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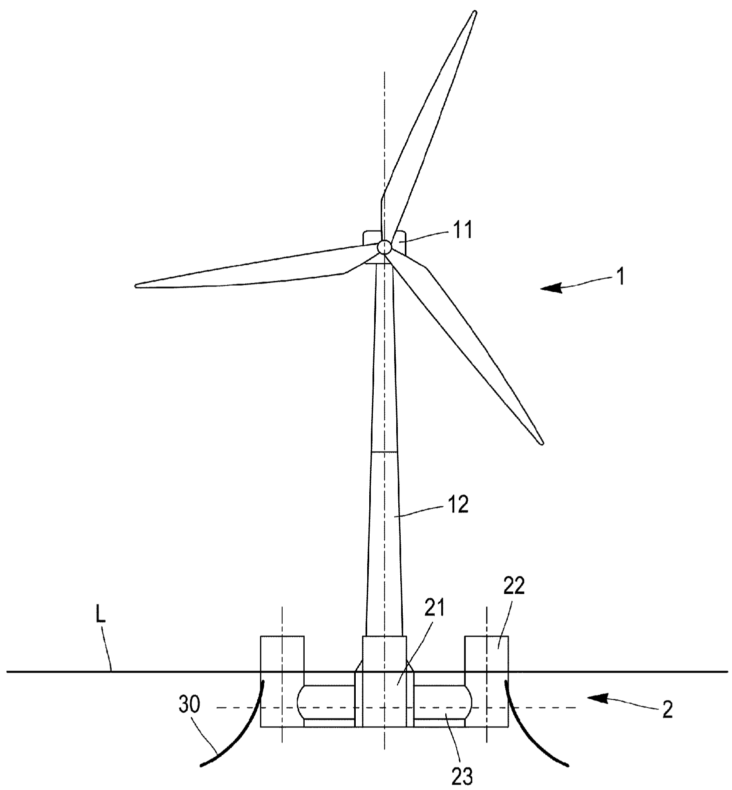
(54) FLOATING PLATFORM FOR A FLOATING WIND TURBINE FACILITY

(57) Floating platform for a floating wind turbine facility, with a structure which comprises a central base (21) to receive a wind turbine, four peripheral floaters (22) distributed around the central base (21), arms (23) joining the floaters (22) to the central base (21). The central base (21) and arms (23) are of concrete.

The arms are profiled and have a transverse cross-section of a polygon with rounded edges, with the radius of curvature of the edges (66) between one and four meters.

[Fig. 1]



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Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of the floating wind turbine facilities. It relates more particularly to a floating platform for supporting an offshore wind turbine and a floating wind turbine facility comprising this platform and a wind turbine.

BACKGROUND OF THE INVENTION

[0002] Floating wind turbine facilities, comprising a floating platform and an offshore wind turbine supported by the floating platform, are known. The wind turbine comprises a tower and a turbine.

[0003] One of the main difficulties encountered by floating platforms for supporting an offshore wind turbine is the ability to support the fatigue loads, due to the repetitive loads imposed on the floating wind turbine in particular by the turbine, the wind, the waves and the swell, and the extreme loads generated in case of storm or hurricane. A disadvantage of current floating platforms is that they are designed from materials that are not particularly resistant to the fatigue loads. Indeed, they are conventionally designed from metal and in particular from steel. The dimensioning of such structures in order to resist the fatigue loads and the extreme loads mentioned hereinabove therefore leads to complex details and require voluminous analyses.

[0004] This results in a manufacturing process for these structures that is complex and expensive. In particular, given the size of these structures, large-size dry docks or construction yard footprint are necessary in order to manufacture them, and large vessels are needed for transitory phases.

[0005] These various disadvantages limit in particular the power of wind turbines that the floating platforms can support.

[0006] The current floating facilities are penalized not only by the use of materials that are not particularly resistant to fatigue, but also by the choice of a geometry that does not optimally limit the generation of loads exerted on the facility. The generated loads are for example gravity loads linked to the inclination of the tower of the wind turbine in relation to the vertical direction, inertial loads linked to the movements of the tower of the wind turbine around its position at rest, loads resulting from the rotation of the turbine, or loads resulting from the hydrostatic pressure being exerted on the walls of the floating platform.

[0007] Moreover, the current floating wind turbine facilities commonly use elements that have solid volumes in order to resist the fatigue loads and the extreme loads. However, these solid volumes do not participate in the overall floatability of the system, which requires both increasing the size of the floating elements in order to increase their floatability and increasing the overall size of the system in order to support the bending and shear stresses that are transmitted between the elements.

[0008] Other aspect of the existing solutions is the number of columns when semi-submersible, or anchors for tension legged, that is limited to three. Although this can be viewed as the most economical by limiting to the minimum required to provide static stability, it is inefficient for dynamic stability as the inertia varies depending on the direction, and the overall horizontal size is about two thirds of the height of the turbine tower.

BRIEF SUMMARY OF THE INVENTION

[0009] Embodiments of the invention propose a solution that aims to overcome the aforementioned disadvantages.

[0010] Thus, the first objective of embodiments of the invention is to support the fatigue loads and the extreme loads that are exerted on the floating platform while still limiting the generation of new loads in particular on the turbine. This is provided by the geometry of the various elements in such a way as to limit the generation of new loads and to provide the elements with a neutral or positive floatability.

[0011] Another objective of embodiments of the invention is to retain a similar behaviour regardless of the orientations of the environmental disturbances, such as the wind, sea current, waves or swell, thanks to symmetries with shapes that open up expanded possibilities with regards to installation sites. The invention provides flexibility with regards to installation sites that is all the more so substantial as it makes it possible to obtain a floating wind turbine facility with a relatively low draught with respect to what exists, which favours the transport and set-up of such a facility.

[0012] An objective of embodiments of the invention is also to obtain a floating platform that has a small size, in particular with respect to existing platforms for supporting high-power turbines. As a corollary of this objective, embodiments of the invention aim to propose a floating platform that can be adapted quickly to the use of turbines having a power that is greater than that of the turbines currently used in floating wind turbine facilities, without modifying the architecture of the floating platform.

[0013] The characteristics linked to the orientation in space are given throughout the document when the floating facility is floating on an aquatic mass at rest, i.e. with a horizontal surface in the absence of wind, current, waves and swell. The vertical direction is defined by the direction of the force of gravity, with the field of the force of gravity pointing downwards. Any direction orthogonal to the vertical direction is horizontal.

[0014] Thus, the invention relates to a floating platform for a floating wind turbine facility, wherein the floating platform comprises a structure, the structure comprising a central base adapted to receive a wind turbine and four peripheral floaters distributed around the central base, the structure further comprising arms each joining a respective floater to the central base, wherein at least the central base and the arms are made of concrete, wherein an arm, in particular two opposed arms, more particularly each arm is profiled and has a transverse cross-section of a polygon with rounded edges, wherein the radius of curvature of an edge, in particular all edges, is comprised between one and four meters.

[0015] Thanks to these provisions, an optimum is reached which provides a suitable strength to all kinds of loads encountered during the service life of the facility with a limited volume of constituting material for the platform, and a limited horizontal stretch.

[0016] According to different aspects, it is possible to provide the one and / or the other of the characteristics below taken alone or in combination.

[0017] According to one embodiment, at least one part of at least one floater, in particular of all floaters, is made of concrete, and in particular where at least one floater, more particularly all floaters are made of concrete.

[0018] According to one embodiment, at least one of the central base, a part of a floater, particularly a floater, more particularly the floaters, said arm, in particular two opposed arms, more particularly all arms, is of prestressed concrete.

[0019] According to one embodiment, a part of at least a floater, in particular a floater, more particularly the floaters, is of steel.

[0020] According to one embodiment, the part of the floating platform which is of steel is an upper portion of a floater, in particular of the floaters.

[0021] According to one embodiment, at least one of the central base, the floaters and the arms is hollow.

[0022] According to one embodiment, the floaters are cylindrical with a round cross-section.

[0023] According to one embodiment, the platform comprises at least one vertical plane of symmetry, in particular two orthogonal vertical planes of symmetry for the arms and floaters.

[0024] According to one embodiment, the arms are of equal length.

[0025] According to one embodiment, the floaters are equally distributed around the central base.

[0026] According to one embodiment, the length of a straight side of the polygon between two adjacent rounded edges is at least one radius of curvature of the rounded edge.

[0027] According to one embodiment, the central base comprises a first support platform, one floater comprises a second support platform facing the first support platform, and the floating platform further comprises a transport system adapted to transport loads between the first support platform and the second support platform.

[0028] According to one embodiment, the transport system is removable.

[0029] According to one embodiment, the polygon is a quadrilateral, in particular a rectangle, with a ratio of horizontal dimension to vertical dimension comprised between 1:1 and 4:1.

[0030] According to one embodiment, the platform further comprises a control system adapted to provide active ballasting.

[0031] According to one embodiment, the control system determines a ballast configuration at a frequency of once every hour to once every day, preferably from once every three hours to once every six hours.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] Embodiments of the invention will be described below with reference to the drawings, described briefly below:

FIG. 1 shows a front view of a floating wind turbine unit according to an embodiment of the invention,
FIG. 2 shows a perspective side view of the platform of the floating wind turbine unit of FIG. 1,
FIG. 3 shows a partial perspective side view of an arm of the platform of the floating wind turbine unit of FIG. 2.
FIG. 4 is a view similar to Fig. 2 for a second embodiment.

[0033] In the drawings, identical references designate identical or similar objects.

DETAILED DESCRIPTION OF THE INVENTION

[0034] In the present invention, gravity plays a role. The vertical axis is the axis of gravity. A plane orthogonal to the vertical axis is called horizontal. The water level is considered generally horizontal, but is submitted to local variations due to swell or waves. The description of the floating wing turbine is performed with a tower of the wind turbine generally aligned with the vertical axis.

[0035] FIG. 1 shows a floating wind turbine facility according to an embodiment of the invention. The floating wind turbine facility comprises a wind turbine 1 and a floating platform 2 for supporting the wind turbine 1.

[0036] The wind turbine 1 comprises a turbine 11 and a tower 12 supporting the turbine 11. The turbine 11 is adapted for use offshore and provides a power of up to several megawatts (MW), for example up to at least 12 MW. For example, it is a three-bladed turbine with a horizontal axis. The rotor has a diameter of at least 200 meters. The tower 12 is comprised of truncated conical or cylindrical elements, for example made from steel. The upper portion of the tower 12 is arranged to receive the turbine 11.

[0037] In reference to FIG. 2, the floating platform 2 comprises a central base 21 arranged for receiving the tower 12, four peripheral floaters 22 and one arm 23 per peripheral floater. The central base 21 comprises a trunk 211 having the shape of a straight prism with a vertical generatrix. The floaters 22 are identical to one another. The arms 23 are identical to one another. The floaters 22 are uniformly provided around the central base 21. It means that the angle between the longitudinal axis of two nearby arms is 90°. The floating platform 2 may have a structure made of pre-stressed concrete, or at least mainly made of pre-stressed concrete with additional parts of metal or other materials. In particular, the floating platform may be made of a plurality of components made of pre-stressed concrete, which are assembled to one another. The fastening elements used to assemble the concrete components one to another may be of another material, such as suitable metals. For example, the central base 21 (or at least the trunk 211 thereof), the peripheral floaters 22 and the arms 23 are made of concrete. Pre-stressed concrete is a material adapted to resist the cyclical stresses of fatigue generated in particular by the movements of the wind turbine 1. Pre-stressed concrete is a material suitable to resist the stresses coming from the wind turbine 1, from the aquatic environment and from the dynamics of the floating platform 2. Pre-stressing is dimensioned so that, whatever load is exerted on the platform 2 (in normal expected use conditions), part of the concrete remains compressed, which is providing water tightening.

[0038] The trunk 211 comprises a lower face 2111 and an upper face 2112 that are disk-shaped. The lower face 2111 and the upper face 2112 are horizontal. The upper face 2112 comprises a slab whereon the base of the tower 12 of the wind turbine 1 rests. Furthermore, the central base 21 comprises a securing part 212 comprising a hollow volume 2120 for receiving the tower 12 of the wind turbine 1, the hollow volume 2120 being cylindrical or truncated in such a way as to fit to the tower 12. The securing part 212 is for example made of steel secured to the inside of the central base 21. For example, the central base 21 is made of concrete, the securing part 212 is overmolded by the concrete of the central base. The securing part 212 is adapted to the wind turbine 1 that the floating platform 2 is to receive. On the other hand, the rest of the floating platform 2 is designed in such a way as to be able to receive a wide diversity of wind turbines.

[0039] The central base 21 is hollow.

[0040] The peripheral floaters 22 comprise a cylindrical portion 222. The cylindrical portion 222 extends according to a vertical axis. Here, the vertical axis is a rotational axis of symmetry of the floater, apart considering the assembly of the floater to the arm. The lower base of the peripheral floater 22 is materialized by a slab.

[0041] The geometry of the floaters 22 makes it possible to provide a substantial volume of floatability and a mechanical resistance to the hydrostatic forces.

[0042] Part of the floaters 22 geometry can be conical, in particular the lower base with a larger diameter than the top base 3, with the advantage of enlarging the submerged volume, providing a larger buoyancy.

[0043] The platform is dimensioned to withstand the dynamic loads exerted by both the sea and the wind turbine. The floaters are dimensioned so that the eigenperiods of the platform in roll and pitch are larger than the energy periods of the design waves and swell.

[0044] The central base 21 may comprise a support platform 4 with a horizontal upper surface above the waterline L. For example, the support platform 4 is provided on a part of the periphery of the central base 21. The support platform 4 is for example attached to the securing part 212. The securing part 212 or the mast 12 may comprise an opening (not shown) enabling passing between inside the mast 12 and outside the mast 12. This opening may be closed by a suitable door (not shown). The opening and door are for example provided at the support platform 4, so that it is possible to enter the mast 212 from the support platform and exit the mast 212 to the support platform 4 through the opening.

[0045] At least one floater 22 may comprise a support platform 3 with a horizontal upper surface above the waterline intended to allow for intervention at the wind turbine 1. For example, the floater 22 facing the support platform 4 is provided with the support platform 3. For example, the support platform 3 is level with the support platform 4. Alternatively, there might be a vertical offset between the support platforms 3 and 4. The other floaters 22 may also be provided with support platforms 3, in particular if all floaters 22 are identical.

[0046] The floater 22 further comprises a partitioning device that makes it possible to provide stability to the platform as a whole in case of damage to one floater, for example in case of a floater filling with water further to a damage. The partitioning device enables to limit the volume of the floater 22 which will be filed with water.

[0047] The floaters 22 comprise compartments able to be filled at least partially with ballast. The ballast is for example seawater or another solid, liquid or granular material, denser than seawater, making it possible to adjust the overall mass of the system in order to adjust the draught for docking operations, transit operations or an installation on site. In the case of a liquid ballast, adapted adjustment means are for example means for pumping liquid that make it possible to add or to remove ballast. The compartments intended for the ballast are located far from the vertical central axis of the floater 22 and in the lower portion so as to contribute to the stability of the system by increasing its inertia in roll and pitch.

[0048] The platform is alternatively provided with a control system adapted to provide active ballasting in order to adapt to the loads exerted on the wind turbine. Regularly, in view of current or expected stresses exerted on the wind turbine, in particular due to the direction of the wind, the ballast in the various compartments is adapted in order to reduce the inclination of the tower when the turbine is on production. The ballast configuration is for example determined at a frequency of once every hour to once every day, preferably from once every three hours to once every six hours. The ballast configuration may be determined based on sensed or forecast data, and on a set of rules associating ballast configurations and this data.

[0049] According to one embodiment, a floater 22 comprises a portion which is facing an arm 23. This portion is not to be used for ballast. The rest of the floater 22 may comprise one or more compartments to be used for ballast. According to one example, vertical partition walls extend radially from the central axis of the floater 22 in order to define compartments. For example, the floater is divided in three compartments: one compartment facing the arm 23, and two other compartments, for example of equal size.

[0050] Preferably, the floating platform 2 comprises four floaters 22. It was experienced that four floaters is particularly suitable for the kind of facility as herein disclosed. In particular, with respect to embodiments with three floaters, it is less anisotropic, which enables to provide suitable ability to withstand stresses exerted in all directions of the horizontal plane. This ability is achieved with arms of reduced length (still compared with a platform with three floaters), which is beneficial in terms of bending moments and shear forces to be supported. This reduced length provides an overall footprint that is beneficial for construction, and alongside quay when installing the turbine on the platform 2, still compared to embodiments with three floaters. Further, it provides a cost effective solution with respect to platforms 2 with 5 arms and floaters or more, designed with a similar ability.

[0051] The arms 23 extend in a radial longitudinal direction in relation to the central base 21 and each arm 23 comprises a proximal end secured to the central base 21 and a distal end secured to a floater 22 associated with the arm 23. In reference to FIG. 3, an arm 23 is provided as a profiled tubular element, which extends in the longitudinal direction of the arm 23. The profiled tubular element is the only structural element connecting the central base 21 to the floater 22 in order to withstand operating stresses. The profiled tubular element is provided with a specific geometry enabling to withstand both the hydrostatic pressure applied by the surrounding water and the bending moments applied between the floater 22 and the central base 21. The cross-section of the arm 23 is provided as a polygon with rounded edges 66. The polygon is in particular a quadrilateral, more particularly a parallelogram and even more particularly a rectangle. In the present example, the quadrilateral is presented with at least one horizontal edge, in particular with two horizontal edges. For example, the quadrilateral is a rectangle with a width and height. The shape ratio of the polygon of the dimension along the vertical direction to the dimension along the horizontal dimension is between 1:1 and 4:1, and preferably between 1:1 and 3:1. The polygon further has rounded edges. An edge is defined as the intersection of two adjacent sides. For example, all edges are rounded. The average radius of curvature for an edge is for example comprised between 1 and 4 meters. The average radius of curvature is defined as the radius of curvature of a portion of circle which would join the two adjacent sides. The actually rounded edge may be a portion of circle, or maybe rounded with another geometry. The average radius of curvature is measured at the outer surface of the shell. The length of the straight edge between two adjacent rounded edges is of at least one radius of curvature, for example at least ten times the radius of curvature. The geometry combines the benefits of a polygonal cross-section and a circular cross-section and is studied to take up the forces coming from the turbine and from the marine environment. The polygonal part of the cross-section makes it possible to take up the bending in the plane, generated by the force of the wind on the blades of the turbine, and the alternating bending in the plane, induced by the roll, pitch and heave movements. Indeed, the polygonal part of the cross-section comprises slabs located in particular in a top portion and in a bottom portion of the arm 23 in order to make it possible to provide continuity in the transmission of forces, in particular of the bending moments transmitted from the wind turbine 1 to the arms 23. The force of the wind on the blades of the turbine and the tower 12 induces a bending moment on the central base 21. The bending moment in the central base 21 is transmitted in the form of bending moments in the arms 23 having a longitudinal direction that is parallel to the force of the wind. The bending moments in the arms are taken up in the form of stresses in the slab of the top portion of the arm and in the form of stresses in the slab of the bottom portion of the arm.

[0052] According to an embodiment, the arms 23 extend horizontally. The axes of elongation of the arms 23 are therefore coplanar.

[0053] In another embodiment, the axes of elongation of the arms 23 form generatrix of a cone of revolution of which the vertex is located on the axis of the tower 12.

[0054] The longitudinal direction of an arm 23 and the vertical direction define a radial plane. According to an embodiment, the platform is arranged in such a way that the vertical radial planes are planes of symmetry of the platform, structurally speaking. In other terms, the arms 23 are arranged in a star around the central base 21 in a regular manner, i.e. the angle α formed by the axes of elongation of two arms 23 of a pair of successive arms 23 is the same regardless of the pair of arms 23 and is equal to 360° that divides the total number of arms 23. This symmetrical configuration makes it possible to retain a similar behaviour regardless of the orientations of the environmental disturbances, such as wind, current or waves or swell, in such a way as to expand the scope of possible installation sites. In this case, according to a particular embodiment, the turbine comprises a controlled actuator that orients the turbine with respect to the platform according to the direction of the wind.

[0055] The interfaces between the arms 23 and the central base 21 are located in vertical planes. At the interface between an arm 23 and the central base 21, the cross-section of the arm 23 is tangent to a side of the polygon that is formed by the lower face 2111 of the trunk 211 of the central pillar 21; the diameter of the cross-section of the arm 23 is less than or equal to the distance between the lower face 2112 and the lower face 2111 of the trunk 211. The trunk 211 has, horizontally, a polygonal cross-section of which the number of sides is equal to double the number of arms 23 in such a way that the arms 23 are respectively secured to sides of the polygonal cross-section that are not adjacent between them. For example, when the floating device 2 comprises four floaters 22 and therefore four arms 23, the lower face 2111 and the lower face 2112 of the trunk 211 are octagonal.

[0056] Each arm 23 is secured to the floater 22 that is associated with it. At the interface between the arm 23 and the floater 22, the arm 23 is tangent to the base of the floater. Thus, the transmission of the stresses is provided between the arm 23 and the slab that constitutes the base of the floater 22 and between the arm 23 and the slab that constitutes the interface between the truncated lower portion 221 and the upper cylindrical portion 222.

[0057] The arms 23 are arranged in such a way as to delimit a volume that is sufficient to have positive floatability and are designed hollow. According to an embodiment, the arms 23 are entirely submerged in operation in such a way as to guarantee a behaviour that is acceptable from the standpoint of movements and of the stresses undergone in extreme conditions, i.e. when the wind turbine 1 is stopped and in the case of a strong swell.

[0058] No other structural connection parts are provided between the floaters 22.

[0059] The structure of the floating platform 2 described above may be made of pre-stressed concrete. In a variant embodiment, some parts of the structure may be provided in another material, especially metal, notably steel. This would be the case for example of the parts of structure which are less subject to fatigue in this loading environment. In particular, an upper portion of a floater, and in particular of the floaters, may be made of this alternative material. According to another example, a floater, and in particular the floaters, maybe made of this alternative material. This may enable to reduce the overall mass of the floating platform, and to have a lower centre of gravity.

[0060] In another embodiment, a supplementary reinforcing structure connects the securing part 212 to one floater 22, and particularly the securing part 212 to each floater 22. The supplementary reinforcing structure may comprise braces made of steel or concrete or cables connecting the securing part 212 with the top of the floaters 22. These braces or cables are parallel to the arms 23 and provided above them, and are aimed at reducing the loads and bending in the securing part 212, and in the arms 23.

[0061] According to an embodiment, the floating platform 2 comprises means of anchoring. The anchoring means are a set of lines 30 that connect the platform to a fixed external element, for example, the bottom of the aquatic mass on which the platform is floating. The lines 30 comprise a first end connected to the floating platform 2 in one or several points and a second end connected to the fixed external element, for example by the intermediary of an anchor or of a dead body. The lines 30 can be comprised of cables, chains or other flexible elements adapted to the maintaining in position of a floating object subjected to drift forces under the effect of the environment. According to particular embodiments, the lines 30 are fully or partially stretched vertically or on a slant.

[0062] In an alternative embodiment, the lines 30 are catenaries.

[0063] According to a mode of use, the draught of the floating wind turbine unit is low, for example of about ten meters not ballasted and of about fifteen meters ballasted, in order to facilitate the operations of towing and installation.

[0064] Alternatively, the draught is identical between the installation phase and the operational phase which avoids the operations of ballasting/de-ballasting on the production site. The draught can however be adjusted by ballasting once on the production site.

[0065] According to some embodiments, a transport system 5 is provided in order to transport loads from one floater 22 to the wind turbine 1. According to one example, the transport system 5 comprises transport facilities 6 provided on the support platform 3 of the floater, and transport facilities 7 at the wind turbine 1 or the central base 21. The transport facilities 6, 7 may be in an inactive configuration, such as shown on Fig.2, whereby they do not extend over the underlying arm 23, or in an active configuration, where they continuously extend above the underlying arm 23 in order to bridge the gap between the support platform 3 of the floater and the support platform 4 of the central base 21. In such active configuration, the transport system 5 may be used to transport loads between the support platform 3 of the floater and the support platform 4 of the central base 21 above the underlying arm 23. Loads may be then further transported by additional transport systems. For example, a transport system will carry the load from the support platform 4 inside the tower 12. For example, a transport system will carry the load from the support platform 3 of the floater to a mobile floating system and to the ground. The transport facilities 6, 7 are placed in inactive configuration when no load is to be transported between the floater 23 and the wind turbine 1. For example, the transport facilities 6, 7 are provided integral with the support platforms 3, 4. Alternatively, the transport facilities 6, 7 may be removably associated with the support platforms 3, 4. In such case, the transport facilities 6, 7 may be brought to the support platforms 3, 4 by boat when they are needed, then taken back to port. This enables to use the same transport facilities 6, 7 for various floating platforms 2 of a same field. Hence, a field of wind turbine facilities may comprise a plurality of wind turbine facilities, and a transport system 5 which may be removably associated with each of them.

[0066] According to an embodiment, the floating wind turbine comprises a transport system in order to move load between the support platform 3 of the floater and the tower 12. In a particular example, the load to be moved is an electrical component of the turbine.

[0067] Embodiments of the invention are described hereinabove by way of example. It is understood that those skilled in the art are able to produce various alternatives of the invention, by associating for example the various characteristics hereinabove taken individually or in combination, without however leaving the scope of the invention.

[0068] Preferably, the floating platform 2 comprises four floaters 22. The number of floaters 22 is calculated in order to retain a relatively small size in relation to floating devices for supporting high-power turbines and for remaining within a range of inclination during operation and an extreme environment that is compatible with the use of existing turbines.

[0069] As discussed above, the floating platform 2 may comprise four floaters 22 which are arranged at corners of a square. Alternatively, the four floaters may be arranged at corners of a not-square rectangle. Depending on the geometry, this might not reduce much the mechanical strength of the floating platform, and ease the access by boat to the central base 21.

[0070] Fig. 4 now shows a view similar to Fig. 2 for a second embodiment. This embodiment will be described by reference to the first embodiment. According to this embodiment, the central base 21 has a square cross-section. In particular, each lateral side of the central base 21 extends in the vertical plane for assembly to the facing arm 23. The edges of the square may be rounded or otherwise designed.

[0071] According to some embodiments, the floating platform may comprise more than four peripheral floaters.

LIST OF REFERENCE SIGNS

[0072]

1 : wind turbine
2: floating platform
3: support platform
4: support platform
5: transport system
6, 7: transport facility
11: turbine
12: tower
21: central base
22: peripheral floater
23: arm
30: Lines
66: edge
211: trunk
212: Securing part
222: Cylindrical portion
2111: lower face
2112: upper face
2120: Hollow volume
L: waterline L

Claims

1. Floating platform for a floating wind turbine facility, wherein the floating platform (2) comprises a structure, the structure comprising a central base (21) adapted to receive a wind turbine and four peripheral floaters (22) distributed around the central base (21), the structure further comprising arms (23) each joining a respective floater (22) to the central base (21), wherein at least the central base (21) and the arms (23) are made of concrete, wherein an arm (23), in particular two opposed arms, more particularly each arm is profiled and has a transverse cross-section of a polygon with rounded edges, wherein the radius of curvature of an edge (66), in particular all edges, is comprised between one and four meters.

2. Floating platform according to claim 1, wherein at least one part of at least one floater (22), in particular of all floaters (22), is made of concrete, and in particular where at least one floater, more particularly all floaters (22) are made of concrete.

3. Floating platform according to claim 1 or 2, wherein at least one of:

- the central base (21),
- a part of a floater (22), particularly a floater (22), more particularly the floaters (22),
- said arm (23), in particular two opposed arms, more particularly all arms,

is of pre-stressed concrete.

4. Floating platform according to any of claims 1 to 3, wherein a part of at least one floater (22), in particular a floater, more particularly the floaters, is of steel.

5. Floating platform according to claim 4, wherein the part of the floating platform which is of steel is an upper portion of a floater (22), in particular of the floaters.

6. Floating platform according to any of claims 1 to 5, wherein at least one of the central base (21), the floaters (22) and the arms (23) is hollow.

7. Floating platform according to any of claims 1 to 6, wherein the floaters (22) are cylindrical with a round cross-section.

8. Floating platform according to any of claims 1 to 7, comprising at least one vertical plane of symmetry, in particular two orthogonal vertical planes of symmetry for the arms (23) and floaters (22).

9. Floating platform according to any of claims 1 to 8, wherein the arms (23) are of equal length.

10. Floating platform according to any of claims 1 to 9, wherein the floaters (22) are equally distributed around the central base (21).

11. Floating platform according to any of claims 1 to 10, wherein the length of a straight side of the polygon between two adjacent rounded edges (66) is at least one radius of curvature of the rounded edge.

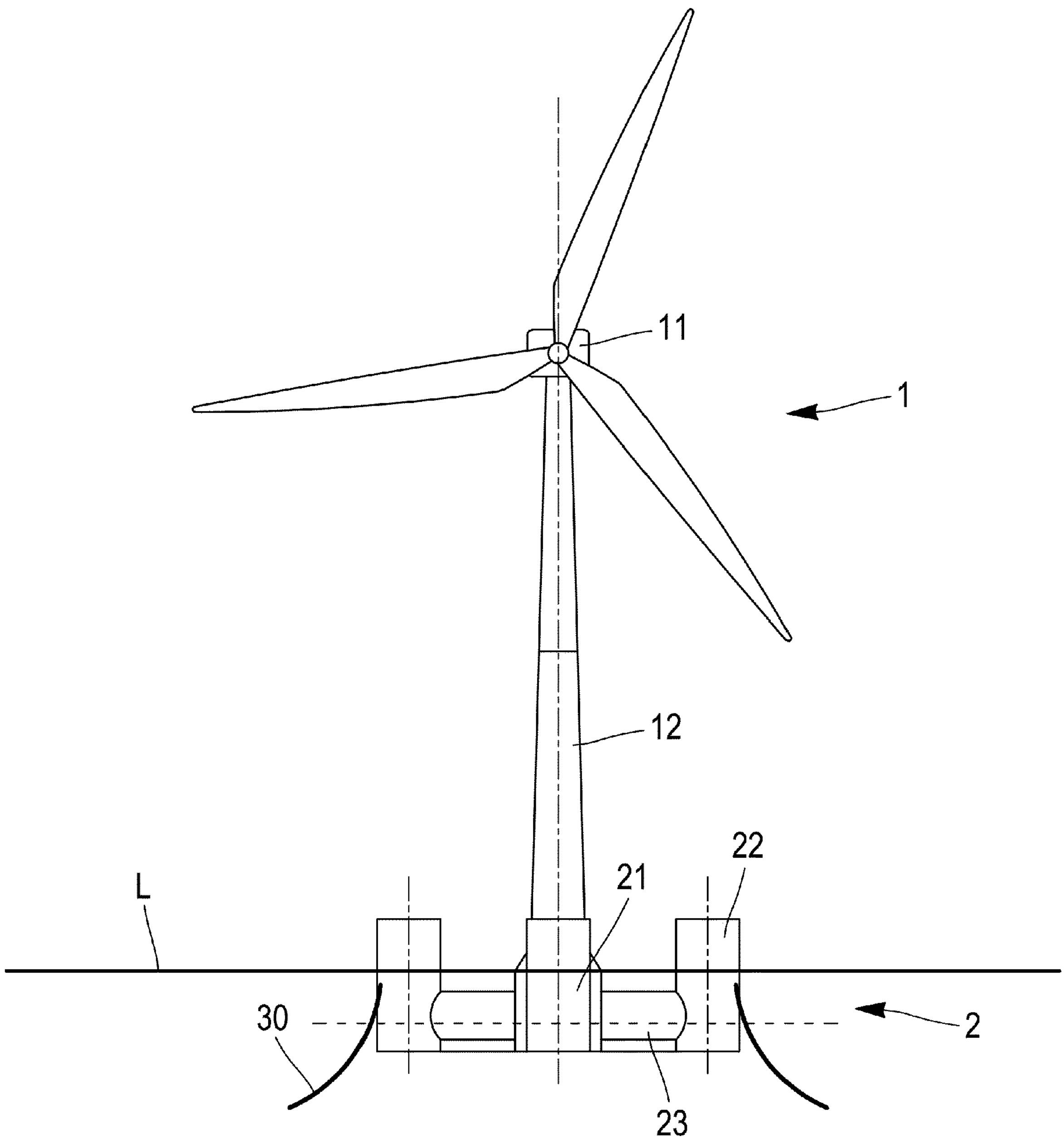
12. Floating platform according to any of claims 1 to 11, wherein the central base (21) comprises a first support platform (3), one floater (22) comprises a second support platform (4) facing the first support platform (3), and the floating platform (2) further comprises a transport system (5) adapted to transport loads between the first support platform (3) and the second support platform (4).

13. Floating platform according to any of claims 1 to 12, wherein the transport system (5) is removable.

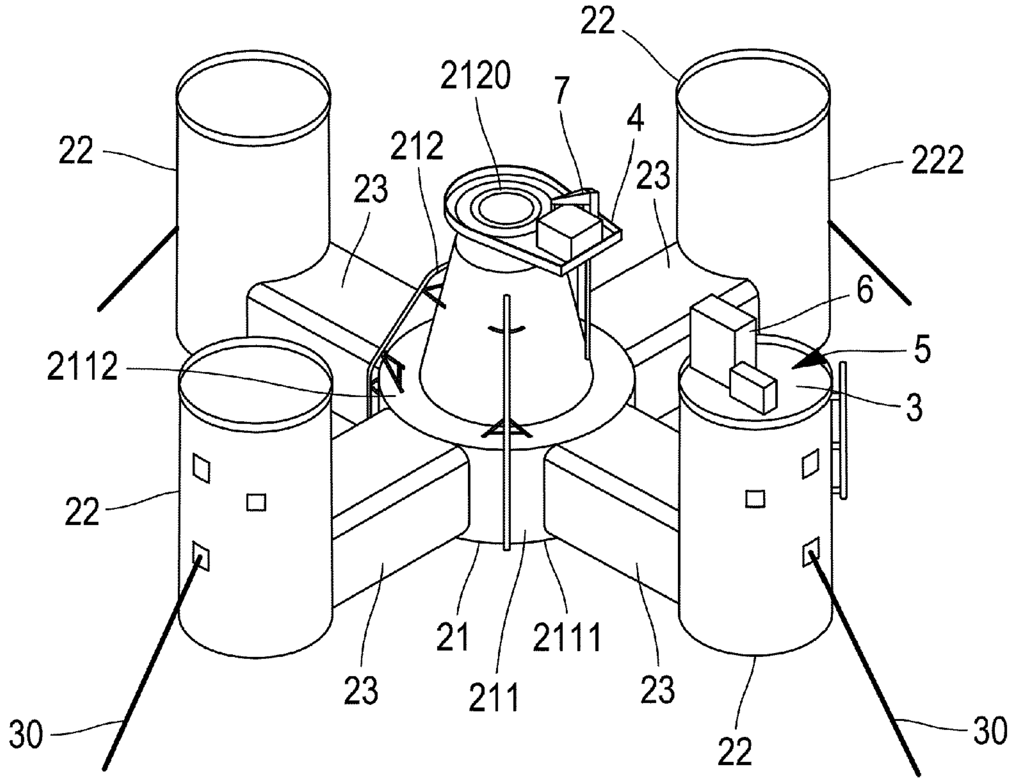
14. Floating platform according to any of claims 1 to 13, wherein the polygon is a quadrilateral, in particular a rectangle, with a ratio of horizontal dimension to vertical dimension comprised between 1:1 and 4:1.

15. Floating platform according to any of claims 1 to 14, further comprising a control system adapted to provide active ballasting, and in particular wherein the control system determines a ballast configuration at a frequency of once every hour to once every day, preferably from once every three hours to once every six hours.

[Fig. 1]



[Fig. 2]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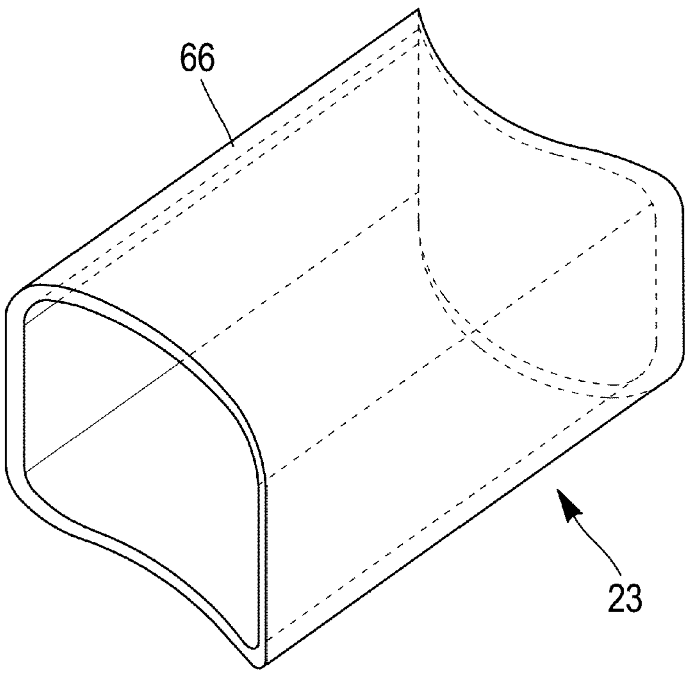
[Fig. 3]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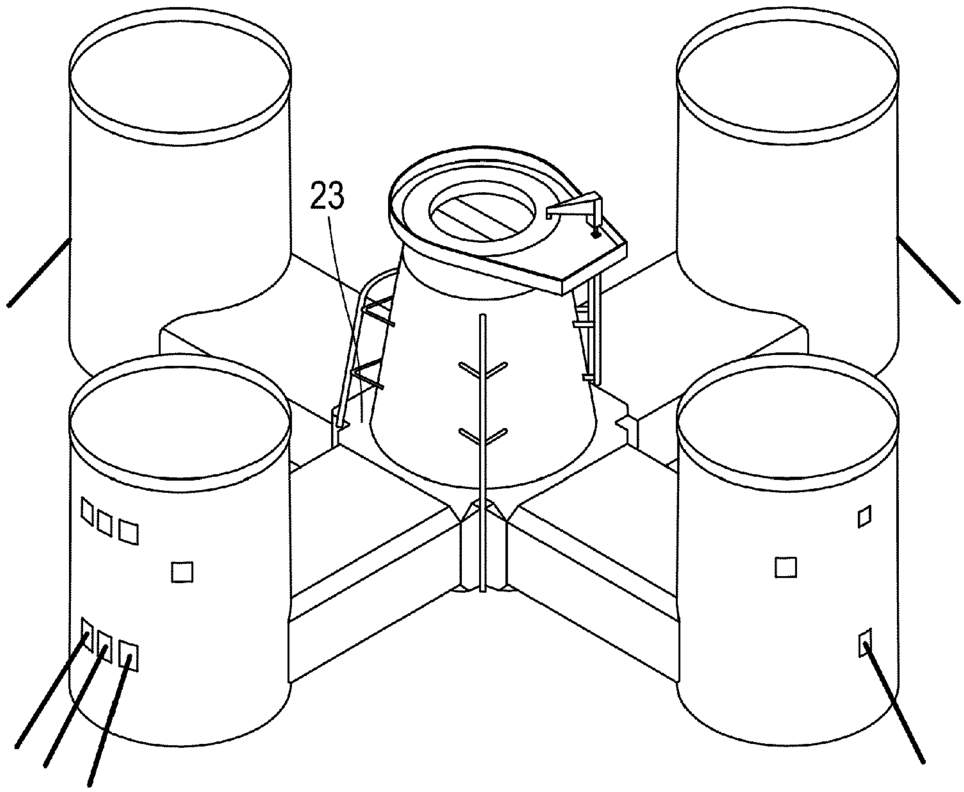
[Fig. 4]



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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 3327

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2019/367136 A1 (GATESCOUPE JULIEN [FR] ET AL) 5 December 2019 (2019-12-05) * paragraph [0004] - paragraph [0010] * * paragraph [0018] - paragraph [0025] * * paragraph [0031] - paragraph [0032] * * paragraph [0047] - paragraph [0063] * * paragraph [0070] - paragraph [0076] * * figures 1-9 * -----	1-15	INV. B63B35/44
Y	DE 10 2018 103894 A1 (MAX BOEGL WIND AG [DE]) 22 August 2019 (2019-08-22) * paragraph [0012] - paragraph [0014] * * paragraph [0031] * * figures 1-4 * -----	1-15	
A	US 2013/233231 A1 (DAGHER HABIB J [US] ET AL) 12 September 2013 (2013-09-12) * paragraph [0177] - paragraph [0183] * * figure 45 * -----	1-15	
A	US 2016/195070 A1 (LI RONGFU [CN] ET AL) 7 July 2016 (2016-07-07) * paragraph [0072] - paragraph [0073] * * figures 1,2,4 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) B63B F03D
A	US 2020/063530 A1 (BOWIE MALCOLM [GB]) 27 February 2020 (2020-02-27) * paragraph [0012] - paragraph [0013] * -----	1-15	
A	US 2009/229505 A1 (WILLIAMS ANTHONY NEIL [US] ET AL) 17 September 2009 (2009-09-17) * paragraph [0015] * * figures 2,3 * -----	1-15	

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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
The Hague	3 January 2022	Soto Salvador, Jesús

CATEGORY OF CITED DOCUMENTS

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03-01-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019367136 A1	05-12-2019	EP 3472458 A1	24-04-2019
		ES 2822172 T3	29-04-2021
		FR 3052817 A1	22-12-2017
		JP 2019521043 A	25-07-2019
		KR 20190027790 A	15-03-2019
		MA 45499 B1	30-09-2020
		PT 3472458 T	21-09-2020
		TW 201802351 A	16-01-2018
		US 2019367136 A1	05-12-2019
		WO 2017220878 A1	28-12-2017
DE 102018103894 A1	22-08-2019	DE 102018103894 A1	22-08-2019
		WO 2019162102 A1	29-08-2019
US 2013233231 A1	12-09-2013	NONE	
US 2016195070 A1	07-07-2016	AU 2015226662 A1	03-03-2016
		CN 103818523 A	28-05-2014
		DK 3115600 T3	15-04-2019
		EP 3115600 A1	11-01-2017
		ES 2718934 T3	05-07-2019
		US 2016195070 A1	07-07-2016
		WO 2015131756 A1	11-09-2015
US 2020063530 A1	27-02-2020	BR 112019023612 A2	26-05-2020
		CA 3062729 A1	22-11-2018
		EP 3625119 A1	25-03-2020
		GB 2575763 A	22-01-2020
		US 2020063530 A1	27-02-2020
		WO 2018211254 A1	22-11-2018
US 2009229505 A1	17-09-2009	US 2009229505 A1	17-09-2009
		US 2011114005 A1	19-05-2011

EPO FORM P0459

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