(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 040 262 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.07.2016 Bulletin 2016/27

(21) Application number: **15203065.6**

(22) Date of filing: **30.12.2015**

(51) Int Cl.:
B63H 25/02 *(2006.01)* ***B63H 25/06*** *(2006.01)*
B63H 25/38 *(2006.01)* ***G05B 11/00*** *(2006.01)*
G05B 13/00 *(2006.01)* ***G05D 1/02*** *(2006.01)*

(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
Designated Validation States:
MA MD

(30) Priority: **30.12.2014 IT RM20140762**

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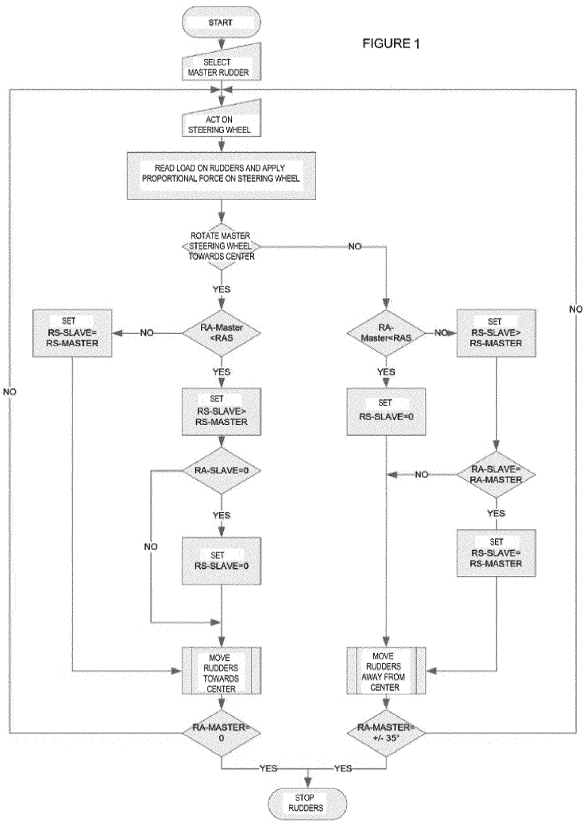
(54) METHOD FOR CONTROLLING VESSEL RUDDERS

(57) An electronic control method for controlling at least two rudders of a vessel during navigation, the method using a control system and comprising the following steps:

- selecting a first rudder as master rudder and at least a second rudder as slave rudder from said at least two rudders;
- as the steering wheel rotates, if a first angle (RA-MASTER) defined between the master rudder and a longitudinal symmetry plane is either higher than or equal to a predetermined threshold angle (RAS), the control system controls a synchronization of the angular speed of the slave rudder with the angular speed of the master rudder, otherwise if said first angle (RA-MASTER) is smaller than said predetermined threshold angle (RAS), the angular speed of the slave rudder is different from the angular speed of the master rudder.

FIGURE 1



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Description

Field of the invention

[0001] The present invention relates to an electronic control method of at least two rudders of a vessel, e.g. a sailboat with two rudders.

Background art

[0002] Vessels or boats, such as sailboats, are often provided with two rudders. This technical solution is mainly due to the need to comply with the construction constraints imposed by the market while ensuring good performance of the boat. Indeed, the rudder has a substantially flat, adjustable leg of the boat, named rudder blade, adapted to offer a given surface under the water level so as to steer the boat. The greater the rudder surface extension, in particular the depth under sea level, the greater will be the steering capacity of the boat when the rudder is directed. However, for marketing reasons, it is not always possible to build boats with the rudder protruding too far deep, because this would make it impossible for the boat to access shallow waters. Therefore, the solution with two rudders having the same shape and size allows to make boats in which the depth of each rudder is less than the depth which would be required for a single rudder while ensuring good steering performance of the boat. In such a solution, the rudders are directed by the user acting on a wheel, referred to as steering wheel. When the user acts on the steering wheel, the two rudders move at the same angular speed, thus being simultaneously directed so that they are always parallel to each other. Boats are often provided with two steering wheels. In this case, the user may act on either the first or the second steering wheel, and the two rudders are, as in the previous case, always directed so as to be parallel to each other. The mechanism which allows the rudders to be directed or rotated, typically requires that each rudder is provided with a respective gear, referred to as steering gear, or steering machine. These gears are electronically and/or mechanically in mutual communication so that the rudders are always parallel to each other. Typically, the rudder surfaces may be rotated with respect to the longitudinal symmetry plane of the hull by a given angle β either in one rotation direction or in the opposite direction. Although the solution of having two rudders which rotate simultaneously, i.e. synchronously at the same speed, and which are maintained always parallel to each other, is convenient from some points of view, it is not free from disadvantages. A disadvantage is that although the rudders directed transversely with respect to the longitudinal symmetry plane of the hull are used to steer the boat, the surface of both rudders thus directed offers a fluid-dynamic resistance which drastically reduces the cruising speed. In particular, the greater the amplitude of angle β, the higher will be the fluid-dynamic resistance offered by the rudders. However, it may occur that in some situations it is actually necessary for both rudders to cooperate to steering the boat in the same manner, but in other situations it could be advantageous for one rudder to offer a smaller surface than the other, thus allowing a lower fluid-dynamic resistance and therefore a faster cruising speed. However, the known technique does not include such a possibility. Such a disadvantage is particularly emphasized for larger-size boats, e.g. sailboats of length equal to or greater than 20 m.

[0003] The need is thus felt to provide a rudder control method which allows to overcome at least the aforesaid drawback.

Summary of the invention

[0004] It is an object of the present invention to provide a method for controlling the rudders of a vessel, in particular a sailboat with two rudders, which allows to operate in a different manner on the rudders in order to steer the boat with better performance than that of the prior art. In particular, the method of the invention allows the boat to be steered in an optimized manner according to given situations which occur during navigation, e.g. during a regatta.

[0005] It is another object of the present invention to provide a method for controlling the rudders of a vessel, in particular of a two rudder sailboat, in which the fluid-dynamic resistance surface offered by the rudders is optimized to steer the boat conveniently while allowing the maximum possible navigation speed.

[0006] The present invention thus achieves the objects discussed above by providing an electronic control method for controlling at least two rudders of a vessel during navigation, in particular a sailboat with two rudders, which according to claim 1, comprises the following steps:

- selecting a first rudder as master rudder and at least a second rudder as slave rudder from said at least two rudders;
- as the master rudder rotates, if a first angle RA-MASTER defined between the master rudder and a longitudinal symmetry plane of the hull of the boat is either higher than or equal to a predetermined threshold angle RAS, a control system starts a synchronization procedure of the angular speed of the slave rudder with the angular speed of the master rudder, otherwise if said first angle RA-MASTER is smaller than said predetermined threshold angle RAS, the angular speed of the slave rudder is different from the angular speed of the master rudder.

[0007] The present invention is particularly adapted to control double rudder vessels allowing to operate in a different manner on the rudder angle, depending on an operative condition pre-selection, i.e. master/slave, of the rudders made manually by the commanding user.

[0008] The control method of the invention is particularly adapted to be implemented on boats the rudders of which are provided with independent, electrically-assisted hydraulic actuation systems, thus not connected by means of mechanical bar or other equivalent device.

[0009] The method of the invention may be implemented on sailboats of length equal to or greater than 20 m, e.g. 50 or 60 m.

[0010] This versatility has many advantages because in all conditions the rudders can be maneuvered in the best possible manner according to the condition itself.

[0011] The invention advantageously allows the two rudders to be directed, in given conditions, so that they are not parallel to each other. For example, the two rudders may have a mutual direction, or orientation, difference from 0 to 20°.

[0012] The invention includes selecting a first rudder as main rudder or master rudder.

[0013] After having selected the master rudder, the second rudder is automatically set as secondary rudder or slave rudder. The invention further includes setting a threshold angle, preferably correlated to the master rudder, with respect to the longitudinal symmetry plane of the vessel. The threshold angle can be from 2° to 20°, preferably from 4° to 15° or from 5° to 12°, e.g. 10°.

[0014] In some cases, the master and slave rudders can advantageously rotate at the same angular speed, while in other cases they rotate at a mutually different angular speed. In particular, the angular speed of the master rudder can be higher than, equal to or lower than the angular speed of the slave rudder. The angular speed of each rudder is typically adjusted according to the method of the invention based on the rotation angle of the master rudder and on the threshold angle.

[0015] The dependent claims describe preferred embodiments of the invention.

Brief description of the drawings

[0016] Further features and advantages of the invention will become more apparent in the light of the detailed description of a preferred, but not exclusive, embodiment of a control method shown by way of non-limitative example, with the aid of the accompanying drawings, in which Fig. 1 is a flow chart of an embodiment of the method according to the invention.

Detailed description of a preferred embodiment of the invention

[0017] Referring to figure 1, an embodiment of a method for controlling at least two rudders of a vessel during navigation is shown.

[0018] In a preferred variant, the control method refers to a vessel, in particular to a sailboat, with only two rudders, for controlling the rudders during a regatta.

[0019] According to such an embodiment of the invention, the user selects a first rudder as main rudder or master rudder and a predetermined threshold angle, referred to the master rudder. The second rudder is automatically set as secondary rudder or slave rudder by the control system. The downwind rudder is preferably chosen as master rudder.

[0020] The electronic control is performed by means of a control system provided, for example, with a programmable logic controller (PLC) with a cycle frequency higher than 1 Hz. The programmable logic controller starts a check cycle as shown in Fig. 1 and described in detail below.

[0021] In general, after having selected the master rudder, such a check cycle includes that:

- as the master rudder rotates, if a first angle RA-MASTER (Master Rudder Angle), defined between the master rudder and the longitudinal symmetry plane of the hull of the vessel, is either higher than or equal to a predetermined threshold angle RAS (Rudder Angle Set-point), the control system starts a synchronization procedure of the angular speed of the slave rudder with the angular speed of the master rudder,
- otherwise if said first angle RA-MASTER is smaller than said predetermined threshold angle RAS, the angular speed of the slave rudder is different from the angular speed of the master rudder.

[0022] Said threshold angle is preferably chosen in the range 2°≤RAS≤20°, e.g. 4°≤RAS≤15°.

[0023] If the first angle RA-MASTER is smaller than the threshold angle RAS, the control system controls the setting of the angular speed of the slave rudder to zero.

[0024] With reference to the rudders, "center" is defined as the position of the rudder parallel to the longitudinal symmetry plane of the hull, i.e. the position in which the angle defined between the rudder, in particular the blade of the rudder, and the longitudinal symmetry plane of the hull is 0°.

[0025] More in detail, the cycle includes that if the master rudder is rotated far, or away, from the center and if the first angle RA-MASTER is either higher than or equal to the predetermined threshold angle RAS, the control system controls a first setting of the angular speed of the slave rudder to a value higher than the angular speed value of the master rudder until the RA-SLAVE=RA-MASTER condition is satisfied, where RA-SLAVE (Slave Rudder Angle) is a second angle defined between the slave rudder and said longitudinal symmetry plane of the hull.

[0026] Thereby, the slave rudder advantageously cooperates, as the rudder master rotates, to steering the boat in an increasing manner. In essence, the slave rudder follows the rudder master. Having satisfied the RA-SLAVE=RA-MASTER condition, the control system controls a second setting of the angular speed of the slave rudder to a value equal to the angular speed value of the master rudder, thus achieving the synchronization of the speed of the two rudders. Continuing the rotation in the same rotation direction, the master rudder, together with the slave rudder, reaches its travel stop angle, e.g. equal to ± 35° with respect to the longitudinal symmetry plane of the hull. Having reached this travel stop angle, the control system locks the rudders in this position until the user decides to rotate the master rudder towards the center. The check cycle is continuously repeated until the travel stop angle is reached. If, although the angular speed of the slave rudder is set to a value higher than the angular speed value of the master rudder, the RA-SLAVE=RA-MASTER is not satisfied, the rudders continue to rotate at a different angular speed until the master rudder reaches its travel stop angle, e.g. equal to ± 35°. This travel stop angle having been reached by the master rudder only, the control system locks the rudders until the user decides to rotate the master rudder towards the center. The check cycle is continuously repeated until the travel stop angle is reached by the master rudder.

[0027] Instead, if the master rudder is rotated away from the center and if the first angle RA-MASTER is smaller than the predetermined threshold angle RAS, the control system directly sets the angular speed of the slave rudder to zero. Continuing the rotation of the master rudder in the same rotation direction, i.e. away from the center, the control system performs the operations described in the preceding paragraph as soon as the first angle RA-MASTER reaches the value of the threshold angle RAS.

[0028] The check cycle also includes that, if the master rudder is rotated towards the center and the first angle RA-MASTER is smaller than the predetermined threshold angle RAS, the control system controls a first setting of the angular speed of the slave rudder to a value higher than the angular speed value of the master rudder until the RA-SLAVE=0° condition is satisfied, i.e. the slave rudder reaches the center, i.e. its position parallel to the longitudinal symmetry plane of the hull. Having satisfied the RA-SLAVE=0° condition, the control system controls a second setting of the angular speed of the slave rudder to a value equal to zero.

[0029] Continuing to rotate in the same rotation direction, i.e. towards the center, the master rudder reaches the position parallel to the longitudinal symmetry plane of the hull, i.e. the 0° position. Having reached this 0° position, the control system locks the rudders until the user decides to rotate the master rudder away from the center. The check cycle is continuously repeated until the master rudder reaches the 0° position. If, although the angular speed of the slave rudder is set to a value higher than the angular speed value of the master rudder, the RA-SLAVE=0° is not satisfied, the rudders continue to rotate at a different angular speed until the master rudder reaches the position parallel to the longitudinal symmetry plane, i.e. the 0° position. Once this 0° position has been reached by the master rudder, the control system locks the rudders until the user decides to rotate the master rudder away from the center. The check cycle is continuously repeated until the master rudder reaches the 0° position.

[0030] If, instead, the master rudder is rotated towards the center and the first angle RA-MASTER is either higher than or equal to the threshold angle RAS, the control system directly controls a setting of the angular speed of the slave rudder to a value equal to the value of the angular speed of the master rudder thus achieving the synchronization of the speeds of the two rudders. Continuing the rotation of the master rudder in the same rotation direction, i.e. towards the center, as soon as the first angle RA-MASTER becomes smaller than the threshold angle RAS, the control system performs the operations described in the preceding paragraph.

[0031] Equivalently, in an alternative check cycle with respect to that described above, the condition concerning the first angle RA-MASTER may consider the following two cases: 1) RA-MASTER higher than the threshold angle RAS, or 2) RA-MASTER either smaller than or equal to the threshold angle RAS. The travel stop angle of the rudders may vary as a function of the type of vessel.

[0032] The control method of the present invention is implemented by means of a control system which interacts with the components of the steering gears, there being a steering gear provided for each rudder. Each steering gear comprises an electrically-assisted, hydraulic actuation system. The rotation of the rudders typically occurs as a consequence of the rotation of the steering wheel. In an exemplary variant, an encoder adapted to detect the angular position of the rudders with respect to the longitudinal symmetry plane of the hull is provided.

[0033] Such an encoder sends a signal to the programmable logic controller (PLC) which, in turn, executes the instructions described above and shown in the flow chart in Fig. 1.

[0034] According to the conditions which occur during the control, the programmable logic controller (PLC) controls the angular speed of the two rudders by adjusting the hydraulic fluid flow in each hydraulic actuation system.

[0035] In particular, a variant includes

- two through-rod, dual-acting cylinders for each rudder, with a pair of cylinders for each rudder and two chambers for each cylinder, and with the through rod connected to an end to the rudder,
- and four proportional valves, each valve managing opposite chambers of a respective pair of cylinders in parallel;

the PLC sends an analog signal to said four proportional valves so as to adjust the flow of hydraulic fluid (oil) in the corresponding hydraulic system, i.e. in the chambers of the two pairs of cylinders, and thus the angular speed of each rudder. Optionally, at each rotation of a steering wheel, the control system reads the load on said at least two rudders and controls the application of a feedback force, which is proportional to said load, on the steering wheel. According to a variant, when the user acts on the steering wheel, e.g. by rotating it in a first rotation direction, a force is automatically applied on the rudder wheel in a second rotation direction opposite to the first direction. The modulus of such a force is proportional to the hydro-dynamic force on the rudder blades. The hydro-dynamic force on the rudders may be detected by means of specific load cells, preferably arranged on a pin integral with the respective rods.

Claims

1. An electronic control method for controlling at least two rudders of a vessel during navigation, the vessel having a hull provided with a longitudinal symmetry plane, the method using a control system and comprising the following steps:

- selecting a first rudder as master rudder and at least a second rudder as slave rudder from said at least two rudders;
- as the master rudder rotates, if a first angle (RA-MASTER) defined between the master rudder and said longitudinal symmetry plane is either higher than or equal to a predetermined threshold angle (RAS), the control system starts a synchronization procedure of the angular speed of the slave rudder with the angular speed of the master rudder, otherwise if said first angle (RA-MASTER) is smaller than said predetermined threshold angle (RAS), the angular speed of the slave rudder is different from the angular speed of the master rudder.

2. A method according to claim 1, wherein the value of said predetermined threshold angle (RAS) is 10°≤RAS≤20°, preferably 10°≤RAS≤15°.

3. A method according to claim 1 or 2, wherein, if said first angle (RA-MASTER) is smaller than said predetermined threshold angle (RAS) the control system controls the setting of the angular speed of the slave rudder to zero.

4. A method according to claim 1 or 2, wherein, if the master rudder is rotated far from a position thereof parallel to said longitudinal symmetry plane and if the first angle (RA-MASTER) is either higher than or equal to the predetermined threshold angle (RAS), the control system controls a first setting of the angular speed of the slave rudder to a value higher than the angular speed value of the master rudder until the RA-SLAVE=RA-MASTER condition is satisfied, wherein RA-SLAVE is a second angle defined between the slave rudder and said longitudinal symmetry plane; having satisfied the RA-SLAVE=RA-MASTER condition, the control system controls a second setting of the angular speed of the slave rudder to a value equal to the angular speed value of the master rudder, thus achieving said synchronization.

5. A method according to claim 1 or 2 or 3, wherein, if the master rudder is rotated far away from a position thereof parallel to said longitudinal symmetry plane and if said first angle (RA-MASTER) is smaller than the predetermined threshold angle (RAS), the control system directly sets the angular speed of the slave rudder to zero.

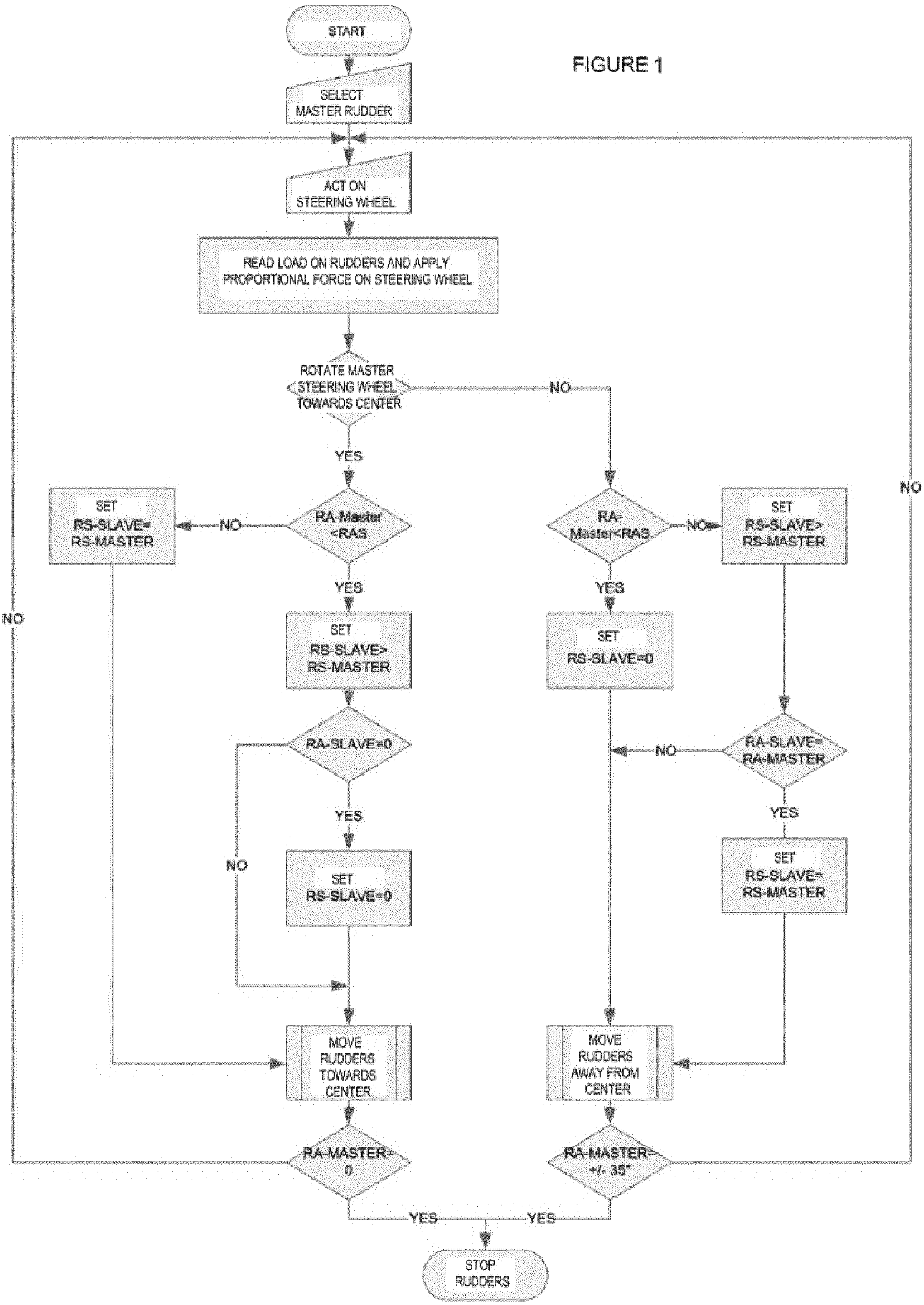
6. A method according to claim 1 or 2, wherein if said master rudder is rotated towards a position thereof parallel to said longitudinal symmetry plane and if the first angle (RA-MASTER) is either higher than or equal to the predetermined threshold angle (RAS), the control system directly sets the angular speed of the slave rudder to a value equal to the value of the angular speed of the master rudder, thus achieving said synchronization.

7. A method according to claim 1 or 2 or 3, wherein, if the master rudder is rotated towards a position thereof parallel to said longitudinal symmetry plane and if the first angle (RA-MASTER) is smaller than the predetermined threshold angle (RAS), the control system controls a first setting of the angular speed of the slave rudder to a value higher than the angular speed value of the master rudder until the RA-SLAVE=0° condition is satisfied, wherein RA-SLAVE is a second angle defined between the slave rudder and said longitudinal symmetry plane; having satisfied the RA-SLAVE=0° condition, the control system controls a second setting of the angular speed of the slave rudder to a value equal to zero.

8. A method according to any one of the preceding claims, wherein at each rotation of a steering wheel, the control system reads the load on said at least two rudders and controls the application of a feedback force, proportional to said load, on the steering wheel.

9. A method according to any one of the preceding claims, wherein the electronic control is carried out by means of a programmable logic controller (PLC) at a cycle frequency higher than 1 Hz.

FIGURE 1


START
SELECT MASTER RUDDER
ACT ON STEERING WHEEL
READ LOAD ON RUDDERS AND APPLY PROPORTIONAL FORCE ON STEERING WHEEL
ROTATE MASTER STEERING WHEEL TOWARDS CENTER
NO
YES
SET RS-SLAVE= RS-MASTER
NO
RA-Master <RAS
YES
SET RS-SLAVE> RS-MASTER
RA-SLAVE=0
YES
NO
SET RS-SLAVE=0
MOVE RUDDERS TOWARDS CENTER
RA-MASTER= 0
RA-Master<RAS
NO
SET RS-SLAVE> RS-MASTER
YES
SET RS-SLAVE=0
NO
RA-SLAVE= RA-MASTER
YES
SET RS-SLAVE= RS-MASTER
MOVE RUDDERS AWAY FROM CENTER
RA-MASTER= +/- 35°
NO
NO
YES
YES
STOP RUDDERS

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EUROPEAN SEARCH REPORT

Application Number
EP 15 20 3065

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	21 March 2016	Barré, Vincent

1

CATEGORY OF CITED DOCUMENTS

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