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(54) **WATER VEHICLE WITH A HYDROFOIL AND ADDITIONAL SECOND STABILIZER**

(57) The water vehicle with hydrofoil is used in the field of water sports and includes an above-water platform (1), a mast (2) connecting the above-water platform (1) with a hydrofoil, including a fuselage (5) with a front wing (7) and a first stabilizer (8), drive means (6) for creating horizontal thrust and a second stabilizer (4) located in the vertical direction between the fuselage (5) and the above-water platform (1), where the second stabilizer (4) in the longitudinal direction is being located behind the front wing (7). It is possible that the second stabilizer (4) is mounted to the above-water platform (1), the mast (2), to the additional structurally supporting parts, to the parts that serve to change the angle of attachment of the main stabilizer, to the fuselage (5) or drive means (6) by means of a support element (3) with the possibility of changing the vertical position.

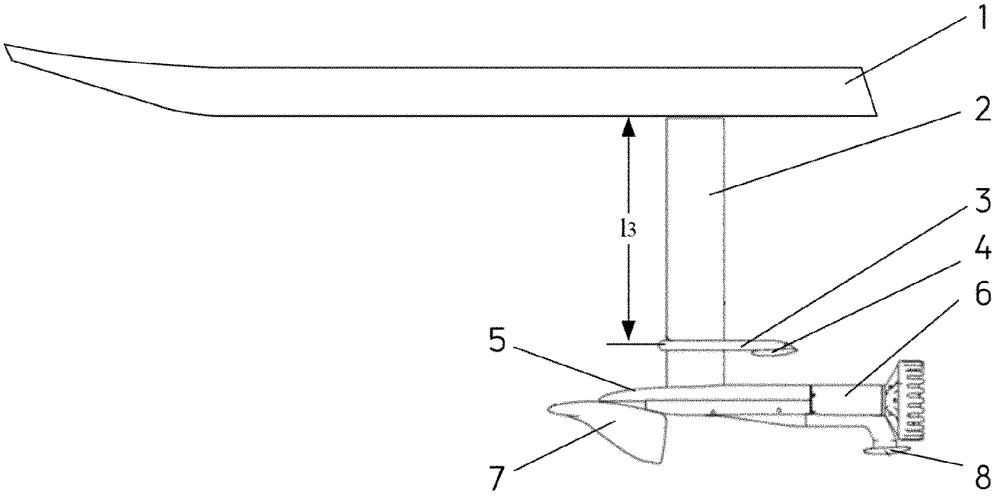

Figure 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a hydrofoil water vehicle used in the field of water sports.

BACKGROUND OF THE INVENTION

[0002] There are various solutions for implementing stabilization of a hydrofoil, such as in patent WO2019091437A1, where additional driven units are used, which create a lifting force in a certain direction, depending on the angle of rotation, the height of the hydrofoil above the water surface changes accordingly. Variants of this solution have poor lateral stability (longitudinal and transverse direction), the vehicle is difficult to control, and requires skills and experience of the surfer to ride it, making it unsuitable for learners.

[0003] Patents JPH1120775A and JPH1120785A disclose a watercraft with a two-wing hydrofoil, which are arranged parallel to each other and are used to prevent lateral rocking of the hull and to increase the load capacity (increase the weight it can carry) of the vehicle. This design is complex and includes controllable movable elements, such as ailerons, which require complex mechanics and control. This way of arranging the stabilizers leads to an increase in the area, but also to a decrease in the efficiency of the two-wing system. When moving in an aquatic environment, the double hydrofoil does not protrude above the water surface.

SUMMARY OF THE INVENTION

[0004] It is an aim of the present invention to provide an additional stabilization of a water vehicle with a hydrofoil and a correction of the angle of attack of the bearing wing without the need for additional movable controllable parts or high driving power. Within this aim, an additional task is to provide a water vehicle with low manufacturing costs.

[0005] This aim is achieved by creating a water vehicle with a hydrofoil with an additional second stabilizer, which creates additional lifting force while in the water, which leads to a longitudinal change in the angle of attack of the front wing. In this way a change in the height of the platform above the water surface is achieved - it rises above the water surface. Upon reaching a height at which the additional second stabilizer rises above the water surface, the lifting force created by it is eliminated (the stabilizer no longer creates lifting force) and the hydrofoil again changes the longitudinal angle to the water surface - the nose of the platform above the water points down and it descends towards the water surface. The additional second stabilizer works on a passive principle, i.e. it is not connected to an energy source.

[0006] In particular, the water vehicle according to the invention includes:

- above-water platform,
- hydrofoil, including fuselage with front wing and first stabilizer,
- a mast connecting the above-water platform to the hydrofoil, and
- a second stabilizer located vertically between the fuselage and the above-water platform, wherein, longitudinally, the second stabilizer is located behind the front wing.

[0007] Preferably, the second stabilizer is mounted to the water vehicle with the possibility of changing the vertical position of the second stabilizer.

[0008] In one embodiment, the second stabilizer is mounted directly or indirectly to the mast, preferably by means of a supporting element.

[0009] The supporting element of the second stabilizer can be a supporting beam, which is attached to the mast with the possibility of changing the vertical position of the supporting element.

[0010] Preferably, the second stabilizer is mounted at a distance of at least 10 cm below the above-water platform.

[0011] In a preferred embodiment, the second stabilizer in the longitudinal direction is located between the front wing and the first stabilizer.

[0012] In one embodiment, the invention also includes a drive means for creating a horizontal thrust, for example at least one electric motor with a water propeller, which electric motor is connected to a power source.

[0013] Advantages of the water vehicle according to the invention are:

- improves the longitudinal stability of the hydrofoil by changing the pitching moment of the hydrofoil;
- prevents the uncontrolled emerging out of the water of the hydrofoil wing;
- restricts the rise (flight) of the above-water platform above the water surface;
- improves the flight stability of the hydrofoil;
- mounting of an additional stabilizer to the mast is a simple and cost-effective design.

BREIF DESCRIPTION OF THE FIGURES

[0014] Further in the description of the water vehicle that is the object of the invention, it is explained via a preferred embodiment, given as a non-limiting the scope of the invention example, with a reference to the attached figures, where:

FIG. 1 is a schematic side view of a water vehicle according to the invention;
FIG. 2 is a diagram of a force analysis of a hydrofoil according to the invention.
FIG. 3 is a schematic side view of the vehicle according to another embodiment - windfoil.

EXAMPLES OF EMBODIMENT AND OPERATION OF THE INVENTION

[0015] The terms "below", "above", "in front", "front", "behind", "rear" in the present description and in the claims reflect the relative position of the structural elements, as shown in the figures and in the usual operating position of the device.

[0016] The water vehicle according to the invention comprises an above-water platform 1, a hydrofoil and a mast 2 connecting the above-water platform 1 and the hydrofoil (Fig. 1).

[0017] The proposed structural scheme of a hydrofoil, as shown in figure 1, complements the standard scheme of a hydrofoil, which includes a fuselage 5, a bearing (front) wing 7 and a rear located first stabilizer 8, with an additional second stabilizer 4 located between the above-water platform 1 and the fuselage 5 in height.

[0018] In the preferred embodiment shown in Figures 1 and 2, the water vehicle has a drive means 6. Typically, the drive means 6 generates thrust in the direction of movement and includes, for example, at least one electric motor with a water screw propeller, which electric motor is connected to a source of electricity, such as rechargeable batteries. The drive means 6 can be located both on the fuselage (figure 1) or be mounted directly to the mast 3 above the fuselage, wherein in the second variant the second stabilizer 4 is mounted above the drive means 6.

[0019] There are other possible solutions for accomplishing a hydrofoil drive without the use of an electric motor. Such an option is, for example, the windfoil, in which the driving force is generated by the wind caught by a sail 9, attached to an additional beam 10, which is mounted to the above-water platform 1 (figure 3). The beam 10 to which the sail 9 is attached has a sufficient degree of freedom so that the surfer can tilt it at a different angle and rotate it 350 degrees in order to catch the headwind to generate the driving force.

[0020] It is possible to combine the water vehicle in a known way with a windfoil as a means of propulsion.

[0021] The additional second stabilizer 4 in the longitudinal direction is located behind the front wing 7. By "longitudinal direction" is meant a direction parallel to the longitudinal axis of the fuselage 5. In the embodiment shown in Figures 1 and 2 the second stabilizer 4 in the longitudinal direction is between the front wing 7 and the first stabilizer 8. This arrangement allows the overall design of the water vehicle to be more compact. In addition, the optimum action of the second stabilizer and the best stabilization effect are achieved.

[0022] Variants are also possible in which the second stabilizer 4 is located immediately above or behind the first stabilizer 8.

[0023] It will be apparent to those skilled in the art that the location, configuration, dimensions and fastening of the front wing 7 and the first stabilizer 8 to the fuselage 5 may be different as long as the above condition is met that the second stabilizer 4 is located longitudinally behind the front wing 7. For example, the front wing 7 and the first stabilizer 8 may be located in one plane or the first stabilizer 8 may be located lower than the front wing 7.

[0024] The second stabilizer 4 may have the shape and dimensions of the first stabilizer 8, but may have another shape that must meet the following criteria:

- to have a streamlined profile, which can be dense (solid) or hollow, and waterproof;
- have a hydrodynamic shape with low hydrodynamic resistance;
- to generate a downward force that creates a stabilizing moment.

[0025] The elements of the hydrofoil are made of the usual, known from the prior art, suitable materials. The second stabilizer 4, as well as the front wing 7 and the first stabilizer 8, for example, may be made of expanded polystyrene (EPS), expanded polypropylene (EPP), impregnated plywood and the like. The listed materials may also be in combination with a carbon coating applied via a known method.

[0026] Preferably, the second stabilizer 4 is mounted at a distance ℓ_3 below the above-water platform 1 not less than 10 cm (figure 1). It is also recommended that the second stabilizer 4 is not mounted directly above the fuselage 5.

[0027] In a preferred embodiment, the second stabilizer 4 is mounted directly or indirectly to the mast 2.

[0028] As shown in Figures 1 and 2, the second stabilizer 4 may be located on a supporting element 3. For example, the second stabilizer 4 may be attached to the rear of a support beam, which with its front part is mounted with fastening means to the mast 2 with the possibility of vertical relocation and fastening in a different vertical position. This can be done, for example, by providing mounting holes in the mast 2 at different heights, in which the fastening means of the

supporting beam, such as a screw, a bolt with a nut or other suitable known detachable fastening means, are arranged. The detachable fastening of the support element 3 to the mast 2 can also be achieved in other ways known to those skilled in the art. The beam can be mounted perpendicular to mast 2 or at another angle from 1 to 179 °. The support element may consist of two arms located at different angles to each other. It is also possible for the support means to be telescopic, for example a telescopic extension beam.

[0029] Attaching the supporting beam with the additional second stabilizer 4 allows to change the position of the whole unit along the height of the mast 2. This allows the second stabilizer 4 to be at a variable distance from the fuselage 5 and to have a different effect on the longitudinal stability of the entire hydrofoil, resulting in a greater or lesser pitching moment, which raises or lowers the nose of the hydrofoil.

[0030] In addition, it is possible that the second stabilizer 4 is mounted to the above-water platform 1, to the additional structurally supporting details, to the details that serve to change the angle of attachment of the main stabilizer, to the fuselage 5 or to the drive means 6 by means of a support element 3 with a possibility to change the vertical position.

[0031] There are additional details that constructively support the attaching of the mast to the above-water platform (such as mounting plates or those that change the profile at one end of the mounting between the mast and the above-water platform), as well as such additional details that allow changing the angle on the mounting of the front wing or the rear main stabilizer (such are the so-called shims).

[0032] Figure 4 shows schematically the following alternatives for attaching the second stabilizer 4 to the water vehicle:

- mounting by means of a support element 3 to the above-water platform 1, the support element being a beam or other suitable mechanical part which descends vertically to the fuselage 5 at an angle of 90 degrees to the above-water platform or at another angle (or a combination of vertical arm and arm at an angle of 1 to 89 degrees);
- mounting by means of a supporting element or directly to the additional structurally supporting details (at an angle), located between the above-water platform 1 and the mast 2;
- mounting by means of a support element or directly to the additional details, which usually serve to change the angle of the first stabilizer 8; in such an installation of the second stabilizer, the supporting element, for example a beam, may be located both parallel to the mast and at an angle to the mast or to the longitudinal axis of the fuselage;
- mounting by a support element to the fuselage 5 of the hydrofoil, wherein the support element, for example a beam, may be attached vertically or at an acute angle to the longitudinal axis of the fuselage 5;
- mounting by means of a support element to the housing of the drive means 6, the support element, for example a beam, being able to be located vertically or at an acute angle to the longitudinal axis of the drive means 6.

[0033] Mounting of a second stabilizer 4 to the hydrofoil of the water vehicle is intended to provide variable behaviour of the hydrofoil during above-water flight, which is expressed in a continuous (cyclic) transition from floating at a certain height to subsequent diving to prevent uncontrolled emerging out of the water of the underwater part, leading to loss of control and falling of the surfer. In other words, a system is created to support stabilization along a longitudinal angle of inclination.

[0034] The principle of operation of the additional second stabilizer 4 is as follows: during the initial acceleration of the hydrofoil, the second stabilizer 4 is under water together with the other structural elements of the underwater part. Thus, it acts as the rear first stabilizer 8, generating a downward force, which in turn creates a stabilizing moment, assisting the first stabilizer 8 in balancing the hydrofoil system. When take-off speed is reached (separation of the above-water platform from the water surface), the hydrofoil begins to rise, which continues until the second stabilizer 4 rises above the water. At this point, it loses its lift power, and the stabilizing moment created by it disappears. Thus, the total moment balancing the hydrofoil system is reduced and a tendency is created to reduce the angle of attack of the wing 7, provided that the surfer's position is maintained invariably relative to the longitudinal axis of the hydrofoil. Reducing the angle of attack of the wing leads to a subsequent dive down and re-entry of the second stabilizer 4 in the water, which in turn leads to a tendency to increase the angle of attack. This is followed by a new rise above the water of the second stabilizer 4 and so diving and rising are repeated cyclically in order to maintain a certain altitude above the water (flight is maintaining a certain distance between the water surface and the above-water platform), without significant intervention of the surfer. The immersion depth of the underwater part of the hydrofoil can be adjusted by changing the vertical position of the second stabilizer 4 on the mast 2, for example by changing the place of attachment of the supporting beam in the vertical direction. The closer the support beam and the stabilizer 4 are to the fuselage 5, the higher will be the surfacing of the above-water platform 1 and vice versa - the farther the second stabilizer 4 is from the fuselage 5, the lower will be the surfacing of the above-water platform 1.

[0035] In the embodiment in which the second stabilizer 4 in the longitudinal direction is located between the front wing 7 and the first stabilizer 8, optimal stabilization is achieved, wherein the distance of the above-water platform to the water surface varies within small limits - with minimal oscillations of movement as to facilitate the management of the surfboard along the longitudinal axis.

[0036] The proposed design with two stabilizers achieves, with appropriate adjustment, stable maintenance of a certain

flight height of the above-water platform above the water.

[0037] The force analysis shown in Figure 2 of a hydrofoil with an additional stabilizer shows the main forces acting on the underwater elements of the hydrofoil.

[0038] Description of reference positions:

M - pitching moment of the wing;
G - total weight of the hydrofoil;
L_1 - lifting force of the first stabilizer;
L_2 - lifting force of the second stabilizer;
ℓ_1 - arm of the first stabilizer;
ℓ_2 - arm of the second stabilizer;
ℓ_G - arm of the total weight;

Equation (1)

$$M + G.l_G - L_1.l_1 - L_2 l_2 = 0 \quad (1)$$

represents the moment equation about the 25% point of the mean aerodynamic chord of the wing, i.e. the application point of the lifting force of the wing. It describes the balance in the longitudinal direction and helps to understand the principle of operation of the additional stabilizer 4

[0039] When all the elements of the hydrofoil, including the additional stabilizer 4, are under water, the complete scheme of figure 2 is valid and the equilibrium is determined by equation (1). When the take-off speed is reached, a process of emerging up at an angle of attack of the wing set by the position of the surfer is performed, as the surfer is the largest single mass in the system. In the case when the second stabilizer 4 emerges above water, and the force L2 becomes zero, then the system tends to dive into the water, reducing its angle of attack. This behaviour is best described by inequality (2):

$$L_1.l_1 + L_2 l_2 > L_1.l_1 \quad (2)$$

[0040] The reference numbers of the technical features are included in the claims only for the purpose of increasing the comprehensibility of the claims and, therefore, these reference numbers have no restrictive effect on the interpretation of the elements indicated by these reference numbers.

Claims

1. A water vehicle comprising:

- an above-water platform (1),
- a hydrofoil comprising a fuselage (5) with a front wing (7) and a first stabilizer (8), and
- a mast (2) connecting the above-water platform (1) with the fuselage (5) of the hydrofoil,

characterized in that the water vehicle comprises a second stabilizer (4) located in the vertical direction between the fuselage (5) and the above-water platform (1), wherein the second stabilizer (4), in the longitudinal direction, is located behind the front wing (7).

2. Water vehicle according to Claim 1, **characterized in that** the second stabilizer (4) is mounted to the water vehicle with the possibility of changing of the vertical position.

3. Water vehicle according to Claim 1 or 2, **characterized in that** the second stabilizer (4) is mounted directly or indirectly to the mast (2).

4. Water vehicle according to Claim 3, **characterized in that** the second stabilizer (4) is mounted to the mast (2) by means of a support element (3).

5. Water vehicle according to Claim 4, **characterized in that** the support element (3) of the second stabilizer (4) is a

support beam which is attached to the mast (2) with the possibility of changing its vertical position.

6. Water vehicle according to one of the preceding claims, **characterized in that** the second stabilizer (4) is mounted at a distance of at least 10 cm below the above-water platform (1).

7. Water vehicle according to one of the preceding claims, **characterized in that** the second stabilizer (4) is located in the longitudinal direction between the front wing (7) and the first stabilizer (8).

8. Water vehicle according to one of the preceding claims, **characterized in that** it also includes an underwater drive means (6) for creating of horizontal thrust.

9. Water vehicle according to claim 7, **characterized in that** the drive means (6) comprises at least one electric motor with a water screw propeller, which electric motor is connected to a source of electricity.

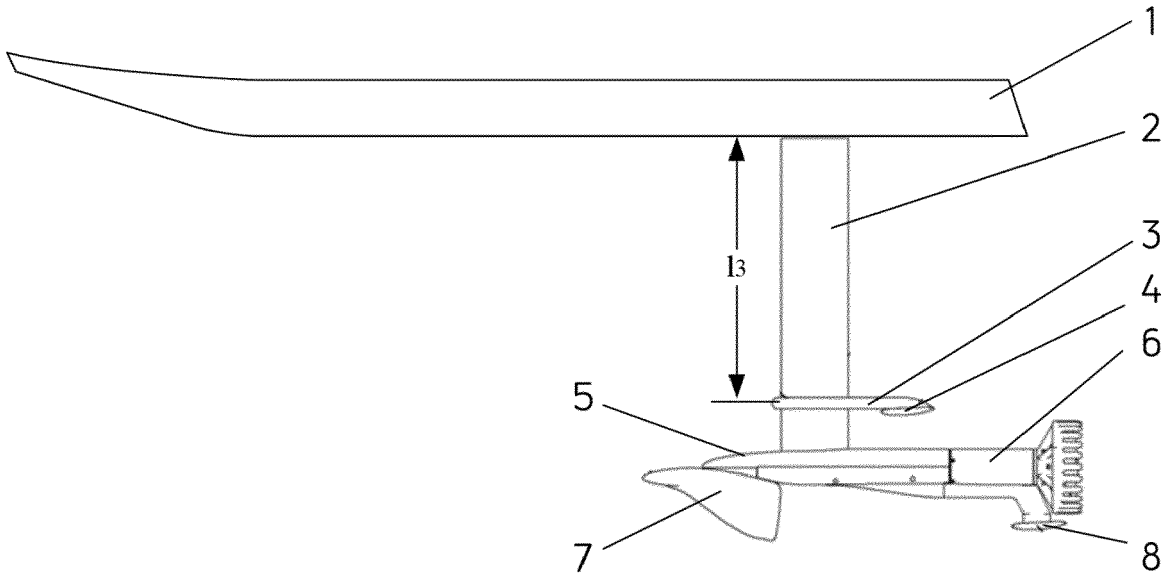

Figure 1

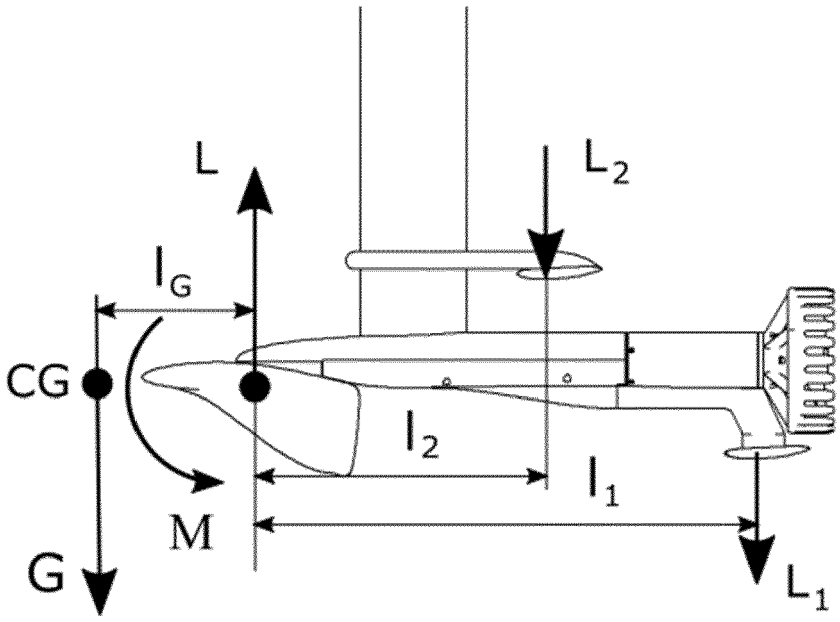

Figure 2

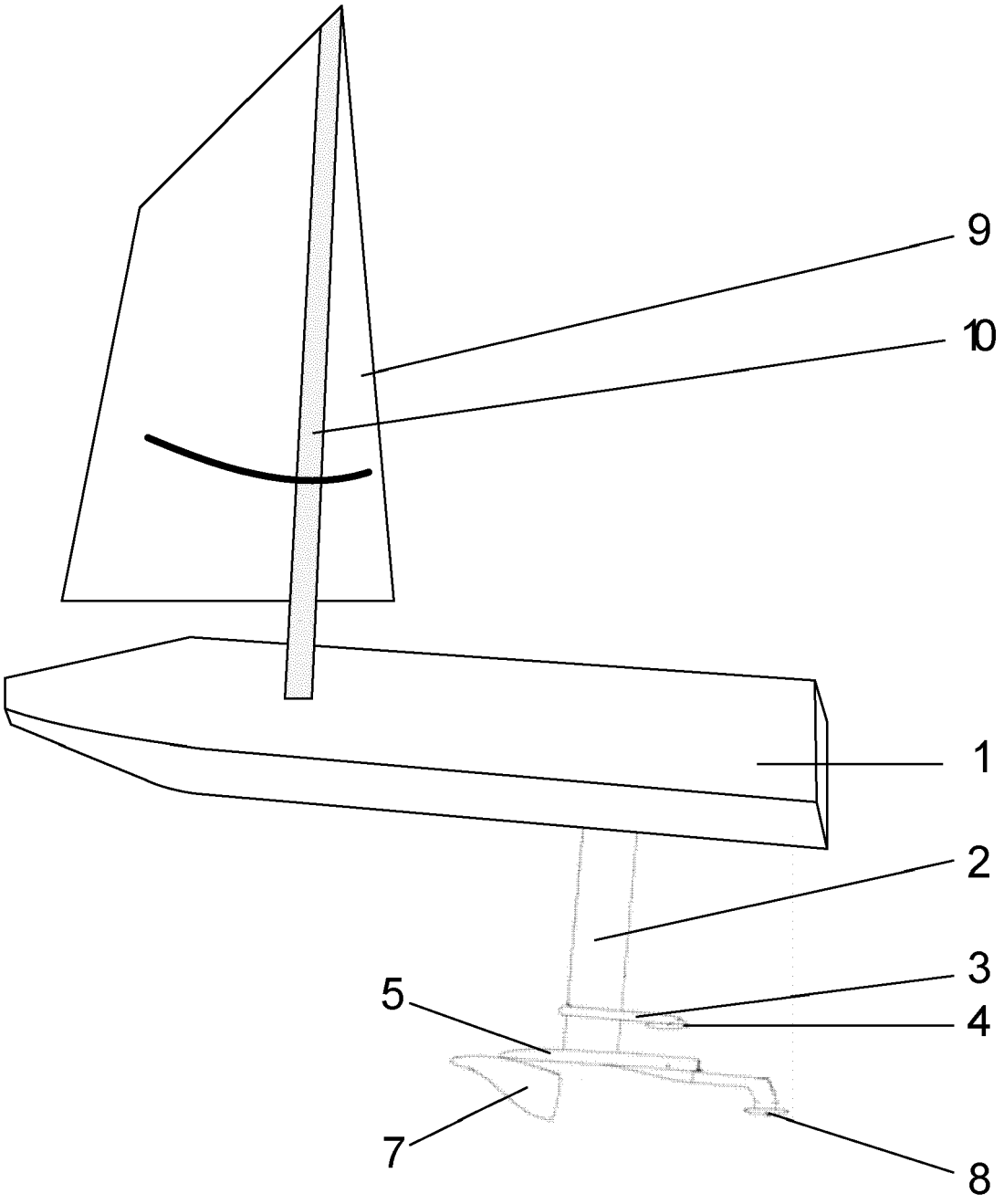

Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 21 47 2011

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	FR 3 049 262 A1 (MOULIN OLIVIER PAUL MICHEL [FR]) 29 September 2017 (2017-09-29)	1-7	INV. B63B1/24 B63B1/26 B63B32/64 B63B32/66 B63B32/10 B63H21/17
Y	* pages 1,3-4; figure 1 *	8,9	
X	WO 2021/149066 A1 (LEVELED HYDROFOILS LTD [IL]) 29 July 2021 (2021-07-29)	1,3,4,8,9	
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A	* page 4; figures 1-3 *	2,5,7-9	
Y	US 2020/079479 A1 (DERRAH STEVEN JOHN [US]) 12 March 2020 (2020-03-12)	8,9	
A	* paragraph [0093]; figure 19 *	1	

TECHNICAL FIELDS SEARCHED (IPC)

B63B
B63H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	26 April 2022	Blazquez Lainez, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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26-04-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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