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(54) Title: UNMANNED SURFACE VEHICLE

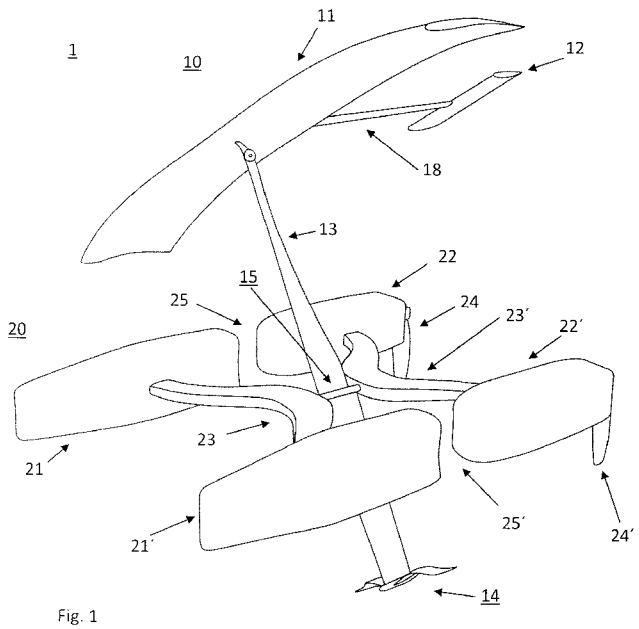


Fig. 1

(57) Abstract: The invention relates to a surface vehicle 1 comprising a keel-mast arrangement 10 where at least one keel 14 is arranged to at least one mast 13 to form the keel-mast arrangement 10 and that the keel-mast arrangement 10 is movabiy arranged to a multihull structure 20 where the keel-mast arrangement 10 is arranged with a rotating joint 15 to the multihull structure 20, where the multi hull structure have at least one opening 25, 25' for the keel- mast arrangement 10 to pass through, so that the multihull structure 20 and the keel-mast arrangement 10 are freely rotatable around an axis formed by a bow-stern axis A. The invention further relates to a method to provide a capsize safe surface vehicle comprising a multihull structure 20 and a keel-mast arrangement 10 where at least one keel 14 is arranged to at least one mast 13 to form the keel-mast arrangement 10 where the keel-mast arrangement 10 is rotatable arranged to the multihull structure 20 so that the multihull structure 20 could freely rotate around the bow-stern axis A to keep the mast 13 substantially above the surface and the keel 14 substantially below the surface when the surface vehicle is in use.

UNMANNED SURFACE VEHICLE

TECHNICAL FIELD

The present invention describes a surface vehicle comprising a keel-mast arrangement where at least one keel is arranged to at least one mast to form the keel-mast arrangement and that the keel-mast arrangement is movably arranged to a multihull structure. The invention further describes a method to provide a capsize safe surface vehicle comprising a multihull structure and a keel-mast arrangement.

BACKGROUND ART

The need of unmanned vehicles for different missions and purposes are rapidly increasing. It is today well known to use unmanned aerial vehicle and unmanned ground vehicles for different security and military missions. Currently unmanned surface vehicles, USV, have mainly been used to collect information with relation to oceanography. One of the commonly used technologies for unmanned surface vehicle is the wave glider principle. A wave glider, as its name indicates, is a vehicle that floats on the surface and harness wave energy to propel the vehicle. Benefits of the wave glider principle are that surface vehicles utilizing the wave glider principle usually have a low above the surface signature and thus a limited surface exposed to the wind making the vehicle relatively capsize safe. Vehicles with the wave glider principle to propel the vehicle are only possible to use where speed is of low or no importance. The speed of the vehicle is so low so that commercial available unmanned surface vehicles utilizing wave energy to propel the vehicle are known to have problems with seaweed accretion.

It is known that surface vehicle could be constructed in different ways to avoid capsize or to reduce disturbances of the surface vehicle in strong wind. The invention published in patent document US 6,394,019 B1 discloses a watercraft with anti-capsizing flotation members and

rotating crew carrier for maintaining safe craft operation under hazardous water conditions.

The invention as disclosed in 6,394,019 B1 is a watercraft for crew transportation in hazardous water conditions. The patent document does not disclose any sailing means or means or methods to modify the watercraft into an unmanned surface vehicle.

It is also known that wind propelled surface vehicle could be constructed so that a mast and keel could move to some degree to make the hull more stable. The hull is thus less affected by the wind acting on the sail to propel the surface vehicle. The invention described in patent document US 5,908,005 A discloses a yacht with a mast mechanically connected to a keel via a bearing to keep the hull substantially horizontal with respect to surrounding flat water.

A problem with the solution described in US 5,908,005 A is that the hull is only kept horizontal for a limited amount of force to the sail (tilt of the mast), if the mast and keel arrangement are forced, by the wind, to its limits the hull of the boat would overturn and the yacht will capsize.

Accordingly, it is an object of the invention to provide a reliable and improved unmanned surface vehicle and a method for an unmanned surface vehicle.

Other problems solved by the invention are described in the detailed description.

SUMMARY OF THE INVENTION

One object of the new invention is to eliminate drawbacks associated with the solutions known in the prior art.

Another object is to provide a wind propelled autonomous capsize safe surface vehicle.

The new invention describes a surface vehicle comprising a keel-mast arrangement where at least one keel is arranged to at least one mast to form the keel-mast arrangement and that the keel-mast arrangement is movably arranged to a multihull structure where the keel-mast arrangement is arranged with a rotating joint to the multihull structure, where the multi hull structure have at least one opening for the keel-mast arrangement to pass through, so that the multihull structure and the keel-mast arrangement are freely rotatable around an axis formed by a bow-stern axis.

Furthermore the improved surface vehicle according to the invention discloses;

that the multihull structure comprises four elongated floats arranged, by holding means, so that a first float and a second float are arranged to form a first elongated hull and a third float and a fourth float are arranged to form a second elongated hull and that the keel-mast arrangement is arranged between the first hull and the second hull.

that the first float and the third float are arranged to the first holding means and that the second float and the fourth float are arranged to the second holding means.

that the elongated floats are symmetrical in the elongated floats bow-stern axis.

that rudders are arranged to the stern of the first hull and the stern of the second hull.

that rudders are symmetrically arranged, to the stern of the elongated floats, so that substantially half the rudder is positioned above the bow-stern axis and half of the rudder is positioned below the bow-stern axis.

that the rotating joint comprises a tubular sleeve pivotally supported by an elongated member connecting the first holding means to the second holding means.

that the rotating joint between the keel-mast arrangement and the multihull structure comprises a slip ring connector for electrical connection between the keel-mast arrangement and the multihull structure.

that at least one wing is arranged on the mast as a sail.

that at least one solar panel is arranged to the wing.

that the keel comprises of two lateral undulating members.

that a lateral wing is arranged to the mast by a boom where the lateral wing comprises at least one aileron.

The invention further describes a method to provide a capsize safe surface vehicle comprising a multihull structure and a keel-mast arrangement where at least one keel is arranged to at least one mast to form the keel-mast arrangement and that the keel-mast arrangement is rotatable arranged to the multihull structure so that the multihull structure could freely rotate around the bow-stern axis to keep the mast substantially above the surface and the keel substantially below the surface when the surface vehicle is in use.

Furthermore the method to provide a capsize safe surface vehicle according to the invention discloses;

that the keel-mast arrangement is rotatable arranged to the multihull structure by an rotating joint, where the rotating joint comprises a tubular sleeve pivotally supported by an elongated member.

that the multihull structure is symmetrical so that the multihull structure could revolve, around the bow-stern axis, where the multi hull structure comprises the elongated member and that the elongated member rotates inside the sleeve, of the joint, while the keel-mast arrangement is substantially vertical.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described in greater detail below by way of illustration of embodiments and with reference to the attached drawings, in which:

Fig. 1 shows a view from the side of an unmanned surface vehicle in accordance with the present invention.

Fig. 2 shows a view from the aft of an unmanned surface vehicle in accordance with the present invention.

Fig. 3 shows a view of the rotating connection between the keel-mast arrangement and the multihull structure of an unmanned surface vehicle in accordance with the present invention.

Fig. 4 shows a view from the side of an unmanned surface vehicle in accordance with the present invention.

DETAILED DESCRIPTION

The unmanned surface vehicle 1, shown in figure 1, comprises a keel-mast arrangement 10 rotatable arranged to a multihull structure 20. The keel-mast arrangement 10 comprises at least one keel 14, or centerboard, arranged to at least one mast 13 to form the keel-mast arrangement 10. The lateral members are preferably shaped to reduce cavitation. In a preferable embodiment the lateral members are S shaped, wave formed or undulating. To the mast 13 a sail 11 could be arranged. A lateral wing 12 is fixedly arranged to the sail 11 and/or the mast 13 by a boom 18 or other arrangement. The arrangement comprising the lateral wing 12, boom 18, and sail 11 serves as a passive control system to keep a defined angle of attack of the sail 11 towards the changing wind. The lateral wing 12 is preferably arranged with at least one moveable aileron, fin and/or rudder or other control surface. By moving the aileron, by a servo or other actuator, the angle of attack of the lateral wing 12 and thus the sail 11 could be altered and controlled. For the unmanned surface vehicle 1 shown in figure 1 the sail 11 is a wing. The multihull structure 20 comprises four elongated floats 21, 21´, 22,

22´ arranged, by holding means 23, 23´, so that a first float 21 and a second float 22 are arranged to form a first elongated hull 21, 22 and a third float 21´ and a fourth float 22´are arranged to form a second elongated hull 21´, 22´. A first rudder 24 is arranged on the first elongated hulls second float 22, i.e. the stern of the first elongated hull. A second rudder 24´ is arranged on the second elongated hulls fourth float 22´, i.e. the stern of the first elongated hull. The keel-mast arrangement 10 is arranged with a rotating joint 15 between the first hull, where the first hull comprises the first float 21 and a second float 22, and the second hull, where the second hull comprises the third float 21´ and a fourth float 22´. The keel-mast arrangement 10 is thus rotatable arranged, by rotating joint 15, to the multihull structure 20 so that the multihull structure 20 could freely rotate so that the mast 13, at least the sail 11 part of the mast, is above the surface of the surrounding water and that the keel 14 is below the surface of the surrounding water and that the keel-mast arrangement 10 is substantially vertically oriented. The rotating joint could include a slip ring connector to electrically connect the keel-mast arrangement 10 to the multi hull structure 20. The first float 21 is arranged to the second float 22 by the first holding means 23 and the third float 21´ is arranged to the fourth float 22´ by the second holding means 23´. In a preferred embodiment solar panels are arranged on the wing 10 to provide electrical power to the unmanned surface vehicle 1. Furthermore the rotating joint 15 could include a generator to provide electrical power to the unmanned surface vehicle 1. Electrical power could be used on the unmanned surface vehicle to power a guidance, navigator and/or control system for the unmanned surface vehicle. Electrical power may also be needed to control the servos or motors for the rudders 24, 24´ and the aileron on the lateral wing 12. Electrical power could also be used to power sensors, measurements instruments or other scientific instruments and for receiving and sending information to and from the unmanned surface vehicle.

Figure 2 shows the unmanned surface vehicle 1 from the aft or stern. The keel 14 is preferably T-shaped with two lateral members 19, 19´ principally orthogonally arranged

to the mast 13. The rudders 24, 24´ are shown in a first embodiment. In the shown figure the rudders are arranged to turn. In a second preferred embodiment, not shown, the rudders 24, 24´ are symmetrically vertically arranged in the elongated floats 22, 22´, 23, 23´ bow-stern axis A vertical extension. In figure 2 the bow-stern axis A is indicated.

Figure 3 shows a close-up of the rotating joint 15 arranged to the first holding means 23 and the second holding means 23´. The first holding means 23 are fixedly arranged to the second holding means 23´. The mast 13, of the keel-mast arrangement 10, are preferably arranged to be rotatable movable around an axis connecting the first holding means 23 to the second holding means 23´. The mast 13 is arranged to a tubular sleeve 16 pivotally supported by an elongated member 17 where the elongated member 17 connects the first holding means 23 to the second holding means 23´. The rotating joint 15 further comprises a machine element to reduce the friction, such as a bearing.

Figure 4 shows a side view of the unmanned surface vehicle 1. The bow-stern axis A is substantially the symmetrical axis of the multi hull structure 20. The multi hull structure 20 is symmetrical turnable around the bow-stern axis A. The bow-stern axis A substantially coincide with an axis axially going through the center of the elongated member 17, where the elongated member 17 is connecting the first holding means 23 to the second holding means 23´

The unmanned surface vehicles commonly used today utilize the wave glider principle. A wave glider comprises a floating body, comprising a hull, and an arrangement for generating energy from the wave and/or from solar panels. To keep the body of the wave glider in a horizontal position and to harvest the wave energy a swimmer, or movable keel, is mounted to the hull of the wave gliders body. The swimmer could be arranged to change position so that the swimmer is moved to a lover position in operation and to a position close the body of the wave glider when the wave glider is not in use. The body of the wave glider, when positioned in water, has a limited surface above the

water level to reduce the wind load on the wave gliders body. Due to the low profile of the wave glider the wind does only have a limited effect on the wave glider making the wave glider resistant to strong wind. The propulsion of the wave glider is by means located under the water level. Commonly the propulsion speed of the wave glider is low and/or limited.

Unmanned surface vehicles with higher propulsion speed are also available. Unmanned surface vehicles with higher propulsion speed commonly utilize a combustion engine or other engine dependable on fuel. The wind provides energy to propel a surface vehicle with high speed. A commonly used surface vehicle that is able to travel with high speed by wind propulsion is the catamaran. The catamaran is known to be a light weight and fast surface vehicle. To safely sail with a catamaran there is a need of constant and incessant control of the sails by the yachtman and/or sailor to keep the catamaran from capsizing. A catamaran of traditional design is thus not suitable for unmanned surface vehicles. By providing a rotatable keel-mast arrangement 10 to a surface vehicle of the catamaran type it is possible to achieve an unmanned surface vehicle that is capsize safe. The keel-mast arrangement 10 is rotatable arranged to the multihull structure 20. In high wind, when the wind energy is acting on the sail 11, the keel-mast arrangement 10 could freely move in correspondence to the winds direction. If the waves/wind is so strong that the sail 11, and thus the keel-mast arrangement 10, is forced to the surface of the surrounding water the contour of the sail 11 is reduced and the force on the sail 11 is also reduced. If the sail 11 is forced to the surface of the surrounding water the keel-mast arrangement 10 is substantially horizontal. When the wind/waves is reduced, due to change in weather conditions, the weight and momentum the keel 14 puts on the mast 13, and thus the sail 11, provides that the sail 11 again is forced to a position above the surface of the water in an upright position. In the upright position the keel-mast arrangement 10 is substantially vertical. Even if the waves/wind acting on the sail 11 forces the keel-mast arrangement into the water surrounding the unmanned surface vehicle 1 the opening 25, 25´ let the keel-mast arrangement 10 to move without moving

or in another way touch or contact the multihull structure 20. And if the waves/wind acts on the multihull structure 20, the multi hull structure 20 could rotate around the rotating joint 15 and make a 180 degree turn since the opening 25, 25´ of the multi hull structure 20 lets the keel-mast arrangement 10 to pass between the openings 25, 25´ when the multi-hull structure 20 revolve.

The multi-hull structure 20 is symmetrical with regards to the bow-stern axis A. The rudders 24, 24´ are preferably arranged to be extending symmetrically above and below the bow-stern axis A. The rudders 24, 24´ could also be arranged to turn, by gravity or other means, to always be positioned beneath the surface of the water and in a substantially vertical orientation. The multi-hull structure could thus be revolved around the bow-stern axis A and the axis formed by the elongated member 17, where the elongated member 17 connects the first holding means 23 to the second holding means 23´. Surrounding the elongated member 17 is a tubular sleeve 16 pivotally supported by the elongated member 17. The tubular sleeve is arranged to or integrated with the mast 13. The multi-hull structure 20 is arranged with a sensor to determine the orientation of the multi-hull structure 20. Depending upon the orientation of the multi-hull structure 20 the rudders 24, 24´ control direction are interchanged.

Sailing of the unmanned surface vehicle 1 is by traditional methods including beating, reaching and running all controlled by the unmanned surface vehicles guidance, navigation and control unit or by a remote operator. Preferably a wind sensor is used on the unmanned surface vehicle 1 to determine wind direction and intensity. The wing 11, or other part of the unmanned surface vehicle 1 such as the keel 14, could be arranged with a device or technical solution to hinder the unmanned surface vehicle 1 to be lifted by an extremely strong wind or gust of wind. As an example the wing 11 could be arranged to flex or change direction when the wind act upon the wing 11 with a certain wind force.

ALTERNATIVE EMBODIMENTS

The invention is not limited to the shown embodiments. The invention could be varied regarding to the number of elements, size, material, and form factor within the scope of the patent claims.

It is obvious that the presented new invention could be used for all kinds of navigation systems, for all types of vehicles and ships, including airships, spaceships, and sea ships and on land vehicles.

CLAIMS

1. Surface vehicle (1) comprising a keel-mast arrangement (10) where at least one keel (14) is arranged to at least one mast (13) to form the keel-mast arrangement (10) and that the keel-mast arrangement (10) is movably arranged to a multihull structure (20) **characterized by** that the keel-mast arrangement (10) is arranged with a rotating joint (15) to the multihull structure (20), where the multi hull structure have at least one opening (25), (25´) for the keel-mast arrangement (10) to pass through, so that the multihull structure (20) and the keel-mast arrangement (10) are freely rotatable around an axis formed by a bow-stern axis (A).

2. Surface vehicle (1) according to claim 1 **characterized by** that the multihull structure (20) comprises four elongated floats arranged, by holding means (23), (23´), so that a first float (21) and a second float (22) are arranged to form a first elongated hull and a third float (21´) and a fourth float (22) are arranged to form a second elongated hull and that the keel-mast arrangement (10) is arranged between the first hull and the second hull.

3. Surface vehicle (1) according claim 2 **characterized by** that the first float (21) and the third float (21´) are arranged to the first holding means (23) and that the second float (22´) and the fourth float (22´) are arranged to the second holding means (23´).

4. Surface vehicle (1) according to any of claims 2 - 3 **characterized by** that the elongated floats (21), (21´), (22), (22´) are symmetrical in the elongated floats (21), (21´), (22), (22´) bow-stern axis (A).

5. Surface vehicle (1) according to any of claims 2 - 4 **characterized by** that rudders (24), (24´) are arranged to the stern of the first hull and the stern of the second hull.

6. Surface vehicle (1) according to claim 5 **characterized by** that rudders (24), (24´) are symmetrically arranged, to the stern of the elongated floats (22), (22´), so that substantially half the rudder (24), (24´) is positioned above the bow-stern axis (A) and half of the rudder (24), (24´) is positioned below the bow-stern axis (A).

7. Surface vehicle (1) according to any of the preceding claims **characterized by** that the rotating joint (15) comprises a tubular sleeve (16) pivotally supported by an elongated member (17) connecting the first holding means (23) to the second holding means (23´).

8. Surface vehicle (1) according to any of the preceding claims **characterized by** that the rotating joint (15) between the keel-mast arrangement (10) and the multihull structure (20) comprises a slip ring connector for electrical connection between the keel-mast arrangement (10) and the multihull structure (20).

9. Surface vehicle (1) according to any of the preceding claims **characterized by** that at least one wing (11) is arranged on the mast (13) as a sail.

10. Surface vehicle (1) according to claim 9 **characterized by** that at least one solar panel is arranged to the wing (11).

11. Surface vehicle (1) according to any of the preceding claims **characterized by** that the keel (14) comprises of two lateral undulating members (19), (19´).

12. Surface vehicle (1) according to any of the preceding claims **characterized by** that a lateral wing (12) is arranged to the mast (13) by a boom (18) where the lateral wing (12) comprises at least one aileron.

13. Method to provide a capsize safe surface vehicle (1) comprising a multihull structure (20) and a keel-mast arrangement (10) where at least one keel (14) is arranged to at least one mast (13) to form the keel-mast arrangement (10) **characterized by** that the keel-mast arrangement (10) is rotatable arranged to the multihull structure (20) so that the multihull structure (20) could freely rotate around the bow-stern axis (A) to keep the mast (13) substantially above the surface and the keel (14) substantially below the surface when the surface vehicle (1) is in use.

14. Method to provide a capsize safe surface vehicle (1) according to claim 13 **characterized by** that the keel-mast arrangement (10) is rotatable arranged to the multihull structure (20) by an rotating joint (15), where the rotating joint (15) comprises a tubular sleeve (16) pivotally supported by an elongated member (17).

15. Method to provide a capsize safe surface vehicle (1) according to claim 14 **characterized by** that the multihull structure (20) is symmetrical so that the multihull structure (20) could revolve, around the bow-stern axis (A), where the multi hull structure (20) comprises the elongated member (17) and that the elongated member (17) rotates inside the sleeve (16), of the joint (15), while the keel-mast arrangement (10) is substantially vertical.

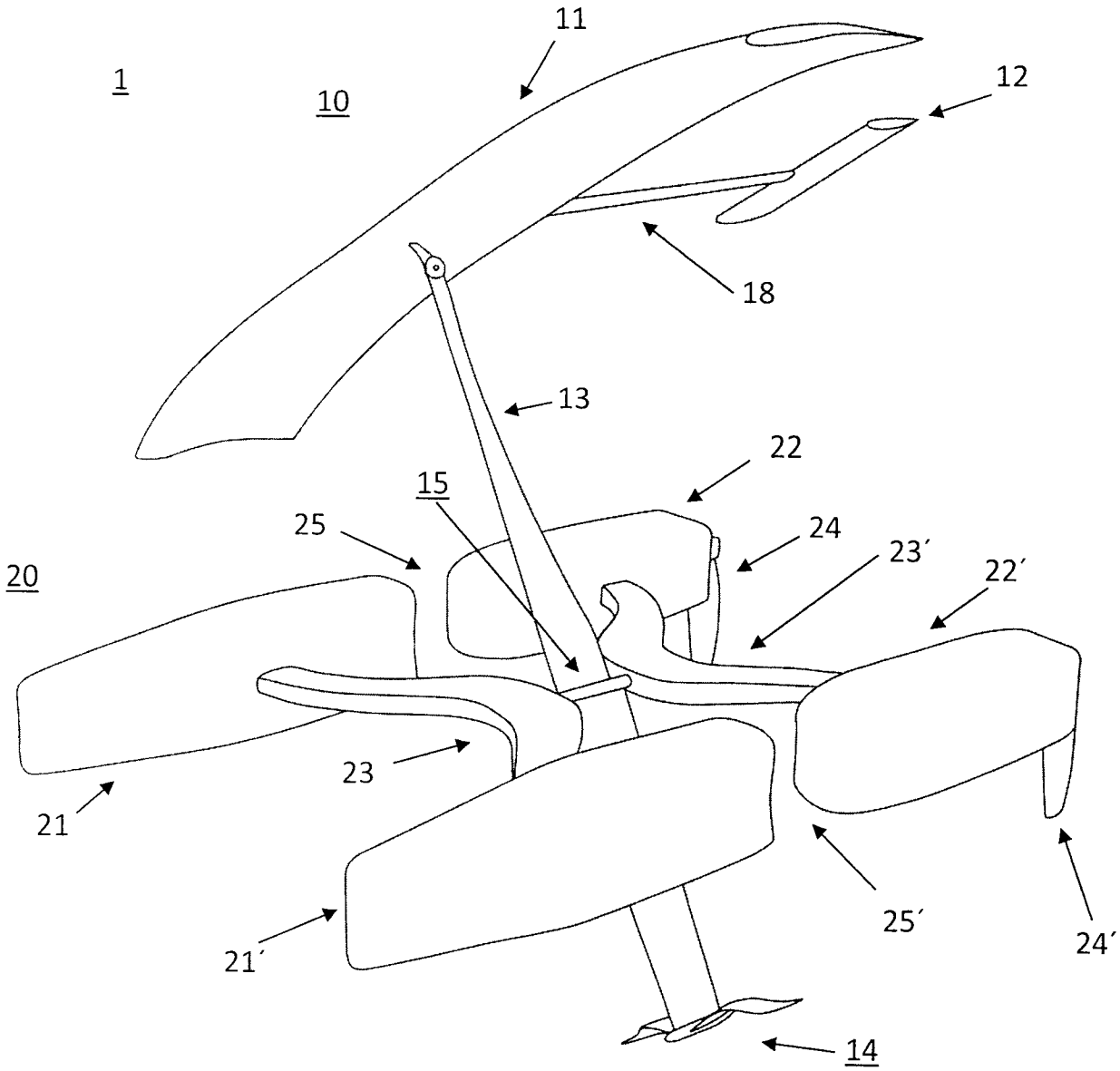


Fig. 1

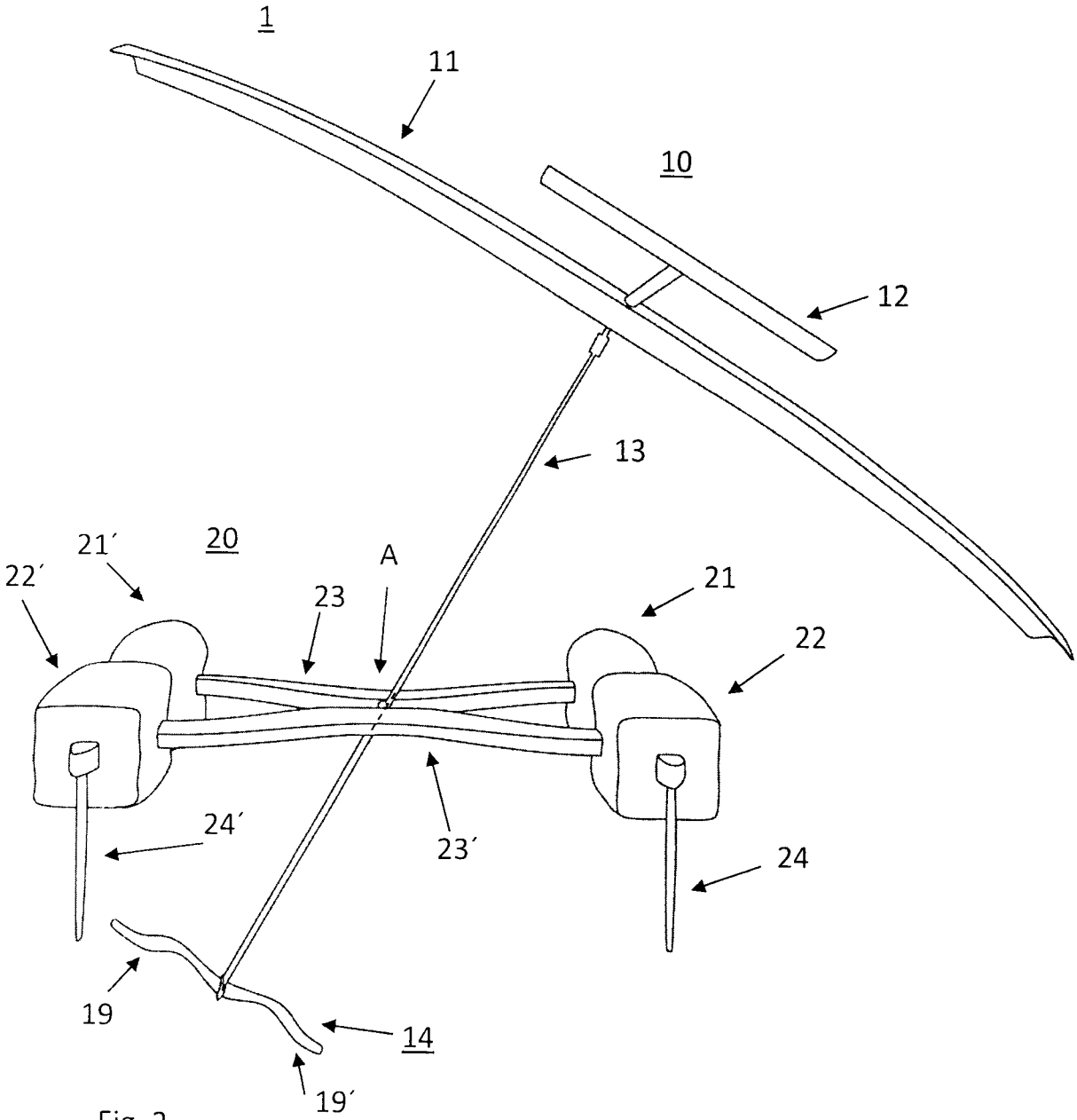
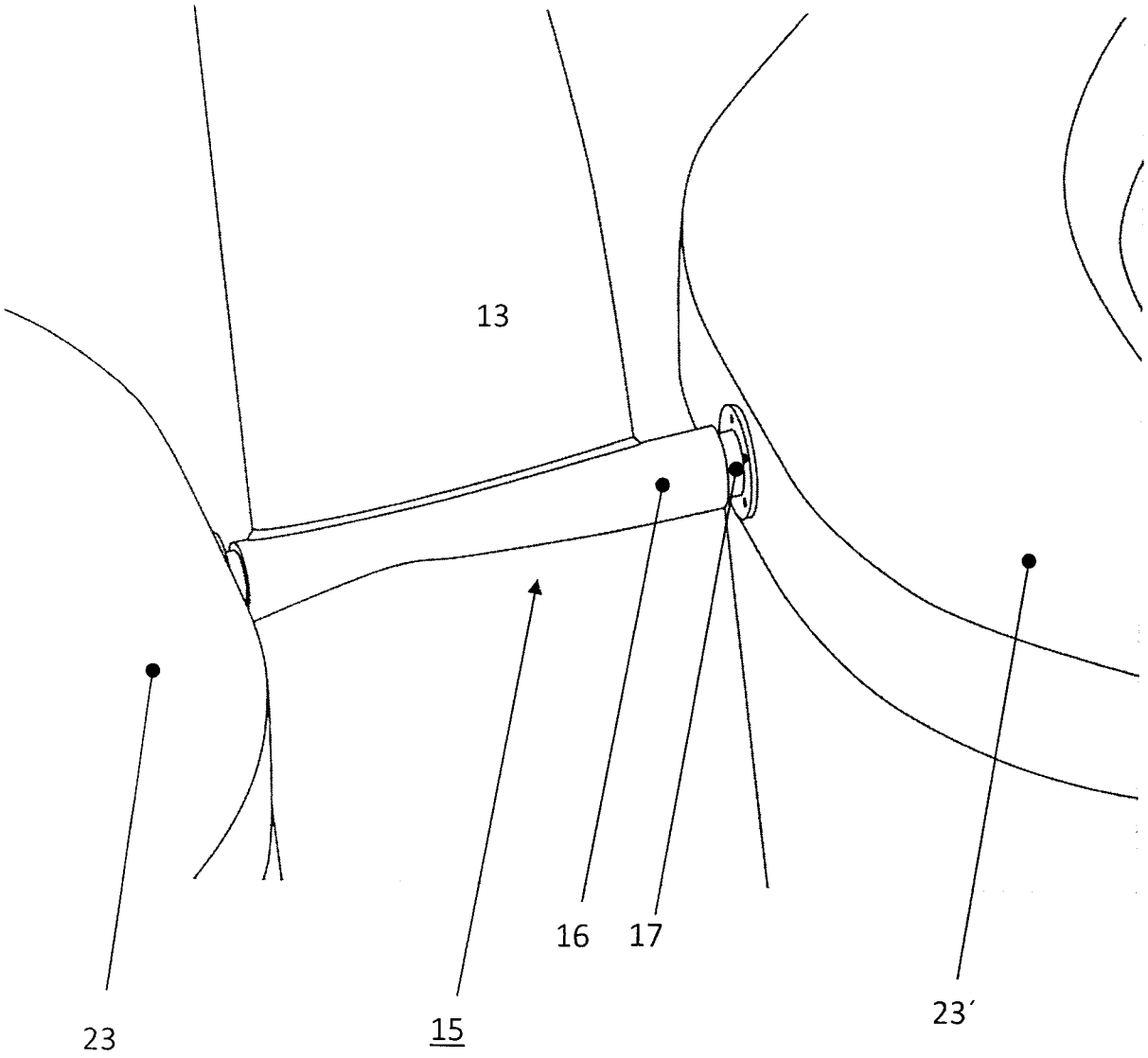


Fig. 2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23
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23´

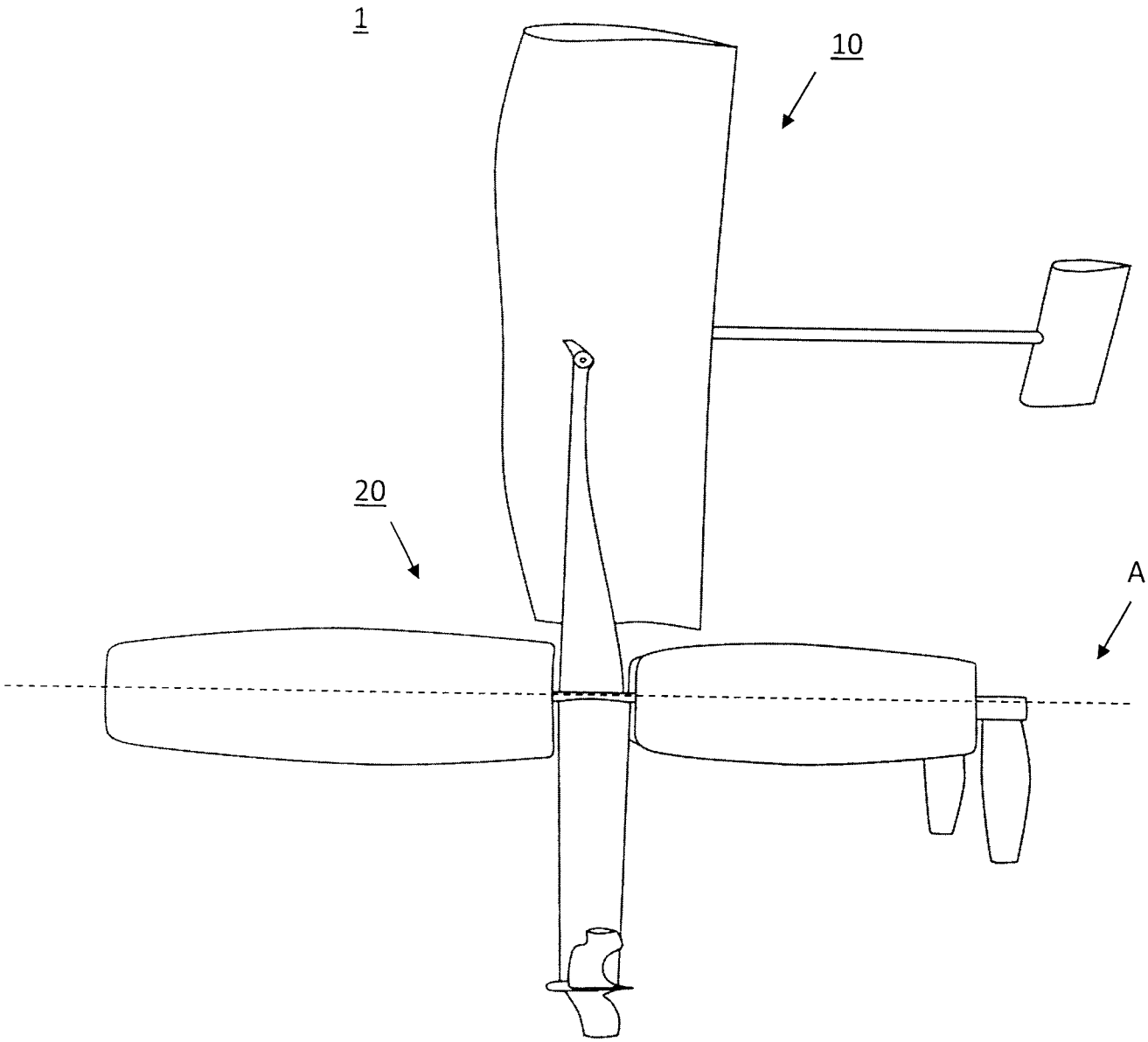

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2014/000066

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20140116311 A1 (HOLEMANS WALTER), 1 May 2014 (2014-05-01); whole document --	1-15
A	WO 2005012079 A1 (SOLAR SAILOR PTY LTD ET AL), 10 February 2005 (2005-02-10); whole document --	1-15
A	US 6789489 B1 (PHIPPS JEFFREY S), 14 September 2004 (2004-09-14); whole document --	1-15
A	US 20030121462 A1 (RAYNER WILLIAM RICHARDS), 3 July 2003 (2003-07-03); whole document --	1-15

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11-02-2015	11-02-2015
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INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 8702320 A1 (PETROVICH ENRIQUE G), 23 April 1987 (1987-04-23); whole document --	1-15
A	FR 2689482 A1 (HUYGHUES DESPOINTES HUBERT -(B1) HUYGHUES DESPOINTES HUBERT), 8 October 1993 (1993-10-08); whole document -- --------	1-15

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B63B 1/12 (2006.01)
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B63B 43/02 (2006.01)

US	20140116311	A1	01/05/2014	WO	2014153299	A1	25/09/2014
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				NO	20060334	A	27/04/2006
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