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(57) The invention provides a system which facilitates the safe passage between two floating bodies (2, 6). The system comprises a bridge structure (1) supported on both floating bodies (2, 6) by means of supporting platforms (4, 8) and trimmers (5, 9) such as Stewart systems (10). The trimming of the supporting platforms (4, 8) allows stabilizing the bridge structure (1) in a fixed position and therefore allows a safe passage through the bridge between the floating bodies (2, 6).

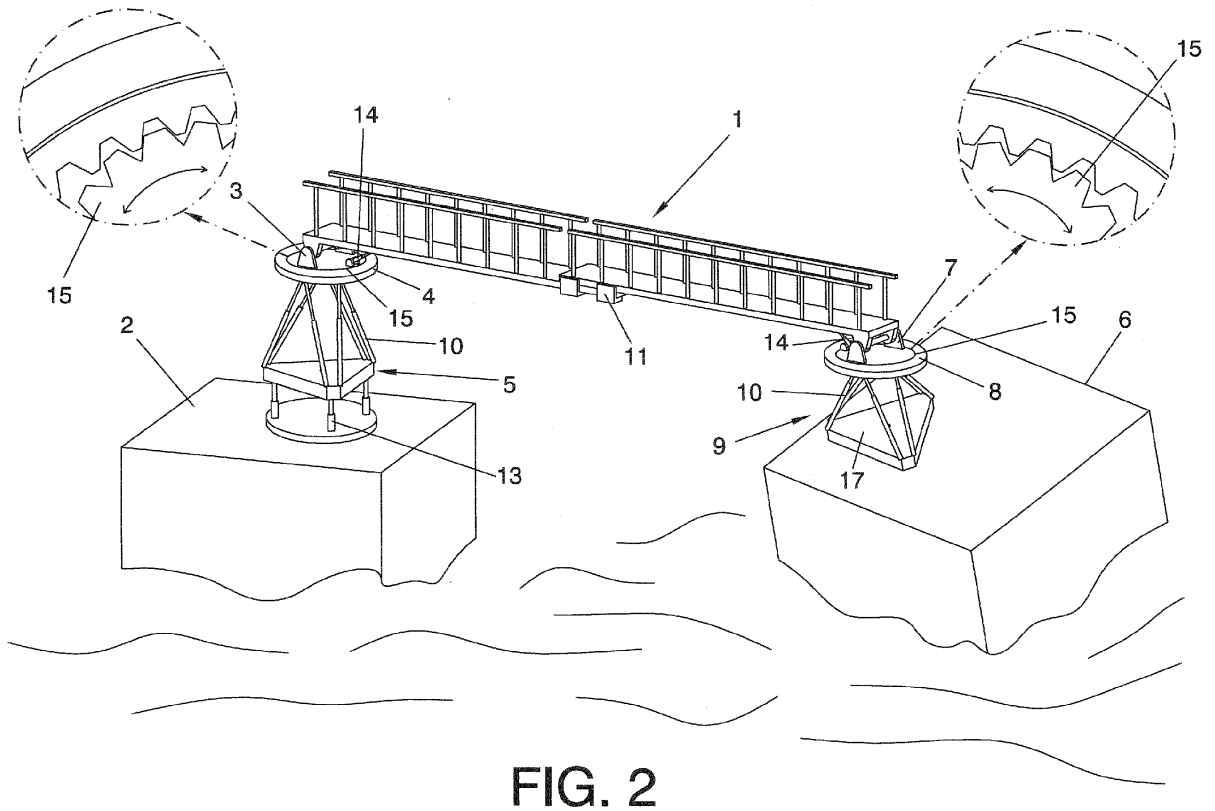

FIG. 2

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Description

Object and Technical Field of the Invention

[0001] The object of the present invention is to provide a system which facilitates passage between floating bodies, i.e., the passage of people, goods, equipment, etc., including the transfer of products, in a safe manner.

[0002] The concept of floating body in the present specification includes the concepts of a craft, ship, buoy, floating platform, wind power-generating floating installation, marine, tidal or wave power-generating floating installation, and generally any floating installation, structure, construction or system. The concept of a wind power-generating floating installation includes the concept of a floating wind generator. Likewise, the concept of a wave power-generating floating installation includes the concept of WEC (Wave Energy Converter).

[0003] The invention is of application regardless of the floating means, including: seas and oceans, lakes, rivers, estuaries, etc. The invention is especially, but not only, designed to allow safe access to offshore floating bodies, particularly for offshore WECs and floating wind generators.

Background of the Invention

[0004] Floating wind generators and WECs have a problem with access thereto from support crafts, for example for maintenance tasks, when wind and swell conditions are unfavorable, due to oscillating movements in floating installations. Only when floating installations are in a static or quasi-static stationary position is it possible to safely access them, for which purpose it is necessary for there to be suitable wind and swell conditions or for the installation to be stable enough to allow access, which generally only occurs in very large installations or for relatively short time intervals (windows). The impossibility of accessing floating installations to perform maintenance tasks or to start up electric generating systems increases the costs resulting from the longer energy production stop time.

[0005] On the other hand, there is currently a tendency to install offshore wind generators and electric generation systems, basically because of the advantages derived from better incident energy harnessing, whether it is wind, tidal, wave or marine energy, as a consequence of better resource or wind conditions, as well as for environmental and visual impact reasons. This in contrast implies more unfavorable wind and swell conditions for accessing the installations.

[0006] Floating bodies have freedom of movement as a rigid solid according to its six degrees of freedom, and still having an anchoring system. In a general case, the floating body is subjected to oscillating movements according to all its degrees of freedom. These oscillating movements are known as: forwards/backwards (longitudinal movement), left/right (lateral movement), up/down (vertical movement), roll (rotation about the longitudinal axis), pitch (rotation about the lateral axis) and yaw (rotation about the vertical axis). Both floating installations and crafts used to access the installations generally present oscillating movement that is a combination of the foregoing.

[0007] The technical problem which the present invention tries to solve is to provide a system which allows safe passage between a support craft and said floating installations regardless of the oscillating movements to which they are subjected, thus facilitating start up tasks and accordingly increasing their productivity.

[0008] Using general terms to describe the technical problem considered, the invention tries to provide a system which allows safe passage between floating bodies regardless of the oscillating movement of the bodies as a consequence of the wind, swell and currents conditions.

[0009] Given this technical problem, document NL-1031263 describes the use of a Stewart-type stabilization system with 6 degrees of freedom coupled to a craft to allow safe passage between the craft and a fixed construction such as an offshore wind generator, for example, founded to the seabed. To that end, the stabilizing platform stays in a static position with respect to the installation by trimming the oscillating movement of the craft in response to position and orientation sensor signals thereof, which allows safe passage between the stabilized platform and the installation.

[0010] Document NL-1033767 describes a telescopic walkway including stabilizing means at one of its ends coupled to a craft, also by means of a stabilizing platform adjusted using position sensor signals from the carrying craft. The described walkway can rotate at its end about a vertical axis and a horizontal axis, and can be longitudinally elongated or shortened. Unlike the aforementioned case, this solution allows connecting the walkway at the opposite end to a fixed structure.

[0011] Finally, patent document US-4162551 is known, which describes a connection system for passage between a fixed body and a floating body. To that end, the system incorporates a bridge structure divided into three articulated sectors extending from the fixed body and coupled to the floating body by means of a support connected to an oscillating platform on the floating body. The oscillating platform allows maintaining constant inclination of the last articulated sector of the bridge structure on the deck of said floating body.

[0012] However, none of the known solutions allows providing a connection and safe passage between two floating bodies. One of the bodies must remain static or quasi-static in order to be able to carry out the connection in a manner that is known from the state of the art.

Description of the Invention

[0013] For the purpose of solving the technical problem indicated providing a system which allows the connection

and safe passage between two floating bodies, the proposed invention incorporates the technical effects and features described below.

[0014] The connection system of the invention comprises:

- a bridge structure for passage between a first floating body and a second floating body;
- a first coupling between the bridge structure and the first floating body; and
- a second coupling between the bridge structure and the second floating body.

[0015] The couplings are located preferably at the ends of the bridge structure.

[0016] The concept of "bridge structure" in the present specification includes the concepts of bridge, walkway and nexus. The system of the invention is characterized in that the first coupling comprises a first trimmer and the second coupling comprises a second trimmer, such that the joint action of the trimmers allows stabilizing the bridge structure making the connection and safe passage between floating bodies possible.

[0017] "Stabilization" is understood in the present specification as the trimming movements of floating bodies to maintain a required position of the bridge structure. Stabilization is preferably performed such that the bridge structure remains in a substantially fixed position with respect to a fixed global reference system. Alternatively, stabilization can be performed such that the bridge structure only remains in a substantially horizontal, not necessarily fixed, position with respect to a fixed horizon. "Trimming" is understood in the present specification as the action and effect of a "trimmer" to stabilize the bridge structure as required.

[0018] In a preferred embodiment, the first coupling can additionally comprise a first support for the bridge structure connected to a first supporting platform and/or the second coupling can additionally comprise a second support for the bridge structure connected to the second supporting platform, such that the bridge structure is stabilized by means of stabilizing the supporting platforms, which allows the connection and safe passage between the floating bodies. The supports can be of any type, such as single pivots (flapping or dragging pivots respectively) and dual pivots (i.e. flapping and dragging pivots) with respect to the respective supporting platforms. The supports can be formed by means of known bearings. For the purpose of the present specification, "flapping" is understood, with respect to a determined reference plane, to the articulation movement in a plane vertical to the reference plane (for example, in the present specification "flapping with respect to the supporting platform" refers to flapping with respect to a plane parallel to the supporting platform). Likewise, "dragging" is understood as the articulation movement in a horizontal plane parallel to the same reference plane (for example, in the present specification "dragging with respect to the supporting platform" refers to dragging with respect to a plane parallel to the supporting platform).

[0019] The trimmers can be active trimmers, passive trimmers and a combination of active and passive trimmers (the latter are referred to as partially passive trimmers).

[0020] The trimmers can comprise suspension means to bear the supporting platform. The suspension means can include at least one suspension which can be of any type, such as ball suspension, single pivot suspension, dual pivot suspension and universal suspension with respect to the floating platform. In a simpler configuration, the trimmers can comprise one or more joints, such as universal or homokinetic joints. The arrangement, number and type of suspension and/or joints must be such that it allows the necessary free movement to allow stabilizing the bridge structure.

[0021] Unlike active trimmers, passive trimmers autonomously trim the movements. The use of passive trimmers by gravity and/or by constant pressure is contemplated. Passive trimmers by gravity comprise a counterweight configured to move the supporting platform to a stabilizing position by the action of gravity. Passive trimmers by constant pressure include passive trimmer actuation means operated in a known manner, for example from document NL-1031263.

[0022] In contrast, active trimmers stabilize the supporting platforms from the measurement of the movements of the floating bodies and by trimming said movements. To that end, they comprise:

- position and orientation sensors;
- data control and processing means; and
- active trimmer actuation means to move the supporting platform to the required stabilizing position and stay in said position.

[0023] The position and orientation sensors allow determining the position and/or orientation of the floating bodies and/or the bridge structure necessary for being able to stabilize the bridge structure, and the supporting platforms where appropriate, and hence the bridge structure, in the required position. This information about the position and orientation of the floating bodies and/or the bridge structure is processed by the data control and processing means, which accordingly control the actuation means to generate a resulting trim movement in the supporting platforms. The position and orientation sensors, the data control and processing means, and the active trimmer actuation means electronically communicate with one another in a known manner, for example by means of digital cable signals or wirelessly.

[0024] The position and orientation sensors can comprise any position and orientation system known in the art, such as inertial systems, external reference systems, global satellite systems (GNNSS, Global Navigation Satellite System), as well as any suitable combination thereof. Inertial sensors can include systems such as accel-

erometers, gyroscopes, inclinometers and any suitable combination thereof. The position and orientation external reference sensors can include optic sensors, acoustic sensors, compass sensors, encoder sensors, laser sensors or the like and any suitable combination thereof.

[0025] Preferably, the active trimmers of the invention comprise a Stewart-type stabilization system or hexapod providing the supporting platform to which it is coupled with 6 degrees of freedom for controlled movement, thus eliminating the need to provide the supporting platforms with suspension means.

[0026] Another aspect of the invention relates to the process necessary for connecting/disconnecting the bridge structure between the floating bodies. The process of connecting the bridge structure comprises extending and engaging the bridge structure, in contrast the process of disconnecting it comprises disengaging and retracting it. "Extension of the bridge structure" in the present specification is understood as the action of moving (transferring and/or rotating) and/or deforming (elongating/shortening, twisting, bending, etc.) the bridge structure to a position in which the structure allows connecting the floating bodies. "Retraction of the bridge structure" in the present specification is understood as the action of moving (transferring and/or rotating) and/or deforming (elongating/shortening, twisting, bending, etc.) the structure to a position in which the bridge is disconnected from one of the floating bodies. On the other hand, "engaging the bridge structure" is understood as the action of fixedly coupling it between the floating bodies. "Disengaging the bridge structure" is understood as the reverse action. The system of the invention can additionally comprise engagement means with said function of engaging and disengaging the bridge structure.

[0027] The present invention is preferably, but not only, designed so that the bridge structure is transported by a first floating body and remains fixed thereto, such that it is connected with a second floating body, once the first floating body is located close enough to the second floating body, by the extension of the bridge structure from the first floating body to later be coupled in a fixed but removable manner to the second floating body. Advantageously, the first floating body transports the entire complete connection system of the invention in addition to the bridge structure, which allows simplifying the means to be incorporated in the second floating body to make the connection/disconnection and engagement/disengagement of the bridge structure possible. In the event that the first floating body transports the entire connection system, the incorporation of engagement means comprising an engagement platform connected to the second trimmer is preferably contemplated. Said engagement platform is fixed in a removable manner or it can be fixed to the second floating body.

[0028] Alternatively, it is contemplated that the bridge structure can be selectively connected in multiple ways. For example, the connection can be between a first part of the bridge structure coupled to the first floating body and a second part of the bridge structure coupled to the second floating body. Also, for example, the connection of the bridge structure can be by connecting the second support to the respective second supporting platform, the latter being fixedly coupled to the second floating body by means of the respective second trimmer. Likewise, the disconnection is the reverse.

[0029] Preferably, the process of connecting/disconnecting can be by means of the actuation of the second trimmer so that between the parts to be connected or disconnected there are no significant movements during extension/retraction and engagement/disengagement, thus facilitating said engagement/disengagement.

[0030] For the passage over the bridge structure, once it is connected both supporting platforms can initially remain stabilized according to a fixed plane with respect the floating body from which the passage will begin. Then, while passing over the structure, the supporting platforms and the bridge structure can be stabilized according to a fixed global reference system. Finally, once one has passed over the structure, the system can be stabilized according to a fixed plane with respect to the floating body to the one from which passage is performed. The passage between the two floating bodies is thus facilitated in a safe and comfortable manner.

[0031] On the other hand, the invention contemplates the incorporation of extension/retraction means for extending/retracting the bridge structure. The extension/retraction means incorporate extension/retraction actuation means.

[0032] Optionally, the bridge structure can be divided into a plurality of sectors attached to one another. The attachment between the different sectors can be of any type, such as articulated or longitudinally sliding attachment, the latter to allow elongating/shortening the bridge structure when the extension/retraction means for extending/retracting the bridge structure incorporate said functionality. Likewise, the articulated attachment can be of any type in accordance with the configuration of the bridge structure, such as a single pivot (flapping or dragging pivot), dual pivot (flapping and dragging pivot), universal joint, homokinetic joint. Extension/retraction actuation means can also optionally be arranged between sectors.

[0033] The (passive trimmer, active trimmer and extension/retraction) actuation means can be of any type such as hydraulic means, pneumatic means, electric means and a combination thereof. Likewise, it is also contemplated that the extension/retraction actuation means can be used as active trimmer actuation means.

[0034] Advantageously, the supports and the articulations between sectors, where appropriate, can be configured such that the bridge structure has an isostatic structure behavior.

[0035] Finally, the incorporation of a weight compensation system of the bridge structure is also contemplated by means of a crane and counterweight in a conventional manner, as described in US-4162551 for example.

Brief Description of the Drawings

[0036] To complement the description of the invention and for the purpose of aiding to better understand its technical features, reference is made throughout the rest of this specification to the attached drawings in which a practical embodiment of the invention has been depicted by way of non-limiting example.

[0037] In said drawings:

Figure 1 shows a schematic plan view according to a horizontal plane of an embodiment of the system according to the invention.

Figure 2 shows a schematic perspective view of the embodiment of the system according to the invention.

Figure 3 shows a schematic perspective view of a constructive variant of the embodiment of the system according to the invention in which the bridge structure is provided with several sectors connected to one another by universal joints.

Figure 4 shows a schematic perspective view of another constructive variant of the embodiment of the system according to the invention having a simple configuration.

[0038] The references used in the drawings are the following:

1: bridge structure
2: first floating body
3: first support
4: first supporting platform
5: first trimmer
6: second floating body
7: second support
8: second supporting platform
9: second trimmer
10: Stewart system
11: sliding attachment
12: universal joint
13: elevating actuator
14: flapping actuator
15: dragging actuator
16: elongating/shortening actuator
17: engagement platform

Detailed Description of an Embodiment

[0039] Figures 1 and 2 schematically depict an embodiment of the system of the invention in plan view with respect to a horizontal plane and in perspective view, respectively.

[0040] The system allows the passage between a first floating body (2) (for example a support craft) and a second floating body (6) (for example a floating wind generator).

[0041] To make the connection, once the support craft is in the proximity of the floating platform of the wind generator, the bridge structure (1) is extended from the support craft to be connected to the wind generator with the aid of extension/retraction actuators. As can be seen, the extension/retraction actuators of the illustrated embodiment comprise: elevating actuators (13) for elevating vertically with respect to the first floating body (2), flapping actuators (14) and dragging actuators (15). The system additionally comprises first and second supports (3,7) for the bridge structure (1) on first and second supporting platforms (4,8) and respective first and second trimmers (5,9). Both supports (3,7) are dual pivot type (freely articulated flapping and dragging supports). For the connection, the system is complemented with an engagement platform (17) connected to the second trimmer (9), such that the connection takes place by allowing the weight of the structure (1), of the second support (7), of the supporting platform (8), of the second trimmer (9) and of the engagement platform (17) to rest on the second floating body (6). The engagement can additionally be complemented with detachable or removable engagement fixing means (not depicted). To facilitate the connection of the bridge structure, the illustrated embodiment incorporates two sectors coupled to one another by means of a sliding attachment (11), which allows longitudinally elongating/shortening the bridge structure (1). The disconnection and disengagement of the bridge structure is the reverse.

[0042] The bridge structure (1) is stabilized by keeping the supporting platforms (4,8) in a horizontal position, thus making the safe and comfortable passage between the first floating body (2) and the second floating body (6) possible. To that end, the embodiment of the invention incorporates trimmers (5,9) comprising respective Stewart systems (10), this being done actively. The system includes position and orientation sensors which acquire the relative movement data of both floating bodies with respect to a fixed global reference system, said data are processed by data control and processing means controlling actuation means of the platform to trim the movements of the floating bodies (2, 6) such that the respective supporting platforms (4,8) and the bridge structure (1) remain in a fixed position with respect to the fixed global reference system. The passage over the bridge structure (1) can be done once said structure is stabilized.

[0043] Figure 3 shows a schematic perspective view of a constructive variant of the described embodiment. As can be seen in Figure 3, in this variant the bridge structure (1) is divided into different sectors connected to one another by means of a universal joint (12), allowing dual pivoting as well as rotation about a longitudinal axis of the last sector of the bridge structure (1), such that the connection of the structure (1) to the second floating body (6) is facilitated. Elongating/shortening actuators (16) for elongating/shortening the bridge structure (1) have also been schematically depicted in this drawing.

[0044] Finally, Figure 4 depicts another constructive variant of the system according to the invention; the sec-

ond floating body (6) has been omitted in the drawing. This illustrated constructive variant corresponds to a simplified embodiment of the invention in which the second coupling does not incorporate a supporting platform but rather the second trimmer (9) is connected directly between the bridge structure (1) and an engagement platform (17) by means of a universal joint (12). Similarly to the previous constructive variants described, the connection and engagement of the bridge structure (1) is by means of fixing the engagement platform (17) to the second floating body (6) in a detachable or removable manner. Likewise, the disconnection and disengagement of the bridge structure (1) is the reverse.

Claims

1. Connection system for passage between floating bodies, comprising:

- a bridge structure for passage between a first floating body and a second-floating body;
- a first coupling between the bridge structure and the first floating body; and
- a second coupling between the bridge structure and the second floating body;

the system is **characterized in that**:

the first coupling comprises a first trimmer; and
the second coupling comprises a second trimmer;
such that the joint action of the trimmers allows stabilizing the bridge structure making the connection and safe passage between floating bodies possible.

2. Connection system for passage between floating bodies according to claim 1, **characterized in that**:

the first coupling additionally comprises a first support for the bridge structure connected to a first supporting platform;
such that stabilizing the first supporting platform by means of the first trimmer allows stabilizing the bridge structure making the connection and safe passage between floating bodies possible.

3. Connection system for passage between floating bodies according to one of claims 1-2, **characterized in that**:

the second coupling additionally comprises a second support for the bridge structure connected to a second supporting platform;
such that stabilizing the second supporting platform, or the first and the second supporting platforms together, by means of the respective trimmers allows stabilizing the bridge structure making the connection and safe passage between floating bodies possible.

4. Connection system for passage between floating bodies according to one of claims 2-3, **characterized in that** the supports are selected from the group consisting of: flapping pivot, dragging pivot, and dual flapping and dragging pivot.

5. Connection system for passage between floating bodies according to one of claims 1-4, **characterized in that** the system additionally comprises an engagement platform connected to the second trimmer and which is fixed in a retractable manner or can be fixed to the second floating body;
such that the system is connected by a process which comprises leaving the engagement platform resting on the second floating body and fixing said base platform to said second body.

6. Connection system for passage between floating bodies according to one of claims 1-5, **characterized in that** it additionally comprises extension/retraction means for extending/retracting the bridge structure.

7. Connection system for passage between floating bodies according to claim 6, **characterized in that** the extension/retraction means comprise extension/retraction actuation means.

8. Connection system for passage between floating bodies according to one of claims 1-7, **characterized in that** the first and second trimmers are selected from the group consisting of: active trimmers, passive trimmers and a combination thereof;
the passive trimmer is selected from the group consisting of: at least one universal joint, at least one homokinetic joint, by gravity with ball suspension, by gravity with pivot suspension, by gravity with dual pivot suspension, by gravity with universal suspension, by constant pressure with passive trimmer actuation means and a combination thereof;
the active trimmer comprises:

- position and orientation sensors;
- data control and processing means; and
- active trimmer actuation means.

9. Connection system for passage between floating bodies according to claim 8, **characterized in that**:

the position and orientation sensors are selected from the group consisting of: inertial sensors, external reference sensors, GNSS sensors and a combination thereof;
the inertial position and orientation sensors are

selected from the group consisting of: accelerometers, gyroscopes, inclinometers and a combination thereof; and
the external reference sensors are selected from the group consisting of:

optic sensors, acoustic sensors, compass sensors, encoder sensors, laser sensors and a combination thereof.

10. Connection system for passage between floating bodies according to one of claims 8-9, **characterized in that** the active trimmer of the first trimmer comprises a Stewart system.

11. Connection system for passage between floating bodies according to one of claims 8-9, **characterized in that** the active trimmer of the second trimmer comprises a Stewart system.

12. Connection system for passage between floating bodies according to one of claims 1-11, **characterized in that** the bridge structure comprises a plurality of sectors connected to one another by means of an attachment selected from the group consisting of: sliding attachment, single pivot attachment, dual pivot attachment, by a universal joint, by a homokinetic joint and a combination thereof.

13. Connection system for passage between floating bodies according to one of claims 7-12, **characterized in that** the actuation means comprise actuation means selected from the group consisting of: elevating actuation means, elongating/shortening actuation means, flapping actuation means, dragging actuation means and a combination thereof.

14. Connection system for passage between floating bodies according to one of claims 7-13, **characterized in that** the actuation means are selected from the group consisting of: hydraulic means, pneumatic means, electric means and a combination thereof.

15. Floating body for a connection system, the connection system defined according to one of claims 1-14.

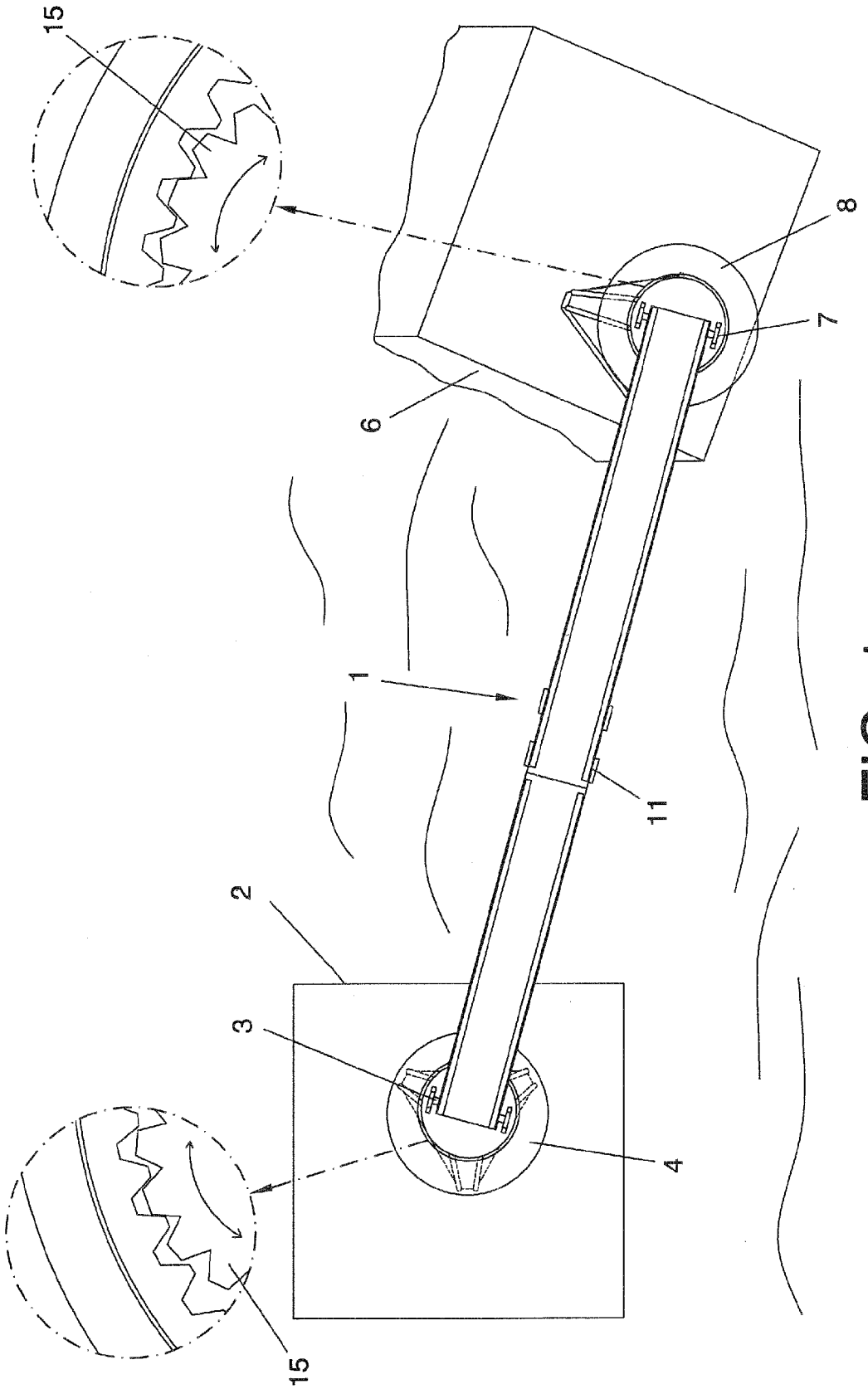

FIG. 1

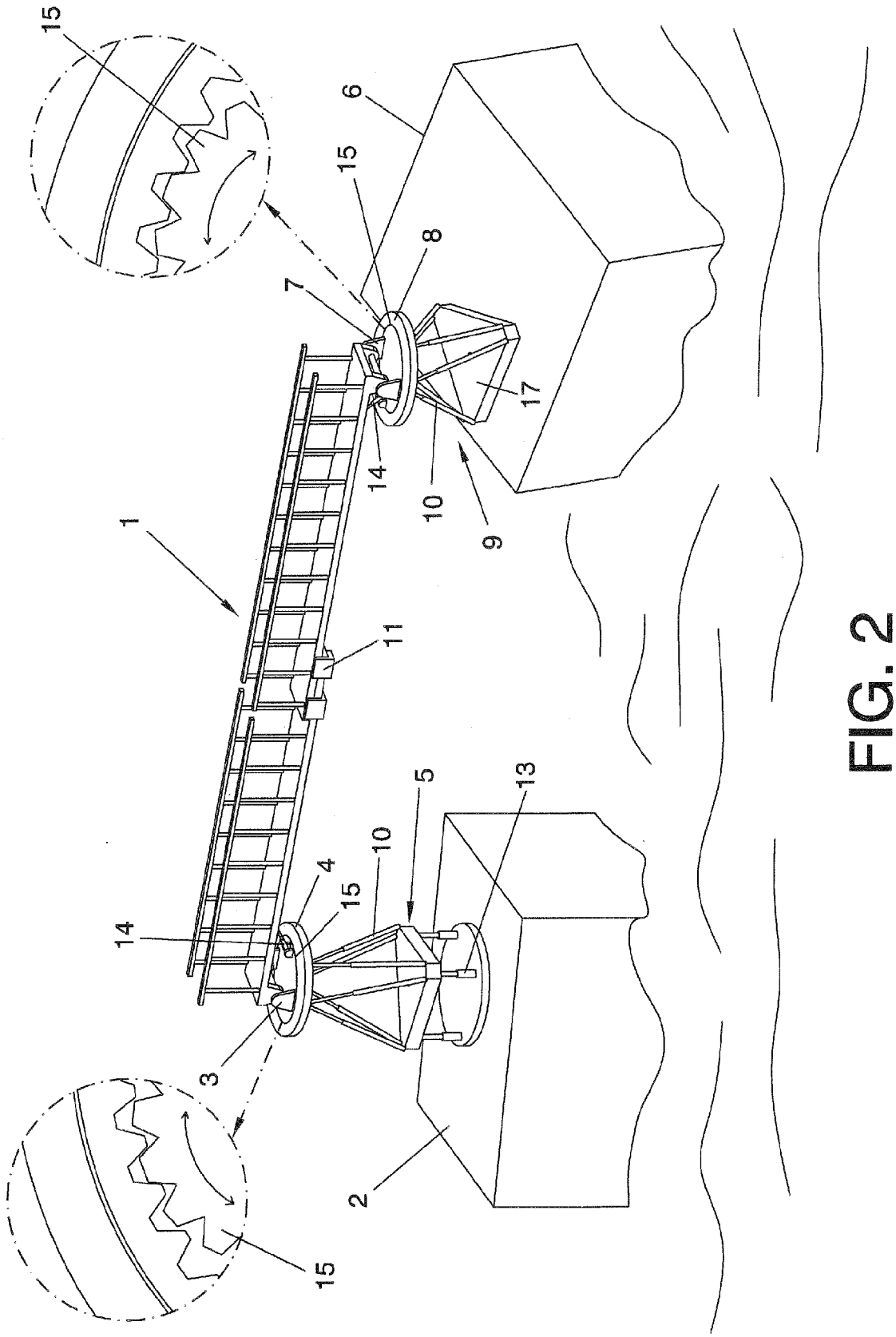

FIG. 2

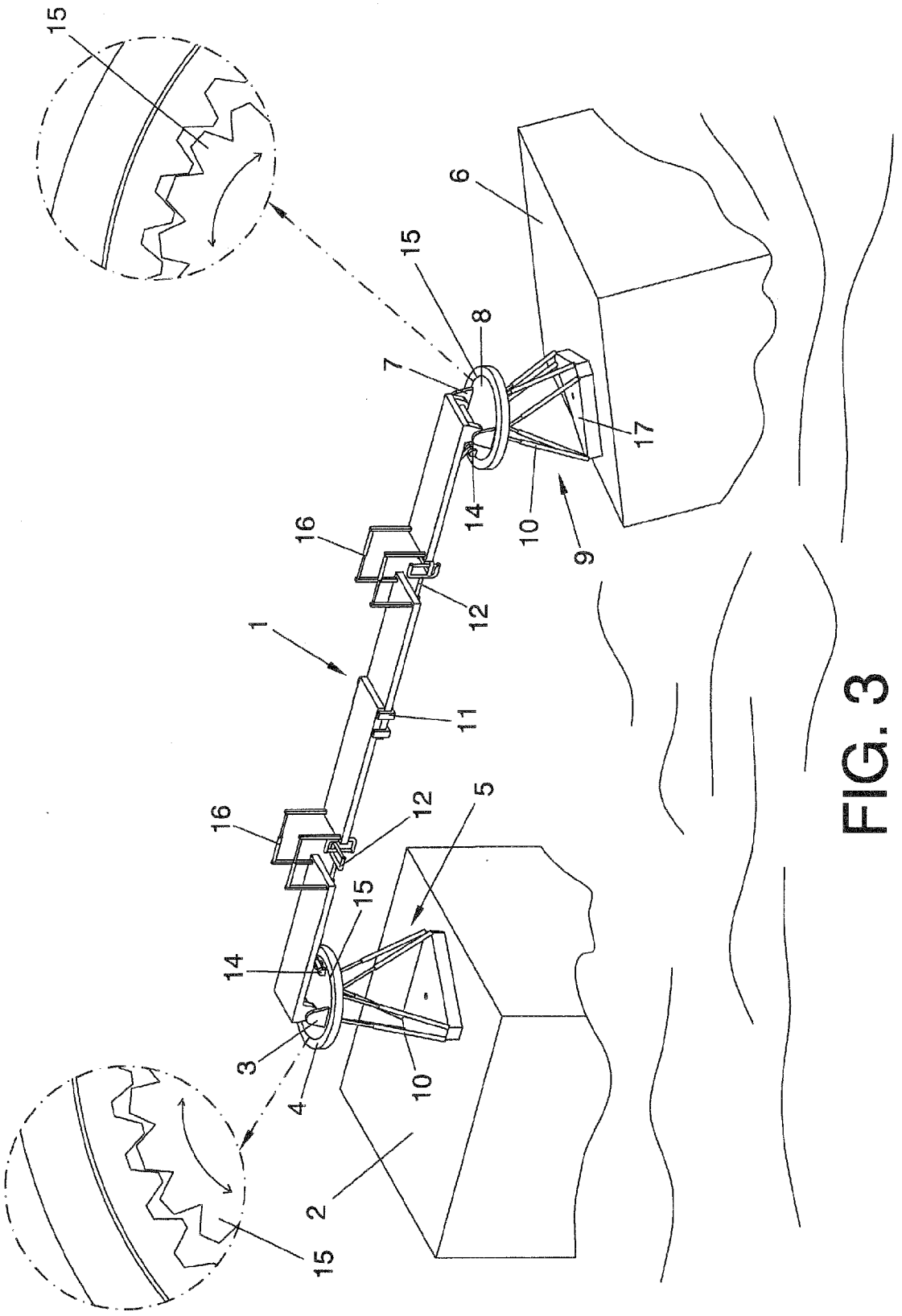

FIG. 3

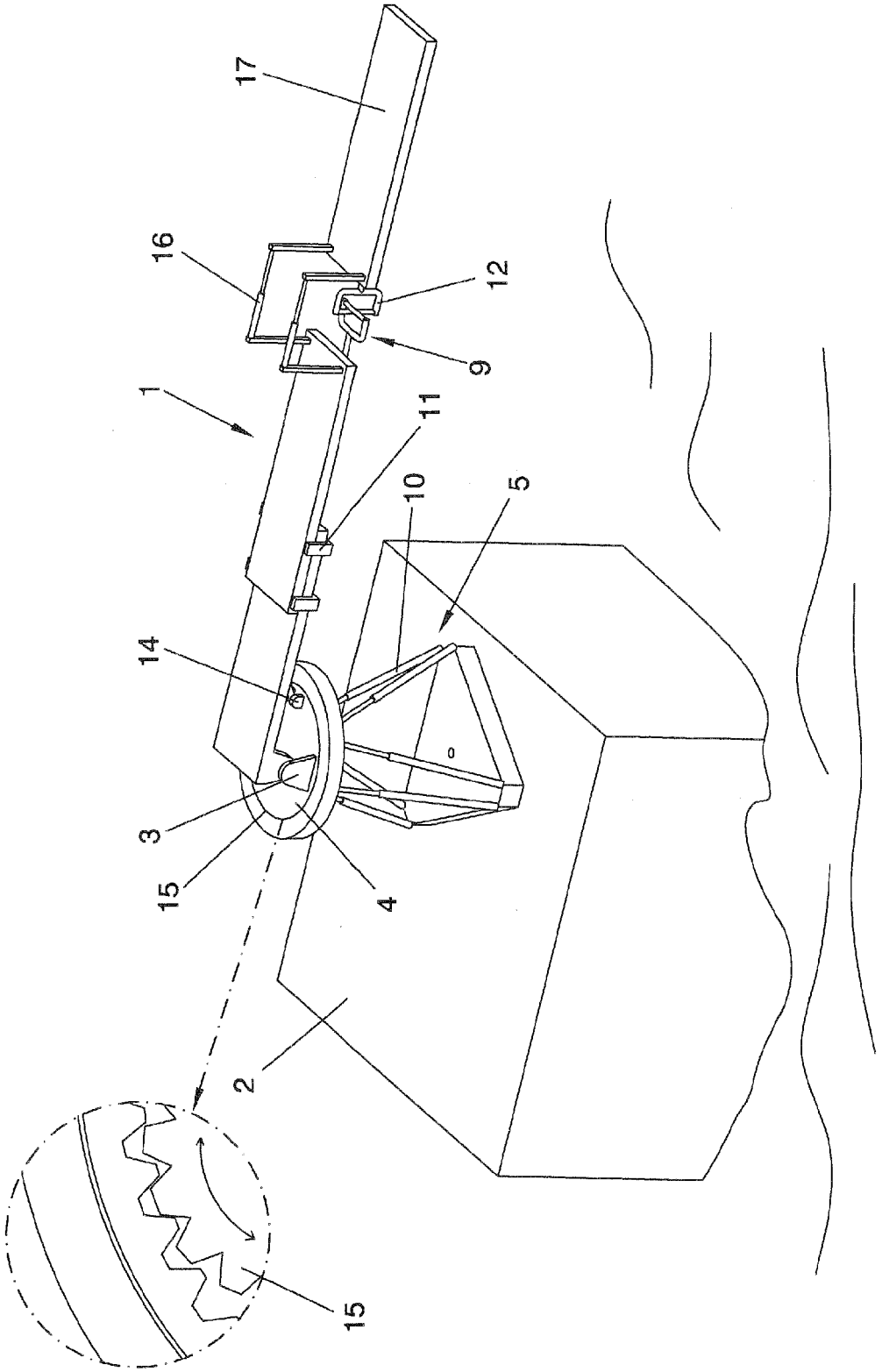

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 11 38 2092

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 October 2011	Beucher, Stefan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 38 2092

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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