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(54) System and method for mooring a floating vessel against a stationary object

(57) A system is provided for mooring a vessel against a stationary object, for example the mast of a wind turbine erected in water. The stationary object comprises at least one substantially vertical bumper bar which is attached to the stationary object by means of an extension. The vessel comprises a hull, an engine for propelling the vessel, and a buffer body which protrudes in relation to the hull. The bumper bar comprises a substantially vertical, inside guide track which substantially faces the stationary object and a substantially vertical, outside guide track which substantially faces away from the stationary object. The vessel comprises at least one engagement arm which at one end is provided with an engagement member. The engagement arm can be moved in relation to the hull between a mooring state, in which the engagement member engages on the inside guide track of the bumper bar and is vertically displaceable along this, and a release state, in which the engagement member is out of engagement with the inside guide track. The buffer body in the mooring state engages on the outside guide track of the bumper bar and is vertically displaceable along this. The inside guide track protrudes sideways in relation to an adjacent part of the extension of the bumper bar such that the engagement member of the engagement arm in the mooring state can be moved past the extension on vertical displacement along the inside guide track of the bumper bar.

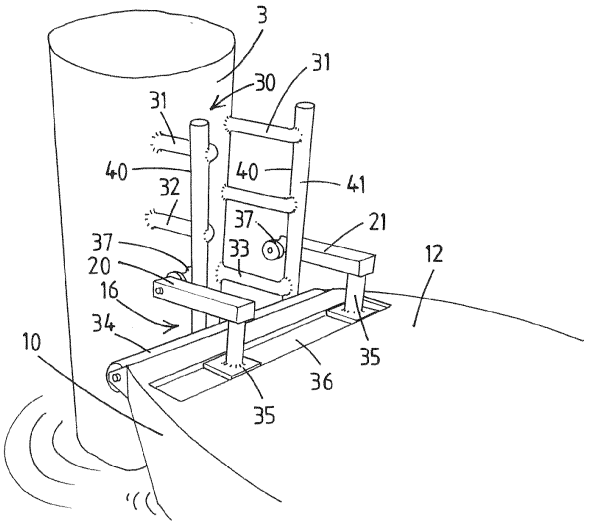

Fig.2a

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Description

[0001] The invention relates to a method for mooring a floating vessel against a stationary object, for example a mast of an offshore wind turbine. The stationary object is for example placed in the sea, wherein the vessel is moored against this to transfer persons or goods. When erecting a wind turbine park at sea, persons and goods are transferred many times to the offshore wind turbines under construction. Furthermore, installed wind turbines are visited regularly for maintenance activities. Other stationary objects at sea are also often visited by vessels to transfer personnel or equipment.

[0002] EP 1695902 describes a method for stabilising a floating vessel against an offshore structure. The vessel has an engine to propel the vessel. The engine pushesa fender at the bow of the vessel firmly against bumper bars of the offshore structure. The force exerted by the engine and the friction between the fender and the bumper bars of the offshore structure prevent the fender from slipping up or down along the bumper bars. As long as the fender is stabilised against the bumper bars of the offshore structure, personnel or equipment can be transferred between the vessel and the offshore structure.

[0003] If the engine of the vessel pushes the fender at the bow so firmly against the offshore structure that the fender is stabilised against the offshore structure, the fender at the bow forms a hinge point on rotation of the vessel under the effect of the waves (pitch). The stabilised fender however prevents rotation about the longitudinal axis of the vessel (roll) and translation in the height direction (heave). As a result, high waves can break over the bow of the vessel, which leads to hazardous situations in the transfer of personnel and/or goods. Also, as a result of the wave movement, the bow of the vessel can come clear of the water while the engine holds the fender at the bow pushed against the bumper bars of the offshore structure, provided that the engine has sufficient power. As a result however substantial forces are exerted on the bumper bars. This can lead to damage to the bumper bars and the offshore structure. In addition, there is a risk that the fender will unexpectedly become detached from the offshore structure and suddenly fall down. On sudden higher waves, the fender can also unexpectedly move up. This is particularly dangerous.

[0004] Therefore safety regulations apply which limit the use of this method to maximum 1.5 m significant wave height. The significant wave height Hs is a term generally understood in the field of seamanship, traditionally meaning the wave height which an experienced sailor perceives by eye. The significant wave height in practice appears to be the average height of the highest 1/3 of the waves. The significant wave height can thus be determined visually or by measurement. If the significant wave height is less than 1.5 m however there will still be waves which are higher. It cannot be predicted when this will happen precisely and what the height of the wave will be. In principle every following wave can cause an unsafe situation in the transfer of persons or goods. Another factor is the random wind and current circumstances which are unpredictable or scarcely predictable. In addition, there is a risk that the engine will hesitate or stall, for example due to contaminated fuel, mechanical or electrical defects, leading directly to a dangerous situation. It must be recalled that the transfer of persons or goods to an offshore wind turbine can for example take 20 minutes or longer.

[0005] An object of the invention is to provide an improved system for mooring a vessel against a stationary object.

[0006] This object is achieved according to the invention by a system for mooring a vessel against a stationary object, for example the mast of an offshore wind turbine, which system comprises a stationary object and a vessel, wherein the stationary object is provided with:

- at least one substantially vertical bumper bar which is attached to the stationary object by means of an extension,

and wherein the vessel is provided with:

- a hull,
- an engine for propelling the vessel,
- a buffer body which protrudes in relation to the hull,

wherein the bumper bar of the stationary object is provided with a substantially vertical, inside guide track, which substantially faces the stationary object, and a substantially vertical, outside guide track, which substantially faces away from the stationary object, and the vessel is provided with at least one engagement arm which at one end is provided with an engagement member, and the engagement arm is moveable in relation to the hull between a mooring state, in which the engagement member engages on the inside guide track of the bumper bar and is vertically displaceable along this, and a release state, in which the engagement member is out of engagement with the inside guide track, and the buffer body in the mooring state of the engagement arm engages on the outside guide track of the bumper bar and is vertically displaceable along this, and the inside guide track protrudes sideways in relation to an adjacent part of the extension of the bumper bar such that the engagement member of the engagement arm in the mooring state can be moved past the extension on vertical displacement along the inside guide track of the bumper bar.

[0007] With the system according to the invention, first by means of the engine the buffer body of the vessel is pressed against the outside guide track of the bumper bar of the stationary object, for example a mast of an offshore wind turbine. The engagement arm is then in the release state. While the engine holds the buffer body pressed against the bumper bar, the buffer body can move over the outside guide track vertically up and down with the wave movement.

[0008] While the engine holds the buffer body pressed against the bumper bar and the buffer body moves up

and down over the outside guide track of the bumper bar, the engagement arm is moved from the release state to the mooring state. Hereby the engagement member hooks behind the inside guide track of the bumper bar. The engagement member of the engagement arm in the mooring state can move vertically over the inside guide track so that the engagement member can also move up and down with the wave movement.

[0009] On the vertical displacement of the engagement member along the inside guide track of the bumper bar in the mooring state, the extension with which the bumper bar is attached to the stationary object is not in the way. The inside guide track according to the invention protrudes sideways in relation to the extension so that the engagement member of the engagement arm can be moved past the extension. The bumper bar with the sideways protruding, inside guide track and the engagement member are configured to allow a free stroke of the engagement member. The engagement member can pass the extension on vertical displacement along the inside guide track of the bumper bar. As the vessel moves up and down with the waves, the engagement member and the buffer body of the vessel thus move vertically along the inside and outside guide tracks respectively without this vertical displacement being hindered by the extension.

[0010] With the system according to the invention mooring of the vessel is therefore achieved by the fact that the bumper bar is enclosed between the buffer body and the engagement member. This prevents a translation of the vessel away from the bumper bar. At the same time a translation in the height direction is still possible so that the vessel can move with the waves. As a result the system according to the invention can be used with relatively high waves.

[0011] In one embodiment the stationary object is provided with at least two substantially vertical bumper bars which are each provided with a substantially vertical, inside guide track running transversely in relation to the extension of the bumper bar and substantially facing towards the stationary object, wherein for example the inside guide track protrudes sideways in relation to the extension of the bumper bar, and a substantially vertical, outside guide track substantially facing away from the stationary object, and the vessel is provided with at least two engagement arms which are each provided at one end with an engagement member, and the engagement arms are each moveable in relation to the hull between a mooring state, in which the engagement member of the first or second engagement arm respectively engages on the inside guide track of the first or second bumper bar respectively and is vertically displaceable along this, and a release state, in which the engagement member of the first or second engagement arm respectively is out of engagement with the inside guide track of the first or second bumper bar respectively, and the buffer body in the mooring state of the engagement arms engages on the outside guide track of the bumper bars and is vertically displaceable along this, wherein the inside guide track of the first and second bumper bar respectively protrudes sideways in relation to an adjacent part of the extension of the first and second bumper bar respectively such that the engagement member of each engagement arm in the mooring state, on vertical displacement along the inside guide track of the first or second bumper bar respectively, can be moved past the extension of the first or second bumper bar respectively.

[0012] When two substantially vertical bumper bars are used, the bumper bars of the stationary object are arranged mutually parallel and spaced apart from each other. By connecting the vessel with the two bumper bars via the two engagement arms, the vessel can be prevented from swivelling in a horizontal plane about the stationary object (yaw). This also prevents a translation movement in the width direction of the vessel (sway), as the bumper bars are enclosed between the engagement members of the engagement arms. This increases safety during the transfer of persons or goods.

[0013] For example, the extension is provided with at least one top support, a bottom support, which is below the top support, and/or a middle support, which is located between the top support and bottom support. The supports of the extension run for example substantially horizontally, each support being attached with a first end to the stationary object and with a second end to the bumper bar. Thus the engagement member of the or each engagement arm in the mooring state, on vertical displacement along the inside guide track of the bumper bar or bumper bars, can be moved past the top support and/or the middle support and/or the bottom support of the extension.

[0014] In this case the supports of the extension with which the bumper bar or bumper bars are attached to the stationary object do not, in the mooring state, obstruct the vertical displacement of the engagement member or engagement members along the inside guide track of the bumper bar or bumper bars. The inside guide track protrudes sideways in relation to the extension supports. The bumper bar or bumper bars with the sideways protruding, inside guide track and the engagement member or engagement members are configured to allow a free stroke of the engagement member or engagement members. The engagement member or engagement members can pass the supports of the extension on vertical displacement along the inside guide track of the bumper bar or bumper bars. When the vessel moves up and down with the waves, the engagement member or engagement members and the buffer body of the vessel move vertically along the inside and outside guide tracks respectively without the vertical displacement being hindered by the extension supports.

[0015] In one embodiment the or each engagement arm comprises a support part and an engagement part wherein the support part is connected with the vessel, and wherein the engagement part is displaceable in the mooring direction of the vessel in relation to the support

part, and wherein the engagement part at the end facing away from the support part is provided with the engagement member. The engagement part is for example mounted so as to be reciprocatingly moveable on the support part. The support part is for example tubular, wherein the engagement part is held telescopically in the tubular support part.

[0016] Say that the buffer body is attached firmly to the hull of the vessel. When the buffer body is pressed against the bumper bar or bars, the vessel can still rotate about a transverse axis determined by said buffer body (pitch). The or each engagement arm is situated at a distance above said transverse axis. When the vessel for example as the result of a wave rotates down about the transverse axis, the engagement part moves out in relation to the support part. The length of the engagement arm thus increases. The extent of movement of the engagement part in relation to the support part is smaller than the length of the engagement arm, such as no greater than around 25% of the length of the engagement arm. The extent of this movement is for example less than 70 cm, in particular less than around 50 cm.

[0017] In one embodiment, the or each engagement arm and the buffer body are mutually displaceable and drivable such that the or each bumper bar can be clamped between the engagement member of the or each engagement arm and the buffer body. When the vessel is moored against the stationary object by the form-fit connection between firstly the buffer body and the engagement member of the or each engagement arm and secondly the inside and outside guide tracks of the or each bumper bar, the engagement arm can pull the vessel more firmly against the stationary object, or the buffer body of the vessel is pushed away from the stationary object. For this the or each engagement arm or the buffer body respectively comprises a drive member. As a result, the or each bumper bar is clamped between the engagement member of the or each engagement arm. The engagement arm or arms can be continuously subjected to tensile load. This increases the stability of the connection between the vessel and the stationary object, in particular the translation of the vessel in the longitudinal direction (surge) is prevented.

[0018] In this case, it is possible that the drive member of the or each engagement arm allows a displacement of the engagement part in the longitudinal direction in relation to the support part while the engagement arm is continuously under tensile load. The bumper bars remain clamped between the buffer body and the engagement member of the or each engagement arm while rotation of the vessel about the transverse axis formed by the buffer body (pitch) is possible. Thus continuous clamping is possible which is independent of the rotation of the vessel about the transverse axis formed by the buffer body (pitch) and can be maintained in almost all circumstances.

[0019] In one embodiment, the engagement member of the or each engagement arm of the vessel is provided with at least one roller which is vertically displaceable along the inside guide track of the or each bumper bar. It is also possible that the buffer body of the vessel is provided with at least one roller which is vertically displaceable along the outside guide track of the or each bumper bar. The use of rollers allows a smooth and low-friction movement over the inside and/or outside guide tracks of the bumper bar. Incidentally, the rollers can also be replaced by other guide elements such as slide blocks.

[0020] In one embodiment, the vessel is provided with a substantially horizontal guide track, wherein the engagement arms are each attached non-rotatably to a carriage which is arranged displaceable along the horizontal guide track, and wherein the engagement arms in the release state are at a distance from each other, and wherein the engagement arms, in particular with the carriage, can move along the horizontal guide track towards each other on movement from the release state to the mooring state and move apart from each other on movement from the mooring state to the release state.

[0021] In this case, the or each engagement arm is mounted on the carriage which is connected in a sliding manner with the substantially horizontal guide track, which for example runs in the width direction of the vessel. The substantially horizontal guide track is for example mounted on the deck of the vessel. The guide track is for example rectilinear or curved. The carriages with the engagement arms can move from outside to inside so that for example at first only one engagement member moves against a bumper bar of the stationary object. After the engagement member has made contact with one of the bumper bars, the carriages are driven such that the engagement arms move closer together. This moves the vessel in the width direction (sway) until the engagement members of both engagement arms hook behind the inside guide tracks of the bumper bars. On driving the engagement arms, the vessel is therefore manoeuvred towards the centre of the stationary object .

[0022] It is also possible that the or each engagement arm is connected swivellably about a substantially vertical rotational axis with the vessel. In this case the or each engagement arm swivels against the bumper bars of the stationary object. When the engagement arms move towards each other on movement from the release state to the mooring state, and move apart on movement from the mooring state to the release state, the vessel can also be manoeuvred into the desired position in relation to the bumper bars by the driving of the engagement arms.

[0023] The bumper bar or bumper bars with the inside and outside guide tracks can be designed in various ways. For example the or each bumper bar is provided with a substantially vertical rod which comprises the inside guide track, wherein the supports of the extension extend substantially horizontally, wherein each support is attached with a first end to the stationary object and with a second end to the rod, leaving the inside guide track of the rod clear. The bumper bars in this case are

different from conventional bumper bars of offshore wind turbine masts. These bumper bars according to the invention can nonetheless easily be used on new offshore wind turbines to be constructed.

[0024] It is also possible that the or each bumper bar is provided with a substantially vertical rod and a guide rail which protrudes sideways in relation to the rod, wherein the guide rail contains the inside guide track, and wherein the supports of the extension extend substantially horizontally, wherein each support is attached with a first end to the stationary object and with a second end to the rod, leaving the inside guide track of the guide rail clear. In this case conventional bumper bars can easily be adapted by attachment of the guide rail, for example by welding or otherwise. The bumper bars of existing offshore wind turbines can easily be converted for use of the invention.

[0025] In one embodiment, the substantially vertical bumper bars are mounted at a horizontal distance from each other, wherein the vessel is provided with a nose body which protrudes in relation to the buffer body, and wherein the nose body has a width which substantially corresponds to the horizontal distance between the bumper bars, and wherein the nose body in the mooring state of the engagement arms is mounted between the bumper bars. The nose body in this case prevents translation of the vessel in the width direction (sway) by the fact that the nose body is tightly enclosed between the bumper bars.

[0026] The invention also relates to a method for mooring a vessel against a stationary object, for example the mast of a wind turbine erected in water,
wherein the stationary object is provided with:

- at least one substantially vertical bumper bar which is attached to the stationary object by means of an extension, which bumper bar is provided with a substantially vertical, inside guide track substantially facing the stationary object, and a substantially vertical, outside guide track substantially facing away from the stationary object,
  and wherein the vessel is provided with:
- a hull,
- an engine for propelling the vessel,
- a buffer body which protrudes in relation to the hull,
- at least one engagement arm which is provided at one end with an engagement member, and the engagement arm is moveable in relation to the hull between a mooring state, in which the engagement member engages on the inside guide track of the bumper bar and is vertically displaceable along this, and a release state, in which the engagement member is out of engagement with the inside guide track, and the buffer body in the mooring state of the engagement arm engages on the outside guide track of the bumper bar and is vertically displaceable along this, and the inside guide track protrudes sideways in relation to an adjacent part of the extension of the bumper bar such that the engagement member of the engagement arm in the mooring state can be moved past the extension on vertical displacement along the inside guide track of the bumper bar,
  and wherein the method comprises:
- the pushing of the buffer body of the vessel against the bumper bar of the stationary object by means of the engine while the engagement arm is in the release state, wherein the buffer body by means of the pushing engages on the outside guide track of the bumper bar and is vertically displaceable along this,
- the subsequent movement of the engagement arm from the release state into the mooring state.

[0027] As indicated above, two substantially vertical bumper bars and two engagement arms may be used. It is preferred in that case if the vessel is provided with a substantially horizontal guide track, wherein the engagement arms are each mounted non-rotatably to a carriage which is mounted displaceable along the horizontal guide track, and wherein the engagement arms in the release state are spaced apart from each other, and wherein the engagement arms on moving from the release state to the mooring state move towards each other and thus manoeuvre the vessel into a position in relation to the bumper bars in which the bumper bars are enclosed between the engagement arms. Hereby the driving of the engagement arms helps manoeuvre the vessel into the correct position in relation to the bumper bars. This is easier than manoeuvring the vessel by means of the engine alone.

[0028] The invention will now be explained in more detail as an example with reference to the accompanying drawing.

Figure 1a shows a top view of a first embodiment of a vessel approaching a stationary object, wherein the engagement arms are in the release state.

Figure 1b shows a top view of the vessel shown in figure 1a which is pushed by the engine against a stationary object, wherein the engagement arms are in the release state.

Figure 1c shows a top view of the vessel shown in figure 1a, wherein the engagement arms are in the mooring state.

Figure 1d shows a side view of the vessel shown in figure 1a, wherein the engagement arms are in the mooring state.

Figure 2a shows a perspective view of a second embodiment of a vessel, wherein the engagement arms are in the mooring state.

Figure 2b shows an enlarged top view of the vessel shown in figure 2a, wherein the engagement arms

are in the mooring state.

Figure 3 shows a side view of a vessel which is rotated down about the buffer body.

Figures 4a - 4f and figures 5a - 5f show various embodiments of bumper bars and engagement arms according to the invention.

[0029] A stationary object 3 is erected in a sea 2. In this exemplary embodiment , the stationary object 3 is an offshore wind turbine which is provided with a mast. On the mast of the wind turbine 3, two substantially vertical bumper bars 5, 6 are mounted by means of an extension or boom 30. The extension 30 in this exemplary embodiment comprises a top support 31, two middle supports 32 and a bottom support 33. Between the bumper bars 5, 6 is a ladder 7 with which installation or maintenance personnel can climb up and down the wind turbine 3.

[0030] The bumper bars 5, 6 of the wind turbine 3 each comprise a substantially vertical, inside guide track 40 which protrudes sideways in relation to the supports 31, 32, 33 of the extension 30 of the bumper bars 5, 6. The inside guide tracks 40 substantially face the mast of the wind turbine 3. The inside guide tracks 40 run transversely in relation to the supports 31, 32, 33. The bumper bars 5, 6 of the wind turbine 3 comprise a substantially vertical, outside guide track 41 which substantially faces away from the mast of the wind turbine 3 .

[0031] The personnel is brought to the offshore wind turbine 3 with a vessel 1 (a so-called crew transport vessel). The vessel 1 comprises an engine 14 to propel the vessel 1. The engine 14 in this embodiment example drives a propeller. The engine 14 can however drive a different propulsion member such as a water jet or other (not shown). The engine 14 for example has a power to supply 4 - 8 tonnes thrust.

[0032] The vessel 1 has a hull 9 which is provided with a bow 10, a midships and a stern 11. In this exemplary embodiment the vessel 1 has a flat bow 10. On the deck 12 of the vessel 1 is attached a carrier frame 17 (see figures 1a-1d) which is located at the bow 10. The carrier frame 17 comprises a platform on which a person can stand (not shown). On the carrier frame 17 is attached a buffer body 16 which protrudes in relation to the hull 9. The buffer body 16 comprises a roller 34 with a substantially horizontal rotational axis. The buffer body 16 with the roller 34 can also be mounted on the outside of the hull 9 (see figure 2a). In this case the carrier frame 17 is integrated with the structure of the vessel 1.

[0033] The vessel 1 comprises two engagement arms 20, 21 each of which at a free end is provided with an engagement member 24. Each engagement member 24 in this exemplary embodiment comprises a roller 37 with a substantially horizontal rotational axis. The engagement members 24 of the engagement arms 20, 21 are configured to engage on the inside guide tracks 40 of the bumper bars 5, 6 of the wind turbine 3. In this exemplary embodiment , the engagement arms 20, 21 are hook-shaped. Each engagement member 24 forms a hook part which protrudes transversely in relation to the engagement arm 20, 21.

[0034] In the exemplary embodiment shown in figures 1a - 1d, the engagement arms 20, 21 are each attached non-rotatably to a carriage 35 which is mounted so as to be displaceable in the transverse direction of the vessel 1 along a horizontal guide track 36. The engagement arms 20, 21 are each hereby moveable in relation to the hull 9 between a release state and a mooring state. In the release state the rollers 37 of the engagement members 24 of the engagement arms 20, 21 are out of engagement with the inside guide track 40 of the bumper bars 5, 6. Figures 1a, 1b show the release state in which the engagement arms 20, 21 are moved apart.

[0035] In the mooring state the rollers 37 of the engagement members 24 of the engagement arms 20, 21 engage on the inside guide track 40 of the bumper bars 5, 6, so that the rollers 37 are displaceable vertically along this. Figures 1c and 1d show the mooring state in which the engagement arms 20, 21 have moved towards each other and enclose the bumper bars 5, 6. The hook part 24 with the roller 37 of each engagement arm 20, 21 thus at least partly hooks behind the inside guide track 40 of the respective bumper bars 5, 6. The roller 34 of the buffer body 16 in the mooring state of the engagement arms 5, 6 engages on the outside guide track 41 of the bumper bars 5, 6 so that the roller 34 is vertically displaceable along this.

[0036] Each engagement arm 20, 21 comprises for example an elongated support part and an elongated engagement part which are connected telescopically together (not shown). Each engagement arm 20, 21 can comprise a drive member for driving the engagement part in relation to the support part, for example a hydraulic cylinder (not shown). The engagement part is then connected with the support part by means of the hydraulic cylinder such that the engagement part can be moved reciprocatingly in relation to the support part by operation of the hydraulic cylinder. When the engagement arms 20, 21 are hooked by means of engagement members 24 behind the guide tracks 40 of the bumper bars 5, 6 of the wind turbine 3, the engagement arms 20, 21 can be maintained continuously under tensile load by exercising a tensile force in the hydraulic cylinders of the engagement arms 20, 21.

[0037] The drive members in the engagement arms 20, 21 can optionally be designed to allow a displacement of the engagement part in relation to the support part while the engagement arms 20, 21 at the same time remain continuously under tensile load. For example the drive member of each engagement arm 20, 21 comprises an accumulator (not shown). The accumulator is provided with a receptacle containing a movable partition wall. The partition wall divides the inside of the receptacle into two chambers, the volume of which can be varied by

movement of the partition wall.

[0038] The first chamber is closed by the movable partition wall while the second chamber is connected with the hydraulic cylinder of the associated engagement arm 20, 21. The first chamber contains a compressible fluid under pressure, for example air or another gas. The second chamber is filled with hydraulic fluid which can flow to and from the hydraulic cylinder. Thus the engagement arms 20, 21 are each held under a substantially constant pressure during the continuous tensile load of the engagement arms 20, 21, while a displacement of the engagement part in relation to the support part remains possible by the displacement of the movable partition wall in the receptacle.

[0039] The vessel 1 is moored as follows against the bumper bars 5, 6 of the offshore wind turbine 3. First by means of the engine 14, the roller 34 of the buffer body 16 of the vessel 1 is pushed against the outside guide tracks 41 of the bumper bars 5, 6. The mooring direction of the vessel 1 is the direction in which the vessel 1 moves towards the offshore wind turbine - the mooring direction of the vessel 1 corresponds for example to the longitudinal direction of the vessel 1. Although the thrust of the engine 14 then continues to press the roller 34 of the buffer body 16, the roller 34 of the buffer body 16 can move up and down with the waves along the outside guide tracks 41 of the bumper bars 5, 6. The engagement arms 20, 21 are then in the release state (see the figures 1 a and 1 b).

[0040] While the buffer body 16 is held in contact with the outside guide tracks 41 of the bumper bars 5, 6 by means of the pushing by the engine 14, the engagement arms 20, 21 are moved into the mooring state shown in figure 1 c. The engagement arms 20, 21 move, driven by the carriages 35, towards each other until the engagement arms 20, 21 come into contact with the bumper bars 5, 6. The rollers 37 of the engagement members 24 of the engagement arms 20, 21 then hook behind the inside guide tracks 40 of the bumper bars 5, 6.

[0041] Then the hydraulic cylinders in the engagement arms 20, 21 can be actuated so that the engagement arms 20, 21 pull the buffer body 16 of the vessel 1 more firmly against the bumper bars 5, 6, i.e. to clamp the bumper bars 5, 6 between the roller 34 of the buffer body and the rollers 37 of the engagement members 24. The pulling of the engagement arms 20, 21 is however optional because the bumper bars 5, 6 are held by form fit between the buffer body 14 and the rollers 37 of the engagement members 24.

[0042] When the form fit connection has been achieved in the mooring state, the vessel 1 can still rotate about a transverse axis 27 (pitch) which is determined by the buffer body 16 (see figure 3). The engagement arms 20, 21 lie above the transverse axis 27. If for example as a result of a wave, the vessel 1 rotates downward about the transverse axis 27, the engagement part 23 moves out in relation to the support part 22 of the engagement arms 20, 21. The extent of movement of the engagement part 23 in relation to the support part 22 is for example no more than around 30 cm.

[0043] On extension of the hydraulic cylinders in the engagement arms 20, 21, hydraulic fluid flows out of each receptacle into the hydraulic cylinders. The moveable partition wall in each receptacle also moves to the outside i.e. the volume of the second chamber diminishes while the volume of the first chamber increases proportionally. As a result the engagement arms 20, 21 are held at a constant pressure. While the length of the engagement arms 20, 21 is varied by wave movements, the engagement arms 20, 21 can therefore be kept under continuous tension.

[0044] Also it is possible that the engagement arms 20, 21 are placed under tension by a pushing force being exerted from the vessel 1 onto the bumper bars 5, 6 of the wind turbine 3. The carrier frame 17 is for example guided in a displaceable manner on a chassis mounted on the deck 12 of the vessel 1 (not shown). If the buffer body 16 is attached to the carrier frame 17, the buffer body 16 is displaceable in relation to the hull 9 of the vessel 1 and the buffer body 16 and the engagement member 24 are then displaceable in relation to each other. The buffer body 16 can be moved reciprocatingly in relation to the hull 9 by means of one or more hydraulic cylinders, whereby a pushing force can be exerted by the buffer body 16. The buffer body 16 can then move against the bumper bars 5, 6. The hydraulic cylinders can also be designed such that these cylinders contribute to the buffering effect of the buffer body 14.

[0045] Figures 4a - 4f and figures 5a - 5f show various embodiments of bumper bars and engagement arms according to the invention. The bow 10 of the vessel 1 comprises a nose body 50 which protrudes in relation to the buffer body 14. The nose body 50 has a width which substantially corresponds to the horizontal distance between the bumper bars 5, 6. The nose body 50 in the mooring state of the engagement arms 20, 21 is arranged between the bumper bars 5, 6. The nose body 50 in this exemplary embodiment is however optional and can be omitted.

[0046] Also figures 4a - 4f and figures 5a - 5f show a number of exemplary embodiments of bumper bars 5, 6 which comprise a substantially vertical rod 51 and a guide rail 52. This makes it possible to fit the guide tracks 40, 41 according to the invention easily to bumper bars of existing offshore wind turbines.

[0047] The two engagement arms 20, 21 in these exemplary embodiments can also each be rotatable about a vertical rotational axis (not shown). The engagement arms 20, 21 can then swivel about the vertical axis between the release state and the mooring state.

[0048] The invention is not restricted to the exemplary embodiments shown in the figures. The person skilled in the art can make various adaptations which lie within the scope of the invention. For example the buffer body and the engagement arms can be mounted on the stern of the vessel. In this case the vessel approaches the sta-

tionary object in reverse.

Claims

1. System for mooring a vessel (1) against a stationary object (3), for example the mast of a wind turbine erected in water, which system comprises a stationary object (3) and a vessel (1),
wherein the stationary object (3) is provided with:

    - at least one substantially vertical bumper bar (5, 6) which is attached to the stationary object (3) by means of an extension,

    and wherein the vessel (1) is provided with:

    - a hull (9),
    - an engine (14) for propelling the vessel (1),
    - a buffer body (16) which protrudes in relation to the hull (9),

    characterized in that
    the bumper bar (5, 6) of the stationary object (3) is provided with a substantially vertical, inside guide track which substantially faces the stationary object (3), and a substantially vertical, outside guide track, which substantially faces away from the stationary object (3), and the vessel (1) is provided with at least one engagement arm (20, 21) which at one end is provided with an engagement member (24), and the engagement arm (20, 21)can be moved in relation to the hull (9) between a mooring state, in which the engagement member (24) engages on the inside guide track of the bumper bar (5, 6) and is vertically displaceable along this, and a release state, in which the engagement member (24) is out of engagement with the inside guide track, and the buffer body (16) in the mooring state of the engagement arm (5, 6) engages on the outside guide track of the bumper bar (5, 6) and is vertically displaceable along this, and the inside guide track protrudes sideways in relation to an adjacent part of the extension of the bumper bar (5, 6) such that the engagement member (24) of the engagement arm (20, 21) in the mooring state can be moved past the extension on vertical displacement along the inside guide track of the bumper bar (5, 6).

2. System according to claim 1, in which the stationary object (3) is provided with at least two substantially vertical bumper bars (5, 6) which are each provided with a substantially vertical, inside guide track running transversely in relation to the extension of the bumper bar (5, 6) and substantially facing towards the stationary object (3), and a substantially vertical, outside guide track substantially facing away from the stationary object (3), and the vessel (1) is provided with at least two engagement arms (20, 21) which are eachprovided at one end with an engagement member (24), and the engagement arms (20, 21) are each moveable in relation to the hull (9) between a mooring state, in which the engagement member (24) of the first or second engagement arm (20, 21) respectively engages on the inside guide track of the first or second bumper bar (5, 6) respectively and is vertically displaceable along this, and a release state, in which the engagement member (24) of the first or second engagement arm (20, 21) respectively is out of engagement with the inside guide track of the first or second bumper bar (5, 6) respectively, and the buffer body (16) in the mooring state of the engagement arms (20, 21) engages on the outside guide track of the bumper bars (5, 6) and is vertically displaceable along this, wherein the inside guide track of the first and second bumper bar (5, 6) respectively protrudes sideways in relation to an adjacent part of the extension of the first and second bumper bar (5, 6) respectively such that the engagement member (24) of each engagement arm (20, 21) in the mooring state, on vertical displacement along the inside guide track of the first or second bumper bar (5, 6) respectively, can be moved past the extension of the first or second bumper bar (5, 6) respectively.

3. System according to claim 1 or 2, in which the extension is provided with at least one top support, a bottom support, which is below the top support, and/or a middle support, which is located between the top support and the bottom support, and wherein the engagement member (24) of the or each engagement arm (20, 21) in the mooring state, on vertical displacement along the inside guide track of the bumper bar or bumper bars (5, 6), can be moved past the top support and/or the middle support and/or the bottom support of the extension.

4. System according to any of the preceding claims, wherein the or each engagement arm (20, 21) comprises a support part (22) and an engagement part (23), wherein the support part (22) is connected with the vessel (1), and wherein the engagement part (23) is displaceable in the mooring direction of the vessel (1) in relation to the support part (22), and wherein the engagement part (23) at the end facing away from the support part (22) is provided with the engagement member (24).

5. System according to any of the preceding claims, wherein the or each engagement arm (20, 21) and the buffer body (16) are mutually displaceable and drivable such that the or each bumper bar (5, 6) can be clamped between the engagement member (24) of the or each engagement arm (20, 21) and the buffer body (16).

6. System according to any of the preceding claims, wherein the engagement member (24) of the or each engagement arm (20, 21) of the vessel (1) is provided with at least one roller which is vertically displaceable along the inside guide track of the or each bumper bar (5, 6).

7. System according to any of the preceding claims, wherein the buffer body (14) of the vessel (1) is provided with at least one roller which is vertically displaceable along the outside guide track of the or each bumper bar (5, 6).

8. System according to any of claims 2 to 7, wherein the vessel (1) is provided with a substantially horizontal guide track and wherein the engagement arms (20, 21) are each attached non-rotatably to a carriage which is arranged displaceable along the horizontal guide track, and wherein the engagement arms (20, 21) in the release state are at a distance from each other, and wherein the engagement arms (20, 21) move towards each other on movement from the release state to the mooring state and move apart from each other on movement from the mooring state to the release state.

9. System according to any of claims 3 to 8, wherein the or each bumper bar (5, 6) is provided with a substantially vertical rod, which comprises the inside guide track, and wherein the supports of the extension extend substantially horizontally, wherein each support is attached with a first end to the stationary object and with a second end to the rod, leaving the inside guide track of the rod clear.

10. System according to any of claims 3 to 9, wherein the or each bumper bar (5, 6) is provided with a substantially vertical rod and a guide rail which protrudes sideways in relation to the rod, wherein the guide rail contains the inside guide track, and wherein the supports of the extension extend substantially horizontally, wherein each support is attached with a first end to the stationary object and with a second end to the rod, leaving the inside guide track of the guide rail clear.

11. System according to any of claims 2 to 10, wherein the substantially vertical bumper bars (5, 6) are mounted at a horizontal distance from each other, and wherein the vessel (1) is provided with a nose body which protrudes in relation to the buffer body (16), and wherein the nose body has a width which substantially corresponds to the horizontal distance between the bumper bars (5, 6), and wherein the nose body in the mooring state of the engagement arms (20, 21) is fitted between the bumper bars (5, 6).

12. System according to any of the preceding claims, wherein the engagement member of the or each engagement arm (20, 21) protrudes sideways in relation to an adjacent part of the engagement arm (20, 21).

13. Method for mooring a vessel (1) against a stationary object (3), for example the mast of a wind turbine erected in water,
wherein the stationary object (3) is provided with:

- at least one substantially vertical bumper bar (5, 6) which is attached to the stationary object (3) by means of an extension, which bumper bar (5, 6) is provided with a substantially vertical, inside guide track which substantially facies the stationary object (3), and a substantially vertical, outside guide track which substantially faces away from the stationary object (3),

and wherein the vessel (1) is provided with:

- a hull (9),
- an engine (14) for propelling the vessel (1),
- a buffer body (16) which protrudes in relation to the hull (9),
- at least one engagement arm (20, 21) which is provided at one end with an engagement member (24), and the engagement arm (20, 21) can be moved in relation to the hull (9) between a mooring state, in which the engagement member (24) engages on the inside guide track of the bumper bar (5, 6) and is vertically displaceable along this, and a release state, in which the engagement member (24) is out of engagement with the inside guide track, and the buffer body (16) in the mooring state of the engagement arm (5, 6) engages on the outside guide track of the bumper bar (5, 6) and is vertically displaceable along this, and the inside guide track protrudes sideways in relation to an adjacent part of the extension of the bumper bar (5, 6) such that the engagement member (24) of the engagement arm (20, 21) in the mooring state can be moved past the extension on vertical displacement along the inside guide track of the bumper bar (5, 6),

and wherein the method comprises:

- the pushing of the buffer body (16) of the vessel (1) against the bumper bar (5, 6) of the stationary object (3) by means of the engine (14) while the engagement arm (20, 21) is in the release state, wherein the buffer body (16) by means of the pushing engages on the outside guide track of the bumper bar (5, 6) and is vertically displaceable along this,
- the subsequent movement of the engagement

arm (20, 21) from the release state into the mooring state.

14. Method according to claim 13, wherein the stationary object (3) is provided with at least two substantially vertical bumper bars (5, 6) which are each provided with a substantially vertical, inside guide track protruding sideways in relation to the extension of the bumper bar (5, 6) and substantially facing the stationary object (3), and a substantially vertical, outside guide track substantially facing away from the stationary object (3), and the vessel (1) is provided with at least two engagement arms (20, 21), which are each fitted at one end with an engagement member (24), and the engagement arms (20, 21) are each moveable in relation to the hull (9) between a mooring state, in which the engagement member (24) of the first or second engagement arm (20, 21) respectively engages on the inside guide track of the first or second bumper bar (5, 6) respectively and is vertically displaceable along this, and a release state, in which the engagement member (24) of the first or second engagement arm (20, 21) respectively is out of engagement with the inside guide track of the first or second bumper bar (5, 6) respectively, and the buffer body (16) in the mooring state of the engagement arms (5, 6) engages on the outside guide track of the bumper bars (5, 6) and is vertically displaceable along this, wherein the inside guide track of the first and second bumper bar (5, 6) respectively protrudes sideways in relation to an adjacent part of the extension of the first and second bumper bar (5, 6) respectively such that the engagement member (24) of each engagement arm (20, 21) in the mooring state, on vertical displacement along the inside guide track of the first or second bumper bar (5, 6) respectively, can be moved past the extension of the first or second bumper bar (5, 6) respectively, and wherein the buffer body (16) of the vessel (1) is pushed against the bumper bar (5, 6) of the stationary object (3) by means of the engine (14) while each engagement arm (20, 21) is in the release state, and wherein the engagement arms (20, 21) each move out of the release state into the mooring state after the buffer body (16) of the vessel (1) is pushed against the bumper bar (5, 6) of the stationary object (3) by means of the engine (14).

15. Method according to claim 14, wherein the vessel (1) is provided with a substantially horizontal guide track, and wherein the engagement arms (20, 21) are each mounted non-rotatably on a carriage which is mounted displaceable along the horizontal guide track, and wherein the engagement arms (20, 21) in the release state are spaced apart from each other, and wherein the engagement arms (20, 21) on moving from the release state to the mooring state move towards each other and thus manoeuvre the vessel (1) into a position in relation to the bumper bars (5, 6) in which the bumper bars (5, 6) are enclosed between the engagement arms (20, 21).

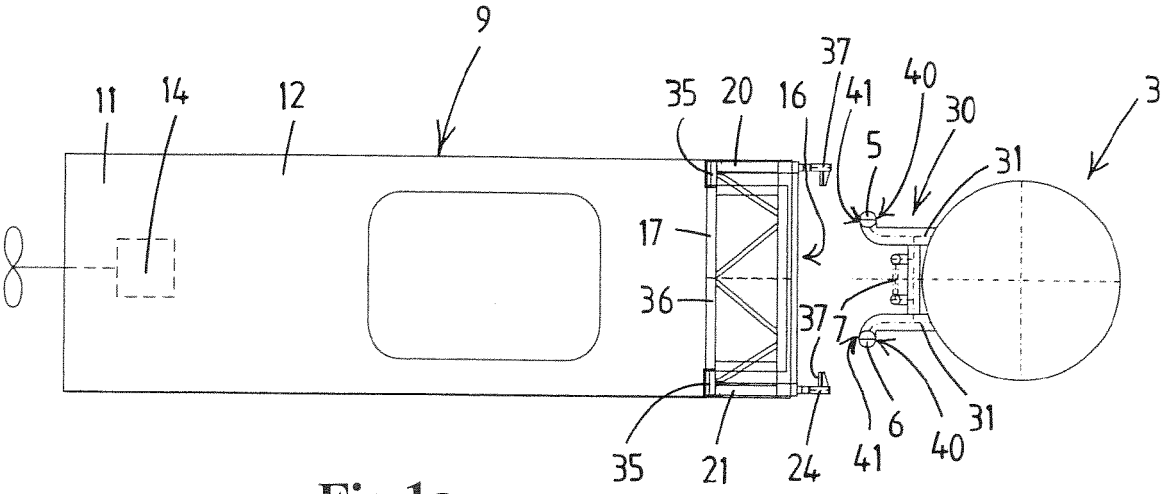
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Fig.1a

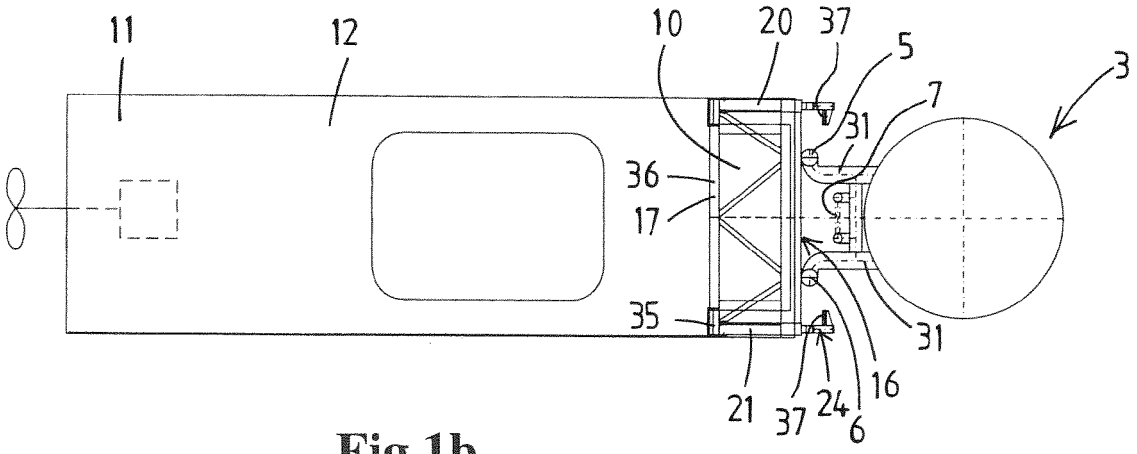
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Fig.1b

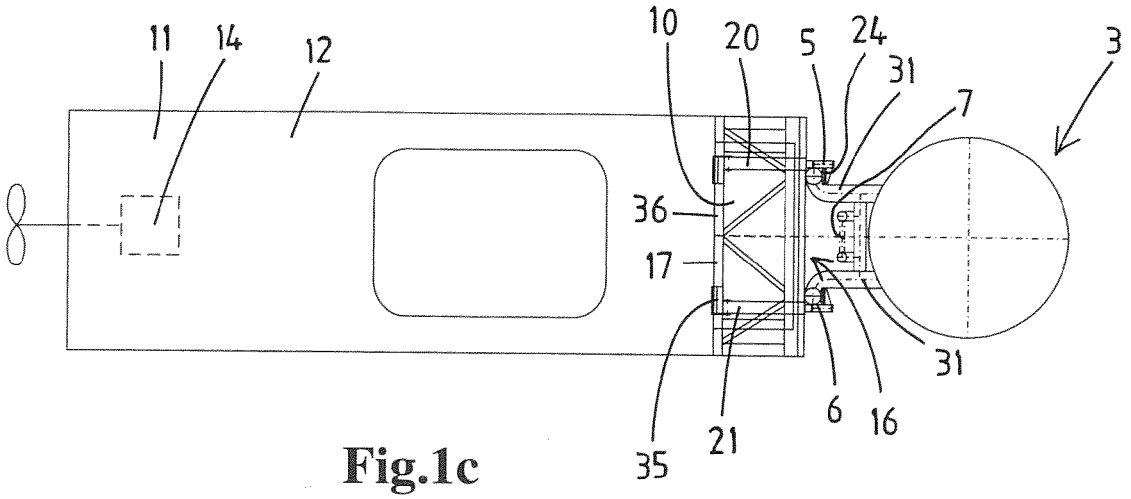
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Fig.1c

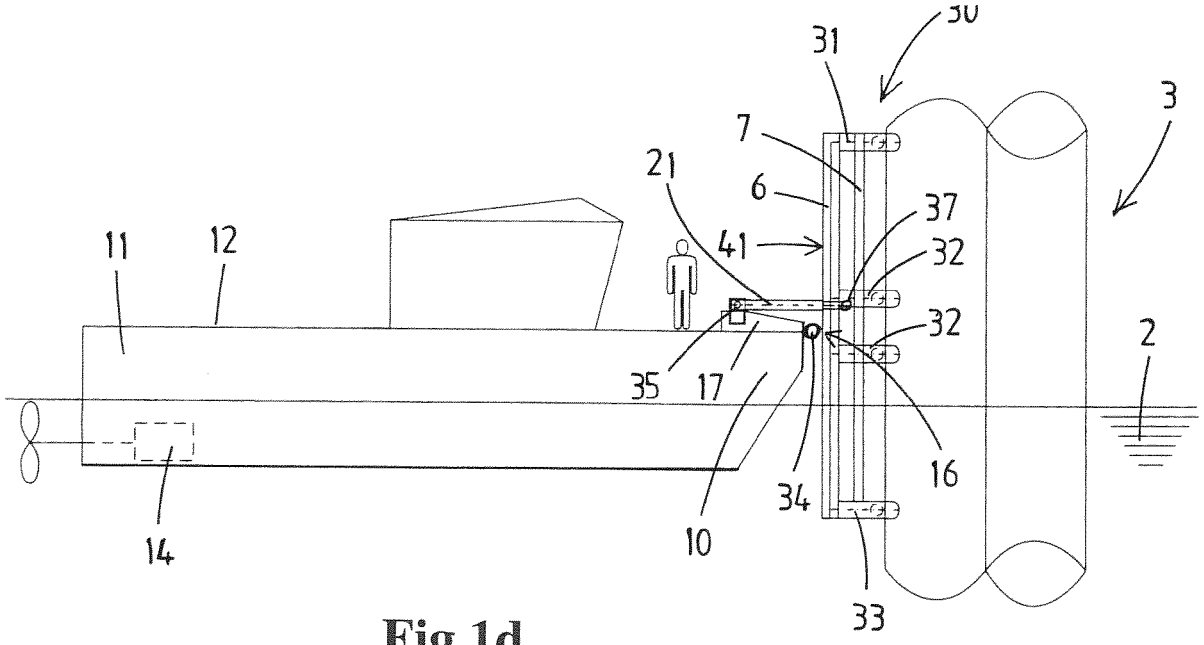
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Fig.1d

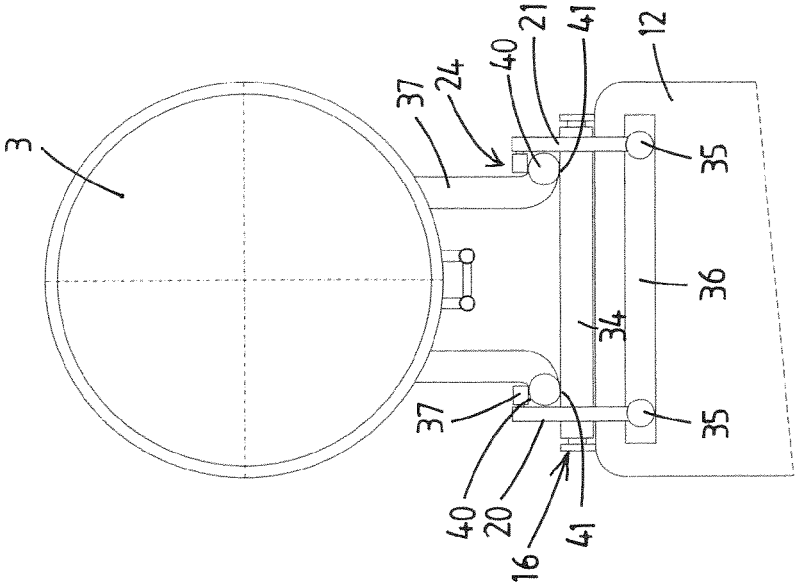
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Fig.2b

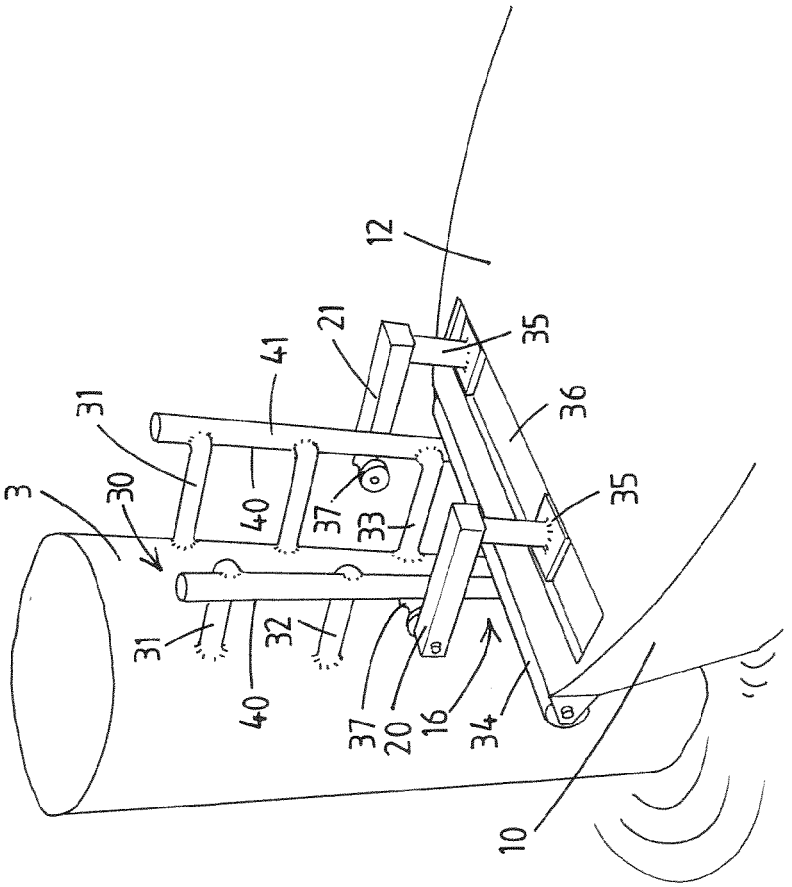
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Fig.2a

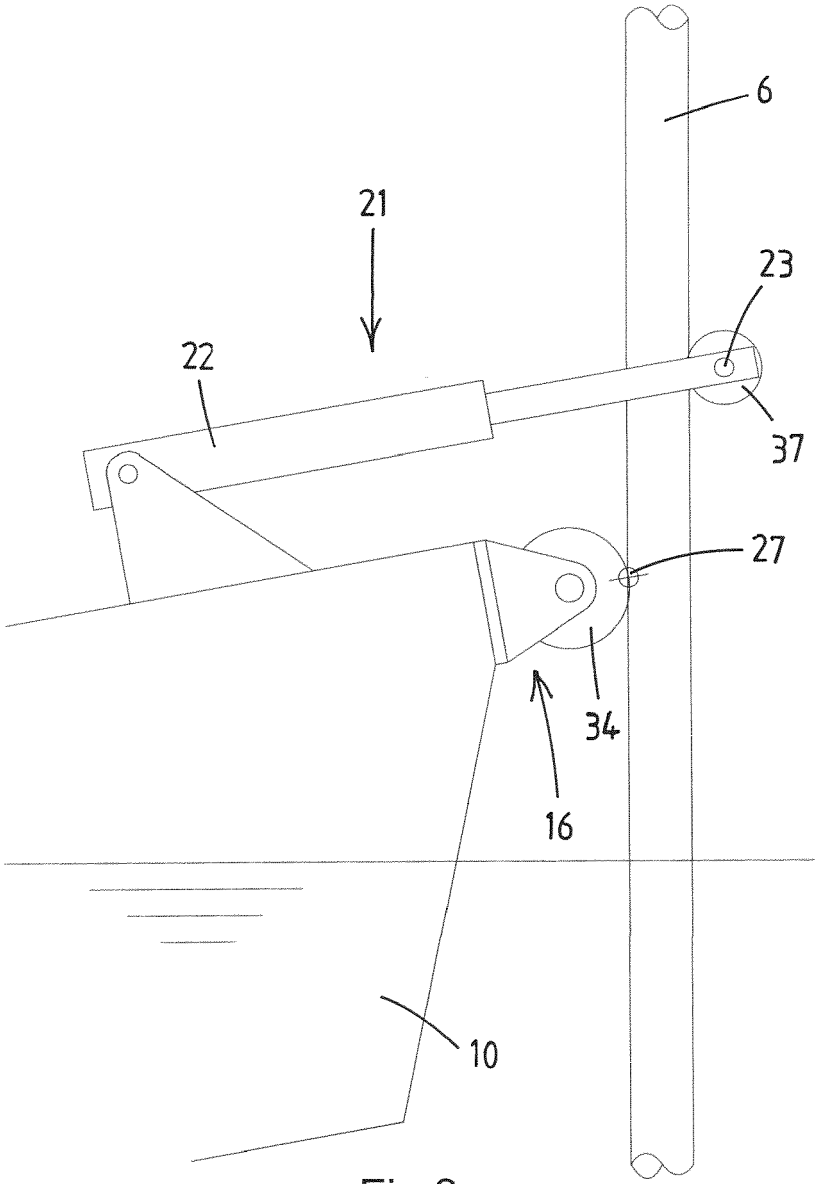

Fig 3

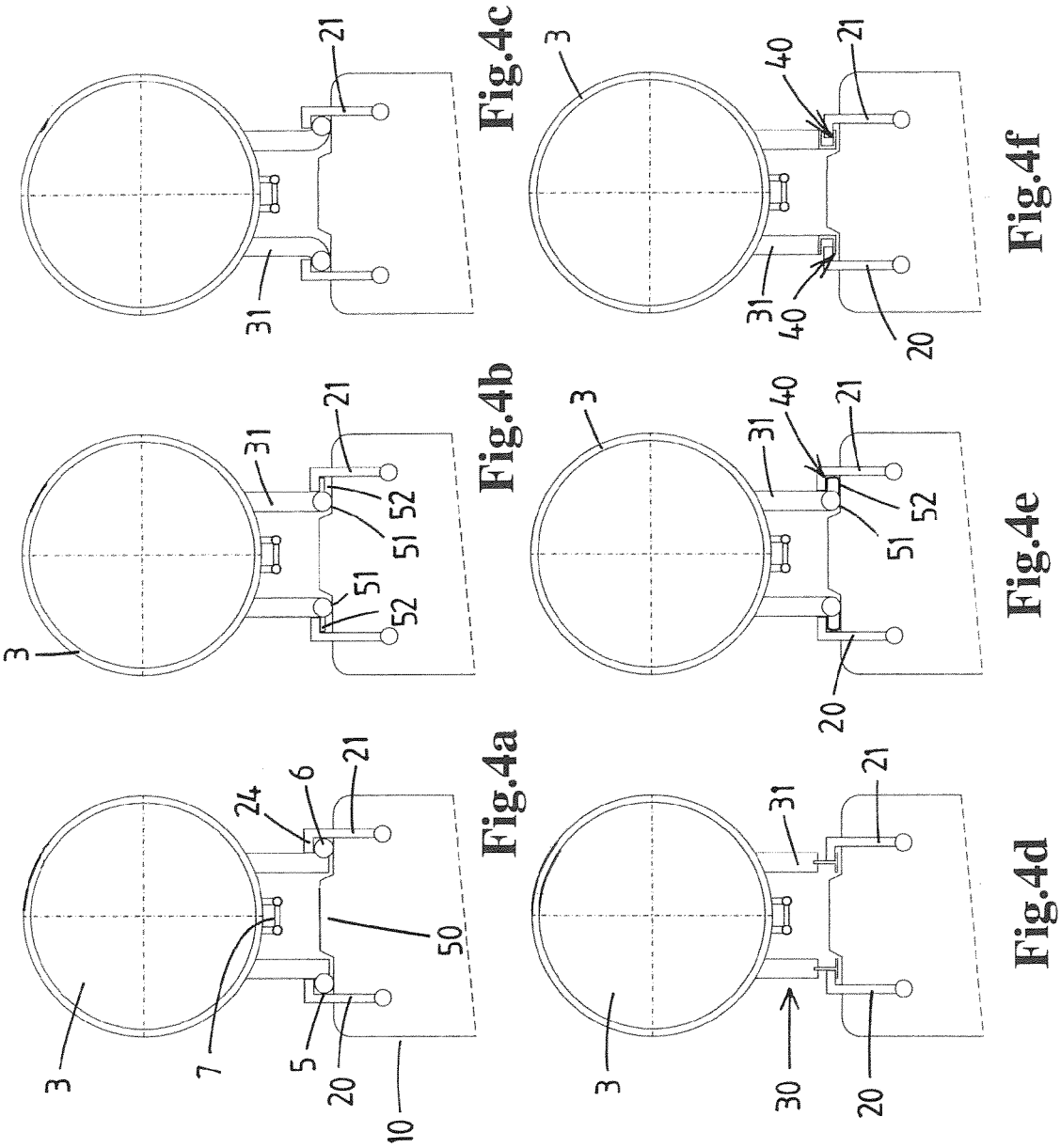
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Fig.4a
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Fig.4b
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Fig.4c
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Fig.4e
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Fig.4f

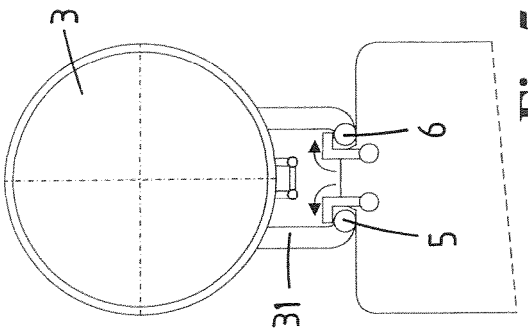

Fig.5c

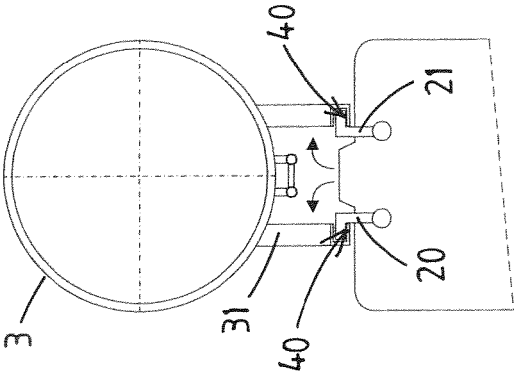

Fig.5f

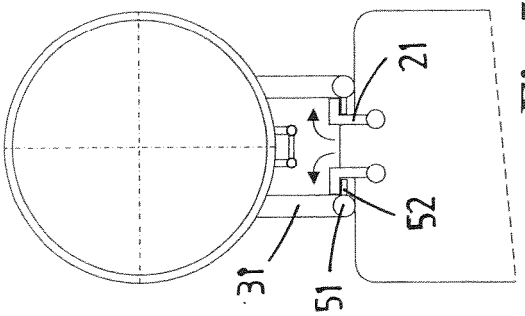

Fig.5b

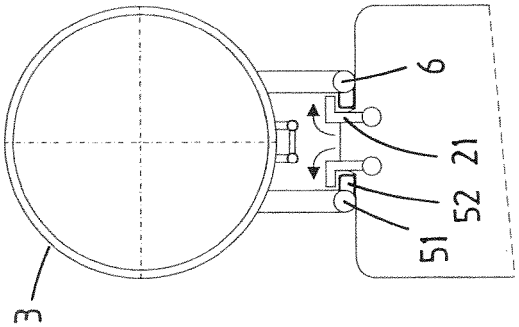

Fig.5e

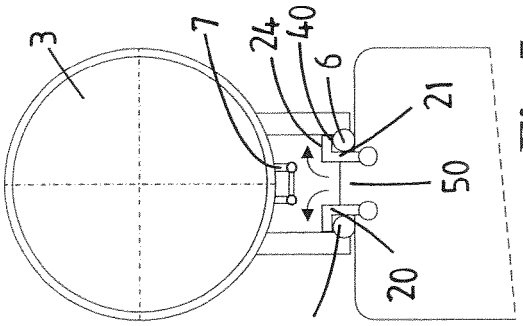

Fig.5a

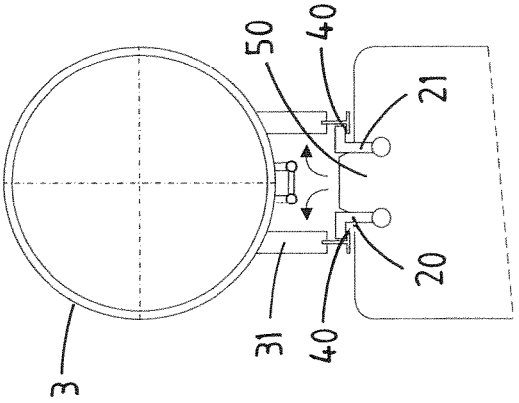

Fig.5d

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 6445

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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	16 August 2012	van Rooij, Michael

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

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