 H

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[21] Appl. No.: **231,101**

[57] **ABSTRACT**

[52] U.S. Cl. **114/66.5 H**

[51] Int. Cl. **B63b 1/18**

[58] Field of Search 114/66.5 H, 66.5 R

A mechanism for steering and stabilizing hydrofoil watercraft comprising mounting submerged foils under the stern in a plane parallel to the fore and aft lines of the craft and pivoted on an axis lying in a plane perpendicular to those fore and aft lines. When these submerged foils are then provided with a means for independently turning them from inside the craft, they form an effective method of turning the craft with reduced side slippage, especially if they are extended outboard of the craft.

[56] **References Cited**

UNITED STATES PATENTS

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3,688,723	9/1972	Ulvesand et al.	114/66.5 H
3,162,166	12/1964	Handler	114/66.5 H

5 Claims, 4 Drawing Figures

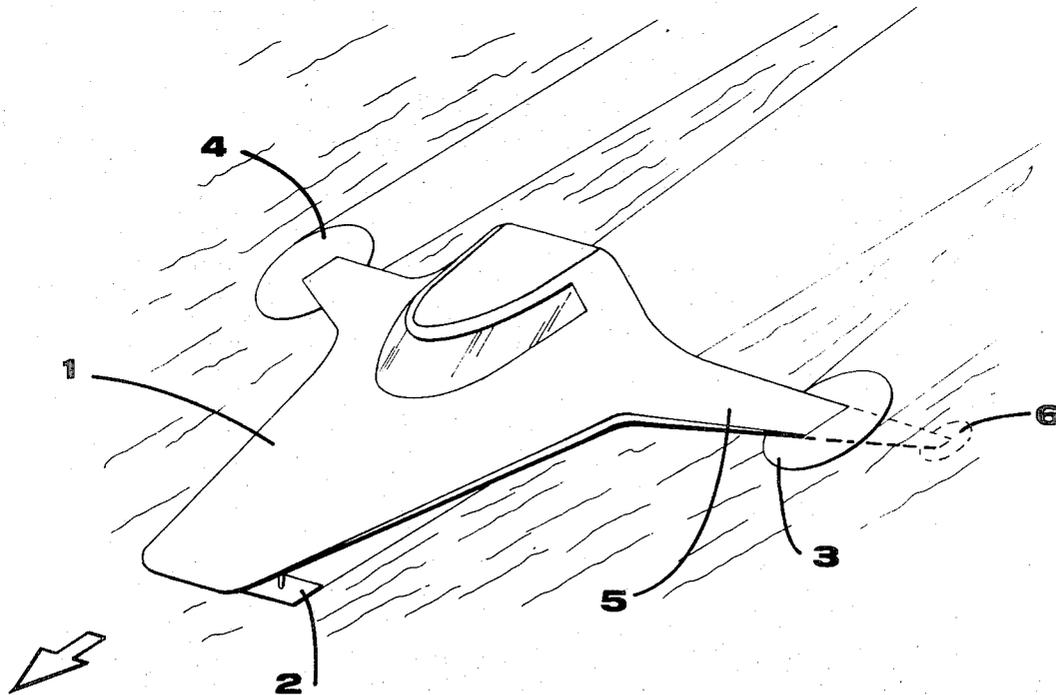


FIG. 1

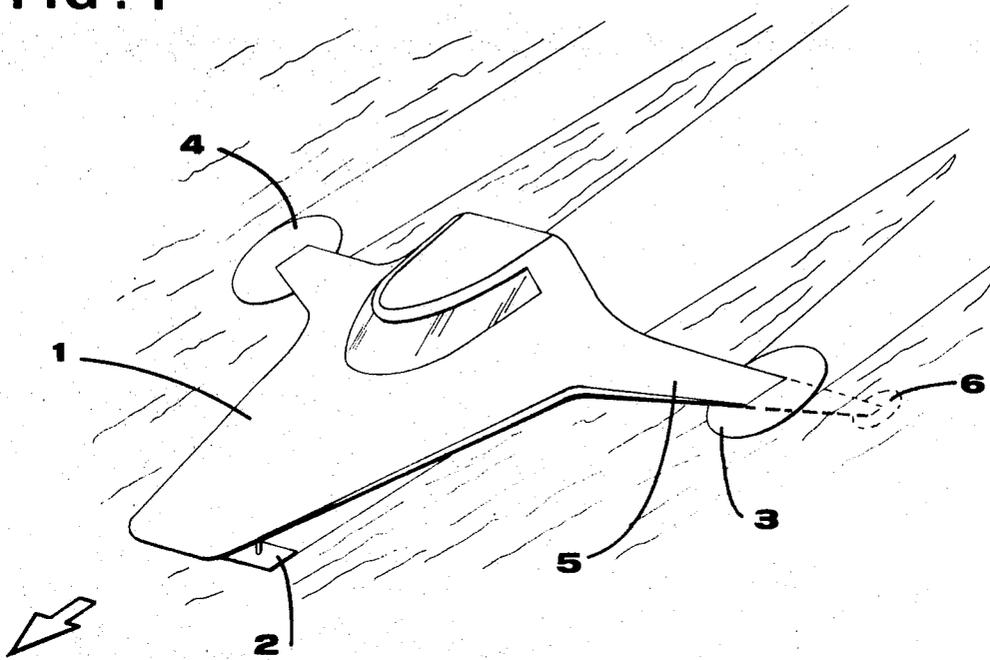


FIG. 2

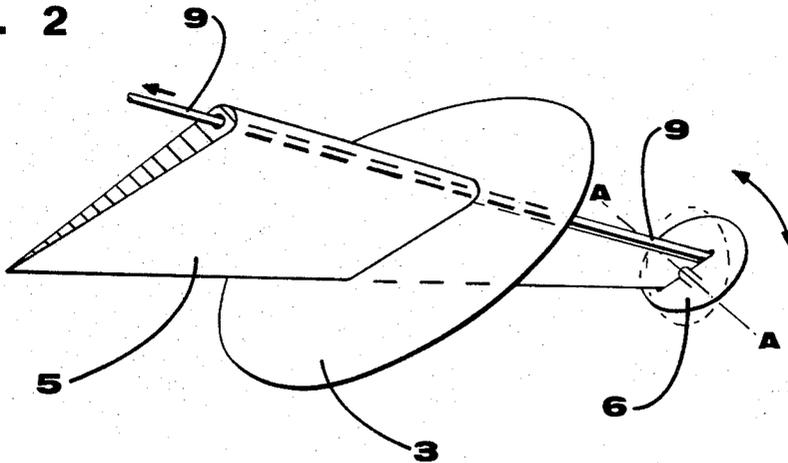


FIG. 3

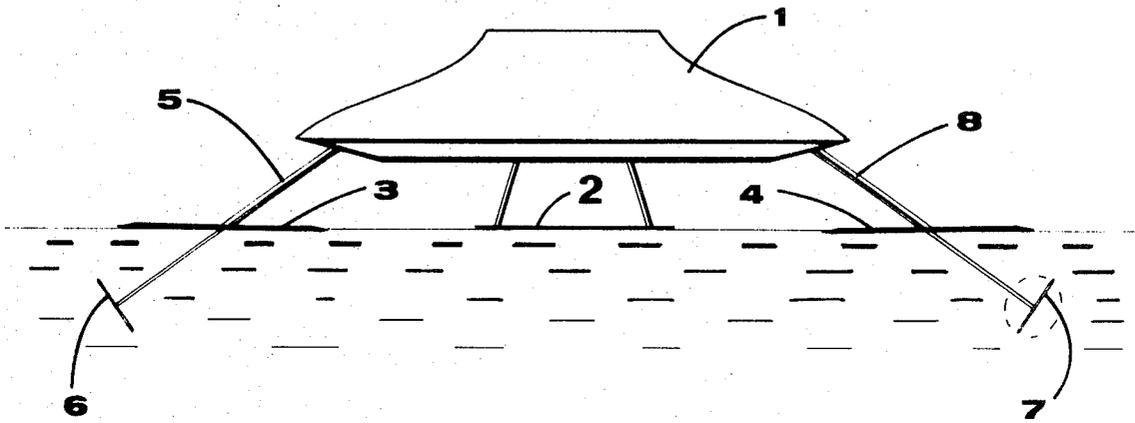
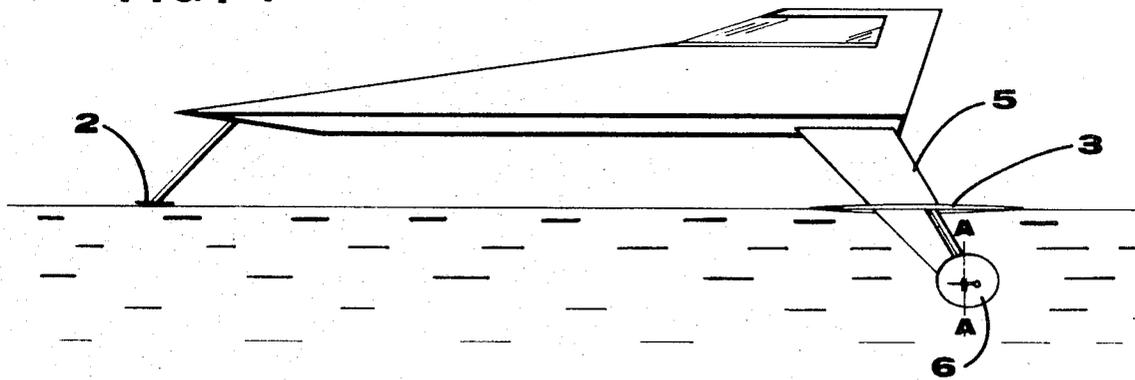


FIG. 4



HYDROFOIL WATERCRAFT STEERING AND STABILIZING MECHANISM

CLOSEST PRIOR ART KNOWN

U.S. Pat. No. 3,237,582
 U.S. Pat. No. 3,162,166
 U.S. Pat. No. 2,400,782
 U.S. Pat. No. 2,877,081
 U.S. Pat. No. 2,387,907

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for simultaneously steering and stabilizing hydrofoil watercraft against side slippage. More specifically, it relates to an improved steering and stabilizing device for hydrofoil watercraft which comprises a pair of completely submerged foils pivotably mounted between the aft hydrofoil in a plane parallel to the fore and aft lines of the craft and pivoted along an axis lying in a plane perpendicular to said fore and aft lines, said submerged foils being independently pivotable from inside said craft.

2. Prior Art

Hydroplane and hydrofoil watercraft are high speed craft which depend on a very small amount planar surface in contact with the water to achieve high speeds, the less the better. They, however, suffer from a serious handicap when turning at such speeds, namely, extreme side slippage. The very lack of friction surfaces, such as keels, etc. which permits the high speeds causes a hydrofoil watercraft to slip sidewise for great distances, from centrifugal force, as it is turned, before the changed angle of the propulsion mechanism alters the direction of its linear momentum. Vertical fins have been placed extending below the plane of the hydrofoil, but such of these as have been pivoted formed a single conventional rudder, and are of little value in preventing side slippage. The hydrofoils have been made independently adjustable in their relation to the hull and to the angle of attack on the water, but this is primary to allow for stability of the hull itself to rocking, and is usually done by pivoting the strut.

Steering of hydrofoil watercraft has usually been done by one or more conventional rudders, that is small pivoted fins extending into the water vertically and, when plural, all operated together. Mechanisms have been described for rotating the load bearing hydrofoils in various ways, partly to assist steering. None of the prior art mechanisms has enabled a hydrofoil watercraft to be turned sharply without excessive side slippage, from the centrifugal force.

Another problem encountered with hydrofoil watercraft, in common with other high speed craft, such as a hydroplane, is the tendency to yaw with wave action from abeam. This, too, is a function of the lack of stabilizing planes, the same lack which allows centrifugal force to cause so much slippage in turns. Consequently, it is very difficult, at high speeds, to hold a straight course and steering requires constant attention.

SUMMARY OF THE INVENTION

The present invention is characterized by the presence, in addition to the usual hydrofoils, of a separate set of completely submerged foils mounted beneath and preferably a bit outboard of the aft hydrofoils. A pair is used, one under each stern quarter of the craft. These are mounted so that their plane surface makes an

acute angle with plane of the hydrofoil (i.e., the plane of the surface of the water) along a line parallel to the fore and aft lines of the ship. Thusly mounted the plane of these foils can pass through the water with a minimum of resistance, yet present a surface against side slip from beam seas and give enough drag astern to effect self straightening at high speeds.

These submerged foils are pivoted along an axis perpendicular to a line parallel to the fore and aft lines of the craft. Further they are independently turnable from inside the craft. When a turn is to be made, the one on the side of the craft towards which the turn is desired is pivoted enough to cause a slightly increased drag on that side. The craft is thus turned but the other unpivoted, submerged foil tends to block the centrifugal force of the turn and prevent slippage. Since the pivoted foil is never completely turned athwart the forward direction of the craft, it, too, has a component of force assisting in this resistance to slippage.

It is thus an advantage of this invention that it stabilizes the hydrofoil craft both on the straightaway and in turns against the action of beam seas.

It is further advantage of this invention that it resists the centrifugal forces of high speed turns to reduce side slippage.

THE DRAWINGS

FIG. 1 is a perspective dynamic view of a hydrofoil watercraft on the surface of the water, showing a submerged foil of this invention.

FIG. 2 is a perspective view of one aft strut of the hydrofoil craft of FIG. 1, showing the hydrofoil, the submerged foil, the mountings therefor and a control lever for pivoting the submerged foil.

FIG. 3 is a rear elevation of the craft of FIG. 1 showing the craft riding on the hydrofoils with the submerged foils of this invention mounted beneath the stern hydrofoils.

FIG. 4 is a side elevation of the craft of FIG. 3.

THE PREFERRED EMBODIMENT

Referring to the Figures, in which the same parts always have the same reference numerals, the hull 1 is supported at high speeds on the forward hydrofoil 2 the port stern quarter hydrofoil 3 and the starboard stern quarter hydrofoil 4. The strut 5 to the aft port hydrofoil 3 extends below the surface of the water as a mount for a completely submerged foil 6. A similar submerged foil 7 is mounted on an extension to the strut 8 which supports the starboard hydrofoil 4.

As shown in FIG. 2 and FIG. 4, the submerged foil 6 is pivoted along the axis a-a which lies in a plane perpendicular to the fore and aft lines of the craft and a movable lever 9 is fastened to one side of foil 6 enabling the pivoting of said foil 6 from inside the craft. The starboard submerged foil 7 is similarly pivoted and independently controllable from inside the craft.

The craft is driven at high speeds by any conventional means (not shown). This may be a water or air propeller or even a water or air jet or rocket. Power is supplied by any desired type of engine—inboard or outboard of marine automotive or aircraft type. It is then riding on the hydrofoils 2, 3 and 4 with the submerged foils 6 and 7 riding in a plane parallel to the fore and aft lines of the craft. When it is desired to turn the craft to port, lever 9 is actuated so as to pivot foil 6 slightly on axis a-a. The resultant drag on the port quarter piv-

ots the craft to port. The starboard submerged foil 7, still in a plane parallel to the fore and aft lines of the craft, aids in resisting the centrifugal force of the turn and preventing side slippage in the turn.

The submerged foils of this invention are shown in the Figures mounted on struts extending out abeam of the craft. This is to increase the moment of the dragging force and to reduce the force necessary to pivot the submerged foil and to reduce the amount of pivoting needed for the same effect. The further outboard they are mounted, the better this desirable effect is achieved. However, it is within the scope of this invention to mount the submerged foils directly beneath the stern quarters of the craft. Turning moment and stability against slippage are then sacrificed to reduce the over-all beam of the craft.

The submerged foils must be substantially or completely submerged. It is generally desirable not to mount them too deep, in order to keep submerged surfaces to a minimum. Similarly, it is desirable to shape or streamline the mounting means, such as the extensions of struts 5 and 8 as shown, in order to reduce submerged surface areas presented to the slip stream of the craft. For the same reason, the submerged foils 6 and 7 also are kept as thin as possible commensurate with the rigidity needed to perform their function.

The submerged foils of this invention are shown as more or less circular, but any desired shape—rectangular, triangular, oval, diamond shaped, etc.—may be used. The pivoting of the submerged foils is preferably such that more surface is aft of the pivot than is forward of it, in order to give the foils a tendency to straighten themselves. If the pivoting were to have more surface forward, the invention would still work but great force and effort would be needed on the controls to hold the foils from turning spontaneously. If all the surface of the foil is aft of the pivot, much force is needed to effect any turning of the foil. Thus a smaller area forward and a larger area aft is the most desirable.

The plane of the submerged foils must be normally parallel to the fore and aft lines of the craft. If it is also parallel to the surface of the water, it will be effective in turning the craft but will be ineffective to resisting the centrifugal force of the turn and thus in preventing slippage. Generally, the plane of the submerged foil should make an angle of more than 0° and less than 90° with the surface of the water in order to add this desirable advantage. When the angle between the plane of the submerged foil and that of the water surface approaches 0° , the resistance to slippage is reduced but resistance to the tendency to roll over on high speed turns is enhanced. Conversely, when the angle approaches 90° , the resistance to slippage becomes

greater but there is little resistance to the tendency to roll over on a turn. An angle of 45° is most desirable. When the angle approaches 90° , any part of foils 6 and 7 which emerge from the water are superfluous and can be eliminated.

The means for mounting the submerged foils can be any convenient structure and can be fastened to the craft either directly to the hull or through the aft hydrofoils as shown in the Figures. It is generally desirable to keep the size of such structures to a minimum in order to reduce the submerged surface area.

The means for turning the submerged foils can be any desirable standard mechanism—levers, chains, wires, wormgears, etc. Again, it is desirable that the means should be designed so as to reduce the underwater surface. The foil can be pivoted on a journaled rod which is completely contained within the mounting means and the turning means will then be up in the craft or at least above the hydrofoil. The turning means for each submerged foil must be separately actuable.

Other variations will be seen by those skilled in the art and these are within the scope of this invention.

I claim:

1. In a high speed hydrofoil watercraft comprising a floatable hull, forward and aft hydrofoils mounted beneath said hull and power means for propulsion, the improvement which comprises in combination,

a. mounting means extending beneath the plane of said rear hydrofoils near each of the port and starboard quarters of said watercraft,

b. on each said mounting means, a submerged pivotably mounted foil,

1. said submerged foils being mounted in a plane parallel to the fore and aft lines of said craft,

2. said pivoting being on an axis of rotation lying in a plane perpendicular to the fore and aft lines of the craft, and

c. means for independently pivoting each said submerged foil from inside said watercraft.

2. The watercraft of claim 1 in which said submerged foils are mounted in a plane which also makes an angle greater than 0° and less than 90° with the plane of the water surface.

3. The watercraft of claim 2 in which the said submerged foils are substantially outboard of the sides of said watercraft.

4. The watercraft of claim 3 in which the said submerged foils have a larger surface aft of said pivot than forward of it.

5. The watercraft of claim 4 in which said submerged foils are mounted in a plane which also makes an angle of 45° with the plane of the water surface.

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