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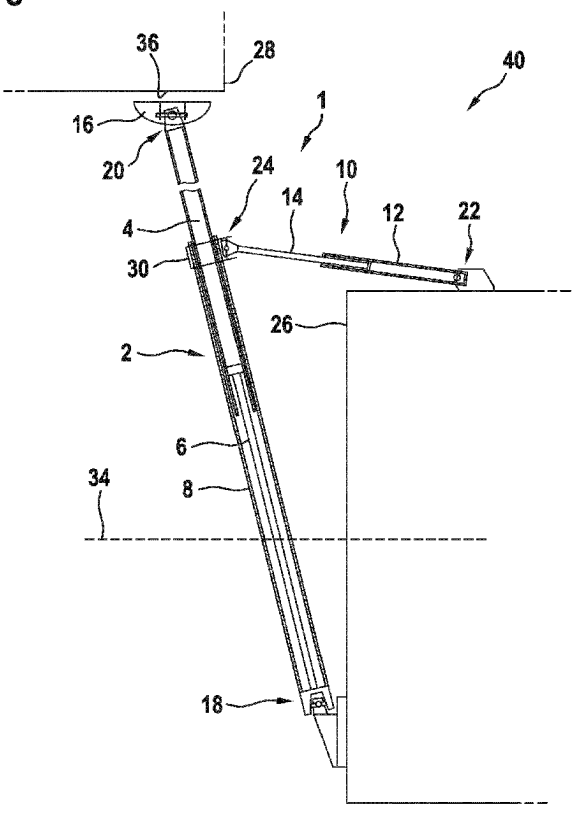
(54) **TOPSIDE LIFTING DEVICE, TOPSIDE LIFTING ARRANGEMENT, VESSEL COMPRISING THE TOPSIDE LIFTING ARRANGEMENT, AND METHOD OF LIFTING OR LOWERING A TOPSIDE**

(57) Disclosed is a topside lifting device (1) including: a lifting actuator (2) as a linear actuator having a first end (18) and a second end (20), wherein the second end (20) is engageable with a support portion (36) on a topside (28), wherein the second end (20) can rotate about the first end (18) around at least one axis, including an axis other than the lifting actuator's actuating axis.

Fig. 3



EP 3 508 412 A1

Description

Field of the Invention

[0001] The present invention relates to a topside lifting device, a topside lifting arrangement, a vessel comprising the topside lifting arrangement, and a method of lifting or lowering a topside.

Background of the Invention

[0002] In order to transport a heavy load on a floating vessel, the load must be lifted and then lowered onto the floating vessel. Lifting can occur in the case of the decommissioning of end-of-life topsides, for example from old oil rigs.

[0003] An increasing number of topsides in operation around the world are of relatively small size, due to the increasing number of wind energy farms at sea which tend to have smaller topsides than e.g. oil rigs. Therefore the (de)commissioning of small topsides with an expensive lifting apparatus that is suitable for large topsides is not commercially or operationally desirable.

[0004] Known technologies for lifting/lowering topsides of various sizes are identified in the following. It is known to lift the topside from above, e.g. with a floating crane (i.e. a vessel provided with one or more cranes); an example is disclosed in US 20090028647 A1. It is also known to lift the topside essentially vertically from underneath by hydraulic jacks provided at the deck of a floating vessel; an example is disclosed in GB 2306407 A1. Finally, it is also known to lift the topside from below by deballasting a transporting vessel; an example is disclosed in US 2013045056 A1.

Summary of the Invention

[0005] It is an object of the invention to make it possible to lift topsides of various sizes in a highly effective way, e.g. with increased flexibility in accommodating any one or more of: the topside's dimensions; the topside's support points positions, the decommissioning vessel's movements; and follow-up processes like lowering and/or lifting of the topsides, while providing excellent possibilities for heave compensation (reduction in the influence of waves or the tide on the floating equipment). A side aspect of the object is to allow a simplified construction.

[0006] The object is achieved by the respective subject-matter of claims 1, 9, 10 and 12. Advantageous further developments are subject-matter of the dependent claims.

[0007] A topside lifting device according to the invention includes: a lifting actuator as a linear actuator having a first end and a second end, wherein the second end is engageable with a support portion of a topside, and the second end is configured to rotate about the first end around at least one axis, including an axis other than the lifting actuator's actuating axis.

[0008] In this way a topside of various sizes can be lifted with a simple and light-weight device. Because the rotation of the lifting actuator is possible about at least one axis, including an axis other than the lifting actuator's actuating axis, the position of the second end in at least two dimensions can be easily set and/or controlled. "Actuating axis" is understood to mean an axis along the direction of actuation of a particular actuator.

[0009] Preferably the support portion may be on or attached to the topside. Thus supporting of the topside by the topside lifting device is facilitated.

[0010] Preferably an axis of rotation of the second end about the first end may be a tilt axis. A tilt axis is understood to be a rotation axis wherein the movement of the actuator is within a plane. In other words the lifting actuator can tilt in at least one direction. In this way the movement of the lifting actuator, especially in a plane, is simplified; the positioning of the second end in at least two dimensions can be further facilitated.

[0011] Preferably the second end may be configured to rotate about the first end around at least two (preferably orthogonal) axes, including axes other than the lifting actuator's actuating axis. Because the rotation of the lifting actuator is possible about at least two (preferably orthogonal) axes, including axes other than the lifting actuator's actuating axis, the second end in three dimensions can be easily positioned.

[0012] Preferably at least two axes of rotation of the second end about the first end may be tilt axes. In other words the lifting actuator can tilt in at least two directions. The movement of the lifting actuator, especially in a plane or a series of planes, is simplified; the positioning of the second end in three dimensions can be further facilitated.

[0013] Preferably the rotation of the lifting actuator about the first end around the at least one axis may be provided by a single joint at the first end. Thus a simplified mechanism is achieved, especially when rotation about at least two axes is possible.

[0014] Preferably the first end may be connectable to an attachment portion. The attachment portion may preferably be on the hull of a vessel. Thus the topside lifting device can be easily positioned by positioning the attachment portion on pre-determined positions on the hull.

[0015] The lifting actuator may preferably comprise a barrel and a piston slidably inserted therein. Therefore telescopic extension and contraction of the lifting actuator is effectable by means of a simple construction.

[0016] The piston may preferably be provided at one of the first end and the second end, and the barrel may be provided at the other of the first end and the second end. Further preferably the piston may be provided at the first end, and the barrel may be provided at the second end. Lateral forces in the region of the second end can be supported by the barrel having a larger diameter (and so being more flexurally rigid) than the piston.

[0017] The topside lifting device may preferably comprise a guide means for guiding the linear actuation of

the lifting actuator. In this way lateral loads on the parts of the lifting actuator (e.g. any piston or barrel) can be supported by the guide means. More particularly the lateral loads on the seals of any piston or barrel can be reduced to an absolute minimum. Lateral loads can be supported even more effectively when the guide means is configured to provide no active contribution to the linear actuation, i.e. when the guide means is configured for providing only a guiding function. Preferably the guide means may be provided at a fixed distance to the first end.

[0018] Preferably the guide means may comprise a guide tube; therefore guidance is achieved with a simple construction. Further preferably the guide tube may be provided on the outside of the lifting actuator.

[0019] Preferably the lifting actuator may comprise the guide means.

[0020] When the lifting actuator comprises a barrel and a piston inserted in the barrel, wherein the piston and the barrel are relatively slidable as described earlier, the guide means may preferably surround at least portions of the piston and/or of the barrel, preferably all of the piston and a portion of the barrel, such as in the case of a retracted position thereof. Therefore support of the piston and/or barrel from all sides is enabled.

[0021] Preferably the topside lifting device may comprise at least one positioning actuator wherein the rotation of the lifting actuator about its first end axis is guidable, preferably controllable, further preferably effectable, by the at least one positioning actuator. The position of the second end is thus easily set and/or controlled. Various lateral loads on the lifting actuator are easily transferable to and supportable by the positioning actuator.

[0022] In a preferable embodiment, the topside lifting device may comprise at least two positioning actuators (further preferably two positioning actuators), and the rotation of the lifting actuator about its first end may be guidable, preferably controllable, further preferably effectable, by at the least two positioning actuators; preferably each positioning actuator may be provided as a linear actuator connected at its one end to the lifting actuator. Said features have, for example, the following effect: since the at least two positioning actuators are provided as linear actuators configured to effect the rotation of the lifting actuator, the position of the second end may be more easily set and/or controlled. Various lateral loads on the lifting actuator are easily transferable to and supportable by the positioning actuators which can particularly efficiently support loads essentially along the positioning actuators' axes of actuation. When the second end is configured to rotate about the first end around at least two axes, including axes other than the lifting actuator's actuating axis as described above, and the at least two positioning actuators are provided, the positioning of the second end in at least two directions can be more easily effected.

[0023] Preferably the other end of the at least one positioning actuator is connectable to an attachment portion. Mountability of the topside lifting device and the lifting of large loads with a simple construction are facilitated. Further preferably the first end of the lifting actuator may be connectable to a further attachment portion; even further preferably the attachment portions may be separate and optionally they may be relatively fixed (e.g. fixed in position and/or orientation, relative to each other).

[0024] Further preferably the positioning actuators may be provided on either side of the lifting actuator. The movement of the lifting actuator is thus more easily controlled.

[0025] One or more of the linear actuators may be provided as one or more fluid (preferably hydraulic) cylinders, wherein further preferably each cylinder may comprise the barrel and a piston. Therefore the supporting of large loads is facilitated. If all the linear actuators are provided as hydraulic cylinders, a common hydraulic control system can be used, and so the control will be further simplified.

[0026] When the lifting device comprises a guide tube for guiding the linear actuation of the lifting actuator as described above, then preferably at least one, further preferably each, positioning actuator may be connected to the guide tube. In this way a positioning actuator is connected to the lifting actuator via the guide tube. Lateral loads between the guide tube and the positioning actuator are effectively supported, so guiding of the linear actuation of the lifting actuator is facilitated.

[0027] Preferably the topside lifting device may comprise a guide collar rotatable (further preferably to a predetermined extent) about the axis of actuation of the lifting actuator. Each of the at least one or the at least two positioning actuators may be connected to the guide collar at the positioning actuator's one end, preferably by a joint such as a universal joint. Since the guide collar is rotatable about the axis of actuation of the lifting actuator, any twisting forces from the positioning actuator/s need not be transferred to the other elements of the lifting actuator (e.g. any barrel or piston).

[0028] Preferably the lifting actuator may comprise the guide collar.

[0029] Preferably, when the topside lifting device comprises the guide tube for guiding the linear actuation of the lifting actuator, the guide collar may be (e.g. rotatably) connected to the guide tube, and may further preferably be provided at a fixed distance from the first end, in particular a fixed distance along the guide tube. This allows for a simplified and stronger construction. Loads from the guide collar are efficiently transferred to the guide tube.

[0030] Preferably the actuator/s may be connected at each end by a respective joint (e.g. universal joint). A universal joint will facilitate rotation, especially tilting.

[0031] Preferably the two ends of an actuator may relatively rotate along the axis of actuation of the lifting actuator.

[0032] Preferably, the support portion may be rotatable about the axis of actuation of the lifting actuator.

[0033] A topside lifting arrangement according to the

invention comprises at least one topside lifting device, such as at least three or at least four topside lifting devices. With more than one device, the lifting of higher loads is achievable. Manoeuvring of the topside is facilitated. Preferably more than three topside lifting devices may be provided, each being rotatable around at least two axes including axes other than the lifting actuator's actuating axis as described above; so controlled movement of a topside in up to six degrees of freedom is facilitated. Preferably the lifting devices may be positioned so as to coincide with the vertices of a polygon. Alternatively or in addition, the topside lifting devices may be configured to move independently.

[0034] Preferably the topside lifting arrangement may comprise attachment portions and a lifting device may comprise at least two positioning actuators each provided as a linear actuator connected at its one end to the lifting actuator as described above, wherein the other end of each positioning actuator is connected to a respective attachment portion, each first end is connected to a further respective attachment portion; and the attachment portions are separate. Various lateral loads on the lifting actuator are easily transferable to, and supportable by, the positioning actuators which support the loads essentially along the positioning actuators' axes of actuation, in particular since the positioning actuators and the lifting actuator are each connected to separate attachment portions. The topside lifting arrangement as a whole can be positioned via the attachment portions (e.g. by manoeuvring a vessel). The mountability of the topside lifting device and/or the topside lifting arrangement is simplified. Preferably the attachment portions may be relatively fixed (i.e. fixed relative to each other). By relatively fixing the separate attachment portions for the at least one device, operational loads can be effectively supported by these.

[0035] A vessel according to the invention comprises the topside lifting arrangement. Preferably the vessel may be configured so that part of a lifting actuator, further preferably a part of each lifting actuator, is providable below the water level during operation (e.g. during any of a lifting operation, a transporting operation, and a lowering operation). In this way the vertical extent of the vessel can be fully exploited and a lifting actuator can have a long stroke, compared to a comparative example wherein hydraulic jacks are mounted on or near the deck of a vessel, above the water line.

[0036] A method of lifting or lowering a topside, according to the invention comprises actuating a lifting actuator of the topside lifting arrangement. Preferably the topside lifting arrangement may be provided on a vessel.

Description of Figures

[0037] A preferable exemplary embodiment of the invention is explained in more detail in the following, with the help of schematic drawings, wherein like numerals are used to represent like elements and wherein:

Fig. 1 shows a representation of a vessel comprising a topside lifting arrangement of the invention.

Fig. 2 shows an enlarged view of the representation of the vessel of Fig. 1.

Fig. 3 shows a schematic side view of a topside lifting arrangement of the invention.

Detailed Description of Exemplary Embodiment

[0038] Fig. 1 shows a vessel 26 comprising a topside lifting arrangement 40 ("lifting arrangement") according to the invention. The vessel 26 has a U-shaped access area at its bow and can be manoeuvred around an off-shore structure comprising a topside 28 (shown in wire-frame) and a tubular jacket 32 which supports the topside 28 during operational of the off-shore structure which can be, e.g. an oil rig or a wind turbine.

[0039] The vessel 26 is configured to lift the topside 28 off the jacket 32 (e.g. during decommissioning), and/or to lower a topside 28 onto the jacket 32 (e.g. during commissioning). In the following the lifting operation is described, but it is understood that the lowering operation comprises similar or corresponding procedures.

[0040] The lifting operation is performed by means of the lifting arrangement 40 which comprises four identical topside lifting devices 1 ("lifting devices") each configured to contact the underside of the topside 28 to lift it away from the jacket 32. The height of the contact point (support portion 36) with the topside can be adjusted essentially by raising and lowering the lifting actuator 2. The lifting devices 1 may preferably be arranged in a quadrilateral pattern around two adjacent sides of the U-shaped access area of the vessel 26 so that each lifting device 1 faces and is inclined towards another one, and each lifting device 1 contacts the topside 28 at a respective support portion 36, the positions of the support portions 36 lying essentially in a pivotable plane.

[0041] A lifting device 1 is shown partially in Fig. 2, which is an enlarged view of Fig. 1. Each lifting device 1 comprises a lifting actuator 2 and two positioning actuators 10. The essentially longitudinal actuators 2, 10 operate under fluid pressure, and so are provided as hydraulic cylinders.

[0042] As can be seen from Figs. 1 and 2, the first end 18 of the lifting actuator 2 is connected to an underwater portion of the hull of the vessel 26 via a universal joint. The second end 20 connects to a mount 16 via another universal joint. The mount 16 in turn contacts the underside of the topside 28. The positioning actuators 10 are connected to the deck of the vessel 26 via respective universal joints so as to be attached to the vessel 26 at different places. The other ends of the positioning actuators 10 are connected to the lifting actuator 2. The position of the support portion 36 in an essentially horizontal plane can be adjusted by actuating the positioning actuators 10 and lifting actuator 2 in cooperation. For example

by extending one positioning actuator 10 while contracting the other positioning actuator, the lifting actuator 2 will swing about its first end along one axis. By extending or contracting both positioning actuators 10 simultaneously, the lifting actuator 2 will swing about its first end 18 along another axis orthogonal to the one axis. Therefore when three or more independent lifting devices 1 are provided (four in the present embodiment), the topside 28 can be lifted off its jacket 32 and can be positioned using six degrees of freedom, that is it can be moved in three orthogonal dimensions and rotated about three orthogonal axes.

[0043] A schematic of a lifting device 1 is shown in Fig. 3, wherein only one of the positioning actuators 10 is shown.

[0044] The lifting actuator 2 comprises a cylindrical barrel 4 and a piston 6 configured to actuate under hydraulic pressure. The piston 6 (comprising a piston head and a piston rod) is attached to the lower end (first end 18) of the lifting actuator 2. The barrel 4, which is open at one of its ends, is slidably connected to the piston 6 so as to surround the piston 6 and to extend or retract along the piston's axis under hydraulic pressure. The closed end of the barrel 4 forms the second end 20. Thus the barrel 4 can slide along the piston 6 while the piston 6 does not translate, along the lifting actuator's axis. The mount 16 is configured to press on the underside of the topside 28, urged by the barrel 4 of the lifting actuator 2. The water level is represented by the dashed line 34.

[0045] Hydraulic fluid (such as oil or water) can be supplied through a bore (not shown) provided in the piston rod. A flexible hose (not shown) may fluidly connect the bore with a hydraulic power unit (not shown), the connection preferably being at the end of the piston 6 far from the piston head.

[0046] To support the linear movement of the barrel 4 relative to the piston 6, a guide tube 8 (which is a guide means) is provided, which surrounds the piston 6 and part of the barrel 4. The guide tube 8 is attached at (fixed to) the first end 18 of the lifting actuator 2 and extends along the axis of actuation of the lifting actuator 2. The barrel 4 protrudes from one end (upper end) of the guide tube 8 as it extends. In this way loads acting along the actuating axis of the lifting actuator 2 are supported mainly by the barrel 4 and the piston 6, while lateral loads (i.e. loads acting orthogonally to the axis of the lifting actuator 2) are mainly supported by guide tube 8 and any protruding portion of the barrel 4.

[0047] The lifting actuator 2 is supported at its lower end 18 which is connected to an attachment portion on the side of the vessel 26, via the universal joint. Thus the lifting actuator 2 can rotate about its first end 18 about two axes, that is around (mutually orthogonal) rotation axes which pass through the first end 18 and include axes other than the lifting actuator's actuating axis. Furthermore the lifting actuator of the present embodiment can tilt about its first end in at least one direction (preferably two different directions). This rotation is guided and controlled by the two positioning actuators 10 which are described further below. The attachment portion is below the water level and connected to the attachment portion for an adjacent lifting device by a beam; to improve rigidity. An attachment portion may be, for example, a region on the surface of the vessel provided with receiving or fixing means, e.g. bolt holes.

[0048] Each positioning actuator 10 comprises a barrel 12 open at one end, and a piston 14 (comprising a piston head and a piston rod) slidably inserted in the open end of the barrel 12. The piston 14 is configured to extend and contract under hydraulic pressure. Each positioning actuator 10 is connected to the guide tube 8 at its piston end ("one end") 24 via a universal joint which is in turn attached to a guide collar 30 (described further below) provided on the guide tube 8, and is connected at its barrel end ("other end") 22 to a respective attachment portion on the vessel 26 via a respective universal joint. The positioning actuators 10 are connected to the vessel 26 so that their corresponding attachment portions are a predetermined distance apart, preferably separated by a beam to improve rigidity. The beam and positioning actuators 10 have a triangular formation with the connections with the lifting actuator provided at the tip of the triangle. The actuation axes of the positioning actuators 10 may be inclined to each other, under operational orientations of the lifting actuator 2. The lifting actuator 2 and the positioning actuators 10 are connected to the vessel 26 at separate pre-determined positions. The relation of the connection points in three dimensions may be constant, independent of the position on the vessel.

[0049] The guide collar 30 is a substantially cylindrical hollow member which may preferably rotate by a predetermined angular range around the outer periphery of the guide tube 8 (i.e. around the lifting actuator's axis of actuation). Its axial position along the guide tube 8 is fixed.

[0050] The position of the mount 16 in three dimensions can thus be set by actuating the lifting actuator 2 and the positioning actuators 10, by means of a controlling means known in the art (e.g. computer-controlled hydraulic circuit/s).

[0051] In conclusion, the vessel 26 comprises four lifting devices 1 which are mounted to the hull of the vessel 26 at different positions. The position of each mount 16 in three dimensions is independently controllable. Therefore the mounts 16 can support the topside 28 at four predetermined locations (support portions 36) so as to set the position and orientation of the topside 28 with six degrees of freedom (corresponding to surge, sway, heave, roll, pitch and yaw).

[0052] The example embodiment has the following advantages.

[0053] The topside 28 can be moved in six degrees of freedom, at least because three or more lifting devices 1 of the present embodiment are provided. This manoeuvrability is particularly advantageous for small to medium sized topsides (e.g. 500 to 3000 metric tons) since they do not require a lifting arrangement comprising many (e.

g. more than four) lifting devices. The arrangement can have simple and lightweight construction and the manoeuvrability of small to medium topsides can be exploited.

[0054] The design of the lifting arrangement 40 can be easily adapted to suit heavy topsides by adjusting the number of lifting devices 1. The number can depend on the vessel size, the topside size, and/or the maximum allowable forces per support portion 36. The control system may be adapted depending on the number of lifting devices 1.

[0055] Each lifting device 1 is individually controllable; this leads to increased flexibility which in turn leads to less preparation time per lifting project. Additionally the support portions 36 on the underside of the topside 28 can be more freely selected. Alternatively the lifting arrangement is very flexible in adapting to predetermined support portions 36.

[0056] The stroke of the lifting actuator 2 of the present embodiment allows for a greater heave compensation compared to an example of a lifting actuator provided on or near the deck of a vessel, above the water line. In the comparative example the lifting actuator will have a reduced stroke. Improved heave compensation allows for an enlarged weather window which is the time range within which lifting or lowering is possible.

[0057] In the exemplary embodiment, the stroke of the lifting device can cope with all sizes of topsides and can also overcome the air gap between the bottom of the topside and sea level in all cases. In a possible modification to the exemplary embodiment, a shorter-stroke lifting actuator may be provided, and an extension piece having a predetermined length to overcome the air gap between the topside and sea level may be attached to one end the lifting actuator. In this way a reduced stroke is possible (e.g. a stroke which corresponds to the distance for lifting the topside and compensating for heave). This modification results in reduced manufacturing effort and costs.

[0058] With a longer stroke the lifting device 1 can lift over a large air gap (being the distance between the water level 34 and the underside of the topside 28). Extensive (de)ballasting of a vessel is not required. Additionally the lifting procedure can be much faster than deballasting, e.g. it can be within one wave period of 10 seconds.

[0059] The guide tube 8 can guide the actuation of the linear actuator 2. Lateral loads on the lifting actuator 1 are supported through the guide tube 8. Therefore a long stroke of the lifting actuator 2 is possible. In a comparative example in which lateral loads are not supported so effectively, the lifting actuator's stroke would have to be reduced, and the piston and/or barrel would have to stiffened (e.g. by increasing their radial dimensions). This is particularly true for conventional arrangements wherein the piston slides in a fixed barrel.

[0060] The present embodiment example can compensate not just for heave, but for vessel movements in six degrees of freedom (surge, sway, heave, roll, pitch and yaw).

[0061] After lifting a topside 28, the loaded vessel 26 typically manoeuvres away from the jacket 32 and then sails away. Here it is advantageous at least for safety reasons that the vessel/topside combination has a low centre of gravity. The present embodiment allows the topside 28 to be lowered after lifting it and/or after manoeuvring the vessel 26 away from the jacket 32. This keeps the centre of gravity low. Equally the topside 28 can be further raised above the vessel centreline even after lifting. This is advantageous if the centre of gravity is found to be different than expected during a lifting procedure.

[0062] Each lifting device has low weight since it needs to comprise essentially only one lifting actuator 2, and any positioning actuators 10 can be smaller than the lifting actuator 2.

The arrangement of all actuators is such that no heavy (e.g. steel) structures are needed to cope with bending forces. Without bending forces on parts of the lifting system weight can be reduced.

[0063] The lifting arrangement 40 of the example embodiment can be adapted to suit a particular topside by repositioning the attachment portions (i.e. where the respective actuators 2, 10 are connected to e.g. the vessel 26). Thus adaptation to different shapes and sizes of topside is achieved without the need to exchange the actuators for ones having e.g. different strokes. Repositioning of the lifting arrangement can be performed with the vessel 26 docked in a harbour using e.g. cranes, i.e. before topside lifting.

[0064] The lifting arrangement allows for flexibility in any choice of vessel 26. For example a "semisub" vessel can be used, wherein the main buoyancy is provided by submerged floaters. This arrangement is particularly suited to the lifting device 1 of the present embodiment wherein the lifting actuator 2 is also partly submerged and can be connected to a floater. The lifting actuator 2 may be connected to any lower portion of the vessel 26. Alternatively or in addition the vessel may be a catamaran type, allowing access to the jacket 32 from three of four sides. Advantageously, the first end 18 is connected to a wall of the vessel 26. In this way it is even simpler to connect the lifting actuator 2 to a low portion of the vessel, even below the water level. Furthermore when lifting actuators are inclined to the vertical, they can extend so as to contact the topside 28, yet their first ends (lower ends) are far enough apart from each other in the horizontal direction so that they do not interfere with the jacket 32.

[0065] Various modifications to the embodiment example are shown in the following examples.

[0066] The lifting arrangement is not limited to four lifting devices 1. Any number of lifting devices 1 may be provided in the lifting arrangement 40. Three or more lifting devices 1, each configured so that each respective lifting actuator can rotate about at least two axes, provides motion control of the topside 28 in six degrees of freedom. For example three lifting devices 1 may be ar-

ranged to form three points of an imaginary triangle.

[0067] The lifting device 1 is not limited to two positioning actuators 10. Only one positioning actuator 10 may be provided. An advantageously simple arrangement provides two positioning actuators 10 as linear actuators. As another example: a further (e.g. third) positioning actuator may be provided to effect rotation about the lifting actuator axis, for example to move auxiliary units, such as hydraulic hoses, in complex installations.

[0068] The positioning actuator can be arranged with its barrel end connected to the lifting actuator, and its piston end connected to an attachment portion.

[0069] The actuators 2, 10 are provided as hydraulic cylinders but other actuator types, such as purely mechanical, electromechanical, and/or mechatronic, are possible. Alternatively or in addition, instead of linear positioning actuators 10, one or more rotational actuators, e.g. engaging with the first end 18 may be used.

[0070] Each actuator 2, 10 is connected at each end to a universal joint. Alternatively a joint or joints, for example ball joint, may be used, provided that the second end 20 of the lifting actuator 2 can rotate about the first end 18 around at least one axis, including an axis other than the lifting actuator's actuating axis. As an example two axes of rotation may be orthogonal to the axis of actuation of the lifting actuator 2. Further preferably rotatability of the inclined lifting actuator about a vertical axis through a single joint (e.g. turntable) may be included or excluded, wherein inclusion will facilitate arc-like movement of the second end 20 of the lifting actuator 2, while exclusion can further facilitate the positioning of the second end 20 along two linear dimensions in an essentially horizontal plane (the positioning can be easily determined and executed in a Cartesian coordinate system), e.g. by tilting. The joints need not be provided at the ends of the actuators. For example a joint may be provided partway along the length of the rod of a piston, or the rod may have flexibility. Optionally the axes of rotation may be defined intrinsically or extrinsically, or by a combination of these two.

[0071] The piston and the barrel may be allowed to relatively rotate about the particular linear actuator's axis of actuation, optionally by means of a joint separate from those provided at the ends end of the actuators. Alternatively or in addition the mount 16 or the topside 28 may have a rotational bearing (e.g. turntable).

[0072] The support portion 36 may be a portion of the jacket 32 formed by cutting the jacket, i.e. the support portion 36 may be attached to the topside.

[0073] Instead of a guide tube 8, any guide means may be provided that can guide the linear actuation of the linear actuator 2. Alternatively or in addition the guide means may comprise other bodies such as any one or more of: rollers, wheels, and sliding blocks.

[0074] The guide collar 30 need not be capable of rotation around the axis of actuation of the lifting actuator. For example the guide collar 30 may be fixed from rotating, e.g. may be integral with the guide tube 8, or no guide collar may be provided. The guide tube 8 to may optionally be allowed to rotate around the axis of actuation of the lifting actuator 2. Alternatively a control system may suitably control the positioning actuators 10 to remove any significant twisting of the guide tube 8.

[0075] The attachment portions need not be relatively fixed. For example the attachment portions of the at least two positioning actuators may be fixed to a common bearing-type apparatus (such as a turntable, optionally provided on the deck of the vessel), for increased flexibility in movement. On the other hand, by providing relatively fixed attachment portions, the construction is simpler and mountability is facilitated.

[0076] Disclosed is a topside lifting device including a lifting actuator; the lifting actuator includes a linear actuator having a first end and a second end; the second end can support a topside and is rotatable around at least one axis other than the lifting actuator's actuating axis, wherein preferably the rotation can be achieved by one or more positioning actuators connected to the lifting actuator, so that the rotation can be guided.

Claims

1. Topside lifting device including:

   a lifting actuator (2) as a linear actuator having a first end (18) and a second end (20), wherein the second end (20) is engageable with a support portion (36) of a topside (28), **characterized in that**
   the second end (20) is configured to rotate about the first end (18) around at least one axis, including an axis other than the lifting actuator's actuating axis.

2. Topside lifting device according to claim 1, wherein the second end (20) is configured to rotate about the first end (18) around at least two axes, including axes other than the lifting actuator's actuating axis.

3. Topside lifting device according to one of the previous claims, wherein the lifting actuator (2) comprises a barrel (4) and a piston (6) slidably inserted in the barrel (4).

4. Topside lifting device according to claim 3, wherein the piston (6) is provided at the first end (18) and the barrel (4) is provided at the second end (20).

5. Topside lifting device according to one of the previous claims, wherein the topside lifting device (1) comprises a guide means (8) for guiding the linear actuation of the lifting actuator (2).

6. Topside lifting device according to one of the previous claims, comprising at least one positioning ac-

tuator (10), wherein
rotation of the lifting actuator (2) about its first end (18) is effectable by the at least one positioning actuator (10).

7. Topside lifting device according to claim 6, comprising at least two positioning actuators (10), wherein each positioning actuator (10) is provided as a linear actuator connected at its one end (24) to the lifting actuator (2).

8. Topside lifting device according to claim 6 or 7, wherein
the lifting actuator (2) comprises a guide collar (30) rotatable about the axis of actuation of the lifting actuator (2), and
each positioning actuator (10) is connected at its one end (24) to the guide collar (30).

9. Topside lifting arrangement comprising at least one topside lifting device (1), such as at least three or at least four lifting devices (1), according to one of the previous claims.

10. Vessel comprising a topside lifting arrangement (40) according to claim 9.

11. Vessel according to claim 10, wherein at least part of a lifting actuator (2) is configured to be below the water level (34) in operation.

12. Method of lifting or lowering a topside, comprising actuating a lifting actuator (2) of a topside lifting arrangement (40) according to claim 9.

Fig. 1

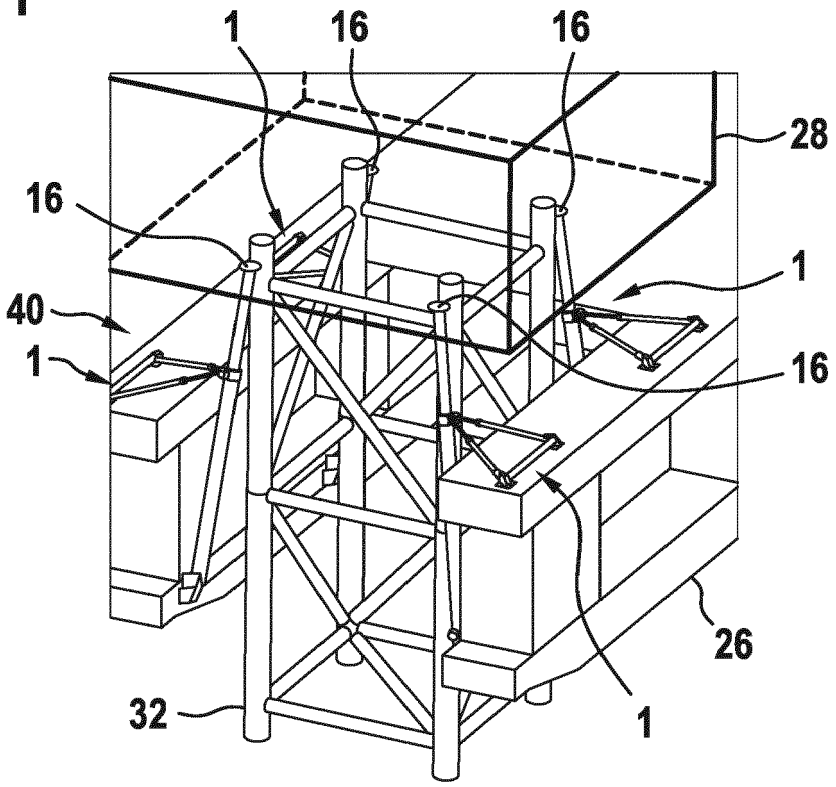


Fig. 2

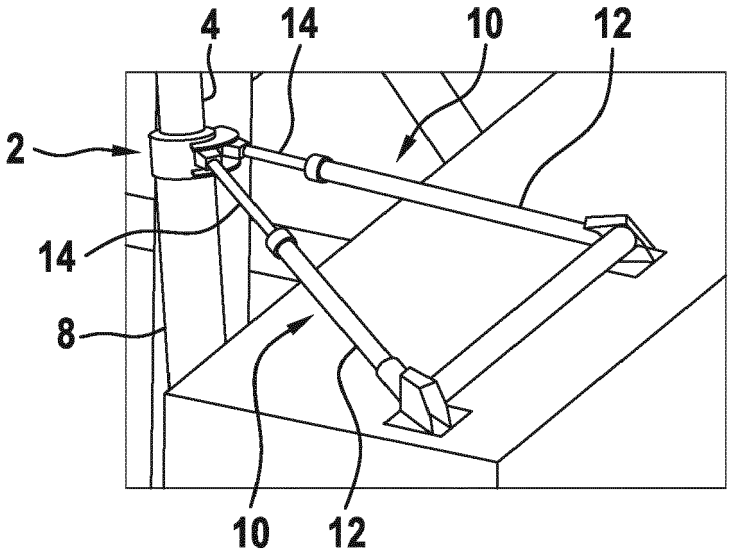
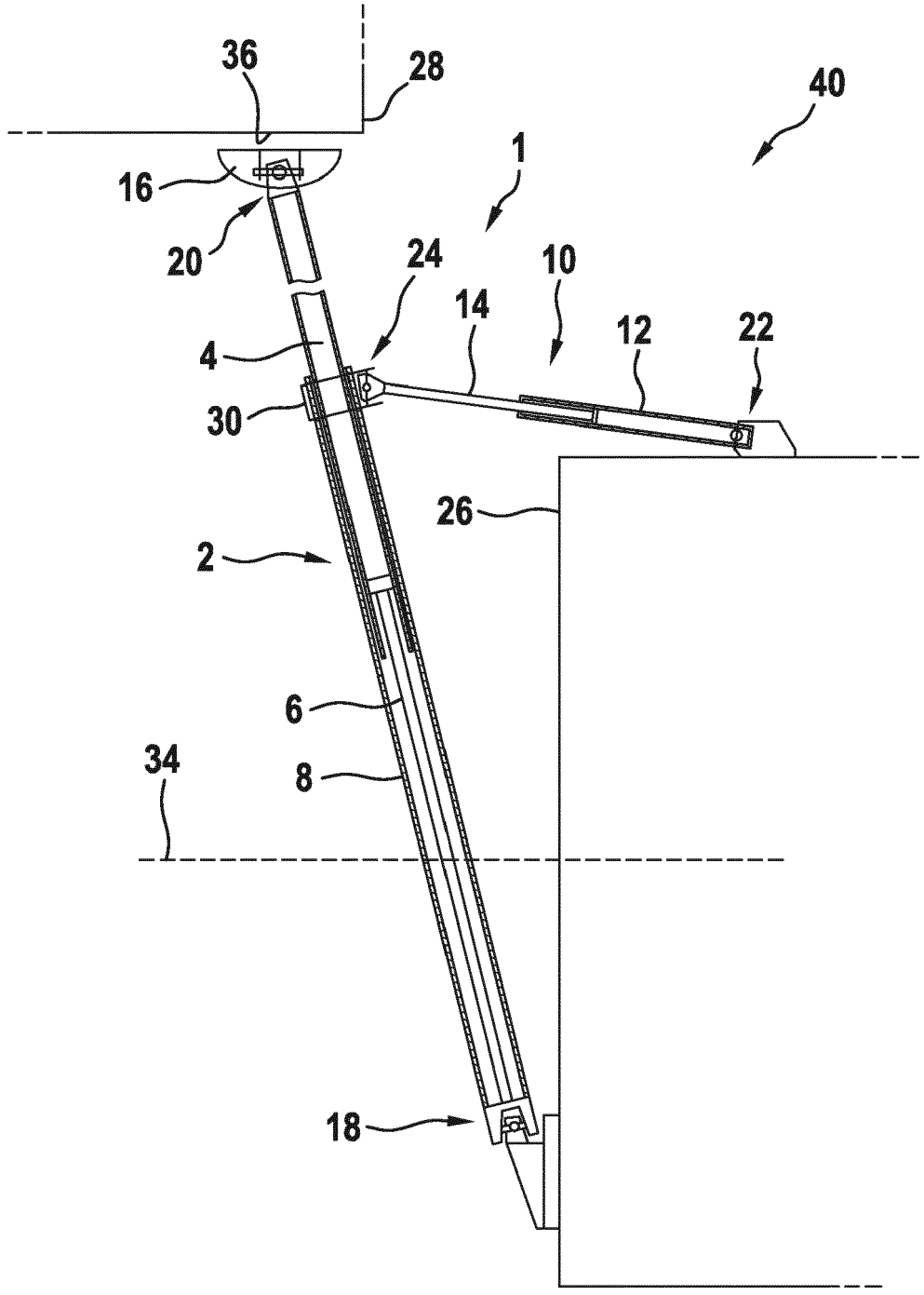


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 18 15 0250

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X	WO 2012/173472 A1 (IHC HOLLAND IE BV [NL]; ZIJLMANS JURGEN ARJAN [NL]) 20 December 2012 (2012-12-20) * abstract * * page 3, line 30 - page 5, line 17 * * figures *	1-12	INV. B63B9/06 B63B35/00
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B63B
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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	31 May 2018	Gardel, Antony

CATEGORY OF CITED DOCUMENTS

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