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(54) Title: FIN PROPULSION BY MEANS OF INCLINED FINS

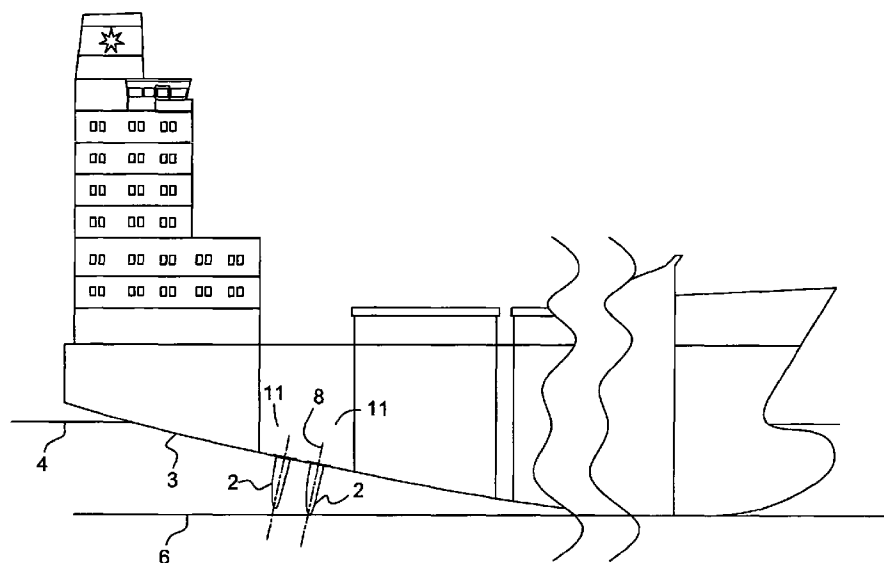


Figure 1

(57) Abstract: A maritime vessel propelled by fin propulsion, wherein the fins (2) having an upper portion (1) and a lower portion (5) extending away from, and with a pitching axis normal to a part of the hull (7) which is above the fins. The fins (2) are rotated by drive means (10) about an axis (8) which is normal to a sloped part of the hull from where the fins extend. The means for rotating (10) the propulsive means (2) may constitute a least one motor or ram powered by electrical power, air or a viscous fluid. Further, the hull (7) is substantially flat on a part of a transversal section around the location where the means for propulsion (2) protrude. The lower part of the fins (5) is located above the base line (6) of the vessel, and the upper part of the fins (1) is at normal operational draught located below the waterline (4).

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Fin propulsion by means of inclined fins

Field of invention

- 5 The present invention relates to a propulsion system for a maritime vessel wherein the employed means for propulsion includes flapping, translating or oscillating foils or fins.

- According to one aspect, the present invention relates to a maritime vessel
- 10 propelled by a mechanism incorporating transversely translating propulsive means. The mechanism comprises:
- at least one hull accommodating the propulsive mechanism;
 - at least one source of propulsive power;
 - water engaging propulsive means having an upper portion facing a
 - 15 portion of the hull and a lower portion extending away from the hull, an axis of rotation oriented substantially normal to a part of the hull which lies substantially above the propulsive means; and
 - means being able to at least partially, and in a controlled manner, rotate the propulsive means about the axis of rotation.

20

Background

- It is recognised that fish and sea mammals move and manoeuvre in water by oscillating fins (i.e. heaving motion of the fins) with higher propulsive
- 25 efficiency than today's maritime vessels.

No technological equivalent to fin propulsion has so far been implemented in maritime vessels.

- 30 The present invention is an important practical element to easily realize efficient and operative flapping propulsion based on the combination of one

periodical translating movement and possibly one periodical rotational movement of one or several fins under the ship.

5 The oscillating motion of a fishtail can be simulated and generated either by rotation of a fin, or, as is the case with sea-mammals and tuna-related fish, by a combination of at least one periodical translation and one periodical rotation of the caudal fin.

10 Today, almost every waterborne vessel, regardless of size, service speed and application, are propelled by one or more rotating propulsive elements.

The propulsive means, e.g. propellers, jets, ducted propellers or pump jets etc., are rotating about their own axis. On larger vessel, the propellers are rotating at about 50-500 rpm.

15 The propellers are carefully designed for their particular application.

One important objective for the designers is to limit the vessels overall fuel consumption. This is achieved through careful design of several parameters
20 such as hull form, propulsion plant and propulsive elements.

The efficiency of today's most effective propellers rarely exceeds 80 %, in fact efficiencies of 30-70 % are generally accepted, leading to unnecessarily large power plants and increased fuel consumption.

25 Therefore, considering the above mentioned inexpediencies, usefulness of a fully operational and improved low-tech but high-efficiency marine propulsion system is apparent.

30 Background art

Propulsion by means of oscillating or translating fins possesses attractive features such as higher efficiency than rotating propellers and inherent steering, which eliminates the need for a separate rudder with the associated costs and the associated reliability issues; in addition it frees volume inside
5 the hull for increased cargo accommodation. The higher efficiency is achieved through lower impulse losses, lower hydrodynamic friction losses, lower induced drag losses and a lower drag on the hull itself, and results in either lower fuel consumption and lower installed power for the prime
10 movers, or a higher service speed with the same installed propulsion power and fuel consumption, or a combination of both.

US patent no 5,401,196, published March 28, 1995 (TRIANTAFYLLOU et al.) disclose a propulsion system employing flapping foils. The patent, which teaches a system utilizing at least one foil, discloses a propulsive system
15 wherein a foil is oscillated in a direction transverse to the vessel's sailing direction and is rotationally oscillated about a vertical axis. Preferably, according to the US patent, the propulsive system is built up from a plurality of foils which are oscillated out of phase resulting in the propulsive elements thrust in a direction transverse to the sailing direction is insignificant.

20

Where an even number of foils are used, half the foils are preferably oscillated 180° out of phase with the other half of the foils. Where e.g. three foils are used, the foils are oscillated 120° out of phase with each other.

25 The main features of a mechanical embodiment of the propulsion system as disclosed in the US patent will be explained below:

Figures 4A, 4B, 5A, 5B & 5C illustrate an embodiment for a foil propulsion system in accordance with the US patent. The propulsive system is build up
30 from two foils (10), each connected via a shaft (34), through a slit (36) in the aft section of the hull (30) to a table (40). The extent of the slits (36), as can

be seen in figure 4A and as illustrated by the arrows (38), being greater than the total maximum heave amplitude for the foils. As may best be seen in figure 4B, each table (40) has two or more wheels or rollers (42) mounted to the forward underside and to the rear underside, in which the wheels or
5 rollers ride in corresponding tracks (44) mounted to hull (32). The tables (40) and the foils (10) attached thereto are thus free to move both directions along one axis (38), and are fixed from movement in any other direction.

Conclusively, the mechanism according to the US patent is working through a number of slits (36) established in the hull (32), each transverse to the
10 vessels forward sailing direction, and the extension of the slits (36) exceeding the transverse motion of the foils. The fins are also rotating under power around axes placed such that rotation substantially affects the angle of the foil with the direction of motion of the ship. All disclosed axes of rotation are established as substantially vertical axes.

15 The teaching according to the patent has not seen commercial application in propulsion of maritime vessels.

The above prior art document discloses the hull provided with a horizontal
20 and transverse slit at the location where the fin axles crosses the shell of the hull. While such a configuration is possible, it would cause significant drag when located close to, or even below, the waterline. The drag would originate from the slits themselves or from the so chosen stern shape.

25 One spontaneous solution would be to install the vertical fins, incl. their corresponding slits, below the waterline with translating sealing means covering the slit, whereby the hydrodynamic disturbance originating from the slits is minimized. This could be done either by designing the longitudinal sternline with an underwater horizontal part, or by having the vertically
30 pitching fins protrude through an inclined longitudinal sternline.

However, if the fins are placed with a vertically rotating axis, and with the hull shape sloping up longitudinally, the efficiency will be reduced significantly as following will occur:

- 5
- higher induced drag of the fins due to the gap between the fin and the hull at non zero pitching angle;
 - higher drag due to negative rake of the fins in a flow that goes up;
 - higher suction between the hull and the fins causing higher thrust deduction;

10

If the sternline includes a horizontal longitudinal section under water, with fins pitching about a vertical axis, the streamlines of flow around the hull would be disturbed due to the abrupt curvature of the longitudinal sternline section, and the boundary layer would be large at the location of the fins, thereby causing operation with poor efficiency. On the other hand, if the longitudinal sternline is not sloped or inclined enough, the transom of the ship would be at least partially submerged in full loading conditions, causing higher hull drag and low total efficiency.

15

20 Conclusively, the prior art incorporating translating or oscillating fin propulsion does not recognise the above problems, which is why the prior art merely teaches a system wherein the fins are rotating about a vertical axis connected substantially above the designed waterline.

25 Prior art propulsive systems incorporating propulsion by one or more rotating propellers suffers under the fact that the fairly large propeller, in order to obtain optimum operating conditions, has to be immersed under all operating conditions. E.g. a vessel with a design draught of 9,0 m, and incorporating a propeller with a diameter of abt. 6,8 m will be able to obtain optimum working conditions only in draughts in excess of abt. 7 m. This leads to, when the vessel is not carrying cargo, a need to ballast at least the aft part of the

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vessel with seawater in order to immerse the propeller, which increases the fuel consumption.

Improving the practical range of draughts, at which the ship is able to operate economically, constitute a further autonomous and so far unsolved problem.

Considering the above drawbacks, the skilled person will acknowledge that a strong need persists for a propulsion system which is able to resolve the above disadvantages.

10

WO 03/026954 A1, published April 3, 2003 (Inocean) suggests a system utilizing a sinusoidal pattern of movement for propulsion or energy recovery. The system comprises a plurality of rigid hull elements arranged in a row and rotatable attached to one another for rotation about parallel axes of rotation across the longitudinal dimension of the row of hull elements. The system further comprises movement devices for rotating the hull elements relative to one another or movement devices for recovery of energy as a result of rotating the hull elements relative to one another.

15

WO 2006/038808 A1, published April 13, 2006 (Clavis Biopropulsion) suggests a device comprising at least one transversely translating fin. The device encompasses actuating and drive means allowing substantially free oscillating motion of the fin. The device operates by means of an impulse, established by drive means, every so many cycles and spring are used to store the pulsating energy provided by the drive means.

25

Brief description of the invention

In order to realize the obvious advantages over prior art, and at the same time resolve the drawbacks according to the introductory part of this specification, a ship equipped with the inventive translating or oscillating fin

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propulsion must be able to operate safely and economically and at a broad range of draughts and speeds.

5 The solution is to construct a maritime vessel wherein a part of the hull, from where the propulsive means extend is sloped with respect to a base line of the hull.

The above configuration leads to the desired economical and environmentally friendly performance.

10

According to one embodiment, the means for rotating the propulsive means constitutes means operating independently from the source of propulsive power.

15 According to one embodiment, the means for rotating the propulsive means constitutes at least one motor or ram powered by electrical power, air or a viscous fluid.

20 According to one embodiment, the oscillating or translating motion of the propulsive means is exclusively powered from the source of propulsive power.

25 According to one embodiment, the hull is substantially flat, locally or not, on a part of a transverse section of the hull from where the means for propulsion extend or protrude.

According to one embodiment, a curvature of the hull is substantially arc-shaped on a part of a transversal and/or longitudinal section around the location where the means for propulsion extend or protrude.

30

According to one embodiment, a lower part of the means for propulsion is in any operating loading condition located above the baseline of the hull.

5 According to one embodiment, an upper part of the means for propulsion may in any operating loading condition be located below the waterline.

10 According to one embodiment, the means for rotating said propulsive means is controlled such that an optimum or desired angle of attack between the propulsive means and the water through which the vessel is propelled is obtained.

15 According to one embodiment, the means for rotating the propulsive means controls and/or rotates the propulsive means in order to compensate for various patterns of translational movement of the propulsive means.

20 According to one embodiment, the control and/or rotation of said propulsive means constitutes an adaptive system wherein the rotation of the propulsive means is adapted to requested thrust vectors and/or optimized in order to achieve optimum, i.e. lowest possible, fuel consumption.

According to another object of the present invention, a method of propelling a ship by means of a propulsion apparatus according to the teachings of this document is provided.

25 Brief description of the drawings

Figure 1 shows a principal and longitudinal sectional view of a ship incorporating translating or oscillating means for propulsion according to the present invention.

Figure 2 shows an enlarged principal and sectional side view of a system incorporating translating or oscillating means for propulsion according to the present invention.

- 5 Figure 3 shows a principal transversal section of a system incorporating translating or oscillating means for propulsion according to the present invention.

- 10 Figure 4 shows a principal and sectional top view of a system incorporating translating or oscillating means for propulsion according to the present invention.

The elements disclosed in the above figures are possibly, mutually and conveniently scaled, and serves the purpose of illustration only.

15

Detailed description with reference to the figures

The oscillating or translating fin propulsion according to the present invention offers improved efficiency over a broad range of draughts and speeds.

20

As shown on the figures 1, 2 and 3, a maritime vessel is provided propulsive means 2, such as fins or foils, arranged with an upper part 1 travelling or translating across and below the shell of the hull 3 under or near the waterline 4 of any normal operational loading condition of the vessel, and the
25 opposite lower part 5 extending into a depth of the water.

For practical reasons, it may be preferred not to allow the lower part 5 of the means for propulsion 2 to protrude below a baseline 6 of the hull 3.

The propulsive means 2, such as fins or foils, must encompass sufficient water engaging surface area in order to obtain sufficient water engaging area.

- 5 The hull form, and thereby the transversally sloped shape of the hull 3 incl. form of the propulsive means 2 are determined from a number of hydrostatical parameters, all of which being optimized in order to obtain the lowest possible towing resistance and best possible propulsive efficiency while maintaining optimal sea keeping and stability properties etc.

10

The vessel may be constructed with its hull 3 sloping longitudinally upwards towards the aft part of the vessel, also at the locations from where the axles 7 of the means for propulsion 2 protrude from the hull 3. The axes 8, about which the axles 7 pivot or rotate, are oriented substantially normal to the hull 3, at the locations from where the axles 7 of the means for propulsion 2 protrude from the hull 3. Therefore, the pivot axis 8 of the means for propulsion 2 is positively inclined meaning that an upper part of the means for propulsion 2 is located forwards the lower part of the means for propulsion 2.

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20

Conclusively, the vessel may be provided with inclined fins or foils.

Inclining the means for propulsion 2 allows the designer of the vessel to design the propulsive means 2 with sufficient water engaging area although the means for propulsion 2 are protruding through the hull from positions located near or below the waterline 4 of all normal operating loading conditions of the vessel, while not protruding below the baseline of the ship.

25

Designing the hull 3 to be substantially flat, or comprising a curvature as an arc of a circle, on a sloped part of the transversal section around the location where the axles 7 of the means for propulsion 2 protrude from the hull 3

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minimizes the gap between the upper part of the means for propulsion 2 and the hull 3 during a pitching and heaving/translating motion. This as a result increase the propulsive systems overall efficiency.

- 5 Further, a substantially flat section around the area of protrusion of the means for propulsion 2 accommodates or facilitates the provision of means for sealing 9.

- 10 The means 10 for rotating the propulsive means 2 may constitute a least one motor or ram, which may suitable by hydraulically or pneumatically powered, or powered by electrical power, air or a viscous fluid.

The means 10 for rotating the propulsive means may be controlled by means of an internal or external processor, such as a PC or equivalent (not shown).

- 15 Further, the processor or PC may be able to control the means 10 for rotating the propulsive means such that any desired translational pattern of movement of the propulsive means 2 is optimized with respect to fuel efficiency and desired directions of thrust.

- 20 The rotation of the propulsive means 2 may also be performed by pure mechanical links. Such links or linkage system may either control the propulsive means 2 jointly or independently. Further, the link or link system may be connected directly to the hull 3, or to other mechanical means assisting the generation of the desired motion or rotation of the propulsive
25 means 2.

- The means 10 for rotating the propulsive means 2 may preferably be able to rotate the propulsive means 2 about their axis of rotation 8 independently from the heave motion of the means for propulsion 2, and further, the means
30 for rotating the propulsive means 2 may constitute at least one separate drive 10 per propulsive system 11.

The means 10 for rotating the propulsive means 2 may preferably control the angle of the propulsive means 2 such that an optimum or desired angle of attack between the propulsive means and the fluid is obtained.

5

The means 10 for rotating the propulsive means 2 may control and/or rotate the propulsive means 2 in order to compensate for various patterns of translational movement of the propulsive means 2, e.g. sinusoidal or non-

10 propulsive means 2 may constitute an adaptive system wherein the rotation of the propulsive means 2 is adapted to requested thrust vectors and/or optimized in order to achieve optimum, i.e. lowest possible, fuel consumption.

15 It will be possible to construct the system with a separate drive 10 for each of the means for propulsion 2 rendering it possible to control each mean for propulsion 2 independently from the rest of the system 11.

20 The transversal cross section of figure 3, positioned substantially through the section where the means for propulsion 2 translates, is, as per the above, preferably substantially flat in order to avoid induced drag through leakage from the pressure side to the suction of the means for propulsion caused by gaps between the upper part of the means for propulsion 1 and the hull 3.

25 The oscillating or translating motion of the propulsive means 2 may be powered exclusively from the source of propulsive power.

30 The propulsive power may originate from one or more engines or prime movers, e.g. a slow speed or medium speed engine. Further, it will be possible to realize the invention utilizing any kind of turbines powered by gas, steam or even nuclear energy.

The propulsive means 2 may constitute fins or foils suitable for producing thrust when operated as per the introductory part of this specification.

5 The propulsive system 11 may be arranged as port and starboard systems being offset in a longitudinal direction. It will be possible to construct a vessel with the systems being juxtaposed or being placed longitudinally one in front of the other, either totally or partially. The propulsion mechanism according to the present invention is not in any way limited to one configuration above another configuration.

10

The propulsive system 11 may be arranged or provided in the hull 3 of a maritime vessel under several configurations, some of which are:

- 15 A. as port and starboard systems being offset in a longitudinal direction, as illustrated by figure 4,
- B. two systems being juxtaposed or being placed longitudinally one in front of the other, either totally or partially, and
- C. one single system arranged substantially in the vessels longitudinal centreline.

20

The propulsion mechanism according to the present invention is not in any way limited to one configuration above another configuration.

25 It should be emphasized that the term "comprises/comprising/comprised of" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Claims

1. A maritime vessel propelled by a mechanism incorporating transversely translating propulsive means (2), the mechanism comprises:

- 5 - at least one hull (3) accommodating the propulsive mechanism (11);
 - at least one source of propulsive power;
 - water engaging propulsive means (2) having an upper portion facing a portion of said hull (3) and a lower portion extending away from said hull (3), an axis of rotation (8) oriented substantially normal to a part of said
10 hull (3) which lies substantially above said propulsive means (2); and
 - means (10) being able to at least partially, and in a controlled manner, rotate said propulsive means (2) about said axis (8);

characterized in that said part of said hull (7) from where said propulsive means (2) extend being sloped with respect to a base line (6) of said hull (3).

15

2. The mechanism according to claim 1 wherein said means (10) for rotating said propulsive means (2) constitute means operating independently from said source of propulsive power.

- 20 3. The mechanism according to claim 2 wherein said means for rotating (10) said propulsive means (2) constitute at least one motor or ram powered by electrical power, air or a viscous fluid.

4. The mechanism according to claim 1 wherein the oscillating or translating
25 motion of said propulsive means (2) is exclusively powered from said source of propulsive power.

5. The mechanism according to claim 1 wherein said hull (3) is substantially flat on a part of a transverse section of said hull (3) from where said means
30 for propulsion (2) extend or protrude.

6. The mechanism according to claim 1 wherein a curvature of said hull (3) is substantially arc-shaped on a part of a transversal and/or longitudinal section around the location where the means for propulsion (2) extend or protrude.

5 7. The mechanism according to claim 1 wherein a lower part of said means for propulsion (2) is in any operating loading condition located above said baseline (6) of said hull (3).

8. The mechanism according to claim 1 wherein an upper part of said means
10 for propulsion (2) is in any operating loading condition located below the waterline (4).

9. The mechanism according to claim 1 wherein said means (10) for rotating said propulsive means (2) is controlled such that an optimum or desired
15 angle of attack between said propulsive means (2) and the water through which said vessel is propelled is obtained.

10. The mechanism according to claim 1, wherein said means (10) for rotating said propulsive means (2) controls and/or rotates said propulsive
20 means (2) in order to compensate for various patterns of translational movement of said propulsive means (2).

11. The mechanism according to claim 1 wherein said control and/or rotation of said propulsive means (2) constitutes an adaptive system wherein the
25 rotation of said propulsive means (2) is adapted to requested thrust vectors and/or optimized in order to achieve optimum, i.e. lowest possible, fuel consumption.

12. A method of propelling a ship by means of a propulsion apparatus
30 according to any of the preceding claims, wherein said part of said hull (7)

from where said propulsive means (2) extend being sloped with respect to a base line (6) of said hull (3).

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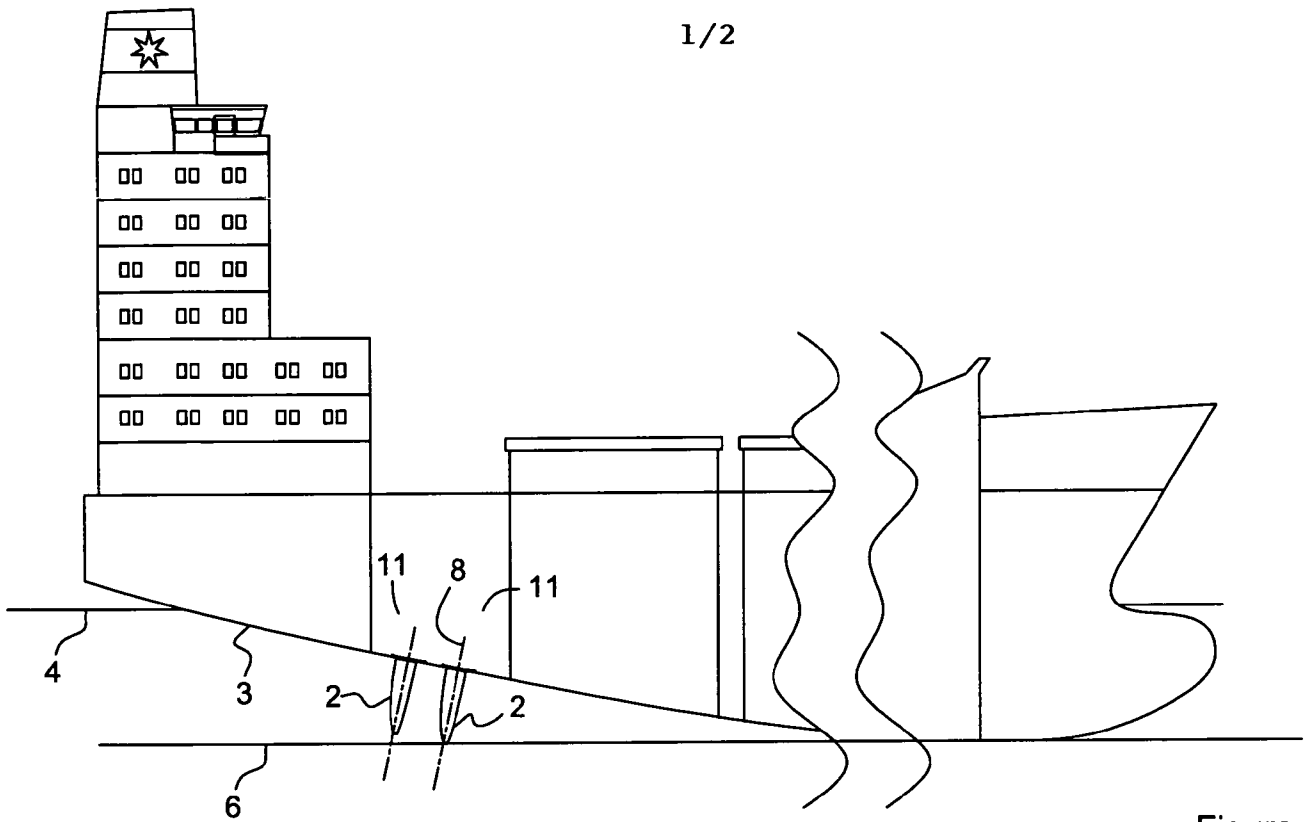


Figure 1

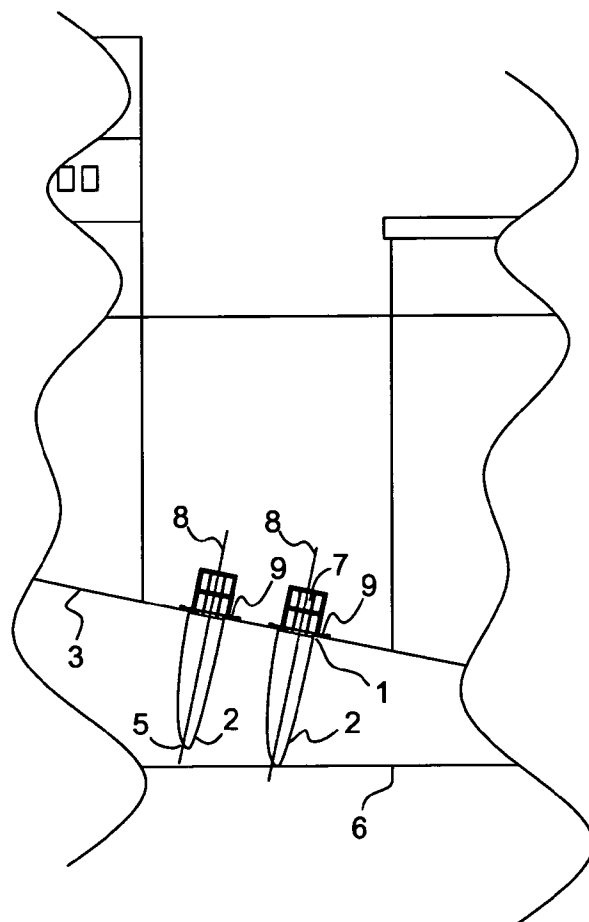


Figure 2

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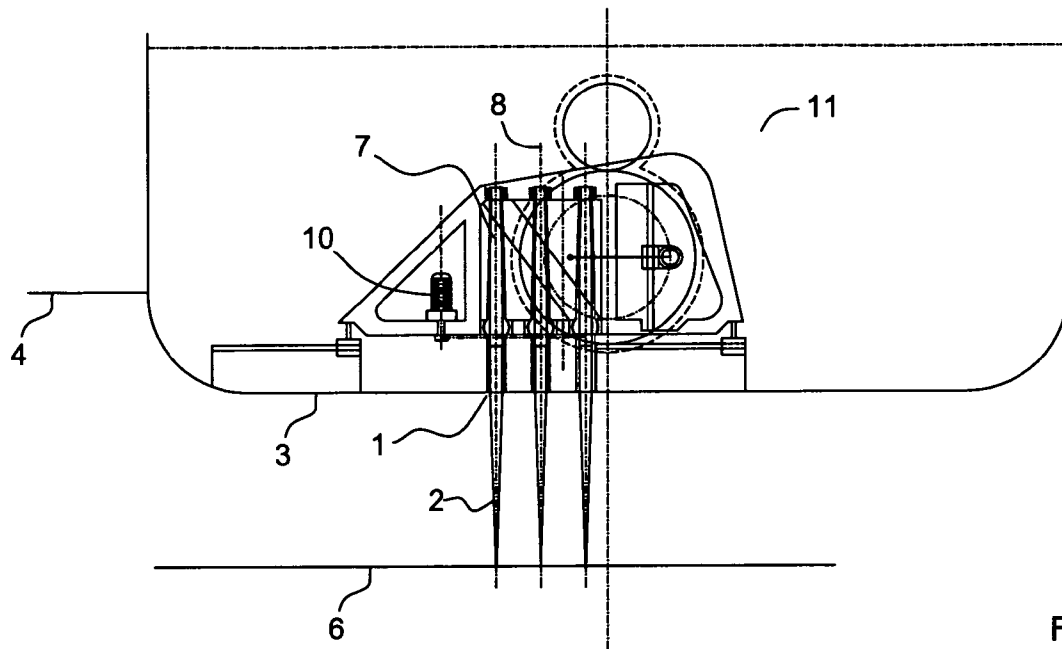


Figure 3

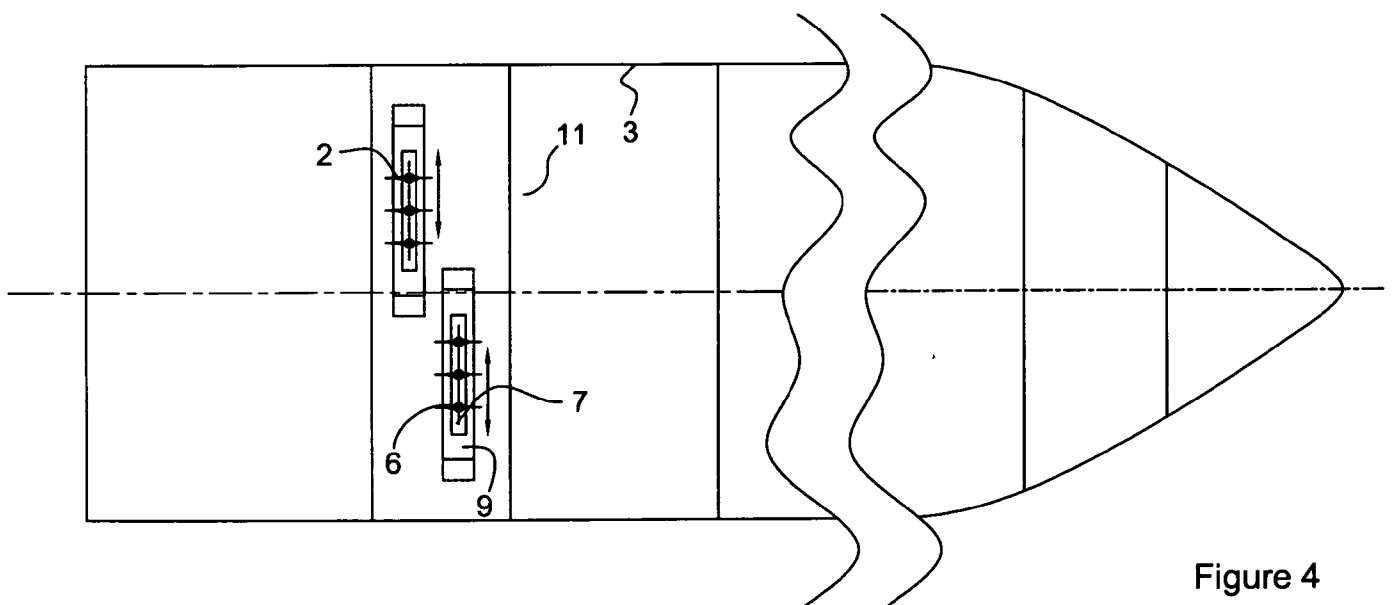


Figure 4

INTERNATIONAL SEARCH REPORT

International application No

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A. CLASSIFICATION OF SUBJECT MATTER
 INV. B63H1/36 B63H1/32

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B63H

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 28 49 027 A1 (KRAUS HELMUT) 14 May 1980 (1980-05-14) figures 6,8 -----	1,12
A	WO 91/08139 A (JAKOBSEN EINAR [NO]) 13 June 1991 (1991-06-13) figure 8 -----	1,12
A	DE 42 12 920 A1 (HENKER ERICH DR ING [DE]) 21 October 1993 (1993-10-21) figures 1,4,5 -----	1,12
A	US 5 401 196 A (TRANTAFYLLOU MICHAEL S [US] ET AL) 28 March 1995 (1995-03-28) cited in the application figures -----	1,12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
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- * & * document member of the same patent family

Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2008/067126

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