Oct. 23, 1956 F. VERTENS 2,767,678

HYDROFOIL

Filed Nov. 24, 1954

Fig. 1

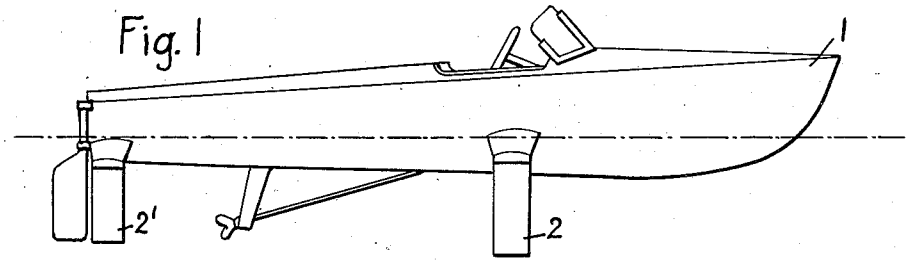



Fig. 2

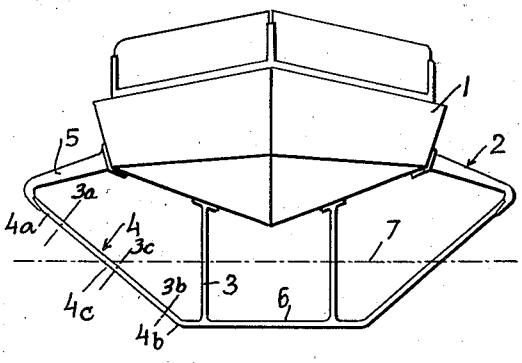



Fig. 3

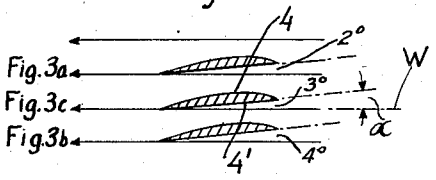



Fig. 4

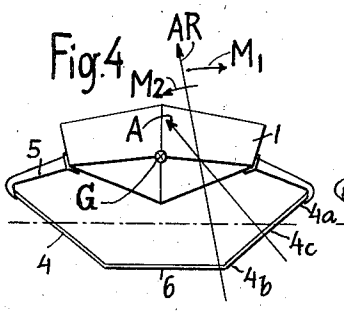



Fig. 5

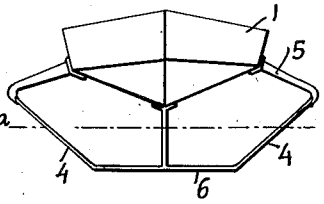



Fig. 6

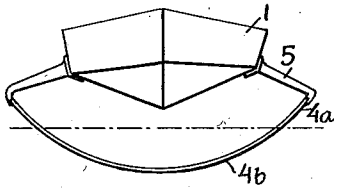



Fig. 7

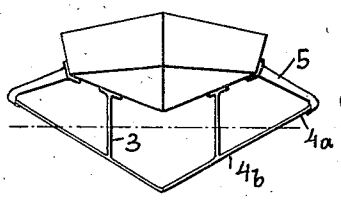



Fig. 8

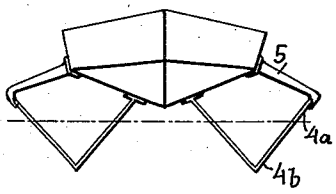
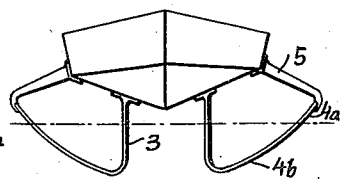



Fig. 9

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United States Patent Office

2,767,678

Patented Oct. 23, 1956



2,767,678

# HYDROFOIL

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Application November 24, 1954, Serial No. 471,039

Claims priority, application Germany February 12, 1954

9 Claims. (Cl. 114—66.5)

The present invention relates to hydrofoils, and more particularly to a hydrofoil whose upper portions have a smaller incidence angle than its lower portions.

Hydrofoils which have lateral inclined hydrofoil portions which serve for improving the longitudinal and transverse stability of the boat are known. In the event that the boat tilts about its longitudinal or transverse axes, upper portions of the hydrofoil are immersed which produce an additional lifting force which tends to righten the boat. Since the stability of the boat depends on the restoring moment produced by the additional lifting forces, it is generally desirable to construct the hydrofoils in such manner than this stabilizing moment is as great as possible assuming that the width of the hydrofoil is not unduly increased.

In order to increase the additional stabilizing lifting force produced by immersed upper portions of the lateral inclined hydrofoil portions, these upper portions are either made wider, or so constructed that the incidence angle thereof increases toward the upper ends of the lateral hydrofoil portions.

When a boat provided with hydrofoils according to the prior art, as above described, moves through a curve, the hydrofoils produce the required stabilizing effect since the boat is outwardly tilted in the curve so that the lateral inclined hydrofoil portion on the side of the boat which is outwardly located with respect to the curve is deeper immersed so that the effective incidence angle between the immersed hydrofoil portion and the flowing water is greater on the outside of the curve.

Due to the greater incidence angle, the hydrofoil located on the side of the boat which is outwardly located in a curve produces a greater lifting force and a stabilizing restoring moment which counteracts the action of the centrifugal force.

While the stabilizing action of the lateral hydrofoil portions according to the prior art is desirable, a serious disadvantage is unavoidable in the constructions according to the prior art in which the incidence angle of the additionally immersed hydrofoil portion is the same, or greater than the incidence angle of the normally immersed portions.

In the event that the boat having hydrofoils of this type moves through a very narrow curve having a small radius of curvature, the maximum permissible incidence angle may be exceeded. The maximum permissible incidence angle is the incidence angle at which the water still produces a lifting force and streams along the hydrofoil. When the permissible maximum incidence angle is exceeded, the flow of the waterstream tends to separate or "peel off" from the hydrofoil surface so that no stabilizing lifting force is exerted at all. This phenomenon occurs suddenly so that a boat which was stabilized by the stabilizing lifting force exerted by the immersed upper portion of the hydrofoil while moving through a curve, is suddenly exposed to the full action of the centrifugal force which is no longer counterbalanced by a stabilizing



force when the flow of the waterstream separates from the hydrofoil. It will be understood that such sudden loss of balance in a narrow curve may result in capsizing of the boat.

It is the object of the present invention to overcome this disadvantage and to provide a hydrofoil in which the permissible maximum incidence angle is not exceeded even in the narrowest curve.

It is another object of the present invention to provide a hydrofoil which is so constructed that its incidence angle decreases towards its upper ends.

It is a further object of the present invention to provide in a hydrofoil a pair of inclined hydrofoil portions which are so constructed that the incidence angles thereof are greater below the water surface than above the water surface in normal position of the boat.

With these objects in view the present invention mainly consists in a hydrofoil adapted to be arranged below the hull of a watercraft having a longitudinal axis, the hydrofoil comprising at least one hydrofoil portion inclined with respect to vertical and horizontal planes, the hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when the craft tilts, the hydrofoil portion being shaped in such manner that the incidence angle of the upper portion thereof is smaller than the incidence angle of the lower portion thereof.

A preferred embodiment of the present invention mainly comprises a hydrofoil adapted to be arranged below and spaced from the hull of the watercraft having a longitudinal axis, the hydrofoil comprising at least one hydrofoil portion located transversely spaced from the longitudinal axis and being inclined with respect to vertical and horizontal planes, the hydrofoil portion having a lower portion adapted to be normally immersed in water, an intermediate portion adapted to be normally located at water level, and an upper portion adapted to normally project above the water level and to be at least partly immersed when the craft tilts, the hydrofoil portion being shaped in such manner that the incidence angle thereof gradually increases from the upper end of the upper portion to the lower end of the lower portion, and is 2° at the upper end of the upper portion, 3° in the intermediate portion, and 4° at the lower end of the lower portion.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 is a side view of a boat provided with hydrofoils according to the present invention;

Fig. 2 is a front view of a boat provided with a hydrofoil;

Fig. 3 shows three cross-sectional views of a hydrofoil, Figs. 3*a*, 3*b* and 3*c* showing the cross-sections of the upper, lower, and intermediate portions of the hydrofoil, respectively, and the incidence angles of these portions, the sections being taken on lines 3*a*, 3*b* and 3*c* in Fig. 2, respectively; and

Figs. 4–9 are front views of boats provided with different types of hydrofoils to which the present invention is advantageously applied.

Referring now to the drawings, and more particularly to Fig. 1, a boat hull 1 is provided with forwardly and rearwardly located hydrofoils 2 and 2'. Any one, or both of the hydrofoils 2 and 2' may be constructed in accordance with the present invention. The particular

shape of the hydrofoils is not an object of the present invention, and the present invention may be applied to any one of the hydrofoil constructions illustrated in Figs. 2, and 4–9. The hydrofoil construction illustrated in these figures include supporting elements 3, inclined lateral hydrofoil portions 4, and supporting members 5. In the constructions illustrated in Figs. 2, 4, 5 and 6, horizontal hydrofoil portions 6 are provided which produce the main lifting force. When the boat tilts due to the action of the centrifugal force in a curve, or rolls about its longitudinal axis due to the action of any foreign force, one of the lateral inclined hydrofoil portions 4 is deeper immersed so that its upper portion 4*a* which is normally located above the water surface 7, is at least partly immersed and exerts a stabilizing lifting force on the boat.

According to the prior art, the incidence angle of the upper hydrofoil portion 4*a* is the same as the incidence angle of the lower hydrofoil portion 4*b*, or the incidence angle of the lower portion 4*b* is smaller than the incidence angle of the higher portion 4*a*. Fig. 3 shows the incidence angle of a hydrofoil 4 which is defined by the plane hydrofoil underside 4' and by the direction of the flow of the stream of water W.

According to the present invention the incidence angle of the hydrofoil portion 4*b* is greater than the incidence angle of the hydrofoil portion 4*a*. In a preferred embodiment of the present invention the incidence angle at the upper end of the upper hydrofoil portion 4*a* is 2°, and gradually increases downwardly so that the incidence angle at the lower end of the lower hydrofoil portion 4*b* is 4°. The incidence angle directly below, or at water level 7 in the intermediate portion 4*c* is preferably 3°. The incidence angle at the upper portion 4*a* is shown in Fig. 3*a*, the incidence angle at the lower portion 4*b* is shown in Fig. 3*b*, and the incidence angle at the intermediate portion 4*c* is shown in Fig. 3*c*.

When the hydrofoils according to the prior art in which the incidence angle in the portion 4*a* is the same, or greater than the incidence angle in the portion 4*b*, are deeper immersed in a curve, a stabilizing effect is exerted since the deeper immersed hydrofoil portion 4*a* produces an additional stabilizing lifting force A. This force A passes through the plane of symmetry of the boat at a point located above the center of gravity G so that the resultant lifting force AR creates a stabilizing moment M2 which counteracts the moment M1 exerted by the centrifugal force tending to tilt the boat. However, as previously explained, the permissible maximum incidence angle may be exceeded in a narrow curve so that the water-stream separates from the hydrofoil, and only the tilting moment M1 is effective which may cause capsizing of the boat.

According to the present invention the upper hydrofoil portion 4*a* which has a smaller incidence angle than the hydrofoil portion 4*b* is at least partly immersed in a curve. The boat can move through a very narrow curve without the risk of the flow of the waterstream separating from the hydrofoil due to the fact that the incidence angle of the upper hydrofoil portion is smaller than the incidence angle of the lower hydrofoil portion, so that the maximum permissible incidence angle is not exceeded even in a very narrow curve, and the boat is stabilized even when moving at great speed. The danger of sudden disappearance of the stabilizing force is avoided.

The stabilizing force in the hydrofoil construction of the present invention in longitudinal and transverse directions is only obtained by the size of the additionally immersed upper hydrofoil portions and by the metacentric height of the boat.

In accordance with the intended use of the boat, and the desired minimum radius of curves through which the boat is to be driven, the incidence angle is adjusted during the manufacture and during the assembly of the hydrofoils so that the inclined lateral portions of the hydrofoil have a smaller incidence angle in the region of the water surface and in the upper portions 4*a* than in the other portions of the hydrofoil 4*b*, and 6 respectively.

It will be understood that the hydrofoil construction of the present invention can be advantageously applied to anyone of the hydrofoil types illustrated in Figs. 2, and 4–9. In Figs. 2, 4, 5, 6, and 7 hydrofoil constructions are illustrated in which the hydrofoil 4, 6 is arranged below and spaced from the hull 1 of the watercraft having a longitudinal axis passing through the point G in Fig. 4. These hydrofoils comprise a pair of inclined hydrofoil portions 4 which are inclined with respect to vertical and horizontal planes and extend upwardly in outward directions with respect to the longitudinal plane of symmetry of the craft passing through the point G.

The constructions illustrated in Figs. 8 and 9 have hydrofoils which include a pair of separate hydrofoil members located on opposite sides of the longitudinal axis of the boat.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of hydrofoils differing from the types described above.

While the invention has been illustrated and described as embodied in a hydrofoil including at least one lateral upwardly and outwardly inclined hydrofoil portion having a smaller incidence angle at its upper end than at its lower end, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. A hydrofoil adapted to be arranged below the hull of a watercraft and comprising at least one hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion being shaped in such manner that the incidence angle of said upper portion thereof is smaller than the incidence angle of said lower portion thereof.

2. A hydrofoil adapted to be arranged below the hull of a watercraft and comprising at least one straight hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion being shaped in such manner that the incidence angle of said upper portion thereof is smaller than the incidence angle of said lower portion thereof.

3. A hydrofoil adapted to be arranged below the hull of a watercraft and comprising at least one arcuate hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion being shaped in such manner that the incidence angle of said upper portion thereof is smaller than the incidence angle of said lower portion thereof.

4. A hydrofoil adapted to be arranged below the hull

of a watercraft and comprising at least one hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion being shaped in such manner that the incidence angle at the upper end of said upper portion thereof is 2° and the incidence angle at the lower end of said lower portion therof is 4°.

5. A hydrofoil adapted to be arranged below the hull of a watercraft and comprising at least one hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water, an intermediate portion adapted to be normally located at water level, and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion being shaped in such manner that the incidence angle at the upper end of said upper portion thereof is 2°, the incidence angle of said intermediate portion thereof is 3°, and the incidence angle at the lower end of said lower portion thereof is 4°.

6. A hydrofoil adapted to be arranged below and spaced from the hull of a watercraft having a longitudinal axis in a position extending transversely to said axis, said hydrofoil comprising a pair of lateral hydrofoil portions inclined with respect to vertical and horizontal planes, each of said hydrofoil portions having a lower portion adapted to be normally immersed in water, an intermediate portion adapted to be normally located at water level, and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portions being shaped in such manner that the incidence angles of said upper portions thereof are smaller than the incidence angles of said lower portions thereof.

7. A hydrofoil adapted to be arranged below and



spaced from the hull of a watercraft having a longitudinal axis in a position extending transversely to said axis, said hydrofoil comprising a pair of lateral hydrofoil portions inclined with respect to vertical and horizontal planes, each of said hydrofoil portions having a lower portion adapted to be normally immersed in water, an intermediate portion adapted to be normally located at water level, and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portions being shaped in such manner that the incidence angles of said upper portions thereof are smaller than the incidence angles of said lower portions thereof and gradually increase from the upper ends of said upper portions to the lower ends of said lower portions, said lower portions of said pair of lateral hydrofoil portions being spaced from each other a greater distance than said upper portions.

8. A hydrofoil as claimed in claim 7 wherein the incidence angle is 2° at the upper ends of said upper portions, 3° on said intermediate portions, and 4° at the lower ends of said lower portions of said hydrofoil portions.

9. A hydrofoil adapted to be arranged below the hull of a watercraft and comprising at least one hydrofoil portion inclined with respect to vertical and horizontal planes, said hydrofoil portion having a lower portion adapted to be normally immersed in water and an upper portion adapted to normally project above the water level and to be at least partly immersed when said craft tilts, said hydrofoil portion having a straight underside being twisted in such manner that the incidence angle of said upper portion thereof is smaller than the incidence angle of said lower portion thereof.

**References Cited** in the file of this patent

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