



(11) **EP 2 452 870 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**16.05.2012 Bulletin 2012/20**

(51) Int Cl.:  
**B63B 39/06 (2006.01)**

(21) Application number: **11181881.1**

(22) Date of filing: **19.09.2011**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**

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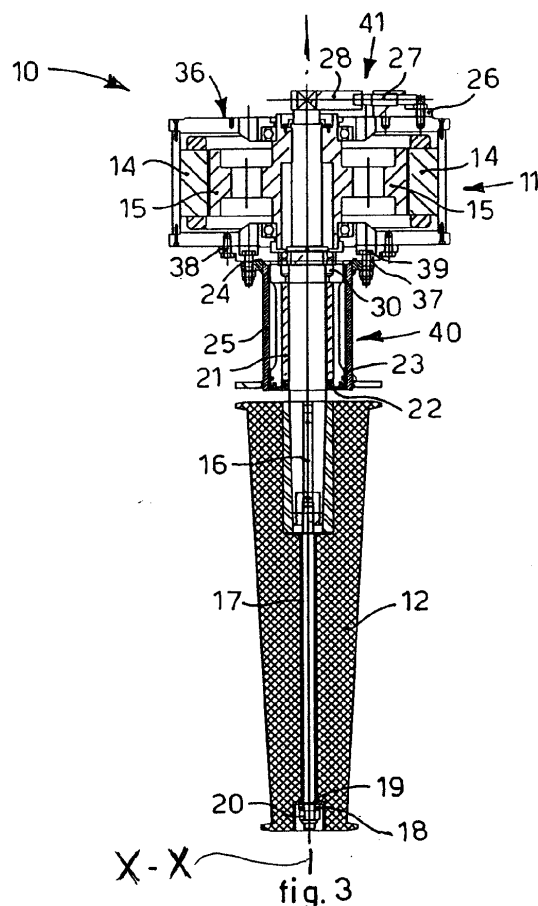
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(30) Priority: **17.09.2010 IT MI20101688**

(54) **Device for watercrafts**

(57) A watercraft comprises a stabilizing unit (10) having a stabilizing appendage (12) located below the water line of the watercraft, actuator means (40), at least partially located within the watercraft and connected to the stabilizing appendage (12) to transfer a rotary motion thereto, about a longitudinal axis (X-X) substantially perpendicular to the watercraft hull, and an electric motor (11). Advantageously, said electric motor (11) is a torque motor (11) which is directly and operatively connected to actuator means (40) to cause movement thereof, and hence movement of the connected stabilizing appendage (12) about the longitudinal axis (X-X).



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## Description

**[0001]** The present invention relates to a stabilizing unit for a watercraft, comprising a stabilizing appendage located below the water line of the watercraft.

**[0002]** More particularly, the present invention relates to a stabilizing unit for stabilizing the trim of a stationary or moving watercraft, mainly for lateral trim stabilization, to reduce rolling, i.e. the oscillating motion of the watercraft about its longitudinal axis.

**[0003]** While the watercraft stabilizing unit of the present invention is also used for controlling bearing appendages of the watercraft, such as flaps for longitudinal trim control, reference will be made hereinafter, for simplicity, to watercraft lateral trim stabilizing appendages (i.e. stabilizing fins). Watercrafts are known to be normally subjected to a movement about their longitudinal axis, known as rolling, caused by current, wave action, wind, or else, both when navigating and when lying at anchor. Stabilizer devices or elements are known for controlling watercraft lateral trim, which comprise a wing surface, commonly known as fin, generally located below the hull at the longitudinal position of the center of gravity thereof.

**[0004]** The fin may be rotated about a longitudinal axis perpendicular to the surface of the watercraft hull. By changing the angle of attack of the fin relative to the incident water flow, a variable lift is generated, which counteracts rolling and hence controls the lateral trim of the watercraft.

**[0005]** The fin is generally connected through a shaft to an actuator which is located within a rudder hole formed in the hull, which rotates such shaft and thus causes the rotation of the fin and hence changes the angle of attack and the lift.

**[0006]** Such actuator is typically operated through a hydraulic circuit comprising a reservoir, one or more pumps, control valves and a pair of hydraulic cylinders.

**[0007]** These prior art devices have a first drawback associated with the size of the hydraulic circuit.

**[0008]** The drawbacks caused by the size of the hydraulic circuit are even worse in case of large watercrafts whose stabilization requires the use of one or more pairs of fins.

**[0009]** Furthermore, these prior art devices have expensive components, and require complex commissioning procedures and very frequent maintenance.

**[0010]** A further drawback of these prior art devices is the risk of oil leakage from the circuit, causing marine pollution.

**[0011]** A second type of lateral trim control devices for watercrafts is known, in which the fin is actuated by an motor coupled to an epicyclic reduction gear, with a crown wheel and pinion for 90° power transmission, or by an motor coupled to a parallel-axes gear.

**[0012]** Such prior art devices have drawbacks associated with the complexity and response times of the gear. The operation of these devices involves some delay and unavoidable clearance in control transmission to actua-

tors, and hence impaired fin movement accuracy. It shall be further noted that this second type of prior art devices is poorly reliable in the long term, due to the wear of gear teeth. The intermittent motion of the fin within a small oscillation angle allows only some of the gear teeth to exert a meshing action, thereby causing early wear thereof.

**[0013]** The problem to be solved by the present invention is to provide a device for controlling a stabilizing appendage for a watercraft, that is light, compact, simple to install and reliable, in which the motor members are always easily accessible for any maintenance or replacement requirement, and are not subjected to stresses that can affect their proper operation with time, while obviating the above mentioned drawbacks of the prior art.

**[0014]** This problem is solved by a stabilizing unit for a watercraft as defined in claim 1.

**[0015]** In another aspect, the problem is solved by a watercraft as defined in claim 10.

**[0016]** Further features and advantages of the stabilizing unit for a watercraft of the present invention will result from the following description of one preferred embodiment thereof, which is given by way of illustration and without limitation with reference to the accompanying figures, in which:

- Figure 1 is a front view of a stabilizing unit for lateral trim control in a watercraft according to the present invention;
- Figure 2 is a top view of the stabilizing unit of Figure 1;
- Figure 3 is a sectional view as taken along the line III-III of Figure 2;
- Figure 4 is a top view of a variant of the stabilizing unit of Figure 1;
- Figure 5 is a perspective view of a variant of the stabilizing unit of Figure 1;
- Figure 6 is a front view of the stabilizing unit of Fig. 5.

**[0017]** Referring to the accompanying figures, numeral 10 generally designates a stabilizing unit of the present invention, which is used to control the lateral trim of a watercraft.

**[0018]** For simplicity, the drawings do not depict the prior art watercraft, but only a rudder hole 25 (see Figure 3).

**[0019]** Particularly referring to Figures 1 to 3, the stabilizing unit 10 comprises a support assembly 29 mounted in the rudder hole 25, a motor unit 11 installed in the watercraft at the upper part of the support assembly 29, an airfoil stabilizer fin 12, namely made of glass-reinforced plastic, located outside the watercraft, actuator means 40, operatively connected to the motor unit 11, and extending from the interior to the exterior of the watercraft to connect the motor unit 11 to the stabilizer fin 12, and a locking unit 41 located adjacent the motor unit 11 opposite to the stabilizer fin 12.

**[0020]** Namely, the support assembly 29 comprises an annular element 37 having a plurality of first holes and a

plurality of second holes, not shown, around its circumference.

**[0021]** The first holes are used to fix the annular element 37 to the motor unit 11 by screws 38, whereas the second holes are used to fix the annular element 37 to the rudder hole 25 by bolts 39.

**[0022]** The motor unit 11 comprises a stator 14 and a rotor 15, which are installed in a housing case 36, appropriately shaped to be mounted to the support assembly 29 by means of the screws 38.

**[0023]** The electric motor is a synchronous torque motor (TORQUE MOTOR) with a large number of poles of pulse-controlled stepper type and operated by inverter. This motor is a three-phase alternating-current electric motor.

**[0024]** The use of this electric motor is particularly advantageous in this type of application, in which the stabilizer fin 12 is not required to be rotated at high speed, but at low speed, e.g. not faster than 70 revolutions/minute, preferably not faster than 40 revolutions/minute. The low rpm of the above mentioned electric motor can avoid the presence of a mechanical rpm reducer interposed in the kinematic chain for transferring motion from the rotor 15 of the electric motor to the stabilizer fin 12, thereby avoiding the above mentioned prior art problems. Furthermore, it shall be noted that such electric motor can be operated by energizing its windings with appropriate pulses not only to rotate the rotor 15, but also to transfer a sufficient torque thereto, to counteract a retrograde motion transferred to the rotor 15 by the stabilizer fin 12 due to the lift generated by the water flow impinging on the stabilizer fin.

**[0025]** The actuator means 40 comprise an actuator shaft 13, which is directly axially coupled to the rotor 15, and is rotated by it.

**[0026]** Preferably, the actuator shaft 13 has a first end that forms, i.e. directly defines the rotor 15 of the electric motor and a second end that is integrally and rotatably coupled to the stabilizer fin 12 to rotate it about said longitudinal axis X-X of rotation, the actuator shaft 13 extending parallel and as an extension of the longitudinal axis X-X of rotation.

**[0027]** According to a different embodiment, the actuator shaft has a first end integrally and rotatably coupled, e.g. by flanged connection, to the rotor of the electric motor and a second end integrally and rotatably coupled to the stabilizer fin to rotate it about the longitudinal axis of rotation, the actuator shaft extending parallel and as an extension of the longitudinal axis X-X of rotation.

**[0028]** The actuator means further include a bearing 30 and a bush 21, which are disposed coaxial with the actuator shaft 13 in the area within the rudder hole 25. The bearing 30 and the bush 21 absorb the stresses applied by the loads generated by the stabilizer fin 12 and transferred to the actuator shaft 13, thereby assisting rotation thereof.

**[0029]** Namely, the bush 21 is made of bronze. However, it can be also made of another metal material, provided

it can withstand the above mentioned stresses. According to a variant, first and second bearings are used to absorb the stresses generated by the stabilizer fin 12, which bearings are mounted to the upper surface and the lower surface of the annular element 37 respectively.

**[0030]** According to a variant embodiment, an elastic joint may be interposed between the rotor 15 and the actuator shaft 13 or the stabilizer fin 12, for reducing the dynamic stresses transferred to the torque electric motor and allow the use of a larger fin with the same power of the installed electric motor.

**[0031]** The stabilizing unit of the invention comprises encoder detection means associated with the actuator means 40 to detect the angular position of the stabilizer fin 12 relative to the longitudinal axis X-X of rotation, thereby allowing accurate determination of its position.

**[0032]** To avoid water infiltration into the rudder hole 25, which might damage the actuator shaft 13, and water infiltration into the watercraft, which might also affect the operation of the motor unit 11, two gaskets 22 and an O-ring seal 23 are provided at the lower portion of the rudder hole 24, and an O-ring seal 24 is provided at the contact portion between the annular element 37 and the rudder hole 25.

**[0033]** The stabilizer fin 12 is coupled to the lower end portion of the actuator shaft 13 by a conical coupling.

**[0034]** To ensure coupling between the stabilizer fin 12 and the actuator shaft 13, fastening means are provided, which comprise a tie rod 17, cooperating between the lower edge of the actuator shaft 13 and the base of the stabilizer fin 12, and a key 16, which extends from the lower portion of the actuator shaft 13 to the base of the stabilizer fin 12 and is fastened thereto by a washer 19, a spring washer 18 and a self-locking nut 20.

**[0035]** Advantageously, the watercraft comprises:

- sensor means for providing a signal indicative of the angular position of the watercraft, the rolling speed and acceleration and
- a microprocessor-based processing and control unit for processing the signals received from the sensors and generating a signal adapted to control the electric motor for suitable angular positioning of the stabilizer fin 12 to change the lift generated by the water flow impinging on the stabilizer fin 12 to counteract the rolling motion of the watercraft. Therefore, when the watercraft requires stabilization, the electric motor unit 11 is actuated by the above mentioned microprocessor-based processing and control unit, and rotates the actuator shaft 13. As mentioned above, the electric motor is pulse-controlled by an inverter.

**[0036]** The rotation of the actuator shaft 13 moves the stabilizer fin 12, thereby changing the angle between the latter and the impinging flow and generating, as a result, a lift that counteracts the rolling motion of the moving or stationary watercraft.

[0037] The rotor of the torque motor is appropriately sized to ensure the torque required for rotation of the stabilizing appendage.

[0038] Since the torque motor directly transfers the power it produces to the actuator means, with no transmission unit interposed therebetween, the stabilizing unit of the present invention affords both dramatically shorter response times as compared with those of an epicyclic reduction gear and a considerably improved accuracy in airfoil control due to the elimination of any clearance.

[0039] Furthermore, as compared with prior art devices, the stabilizing unit of the present invention has a light weight, a compact size, simple installation and low cost.

[0040] Also, the stabilizing unit of the present invention is more reliable than prior art devices, as it has a smaller number of parts susceptible to wear and breaking.

[0041] Since the stabilizing unit of the invention uses no contaminating fluid element, such as the oil of hydraulic devices, it involves no risk for the marine environment.

[0042] Due to its simple installation and adaptability to the most widely used control systems, the stabilizing unit can be easily installed on watercrafts both on and off the stocks and is easily accessible for maintenance and/or replacement.

[0043] Furthermore, commissioning according to the present invention is considerably simpler than in prior art devices, as it requires no flow regulation or other operations required by the use of hydraulic components.

[0044] Those skilled in the art will obviously appreciate that a number of changes and variants may be made to the above stabilizing unit, still within the scope of the invention, as defined in the following claims.

[0045] For example, Figures 5 and 6 show a variant of the stabilizing unit 10 in which:

- the watercraft hull comprises a housing 101 for receiving and holding the stabilizer fin 12,
- the stabilizing appendage 12 is movable relative to the watercraft hull from a forward operating position, in which the stabilizing appendage 12 projects of the hull surface to carry out its watercraft stabilizing task, to a retracted position, in which the stabilizer fin 12 is at least partially, preferably wholly retracted in the housing 101 of the watercraft hull;
- the watercraft comprises a drive unit 102 associated with the stabilizing fin 12 through said actuator means 40 to move the stabilizing fin 12 from the forward operating position to the retracted position and vice versa.

[0046] The drive unit 102 comprises a piston 103 connected to a slider-crank assembly 104 which rotates the shaft 105 pivoted on the stabilizer fin 12 at the above mentioned transverse axis.

## Claims

1. A stabilizing unit for a watercraft comprising:

- a stabilizing appendage (12) which is supported to rotate about a longitudinal axis (X-X), said stabilizing appendage (12) having at least one portion designed to project of the hull of said watercraft below the water line, with said longitudinal axis (X-X) substantially perpendicular to the surface of the watercraft hull,
- actuator means (40) being designed to be at least partially housed within said watercraft and being connected to said stabilizing appendage (12) to rotate said stabilizing appendage (12) about said longitudinal axis (X-X),

**characterized in that** it comprises a synchronous electric torque motor (TORQUE MOTOR) with a large number of poles of pulse-controlled stepper type, said torque motor comprising a stator (14) and a rotor (15) and being housed in the hull of said watercraft, wherein said rotor (15) is directly and operatively connected to said actuator means (40) to rotatably actuate them and cause rotation of said stabilizing appendage (12) about said longitudinal axis (X-X).

2. A stabilizing unit as claimed in claim 1, wherein said torque motor is a three-phase alternating-current electric motor.

3. A stabilizing unit as claimed in claim 1 or 2, **characterized in that** the actuator means (40) comprise an actuator shaft (13) having a first end that constitutes the rotor (15) of said torque motor and a second end that is integrally and rotatably coupled to the stabilizing appendage (12) to rotate it about said longitudinal axis (X-X), wherein said actuator shaft (13) extends parallel to said longitudinal axis (X-X).

4. A stabilizing unit as claimed in claim 1 or 2, **characterized in that** the actuator means comprise an actuator shaft having a first end integrally and rotatably coupled to said rotor and a second end integrally and rotatably coupled to the stabilizing appendage to rotate it about said longitudinal axis, wherein said actuator shaft and said rotor extend parallel to said longitudinal axis.

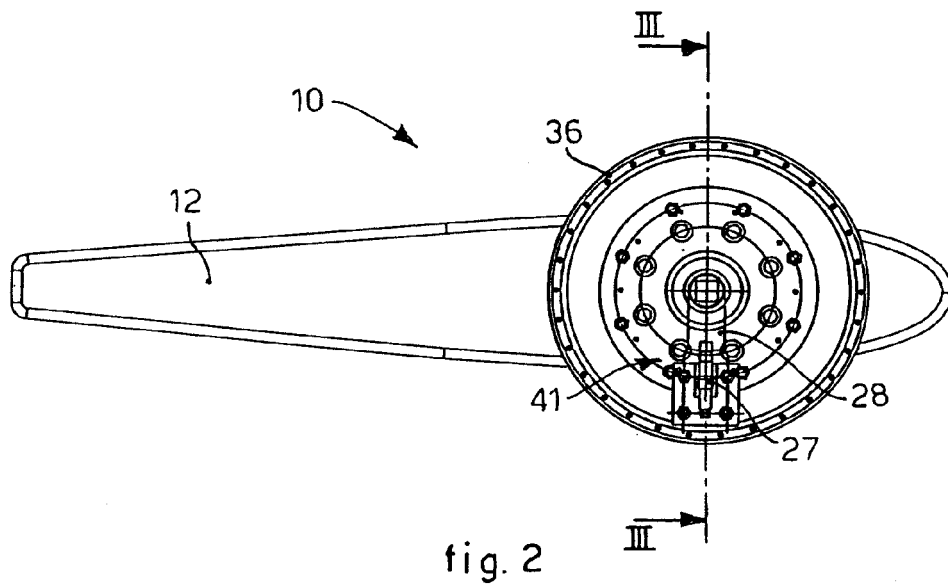
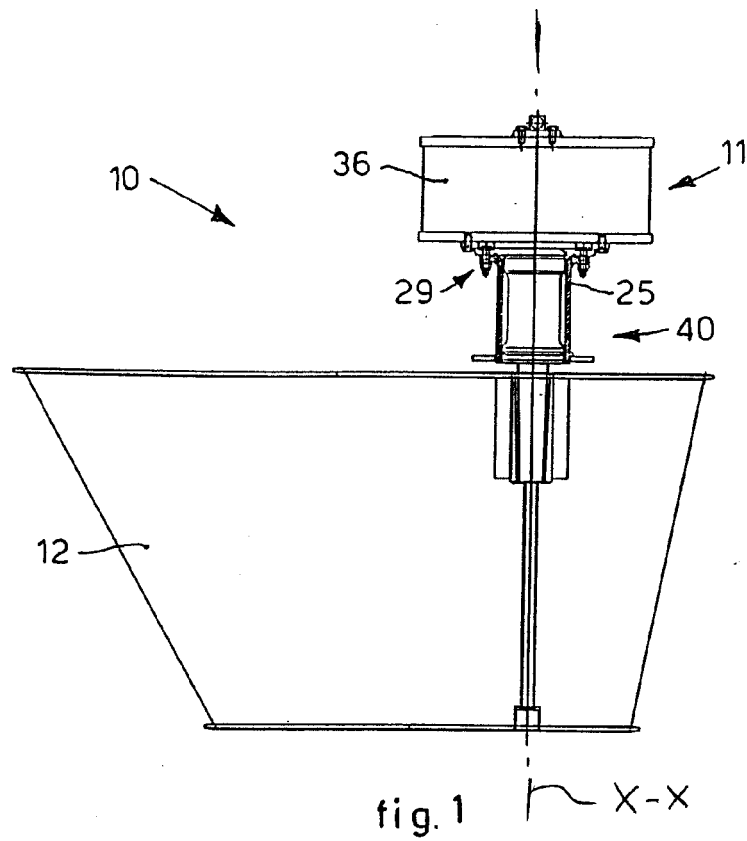
5. A stabilizing unit as claimed in claim 3 or 4, **characterized in that** it comprises an elastic joint interposed between the rotor and the stabilizing appendage.

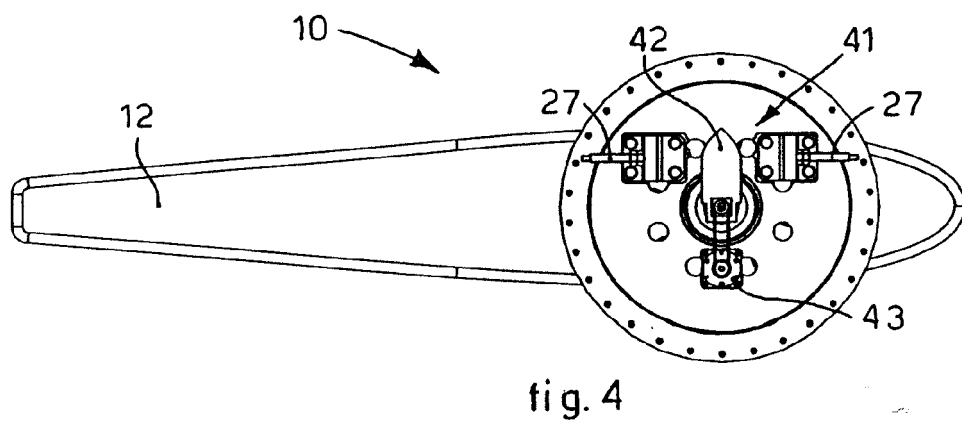
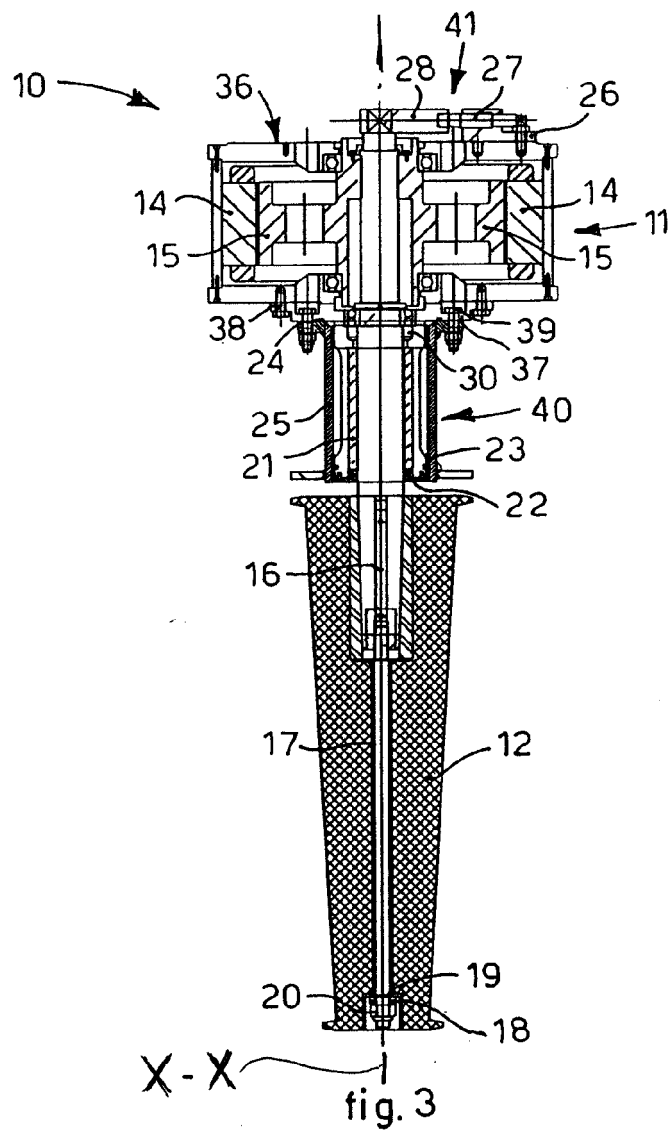
6. A stabilizing unit as claimed in claim 3 or 4, **characterized in that** said actuator shaft (13) extends as a prolongation of said longitudinal axis (X-X) of ro-

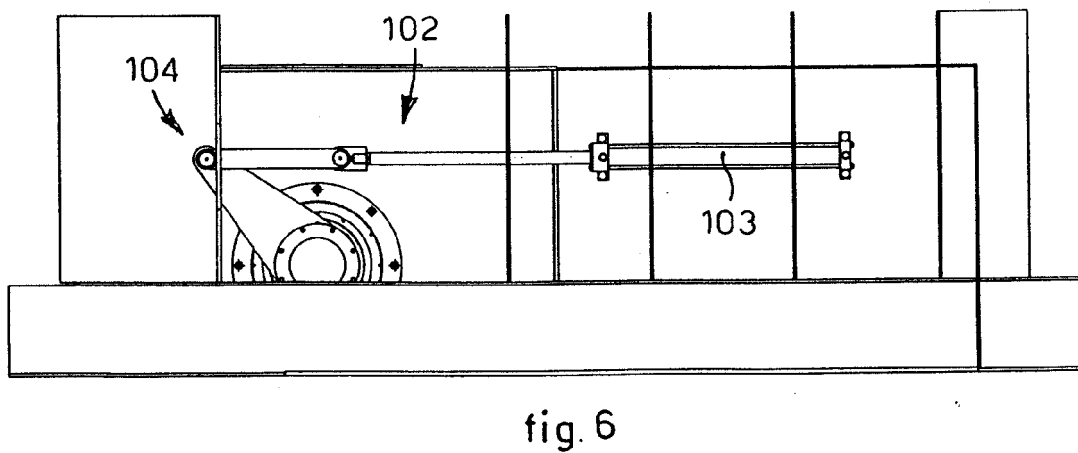
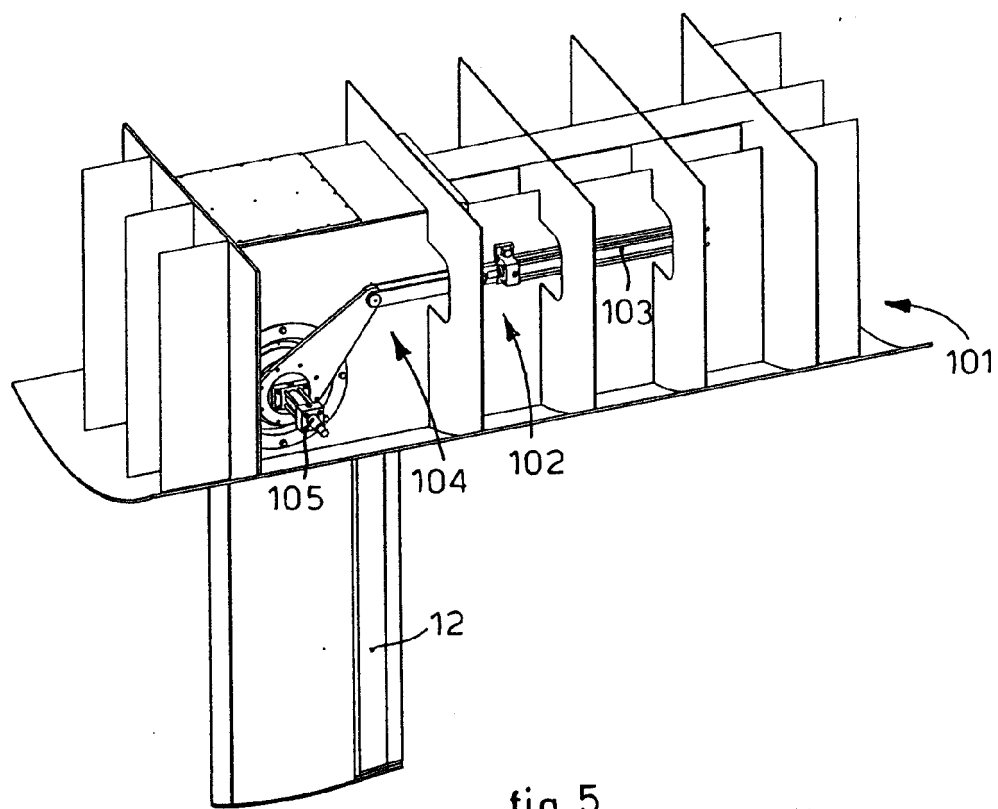
tation.

7. A stabilizing unit as claimed in any claim from 1 to 6, **characterized in that** said electric motor is operated by an inverter. 5
8. A stabilizing unit as claimed in any claim from 1 to 7, **characterized in that** it comprises a locking unit (41) associated with said actuator means (40) to lock the rotation of said actuator means (40) in a preset position. 10
9. A stabilizing unit as claimed in any claim from 1 to 8, **characterized in that** it comprises encoder detection means associated with said actuator means (40) to detect the angular position of said stabilizing appendage (12) relative to the longitudinal axis (X-X) of rotation. 15
10. A stabilizing unit as claimed in any claim from 1 to 9, **characterized in that** it comprises auxiliary drive means connected to said actuator means (40) for manually moving said stabilizing appendage (12) in case of failure of said electric motor. 20
11. A watercraft **characterized in that** it comprises a stabilizing unit as claimed in any claim from 1 to 10, having said stabilizing appendage (12) projecting of the hull and said electric motor housed within the hull of said watercraft. 25 30
12. A watercraft as claimed in claim 11, wherein:
  - the watercraft hull comprises a housing (101) for receiving said stabilizing appendage (12), 35
  - said stabilizing appendage (12) is movable relative to said watercraft hull from a forward operating position, in which said stabilizing appendage (12) projects of the hull surface to carry out a watercraft stabilizing task, to a retracted position, in which said stabilizing appendage (12) is at least partially, preferably wholly retracted in said housing (101) of the watercraft hull; 40
  - said watercraft comprises a drive unit (102) associated with said stabilizing appendage (12) through said actuator means (40) to move said stabilizing appendage (12) from said forward operating position to said retracted position and vice versa. 45
13. A watercraft as claimed in claim 11 or 12, wherein said stabilizing appendage (12) is at least partially formed on a stabilizer element for control of the lateral and/or longitudinal trim of the watercraft hull. 50
14. A watercraft as claimed in claim from 10 to 13, **characterized in that** it comprises: 55

- sensor means for providing a signal indicative of the angular position of the watercraft, the rolling speed and acceleration and
- a microprocessor-based processing and control unit for processing the signals received from said sensors and generating a signal adapted to control said electric motor for suitable angular positioning of said stabilizing appendage (12) to change the lift generated by the water flow impinging on said stabilizing appendage (12) to counteract the rolling motion of the watercraft.









## EUROPEAN SEARCH REPORT

Application Number  
EP 11 18 1881

| 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                                                                                                                                                                                                                                                      | EP 2 172 394 A1 (CMC MARINE S R L [IT])<br>7 April 2010 (2010-04-07)                                                                             | 1,2,7,9,<br>11,13,14                                                                                                                                                                                                                                                                  | INV.<br>B63B39/06                          |
| Y                                                                                                                                                                                                                                                      | * paragraphs [0001], [0013], [0015],                                                                                                             | 10,12                                                                                                                                                                                                                                                                                 |                                            |
| A                                                                                                                                                                                                                                                      | [0017], [0019] - [0024], [0026] *<br>* abstract *<br>* claims 1-3,5 *<br>* figures 1,2 *                                                         | 3,4                                                                                                                                                                                                                                                                                   |                                            |
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| A                                                                                                                                                                                                                                                      | * page 1, lines 10-33,66-90 *<br>* page 2, lines 1-11,27-40,75-130 *<br>* figures 1-3 *                                                          | 1                                                                                                                                                                                                                                                                                     |                                            |
| A                                                                                                                                                                                                                                                      | -----<br>GB 802 105 A (WERFT AG DEUTSCHE)<br>1 October 1958 (1958-10-01)                                                                         | 1                                                                                                                                                                                                                                                                                     |                                            |
|                                                                                                                                                                                                                                                        | * page 1, lines 9-15,63-66 *<br>* page 2, lines 1-7,65-71,104-117 *<br>* page 3, line 40 - page 4, line 69 *<br>* abstract *<br>* figures 1-10 * |                                                                                                                                                                                                                                                                                       |                                            |
|                                                                                                                                                                                                                                                        | -----                                                                                                                                            |                                                                                                                                                                                                                                                                                       |                                            |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                  |                                                                                                                                                                                                                                                                                       | TECHNICAL FIELDS<br>SEARCHED (IPC)<br>B63B |
| Place of search<br>The Hague                                                                                                                                                                                                                           |                                                                                                                                                  | Date of completion of the search<br>24 January 2012                                                                                                                                                                                                                                   | Examiner<br>Blazquez Lainez, R             |
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