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TWIN-HULL BOAT WITH HYDROFOILS

FIELD OF THE INVENTION

The present invention relates to a twin-hull boat which is equipped with a plurality of hydrofoils across a twin hull and capable of cruising itself at a high speed.

BACKGROUND OF THE INVENTION

Today, any of conventional twin-hull boats with hydrofoils is transversely equipped with a plurality of hydrofoils below the bottom of the stem and the stern across a twin hull.

In the course of securing a plurality of hydrofoils to the bottom of the stem and the stern of a twin-hull, predetermined hydrofoils are provisionally secured to the bottom of the completed twin hull before executing trial runs by cruising the boat as of this condition. Finally, based on the result of trial runs, optimal angle for securing hydrofoils to the twin-hull boat is eventually determined.

Nevertheless, in the case of the conventional twin-hull boat with hydrofoils cited above, since optimal angle for securing hydrofoils to the twin-hull is determined in final stage in order that the angle can be suited for cruising the boat at a very high speed, the determined angle cannot be optimal in transitional period from the time in which hydrofoils remain still to the time at which the twin-hull

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☒ Drawing(s) : paged $\frac{1}{3}$ to paged $\frac{13}{3}$	
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boat starts to cruise itself via hydrofoils being afloat the water surface.

Therefore, any conventional twin-hull boat with hydrofoils in service today necessarily spends much time in the transitional period before actually starting to cruise itself via hydrofoils being afloat the water surface.

Even though there is such a known twin-hull boat based on a system for swinging hydrofoils in order to vary postural position of hydrofoils, this in turn requires installation of a special device in limited space of the hull to materialize swinging of the hydrofoils, and yet, involves much difficulty to install the device therein. In addition, total cost for manufacturing the twin-hull boat incorporating this system is quite high.

DISCLOSURE OF THE INVENTION

Therefore, primary object of the invention is to provide a novel twin-hull boat which is equipped with a plurality of hydrofoils and capable of effectively exerting floating function in accordance with actual cruising condition despite of own simple structure.

To achieve the above object, as an important aspect of the invention, according to the novel twin-hull boat equipped with a plurality of hydrofoils which are transversely disposed across both-side hulls below the stem and the stern, a pair of auxiliary wings are independently secured at least to either

the internal wall on the part of the center line of the twin hulls or the external wall thereof at a predetermined position between the upper water line formed in the course of cruising the boat at a low speed and the lower water line formed in the course of cruising it at a very high speed. In association with the auxiliary wings, a wing postural angle regulating device is provided, which properly regulates postural angle of these auxiliary wings by causing them to individually pivot on a horizontal axis.

According to the structure of the first embodiment of the invention, since the novel twin-hull boat with hydrofoils according to the invention is provided with at least a pair of auxiliary wings respectively being capable of varying own postural angle by operating the wing-postural angle regulating device, the twin-hull boat can quickly be lifted above the water surface in a short period of time before starting to cruise itself at a very high speed.

Unlike hydrofoils, since the auxiliary wings are constantly held above the water surface, wave resistance is minimized, and yet, visual surveillance against the auxiliary wings can easily be performed.

By virtue of the provision of the novel auxiliary wings according to the invention, the twin-hull boat related to the invention dispenses with such a conventional device for adjusting angle for securing hydrofoils to the bottom of the

stem and the stern, thus resulting in the simplified structure.

As another important aspect of the invention, according to the novel twin-hull boat equipped with hydrofoils, the front hydrofoil on the part of the stem is structured by way of V-shape, whereas the rear hydrofoil on the part of the stern is linearly structured and disposed in the horizontal direction. A pair of auxiliary wings are disposed in local domains close to both ends of the front and rear hydrofoils, where the auxiliary wings are driven to swing themselves independent of the corresponding hydrofoils.

According to the structure of the above second embodiment of the invention, since a pair of hydrofoils disposed across the twin hulls are respectively provided with an auxiliary wing, by causing the auxiliary wings to swing themselves during transitional period from the time in which the boat cruises at a low speed to the time at which the boat starts to cruise itself at a high speed, the twin-hull boat can assume an optimal posture in order to minimize time needed for floating itself above the water surface.

In addition, by virtue of mechanism to cause the auxiliary wings to independently swing themselves, rolling and pitching effect adversely affecting the twin-hull boat in the course of high-speed cruising can securely be minimized.

As another important aspect of the invention,

according to the novel twin-hull boat equipped with hydrofoils related to the invention, fin units are provided in the longitudinal direction below the bottom surface of the rear hydrofoil disposed on the part of the stern by way of traversing the twin hull.

According to the structure of the above third embodiment of the invention, fins are provided in the longitudinal direction below the bottom surface of the rear hydrofoil disposed on the part of the stern across the twin hull. Owing to this arrangement, the novel twin-hull boat equipped with hydrofoils can securely prevent the twin hull from drifting itself traverse even when being hit by beam wind or beam waves on the way of cruising itself at a fast speed, thus achieving reliable stability in the course of high-speed cruising.

A variety of advantageous features and effects of the invention will more fully be clarified from the detailed description rendered in association with the accompanying drawings that follow.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of the twin-hull boat provided with hydrofoils according to the first embodiment of the invention;

Fig. 2 is a lateral view of the twin-hull boat according to the first embodiment of the invention;

Fig. 3 is a front view of one of a pair of auxiliary wings provided for the twin-hull boat according to the first embodiment of the invention;

Fig. 4 is a cross-sectional view of fundamental components of drive mechanism provided for each of the auxiliary wings according to the first embodiment of the invention;

Fig. 5 is a cross-sectional view of the drive mechanism provided for each auxiliary wing taken on line A-A shown in Fig. 4;

Fig. 6 is a lateral view of the twin-hull boat provided with hydrofoils according to the second embodiment of the invention;

Fig. 7 is a cross-sectional view of the rear hydrofoil on the part of the stern according to the second embodiment of the invention;

Fig. 8 is a plan of the rear hydrofoil corresponding to a range indicated by arrowed lines B-B shown in Fig. 7;

Fig. 9 is a cross-sectional view of fundamental components of the rear hydrofoil on the part of the stern according to the second embodiment of the invention;

Fig. 10 is a cross-sectional view of the components of the rear hydrofoil taken on line C-C shown in Fig. 9;

Fig. 11 is a cross-sectional view of the front hydrofoil on the part of the stem according to the second

embodiment of the invention;

Fig. 12 is a plan of the front hydrofoil corresponding to a range indicated by arrowed lines D-D shown in Fig. 11;

Fig. 13 is a lateral view of the twin-hull boat provided with hydrofoils according to the third embodiment of the invention;

Fig. 14 is a front view of the twin-hull boat provided with hydrofoils according to the third embodiment of the invention;

Fig. 15 is a lateral view of a fin unit provided for the third embodiment of the invention;

Fig. 16 is a cross-sectional view of the fin unit taken on line E-E shown in Fig. 15; and

Fig. 17 is a cross-sectional view of fundamental components of a variant of the fin unit according to the third embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figures 1 through 5, structural detail of a novel twin-hull boat equipped with a pair of hydrofoils according to the first embodiment of the invention is described below.

The reference numeral 1 shown in Figures 1 and 2 designates a twin hull of the twin-hull boat equipped with a pair of hydrofoils according to the first embodiment of the invention.

A pair of twin-hull structures 3A and 3B are disposed on both sides of the main hull structure 2 furnished with deck on the top surface.

In order to securely sustain the twin hull 1 afloat while the twin-hull boat cruises at a high speed, a pair of hydrofoils consisting of a stem-side hydrofoil 4 and another stern-side hydrofoil 5 are transversely secured to the bottom of the twin-hull across the twin-hull structures 3A and 3B.

A pair of auxiliary wings (or called floating blades) 6A and 6B are respectively secured to the internal wall domains of the twin-hull structures 3A and 3B at a forward position from the front hydrofoil 4 by way of projecting themselves in the horizontal direction and facing the center line CL of the twin hull 1.

The auxiliary wings 6A and 6B are provided in order to contract transitional period needed for activating the twin-hull boat 1 to cruise itself at a high speed above the water surface from the initial rise-up posture by way of cruising itself at a low speed. The auxiliary wings 6A and 6B are respectively disposed at a position below the high water line HWL formed in the course of cruising the twin-hull boat 1 at a low speed and the lower water line LWL formed in the course of cruising the boat 1 at a high speed so that these auxiliary wings 6A and 6B can fully be submerged in water while the twin-hull boat 1 cruises at a low speed, and yet, the

auxiliary wings 6A and 6B can externally be exposed above the water surface while the twin-hull boat 1 cruises at a very high speed.

As shown in Fig. 3, the auxiliary wings 6A and 6B are respectively provided with wing-shape section. As shown in the plan of Fig. 5, the auxiliary wings 6A and 6B are of rectangular shape.

As shown in Figures 4 and 5, each of the auxiliary wings 6A and 6B is rotatably secured to a bearing case 9 which is integrated with an external hull plate 8 (constituting internal wall of the twin hull structures 3A and 3B) via a bearing 10, a supporting boss 6a, and a shaft member 7 outwardly projecting itself from the base of the boss 6a.

The reference numeral 11 shown in Fig. 4 designates a bearing unit, whereas the reference numeral 12 designates a plurality of sealing members such as O-rings for example.

A postural angle regulating device 15 is secured to an end of the shaft member 7 in order to properly regulate postural angle of the auxiliary wings 6A and 6B.

More particularly, the postural angle regulating device 15 consists of a lever member 16 having an end linked with the tip of the shaft member 7 and a cylinder unit 17 such as an oil-pressurized cylinder for example linked with the other end of the lever member 16. The lever member 16 is linked with a rod member 17a of the cylinder unit 17. The

cylinder unit 17 incorporates a stroke sensor for detecting projected amount of the rod member 17a.

According to the structural arrangement described above, simultaneous with the shift from the low-speed cruising mode to the high-speed cruising mode, postural angles of the auxiliary wings 6A and 6B are properly regulated by the cylinder 17 in accordance with actual cruising speed of the twin-hull boat 1.

By implementing adjustment of the postural angles of those auxiliary wings 6A and 6B, the twin-hull boat 1 can contract transitional period ranging from the time for lifting the twin-hull 1 above the water surface to the time at which the twin-hull boat 1 starts to cruise itself at a high speed. In other words, the twin-hull boat 1 can efficiently cruise itself.

Furthermore, since the auxiliary wings 6A and 6B are respectively secured to specific positions higher than the bottom of the twin-hull structures 3A and 3B, in contrast with hydrofoils 4 and 5 respectively being secured to narrow space of the bottom domain, the auxiliary wings 6A and 6B can easily be secured to the predetermined positions.

Furthermore, since the auxiliary wings 6A and 6B are respectively exposed above the water surface while the twin-hull boat 1 cruises at a high speed, physical condition of the auxiliary wings 6A and 6B can be checked via visual inspection

to facilitate maintenance and inspection work.

Furthermore, unlike any conventional twin-hull boat requiring adjustment of angles of the installed hydrofoils whenever the boat cruises above the water surface, the novel twin-hull boat 1 according to the invention dispenses with such a device otherwise needed for adjusting angles of the installed hydrofoils, thus resulting in the reduced cost.

When implementing the first embodiment, the auxiliary wings 6A and 6B are projectively secured to internal walls of the twin-hull structures 3A and 3B facing the hull center line CL. However, as indicated by double-dotted imaginary lines shown in Fig. 1, the auxiliary wings 6A and 6B may also be provided by way of outwardly projecting themselves from external walls of the twin-hull structures 3A and 3B. Depending on circumstances, it is also possible for the twin hull boat of the invention to provide two pairs of auxiliary wings 6A and 6B on both the internal and external walls of the twin-hull structures 3A and 3B by way of horizontally projecting themselves.

Next, referring to Figures 6 through 12, another structural feature of the novel twin-hull boat according to the second embodiment of the invention is described below.

The reference numeral 21 shown in Fig. 6 designates a twin hull of the twin-hull boat equipped with a pair of hydrofoils, where twin-hull structures 23A and 23B are

provided on both sides of the main hull structure mounting deck thereon.

As shown in Figures 7 through 11, a pair of rear mounts 25 for securing a stern-side hydrofoil 24 are respectively set to the bottom of each keel 23a of the twin-hull structures 23A and 23B based on substantially 5% of distance M against total length L between the stem and the stern of the twin hull 21.

More particularly, the center of each of the rear mounts 25 is set in order that (M/L) can be within substantially 5%.

As shown in Fig. 10, each of the rear mounts 25 consists of a perpendicular member 26 secured to bottom surface of the keel 23a of the twin-hull structure 23A and 23B and a horizontal member 27 which is horizontally linked with bottom surface of the perpendicular member 26. The bottom surface of the horizontal member 27 makes up a junction surface 28 having curvature in the longitudinal direction.

The stern-side hydrofoil 24 is horizontally secured to the rear mounts 25 and fully submergible in water. A pair of auxiliary wings 29 are respectively secured to trailing edge positions close to both edges of the stern-side hydrofoil 24, where the auxiliary wings 29 are swingably driven independent of the hydrofoil 24.

A pair of fin units (these may be called skegs) 30 are

respectively secured to both edges of the stern-side hydrofoil 24. As is used for composing hydrofoils, high-tensile steel plates are used for composing the fin units 30. The fin units 30 are thinly structured to minimize own weight.

The stern-side hydrofoil 24 and the fin units 30 are respectively secured to the bottom of the junction surface 28 of the rear mounts 25 on both sides by means of bolt 31. The center of the stern-side hydrofoil 24 is supported by a strut 32 vertically projected from the bottom center line CL of the main hull 22.

As shown in Fig. 9, a drive unit 33 for swingably operating the auxiliary wings 29 consists of a wing-control cylinder 34 such as an oil-pressurized cylinder which is disposed inside of the bottom domain of the twin-hull structures 23A and 23B. Tip of a rod member 34a of the wing-control cylinder 34 is linked with a rotary shaft 35 for supporting each of the auxiliary wings 29 via a lever unit 36. In association with reciprocation of the rod member 34a of the wing-control cylinder 34, the auxiliary wings 29 swing themselves in the vertical direction. The reference numeral 37 designates a body making the water flow smooth.

As shown in Figures 6, 11, and 12, a pair of front mounts 42 for securing a stem-side hydrofoil 41 is set to the bottom of each keel 23a of the twin-hull structures 23A and 23B based on substantially 60 through 70% of distance N

against total length L in the longitudinal direction of the twin hull 21.

More particularly, the center of each of the front mounts 42 is set in order that (N/L) can be within substantially 60 through 70%. Structurally, the front mounts 42 are identical to the rear mounts 25.

The stem-side hydrofoil 41 is structured by forming V-shape and fully submergible in water, which is secured to the junction surfaces of the front mounts 42 via bolts.

The center of the stem-side hydrofoil 41 is supported by a strut 43 vertically projected from the bottom center line CL of the hull 21.

The fully submergible stem-side hydrofoil 41 has upwardly inclined angles on both sides in a range from 10 degrees to 18 degrees. A pair of auxiliary wings 44 and 44 having structure identical to that of the auxiliary wings 29 of the stern-side hydrofoil 24 are secured to trailing edge positions close to both edges of the stern-side hydrofoil 41 and being disposed on the part of the stern. The auxiliary wings 44 and 44 are respectively driven by a drive unit 46 incorporating a cylinder unit 45 so that they can swing themselves in the vertical direction.

While the twin-hull boat 21 cruises, the stem portion is lifted above the water surface by functional effect of the stem-side hydrofoil 41 without causing the twin-hull 21 to

fully become afloat. On the other hand, by functional effect of the stern-side hydrofoil 24, the stern portion is lifted as of the condition in which the bottom remains submerged. In other words, the stem portion is afloat above the water surface, but the stern portion remains submerged.

Since the stem-side hydrofoil 41 and the stern-side hydrofoil 24 are respectively equipped with swingable auxiliary wings 29/29 and 44/44, when the low-speed cruising mode is shifted to the high-speed cruising mode, swing angle (i.e., postural angle) of the auxiliary wings 29/29 and 44/44 can properly be adjusted in accordance with the actual cruising speed via operation of the cylinder units 34 and 45 provided for the drive units 33 and 46.

By virtue of the adjustment of postural angle of those auxiliary wings 29/44, transitional time from the floating to the activation of high-speed cruising of the twin-hull boat 21 can securely be contracted. This means that the twin-hull boat 21 can cruise itself with high efficiency.

While the twin-hull boat 21 embodied by the invention cruises under normal speed, the twin-hull 21 is prevented from fully becoming afloat above the water surface. In other words, the twin-hull boat 21 cruises itself by way of sustaining the stem-side hydrofoil 41 in the submerged condition, and therefore, the stem-side hydrofoil 41 is free from being exposed to beam waves, thus making it possible for

the inventive twin-hull boat 21 to cruise itself under constantly stabilized condition.

Furthermore, since the fully submergible stem-side hydrofoil 41 is secured to a forward position corresponding to about 60 through 70% of total hull length from the stern edge, and yet, since the fully submergible stern-side hydrofoil 24 is secured to a forward position from the stern edge by a distance corresponding to a maximum of 5% of total hull length, weight of the twin-hull 21 is properly distributed to promote stability of the hull 21.

Since the stem-side and stern-side hydrofoils 24 and 41 are respectively secured across the twin-hull structures 23A and 23B without significantly projecting from the keels 23a, resistance generated by the twin-hull 21 on the way of high-speed cruising is minimized. Mooring convenience is also promoted.

The stem-side and stern-side hydrofoils 24 and 41 are solidly secured to the twin-hull structures 23A and 23B, and yet, center positions of the hydrofoils 24 and 41 are solidly supported by the corresponding struts 32 and 43, thus resulting in the reinforced strength of the hydrofoils 24 and 41. This in turn results in the reduced weight of the hydrofoils 24 and 41.

In addition, since the auxiliary wings 29/29 and 44/44 are independently driven to swing themselves, rolling and

pitching on the way of high-speed cruising can effectively be minimized.

Furthermore, by virtue of the provision of the fin units 30 for the stem-side hydrofoil 24, even when being exposed to beam wind or beam waves on the way of high-speed cruising, the twin-hull 21 can securely be prevented from being drifted aside, thus promoting own stability and cruising comfort.

Furthermore, owing to the above structural arrangement, the twin-hull boat 21 according to the invention minimizes generation of waves on the way of towing and suppresses pitching behavior caused by head sea.

Next, referring to Figures 13 through 17, structural features of the novel twin-hull boat according to the third embodiment of the invention are described below.

The reference numeral 51 shown in Figures 13 and 14 designates a twin-hull of the twin-hull boat equipped with hydrofoils according to the third embodiment of the invention. Twin-hull structures 53A and 53B are provided on both sides of the main hull 52 mounting deck thereon.

A stem-side hydrofoil 54 and a stern-side hydrofoil 54A used for floating the twin hull 51 in the course of high-speed cruising are respectively secured across bottom domains of the twin-hull structures 53A and 53B on the part of the stem and the stern via corresponding struts 55.

A pair of fin units (or called skegs) 56 each having a predetermined height are respectively secured to both-side edges of the bottom surface of the stern-side hydrofoil 54A in the longitudinal direction. Each of the fin units 56 has a specific length equal to distance (chord length) between the leading edge and the trailing edge of the stern-side hydrofoil 54A for example. As is used for composing the hydrofoils 54 and 54A, high-tensile steel plates are used for composing the fin units 56. The fin units 56 are thinly composed to minimize own weight.

As shown in Figures 15 and 16, the fin units 56 are integrally combined with the stern-side hydrofoil 54A by means of a pair of bolts 57 respectively being used for securing both edges of the stern-side hydrofoil 54A to the corresponding struts 55. More particularly, a fixing flange 56a of each fin unit 56 is secured to the bottom surface at an edge of the hydrofoil 54A via the bolts 57 used for securing the hydrofoil 54A. The main fin unit 56b perpendicularly extends itself from the center of the fixing flange 56a.

Therefore, by virtue of the structural arrangement described above, even when the twin-hull boat 51 is exposed to beam wind or beam waves on the way of cruising itself at a high speed, owing to the provision of the fin units 56 secured below the bottom surface of the stern-side hydrofoil 54A at both-side edges, the twin-hull boat 51 according to the

invention can securely be prevented from being drifted aside.

Furthermore, since the fin units 56 are secured to the stern-side hydrofoil 54A, the fin units 56 can submerge themselves in water more deeply than the case of being secured to the stem-side hydrofoil 54, and therefore, the twin-hull boat 51 can be prevented from meandering itself on the way of high-speed cruising.

In addition, since the fin units 56 are secured to the twin-hull 51 via the hydrofoil 54A by means of bolts 57, maintenance and inspection can be carried out very easily against the fin units 56 and the hydrofoil 54A.

Incidentally, according to the third embodiment, the fin units 56 are respectively disposed by way of downwardly extending the main fin unit 56b from the center of the fixing flange 56a. However, in place of this arrangement, as shown in Fig. 17 for example, the main fin unit 56b may downwardly extend itself from the right side or the left side of the fixing flange 56a.

According to the foregoing embodiments, the fin units are respectively secured to the twin-hull via corresponding struts. However, instead of this, the fin units may directly be secured to the bottom domain of the twin hull.



WHAT IS CLAIMED IS:

1. A twin-hull boat equipped with a plurality of hydrofoils on the part of the stem and the stern across both-side twin-hull structures comprising;

a plurality of auxiliary wings which are respectively secured to at least either of internal wall domain facing center line of said twin hull and external wall domain outside of said twin hull at a forward position between said twin-hull structures and between upper water line formed in the course of low-speed cruising and lower water line formed in the course of high-speed cruising; and

a postural angle regulating device which properly regulates postural angle of said auxiliary wings by causing said auxiliary wings to respectively pivot on horizontal axis.

2. A twin-hull boat equipped with a plurality of hydrofoils on the part of the stem and the stern across both-side twin-hull structures comprising;

a stem-side hydrofoil structured in V-shape;

a stern-side hydrofoil linearly formed in horizontal direction; and

a plurality of auxiliary wings which are respectively disposed at positions close to both edges of corresponding hydrofoils in order to be operated by way of independently swinging themselves.

3. The twin-hull boat equipped with a plurality of



hydrofoils as defined in Claim 2, wherein said stem-side hydrofoil is disposed at a forward position corresponding to substantially 60 through 70% of distance from the stern against total length of said twin hull, and wherein said stern-side hydrofoil is disposed at a forward position corresponding to substantially 5% of distance from the stern against total length of said twin hull.

4. A twin-hull boat equipped with a plurality of hydrofoils on the part of the stem and the stern across both-side twin-hull structures comprising;

a plurality of fin units which are respectively disposed below bottom surface of a stern-side hydrofoil secured across said both-side twin-hull structures, wherein said fin units are respectively aligned in the stem-to-stern direction.