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(54) **Active roll stabilisation system for ships**

Aktives Rollstabilisierungssystem für Schiffe

Système de stabilisation active du roulis pour bateaux

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(56) References cited:
EP-A- 0 754 618
WO-A-87/02641
GB-A- 893 054
GB-A- 922 977
US-A- 3 818 959
US-A- 4 777 899

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Description

[0001] The invention relates to an active roll stabilisation system for ships, comprising at least one stabilisation element extending below the water line, which is mounted on a rotary shaft that extends through the ship's hull, sensor means for sensing the ship's movements and delivering control signals on the basis thereof to rotation means for rotating the rotary shaft for the purpose of damping the ship's movements that are being sensed by means of the stabilisation element.

[0002] Such an active roll stabilisation system for ships is known, for example from US patent No. 3,818,959. In said US patent it is proposed to impart a reciprocating rotary motion to a fin-like stabilisation element that projects into the water from the ship's hull below the waterline so as to compensate for the rolling motions that the ship undergoes while sailing. To that end, the ship is fitted with sensor means, for example angle sensors, speed sensors and acceleration sensors, by means of which the angle, the rate of roll or the roll acceleration are sensed. Control signals are generated on the basis of the data being obtained, which signals control the direction of rotation and the speed of rotation of the stabilisation element via the rotation means.

[0003] A reaction force acting on the water can be generated by means of said fin-like stabilisation element while sailing, which reaction force imparts a counteracting lifting or torsional moment to the ship, which is to counter the ship's roll, if the stabilisation element is correctly controlled.

[0004] A drawback of the stabilisation system according to said US patent is the fact that it is fairly static as regards the control thereof and that it can only be used while the ship is sailing. The above-described lifting effect does not occur, or not to a sufficient extent, while the ship is stationary, because there is no functional water movement past the stabilisation elements, and consequently there can be no effective roll stabilisation.

[0005] The object of the invention is therefore to provide an active roll stabilisation system for ships that can be used both with sailing ships and with ship that are at anchor. According to the invention, the active roll stabilisation system is to that end characterized in that the stabilisation element is provided with a sub-element that is movable with respect to the stabilisation element. This makes it possible to impart an additional lifting moment to the ship via the stabilisation element, both while the ship is sailing and while the ship is at anchor, for the purpose of effectively damping or countering the ship's movements that are being sensed.

[0006] In a functional embodiment, the sub-element is pivotable about a sub-pivot, whilst the sub-pivot may extend parallel to the rotary shaft. In another effective embodiment, the sub-element may be slidably accommodated in a space formed in the stabilisation element.

[0007] To achieve a more effective damping of the ship's movements being sensed, the sub-element is capable of movement independently of the rotary motion of the stabilisation element.

[0008] The sub-element may have a curved shape or a wing shape, in a specific embodiment it is made of a flexible material.

[0009] According to the invention, one embodiment of the active stabilisation system is characterized in that the rotation means comprise at least one piston-cylinder combination, said piston being connected to the rotary shaft. Also other rotation means, such as rotation actuators or an electrical driving mechanism may be used, however.

[0010] More specifically, the rotation means comprise two piston-cylinder combinations, each piston being connected on either side of the longitudinal direction of the rotary shaft to a yoke mounted to the shaft end that extends into the ship's hull, Said latter construction provides a more reliable control of the stabilisation element and thus a more functional damping of the ship's movements that are being sensed.

[0011] In another functional embodiment, drive means are present for driving the sub-element, which drive means are at least partially accommodated in the stabilisation element. The rotary shaft may be of hollow construction, and the drive means may also comprise a hinging drive shaft, that is carried through said hollow, rotary shaft.

[0012] In another embodiment, on the other hand, the drive means comprise a linkage accommodated in the stabilisation element, which linkage is connected to the sub-element on the one hand and to the hinging drive shaft on the other hand.

[0013] The above aspects provide a simple, robust yet reliable driving mechanism for the sub-element.

[0014] In another embodiment, the drive means comprise at least one extension element accommodated in the stabilisation element, which is connected to the sub-element, for extending and retracting the sub-element.

[0015] The extension element may form part of a spindle driving mechanism of a piston-cylinder combination.

[0016] More specifically, according to the invention the position of the sub-element with respect to the stabilisation element is adjustable in dependence on the speed of movement of the ship.

[0017] The invention also relates to a method for active roll stabilisation of ship through the use of an active stabilisation system according to the invention, which method comprises the steps of:

A) sensing the ship's movements

B) delivering control signals on the basis thereof for rotating the rotary shaft for the purpose of

C) damping the ship's movements that are being sensed by means of the stabilisation element. According to the invention, the method is further characterized by the steps of:

D) measuring the speed of the ship in the direction of travel; and

E) adjusting the position of the sub-element with respect to the stabilisation element on the basis of the speed measured in step D).

[0018] The invention will now be explained in more detail with reference to a drawing, in which:

Fig. 1 shows a ship fitted with an active stabilisation system according to the prior art;
Figs. 2A and 2B show two embodiments of stabilisation elements according to the prior art;
Fig. 3 shows a first embodiment of a stabilisation element according to the invention;
Figs. 4 and 5 are detail views of the embodiment that is shown in Fig. 3;
Fig. 6 shows the stabilisation principle of the active stabilisation system according to the invention;
Figs. 7A and 7B show other possible stabilisation principles of the active stabilisation system according to the invention;
Fig. 8 shows a second embodiment of a stabilisation element according to the invention.

[0019] For easy reference, like parts will be indicated by the same numerals in the description of the figures below.

[0020] Fig. 1 shows an active stabilisation device according to the prior art. A ship 1 having a stem 1a and a stern 1b is fitted with an active stabilisation device indicated at 2. This known active stabilisation device 2 for ship's movements as described in US patent No. 3,818,959 is built up of two stabilisation elements 3, which project from the ship 1 on the port side 1' and on the starboard side 1'', respectively, below the water line 5.

[0021] To that end, each stabilisation element 3 is mounted, whether or not by means of a flange 8 (see the partial view of the stabilisation element in Fig. 1), to the shaft end 4a of a shaft 4 extending from the ship's hull 1c, which can be rotated by rotation means (not shown).

[0022] Although this is not shown in the drawing, the active stabilisation system 2 according to the prior art is also provided with a sensor means, which sense the ship's movements and more in particular the ship's roll as indicated at 6. On the basis thereof, control signals are delivered to the rotation means (not shown), which rotate the stabilisation elements 3 via the rotary shafts 4 (depending on the stabilisation correction that is to be carried out). The sensor means may consist of angle sensors, roll speed sensors and acceleration sensors, which continuously sense the angle of the ship 1 with respect to the horizontal water surface 5, the speed or the acceleration effected by the rolling motions 6.

[0023] The active stabilisation system as shown in Fig. 1 is intended for damping ship's movements while the ship is sailing (indicated at 7 in Fig. 1). The interaction between the rotating stabilisation element 3 and the water flowing past results in a reaction force or lifting moment opposed to the rolling movement 6 of the ship 1. The rolling movement 6 of the ship 1 can be corrected by means of said lifting moment and the resulting reaction forces.

[0024] One drawback of the known active stabilisation device 2 is the fact that it can only be used with ships while sailing and to a limited, not very effective degree with ships that are substantially stationary ("at anchor"). It is in particular with the latter group of ships (for example chartered ships that lie at anchor in a bay for prolonged periods of time) that the present invention can be suitably used.

[0025] Figs. 2A and 2B show two embodiments of stabilisation elements 3 according to the prior art. As already explained with reference to Fig. 1, a fin or stabilisation element 3 projecting under the ship, being rotatable about a shaft 4, is used for effectively damping the ship's roll imparted to the ship 1 by the waves while the ship is sailing. As the stabilisation element 3 reciprocates about its axis of rotation 4, a reaction force is generated by the water flowing past while the ship is sailing, which reaction force, provided the movement of the stabilisation element is properly controlled, generates a counteracting moment to counter the ship's roll.

[0026] The constructional dimensions of the stabilisation element 3 determine the effectiveness of the stabilisation element, i.e. the effect of the stabilisation element moving through the water. More in particular, to obtain a maximum effective stabilisation effect while is sailing, it is desirable to select a maximum ratio between the width and the length of the stabilisation element, the so-called Aspect Ratio (AR). This implies that the width of the stabilisation element must be much greater than the length thereof, as is shown in Fig. 2A, so that the turning moment of the stabilisation element 3 will be small while sailing and the stabilisation element can be quickly reciprocated through the water, using little energy/power.

[0027] While the ship is stationary, the interaction between the stabilisation element and the water flowing past (while sailing) is absent, so that the counteracting lifting moment does not occur. It is desirable, therefore, to select a minimum value for the Aspect Ratio between the width and the length of the stabilisation element while the ship is stationary. This means that the length of the stabilisation element must be much greater than the width thereof, as is shown in Fig. 2B. During stabilisation, as much water as possible is "scooped" or moved during the movement of the stabilisation element 3 through the water, thus generating a counteracting lifting moment.

[0028] The Aspect Ratio (AR) of a stabilisation element according to the prior art is defined by:

$$AR = \frac{S}{\left(\frac{C_r + C_t}{2}\right)}$$

wherein;

AR = the Aspect Ratio
S = the width of the stabilisation element
C_t = the smallest length of the stabilisation element
C_r = the greatest length of the stabilisation element

[0029] As for the time being the stabilisation elements shown in Fig. 1 will be used for stabilising the ship's roll while sailing, considering the current state of the art, it must be attempted to find an optimum Aspect Ratio between the two stabilisation situations (the ship sailing and the ship being stationary).

[0030] From a viewpoint of effectiveness it is desirable to use a stabilisation element 3 having a high AR ratio while sailing, whereas a stabilisation element 3 having a low AR is preferred while the ship is stationary. This can be explained by the fact that the moment required for turning or rotating the stabilisation element about the shaft 4 is higher in the case of a stabilisation element having a high AR than in the case of a stabilisation element 3 having a low AR.

[0031] The turning moment of the stabilisation element is determined in part by the distance A (the moment arm) of the centre of pressure C_p of the forces that act on the stabilisation element. The distance or arm A between the axis 4 and the centre of pressure C_p of a stabilisation element having a high AR (see Fig. 2A) is smaller than that of a stabilisation element having a low AR (see Fig. 2B).

[0032] From a viewpoint of functionality it is desirable, therefore, to design a stabilisation element that can be used both while the ship is sailing and while the ship is stationary.

[0033] One embodiment of such a stabilisation element is shown in Fig. 3. The stabilisation element 10 that is shown therein is composed of a main element 11 of elongated shape, which is movable about an axis of rotation 4 with respect to the ship 1 with a first end 11a, similar to the situation that is shown in Fig. 1.

[0034] As is clearly shown in Fig. 3, the main axis of rotation 4 and the sub-axis of rotation 13 are spaced some distance apart. The sub-axis of rotation may extend parallel to the main axis of rotation, although this is not necessary. Using the sub-element 12, it is possible to effectively adapt the constructional dimensions of the stabilisation element 10 to the stabilisation situation in which the stabilisation element 10 is to be used.

[0035] As is shown in Figs. 4 and 5, the sub-element 12 can be actively rotated with respect to the main element 11 in one embodiment. To that end, the shaft 4 on which the main element 11 is mounted is of hollow construction, and a drive shaft 14 extends through the hollow shaft 4. The rotary shaft 4 and the drive shaft 14 both extend through the ship's hull, being connected in the interior of the ship with, respectively, rotation means (not shown) for rotating the rotary shaft 4 (and the main element 11 and the sub-element 12) and drive means (not shown) for driving the drive shaft 14 that extends through the hollow rotary shaft.

[0036] The drive shaft 14 is connected with its free end 14' to a transmission 15, which transmits the rotation that is imparted to the drive shaft 14 by the drive means to the free end 13' of the sub-shaft 13. As is shown in the partial views (a)-(d) of Fig. 4, the transmission 15 may consist of a linkage, which transmits the rotation of the drive shaft 14 to the sub-shaft 13 by making use of a lever principle, thus effecting a rotation of the sub-element 12 with respect to the main element 11, independently of the rotation imparted to the main element 11 by the rotary shaft 4.

[0037] Since the sub-element 12 is driven independently of the rotary main element 11, it is possible to change the Aspect Ratio (AR) of the stabilisation element 10 in an effective manner in dependence on the desired stabilisation action that the stabilisation element 10 is to carry out in order to oppose or damp the ship's roll while the ship is stationary or while the ship is sailing.

[0038] Fig. 6 shows the stabilisation principle of the active stabilisation system according to the invention with a stationary ship 1.

[0039] As a result of the wave motion, a ship 1 undergoes a reciprocating (harmonic) rolling motion about its longitudinal axis 1d with a maximum heel toward port (indicated at 16) and toward starboard (indicated at 18). The heel or inclination of the ship is minimal in the positions indicated at 19 and 17. At the points of maximum heel 16 and 18 (port side 1' and starboard side 1'', respectively), the ship has a rate of roll that equals zero (phase I), whilst the maximum rate of roll during the rolling movement from port 1' to starboard 1'' (from position 16 to position 17 and onwards to position 18) is reached at the point of equilibrium 17 (phase II).

[0040] The rate of roll of the ship will decrease during the movement of the ship from the point of a equilibrium 17 to the starboard side, until the rate of roll of the ship equals zero again (phase III) at the point of maximum heel of the ship to starboard 1'' (position 18). From said position 18. the ship 1 will roll back to port 1', reaching its maximum rate of roll again at the point of equilibrium 19 (phase IV). This rate of roll will decrease as the ship further heels over to port 1', reaching a value that equals zero (phase I) again at the point of maximum heel 16 to port.

[0041] The ship 1 is provided with at least one stabilisation device according to the invention both on the port side 1' and on the starboard side 1''. Alternatively, the ship 1 may be provided with more than one stabilisation device on either side thereof. Each stabilisation device comprises a stabilisation element 10' (10'') consisting of a main element 11' (11'') and a sub-element 12' (12''). Fig. 6 shows a stabilisation element 10' (10'') as shown in Figs. 3-5.

[0042] One stabilisation device according to the invention, or both, can be controlled and activated during the phases I-II-III-IV for damping the ship's roll 6.

[0043] During phase I of the rolling movement 6 of the ship, the ship 1 heels over to port 1', which downward movement is offset by an counter moment in upward direction on the port side 1' and by a counter moment in downward direction on the starboard side 1''. To that end, a downward rotary motion about axis of rotation 4' in the direction of the bottom of the sea is imparted to the stabilisation element 10 on the port side 1'. On the starboard side 1'', the stabilisation element 10 is rotated in upward direction toward the water surface 5 about the axis of rotation 4''.

[0044] The sub-element 12' (12") is held in line with the main element 11' (11'') during the larger part of the rotary motion during phase I. The stabilisation element 10' (10'') obtains a low AR, which, as already explained before, is the most effective ratio for damping the roll of a stationary ship. The downwardly rotating main element 11' on the port side 1' and the upwardly rotating main element 11'' on the starboard side 1'' displace water in downward (and upward, respectively) direction, resulting in an upward (and downward, respectively) reaction force and counter moment on the ship, as a result of which the downward roll to port is damped.

[0045] At the end of phase I, the rotary motion of the main element 11' (11'') is no longer directed downwards (upwards), so that the element no longer displaces water downwards (upwards) in an effective manner. The damping of the ship's roll through rotation of the main element 11' (11'') has "worn off". To be able to damp the ship's rolling movement at the end of phase I yet, the sub-element 12' (12'') is rotated further downwards (upwards) via the drive means (not shown), the drive shaft 14 and the transmission 15, so that the sub-element 12' (12'') is no longer in line with the main element 11' (11'') at the end of phase I, but extends at an angle thereto.

[0046] An additional downward (upward) counterforce is exerted on the water by the moving sub-element 12' (12''), which makes it possible to additionally damp the downward roll of the ship to port.

[0047] While the main element 11' (11'') is at the end of its downward (upward) stroke at the end of phase I, and consequently is no longer able to generate an effective counter moment for damping the ship's roll. such an effective counter moment can on the other hand be generated by means of the sub-element 12' (12'').

[0048] During phase II of the ship's roll 6, the ship 1 rolls about its longitudinal axis 1d towards starboard 1'', with the rate of roll of the ship gradually increasing in the direction of position 17. During phase II, the weight of the ship generates a turning moment about the longitudinal axis 1d, which moment is so large that a lifting moment generated by the stabilisation elements 10' (10'') will by no means suffice to counter this moment. During phase II, the sub-element 12' (12'') is returned to an advantageous starting position with respect to the main element 11' (11''), as shown in Fig. 6, for damping the ship's rolling motion during phase III.

[0049] The ship's roll toward starboard 1'' (phase III) must be compensated by a downward (upward) movement of the stabilisation element 10' (10'') on the port side 1' and the starboard side 1'', respectively. To achieve the most effective stabilisation, the sub-element 12' (12'') is held in line with the main element 11' (11'') as much as possible so as to obtain a stabilisation element 10' (10'') having a minimum AR. During phase III, the stabilisation elements 10' (10'') are capable of "scooping" a maximum amount of water in this position and moving it upwards (downwards), making it possible to generate the most effective reaction force and the resulting lifting moment for opposing the ship's rolling movement toward starboard.

[0050] At the end of phase III, the rotary motion of the main element 11' (11'') is no longer directed upwards (downwards), so that water is no longer effectively displaced in upward (downward) direction. The damping of the ship's roll through rotation of the main element 11' (11'') has "worn off". Analogously to the description of phase I, an additional stabilising action can be obtained by imparting an upward (downward) movement to the sub-element 12' (12"), so that the sub-element 12' (12") will take up an angle with respect to the main element 11' (11"), as is shown in Fig. 6.

[0051] At the end of phase III, the ship 1 heels over maximally toward starboard 1'' (indicated at 18), after which the ship 1 will roll back toward port 1' during phase IV. The rate of roll of the ship gradually increases while the ship rolls towards position 19, so that the stabilisation elements 10' (10'') will have little effect. The weight of the ship generates a turning moment about the longitudinal axis 1d, which moment is so large that a lifting moment generated by the stabilisation elements 10' (10'') will by no means suffice to counter this moment.

[0052] During phase IV, the sub-element 12' (12'') is merely returned to an advantageous starting position with respect to the main element 11' (11''), as shown in Fig 6, for damping the ship's rolling motion during phase I. During phase I, the ship's roll is damped or opposed in the manner described above.

[0053] Figs. 7A and 7B show two other stabilisation principles of the active stabilisation system according to the invention. While Fig. 6 shows the stabilisation principle of the active stabilisation system according to the invention with a stationary ship, Figs, 7A and 7B show the stabilisation principle of the active stabilisation system according to the invention with a sailing ship, with Fig. 7A relating in particular to a ship sailing at low speeds and Fig. 7 relating to the stabilisation principle with the ship sailing at high speed (for example cruising speed).

[0054] Referring to that which is shown in Figs. 2A and 2B, in the stabilisation principle as shown in Fig. 7A the sub-element 12 is so controlled with respect to the main element 11 that, in particular at low speeds, the stabilisation element 10 (composed of the main element 11 and the sub-element 12) has a maximum damping effect on the roll that the ship undergoes at low speeds as well. The water flowing past is additionally deflected by the adjusted sub-elements 12, as a result of which the so-called lifting action of the water flowing past is enhanced and consequently the reaction force exerted on the water by the stabilisation element 10 for correcting the ship's roll is most effective. Especially at low speeds, a stabilisation element 10 having a low AR value is created.

[0055] Fig. 7B, on the other hand, shows the stabilisation principle of the active stabilisation system according to the invention with a ship sailing at a high speed or cruising speed. To generate a minimum moment in order to enable quick rotation of the stabilisation element 10 about the axis of rotation 4, using little energy/power, it is desirable to realise a stabilisation element 10 having a high AR value at high speeds. The sub-element 12 is to that end controlled in such a manner during operation that it will extend or be oriented more or less parallel to the direction of flow at all times, and consequently does not contribute to the stabilising effect that the stabilisation element 10 can have on the ship's roll. In some cases, the flow under the ship is oriented altogether different from the direction of travel of the ship.

[0056] In this operating condition (Fig. 7B), only the main element 11 contributes towards the creation of a reaction force on the water for the purpose of opposing or damping the ship's roll.

[0057] The stabilisation principle or the stabilisation method according to the invention utilizes the speed of the ship 1. Measuring the speed enables the control electronics to determine whether the sub-element 12 must actively contribute towards the damping of the ship's roll (Fig. 7A) or whether a position parallel to the water flowing past must be imparted to said sub-element at all times, as in Fig. 7B.

[0058] Fig. 8 shows another embodiment of a stabilisation element 10 according to the invention. Also in this case, the stabilisation element 10 is built up of a main element 110, which is capable of reciprocating rotating movement about an axis of rotation 40 in dependence on the ship's rolling movements as sensed. The sub-element according to the invention is indicated at 120 in this figure, it can be slidably accommodated in a recess 50 formed in the main element 110 (see partial view (c)).

[0059] In view (a) of Fig. 8, the sub-element 120 is accommodated in fully telescoped position in the space of 50 in the main element 110, so that the stabilisation element 10 thus obtained has a high Aspect Ratio (AR). Such a stabilisation element has a low turning moment, therefore, which makes it very suitable for use while the ship is sailing.

[0060] View (b) shows the sub-element 120 in the extended position, as a result of which the stabilisation element of 10 has a low Aspect Ratio (AR). This enables the stabilisation element 10 to "scoop" a large amount of water, which makes it very suitable for damping the roll of a stationary ship.

[0061] The sub-element 120 is accommodated in guides (not shown) in the space 50 in order to enable the sub-element 120 to telescope in and out as shown in views (a) and (b). The sub-element 120 can be moved in and out along said guides by suitable drive means 60, for example in the form of piston-cylinder combinations 60a and 60 b, respectively, mounted on either side of the sub-element 120, near each guide.

[0062] Each piston-cylinder combination 60a-60b comprises a cylinder 62a-62b and a piston 61a-61b connected to the sub-element 120. The piston 61a-61b can be made to carry out a stroke by adding a suitable pressurised medium (air, water or, for example, oil), causing the sub-element 120 to move out of the space 50 along the guides and thus effect a random extension of the main element 110 in dependence on the desired reaction force or lifting moment that the stabilisation element 10 is to generate for damping the ship's roll.

[0063] In another embodiment, the drive means may be configured as a (screwed) spindle driving mechanism.

[0064] Thus the Aspect Ratio of the stabilisation element 10, and consequently also the stabilising counter action of the stabilisation element 10 on the ship's roll, can be adapted in a simple manner by moving the sub-element 120 in and out in a variable manner during the rotary motion of the sub-element 110 about the axis of rotation 4.

[0065] It will be apparent that the active stabilisation system according to the invention provides a more effective stabilisation technique for opposing a ship's rolling movements both while the ship is stationary and while the ship is sailing (at low speed and at high speed). The simple yet robust construction and driving arrangement of the sub-element with respect to the main element enable the active stabilisation system according to the invention to realise a stabilisation effect on the rolling movements being sensed in a quick and simple manner, but above all the system can be adjusted very quickly for stabilising the ship's roll while the ship is sailing at low speed or at high speed or while the ship is stationary.

Claims

1. An active roll stabilisation system (2) for ships (1), comprising at least

- one stabilisation element (3; 11; 110) extending below the water line (5), which is mounted on a rotary shaft (4; 40) that extends through the ship's hull (1c),
- sensor means for sensing the ship's movements and delivering control signals on the basis thereof to
- rotation means for rotating the rotary shaft for the purpose of damping the ship's movements that are being sensed by means of the stabilisation element, **characterized in that** the stabilisation element is provided with a sub-element (12; 120) that is movable with respect to the rotating stabilisation element thereby imparting an additional lifting moment to the ship via the stabilisation element for the purpose of

damping the ship's movements that are being sensed.

2. An active stabilisation system according to claim 1, **characterized in that** said sub-element (12) is pivotable about a sub-shaft (13).

3. An active stabilisation system according to claim 2, **characterized in that** the sub-pivot (13) extends parallel to the rotary shaft (4).

4. An active stabilisation system according to claim 1, **characterized in that** the sub-element (120) is slidably accommodated in a space (50) formed in the stabilisation element (110).

5. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the sub-element (12; 120) is capable of movement independently of the rotary movement of the stabilisation element (11; 110).

6. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the sub-element has a curved shape.

7. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the sub-element has a wing shape.

8. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the sub-element is made of a flexible material.

9. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the rotation means comprise at least one piston-cylinder combination, said piston being connected to the rotary shaft.

10. An active stabilisation system according to claim 9, **characterized in that** the rotation means comprise two piston-cylinder combinations, each piston being connected on either side of the longitudinal direction of the rotary shaft to a yoke mounted to the shaft end that extends into the ship's hull.

11. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** drive means are present for driving the sub-element, which drive means are at least partially accommodated in the stabilisation element.

12. An active stabilisation system according to claim 11, **characterized in that** the rotary shaft is of hollow construction, and the drive means also comprise a drive shaft that is carried through said hollow, rotary shaft.

13. An active stabilisation system according to claim 12, **characterized in that** the drive means comprise a linkage accommodated in the stabilisation element, which linkage is connected to the sub-element on the one hand and to the drive shaft on the other hand.

14. An active stabilisation system according to claim 11, **characterized in that** the drive means comprise at least one extension element accommodated in the stabilisation element, which is connected to the sub-element, for extending and retracting the sub-element.

15. An active stabilisation system according to claim 14, **characterized in that** said extension element forms part of a spindle driving mechanism.

16. An active stabilisation system according to claim 14, **characterized in that** said extension element forms part of a piston-cylinder combination.

17. An active stabilisation system according to any one or more of the preceding claims, **characterized in that** the position of the sub-element with respect to the stabilisation element is adjustable in dependence on the speed of movement of the ship.

18. A ship provided with an active stabilisation system according to any one or more of the preceding claims.

19. A method for active roll stabilisation of ship through the use of an active stabilisation system according to one of the claims 1 to 17, which method comprises the steps of:

A) sensing the ship's movements
B) delivering control signals on the basis thereof for rotating the rotary shaft for the purpose of
C) damping the ship's movements that are being sensed by means of the stabilisation element, the method being further **characterized by** the steps of:
D) measuring the speed of the ship in the direction of travel; and
E) adjusting the position of the sub-element with respect to the stabilisation element on the basis of the speed measured in step D) as part of the stabilisation action.

Patentansprüche

1. Aktives Rollstabilisierungssystem (2) für Schiffe (1), das mindestens Folgendes umfasst:

- ein Stabilisierungselement (3, 11, 110), das unter der Wasserlinie (5) verläuft, das auf einer

drehbaren Welle (4, 40) angebracht ist, die sich durch den Schiffsrumpf (1c) erstreckt,
- ein Sensormittel zum Erfassen der Schiffsbewegungen und Abgeben von Steuersignalen auf deren Grundlage an
- Rotationsmittel zum Drehen der Rotationswelle zum Zwecke des Dämpfens der Schiffsbewegungen, die mit dem Stabilisierungselement erfasst werden, **dadurch gekennzeichnet, dass** das Stabilisierungselement mit einem Unterelement (12, 120) bereitgestellt ist, das gegenüber dem drehbaren Stabilisierungselement beweglich ist, wodurch über das Stabilisierungselement ein zusätzliches Anhebemoment auf das Schiff übertragen wird, um die erfassten Schiffsbewegungen zu dämpfen.

2. Aktives Stabilisierungssystem nach Anspruch 1, **dadurch gekennzeichnet, dass** das Unterelement (12) um eine Unterwelle (13) rotierbar ist.

3. Aktives Stabilisierungssystem nach Anspruch 2, **dadurch gekennzeichnet, dass** sich die Unterachse (13) parallel zur Rotationswelle (4) erstreckt.

4. Aktives Stabilisierungssystem nach Anspruch 1, **dadurch gekennzeichnet, dass** das Unterelement (120) verschiebbar in einem Raum (50) angeordnet ist, der in dem Stabilisierungselement (110) ausgebildet ist.

5. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Unterelement (12, 120) unabhängig von der Rotationsbewegung des Stabilisierungselementes (11, 110) beweglich ist.

6. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Unterelement eine gebogene Form aufweist.

7. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Unterelement flügelartig ausgebildet ist.

8. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Unterelement aus einem flexiblen Material hergestellt ist.

9. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Rotationsmittel mindestens eine Kolben-Zylinder-Kombination umfassen, wobei der Kolben mit der Rotationswelle verbunden ist.

10. Aktives Stabilisierungssystem nach Anspruch 9, **dadurch gekennzeichnet, dass** die Rotationsmittel zwei Kolben-Zylinder-Kombinationen umfassen, wobei jeder Kolben auf beiden Seiten der Längsrichtung der Rotationswelle mit einem Gabelstück verbunden ist, das an dem Wellenende angebracht ist, das sich in den Schiffsrumpf erstreckt.

11. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** Antriebsmittel zum Antreiben des Unterelementes vorhanden sind, wobei diese Antriebsmittel mindestens teilweise in dem Stabilisierungselement aufgenommen sind.

12. Aktives Stabilisierungssystem nach Anspruch 11, **dadurch gekennzeichnet, dass** die Rotationswelle eine Hohlkonstruktion ist und die Antriebsmittel auch eine Antriebswelle umfassen, die durch diese hohl ausgeführte Rotationswelle geführt wird.

13. Aktives Stabilisierungssystem nach Anspruch 12, **dadurch gekennzeichnet, dass** die Antriebsmittel eine Kopplung umfassen, die in dem Stabilisierungselement aufgenommen ist, wobei diese Kopplung mit dem Unterelement auf der einen Seite und mit der Antriebswelle auf der anderen Seite verbunden ist.

14. Aktives Stabilisierungssystem nach Anspruch 11, **dadurch gekennzeichnet, dass** die Antriebsmittel mindestens ein Erweiterungselement umfassen, das in dem Stabilisierungselement enthalten ist, das mit dem Unterelement verbunden ist, um das Unterelement auszufahren und zurückzuziehen.

15. Aktives Stabilisierungssystem nach Anspruch 14, **dadurch gekennzeichnet, dass** das Erweiterungselement Teil einer Spindelantriebseinrichtung ist.

16. Aktives Stabilisierungssystem nach Anspruch 14, **dadurch gekennzeichnet, dass** das Erweiterungselement Teil einer Kolben-Zylinder-Kombination ist.

17. Aktives Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Position des Unterelementes gegenüber dem Stabilisierungselement abhängig von der Geschwindigkeit der Schiffsbewegung verstellbar ist.

18. Ein Schiff, bereitgestellt mit einem aktiven Stabilisierungssystem nach mindestens einem der vorhergehenden Ansprüche.

19. Verfahren zur aktiven Rollstabilisierung eines Schiffs durch Verwendung eines aktiven Stabilisierungssystems gemäß einem der Ansprüche 1 bis

17, wobei dieses Verfahren die folgenden Schritte umfasst:

A) Erfassen der Schiffsbewegungen,
B) auf deren Grundlage Abgeben von Steuersignalen zum Drehen der Rotationswelle, um
C) die Schiffsbewegungen zu dämpfen, die mit dem Stabilisierungselement erfasst werden, wobei das Verfahren ferner durch folgende Schritte **gekennzeichnet** ist:
D) Messen der Schiffsgeschwindigkeit in Fahrtrichtung und
E) Einstellen der Position des Unterelementes gegenüber dem Stabilisierungselement auf der Grundlage der in Schritt D) als Teil des Stabilisierungsvorgangs gemessenen Geschwindigkeit.

Revendications

1. Système de stabilisation active du roulis (2) de bateaux (1), comprenant au moins un élément de stabilisation (3 ; 11 ; 110) s'étendant au-dessous de la ligne de flottaison (5), monté sur un arbre rotatif (4 ; 40) qui s'étend à travers la coque du bateau (1c), des moyens de détection permettant de détecter les mouvements du bateau et de fournir des signaux de commande sur la base de ceux-ci à des moyens de rotation permettant de faire tourner l'arbre rotatif afin d'amortir les mouvements du bateau qui sont détectés au moyen de l'élément de stabilisation, **caractérisé en ce que** l'élément de stabilisation est pourvu d'un sous-élément (12 ; 120) qui est mobile par rapport à l'élément de stabilisation rotatif, transmettant de ce fait un moment de soulèvement supplémentaire au bateau par l'intermédiaire de l'élément de stabilisation afin d'amortir les mouvements du bateau qui sont détectés.

2. Système de stabilisation active selon la revendication 1, **caractérisé en ce que** ledit sous-élément (12) peut pivoter autour d'un sous-arbre (13).

3. Système de stabilisation active selon la revendication 2, **caractérisé en ce que** le sous-pivot (13) s'étend de manière parallèle à l'arbre rotatif (4).

4. Système de stabilisation active selon la revendication 1, **caractérisé en ce que** le sous-élément (120) est logé de manière coulissante dans un espace (50) formé dans l'élément de stabilisation (110).

5. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le sous-élément (12, 120) peut se déplacer indépendamment du mouvement rotatif de l'élément de stabilisation (11 ; 110).

6. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le sous-élément à une forme courbée.

7. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le sous-élément a une forme similaire à une aile.

8. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le sous-élément est réalisé à partir d'un matériau flexible.

9. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les moyens de rotation comprennent au moins une combinaison piston-cylindre, ledit piston étant relié à l'arbre rotatif.

10. Système de stabilisation active selon la revendication 9, **caractérisé en ce que** les moyens de rotation comprennent deux combinaisons piston-cylindre, chaque piston étant relié sur l'un quelconque des côtés de la direction longitudinale de l'arbre rotatif à une chape montée au niveau de l'extrémité de l'arbre s'étendant à l'intérieur de la coque du bateau.

11. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** des moyens d'entraînement sont présents pour entraîner le sous-élément, lesquels moyens d'entraînement sont, au moins en partie, logés dans l'élément de stabilisation.

12. Système de stabilisation active selon la revendication 11, **caractérisé en ce que** l'arbre rotatif est creux et **en ce que** les moyens d'entraînement comprennent également un arbre d'entraînement qui est porté à travers ledit arbre rotatif creux.

13. Système de stabilisation active selon la revendication 12, **caractérisé en ce que** les moyens d'entraînement comprennent une liaison logée dans l'élément de stabilisation, laquelle liaison est reliée au sous-élément d'une part et à l'arbre d'entraînement d'autre part.

14. Système de stabilisation active selon la revendication 11, **caractérisé en ce que** les moyens d'entraînement comprennent au moins un élément d'extension logé dans l'élément de stabilisation, qui est relié au sous-élément, pour étendre et rétracter le sous-élément.

15. Système de stabilisation active selon la revendication 14, **caractérisé en ce que** ledit élément d'extension fait partie d'un dispositif d'entraînement de

transmission à broches.

16. Système de stabilisation active selon la revendication 14, **caractérisé en ce que** ledit élément d'extension fait partie d'une combinaison piston-cylindre.

17. Système de stabilisation active selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la position du sous-élément par rapport à l'élément de stabilisation est ajustable selon la vitesse de déplacement du bateau.

18. Bateau équipé d'un système de stabilisation active selon l'une quelconque des revendications précédentes.

19. Procédé de stabilisation active du roulis d'un bateau en utilisant un système de stabilisation active selon l'une quelconque des revendications 1 à 17, le procédé comprenant les étapes consistant à :

A) détecter les mouvements du bateau ;
B) fournir des signaux de commande sur la base de ces mouvements pour faire tourner l'arbre rotatif pour
C) amortir les mouvements du bateau qui sont détectés au moyen de l'élément de stabilisation, le procédé étant en outre **caractérisé par** les étapes consistant à :
D) mesurer la vitesse du bateau suivant la direction de déplacement ; et
E) ajuster la position du sous-élément par rapport à l'élément de stabilisation sur la base de la vitesse mesurée à l'étape D) comme faisant partie de l'action de stabilisation.

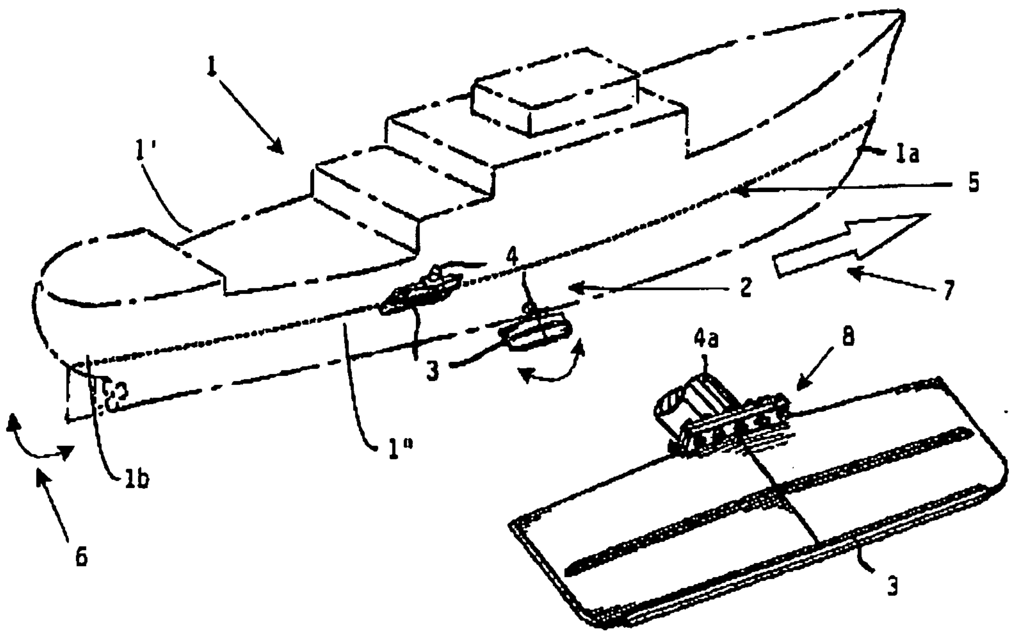

Fig. 1

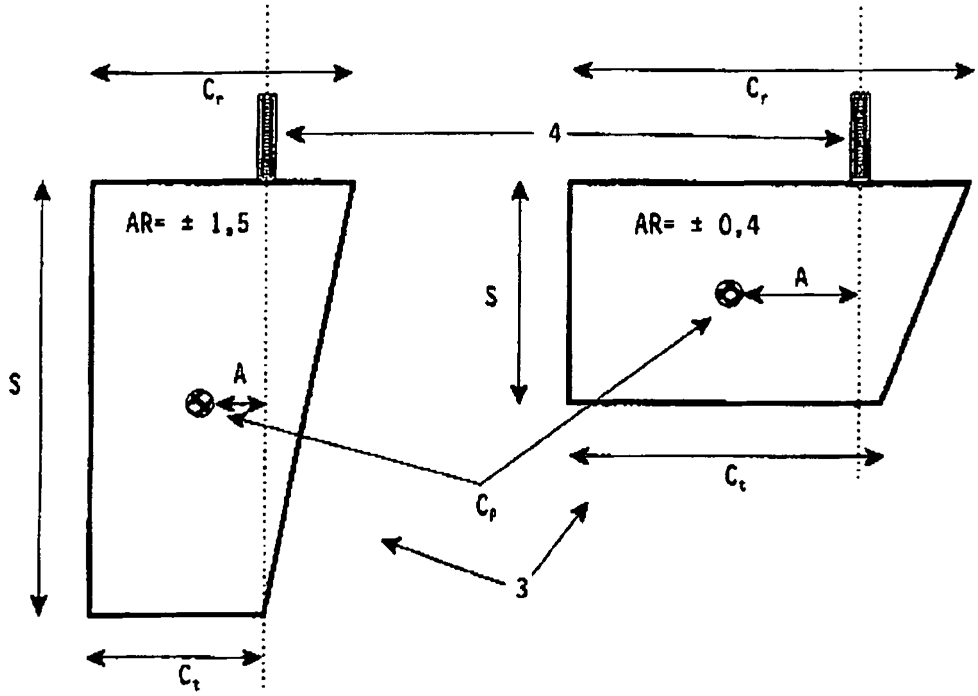

Fig. 2A

Fig. 2B

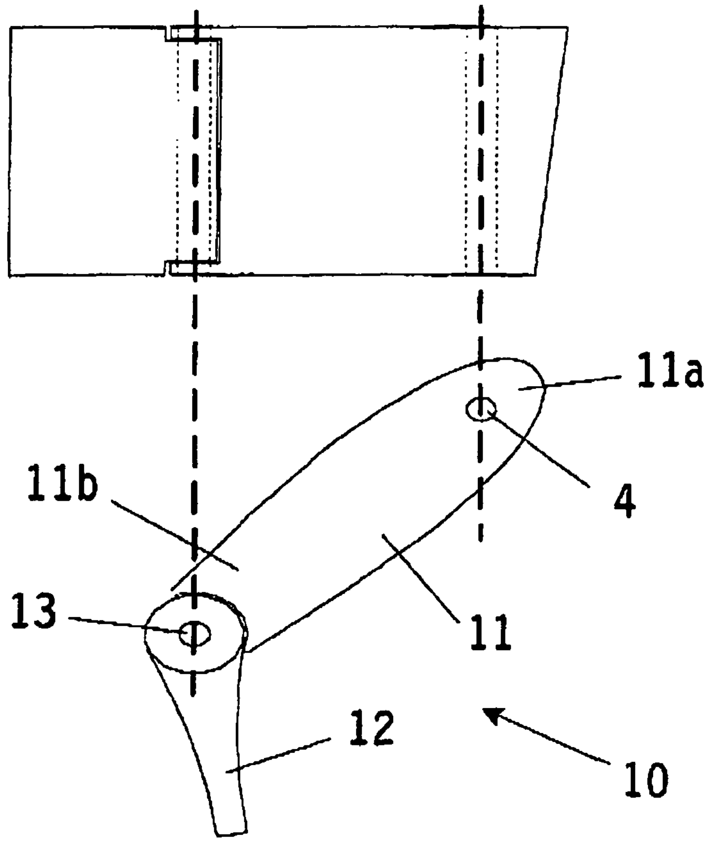

Fig. 3

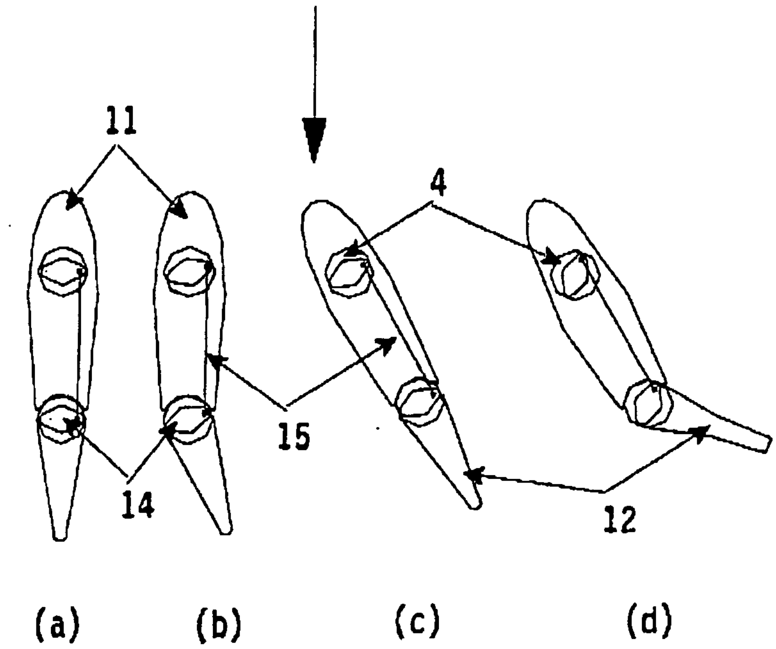

Fig. 4

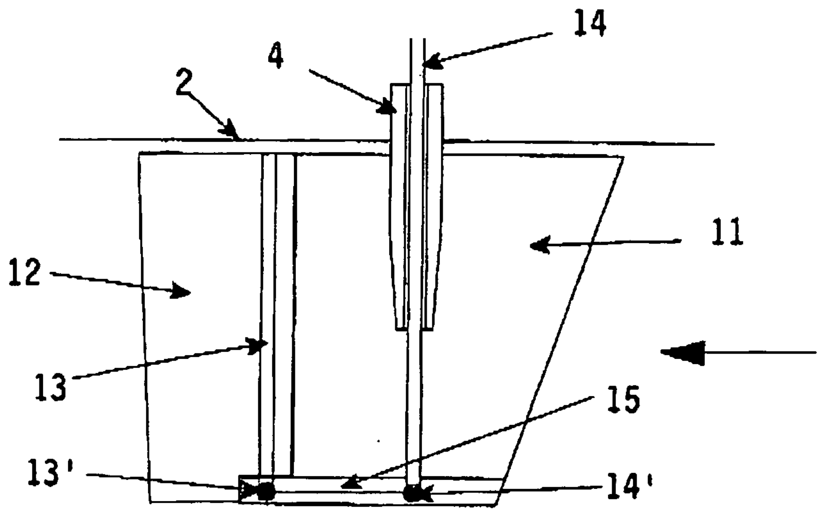

Fig. 5

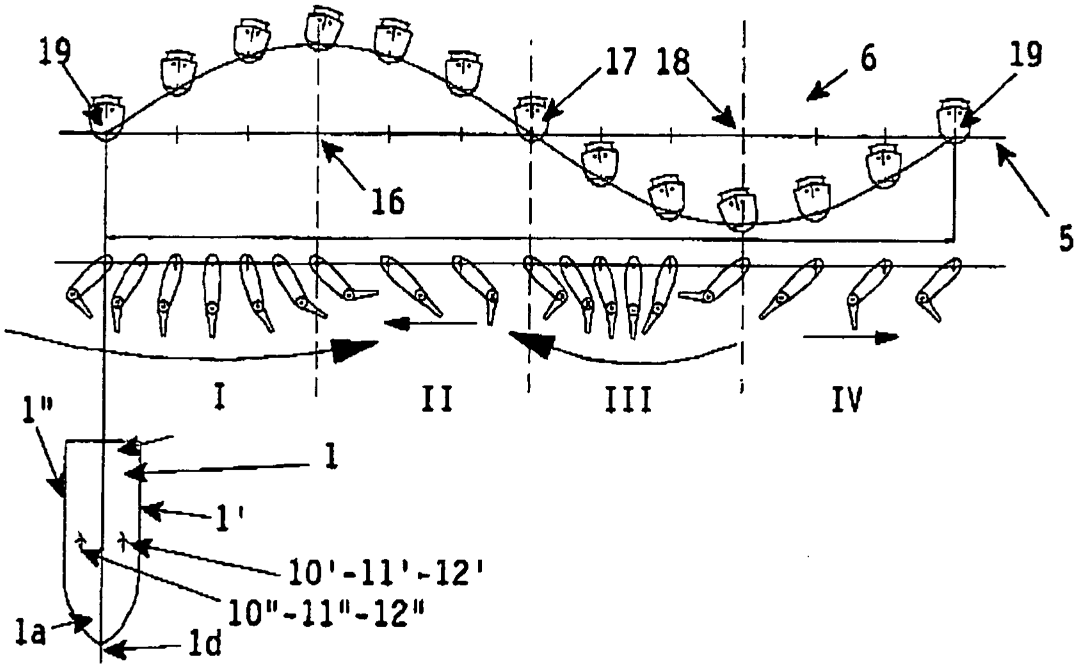

Fig. 6

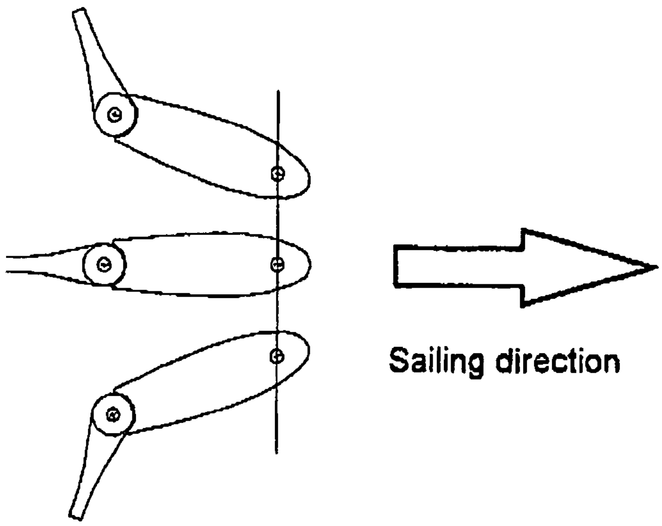

Fig. 7A

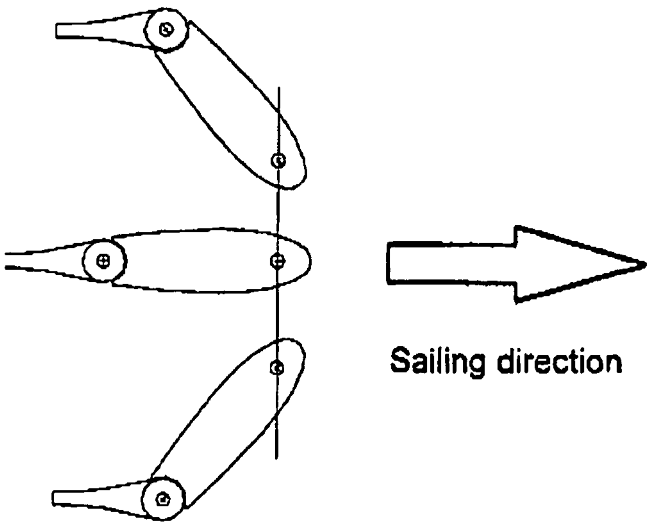

Fig. 7B

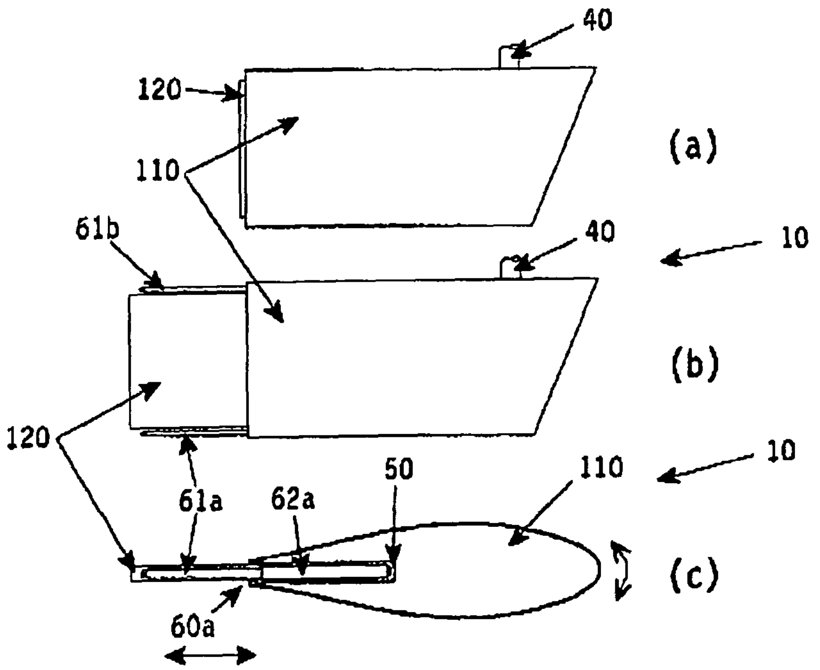

Fig. 8

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US 3818959 A **[0002] [0020]**