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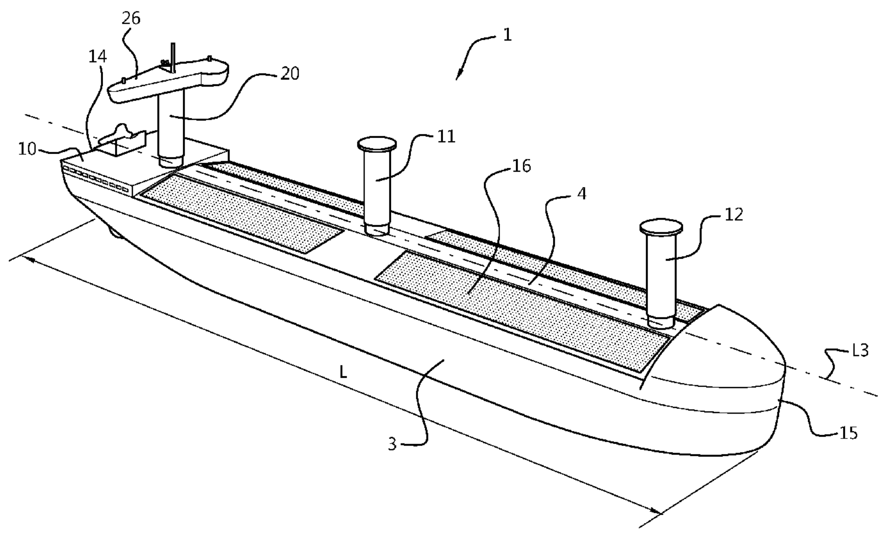
(54) Title: VESSEL WITH A ROTOR INSTALLATION

Fig. 1



(57) Abstract: A vessel provided with a vertical axis rotor installation comprising a rotor for generating thrust or electricity by action of the wind, wherein a bridge for directing navigation of the vessel is located above and supported by the rotor installation.

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[Continued on next page]

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

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Vessel with a rotor installation

BACKGROUND OF THE INVENTION

1. Field of the invention

[0001] The present invention relates to a vessel that is at least partially powered by wind energy. In particular, the invention relates to a vessel comprising a rotor such as a Flettner rotor for generating supplementary thrust.

2. Description of the related art

[0002] Saving energy is a major challenge for marine vessels. In order to reduce the amount of fuel, partial propulsion by means of wind energy using rotors that are rotatable around a vertical axis has been proposed. Such rotors include vertical-axis wind turbines and Flettner rotors. Flettner rotors are also known as Magnus rotors or rotor sails, and are essentially vertically oriented cylinders. The Flettner rotors, typically between one and four, are mounted on the deck and driven by a power source to rotate. When the rotors are exposed to wind from an angle which has a component perpendicular to the longitudinal axis of the vessel, the so-called Magnus effect generates a thrust in a direction perpendicular to the direction of the wind. The sense of rotation of the rotors can be chosen such that a thrust in the moving direction is generated. In this way, the propulsion of the vessels by e.g. diesel engines is supported by the thrust delivered by the rotors. Effectively, the rotors thus convert wind power into additional propulsion power for the vessel.

[0003] Using the rotors reduces the amount of fuel needed during navigation, particularly on long ocean crossings, which saves costs and reduces carbon emissions.

[0004] US2014137781 shows a vessel with a Flettner rotor, the content of which is incorporated herein by reference in its entirety.

[0005] However, rotors are also only presently practical on large carrier vessels such as tankers, having adequate unobstructed deck space for installation of the rotors. The cost of a rotor installation is also significant whereas the actual energy savings may be marginal. As yet, such rotors have not been widely implemented, partially due to limited overall cost-effectiveness.

SUMMARY OF THE INVENTION

[0006] It would be desirable to increase the cost-effectiveness of vessels with rotors.

[0007] It would also be desirable to provide a vessel which at least partially overcomes some of the inconveniences of the prior art.

[0008] According to the invention there is provided a vessel provided with a vertical axis rotor installation comprising a rotor for generating thrust or electricity by action of the wind, wherein a bridge for directing navigation of the vessel is located above and supported by the rotor installation.

[0009] The bridge needs to be placed at an elevated height above the deck of the vessel in order to ensure a unobstructed view for personnel in the bridge, for directing navigation of the vessel. In conventional vessels, a bridge is mounted above the deck as part of a superstructure. This requires any rotor installation to be placed on the deck at a certain minimum distance from the bridge in order to receive a relatively unobstructed flow of wind. As the bridge is usually mounted at the stern of the vessel, close to the rudder, the rotor installations are often positioned at a distance from the rudder. Such arrangement complicates manoeuvrability since wind reaction generates a significant moment on the vessel between the rotor installation and the rudder. Nevertheless, the rotor will, under certain wind conditions, still receive a disturbed flow of wind which is affected by the presence of the bridge on the deck.

[0010] The vessel according to the invention has the advantage that the bridge causes virtually no disturbance to the wind flow around the rotor, but in fact acts as an end plate for the rotor. Less disturbance improves the controllability and the effectiveness of the rotor installation. In a conventional vessel which has a large superstructure behind the rotor installation, such as that shown in Fig. 4 of US 4602584, disturbance of the wind flow by the bridge occurs when the wind comes at a narrow angle from behind. That is not the case for the present arrangement.

[0011] The bridge will of course be stationary with respect to the hull of the vessel, i.e. it does not rotate with the rotor. Although it is not excluded that the bridge could be mobile e.g. to improve visibility or for motion compensation. In the context of the present invention, reference to a bridge is understood to refer to the location from which the captain or first officer normally steers the vessel. It will be understood that with increased automation, certain functions may take place remotely and that the bridge may not always need to be manned. Nevertheless, certain functions will remain at this location and, at a minimum, the bridge should comprise a viewing camera and/or a platform for viewing the vessel and its immediate surroundings. Preferably, it further comprises GPS navigation equipment, compass and a communication system.

[0012] In the context of the present invention, the rotor is rotatable with respect to the vessel around a vertical axis. It will be understood that a slightly inclined axis is included in the scope of the present invention.

[0013] In an embodiment, the rotor installation comprises a vertically oriented column, wherein the rotor surrounds the column and is adapted to rotate around the column, and wherein the bridge is located above and supported by the column.

[0014] The column preferably extends above the rotor such that the bridge can extend laterally or longitudinally beyond the rotor without disturbing its rotation. If desirable, a further rotor can be built above the bridge.

[0015] The column may extend into the hull, below the main deck, possibly across at least two decks, in order to ensure a stable connection of the column to the decks and the hull. In this way, shear forces and moments can be handled by the structural arrangement. The column may extend into the hull for at least 25% of the height of the hull between keel and main deck and may even extend all the way to the keel.

[0016] The rotor is adapted to exert a propulsive force on the vessel due to the wind. Any rotors or sails can be used, as long as they have a rotor which is rotatable with respect to a column, around a vertical axis. The vessel may additionally have an engine, such as a diesel engine, for propulsion. In normal operation, part of the propulsive power of the vessel is delivered by the rotor. In an embodiment, between 3% and 6% of the propulsive power may be delivered by the rotor. The relative share of thrust is dependent on the design of vessel and rotor as well as on the sailing speed of the vessel.

[0017] The rotor may have any suitable shape that allows it to perform its function of generating thrust or electricity by action of the wind. The rotor may have a height of between 5 and 35 metres, depending on vessel size on which it will be installed, preferably between 10 and 30 metres, more preferably between 15 and 25 metres. Although a larger height will result in a larger potential thrust generated by the rotor, it may also increase acceleration levels at the bridge and potentially negatively influence the stability since it elevates the centre of gravity of the vessel. The acceleration levels at the bridge should remain limited, which additionally limits the height of the rotor installation. Also the weight of the bridge is relevant, as the rotor installation should be strong enough to ensure mechanical stability, including when experiencing heavy winds. The diameter and height of the rotor installation may thus be chosen depending on the size of the bridge and the vessel. It will be understood that a slightly inclined column with respect to the vertical is included in the scope of the present invention.

[0018] In an embodiment, the rotor comprises a Flettner rotor.

[0019] The Flettner rotor is preferably cylinder-shaped. The outer diameter of the rotor may be between 3 and 15 metres depending on vessel size on which it is installed, preferably between 5 and 10 metres, more preferably between 6 and 8 metres. For the purpose of the present invention, reference to a Flettner rotor is understood to mean an essentially smooth, cylindrical shell which is spun along its longitudinal axis. The rotor is arranged such that, when it is exposed to wind at a right angle from the longitudinal axis, it causes an aerodynamic force in the direction perpendicular to the wind direction and the longitudinal axis.

[0020] A Flettner rotor is also referred to as Magnus rotor or rotor sail. When using a Flettner rotor, the column may be cylindrical, wherein the rotor has an inner radius which may be slightly greater, e.g. 10% greater, than the outer radius of the column. The rotor installation may comprise a drive for driving the rotation of the rotor with respect to the column. The drive may be placed near the top of the rotor, close to the bridge or integrated with the bridge. Alternatively, the drive may be located close to the bottom of the bridge such as is the case with conventional Flettner rotors. The rotor installation comprises suspension means such as bearings to support the rotor. The bearings may be provided at or near the top of the rotor, near the middle and/or near the bottom of the rotor. Bearings and drive may be combined, for instance by wheels which are driven and support the rotor, but they may also be separated, depending on the structural requirements of the rotor.

[0021] When the Flettner rotor rotates, wind will exert a force onto the vessel perpendicular to the wind direction. Therefore, wind with a non-zero component perpendicular to the longitudinal axis of the vessel will result in a propulsive force along the longitudinal axis of the vessel. In use, the sense of rotation of the rotor is chosen such that the propulsion force is directed in the preferred moving direction of the vessel.

[0022] As an alternative to a Flettner rotor, the rotor may also be a conventional vertical axis wind turbine for generating electricity.

[0023] In an embodiment, the rotor extends at least 50%, preferably more than 80% of a distance between a main deck of the vessel and the bridge. The rotor may extend less than 95% or less than 90% of a distance between a main deck of the vessel and the bridge. Between a lower edge of the rotor and the main deck there may be a free distance of at least three metres, to allow access to the column and to allow personnel to walk on the deck below the rotor.

[0024] In an embodiment, the rotor installation comprises a staircase and/or an elevator shaft extending from a main deck to the bridge, wherein the bridge is accessible from the staircase or an elevator in the elevator shaft.

[0025] The staircase and/or elevator shaft are preferably placed within the column, such that they do not disturb the wind flow around the rotor. At the same time, the staircase and/or elevator shaft are shielded from the environmental conditions to improve safety and durability.

[0026] In an embodiment, the column comprises a staircase and an emergency ladder, both providing access to the bridge, and a safety wall separating the staircase from the emergency ladder. In this way there are two separate, independent exits from the bridge in the event of e.g. fire. The safety wall preferably complies with A-60 division regulations.

[0027] In an embodiment, the rotor installation comprises an exhaust pipe having an outlet above the rotor installation, for exhaust of e.g. combustion gases from the vessel's motors.

[0028] The column may comprise at least one exhaust pipe or all exhaust pipes of the vessel. When exhaust pipes are placed inside the column, they do not disturb the wind flow around the rotor. Also, the exhaust pipes can be easily accessed for maintenance or checks using the staircases in the column. Integration of the exhaust pipes with the rotor installation and superstructure supporting the bridge results in a compact and efficient construction, such that the only wind load above the deck is on the rotor and bridge.

[0029] In an embodiment, the bridge extends beyond the rotor towards a lateral side or both lateral sides of the vessel.

[0030] In this way, the viewing scope of personnel inside the bridge is enlarged. The bridge may extend to the lateral sides of the vessel, which will be convenient for mooring.

[0031] In an embodiment, the vessel is a tanker, or a vessel with unobstructed deck space i.e. without cargo on the deck.

[0032] Vessels with substantially planar, cargo-free decks are preferred since they have less disturbance to the wind flow around the rotor. However, the invention may apply to other vessels too. In particular, since maximum advantage is achieved when the wind is abeam, a vessel with an elevated bow or cargo in the bow area may nevertheless have benefit from a rotor mounted at the stern. The vessel may have any length, but typically more than 80 metres, preferably between 150 and 450 metres, more preferably between 200 and 400 metres. Tankers or bulk carriers are particularly advantageous since they have a reasonably low sailing speed (up to 16 knots, but typically around 12 knots), which gives a relatively higher fuel saving potential to the rotors. Also, tankers or bulk carriers generally do not require large cranes or other voluminous deck equipment, which may disturb wind flow around the rotors.

[0033] In an embodiment, the rotor installation is positioned on a centre line connecting bow and stern of the vessel. Such a symmetric configuration benefits the viewing angles of the personnel in the bridge as well as the stability of the vessel.

[0034] In an embodiment, a longitudinal distance between a rudder for steering the vessel and a rotation axis of the rotor is less than 10% of a length of the vessel.

[0035] Positioning the rudder close to the rotor improves the manoeuvrability of the vessel. The moment on the vessel caused by wind-induced force is thus limited, since this moment depends on the longitudinal distance between a rudder and the rotation axis.

[0036] In an embodiment, the rotor is substantially unobstructed from exposure to wind. ‘Substantially unobstructed’ means in this context that no wind-blocking obstacle which extends more than 10% of the rotor height above the horizontal plane defined by the lower edge of the rotor, is located within a distance equal to the rotor height from the rotor. The area directly astern of the rotor may be excluded from this determination, since wind from astern will not generate a component of thrust in the direction of movement.

[0037] In an embodiment, the vessel comprises an accommodation block which is arranged lower than the rotor. The accommodation block may be accessible from the bridge via a column which is surrounded by the rotor. The accommodation block may be provided directly below the rotor installation, or next to it, but still provided entirely at a lower height than the rotor.

[0038] In an embodiment, the main deck is arranged lower than the rotor, and all cargo is arranged below the main deck.

[0039] In any case, disturbance of accommodation block and cargo to the wind flow around the rotor should be prevented as much as possible.

[0040] In an embodiment, the vessel comprises at least one or at least two further rotor installations.

[0041] Multiple rotor installations allow for more propulsive force to the vessel compared to a single rotor installation, thus further reducing costs and fuel consumption. The reduction in fuel and costs due to the rotor installations may be between 3% and 30%, preferably at least 10%, depending on the number of further rotor installations. The further rotor installations all comprise a rotor and are preferably in accordance with the rotor installation as described above. In an embodiment, one of the further rotor installations comprises a stationary column which comprises at least one exhaust pipe with an outlet above the rotor installation. All rotor installations may have the same size. Preferably, the further rotor installations are positioned on a centre line connecting bow and stern of the vessel. In an embodiment, the rotor installations are evenly distributed along the length of the vessel, i.e. a longitudinal distance between pairs of adjacent rotors is substantially equal. In this way, the rotors have minimum influence on one another.

[0042] In an embodiment, the bridge is asymmetric with respect to a centre line connecting bow and stern of the vessel, as seen in plan view. The bridge may, at one side, comprise a protruding part which protrudes forward with respect to the rotor, so as to allow personnel in the protruding part to view at least 180 degrees of the horizontal viewing angle, for instance from a view at a right angle at starboard via frontal view to a view at a right angle at portside. The protruded part is the part which is typically used for the captain or first officer to oversee the movement of the vessel and/or to direct navigation of the vessel. The protruded part may comprise a viewing camera and/or a platform for viewing the vessel and its immediate surroundings. Preferably, the protruded part further comprises GPS navigation equipment, compass and a communication system. This asymmetric arrangement is especially advantageous when other rotor installations are located on the centre line in front of the bridge.

[0043] According to a further aspect of the invention, and in accordance with the advantages and effects described hereinabove, there is provided a vessel, having a hull and at least a main deck, and further comprising a bridge for directing navigation of the vessel at an elevated height above the main deck, supported by a vertical column which is structurally connected to the hull and/or the main deck, wherein a rotor for generating thrust or electricity by action of the wind is mounted surrounding the column and adapted to rotate with respect to the column.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] The features and advantages of the invention will be further appreciated upon reference to the following schematic drawings of a number of exemplary embodiments, in which corresponding reference symbols indicate corresponding parts.

[0045] Figure 1 schematically shows a vessel with a rotor installation according to an embodiment;

[0046] Figure 2 schematically shows a side view of the vessel of Figure 1;

[0047] Figure 3 schematically shows a cross-sectional top view of the rotor of the vessel of Figures 1 and 2.

[0048] The figures are for illustrative purposes only, and do not serve as a restriction on the scope or the protection as laid down by the claims.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0049] Figure 1 schematically shows a vessel 1 with a rotor installation 20. The rotor installation 20 is provided near the stern 14 of the vessel 1. An accommodation block 10 is arranged on a single floor in order to stay entirely below the rotor installation 20, and not disturb the wind flow around it. The vessel 1 comprises a bridge 26 on top of the rotor installation 20 and stationary with respect to the hull 3. The bridge 26 is thus positioned well above the deck 4 to ensure broad viewing angles for the personnel in the bridge 26, without disturbing the wind flow around the rotor installation 20.

[0050] The vessel 1 comprises further rotor installations 11, 12 amidships and near the bow 15 of the vessel 1. All rotor installations 20, 11, 12 are provided on a centre line L3 connecting the bow 15 to the middle of the stern 14 of the vessel 1. The rotor installations 20, 11, 12 are distributed evenly along the length L of the vessel 1 with large distances in between, such that they do not disturb each other's wind flow. Solar panels 16 are located on the deck 4, which generate electricity used for propulsion or otherwise. Apart from the rotor installations 20, 11, 12, the only items that extend higher than the accommodation block 10 are small structures such as fences, venting house and lifeboat, which have little effect on the flow of wind around the rotor installation 20.

[0051] Figure 2 shows a side view of the vessel 1 of Figure 1, not necessarily to scale. The rotor installation 20 comprises a cylindrical column 21 and a cylindrical rotor 22. The column 21 is structurally connected to the vessel 1, e.g. to the hull or to the deck 4. The rotor 22 is rotatably connected to the vessel 1, for instance to the column 21 by means of bearings (not shown). The column 21 extends substantially from a first level L1 near the deck 4 to a second level L2 at the bridge 26. The rotor 22 can rotate around the column 21 defining a vertical rotation axis a. The bridge 26 is mounted on top of the column 21, such that the rotation of the rotor 22 is not affected. Exhaust pipes 25 extend through the column 21 and vent above the bridge 26. In this way, the exhaust gases are released at a sufficient height above the deck 4 and above the accommodation block 10, such that inconvenience and also wear and corrosion is prevented as much as possible. A distance D is defined as the longitudinal distance between the rudder 13 and the rotation axis a. The distance D is preferably as small as possible, in order to reduce the moment about the rudder 13 of any forces acting on the rotor 22. The rotation of the rotor 22 is driven by a drive 31 which is provided at the top side of the rotor 22. Alternatively, the drive may be located near the bottom of the rotor 22.

[0052] Figure 3 shows a cross-sectional top view of the rotor installation 20 as shown in Figures 1 and 2, as indicated by the dashed line referenced by 'III' in Figure 2. The rotor 22 is a cylindrical shell, rotatable around the double-walled column 21. At the first level, doors 27 are provided for access to the column 21. In this embodiment, the column 21 comprises a staircase 23 and a shaft for an elevator 24, as well as exhaust pipes 25. In this way, there are multiple routes to access the bridge. The staircase 23 simultaneously serves as access to the bridge and as access to the exhaust pipes 25, e.g. for maintenance and checks. The column 21 further comprises an emergency ladder 29 which can serve as an exit for the bridge in the event of an emergency. The emergency ladder 29 and staircase 23 are provided in different portions of the column 21 which are separated by a safety wall 30, which is preferably fireproof and gastight. The column 21 may have several floors mounted at different heights between the first level and the second level, and accessible by the elevator 24 and/or by the stairs 23.

[0053] The dashed line surrounding the rotor 22 indicates the contour of the bridge 26, including the protruding part 28 which protrudes forward with respect to the rotor 22 to allow a wider view to the personnel.

[0054] The invention has been described by reference to certain embodiments discussed above. It will be recognized that these embodiments are susceptible to various modifications and alternative forms well known to those of skill in the art.

[0055] Many modifications in addition to those described above may be made to the structures and techniques described herein without departing from the spirit and scope of the invention.

Accordingly, although specific embodiments have been described, these are examples only and are not limiting upon the scope of the invention. In particular, although the examples show only the most stern-side rotor installation supporting the bridge, a person skilled in the art will understand that alternatively a middle rotor installation or the most bow-side rotor installation may support the bridge.

CLAIMS

1. A vessel provided with a vertical axis rotor installation comprising a rotor for generating thrust or electricity by action of the wind, wherein a bridge for directing navigation of the vessel is located above and supported by the rotor installation.

2. Vessel according to claim 1, wherein the rotor installation comprises a vertically oriented column, wherein the rotor surrounds the column and is adapted to rotate around the column, and wherein the bridge is located above and supported by the column.

3. Vessel according to claim 1 or 2, wherein the rotor comprises a Flettner rotor.

4. Vessel according to any one of the preceding claims, wherein the rotor extends at least 80% of a distance between a main deck of the vessel and the bridge.

5. Vessel according to any one of the preceding claims, wherein the bridge comprises a viewing camera or viewing platform and preferably steering control, GPS navigation equipment, compass and/or a communications system.

6. Vessel according to any one of the preceding claims, wherein the rotor installation comprises a staircase and/or an elevator shaft extending from a main deck to the bridge, wherein the bridge is accessible from the staircase or an elevator in the elevator shaft.

7. Vessel according to any one of the preceding claims, wherein the rotor installation comprises an exhaust pipe having an outlet above the rotor installation.

8. Vessel according to any one of the preceding claims, wherein the bridge extends beyond the rotor towards a lateral side or both lateral sides of the vessel.

9. Vessel according to any one of the preceding claims, wherein the vessel is a tanker or bulk carrier.

10. Vessel according to any one of the preceding claims, wherein the rotor installation is positioned on a centre line connecting bow and stern of the vessel.

11. Vessel according to any one of the preceding claims, wherein a longitudinal distance between a rudder for steering the vessel and a rotation axis of the rotor is less than 10% of a length of the vessel.

12. Vessel according to any one of the preceding claims, wherein the rotor is substantially unobstructed from exposure to wind.

13. Vessel according to any one of the preceding claims, wherein the vessel comprises an accommodation block which is arranged lower than the rotor.

14. Vessel according to any one of the preceding claims, wherein a main deck of the vessel is arranged lower than the rotor, and wherein all cargo is arranged below the main deck.

15. Vessel according to any one of the preceding claims, wherein the vessel comprises at least one or at least two further rotor installations comprising rotors.

16. Vessel according to any one of the preceding claims, wherein the bridge has an asymmetric shape with respect to a centre line connecting bow and stern of the vessel.

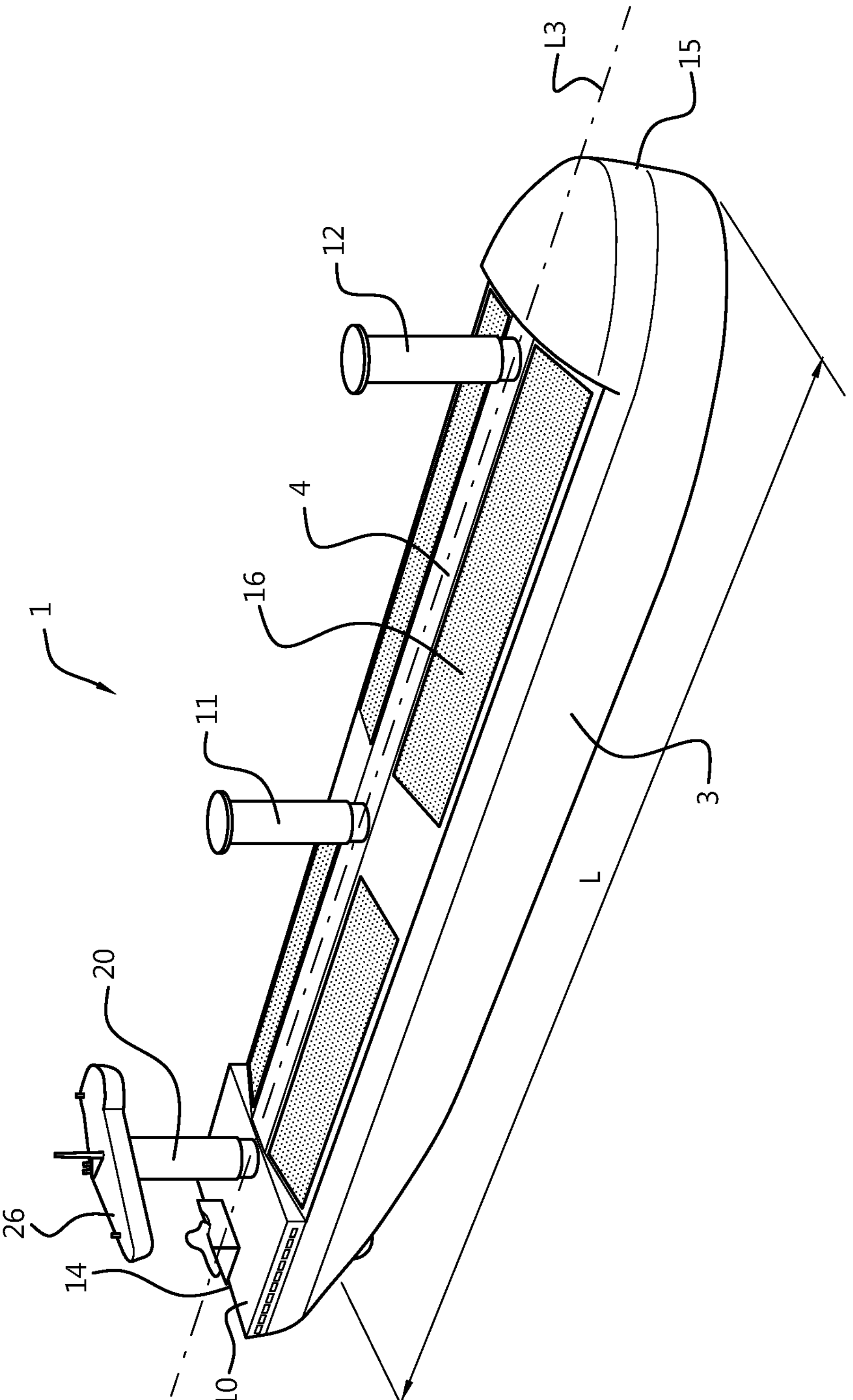


Fig. 1

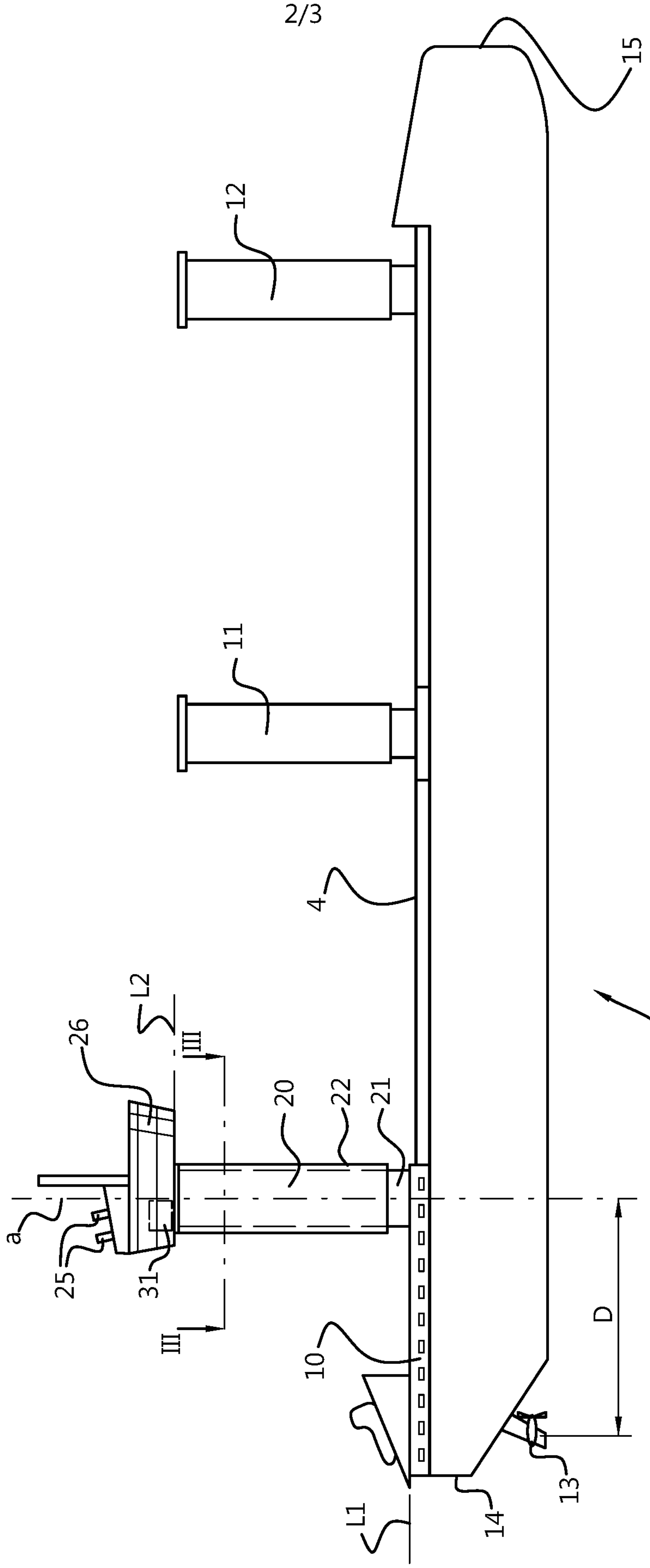
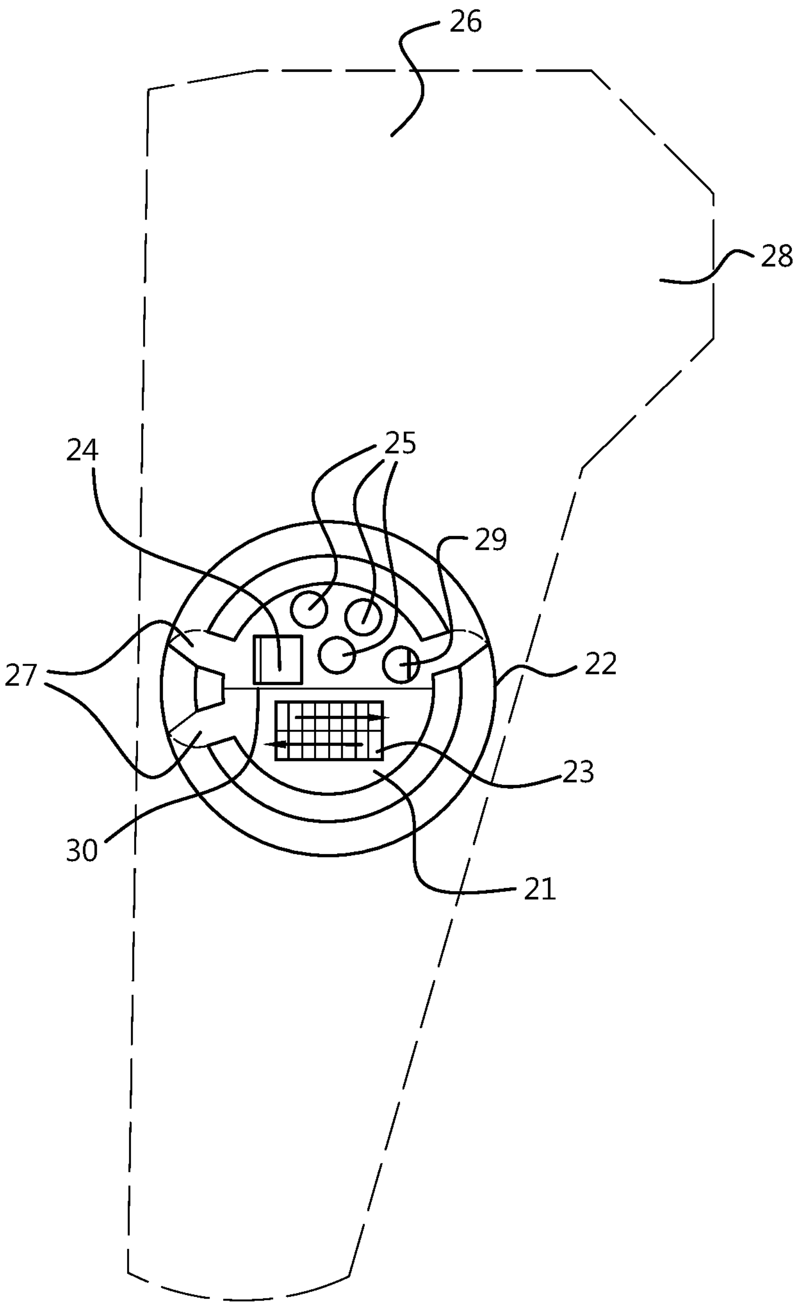


Fig. 2

Fig. 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2019/050563

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63H9/02
ADD.

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 398 895 A (ASKER GUNNAR C F [US]) 16 August 1983 (1983-08-16) column 3, line 6 - column 9, line 6; figure 10	1-16
A	US 2014/196648 A1 (HOLOHAN ERIC [US] ET AL) 17 July 2014 (2014-07-17) paragraph [0025] - paragraph [0126]; figures 1-19	1-16

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Martínez, Felipe

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2019/050563

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4398895 A	16-08-1983	NONE	
US 2014196648 A1	17-07-2014	US 2014196648 A1 US 2016332712 A1	17-07-2014 17-11-2016