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(54) VESSELS WITH ROLL DAMPING MECHANISM

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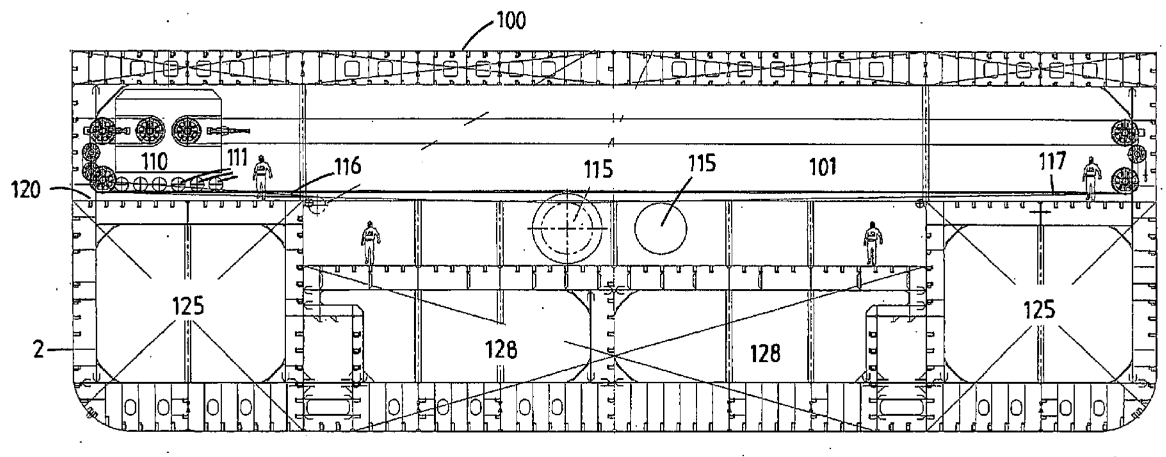
(57) **ABSTRACT**

The present invention relates to a monohull vessel with a heavy lift crane. The crane (**20**) comprises a jib (**24**), which has a reach beyond the hull of the vessel and hoisting means for hoisting a load. The vessel is provided with a water ballast system, and further comprises an active roll damping mechanism. According to the present invention, the active roll damping mechanism comprises a solid roll damping ballast (**110**) which is movable in the transverse direction of the hull, a sensor detecting the rolling motion of the hull, and a drive and control system (**115**) operable to cause and control the movements of the solid roll damping ballast in response to the detections of the sensor to provide roll stabilization.



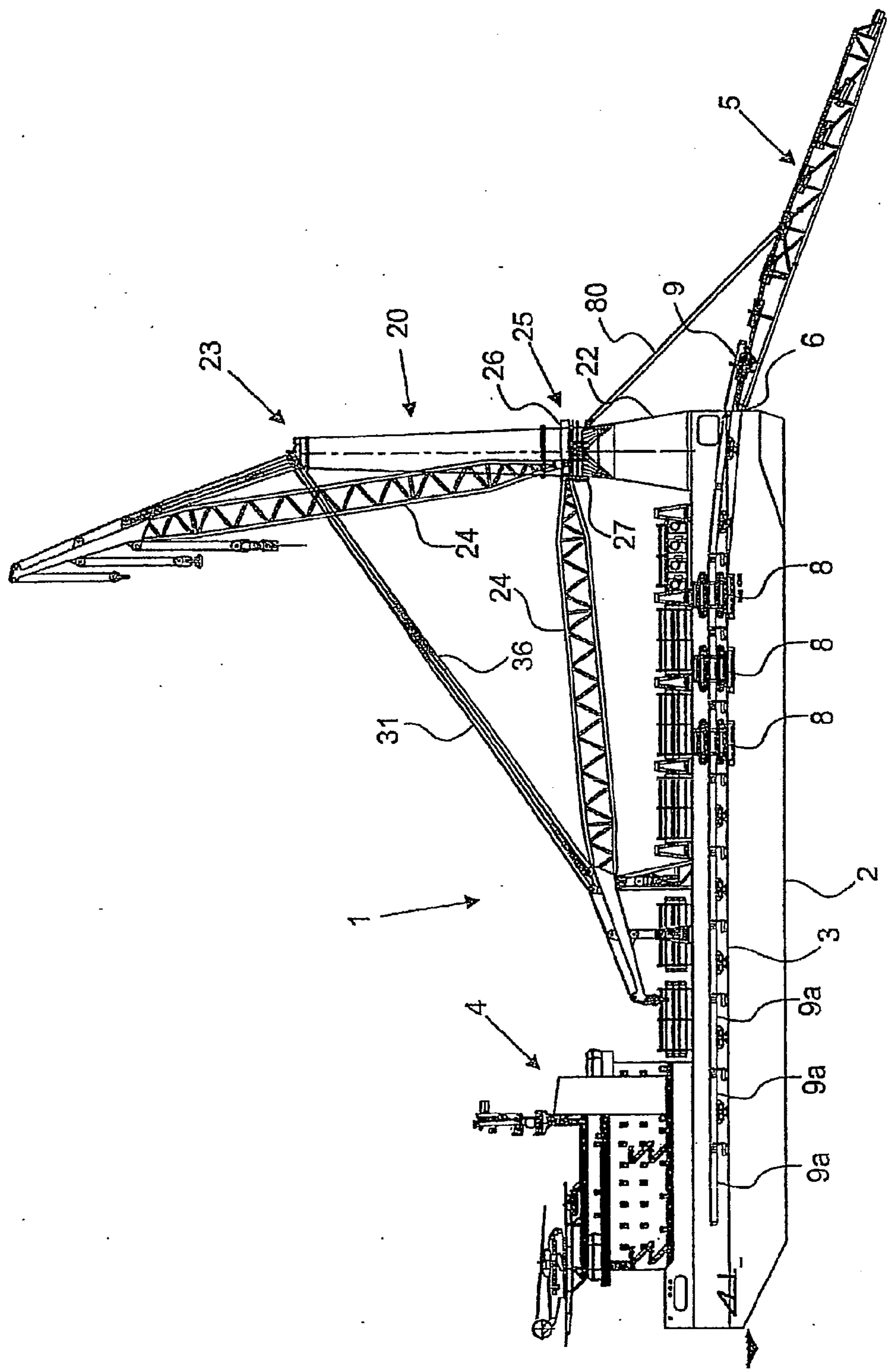


Fig.1

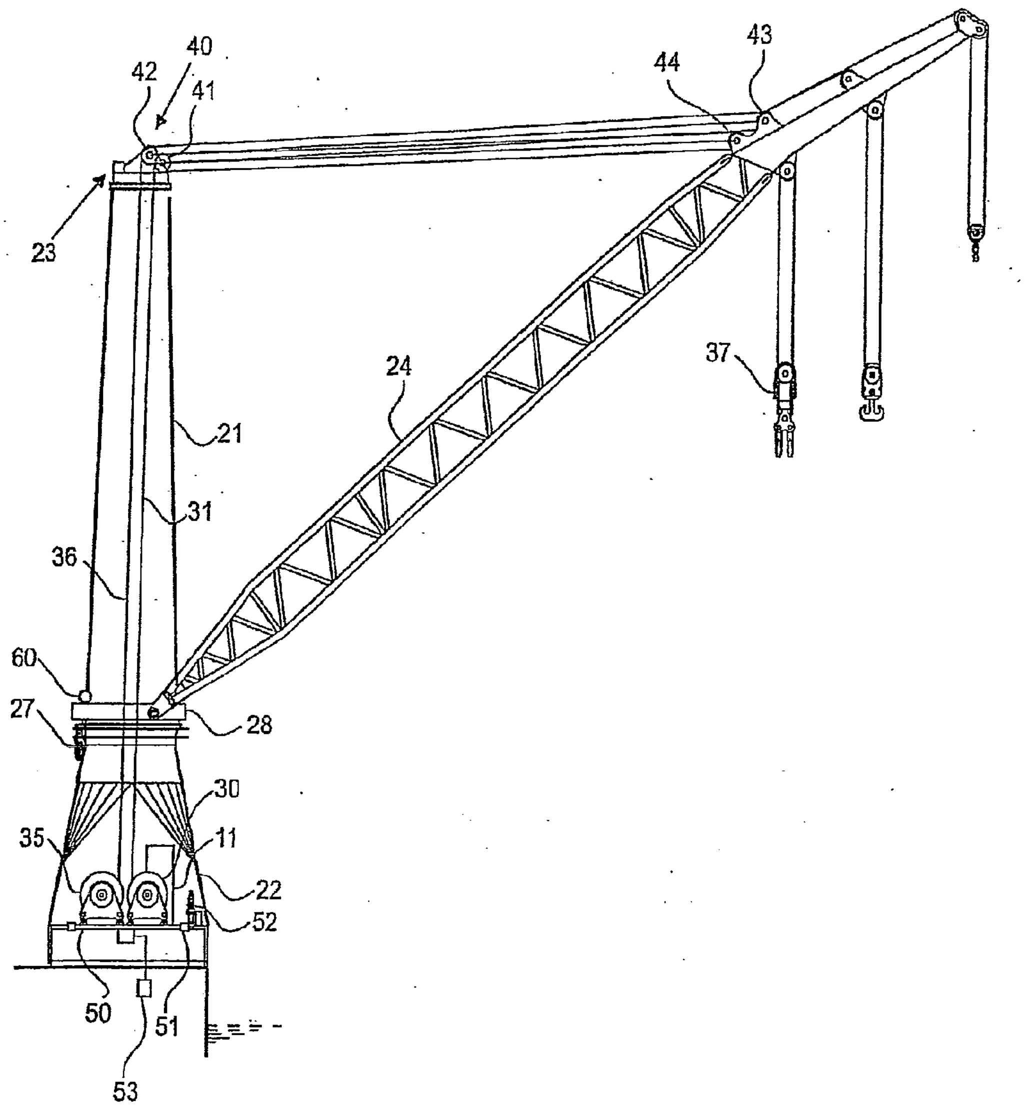


Fig.2

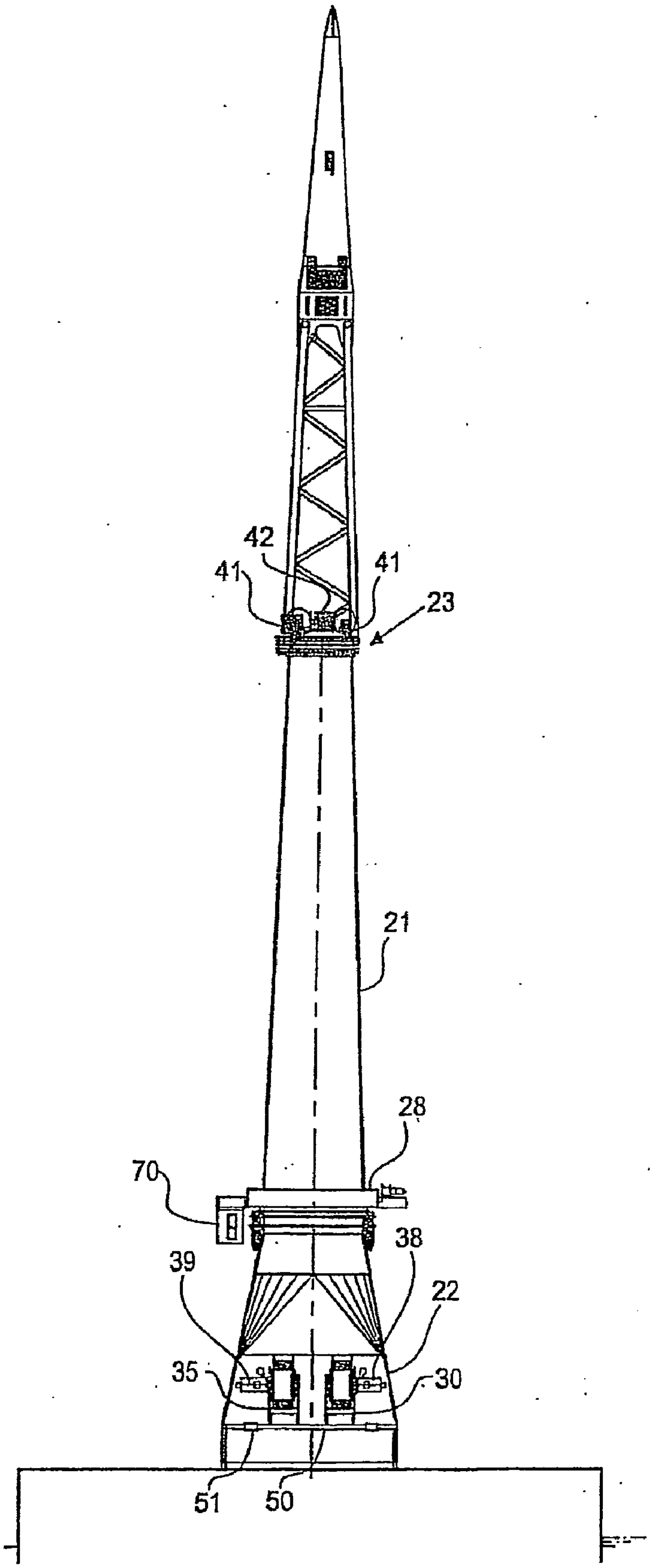


Fig.3

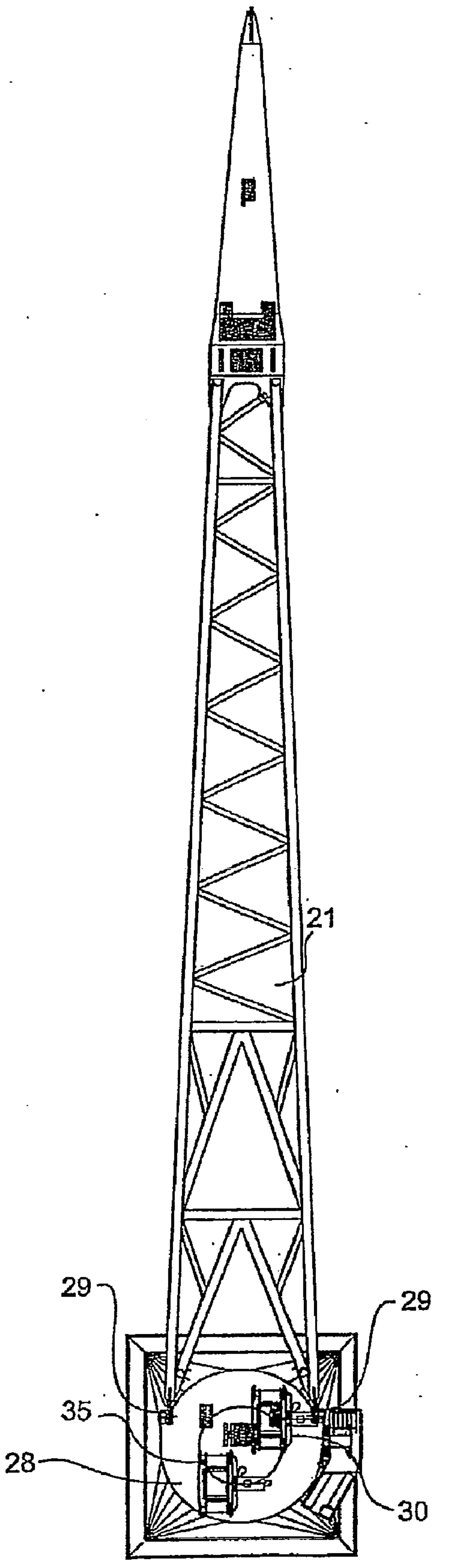


Fig.4

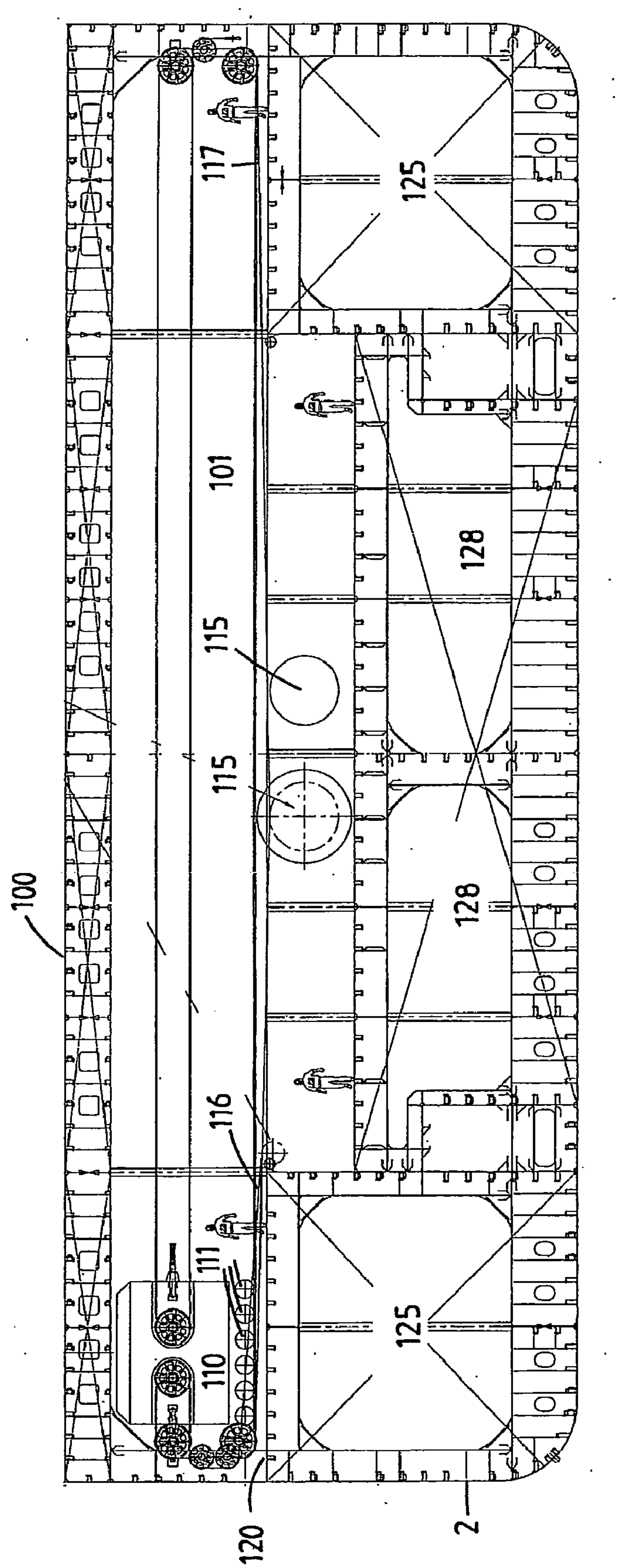


Fig.5

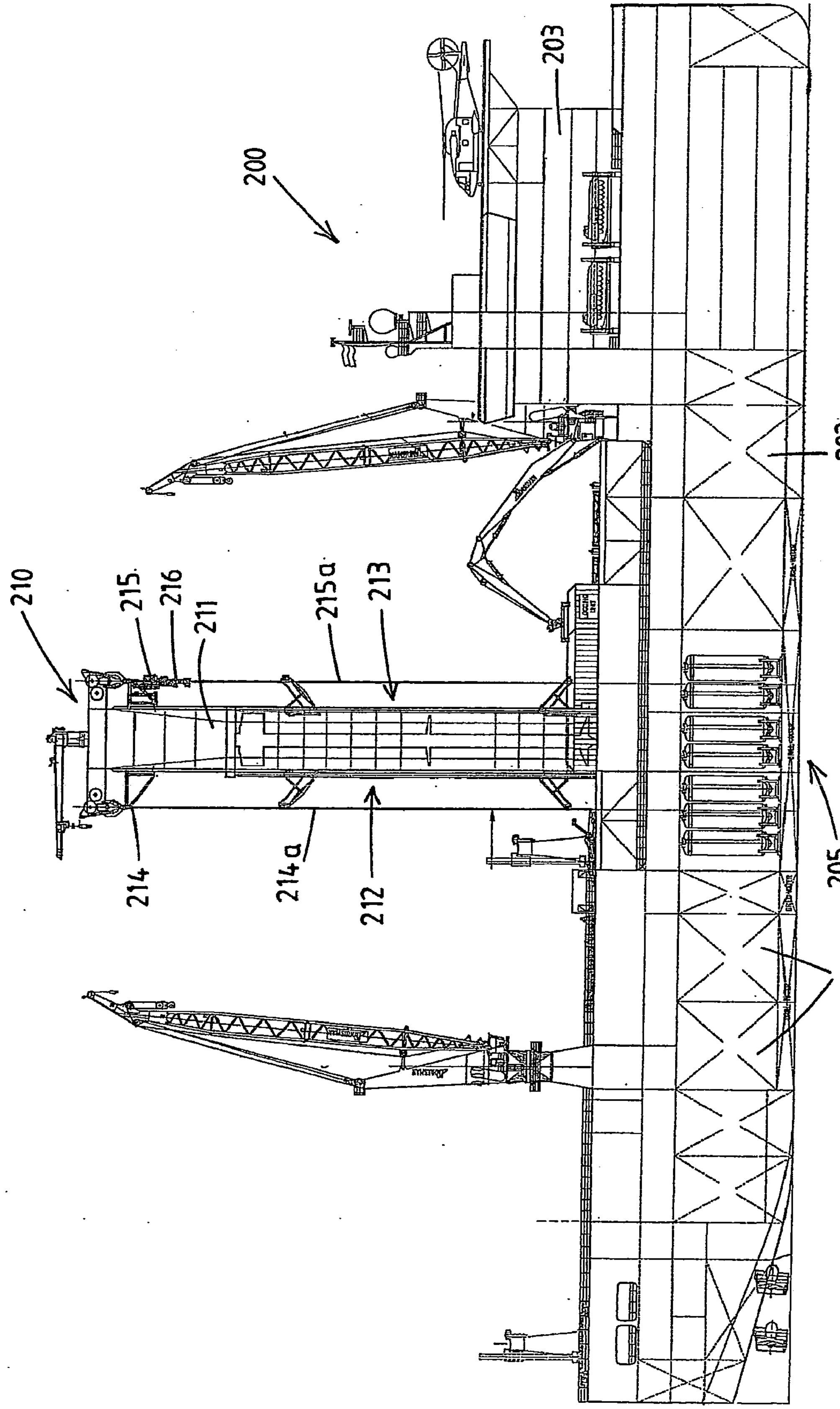


Fig.6

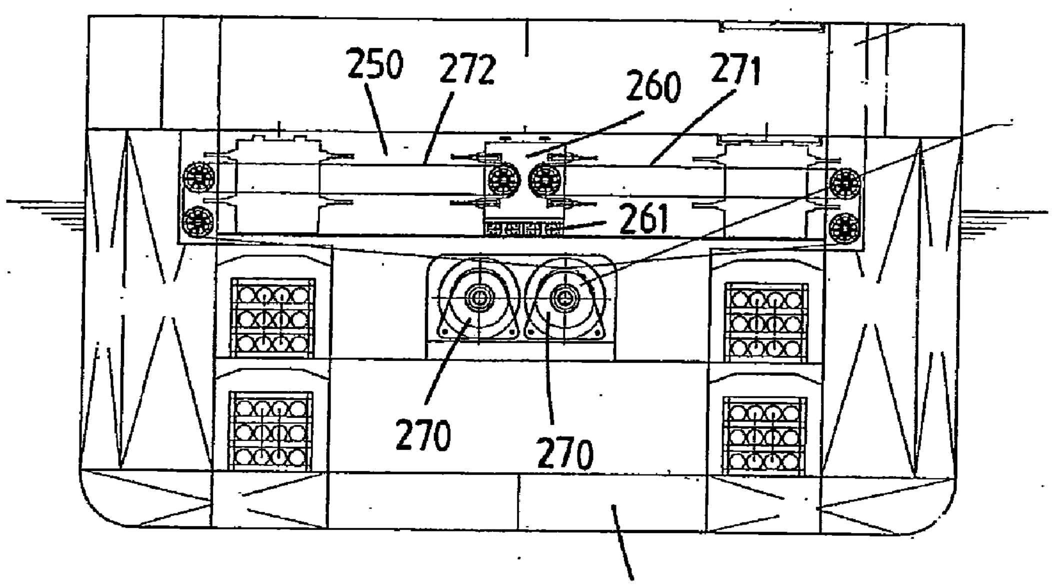


Fig.7

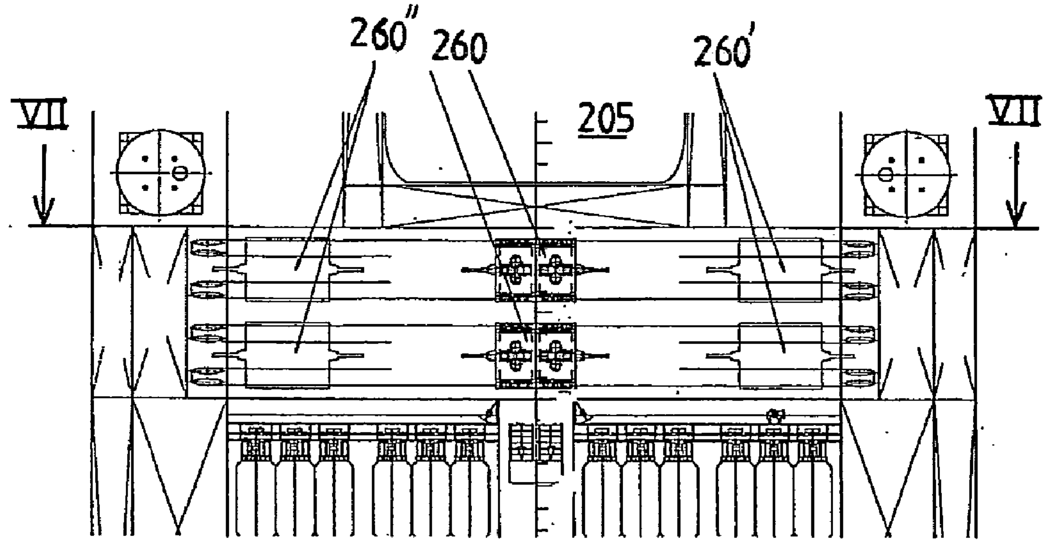


Fig.8

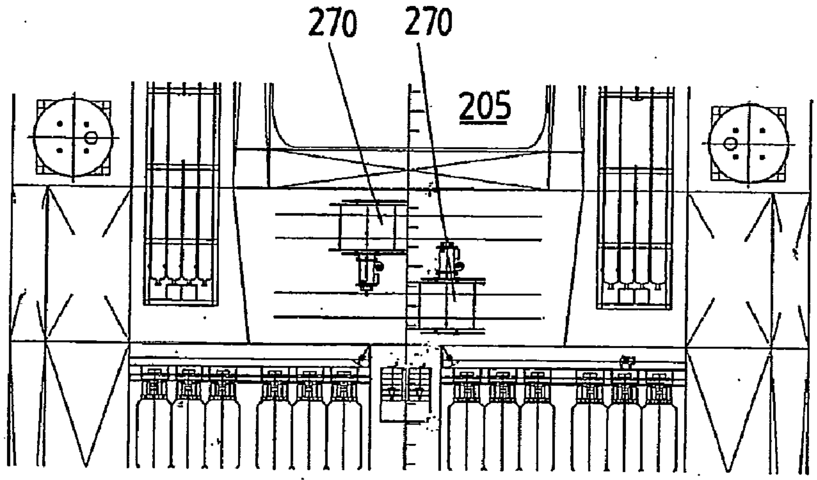


Fig.9

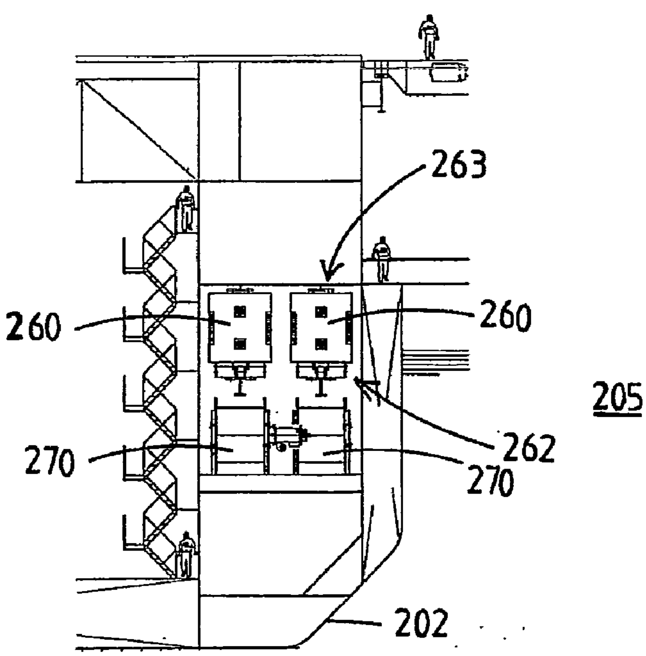


Fig.10

VESSELS WITH ROLL DAMPING MECHANISM

[0001] The invention relates to a monohull heavy lift crane vessel and to a monohull offshore drilling vessel.

[0002] Heavy lift cranes of the type mentioned in the preamble of claim **1** have already been commercially available from the applicant for decades, in particular for installation on a vessel, such as for example a cargo vessel, a tender ship used in the offshore industry, etc. Such a monohull vessel with a heavy lift crane is e.g. suitable to support the construction and maintenance of offshore surface and sub-sea oil and gas field development facilities. A heavy lift mast crane with a lift capacity of 3000 ton has been built by the applicant for the Sapura 3000, a heavy lift and pipelay vessel.

[0003] In general a heavy lift crane vessel is provided with a water ballast system that allows to compensate for static heel caused by the weight of the jib and possible suspended load during lifting operations, in particular when overboarding a load. Such a water ballast system usually comprises water ballast tanks and associated pumps in the hull of the vessel. In general the pump capacity forms a limitation on the ballast transfer and in practice limits the slew speed of the jib of the crane.

[0004] It is known to stabilize a crane vessel additionally by an active roll damping mechanism. Such a mechanism actively suppresses rolling motion. Rolling motion is the rotational movement about the ship's longitudinal axis, which is generated by a wave-excited moment that periodically opposes a moment on the ship. With crane vessels even small roll moments can produce large roll excursions as a result of the load suspending from the heavy lift crane.

[0005] An example of an active roll damping mechanism based on the use of a Voith Schneider Propellor is described in US 2007/0123120. A disadvantage of this active roll damping mechanism is its limited capacity for vessels with heavy lift cranes, in particular for heavy lift cranes with a lift capacity of 1500 tons or more.

[0006] It is an object of the present invention is to provide a monohull vessel with a heavy lift crane, the vessel being equipped with an improved active roll damping mechanism.

[0007] This object is achieved by equipping the heavy lift crane vessel with an active roll damping mechanism comprising a solid roll damping ballast which is movable in the transverse direction of the hull, a sensor detecting the rolling motion of the hull, and a drive and control system operable to cause and control the movements of the solid roll damping ballast in response to the detections of the sensor to provide roll stabilization.

[0008] Thus, active roll stabilization is accomplished by producing a counteracting moment by means of actively controlled solid ballast. A sensor detects the rolling motion and a drive and control system controls the counteracting moment as required.

[0009] The mechanism can be used in dynamic mode, wherein the reciprocal transverse motion of the solid ballast is matched to counteract the sea wave induced rolling motion of the vessel, and in a static or semi-static mode, wherein the solid ballast is used to counteract heel induced by the jib or a (light) load suspended from the crane (e.g. during stewing).

[0010] The vessel provided with a heavy lift crane may operate at a high slew speed of the jib due to its active roll damping mechanism. Obviously the "slower" water ballast may simultaneous be used to counteract heel of the vessel during slewing of the jib (e.g. with a light load).

[0011] The present invention also relates to a monohull offshore drilling vessel for use in the offshore oil and gas drilling industry. This vessel according to the invention is equipped with an active roll damping mechanism comprising a solid roll damping ballast which is movable in the transverse direction of the hull, a sensor detecting the rolling motion of the hull, and a drive and control system operable to cause and control the movements of the solid roll damping ballast in response to the detections of the sensor to provide roll stabilization.

[0012] It will be appreciated that the inventive monohull offshore drilling vessel can also be provided with one or more features disclosed herein with reference to a monohull heavy crane vessel and vice versa.

[0013] It is noted that the French nuclear powered aircraft carrier Charles De Gaulle is equipped with a computerised, integrated stabilisation system designed to maintain stabilisation to within 0.5 degrees of horizontal, allowing aircraft to be operated up to Sea State 5/6. As well as the carrier's two pairs of active stabilising fins and twin rudders, the system has two computer controlled compensation units which consist of two straight rail tracks for trains carrying 22 tonnes of deadweight. These tracks run transversely below the flight deck. This system is designed to compensate for wind and heel and control roll, yaw and surge. A further development of this air craft carrier stabilisation system is disclosed in U.S. Pat. No. 6,349,660. A further development of this system for small vessel having a train of ballast bodies mounted on U-shaped tracks is disclosed in EP 1304289.

[0014] The heavy lift crane vessel according to the invention preferably has a mast crane with a maximum hoisting capacity of at least 3000 tons, more preferably having a hoisting capacity of 5000 tons or more.

[0015] The height of the mast of the crane preferably exceeds 75 meters, while the length of the jib may exceed 75 m.

[0016] The radius of a hoisting cable guided by a hoisting cable guide at the outer end of the jib, which may be referred to as the whip hoist, may be up to 122 m.

[0017] The monohull vessel with a mast crane according to the invention is preferably suitable to handle large subsea modules, e.g. modules up to 600 tons at 3000 meters water depth.

[0018] In a preferred embodiment of the invention, the crane is provided at the stern of the vessel.

[0019] Preferably the heavy lift crane vessel is prepared to also accommodate S-lay pipelaying equipment or equipped with such equipment.

[0020] In a preferred embodiment, the vessel according to the invention is further provided with dynamic positioning means, which are preferably operable together with the active roll damping mechanism during hoisting or drilling operations.

[0021] The active roll damping mechanism according to the invention comprises a solid roll damping ballast which is movable in the transverse direction of the hull.

[0022] For the heavy lift crane vessel the total mass of the roll damping ballast preferably is between 500 and 2500 tons, more preferably between 1000 and 2000 tons, e.g. 1000 or 1500 tons.

[0023] For the drilling vessel the total mass of the roll damping ballast is preferably between 100 and 750 tons, more preferably between 200 and 400 tons, e.g. 300 tons.

[0024] Preferably the roll damping mechanism is formed such that a single ballast body is mounted on and guided along a set of associated rail tracks, in contrast to the known aircraft carrier system with a train of ballast bodies being mounted on a set of rail tracks. This allows to avoid any problems associated with the interconnections of the ballast bodies within the train of ballast bodies. Also this allows to displace the centre of gravity of the ballast body as much as possible outwards with respect to the centreline of the vessel, thus obtaining an increased restoring moment.

[0025] Preferably a ballast body is embodied as a monolithic metal block, or a set of metal blocks fixed to each other so as to form a single solid body, having a weight of at least 100 tons, in order to arrive at a compact ballast body.

[0026] Preferably a ballast body has a height that is greater than its transverse dimension, thereby allowing to displace the centre of gravity of the ballast body as much as possible outwards with respect to the centreline of the vessel, thus obtaining an increased restoring moment.

[0027] The wave-excited moment opposed on the crane vessel typically has a wave period of 5-25 seconds. To move such a large solid roll damping ballast at such high frequency, a drive system with a very large power capacity is required, even up to several megawatts. Preferred embodiments have a power capacity of more than 2.5 megawatts, e.g. 3 or 4 megawatts.

[0028] When suitably dimensioned the roll damping ballast mechanism is expected to decrease the static heel of a crane vessel provided with a 5000 tons heavy lift mast crane from over 9 degrees to less than 3 degrees with a horizontally extending jib directed transverse with respect to the vessel.

[0029] The active roll damping mechanism gives a significant improvement of the crane-vessel performance for light load operations as well as significant improvement of workability in offshore conditions.

[0030] The roll damping mechanism can compensate the static heel caused by slew motion of the crane hoisting light loads significantly. The reaction time of this system is preferably quicker than the slew speed of the crane meaning that the speed of crane operations is not limited by the new anti heel system.

[0031] The principle of the mechanism is to create a restoring moment. In case of slewing the crane with light loads this restoring moment will compensate the heel moment caused by the weight of the jib of the crane. In case of roll motions the restoring moment will compensate the roll moment caused by waves.

[0032] The active roll damping mechanism on the monohull drilling vessel allows for a significant increase of workability in offshore conditions, e.g. in hostile environment and weather conditions, e.g. obviating the need to employ more expensive semi-submersible drilling vessels.

[0033] Further advantageous embodiments are described in the dependent claims and in the following description with reference to the drawing.

[0034] In the drawing:

[0035] FIG. **1** diagrammatically depicts an offshore vessel with a heavy lift mast crane, which is suitable, inter alia, for laying a pipeline on the seabed,

[0036] FIG. **2** shows the hoisting crane at the rear side of the vessel shown in FIG. **1**, partially in the form of a cut-away view,

[0037] FIG. **3** shows the hoisting crane from FIG. **2** from a different direction,

[0038] FIG. **4** shows a view of the hoisting crane shown in FIGS. **2** and **3** from above,

[0039] FIG. **5** shows a cross-section of the hull of the vessel of FIG. **1**,

[0040] FIG. **6** shows a monohull offshore drilling vessel,

[0041] FIG. **7** shows a transverse section over the line VII-VII in FIG. **8**,

[0042] FIG. **8** shows in plan view of part of the vessel of FIG. **6**,

[0043] FIG. **9** shows in plan view the part of FIG. **8** at a lower deck level,

[0044] FIG. **10** shows a longitudinal section of the vessel of FIG. **6**.

[0045] FIG. **1** shows an offshore heavy lift crane vessel **1** which is also suitable, inter alia, for laying a pipeline on the seabed.

[0046] The vessel **1** has a monohull **2** with a working deck **3** and, at the front of the hull **2**, a superstructure **4** for crew accommodation, etc.

[0047] The vessel **1** is equipped with a water ballast system, e.g. including anti-roll tanks **12**. Water ballast systems are known in the art, e.g. the open-bottom tank system which reduces roll by modifying the roll resonance period.

[0048] In this example the vessel **1** has a length of 180 meters and a beam of 46 meters.

[0049] The vessel **1** in this example is also provided with a pipeline-laying installation, here of the S-lay type, with one or more welding stations on the working deck **3**, for coupling pipeline sections **9***a* in a substantially horizontal orientation. On the working deck **3** there are also what are known as tensioners **8** for carrying the weight of the pipeline **9** which is hanging downwards from the vessel **1**. The vessel may also be equipped with another type of pipeline-laying installation, e.g. a (rigid) reel lay installation.

[0050] Furthermore, the vessel **1** has a stinger **5** which projects outside the hull **2** of the vessel **1** at the rear side of the vessel **1**, engages on the hull **2** at an engagement point such that it can pivot about a substantially horizontal pivot structure **6** and forms a downwardly curved support for pipeline moving towards the seabed.

[0051] Furthermore, the vessel **1** has a heavy lift crane **20**, in this embodiment disposed in the vicinity of the same side of the hull as the stinger **5**, here at the stern of the hull **2**, which hoisting crane **20** has a vertical structure fixed to the hull **2**. The hoisting crane **20** will be described in more detail below. Here, the crane **20** is disposed above the location where the pipeline **9** leaves the working deck **3**, on the longitudinal axis of the vessel **1**.

[0052] The hoisting crane **20**, which is illustrated in detail in FIGS. **2-4**, has a substantially hollow vertical column **21** with a foot **22**, which is fixed to the hull **2** of the vessel **1**. Furthermore, the column **21** has a top **23**.

[0053] The hoisting crane **20** has a jib **24**, which is illustrated in two different positions in FIG. **1**. An annular bearing structure **25** extends around the vertical column **21** and guides and carries a jib connection member **26**, so that the jib connection member **26**, and therefore the jib **24**, can rotate about the column **21**.

[0054] In this case, the jib connection member **26** forms a substantially horizontal pivot axis, so that the jib **24** can also be pivoted up and down. There is at least one drive motor **27** for displacing the jib connection member **26** along the annular bearing structure **25**. By way of example, the annular bearing structure **25** comprises one or more guide tracks which extend around the column **21** and on which an annular component **28** of the jib connection member **26** is supported via running wheels. Jib securing supports **29** are arranged on the component **28** at two positions. The drive motor **27** may, for example, drive a pinion which engages with a toothed track around the column **21**.

[0055] To pivot the jib **24** up and down, there is a topping winch **30** provided with a topping cable **31** which engages on the jib **24**.

[0056] Furthermore, the hoisting crane **20** comprises a hoisting winch **35** for raising and lowering a load, with an associated hoisting cable **36** and a hoisting hook **37**.

[0057] At the top **23** of the column **21** there is a top cable guide **40** provided with a cable pulley assembly **41** for the topping cable **31** and a cable pulley assembly **42** for the hoisting cable **36**.

[0058] One or more cable pulley assemblies **43** for the hoisting cable **36** and a cable pulley assembly **44** for the topping cable **31** are arranged on the jib **24**. The number of cable parts for each cable can be selected as appropriate by the person skilled in the art.

[0059] The winches **30** and **35** are in this case disposed in the foot **22** of the vertical column **21**, so that the topping cable **31** and the hoisting cable **36** extend from the associated winch **30**, **35** upward, through the hollow vertical column **21** to the top cable guide **40** and then towards the cable guides **43**, **44** on the jib **24**.

[0060] The top cable guide **40** has a rotary bearing structure, for example with one or more running tracks around the top of the column **21** and running wheels, engaging on the running tracks, of a structural part on which the cable pulley assemblies are mounted. As a result, the top cable guide **40** can follow rotary movements of the jib about the vertical column **21** and adopt substantially the same angular position as the jib **24**.

[0061] The top cable guide **40** may have an associated drive motor assembly which ensures that the top cable guide **40** follows the rotary movements of the jib **24** about the column **21**, but an embodiment without drive motor assembly is preferred.

[0062] The jib winch **31** and the hoisting winch **35** are arranged on a rotatable winch support **50**, which is rotatable about a rotation axis substantially parallel with the vertical column **21**. The movable winch support **50**, which is mounted movably with respect to the vertical column **21**. The winch support **50** here is located in the vertical crane structure, preferably in the region of the foot **22** under the circular cross section part of the column **21**, and is mechanically decoupled from the top cable guide **40**. The support **50** could e.g. also be arranged in the hull of the vessel below the column, e.g. the foot could have an extension which extends into the hull.

[0063] In the example shown, the winch support **50** is a substantially circular platform which at its circumference is mounted in an annular bearing **51**, with the winches **31**, **35** arranged on the platform. The annular bearing **51** is in this case such that the platform can rotate about a vertical axis which coincides with the axis of rotation of the top cable guide. The bearing can have any appropriate design including trolleys running along a circular track.

[0064] The rotatable winch support **50** has an associated drive motor assembly **52** for moving the winch support **50**, in such a manner that the winch support **50** maintains a substantially constant orientation with respect to the jib **24** in the event of rotary movements of the jib **24** about the vertical column **21**. The orientation of the winch support **50** with respect to the top table guide **40** likewise remains substantially constant, since its movements are once again the consequence of rotary movements of the jib **24**.

[0065] In the embodiment shown, there is an angle sensor **60** for detecting the position of the component **28** of the jib connection member **26** with respect to the vertical column **21**, the drive motor assembly **52** of the winch support **50** having associated control means **53** which are in operative contact with the angle sensor **60**.

[0066] The winches **31**, **35** each have an associated electrical (or electro-hydraulic) winch drive motor assembly **38**, **39** which is disposed on the movable winch support **50**. The electrical energy required is supplied by generators disposed elsewhere on the vessel, at a distance from the movable winch support **50**. One or more sliding contacts (not shown) are provided in the electrical connection between these generators and the winch drive motor assemblies **38**, **39**.

[0067] In a variant which is not shown, the winch support **50** can rotate about a vertical shaft, this shaft being provided with one or more sliding contacts. In such an embodiment, the deep water lowering cable extends trough the centre of such shaft.

[0068] Via the one or more sliding contacts, a power current supply is preferably fed to the electrical equipment on the winch support **50**.

[0069] The hoisting crane **20** is provided with a cab **70** for a hoisting crane operator, which cab **70** is in this case carried by the annular bearing structure **25** to which the jib **24** is secured, so that the cab **70** can rotate with the jib about the vertical column **21**.

[0070] In the cab **70** there are at least control members (not shown) for operating the winch **35** of the hoisting cable **36** and for operating the winch **31** of the topping cable **31**. The winch drive motor assemblies **38**, **39** have associated control means (not shown) which are in wireless communication with the associated control members in the cab **70**. By way of example, a plurality of wireless transmission/reception units are disposed around the vertical column, in or in the vicinity of the path of the cab **70** around the vertical column.

[0071] The control means, for example electronic control equipment, for the one or more winches on the winch support **50** are preferably also positioned on this winch support **50**.

[0072] It can be seen from the figures that, as is preferred, the vertical column **21** has a substantially continuous outer wall. In this case, the horizontal section through the vertical column is substantially circular from the jib connection member to the top **23**, with the cross section gradually decreasing towards the top of the column. The foot **22** of the column **21** is substantially rectangular, which has the advantage that the foot **22** can easily be secured (by welding or using bolts) to the longitudinal and cross bulkheads of the hull **2** of the vessel **1**. In a variant which is not shown, the vertical column is partly or completely a framework of bars.

[0073] It can be seen from FIG. **1** that a load-bearing connecting structure **80**, which holds the stinger in a desired position, extends between the vertical structure of the hoisting crane **20** at a location above the point of engagement **6** of the stinger **5** on the vessel hull **2** (in this case in the vicinity of the annular bearing structure for the jib **24**), and the stinger **5**, at a location remote from the point of engagement **6** of the stinger **5** on the vessel hull **2**.

[0074] The vessel **1** can be used to lay a pipeline **9**, but also for hoisting work, such as the hoisting work carried out, for example, in the offshore industry when installing platforms, underwater installations, etc.

[0075] In FIG. **5** a cross-section of the vessel **1** is shown. In the hull of the vessel, preferably below the main deck **100** on the between deck **120** as shown here, the vessel has a room **101** wherein the roll damping mechanism is located. This mechanism here includes a number of solid ballast bodies **110** which are displaceable in a reciprocable manner in the transverse direction of the hull.

[0076] As can be seen the transverse distance for travel of the solid ballast bodies **110** is at least 10 meters to either side of the centreline of the vessel, more preferably at least 15 meters. As is even more preferred the entire beam of the vessel with the exception of the outer compartments of the vessels hull is made available for the travel of the solid ballast bodies **110**.

[0077] Preferably, the ballast body **110** is a solid metal block, or a number of solid metal blocks or plates. Alternatively, the ballast body includes a length of cable or chain, e.g. for underwater operations. In an alternative embodiment, the ballast body comprises vessel related equipment or supplies (spare parts etc.).

[0078] Here each ballast body **110** is equipped with rollers **111**, and the vessel has one or more straight tracks extending transverse relative to the vessel and having opposed ends near the sides of the hull. Obviously other guide and bearing arrangements than one or more tracks and rollers on the ballast body can be envisaged.

[0079] The drive for each of the ballast bodies **110** in this example comprises two winches **115** and a cable arrangement with cables **116**, **117** that allow displacing the ballast body in both directions. The winch **115** preferably is a winch with a drum having a double helical groove for the cables. For example each winch has a capacity of 400 kW. Preferably multiple ballast bodies and associated drives are placed side by side in the room, e.g. 4 or 5 of such ballast bodies.

[0080] Each ballast body here is equipped with dampers at its opposed transverse side, e.g. oleo dampers, preferably having a stroke of more than 0.25 meters.

[0081] The hull is further equipped with water ballast tanks **125** and roll damping water tanks **128**.

[0082] The drive for the one or more ballast bodies further includes a control system operable to cause and control the movements of the solid roll damping ballast bodies in response to the detections of the sensor to provide roll stabilization.

[0083] It will be appreciated that the roll damping mechanism can also be employed in a semi-static mode, wherein the one or more ballast bodies are positioned to counter a more or less static or slow changing heel caused by a load on the vessel, e.g. to counter the heel induced by slewing the jib of the crane, with or without a load being suspended from the crane. It is noted that a heavy lift crane may have a jib of such a weight that stewing the jib to a position transverse to the vessel induces a significant heel that may then be compensated (partly or entirely) by suitable semi-static operation of the roll damping mechanism.

[0084] An example of a monohull offshore drilling vessel equipped with a roll damping mechanism according to the invention will now be elucidated with reference to FIGS. **6-10**. It will be appreciated that the roll damping mechanism is of the same basic design as the roll damping mechanism explained with reference to the heavy lift crane vessel, and that features, e.g. preferred features, thereof may be included in the embodiment for the drilling vessel.

[0085] The drilling vessel **200** in general is suitable for offshore drilling, e.g. for oil and gas exploration, well servicing and/or other drilling related activities (e.g. servicing and/or placement of subsea equipment).

[0086] The hull **202** has crew quarters and a bridge **203** on the bow side, here with helicopter platform.

[0087] The vessel includes a water ballast system, preferably configured to allow for roll motion suppression, e.g. including anti-roll tanks **207**.

[0088] As is preferred the hull **202** of the vessel **200** has a moonpool **205**, preferably centred on the longitudinal axis of the vessel.

[0089] In this example, effectively above the moonpool **205**, a multiple firing line hoist system **210** is mounted on the hull **202** so that—as preferred—a forward portion and a rear portion of the moonpool **205** are accessible at the front and the rear of the system **210**. It will be appreciated that a single firing line hoist system can also be present on an alternative version of the vessel.

[0090] In this example, as is preferred, the multiple firing line hoist system **210** comprises:

- **[0091]** a mast **211** having a top side and a base, which in this example as a transverse girder, is connected to the hull of the drilling vessel, wherein the mast **211** has a hollow construction with a first side **212** (in this example the rear side) and an opposed second side **213** (in this example the front side),
- **[0092]** a first hoisting device supported by the mast and having load attachment means **214** displaceable along a first firing line **214***a*, which extends on the outside of and adjacent to the first side of the mast **212**;
- **[0093]** a second hoisting device supported by the mast and having load attachment means **215** displaceable along a second firing line **215***a*, which on the outside of and adjacent to the second side **213** of the mast.

[0094] The first and second hoisting devices each include one or more cables and one or more associated winches to manipulate the position of each of the load attachment devices relative to the mast. The winches are preferably located in the mast **211**, most preferably in the base of the mast, but other location are also possible.

[0095] Details of the mast **211** and the hoisting devices can be derived from U.S. Pat. No. 6,763,898 which is incorporated herein by reference.

[0096] A BOP storage is present, preferably in the hull of the vessel adjacent the moonpool **205**.

[0097] The first hoisting device here is adapted for raising and lowering the BOP to the seabed. The vessel includes a riser storage not shown in the drawing.

[0098] One or more working decks are preferably provided near the mast, e.g. at the rear and the front of the mast, which allow to cover a portion of the moonpool **205**. A working deck may be mobile and/or include mobile deck portions.

[0099] In this example the vessel **200** is provided with a rotary drilling drive, namely a top drive **216**, at the front side of the mast, so that drilling is possible via the front firing line

215*a*. It will be appreciated that a rotary drilling drive could also (or as alternative) be located at the rear side of the mast. Similar the riser storage and handling system could be arranged at the front side of the mast is desired.

[0100] In FIG. **7** a cross-section of the vessel **1** is shown, generally just aft of the moonpool **205**. In the hull of the vessel, below the main deck, the vessel has a room **250** wherein the roll damping mechanism is located. This mechanism here includes two solid ballast bodies **260** which are arranged side by side and are displaceable in transverse direction of the hull.

[0101] As can be seen the transverse distance for travel of the solid ballast bodies **260** is at least 5 meters to either side of the centerline of the vessel, more preferably at least 7.5 meters, in this example 9 metres. The FIGS. **7**,**8** show the bodies **260** also in their extreme positions **260'** and **260"**.

[0102] Preferably, the ballast body **260** is a solid metal block, or a number of solid metal blocks or plates. In this example each ballast body weighs between 100 and 200 tons, e.g. 150 tons. Here each ballast body **260** is equipped with bottom rollers **261** that run on associated rail tracks **262** of the vessel, said tracks being straight and having opposed ends at opposite side of the room **250** in the vessel. As is preferred, also one or more rail tracks are fitted above the path of the ballast body, and the ballast body is provided with upper rollers that run on said upper rail tracks **263**. These rail tracks are visible in FIG. **10**.

[0103] The drive for each of the ballast bodies **260** in this example comprises a winch **270** and a cable arrangement with cables **271**, **272** that allow displacing the ballast body in both directions. The winch **270** is preferably arranged at a level below the associated path of the ballast body as is shown in FIG. **7**. The winch may have a drum having a double helical groove for the cables. For example each winch has a capacity of several 100 kW's.

[0104] The drive for the one or more ballast bodies **260** further includes a winch control system operable to cause and control the movements of the winches for the solid roll damping ballast bodies in response to the detections of one or more suitable sensors to provide roll stabilization.

[0105] It is noted that a sensor to detect rolling motion is any sensor or sensor system, e.g. including one or more sensor and an associated computer, that allows to provide relevant control information to suitably control the operation of the drive means for the solid roll damping ballast bodies. It can e.g. be an angle detecting sensor, e.g. including one or more gyroscopic sensors that provide angle information of the vessel, but can also be a sensor that measures or interprets actual wave-motion, e.g. wave height, wave period (such as infrared and radar based sensor systems), and may include also e.g. a sensor system that makes use of previously stored data on wave patterns, e.g. specific to the region where the vessel is employed (e.g. based on measurements from buoys). The sensor system may also make use of wind speed and/or wind direction measurements, or other parameters affecting the motion (not limited to rolling motion) of the vessel.

[0106] Each ballast body here is equipped with dampers at its opposed transverse side, e.g. oleo dampers, preferably having a stroke of more than 0.25 meters.

[0107] Operation of the roll damping mechanism in the vessel **200** allows to reduce the roll of the drilling vessel and so allows to increase the workability of the vessel, e.g. when drilling operations are performed in adverse conditions.

[0108] A particular advantage e.g. arises when handling the BOP or similar equipment. As is known in the art Blow Out Preventers are often bulky and very heavy pieces of equipment. Handling such a BOP, e.g. in order to bring it from its storage position into the firing line or vice versa is greatly facilitated when the roll damping mechanism is in operation, thereby reducing roll of the vessel.

[0109] In general the operation of the roll damping mechanism with movable ballast bodies allows to precisely control the load on the drill string during drilling and may contribute to the effect of a heave compensator acting on said drill string.

[0110] The active use of the roll damping mechanism on the drilling vessel also is of advantage during the assembly (and possible also disassembly) of a riser string, wherein riser sections are connected end-to-end. As the suspended riser string will in general have a vertical orientation, rolling motion of the vessel causes an alignment error between the suspended riser and a new riser section to be connected to the riser string. Many connectors on riser sections only allow for a small alignment error, and in general the connection process will be hindered by the rolling motion. Use of the roll damping mechanism during this process will reduce or alleviate any alignment error and thus be beneficial to an efficient process.

[0111] In general the roll damping mechanism allows for the deployment of monohull drilling vessel in geographical areas wherein up till now large and expensive semi-submersible drilling vessels were required in order to obtain a stable drilling situation.

[0112] For each of the vessels shown in the drawings—as is preferred—the roll damping mechanism is formed such that a single ballast body is mounted on and guided along a set of associated rail tracks. This allows to displace the centre of gravity of the ballast body as much as possible outwards with respect to the centreline of the vessel, thus obtaining an increased restoring moment.

[0113] Also for each of the vessels shown in the drawings—as is preferred—a ballast body is embodied as a monolithic metal block, or a set of metal blocks fixed to each other so as to form a single solid body, having a weight of at least 100 tons, in order to arrive at a compact ballast body.

[0114] Also for each of the vessels shown in the drawings—as is preferred—a ballast body has a height that is greater than its transverse dimension, thereby allowing to displace the centre of gravity of the ballast body as much as possible outwards with respect to the centreline of the vessel, thus obtaining an increased restoring moment.

1. A monohull vessel with a heavy lift crane, the crane comprising:
  - a substantially hollow vertical column with a foot which is fixed to the hull and with a top,
  - a jib, which has a reach beyond the hull of the vessel,
  - a jib connection member rotatable about the column, the jib connection member forming a substantially horizontal pivot axis so that the jib can be pivoted up and down,
  - topping means for pivoting the jib up and down, comprising a jib winch and a jib hoisting cable
  - one or more hoisting cable guides on the jib of the hoisting crane;
  - hoisting means for hoisting a load, comprising a hoisting winch and an associated hoisting cable which extends from the winch to a hoisting cable guide on the jib,

wherein the vessel is provided with a water ballast system, and

wherein the vessel further comprises an active roll damping mechanism,
wherein
the active roll damping mechanism comprises:
- a solid roll damping ballast which is movable in the transverse direction of the hull,
- a sensor detecting the rolling motion of the hull,
- a drive and control system operable to cause and control the movements of the solid roll damping ballast in response to the detections of the sensor to provide roll stabilization.

2. A monohull offshore drilling vessel, the vessel comprising:
- a drilling structure with one or more drilling stations allowing subsea drilling operations to be performed from the vessel,

wherein
the vessel is equipped with an active roll damping mechanism comprising:
- a solid roll damping ballast which is movable in the transverse direction of the hull,
- a sensor detecting the rolling motion of the hull,
- a drive and control system operable to cause and control the movements of the solid roll damping ballast in response to the detections of the sensor to provide roll stabilization.

3. Vessel according to claim **1**, wherein the solid roll damping ballast has a total mass of at least 800 ton, preferably between 1000 and 3000 tons, e.g. a mass of 2000 tons.

4. Vessel according to claim **2**, wherein the solid roll damping ballast has a total mass between 100 and 750 tons, more preferably between 200 and 400 tons.

5. Vessel according to claim **1**, wherein the vessel is provided with dynamic positioning means.

6. Vessel according to claim **1**, wherein the roll damping mechanism is such that a single ballast body is mounted on and guided along a set of associated rail tracks.

7. Vessel according to claim **1**, wherein a ballast body is embodied as a monolithic metal block, or a set of metal blocks fixed to each other so as to form a single solid body, having a weight of at least 100 tons.

8. Vessel according to claim **1**, wherein a ballast body has a height that is greater than its dimension in transverse direction of the vessel, e.g. a height between 1.5 and 4 metres.

9. Vessel according to claim **1**, wherein the heavy lift crane is capable of hoisting a load of at least 5000 tons.

10. Vessel according to claim **1**, wherein the crane further comprises a top cable guide provided at the top of the vertical column; the top cable guide comprising a rotary bearing structure, so that the top cable guide can follow rotary movements of the jib about the vertical column and adopts substantially the same angular position as the jib.

11. Vessel according to claim **1**, wherein the hoisting winch is disposed in the column, preferably in the vicinity of the foot of the vertical column, so that the hoisting cable extends from the winch through the hollow vertical column to the top cable guide and then to a hoisting cable guide on the jib.

12. Vessel according to claim **1**, wherein the jib winch and the hoisting winch are arranged on a rotatable winch support, which is rotatable about a rotation axis substantially parallel with the vertical column, such that the winch support is mounted movable with respect to the vertical column; the winch support having an associated drive motor assembly for moving the winch support, in such a manner that the winch support maintains a substantially constant orientation with respect to the jib in the event of rotary movements of the jib about the vertical column.

13. Vessel according to claim **1**, wherein the vertical column has a substantially continuous outer wall.

14. Vessel according to claim **1**, wherein the horizontal section through the vertical column is substantially circular, and in which the cross section preferably decreases gradually towards the top of the column.

15. Vessel according to claim **1**, in which the foot of the column is substantially rectangular.

16. Vessel according to claim **2**, wherein the vessel comprises a moonpool and multiple firing line hoist system arranged at the moonpool, preferably above a moonpool so that portions of the moonpool extend at two opposed sides of the hoist system, wherein the system comprises:
- a mast having a top side and a base, e.g. a transverse girder, which is connected to the hull of the drilling vessel, wherein the mast has a hollow construction with a first side and an opposed second side,
- a first hoisting device supported by the mast and having load attachment means displaceable along a first firing line, which extends on the outside of and adjacent to the first side of the mast;
- a second hoisting device supported by the mast and having load attachment means displaceable along a second firing line, which on the outside of and adjacent to the second side of the mast.

17. Vessel according to claim **16**, wherein the roll damping mechanism is disposed in a room below deck of the vessel, preferably adjacent the moonpool.

18. A method for operating a monohull crane vessel according to claim **1**, wherein the roll damping mechanism is used to counter heel induced by slewing of the jib.

19. A method for subsea drilling wherein use is made of a vessel according to claim **2** and the roll damping mechanism is used to counter roll during a drilling operation and/or during a BOP handling operation.

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