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(54) **Attaching device and method for attaching a vessel to a wind power plant, and vessel**

(57) The invention relates to a mooring device (100) for mooring a vessel (200) to a wind power plant (300), which device (100) comprises a frame (110) and a joint (130) arranged in connection with the frame (110), with the aid of which joint the mooring device (100) can be attached to the vessel (200). The mooring device (100) comprises at least two gripping means (120) for gripping impact shields (310) of the wind power plant, which gripping means (120) are attached to the frame (110) in an immobile manner. The invention also relates to a vessel (200) and a method for mooring the vessel (200) to a wind power plant (300).

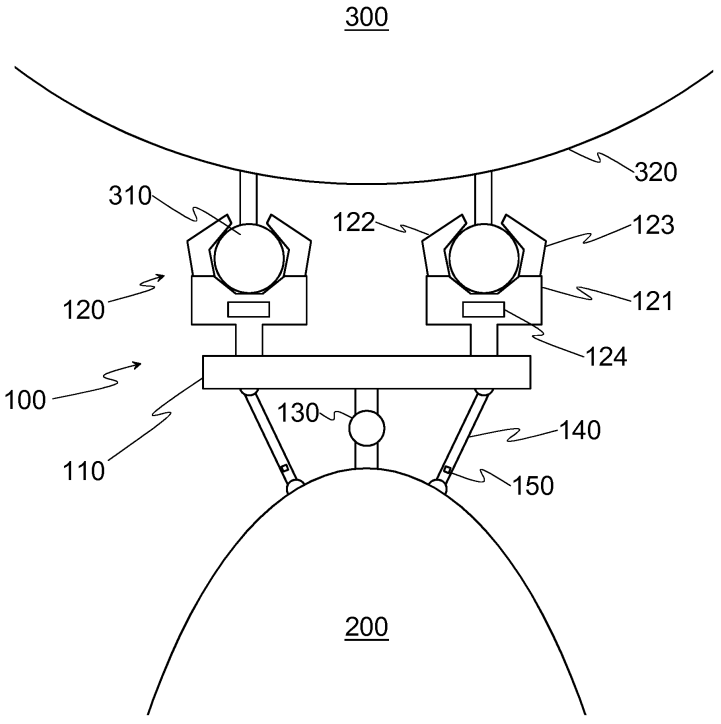

FIG. 1

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a mooring device and a method for mooring a vessel to a wind power plant according to the preambles of the independent claims presented below. The invention also relates to a vessel, which can be moored to a wind power plant.

BACKGROUND OF THE INVENTION

[0002] Electric energy is produced both by using renewable and non-renewable natural resources. With the Kyoto protocol approved in 1997, the interest in limiting greenhouse emissions and thus controlling climate change has increased. Thus the share of electricity produced with renewable natural resources out of the total electricity production has grown during the last few years. Especially the use of wind power has increased significantly.

[0003] Wind power plants are usually placed in groups of a few units in coast and sea areas and in elevated and open inland areas. The power of a single wind power plant is typically 1-3 MW and the height can even be over 100 m. For the operating efficiency of the wind power plant to be sufficient, the mean wind speed must be at least 6 m/s at the location of the wind power plant.

[0004] Even though wind power plants are generally considered to be reliable, it is clear that wind power plants need to be serviced regularly in order to ensure a flawless operation. Especially the service of wind power plants at sea is however challenging, because the transfer of service personnel and the transfer of the equipment they need between the vessel and the wind power plant is difficult, especially during rough seas.

[0005] Typically the transfer of people and equipment is carried out so that the prow of the service vessel is driven against impact shields attached to the body of the wind power plant and the vessel is held to the impact shields with the aid of a propulsion force obtained with a propulsion device of the vessel. The aim is to keep the vessel in place with the aid of the steering devices of the vessel and by adjusting the propulsion force of the propulsion device. A problem with the method is that keeping the vessel in place is difficult and in practice impossible in rough seas. Thus the transfer of the personnel from the vessel to the wind power plant and back may even be life-threatening. Because a propulsion device is used in the method for keeping the vessel moored to the wind power plant, the method is only applicable for short-term mooring. Rope or another corresponding mooring means is typically used for long-term mooring. Mooring of the rope to the wind power plant and detaching thereof from the wind power plant are however difficult and dangerous, especially in rough seas.

[0006] Publication WO 02/20343 A1 shows a vessel, which has an apparatus, with the aid of which the vessel can be moored to a pillar structure at sea. The apparatus comprises a telescopically adjustable landing platform, the first end of which is attached to the vessel. The second end of the landing platform, on the other hand, is equipped with a gripping means, with which the pillar structure is gripped. A problem with the apparatus is that when the vessel is moored, the position and length of the landing platform may freely change, which makes the transfer of people to the vessel and away from the vessel harder, especially in rough seas.

OBJECTS OF THE INVENTION

[0007] It is an object of the present invention to reduce or even completely eliminate the above-mentioned problems and flaws, which appear in the prior art.

[0008] It is an object of the present invention to provide a mooring device and a method, with the aid of which a vessel can easily be moored to a wind power plant. It is also an object of the invention to provide a mooring device and a method, with which the movements of the vessel moored to a wind power plant can be kept small even in rough seas.

[0009] It is further an object of the present invention to provide a mooring device, which withstands great forces and is thus applicable for use also in rough seas. It is also an object of the present invention to provide a mooring device, which is applicable both for short-term and long-term mooring.

[0010] It is also an object of the present invention to provide a vessel, which can be moored to a wind power plant and which stays moored to the wind power plant even in rough seas.

[0011] The above-mentioned disadvantages can be reduced or even completely eliminated, and above-mentioned objects are attained with the present invention, which is characterised in what is defined in the characterising parts of the independent claims presented further below.

[0012] Some preferred embodiments according to the invention are disclosed in the dependent claims presented further below.

DESCRIPTION OF THE INVENTION

[0013] A typical mooring device according to the invention for mooring a vessel to a wind power plant comprises a frame and a joint arranged in connection with the frame, with the aid of which joint the mooring device can be attached to the vessel. A typical mooring device according to the invention is **characterized in that** it comprises at least two gripping means for gripping the impact shields of the wind power plant, which gripping means are attached to the frame in an immobile manner.

[0014] Because the gripping means in the mooring device according to the invention have been attached to the frame in an immobile manner, the vessel moored to the wind power plant can move only so that it rotates

around a pivot point defined by the joint connecting the vessel and the frame. Due to the immobile attachment, the gripping means cannot rotate in relation to the frame.

[0015] It is an advantage of the mooring device according to the invention that the movements of the vessel moored to the wind power plant can be kept small even in rough seas, because the vessel can rotate only around one pivot point. Therefore the transfer of people onto the vessel and from the vessel is easier than with solutions according to prior art. The mooring device according to the invention is suitable for use even in 2.5 meter high waves.

[0016] The joint is preferably of a three axis type. The joint is typically formed of two parts, of which the first joint part attaches to the frame and the second joint part to the vessel. The joint may for example be a ball joint, the ball-shaped joint surface of which allows movement directed in all spatial directions. An advantage of pivoting is that forces directed to the gripping means via the vessel are significantly decreased compared to a situation, where the mooring device is attached to the vessel in an immobile manner.

[0017] The mooring device according to the invention makes possible the mooring of a vessel, such as for example a boat or a ship, to a wind power plant at sea. The mooring is achieved with gripping means, with which the impact shields of the wind power plant are gripped. Preferably the gripping means are used to grip two vertical impact shields, which are situated at a distance from each other. The pressing force of the gripping means is preferably dimensioned so that the grip of the gripping means holds even in rough seas. The mooring device according to the invention is also applicable for mooring to impact shields of other structures at sea, such as oil rigs and production platforms.

[0018] In this text wind power plant means a device, with which the motion energy of the wind, i.e. the flowing air, is via rotating blades transformed into rotation energy of a turbine axis. The axis further rotates a generator, which produces electricity. The wind power plant typically further comprises a transmission, with the aid of which the rotating motion is adapted to suit the generator, and a mast, to the top end of which the machinery of the wind power plant is installed.

[0019] The impact shield of the wind power plant means a structure attached at the bottom end of the mast of the wind power plant, near the sea surface, the purpose of which structure is to prevent the vessel from hitting the mast of the wind power plant and thereto attached other structures, such as ladders, and to thereby protect the wind power plant from damage. Traditionally the prow of the vessel is driven against the impact shields of the wind power plant and the vessel is kept attached to the impact shields with the aid of the propulsion force achieved with the propulsion device of the vessel. The impact shields are typically tube-like structures parallel to the mast, the distance between which is 1-3 m and the diameter of which is 200-350 mm. The wind power plant usually has at least two impact shields.

[0020] According to an embodiment of the invention the gripping means comprises a frame part, which is attached to the frame in an immobile manner, and a first gripping arm and a second gripping arm, which are turnably attached to the frame part. The gripping arms are attached to the frame part so that they form a grab, which can be used to grip the impact shield. In other words the gripping arms function as jaws, between which the impact shield is pressed. The gripping arms are preferably arranged to be moveable, so that they move in the same plane. The gripping arms can be attached to the frame part for example with the aid of a hinge.

[0021] According to an embodiment of the invention a gripping means has been attached at both ends of the frame. The frame is preferably elongated. There can also be more than two, for example three, four, five or six, gripping means attached to the frame. The advantage with more than one gripping means is that different impact shields can then be gripped and thus a sturdier mooring to the wind power plant is achieved.

[0022] The distance between the gripping means is typically essentially the same as the distance between the impact shields, whereby more than one impact shield can be held on to at the same time. The distance between the gripping means can be for example in the range on 1-2 m or 2-3 m. The distance between the gripping means can also be adjustable, whereby said distance is adjustable to the distance between the impact shields of different wind power plants. The frame of the mooring device can have an elongated shape, in the longitudinal direction of which frame the gripping means are moveable to achieve a desired distance.

[0023] According to an advantageous embodiment of the invention the mooring device comprises at least one damper for damping the movement between the mooring device and the vessel, the first end of which damper is attached to the frame and the second end of which damper can be attached to the vessel. Both ends of the damper are preferably attached in a pivoted manner.

[0024] The damper can for example be a spring damper or a hydraulic damper. The damper is **characterized in that** it strives to return to its balance position, when an external force affects it. Thus the damper strives to keep the mutual position of the mooring device and the vessel unchanged. When the vessel moored to the wind power plant turns due to swell of the sea, the damper between the frame of the mooring device and the vessel generates a force, which strives to return the vessel into its original position. The propulsion device and/or the steering devices of the vessel can also be used for returning the vessel to its original position.

[0025] According to a preferred embodiment a damper is attached at both ends of the frame. There can also be more than two, for example three, four, five or six, dampers attached to the frame.

[0026] According to an embodiment of the invention the damping of the damper is adjustable. Changing the

damping of the damper affects what kind of response a certain impulse generates in the damper. In other words how the damper reacts to the movements of the vessel. The damper can be adjusted for example so that a small force directed onto the damper generates a large change in the length of the damper. On the other hand the damper can be adjusted so that even a small change in the length of the damper requires a large force to be directed onto it. The damping can affect the magnitude of the forces directed onto the mooring device.

[0027] According to an embodiment of the invention the length of the damper corresponding to the balance position of the damper is adjustable. In other words the length of the damper can be changed so that the balance position of the damper simultaneously moves.

[0028] By changing the length of the damper corresponding to the balance position of the damper, the mutual balance position of the mooring device and the vessel can be changed, in other words the position to which the damper strives to return the vessel. The restoring force achieved with the damper can be increased by using the vessel's own propulsion device and the vessel's steering devices. The rotation of the vessel in relation to the wind power plant can be restricted for example with the aid of hydraulic cylinders.

[0029] According to an embodiment of the invention the damper comprises a force sensor for measuring the force directed onto the damper. The mooring device preferably also comprises information collecting means for collecting the measuring data obtained from the force sensor and information processing means for processing the collected measuring data.

[0030] For example the damping of the damper can be adjusted based on the measured force. The position of the vessel in relation to the mooring device can also be deduced based on the measured force, and the vessel can be turned into a desired position for example by changing the length corresponding to the balance position of the damper. The vessel can also be turned by using the vessel's propulsion device and/or steering devices.

[0031] According to an embodiment of the invention the gripping means comprises at least one electric magnet, with the aid of the magnetic pull generated by which the gripping means is pulled toward the impact shield. The magnetic pull generated by the electric magnet can be used also when the vessel is moored. In some situations the vessel can be held to the impact shield with the aid of only the electric magnet. The power of the magnet can preferably be adjusted according to demand.

[0032] A typical vessel according to the invention comprises a mooring device for mooring the vessel to a wind power plant, which mooring device comprises a frame and a joint arranged in connection with the frame, with the aid of which joint the mooring device is attached to the vessel. The mooring device of the vessel comprises at least two gripping means for gripping the impact shields of the wind power plant, which gripping means are attached to the frame in an immobile manner.

[0033] According to a preferred embodiment of the invention the vessel is a trimaran, which comprises a middle hull and side hulls on both sides thereof.

[0034] According to a preferred embodiment of the invention the mooring device is attached to the prow of the vessel. When the mooring device is situated in the prow of the vessel, the vessel can be driven straight toward the wind power plant, so that the gripping means of the mooring device hit the impact shields of the wind power plant.

[0035] The invention further relates to a method for mooring a vessel to a wind power plant, in which method the vessel is driven into contact with the wind power plant. The method according to the invention is **characterized in that** at least two gripping means of the mooring device of the vessel are used to grip the impact shields of the wind power plant and movement of the vessel in relation to the wind power plant is allowed only around one pivot point. In the method according to the invention the vessel moored to the wind power plant can thus move only so that it rotates around one pivot point.

[0036] The position of the vessel moored to the wind power plant can be examined by measuring the forces affecting the dampers of the mooring device. Based on the measured forces, the damping of the dampers and/or their length can be adjusted. Additionally based on the measured forces, the propulsion device of the ship and/or steering devices of the ship can be controlled so that the ship stays essentially in its place in relation to the mooring device.

[0037] The embodiments and advantages mentioned in this text relate, where applicable, to each of the mooring device, vessel as well as method according to the invention, even if this is not always specifically mentioned.

BRIEF DESCRIPTION OF THE DRAWING

[0038] In the following the invention will be described in more detail with reference to the embodiments presented as examples and the enclosed figures, in which

Fig. 1 shows from above a situation, where a vessel is moored to a wind power plant with a mooring device according to an embodiment of the invention, and

Fig. 2 shows the situation according to Figure 1 seen from the side.

DETAILED DESCRIPTION OF THE DRAWING

[0039] Figure 1 shows from above a situation, where a vessel is moored to a wind power plant at sea with a mooring device according to an embodiment of the invention. Figure 2 shows the situation according to Figure 1 seen from the side.

[0040] The mooring device 100 comprises a frame 110, in both ends of which a gripping means 120 has been attached. The mooring device 100 is attached to the prow of the vessel 200 via a joint 130. The joint 130 is of a three axis type and thus allows the vessel 200 to move freely in relation to the pivot point.

[0041] The gripping means 120 are moveable in the longitudinal direction of the frame 110. In the situation shown in Figures 1 and 2 the distance between the gripping means 120 is adjusted to be as large as the distance between the impact shields 310 of the wind power plant 300.

[0042] The gripping means 120 comprise a frame part 121 and gripping arms 122, 123, which are attached in a pivoted manner to the frame part 121. The gripping arms 122, 123 are moveable, whereby the gripping means can be used to grip the impact shield 310 and to detach from it. In the situation shown in Figures 1 and 2 the gripping means 120 have gripped the impact shields 310. The impact shields 310 are vertical tubes, which are attached to the lower end of the mast 320 of the wind power plant 300, near the sea surface.

[0043] The gripping means 120 further comprise an electric magnet 124 attached to the frame part 121. With the aid of the pull generated with the electric magnet 124, the gripping means 120 can be pulled toward the impact shield 310, when a mooring to the wind power plant 300 is made. On the other hand the pull generated by the electric magnet 124 can also be used when the gripping means 120 is attached to the impact shield 310, as in the situation shown in Figures 1 and 2.

[0044] In order to minimize and damp the movement between the mooring device 100 and the vessel 200, dampers 140 have been attached between the ends of the frame 110 and the prow of the vessel. The ends of the dampers 140 are pivotedly attached both to the frame 110 and to the vessel 200.

[0045] The dampers 140 strive to keep the mutual position of the mooring device 100 and the vessel 200 unchanged. When the vessel 200 moored to the wind power plant 300 turns due to swell of the sea, the dampers 140 attached between the frame 110 of the mooring device 100 and the vessel 200 generate a force, which strives to return the vessel 200 into its original position.

[0046] The damping of the dampers 140 can be adjusted. The reaction of the dampers 140 to movement of the vessel 200 can be affected by changing the damping of the dampers 140.

[0047] The length of the damper 140 can be changed so that the balance position of the damper 140 simultaneously moves. By changing the length of the damper 140 corresponding to the balance position of the damper 140, the mutual balance position of the mooring device 100 and the vessel 200 can be changed, in other words the position to which the damper 140 strives to return the vessel 200. The restoring force generated by the dampers 140 can be increased by using the vessel's 200 own propulsion device and the vessel's 200 steering devices.

[0048] Both dampers 140 comprise a force sensor 150 for measuring the force directed onto the damper 140. Based on the measured force, the position of the vessel 200 in relation to the mooring device 100 can for example be deduced, and the vessel 200 can be turned in a desired direction for example by changing the lengths corresponding to the balance positions of the dampers 140. The damping of the damper 140 can also be adjusted based on the measured force.

[0049] It is obvious to someone skilled in the art that the invention is not limited merely to the above-described examples, but the invention may vary within the scope of the claims presented below. The dependent claims present some possible embodiments of the invention, and they are as such not to be considered to restrict the scope of protection of the invention.

Claims

1. A mooring device (100) for mooring a vessel (200) to a wind power plant (300), which device (100) comprises:

   - a frame (110) and
   - a joint (130) arranged in connection with the frame (110), with the aid of which joint the mooring device (100) can be attached to a vessel (200);

   characterized in that the mooring device (100) comprises at least two gripping means (120) for gripping impact shields (310) of the wind power plant, which gripping means (120) are attached to the frame (110) in an immobile manner.

2. The mooring device (100) according to claim 1, **characterized in that** the gripping means (120) comprises a frame part (121), which is attached in an immobile manner to the frame (110), and a first gripping arm (122) and a second gripping arm (123), which are attached to the frame part (121) in a turnable manner.

3. The mooring device (100) according to claim 1 or 2, **characterized in that** a gripping means (120) has been attached in both ends of the frame (110).

4. The mooring device (100) according to claim 1, 2 or 3, **characterized in that** the mooring device (100) comprises at least one damper (140) for damping the movement between the mooring device (100) and the vessel (200), the first end of which damper (140) is attached to the frame (110) and the second end of which damper (140) can be attached to the vessel (200).

5. The mooring device (100) according to claim 4, **char-**

acterized in that a damper (140) has been attached in both ends of the frame (110).

6. The mooring device (100) according to claim 4 or 5, **characterized in that** the damping of the damper (140) is adjustable.

7. The mooring device (100) according to claim 4, 5 or 6, **characterized in that** the length corresponding to the balance position of the damper (140) is adjustable.

8. The mooring device (100) according to any of the preceding claims 4-7, **characterized in that** the damper (140) comprises a force sensor (150) for measuring the force directed onto the damper (140).

9. The mooring device (100) according to any of the preceding claims, **characterized in that** the gripping means (120) comprises at least one electric magnet (124), with the aid of the magnetic pull generated by which the gripping means (120) is pulled toward the impact shield (310).

10. A vessel (200), which comprises a mooring device (100) for mooring the vessel (200) to a wind power plant (300), which mooring device (100) comprises:

- a frame (110) and
- a joint (130) arranged in connection with the frame (110), with the aid of which joint the mooring device (100) is attached to the vessel (200);

characterized in that the mooring device (100) comprises at least two gripping means (120) for gripping impact shields (310) of the wind power plant, which gripping means (120) are attached to the frame (110) in an immobile manner.

11. The vessel (200) according to claim 10, **characterized in that** the vessel (200) is a trimaran.

12. The vessel (200) according to claim 10 or 11, **characterized in that** the mooring device (100) is attached to the prow of the vessel (200).

13. A method for mooring a vessel (200) to a wind power plant (300), which method comprises:

- driving a vessel (200) into contact with a wind power plant (300);

characterized in gripping the impact shields (310) of the wind power plant (300) with at least two gripping means (120) of the mooring device (100) of the vessel (200) and allowing the movement of the vessel (200) in relation to the wind power plant (300) only around one pivot point.

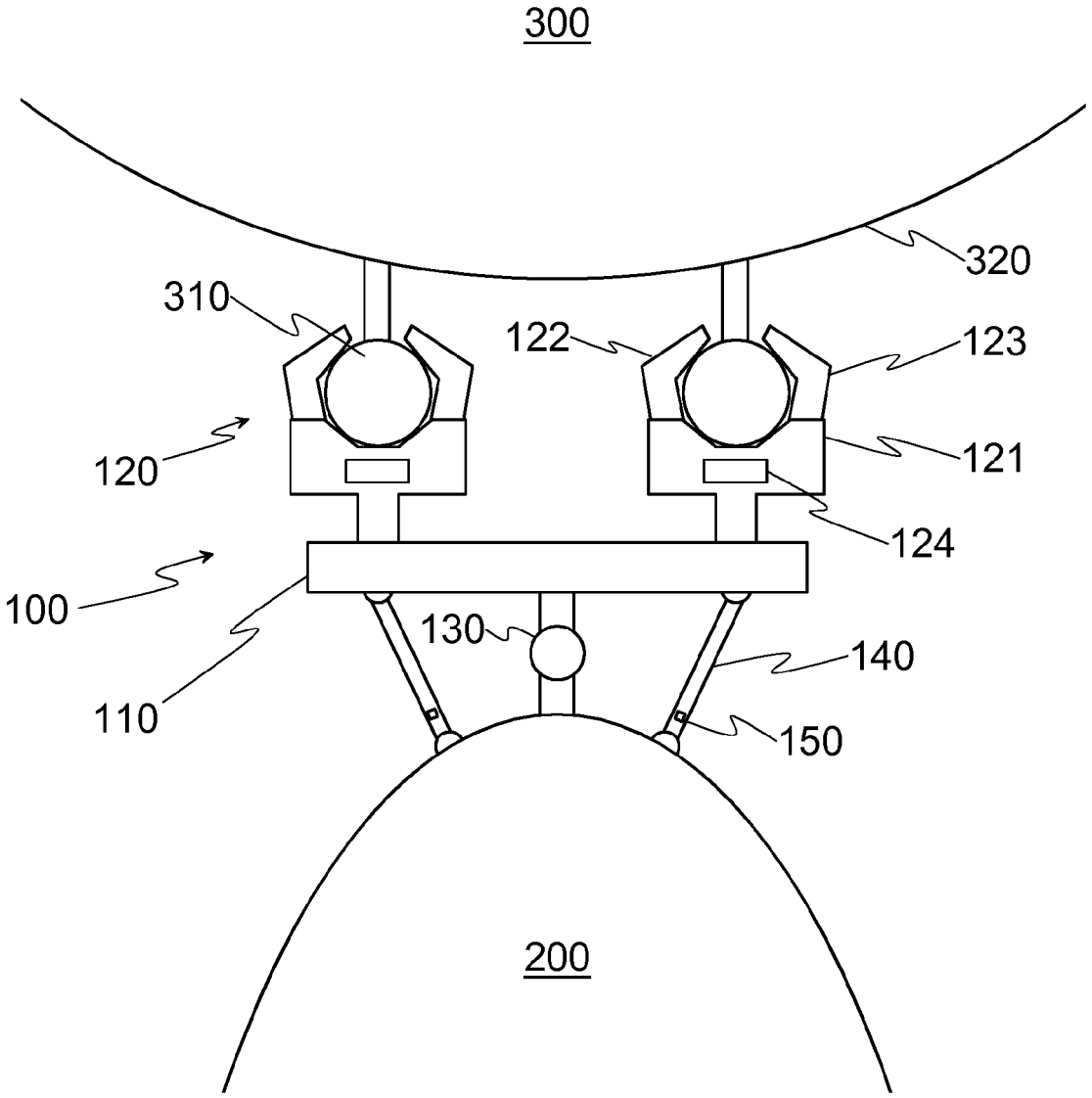

FIG. 1

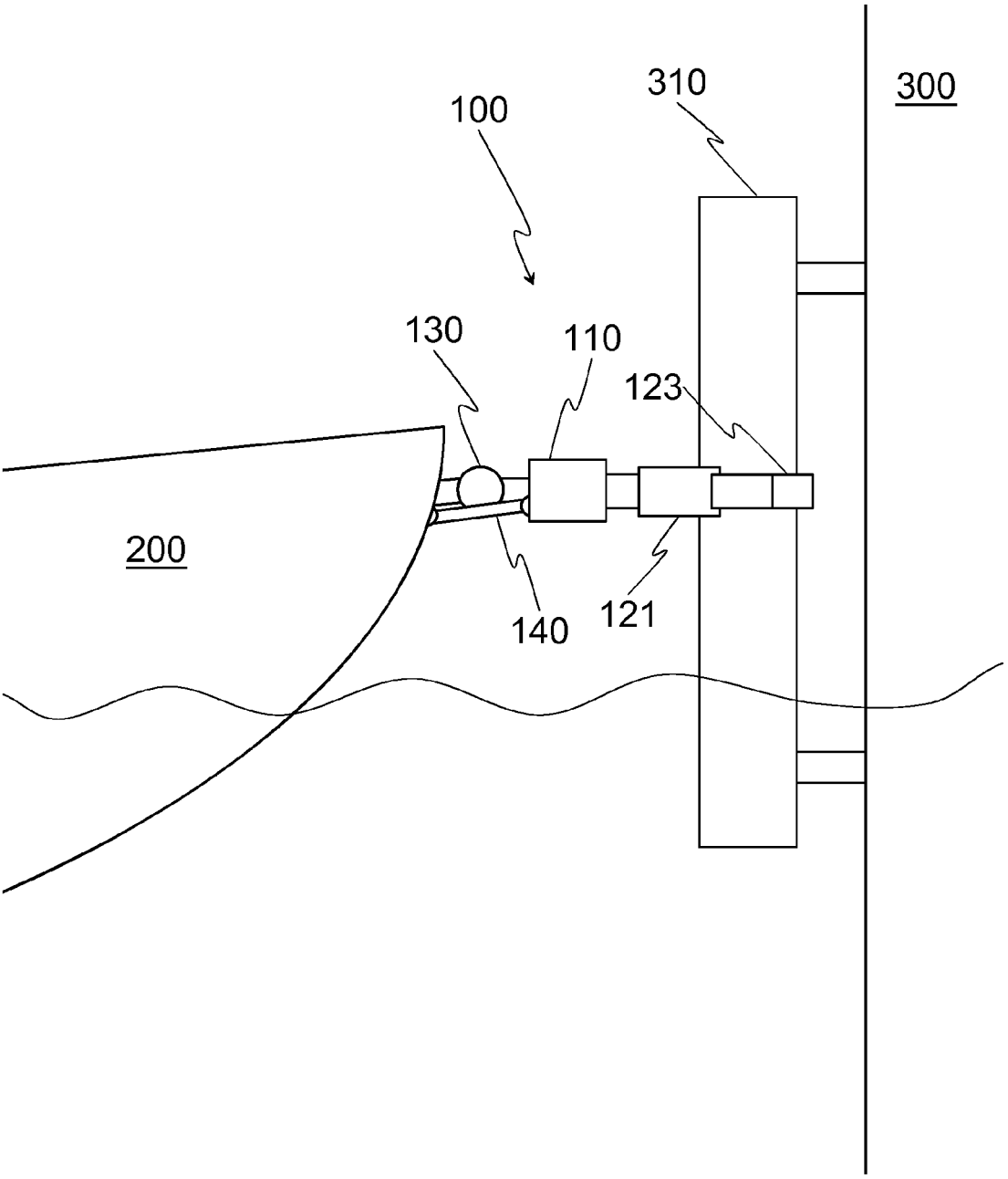

FIG. 2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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