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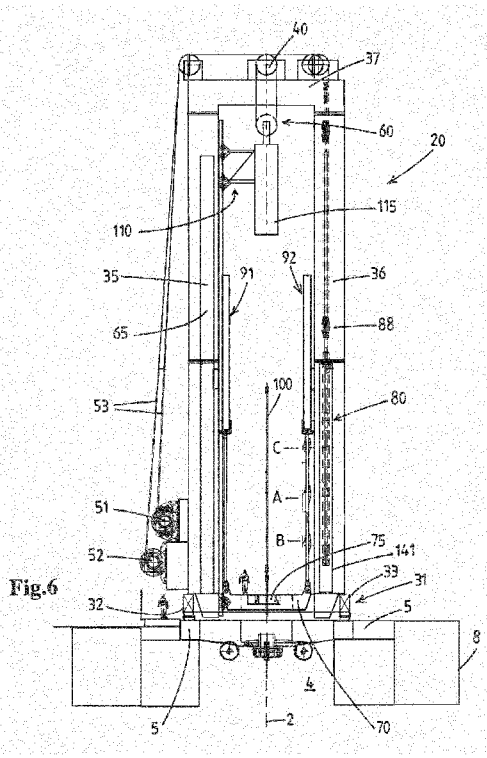


Fig.6

(57) Abstract: A method of retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the existing offshore drilling vessel has a floating hull provided with a moonpool, and wherein the hull has four derrick support structures that are arranged in a rectangular grid about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick. Herein the existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull. The method comprises removing the drilling derrick from the existing offshore drilling vessel. After removal of the drilling derrick, the method comprises mounting a drilling installation on the existing offshore drilling vessel, so that the four derrick support structures of the hull support the drilling installation.

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RETROFITTING AN EXISTING OFFSHORE DRILLING VESSEL

The present invention relates to the field of offshore drilling vessels for performing subsea wellbore related activities along a vertical firing line.

In the field, offshore drilling vessels are in use that have a floating hull provided with a moonpool. The hull has four derrick support structures that are arranged in a rectangular grid about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick. The drilling derrick is placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull.

For example, existing offshore drilling vessels are embodied as a semi-submersible drilling vessel, comprising:
- a deckbox structure;
- one or more pontoons, e.g. two parallel pontoons or a ring pontoon,
- multiple support columns extending upward from the one or more pontoons and supporting thereon the deckbox structure; wherein the deckbox structure has an upper deck and a box bottom, and has a moonpool extending through said deckbox structure. An example of such a prior art offshore drilling vessel is, schematically, depicted in figure 1.

In known embodiments, the drilling derrick is provided with a heave compensated crown block assembly. A travelling block is commonly suspended from the crown block assembly in a multiple fall arrangement of a main cable of a tubular string main hoisting device. This arrangement allows to compensate the tubulars string for heave motion of the vessel, e.g. to avoid undue vertical oscillations of the tubular string, e.g. a drill pipe string, suspended from the travelling block and extending through a riser into the wellbore. This, for example, allows to avoid undue changes in weight-on-it during drilling. An example of such a heave compensated crown block assembly is described in US2015/0008382.

In WO2016062812, the present applicant has disclosed an advanced offshore drilling installation providing enhanced functionality over the above described existing offshore drilling vessels equipped with a drilling derrick and heave compensated crown block assembly.

It is an object of the invention to propose measures that allow for or facilitate the retrofitting of existing drilling vessels with a drilling installation of enhanced functionality.

It is an object of the invention to propose measures that allow for or facilitate the retrofitting of existing drilling vessels with a drilling installation of enhanced functionality, wherein the drilling installation has a limited weight allow to make optimum use of payload capacity of the drilling vessel. This, for instance, in view of operations in remote areas, thereby reducing costs for supply vessels.

It is an object of the invention to provide a versatile offshore drilling installation, for example in view of retrofitting existing offshore drilling vessels.

It is an object of the invention to provide an offshore drilling vessel equipped with a versatile offshore drilling installation.

The invention provides according to a first aspect thereof a method according to claim 1. The method pertains to retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line. The existing offshore drilling vessel, e.g. of the type illustrated schematically in figure 1, has a floating hull provided with a moonpool. The hull has multiple, e.g. four, derrick support structures that are arranged in a grid, e.g. a rectangular grid, about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick. The existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having foot sections, each foot section resting on a respective derrick support structure of the hull.

The inventive method of claim 1 comprises:
- removing the drilling derrick from the existing offshore drilling vessel, e.g. using a blow torch to cut through the connection of each foot section to the hull,
- after removal of the drilling derrick, mounting a drilling installation on the existing offshore drilling vessel, so that the derrick support structures of the hull support the new drilling installation.

Herein the new drilling installation has enhanced functionality over the removed drilling derrick, as it comprises:
- a drilling tower structure comprising:
    - a lower frame configured to rest on the four derrick support structures of the hull of the existing offshore drilling vessel,

- a pair of first and second vertical tower legs erected on said lower frame, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,

- a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

wherein the drilling tower structure is configured so that a vertical load on the crown block assembly is transmitted via the pair of tower legs to the lower frame and thereby to the derrick support structures of the hull of the existing offshore drilling vessel,

wherein the drilling installation further comprises:
- a tubular string main hoisting device comprising:
- one or more main hoisting winches mounted on the drilling tower structure,
- one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,
- a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck arranged between the pair of tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range, wherein, preferably, a slip device is provided on the working deck that is configured to suspend therefrom a tubulars string in the firing line, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:
- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure

and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range,

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator and said hydraulic main cable compensator move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

The method may allow for effectively retrofitting rather old (semi-submersible) drilling vessels, both in view of costs and time.

The drilling tower structure does not require significant changes to the hull, in particular to the derrick support structures thereof as the vertical loads are distributed rather similar to the load distribution when the existing drilling derrick was still present. In comparison, provision of a single mast type drilling tower as shown in the exemplary figures of WO2016062812, would require a total rebuilt of the hull, at least of the deck box structure in a semi-submersible designed to support a four footed drilling derrick. The inventive retrofit method avoids this need.

In an embodiment, the mounting step comprises lifting the drilling installation as a pre-assembled unit onto the vessel in one lift, e.g. using a crane barge or a shore-mounted crane.

In an embodiment, the method comprises the step of functionally testing the drilling installation ahead of lifting the drilling installation as a pre-assembled unit onto the vessel in one lift.

As will be explained herein, the provision of the two tower legs allows for structural design details that are beneficial in view of factors like, reduced total weight of the installation, low center of gravity of the installation, even distribution of weight over the support structures, enhanced integration of additional equipment like a tubulars handling device, racker device, etc.

In an embodiment, the lower frame comprises pair of horizontal girders, e.g. as part of a rectangular lower frame. Herein the horizontal girders are located along opposite sides of the moonpool, each horizontal girder of said pair resting on two derrick support structures. For

example, each tower leg is erected midway between the locations where the horizontal girder rests on the two derrick support structures, so that the girder must be designed to withstand a bending due to the vertical load exerted thereon midway between the derrick support structures.

In an embodiment, the drilling tower structure has two, and just two, single column tower legs, each tower leg having a single column that is erected from the lower frame, the two single column tower legs being arranged in a vertical plane that encompasses the firing line. So the structure than resembles an inverted U structure, with the crown block traverse bridging the tops of the two tower legs as the crown block traverse structure is supported on the two single column tower legs.

For example, each single column tower leg is erected from a respective horizontal girder of the lower frame. For example, each tower leg is erected midway between the locations where the horizontal girder rests on the two derrick support structures.

For example, each vertical tower leg is embodied with multiple vertical chords that are connected by a latticework (diagonal) bracing between the chords, e.g. a triangular or rectangular cross-section vertical tower leg with a chord at each corner of the cross-section.

Most preferably, each single column tower leg is embodied as a hollow box-type tower leg.

In an embodiment, a tower leg is in part, e.g. in a lower part thereof, construed as a hollow box-type tower leg and in another part, e.g. in a top part thereof, construed with multiple vertical chords that are connected by a latticework (diagonal) bracing between the chords.

In an embodiment, the one or more main hoisting winches are mounted to the first tower leg. Preferably, the one or more hoisting winches each have a rotatable winch drum driven by one or more winch motors. In another embodiment, the one or more hoisting winches are embodied as linear winch devices, e.g. each comprising one or more hydraulic cylinders or other linear device to drive the one or more main cables.

In a practically preferred embodiment, the drilling installation has two main hoisting winches each have a rotatable winch drum, each winch drum being connected to a respective end of a single main cable that extends along the crown block and the travelling block. This arranged is illustrated in WO2016062812.

In another embodiment, the tubular string main hoisting device is embodied as disclosed in WO2014/209131. For example, multiple parallel main cables are wound, preferably in a single layer, side by side on the rotatable drum of a winch.

The hydraulic main cable compensator may be passive and/or active, e.g. a switchable compensator, as is known in the art. For example, the hydraulic main cable compensator may be configured as disclosed in WO2018151593 or in WO2011034422.

In an embodiment, the hydraulic main cable compensator is mounted to the second tower leg, e.g. within said second tower leg, e.g. within a hollow-box type second tower leg. In particular in combination with an embodiment wherein the one or more main hoisting winches are mounted to the first tower leg, this arrangement of the hydraulic main cable compensator is beneficial, e.g. in view of distribution of loads within the structure and of weight.

In an embodiment, the hydraulic deck compensator comprises a first hydraulic cylinder that is mounted to and along the first tower leg and a second hydraulic cylinder that is mounted to and along the second tower leg. Preferably, just one hydraulic cylinder is fitted per tower leg, e.g. to a side of a box-type tower leg, e.g. the side facing the other tower leg.

In an embodiment, the hydraulic deck compensator comprises a hydraulic cylinder that is vertically mounted to a respective tower leg, with a cylinder housing thereof attached to the respective tower leg and with a piston rod thereof being extendable downward relative to the cylinder housing, wherein the mobile working deck is connected to the lower end of the piston rod. The provision of this cylinder with the piston rod downwards, essentially results in the working deck hanging directly from the cylinder. The heave compensation effort is then provided by the hydraulic pressure in the annular chamber in the cylinder below the piston, which chamber surrounds the piston rod. This arrangement is structurally simple and allows to make use of the height of the tower legs along which the cylinder extends.

Preferably, the piston rod is extendable downward to a lowered, or lowermost, position where the working deck is at the same level as the deck region of the hull adjoining the moonpool, e.g. the working deck having a deck surface that in a lowered or lowermost position is flush with the adjoin deck region. For example, the working deck is provided with a horizontal rails thereon that align with horizontal rails on the adjoining deck region in the lowered or lowermost position, e.g. allowing transportation of equipment from the adjacent deck region

onto the working deck and vice versa using a rails and, for example, a cart, e.g. a skid cart, moving over said rails.

In an embodiment, the hydraulic main cable compensator comprises a hydraulic cylinder having a cylinder housing, a piston rod, and a piston on the piston rod separating an annular chamber around the piston rod from another, second chamber in the cylinder housing. Herein a main cable heave compensation sheave is connected to the piston rod. The annular chamber of this hydraulic cylinder of the hydraulic main cable compensator is connected to a chamber of a hydraulic liquid/gas separator cylinder, said hydraulic liquid/gas separator cylinder having another chamber that is connected to a gas buffer having an adjustable gas pressure. An example of such an arrangement is illustrated in WO2016062812.

In an embodiment wherein the hydraulic deck compensator cylinder is mounted with the piston rod downwards, each hydraulic deck compensator cylinder has piston on the piston rod, said piston separating an annular chamber around the piston rod and located below the piston from another, second chamber, wherein said annular chamber of the hydraulic deck compensator cylinder is connected to said another, second chamber of the hydraulic main cable compensator cylinder.

In embodiments, the vessel is provided with, e.g. retrofitted with, a horizontal tubulars storage configured for storage of tubulars, e.g. drill pipe, in a horizontal orientation. Preferably, this storage being located on a deck of the vessel at a location adjacent the moonpool. In embodiments, the drilling installation is devoid of any or of a sizable vertical setback for tubulars, so that during a tripping operation a tubular to be added to or removed from a tubular string, e.g. a drill pipe tubulars string or a production tubing string, is to be advanced to the drilling installation from the horizontal tubulars storage or to be returned to the horizontal tubulars storage.

In embodiments, the drilling installation can be provided with a small vertical setback, e.g. within reach of a racker device as described herein. The small vertical setback, e.g. having at most 15 storage positions for a tubular, may serve for storage of bottomhole assemblies, or other components to be integrated in the tubulars string other than the tubulars that make up the majority of the tubular string, e.g. drill pipes or production tubing tubulars.

In embodiments, the vessel is provided with a transport device adapted for transport of a tubular from said horizontal tubulars storage to a horizontal transfer position. For example,

the vessel has guides allowing a tubular to roll into the horizontal transfer position, e.g. gravity based, as is known in the field.

In embodiments, the drilling installation comprises a tubulars handling device.

The tubulars handling device is, preferably, mounted to the drilling tower structure. This allows to avoid any issues with misalignment of the tubulars handled by the handling device relative to the firing line and/or relative to a racker device as described herein. If the handling device where to be mounted on the hull independent from the drilling tower structure, the mounting of the handling device would be complex and still unexpected deviations in alignment relative to the firing line and/or relative to a racker device could occur as the structural behaviour of the existing hull is not always predictable. Also this measure allows, in embodiments, to fully test the entire drilling installation including the tubulars handling device and, preferably, a racker device as described herein, ahead of the installation being mounted on the existing vessel, e.g. in one lift as discussed herein.

The tubulars handling device is configured for moving a tubular, e.g. a drill pipe or a production tubing tubular, between a horizontal transfer position, where a tubular to be handled is pickup or returned, and at least one vertical transfer position, in which the tubular is parallel to the firing line, e.g. vertically aligned with the firing line or parallel to and offset from the firing line.

In an embodiment, the tubulars handling device comprises:
- a base integrated with the drilling tower structure, e.g. in the lower frame thereof, e.g. comprising one or more horizontal girders integrated in the lower frame,
- a boom that is pivotal with respect to the base between a lowered position and a raised position by a boom drive,
- a gripper supported by the boom and adapted for gripping a tubular, for example the gripper being rotatable relative to the boom by a gripper rotation drive, for example wherein the gripper is rotatable about a gripper rotation axis that is parallel to and spaced from a horizontal boom rotation axis,
wherein the boom and gripper are operable so that, with the boom in its lowered position, the gripper is positioned to pick up a tubular at the horizontal transfer position, and with the boom in its raised position, the tubular is in said at least one vertical transfer position.

In a practical embodiment, the boom comprises two parallel beams between which the gripper and a gripped tubular pass upon rotation of the boom between the lowered and raised positions thereof.

In an embodiment, a tower leg is provided with a vertical rail that extends along the tower leg, wherein the working deck is guided along the vertical rail. Preferably, the working deck is only guided along a vertical rail on one of the two tower legs, thereby avoiding alignment issues that would result from guiding the working deck along a vertical rail on each tower leg.

In an embodiment, the drilling installation further comprises:
- at least one first vertical rail that extends along the first tower leg,
- a trolley, said trolley being guided along said at least one first vertical rail,
- a top drive device attached to the trolley, said top drive device comprising one or more top drive motors adapted to impart rotary motion to a tubulars string in the firing line when connected to said top drive device,

wherein the trolley and/or the top drive device is suspended from the travelling block.

In an embodiment, the working deck is also guided along said first vertical rail that guides the trolley, so the deck and the trolley share the first vertical rail.

In an embodiment, the tubulars handling device is configured to bring a tubular into a vertical and offset transfer position that is parallel to and offset from the firing line, outside a vertical path of the vertically mobile working deck relative to the tower legs,

wherein the drilling installation further comprises a racker device that is mounted to the drilling tower structure and that is adapted to take over a tubular from the tubulars handling device when presented at said vertical and offset transfer position and to then move said tubular from said vertical and offset transfer position to a vertical position that is vertically aligned with said firing line and in between the mobile working deck and the travelling block.

Preferably, the racker device is provided with a heave motion synchronization system that is adapted to bring a tubular that has been taken over from the tubulars handling device at said vertical and offset transfer position into a vertical motion that is synchronous with a heave motion of the mobile working deck relative to the hull.

In an embodiment, the drilling installation comprises at least one first vertical rail that extends along the first tower leg,

wherein the racker device comprises, e.g. similar to the disclosure of WO2016/062812, a first motion arm assembly comprising a base and a movable motion arm, e.g. an extensible and retractable motion arm, wherein the base is guided said at least one first vertical rail, and wherein the motion arm has an operative reach that encompasses the firing line and said vertical and offset transfer position, said first motion arm assembly supporting a tubular gripper member adapted for gripping a tubular, said motion arm allowing to move a gripped tubular between said firing line and said vertical and offset transfer position. It will be appreciated that, in embodiments, the racker device could comprise multiple, e.g. two, motion arm assemblies, one above the other, e.g. fitted on the same first vertical rail.

In an embodiment, the one or more motion arm assemblies are provided with, or linked to, a heave motion compensating drive. For example, a toothed rack extends along or is integrated with the first vertical rail, and each motion arm assembly has a motor driven pinion to move the assembly up and down, possibly in heave compensating motion, along the toothed rack. In an embodiment the toothed rack is vertically mobile by a heave compensating drive, e.g. a hydraulic cylinder.

In an embodiment, the vertically mobile working deck is provided with an opening therein that is aligned with said firing line and with a tubulars string supporting slip device that is configured to suspend a tubular string, e.g. a drill pipe string or a production tubing string, in said firing line and within a riser extending to a subsea well when the tubulars string has been disconnected from the travelling block in view of the connection of a new tubular to the suspended tubulars string.

In an embodiment, the drilling installation comprises a well center tool handling device, which well center tool handling device comprises:
- at least one second vertical rail that extends along the second tower leg,
- a second motion arm assembly comprising a base and a movable motion arm, e.g. an extensible and retractable motion arm, wherein the base is guided said at least one second vertical rail, and wherein the motion arm has an operative reach that encompasses the firing line, said motion arm assembly being adapted to support at least a well center tool, e.g. an iron roughneck tool, and allowing to bring said well center tool in the firing line.

In particular with the provision of the racker device at the first tower leg, this arrangement of the well center tool handling device on the second tower leg is beneficial, e.g. in view of weight distribution, interference between the pipe racker and the well center tool handling device, etc.

In an embodiment, the well center tool handling device is provided with a heave motion synchronization system that is adapted to bring the motion arm thereof and the well center tool supported thereby into a vertical motion that is synchronous with a heave motion of the mobile working deck and of a tubulars string supporting slip device provided thereon. For example, the well center tool is an iron roughneck device that is then operated during a tripping operation performed with the working deck and the slip device in heave compensating motion to make up or break a connection between tubulars of the tubulars string.

In an embodiment, the drilling installation comprises a workmen accessible platform that is mountable underneath the vertically mobile working deck allowing one or more workers to perform activities related to the tubulars string at a location underneath the working deck. For example, the workers are involved in securing one or more control lines to the outside of the tubulars string that is to be deployed into the wellbore, e.g. production tubing string, whilst the working deck and the slip device thereon holding the tubulars string are in heave compensating motion relative to the hull. This functionality allows to avoid undue chaffing and possible fatally damaging of such externally mounted control lines during the deployment of the tubulars string.

In an embodiment, the motion range of the vertically mobile working deck comprises a lower stationary position, wherein the working deck is usable as a drill floor deck that is stationary with respect to the hull and preferably aligned with a deck structure of the hull, and wherein the heave compensation motion range lies higher than said lower stationary position. This arrangement allows to use the working deck in the lower stationary position as a regular drill floor.

The invention also relates to a drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, e.g. configured for retrofitting an existing offshore drilling vessel,

wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the drilling installation comprises:

- a drilling tower structure comprising:
    - a lower frame configured to rest on the hull of the offshore drilling vessel,

- a pair of first and second vertical tower legs erected on said lower frame, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,

- a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

wherein the drilling installation further comprises:

- a tubular string main hoisting device comprising:

- one or more main hoisting winches mounted on the drilling tower structure,

- one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,

- a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:

- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range, wherein, preferably, a slip device is provided on the working deck that is configured to suspend therefrom a tubulars string in the firing line, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:

- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range,

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator and said hydraulic main cable compensator move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

The invention also relates to an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line,

wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the offshore drilling vessel has a drilling installation comprises:

- a drilling tower structure comprising:
  - a pair of first and second vertical tower legs, for example erected on a lower frame resting on the hull of the offshore drilling vessel, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,
  - a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

wherein the drilling installation further comprises:
- a tubular string main hoisting device comprising:
  - one or more main hoisting winches mounted on the drilling tower structure,
  - one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,
  - a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range, wherein, preferably, a slip device is provided on the working deck that is configured to suspend therefrom a tubulars string in the firing line, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:

- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range,

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator and said hydraulic main cable compensator move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

It will be appreciated that any of the drilling installations according to the first aspect of the invention may include one or more features discussed herein with reference to the drilling installation of any one or more of the claims 1 – 20 and/or in general discussed or shown herein.

A second aspect of the invention relates to a drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, e.g. for retrofitting an existing drilling vessel equipped with a drilling derrick,

wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the drilling installation comprises:

- a drilling tower structure comprising:
    - a lower frame configured to rest on the hull of the offshore drilling vessel,
    - a pair of first and second vertical tower legs erected on said lower frame, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,

- a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

and wherein the drilling tower structure is configured so that a vertical load on the crown block assembly is transmitted via the pair of tower legs to the lower frame and thereby to the hull of the offshore drilling vessel,

wherein the drilling installation further comprises:
- a tubular string main hoisting device comprising:
  - one or more main hoisting winches mounted on the drilling tower structure,
  - one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,
  - a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range,

wherein the drilling installation comprises:
- a heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the heave compensation system comprises a mechanical connection between the travelling block and the mobile working deck to provide a heave compensated motion of the working deck relative to the drilling tower structure, such that, in operation, said hydraulic main cable compensator provides heave compensation of both the travelling block and the mobile working deck.

For example, similar to the disclosure in WO2013169099, the mobile working deck can be suspended via chains, cables, a rigid links, from the heave compensated travelling block.

The drilling installation of the second aspect of the invention may be provided with one or more of the features, including optional features, discussed herein with reference to the first aspect of the invention, e.g. as discussed in any of claims 1 – 20.

The second aspect of the invention also relates to an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line provided with the drilling installation of the second aspect of the invention.

The second aspect of the invention also relates to a method of retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the existing offshore drilling vessel has a floating hull provided with a moonpool, and wherein the hull has four derrick support structures that are arranged in a rectangular grid about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick, and wherein the existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull, wherein the method comprises:

- removing the drilling derrick from the existing offshore drilling vessel,
- after removal of the drilling derrick, mounting the drilling installation on the existing offshore drilling vessel, so that the four derrick support structures of the hull support the drilling installation.

A third aspect of the present invention relates to a drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the offshore drilling vessel has a floating hull provided with a moonpool, wherein the drilling installation comprises:

- a drilling tower structure comprising, for example:
    - a lower frame configured to rest on the hull of the offshore drilling vessel,
    - a pair of first and second vertical tower legs erected on said lower frame, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,

wherein the drilling installation further comprises:

- a tubular string main hoisting device comprising:
    - one or more main hoisting winches mounted on the drilling tower structure,
    - a vertically mobile crown block assembly mounted on the drilling tower structure, one or more hydraulic crown block cylinders supporting the crown block assembly and configured to move said crown block assembly vertically relative to the drilling tower structure,
    - one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,
    - a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string, e.g. a drill pipe string, therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck that is vertically movable with respect to the drilling tower structure, e.g. relative to the tower legs, along said firing line within a motion range including a heave compensation motion range, e.g. said working deck being arranged between the pair of vertical tower legs,

wherein the drilling installation comprises:
- a heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises said one or more one or more hydraulic crown block cylinders being configured as one or more hydraulic main cable compensators and to provide a heave compensated motion of the travelling block,

and wherein:

a) the integrated heave compensation system comprises a mechanical connection between the crown block assembly and the mobile working deck to provide a heave compensated motion of the working deck relative to the drilling tower structure, such that, in operation, said one or more hydraulic crown block compensators provide heave compensation of both the travelling block and of the mobile working deck, for example, similar to the disclosure in WO2013169099, the mobile working deck can be suspended via chains, cables, a rigid links, from the crown block assembly,

or wherein:

b) the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range, such that, in operation, said hydraulic deck compensator and said one or more hydraulic crown block cylinders move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

The third aspect of the invention pertains to a drilling installation having a main hoisting device of the type that operates in a manner that has become known as the RamRig ® in the field.

The drilling installation of the third aspect of the invention may be provided with one or more of the features, including optional features, discussed herein with reference to the first aspect of the invention, e.g. as discussed in any one or more of claims 1 – 20.

The third aspect of the invention also relates to an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line provided with the drilling installation of the third aspect of the invention.

The third aspect of the invention also relates to a method of retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the existing offshore drilling vessel has a floating hull provided with a moonpool, and wherein the hull has four derrick support structures that are arranged in a rectangular grid about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick, and wherein the existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull, wherein the method comprises:

- removing the drilling derrick from the existing offshore drilling vessel,
- after removal of the drilling derrick, mounting the drilling installation on the existing offshore drilling vessel, so that the four derrick support structures of the hull support the drilling installation.

A fourth aspect of the invention relates to a drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the drilling installation comprises:

- a drilling tower structure comprising:
    - a pair of first and second vertical tower legs, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,

- a tubular string main hoisting device comprising:
    - one or more main hoisting winches mounted on the drilling tower structure,
    - one or more main cables driven by said one or more main hoisting winches,
    - a travelling block suspended from said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range,

- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck, such that, in operation, said travelling block and working deck move synchronously in heave compensation.

The drilling installation of the fourth aspect of the invention may be provided with one or more of the features, including optional features, discussed herein with reference to the first aspect of the invention, e.g. as discussed in any one or more of claims 1 – 20.

The fourth aspect of the invention also relates to an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line provided with the drilling installation of the fourth aspect of the invention.

The fourth aspect of the invention also relates to a method of retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the existing offshore drilling vessel has a floating hull provided with a moonpool, and wherein the hull has four derrick support structures that are arranged in a rectangular grid

about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick, and wherein the existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull, wherein the method comprises:

- removing the drilling derrick from the existing offshore drilling vessel,
- after removal of the drilling derrick, mounting the drilling installation on the existing offshore drilling vessel, so that the four derrick support structures of the hull support the drilling installation.

A fifth aspect of the invention relates to a drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the drilling installation comprises:

- a drilling tower structure,

- a tubular string main hoisting device comprising:
    - one or more main hoisting winches mounted on the drilling tower structure,
    - one or more main cables driven by said one or more main hoisting winches,
    - a travelling block suspended from said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

- a vertically mobile working deck that is vertically movable with respect to the drilling tower structure along said firing line within a motion range including a heave compensation motion range,

- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck, such that, in operation, said travelling block and said working deck move synchronously in heave compensation motion,

- a tubulars handling device that is, preferably, mounted to the drilling tower structure, wherein the tubulars handling device is configured for moving tubulars between a horizontal first transfer position, where a tubular to be handled is pickup or returned, and at least one

vertical and offset transfer position, in which the tubular is parallel and offset from the firing line,

- a racker device that is adapted to take over a tubular from the tubulars handling device and to move said tubular from said vertical transfer position to a firing line position that is aligned with said firing line and in between the mobile working deck and the travelling block,

wherein the racker device is provided with a heave motion synchronization system that is adapted to bring a tubular that has been taken over by the racker device from the tubulars handling device at said vertical transfer position into a vertical motion that is synchronous with a heave motion of the mobile working deck, said working deck, for example, being provided with a drill string slip device that is configured to suspend a drill string therefrom, e.g. during a tripping operation.

The drilling installation of the fifth aspect of the invention may be provided with one or more of the features, including optional features, discussed herein with reference to the first aspect of the invention, e.g. as discussed in any one or more of claims 1 – 20.

The fifth aspect of the invention also relates to an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line provided with the drilling installation of the fourth aspect of the invention.

The fifth aspect of the invention also relates to a method of retrofitting an existing offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, wherein the existing offshore drilling vessel has a floating hull provided with a moonpool, and wherein the hull has four derrick support structures that are arranged in a rectangular grid about the moonpool, each derrick support structure being configured to support thereon a foot section of a drilling derrick, and wherein the existing offshore drilling vessel has a drilling derrick placed above and over the moonpool, the drilling derrick having four foot sections, each foot section resting on and being secured to a respective derrick support structure of the hull, wherein the method comprises:

- removing the drilling derrick from the existing offshore drilling vessel,
- after removal of the drilling derrick, mounting the drilling installation on the existing offshore drilling vessel, so that the four derrick support structures of the hull support the drilling installation.

It will be appreciated that any of the drilling installations according to the first or any other aspect of the invention may be configured for retrofitting an existing offshore drilling vessel. The described installations may, however, also be installed on new drilling vessels when desired. In a retrofit embodiment, preferably, the drilling tower structure of such an installation comprises a lower frame that is configured to be placed on the derrick support structures of an existing vessel, which structures previously supported the drilling derrick that was removed in the course of the retrofit process. For example, the lower frame is embodied as discussed with reference to the installation of claim 1.

The invention also relates to a method for performing subsea wellbore related activities along a vertical firing line, wherein use is made of a drilling vessel, a drilling installation, and/or an offshore drilling vessel as described herein, e.g. according to any one or more of the first, second, third, fourth, and/or fifth aspect of the invention.

The invention will now be explained with reference to the drawings. In the drawings:
Fig. 1 illustrates schematically an existing semi-submersible offshore drilling vessel,
Fig. 2 illustrates an drilling installation according to the invention,
Fig. 3 illustrates another view onto the drilling installation of figure 2,
Fig. 4 shows the drilling installation of figure 2 with the tower structure removed for clarity,
Fig. 5. shows the drilling installation of figure 2 with the tower structure removed for clarity,
Fig. 6 illustrates the mounting of the drilling installation of figure 2 on the hull of an existing offshore drilling vessel having a moonpool,
Fig. 7 shows the mounting of figure 6 at a perpendicular direction,
Figs. 8a,b illustrates the operation of the tubulars handling device of the drilling installation of figure 2,
Fig. 9 illustrates the tubulars string main hoisting device of the drilling installation of figure 2 as well as the integrated heave compensation system thereof,
Fig. 10 illustrates the operation of the well center tool device of the drilling installation of figure 2,
Fig. 11 illustrates the operation of the racker device of the drilling installation of figure 2.

Figure 1 shows an existing offshore drilling vessel 1 for performing subsea wellbore related activities along a vertical firing line 2.

The existing offshore drilling vessel 1 has a floating hull 3 provided with a moonpool 4. The hull has four derrick support structures 5 that are arranged in a rectangular grid about the

moonpool 4. Each derrick support structure 5 is configured to support thereon a foot section 7a of a drilling derrick 7.

The existing offshore drilling vessel 1 has a drilling derrick 7 placed above and over the moonpool 4. The drilling derrick has four foot sections 7a, each foot section 7a resting on and being secured to a respective derrick support structure 5 of the hull.

The depicted existing offshore drilling vessel 1 is embodied as a semi-submersible drilling vessel, comprising:
- a deckbox structure 8;
- one or more pontoons, here two parallel pontoons 9,
- multiple support columns 10 extending upward from the one or more pontoons 9 and supporting thereon the deckbox structure 8.

The deckbox structure 8 has an upper deck 8a and a box bottom above the waterline of the vessel 1.

The moonpool 4 extends through the deckbox structure 8.
In the context of this description it is envisaged that the existing vessel 1 is retrofitted with a drilling installation 20 as illustrated in the figures 2 – 11.

The retrofitting of the vessel 1 is done by a method which comprises:
- removing the drilling derrick 7 from the existing offshore drilling vessel 1, and
- after removal of the drilling derrick 7, mounting a new drilling installation 20 on the existing offshore drilling vessel, so that the four derrick support structures 5 of the hull support the new drilling installation 20.

In an embodiment, the mounting step comprises lifting the drilling installation 20 as a pre-assembled unit onto the vessel 1 in one lift, e.g. using a crane barge or a shore-mounted crane.

In an embodiment, the method comprises the step of functionally testing the drilling installation 20 ahead of lifting the drilling installation as a pre-assembled unit onto the vessel 1 in one lift.

The drilling installation 20 comprises a drilling tower structure comprising:

- a lower frame 31 configured to rest on the four derrick support structures 5 of the hull of the existing offshore drilling vessel 1,

- a pair of first and second vertical tower legs 35, 36 erected on the lower frame 31, said first and second tower legs 35, 36 being spaced apart horizontally on diametrically opposed locations relative to vertical firing line 2,

- a crown block traverse structure 37 supported on the pair of first and second vertical tower legs 35, 36, wherein a crown block assembly 40 is supported by the crown block traverse structure 37.

The lower frame comprises pair of horizontal girders 32, 33 as part of a rectangular lower frame 31.

In the mounting step, the horizontal girders 32, 33 are located along opposite sides of the moonpool, so that each horizontal girder 32, 33 of said pair rests on, and is secured to, two derrick support structures 5.

Each tower leg 35, 36 is erected midway between the locations where the respective horizontal girder 32, 33 rests on the two derrick support structures 5.

The drilling tower structure 20 has two single column tower legs 35, 36, each having a single column that is erected from the lower frame 31. The two single column tower legs are arranged in a vertical plane that encompasses the firing line 2. The crown block traverse structure 37 is supported on the two single column tower legs 35, 36.

Each single column tower leg 35, 36 is embodied as a hollow box-type tower leg. For example, the tower legs 35, 36 have a rectangular cross-section, e.g. of a cross-section of at least 2 x 2 meters, e.g. at most 4 x 4 meters.

The legs 35, 36 may be, as shown here, composed of leg parts that are stacked onto one another, e.g. via a bolted connection.

A cross-beam 39 interconnects the legs 35, 36 at an intermediate height position. That position is, as preferred, higher than the vertical path of working deck 70.

The drilling tower structure may have a height between 30 and 50 meters in practical embodiments, e.g. 42 meters as shown in the drawings.

The drilling tower structure is configured so that a vertical load on the crown block assembly 40 is transmitted via the pair of tower legs 35, 36 to the lower frame 31, here the girders 32, 33, and thereby to the four derrick support structures 5 of the hull of the existing offshore drilling vessel 1.

The drilling installation 20 further comprises a tubular string main hoisting device comprising:

- one or more, here two, main hoisting winches 51, 52 mounted on the drilling tower structure,
- one or more main cables, here one main cable 53, driven by the one or more main hoisting winches 51, 52 and extending to the crown block assembly 40,
- a travelling block 60 suspended from the crown block assembly 40 via said one or more main cables 53, which travelling block is adapted to suspend a tubular string therefrom along the firing line 2 through the moonpool 4.

The one or more main hoisting winches 51, 52 are mounted to the first tower leg 35.

In this example, the two main hoisting winches 51, 52 each have a rotatable winch drum, each winch drum being connected to a respective end of the single main cable 53 that extends along the crown block 40 and the travelling block 60, so that operation of the winches 51, 52 moves the travelling block 60 up and down.

The drilling installation further comprises a vertically mobile working deck 70 that is arranged between the pair of tower legs 35, 36 and that is vertically movable with respect to the tower legs 35, 36 along the firing line 2 within a motion range including a heave compensation motion range.

As shown in figure 6, the motion range of the vertically mobile working deck 70 comprises a lower stationary position, wherein the working deck is usable as a drill floor deck that is stationary with respect to the hull, e.g. generally flush with the deck formed by the deckbox structure of the vessel.

The heave compensation motion range lies higher than said lower stationary position. In figure 6 indication A indicates the center of the heave compensation motion range, e.g. at least 5 meters above the lower stationary position of the deck 7. The indications B and C indicated the lower and upper limit of the heave compensation motion range, e.g. said range extending over a height of at least 5 meters, e.g. at least 7 meters.

A slip device 75 is provided on the working deck 70, which device 75 is configured to suspend therefrom a tubulars string in the firing line 2, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore.

The drilling installation further comprises an integrated heave compensation system configured to provide a heave compensation of the travelling block 60 as well as of the mobile working deck 70.

As shown here, in an embodiment, the integrated heave compensation system comprises a hydraulic main cable compensator 80 engaging on the one or more main cables 53 and configured to provide a heave compensated motion of the travelling block 60. Here the compensator 80 comprises a hydraulic cylinder 81 having a piston rod 81b supporting a sheave assembly 88 acting on the main cable 53.

The integrated heave compensation system further comprises a hydraulic deck compensator 90, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck 70 and is configured to provide a heave compensated motion of the working deck 70 relative to the drilling tower structure within a heave compensation motion range.

The integrated heave compensation system is configured such that, in operation, the hydraulic deck compensator 90 and the hydraulic main cable compensator 80 move synchronously in order to provide synchronized heave compensation of both the travelling block 60 and the mobile working deck 70.

The hydraulic main cable compensator 80 is mounted to the second tower leg 36, here within said second tower leg, that is within the hollow-box type second tower leg 36.

As shown, the hydraulic deck compensator comprises a first hydraulic cylinder 91 that is mounted to and along the first tower leg 35 and a second hydraulic cylinder 92 that is mounted to and along the second tower leg 36. In practical embodiments each hydraulic deck compensator cylinder 91, 92 may have a heave compensating stroke length of at least 5 meters, and in addition thereto another at least 5 meters of stroke length as the heave compensation motion range is envisaged to stay clear above the lowermost stationary position of the deck 70, e.g. by at least 3 meters.

Both the hydraulic cylinder 91 and 92 are vertically mounted to the respective tower leg 35, 36. Herein a cylinder housing 91a, 92a thereof is rigidly attached to the respective tower leg 35, 36 and a piston rod thereof 91b, 92b thereof is extendable downward relative to the cylinder housing. The mobile working deck 70 is connected to the lower end of the piston rods 91b, 92b.

The hydraulic main cable compensator 80 comprises a hydraulic cylinder 81 having a cylinder housing 81a, a piston rod 81b, and piston 81c separating an annular chamber 82 around the piston rod from another, second chamber 83 in the cylinder housing 81. A main cable heave compensation sheave assembly 88 is connected to the piston rod 81b. The annular chamber 82 is connected to a chamber 85a of a hydraulic liquid/gas separator cylinder 85, said hydraulic liquid/gas separator cylinder having another chamber 85b that is connected to a gas buffer 86 having an adjustable gas pressure.

Each hydraulic deck compensator cylinder has piston 91c, 92c separating an annular chamber 91d, 92d around the piston rod and below the piston from another, second chamber 91e, 92e. The annular chambers 91d, 92d are interconnected ad connected to the second chamber 83 of the hydraulic main cable compensator cylinder 81.

Figure 9 schematically indicates, as an optional feature, the provision of an adjusting winch 96 and associated adjusting wire 97 acting on the compensator sheave assembly and/or piston rod 81b, for example as explained in WO2018151593.

The vessel 1 is, e.g. as part of the retrofit, provided with a horizontal tubulars storage configured for storage of tubulars in a horizontal orientation. Preferably said storage is located on a deck of the vessel at a location adjacent the moonpool 4. As known in the field, the vessel is provided with a transport device adapted for transport of a tubular from said horizontal tubulars storage to a horizontal transfer position, indicated as *T horizontal* in the drawings.

The drilling installation 20 comprises a tubulars handling device 120, which tubulars handling device is mounted to the drilling tower structure.

The tubulars handling device 120 is configured for moving a tubular 100 between said horizontal transfer position T horizontal, where a tubular 100 to be handled is pickup or returned, and at least one vertical transfer position, in which the tubular is parallel to the firing line, e.g. vertically aligned with the firing line or parallel to and offset from the firing line.

The depicted tubulars handling device 120 comprises:
- a base 121 integrated with the drilling tower structure, here with the lower frame 31 as preferred,
- a boom 122 that is pivotal with respect to the base 121 between a lowered position and a raised position by a boom drive,
- a gripper 123 supported by the boom 122 and adapted for gripping a tubular 100. For example, the gripper 123 is rotatable relative to the boom 122 by a gripper rotation drive. It is shown here that the gripper 123 is rotatable about a gripper rotation axis that is parallel to and spaced from a horizontal boom rotation axis.

The figures 8a, b illustrate that the boom 122 and gripper 123 for a tubular 100 are operable so that, with the boom 122 in its lowered position, the gripper 123 is positioned to pick up a tubular at the horizontal transfer position T horizontal, and with the boom 122 in its raised position, the tubular 100 is in said at least one vertical transfer position.

It is illustrated that the boom 122 comprises two parallel beams between which the gripper 123 and a gripped tubular 100 pass upon rotation of the boom between the lowered and raised positions thereof.

The drilling installation 20 further comprises:
- at least one first vertical rail 65 that extends along the first tower leg 35,
- a trolley 110, said trolley being guided along said at least one first vertical rail 65,
- a top drive device 115 attached to the trolley 110, said top drive device comprising one or more top drive motors adapted to impart rotary motion to a tubulars string in the firing line 2 when connected to said top drive device,
wherein the trolley and/or the top drive device is suspended from the travelling block 60.

The tubulars handling device 120 is configured to bring a tubular 100 into a vertical and offset transfer position, indicated in figures 10, 11 as *T offset*, that is parallel to and offset from the firing line 2, outside the vertical path of the vertically mobile working deck 70 relative to the tower legs 35,36.

The drilling installation further comprises a racker device 130 that is mounted to the drilling tower structure and that is adapted to take over a tubular 100 from the tubulars handling device 120 when presented at said vertical and offset transfer position *T offset* and to then move said tubular 100 from said vertical and offset transfer position to a vertical position that

is vertically aligned with said firing line 2 and in between the mobile working deck 70 and the travelling block or the top drive device 115 when present.

The racker device 130 is provided with a heave motion synchronization system that is adapted to bring a tubular 100 that has been taken over from the tubulars handling device 120 at said vertical and offset transfer position into a vertical motion that is synchronous with a heave motion of the mobile working deck 70 relative to the hull.

The drilling installation comprises said at least one first vertical rail 65 that extends along the first tower leg 35.

The racker device 130 comprises:
- a first motion arm assembly 135 comprising a base 136 and a movable motion arm 137, e.g. an extensible and retractable motion arm 137, e.g. telescoping. The base is guided by said at least one first vertical rail 65. The motion arm 137 has an operative reach that encompasses the firing line 2 and the vertical and offset transfer position T offset. The first motion arm assembly 135 supports a tubular gripper member 138 adapted for gripping a tubular 100. The motion arm 137 allows to move a gripped tubular between said firing line and said vertical and offset transfer position.

The vertically mobile working deck 70 is provided with an opening 71 therein that is aligned with the firing line 2. The deck 70 is provided with a tubulars string supporting slip device 75 that is configured to suspend a tubular string, e.g. a drill pipe string or a production tubing string, in said firing line 2 and within a riser extending to a subsea well when the tubulars string has been disconnected from the travelling block 60, or the top drive 115, in view of the connection of a new tubular to the suspended tubulars string that extends through riser 101.

The drilling installation further comprises a well center tool handling device 140, which well center tool handling device comprises:
- at least one second vertical rail 141 that extends along the second tower leg 36,
- a motion arm assembly 145 comprising a base 146 and a movable motion arm 147, e.g. an extensible and retractable motion arm, e.g. telescoping, wherein the base 146 is guided said at least one second vertical rail 141. The motion arm 147 has an operative reach that encompasses the firing line 2. For example, as preferred, the motion arm 147 can swing relative to the base 146 about a vertical axis. The motion arm assembly 145 is adapted to support at least a well center tool, e.g. an iron roughneck tool 148, and allowing to bring said well center tool in the firing line 2.

The well center tool handling device 140 may be provided with a heave motion synchronization system that is adapted to bring the motion arm 147 thereof and the well center tool 148 supported thereby into a vertical motion that is synchronous with a heave motion of the mobile working deck 70 and of a tubulars string supporting slip device 75 provided thereon, e.g. the well center tool being an iron roughneck device 148 operated during a tripping operation to make up or break a connection between tubulars of the tubulars string that extends into the riser 101 and into the subsea wellbore.

Figures 7, 10, 11 illustrate the provision of a weather wall 150 protecting the work area. The wall 150 has an opening at the location of the handling device 120.

The drilling installation is provided with a small vertical setback 170 within reach of a racker device 130 as described herein. The small vertical setback 170, e.g. having at most 15 storage positions for a tubular.

Figures 2 – 5 illustrate that riser 101 is installed between the offshore drilling vessel and the subsea wellbore. The riser 101 is tensioned in well-known manner by a riser tensioning system engaging an upper portion of the riser 101. Here a riser tension ring 103 is shown, to which riser tension wires 104 are connected that extend, via an arrangement of sheaves, to riser tensioner devices 105. Alternative riser tensioner systems may also be envisaged, as is known in the art.

A telescopic joint may be provided, as common, in riser 101, for example with a flex joint above the telescopic joint allowing for angular motion of the riser 101 relative to the vessel.

C L A I M S

1. A method of retrofitting an existing offshore drilling vessel (1) for performing subsea wellbore related activities along a vertical firing line,

wherein the existing offshore drilling vessel has a floating hull (3) provided with a moonpool (4), and wherein the hull has multiple, e.g. four, derrick support structures (5) that are arranged in a grid, e.g. a rectangular grid, about the moonpool, each derrick support structure being configured to support thereon a foot section (7a) of a drilling derrick (7),

and wherein the existing offshore drilling vessel has a drilling derrick (7) placed above and over the moonpool, the drilling derrick having four foot sections, each foot section (7a) resting on a respective derrick support structure (5) of the hull,

wherein the method comprises:

- removing the drilling derrick (7) from the existing offshore drilling vessel,

- after removal of the drilling derrick, mounting a drilling installation (20) on the existing offshore drilling vessel, so that the four derrick support structures (5) of the hull support the drilling installation,

wherein the drilling installation comprises:

- a drilling tower structure comprising:
  - a lower frame (31) configured to rest on the derrick support structures (5) of the hull of the existing offshore drilling vessel,
  - a pair of first and second vertical tower legs (35,36) erected on said lower frame (31), said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line (2),
  - a crown block traverse structure (37) supported on said pair of first and second vertical tower legs (35,36) , wherein a crown block assembly (40) is supported by said crown block traverse structure,

and wherein the drilling tower structure is configured so that a vertical load on the crown block assembly (40) is transmitted via the pair of tower legs (35,36) to the lower frame (31)

and thereby to the derrick support structures (5) of the hull of the existing offshore drilling vessel,

wherein the drilling installation further comprises:

- a tubular string main hoisting device comprising:
  - one or more main hoisting winches (51,52) mounted on the drilling tower structure,
  - one or more main cables (53) driven by said one or more main hoisting winches and extending to said crown block assembly (40),
  - a travelling block (60) suspended from said crown block assembly via said one or more main cables (53), which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool (4),

wherein the drilling installation comprises:

- a vertically mobile working deck (70) that is arranged between the pair of tower legs (35,36) and vertically movable with respect to the tower legs along said firing line (2) within a motion range including a heave compensation motion range, wherein, preferably, a slip device (75) is provided on the working deck (70) that is configured to suspend therefrom a tubulars string in the firing line (2), e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:

- an integrated heave compensation system configured to provide a heave compensation of the travelling block (60) as well as of the mobile working deck (70),

wherein the integrated heave compensation system comprises a hydraulic main cable compensator (80,81) engaging on the one or more main cables (53) and configured to provide a heave compensated motion of the travelling block (60),

wherein the integrated heave compensation system further comprises a hydraulic deck compensator (90,91,92), which hydraulic deck compensator is connected to the drilling tower structure (35,36) and to the mobile working deck (70) and is configured to provide a heave compensated motion of the working deck (70) relative to the drilling tower structure within a heave compensation motion range,

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator (90,91,92) and said hydraulic main cable compensator

(80,81) move synchronously in order to provide heave compensation of both the travelling block (60) and the mobile working deck (70).

2. Method according to claim 1, wherein the lower frame (31) comprises pair of horizontal girders (32,33), e.g. as part of a rectangular lower frame, wherein the horizontal girders are located along opposite sides of the moonpool (4), each horizontal girder of said pair resting on two or more derrick support structures (5), e.g. each tower leg (35,36) being erected midway between the locations where the horizontal girder rests on the two derrick support structures (5).

3. Method according to claim 1 or 2, wherein the drilling tower structure has two single column tower legs (35,36), each having a single column that is erected from the lower frame (31), the two single column tower legs being arranged in a vertical plane that encompasses the firing line (2), e.g. each single column tower leg being erected from a respective horizontal girder (32,33) of the lower frame, e.g. each tower leg being erected midway between the locations where the horizontal girder rests on the two derrick support structures (5), and wherein the crown block traverse structure (37) is supported on said two single column tower legs (35,36), preferably wherein each single column tower leg is embodied as a hollow box-type tower leg (35,36).

4. Method according to any one of claims 1 - 3, wherein the one or more main hoisting winches (51,52) are mounted to the first tower leg, e.g. wherein two main hoisting winches (51,52) each have a rotatable winch drum, each winch drum being connected to a respective end of a single main cable (53) that extends along the crown block and the travelling block.

5. Method according to any one of claims 1 - 4, wherein the hydraulic main cable compensator (80,81) is mounted to the second tower leg, e.g. within said second tower leg, e.g. within a hollow-box type second tower leg (36).

6. Method according to any one of claims 1 - 5, wherein the hydraulic deck compensator comprises a first hydraulic cylinder (91) that is mounted to and along the first tower leg (35) and a second hydraulic cylinder (36) that is mounted to and along the second tower leg (36).

7. Method according to any one of claims 1 - 6, wherein the hydraulic deck compensator comprises a hydraulic cylinder (91,92) that is vertically mounted to a respective tower leg (35,36), with a cylinder housing (91a,92a) thereof attached to the respective tower leg and with a piston rod (91b,92b) thereof being extendable downward relative to the cylinder

housing, wherein the mobile working deck (70) is connected to the lower end of the piston rod.

8. Method according to any one of claims 1 - 7, wherein said hydraulic main cable compensator comprises a hydraulic cylinder (81) having a cylinder housing (81a), a piston rod (81b), and piston (81c) separating an annular chamber (82) around the piston rod from another, second chamber (83) in the cylinder housing, wherein a main cable heave compensation sheave (88) is connected to said piston rod, wherein said annular chamber (82) of said hydraulic cylinder of the hydraulic main cable compensator is connected to a chamber (85a) of a hydraulic liquid/gas separator cylinder (85), said hydraulic liquid/gas separator cylinder having another chamber (85b) that is connected to a gas buffer (86) having an adjustable gas pressure.

9. Method according to claims 7 and 8, wherein each hydraulic deck compensator cylinder (91,92) has piston separating an annular chamber around the piston rod and below the piston (91c,92c) from another, second chamber (91e,92e), wherein said annular chamber (91d,92d) is connected to said another, second chamber (83) of the hydraulic main cable compensator cylinder (81).

10. Method according to any one of claims 1 - 9, wherein the vessel (1) is provided with a horizontal tubulars storage configured for storage of tubulars in a horizontal orientation, preferably said storage being located on a deck of the vessel at a location adjacent the moonpool,

and wherein the vessel is provided with a transport device adapted for transport of a tubular from said horizontal tubulars storage to a horizontal transfer position,

and wherein the drilling installation comprises a tubulars handling device (120), which tubulars handling device is preferably mounted to the drilling tower structure,

wherein the tubulars handling device is configured for moving a tubular (101) between said horizontal transfer position (T horizontal), where a tubular to be handled is pickup or returned, and at least one vertical transfer position, in which the tubular is parallel to the firing line, e.g. vertically aligned with the firing line or parallel to and offset from the firing line (T offset).

11. Method according to claim 10, wherein the tubulars handling device (120) comprises:

- a base (121) integrated with the drilling tower structure,
- a boom (122) that is pivotal with respect to the base between a lowered position and a raised position by a boom drive,
- a gripper (123) supported by the boom and adapted for gripping a tubular, for example the gripper being rotatable relative to the boom by a gripper rotation drive, for example wherein the gripper is rotatable about a gripper rotation axis that is parallel to and spaced from a horizontal boom rotation axis,

wherein the boom and gripper are operable so that, with the boom in its lowered position, the gripper is positioned to pick up a tubular at the horizontal transfer position, and with the boom in its raised position, the tubular is in said at least one vertical transfer position.

12. Method according to claim 11, wherein the boom (122) comprises two parallel beams between which the gripper (123) and a gripped tubular pass upon rotation of the boom between the lowered and raised positions thereof.

13. Method according to any one of claims 1 - 12, wherein the drilling installation further comprises:

- at least one first vertical rail (65) that extends along the first tower leg (35),
- a trolley (110), said trolley being guided along said at least one first vertical rail,
- a top drive device (115) attached to the trolley, said top drive device comprising one or more top drive motors adapted to impart rotary motion to a tubulars string in the firing line when connected to said top drive device,

wherein the trolley and/or the top drive device is suspended from the travelling block.

14. Method according to any one of claims 10 – 12, wherein the tubulars handling device (120) is configured to bring a tubular (100) into a vertical and offset transfer position (T offset) that is parallel to and offset from the firing line, outside a vertical path of the vertically mobile working deck (70),

and wherein the drilling installation further comprises a racker device (130) that is mounted to the drilling tower structure and that is adapted to take over a tubular (100) from the tubulars handling device when presented at said vertical and offset transfer position (T offset) and to then move said tubular from said vertical and offset transfer position to a vertical position that is vertically aligned with said firing line (2) and in between the mobile working deck and the travelling block or the top drive device (110).

15. Method according to claim 14, wherein the racker device (130) is provided with a heave motion synchronization system that is adapted to bring a tubular that has been taken over from the tubulars handling device at said vertical and offset transfer position into a vertical motion that is synchronous with a heave motion of the mobile working deck relative to the hull.

16. Method according to claim 14 or 15, wherein the drilling installation comprises:
- at least one first vertical rail (65) that extends along the first tower leg

and wherein the racker device comprises:
- a first motion arm assembly (135) comprising a base (136) and a movable motion arm (137), e.g. an extensible and retractable motion arm, wherein the base is guided said at least one first vertical rail (65), and wherein the motion arm has an operative reach that encompasses the firing line (2) and said vertical and offset transfer position (T offset), said first motion arm assembly supporting a tubular gripper member (138) adapted for gripping a tubular, said motion arm allowing to move a gripped tubular between said firing line and said vertical and offset transfer position.

17. Method according to any one of claims 1 – 16, wherein the vertically mobile working deck is provided with an opening (71) therein that is aligned with said firing line (2) and with a tubulars string supporting slip device (75) that is configured to suspend a tubular string, e.g. a drill pipe string or a production tubing string, in said firing line (2) and within a riser (101) extending to a subsea well when the tubulars string has been disconnected from the travelling block in view of the connection of a new tubular to the suspended tubulars string.

18. Method according to any one of claims 1 – 17, wherein the drilling installation comprises a well center tool handling device (140), which well center tool handling device comprises:
- at least one second vertical rail (141) that extends along the second tower leg,
- a second motion arm assembly (145) comprising a base (146) and a movable motion arm (147), e.g. an extensible and retractable motion arm, wherein the base is guided said at least one second vertical rail, and wherein the motion arm has an operative reach that encompasses the firing line, said motion arm assembly being adapted to support at least a well center tool (148), e.g. an iron roughneck tool, and allowing to bring said well center tool in the firing line.

19. Method according to claim 18, wherein the well center tool handling device (140) is provided with a heave motion synchronization system that is adapted to bring the motion arm thereof and the well center tool supported thereby into a vertical motion that is synchronous with a heave motion of the mobile working deck and of a tubulars string supporting slip device provided thereon, e.g. the well center tool being an iron roughneck device operated during a tripping operation to make up or break a connection between tubulars of the tubulars string.

20. Method according to any of claims 1 -19, wherein said motion range of the vertically mobile working deck (70) comprises a lower stationary position, wherein the working deck is usable as a drill floor deck that is stationary with respect to the hull and preferably aligned with a deck structure of the hull, and wherein the heave compensation motion range (B,C) lies higher than said lower stationary position.

21. A drilling installation configured for use on-board an offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line, e.g. configured for retrofitting an existing offshore drilling vessel,

wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the drilling installation comprises:

- a drilling tower structure comprising:
    - a lower frame configured to rest on the hull of the offshore drilling vessel,
    - a pair of first and second vertical tower legs erected on said lower frame, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,
    - a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

and wherein the drilling tower structure is configured so that a vertical load on the crown block assembly is transmitted via the pair of tower legs to the lower frame and thereby to the hull of the offshore drilling vessel,

wherein the drilling installation further comprises:

- a tubular string main hoisting device comprising:
    - one or more main hoisting winches mounted on the drilling tower structure,

- one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,

- a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range, wherein, preferably, a slip device is provided on the working deck that is configured to suspend therefrom a tubulars string in the firing line, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:
- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range;

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator and said hydraulic main cable compensator move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

22. An offshore drilling vessel for performing subsea wellbore related activities along a vertical firing line,

wherein the offshore drilling vessel has a floating hull provided with a moonpool,

wherein the offshore drilling vessel has a drilling installation comprises:

- a drilling tower structure comprising:
    - a pair of first and second vertical tower legs, for example erected on a lower frame resting on the hull of the offshore drilling vessel, said first and second tower legs being spaced apart horizontally on diametrically opposed locations relative to a vertical firing line,
    - a crown block traverse structure supported on said pair of first and second vertical tower legs, wherein a crown block assembly is supported by said crown block traverse structure,

and wherein the drilling tower structure is configured so that a vertical load on the crown block assembly is transmitted via the pair of tower legs towards the hull, e.g. via a lower frame and thereby to four derrick support structures of the hull of the offshore drilling vessel,

wherein the drilling installation further comprises:
- a tubular string main hoisting device comprising:
    - one or more main hoisting winches mounted on the drilling tower structure,
    - one or more main cables driven by said one or more main hoisting winches and extending to said crown block assembly,
    - a travelling block suspended from said crown block assembly via said one or more main cables, which travelling block is adapted to suspend a tubular string therefrom along a firing line through said moonpool,

wherein the drilling installation comprises:
- a vertically mobile working deck arranged between the pair of vertical tower legs and vertically movable with respect to the tower legs along said firing line within a motion range including a heave compensation motion range, wherein, preferably, a slip device is provided on the working deck that is configured to suspend therefrom a tubulars string in the firing line, e.g. during a tripping operation wherein the tubulars string is tripped into or out of a wellbore,

wherein the drilling installation comprises:
- an integrated heave compensation system configured to provide a heave compensation of the travelling block as well as of the mobile working deck,

wherein the integrated heave compensation system comprises a hydraulic main cable compensator engaging on the one or more main cables and configured to provide a heave compensated motion of the travelling block,

wherein the integrated heave compensation system further comprises a hydraulic deck compensator, which hydraulic deck compensator is connected to the drilling tower structure and to the mobile working deck and is configured to provide a heave compensated motion of the working deck relative to the drilling tower structure within a heave compensation motion range,

wherein the integrated heave compensation system is configured such that, in operation, said hydraulic deck compensator and said hydraulic main cable compensator move synchronously in order to provide heave compensation of both the travelling block and the mobile working deck.

23. A method for performing subsea wellbore related activities along a vertical firing line, wherein use is made of a drilling vessel obtained according to any of claims 1 – 20, a drilling installation according to claim 21, and/or an offshore drilling vessel according to claim 22.

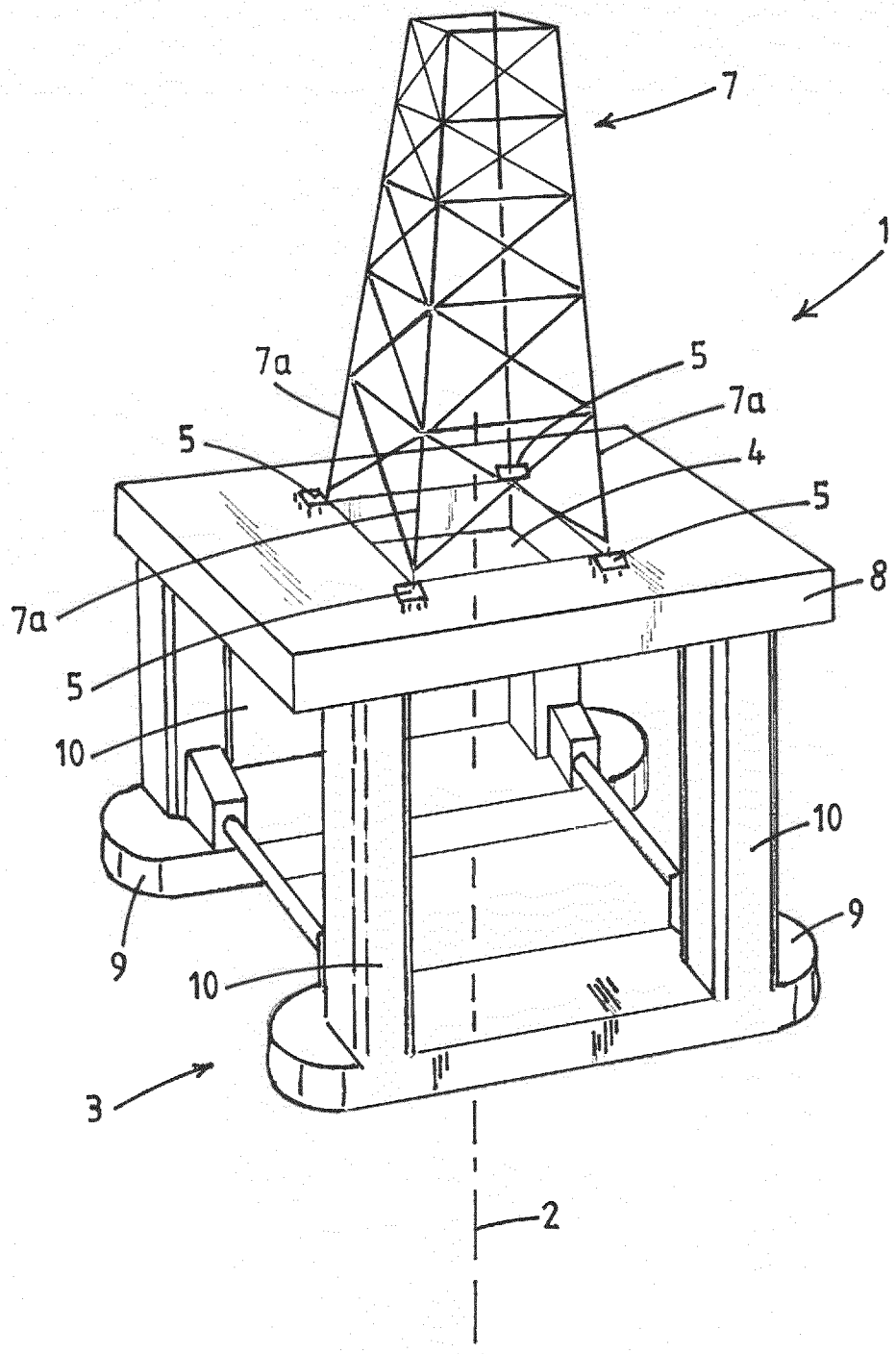


Fig.1

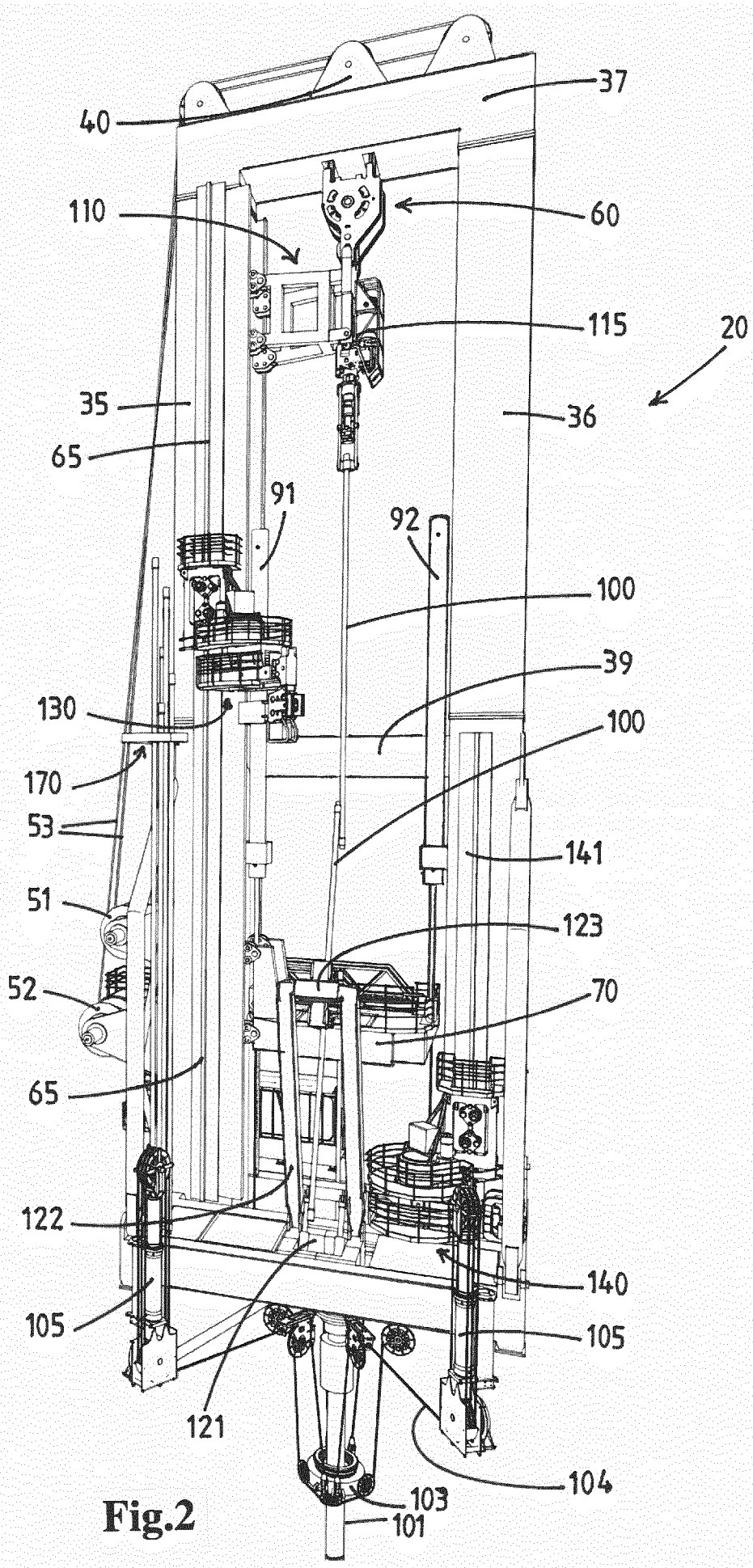

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Fig.2

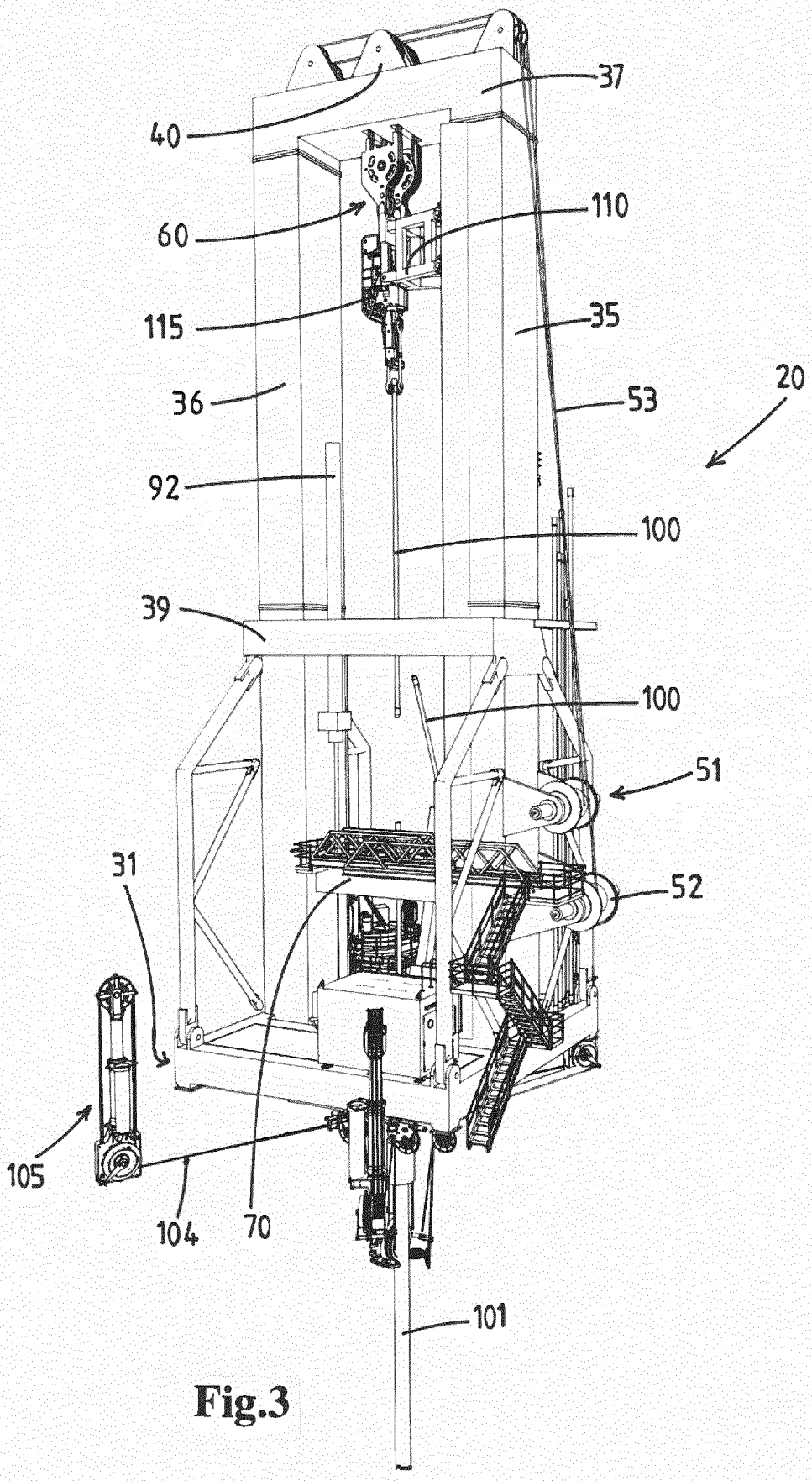


Fig.3

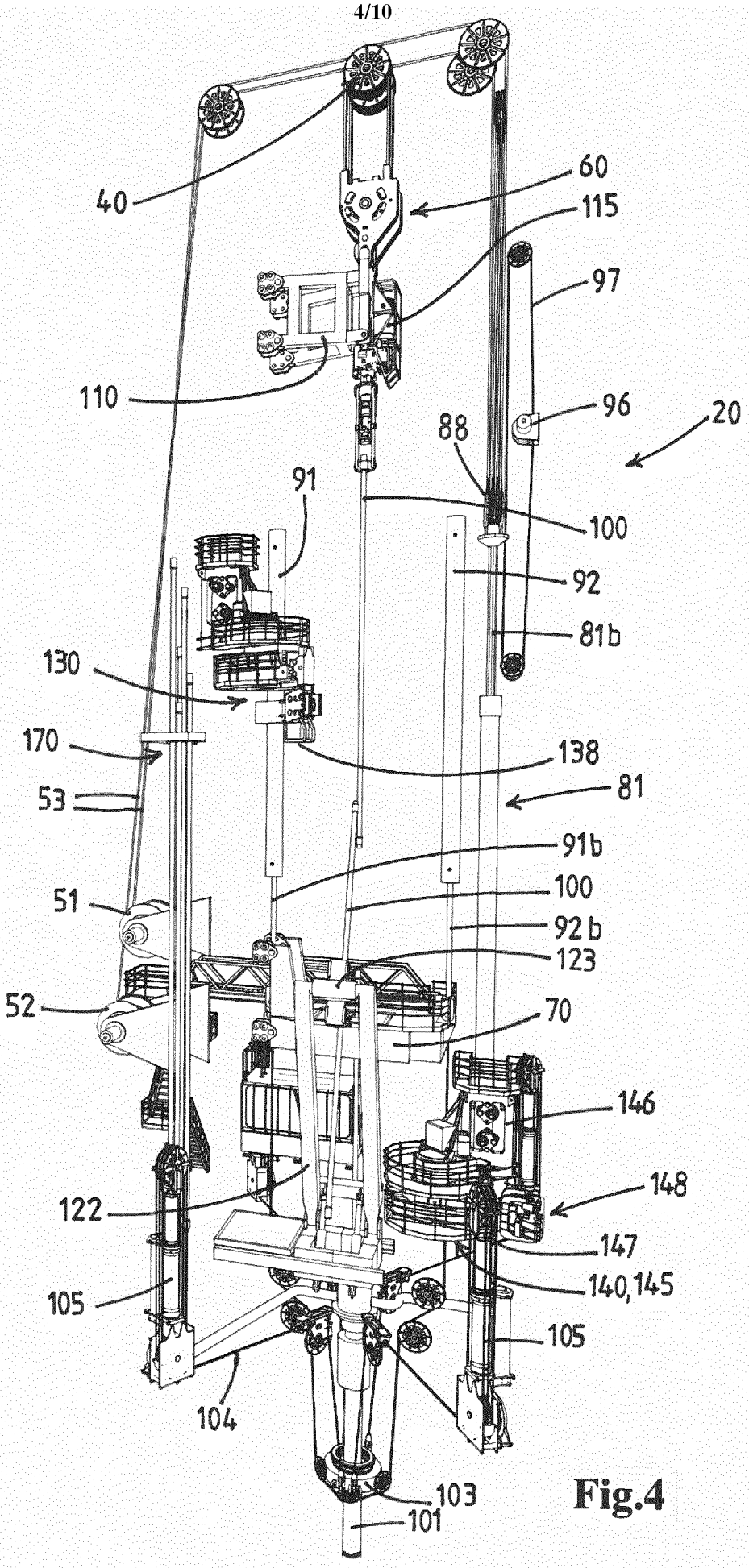

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Fig.4

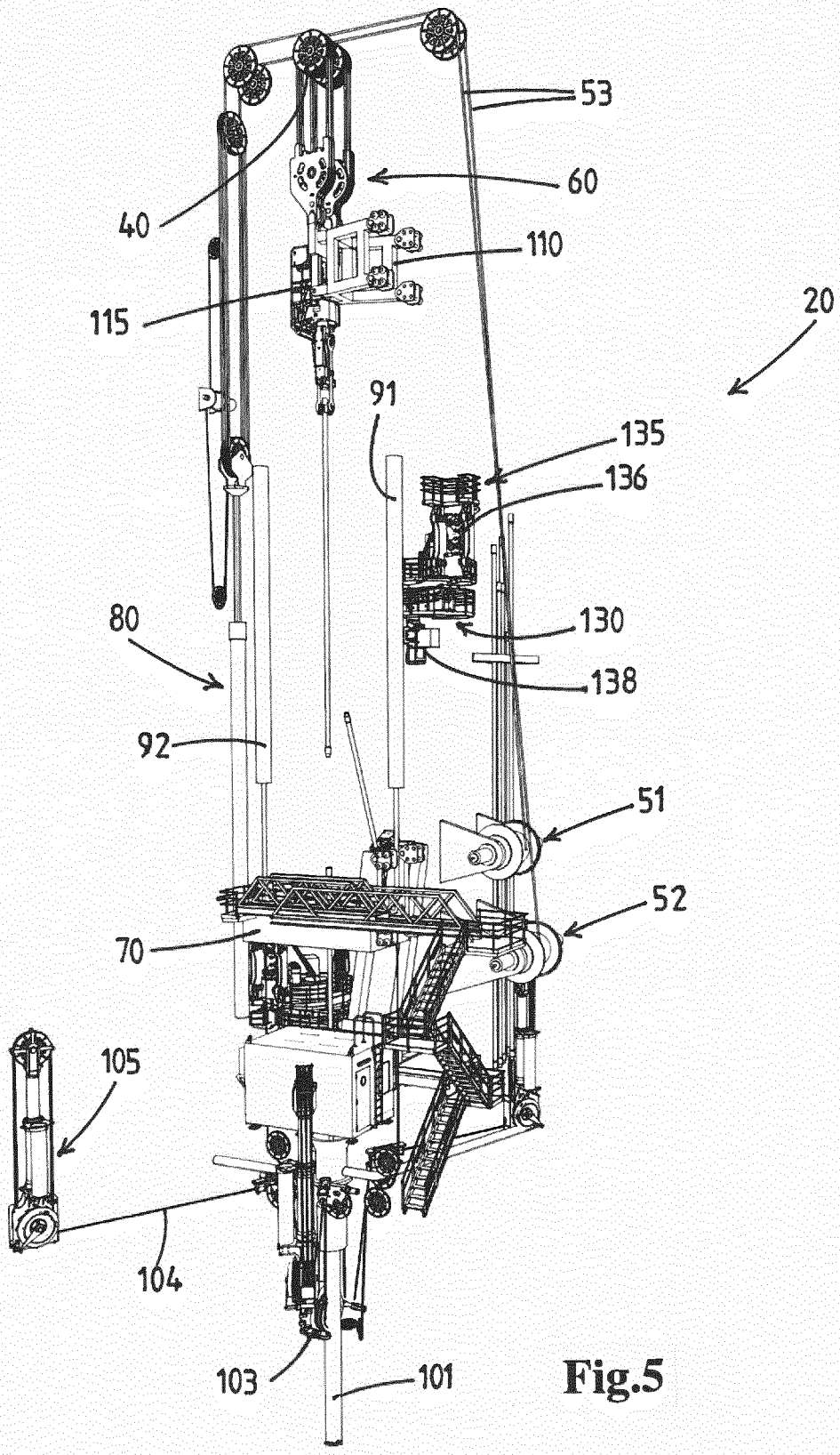

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Fig.5

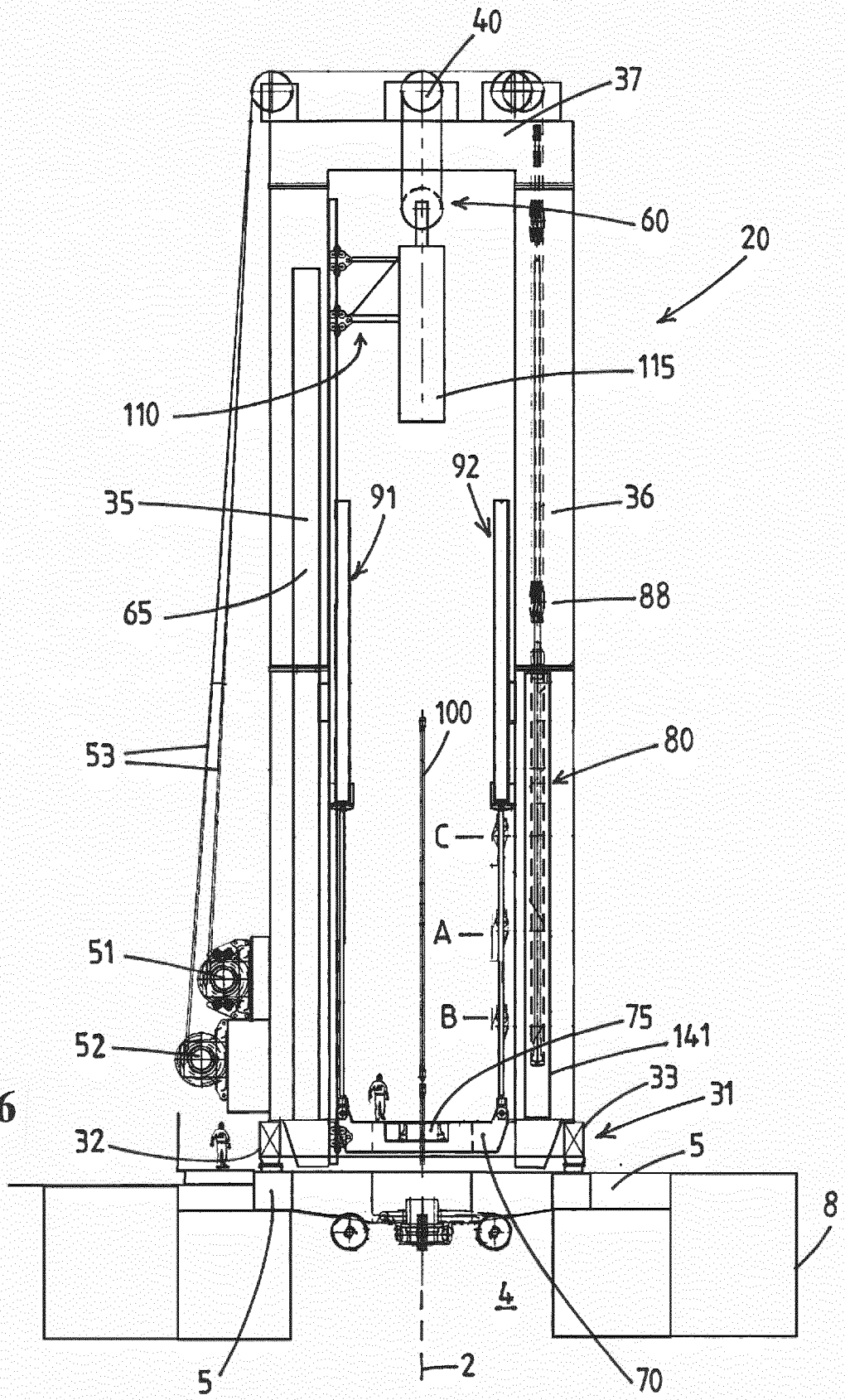

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Fig.6

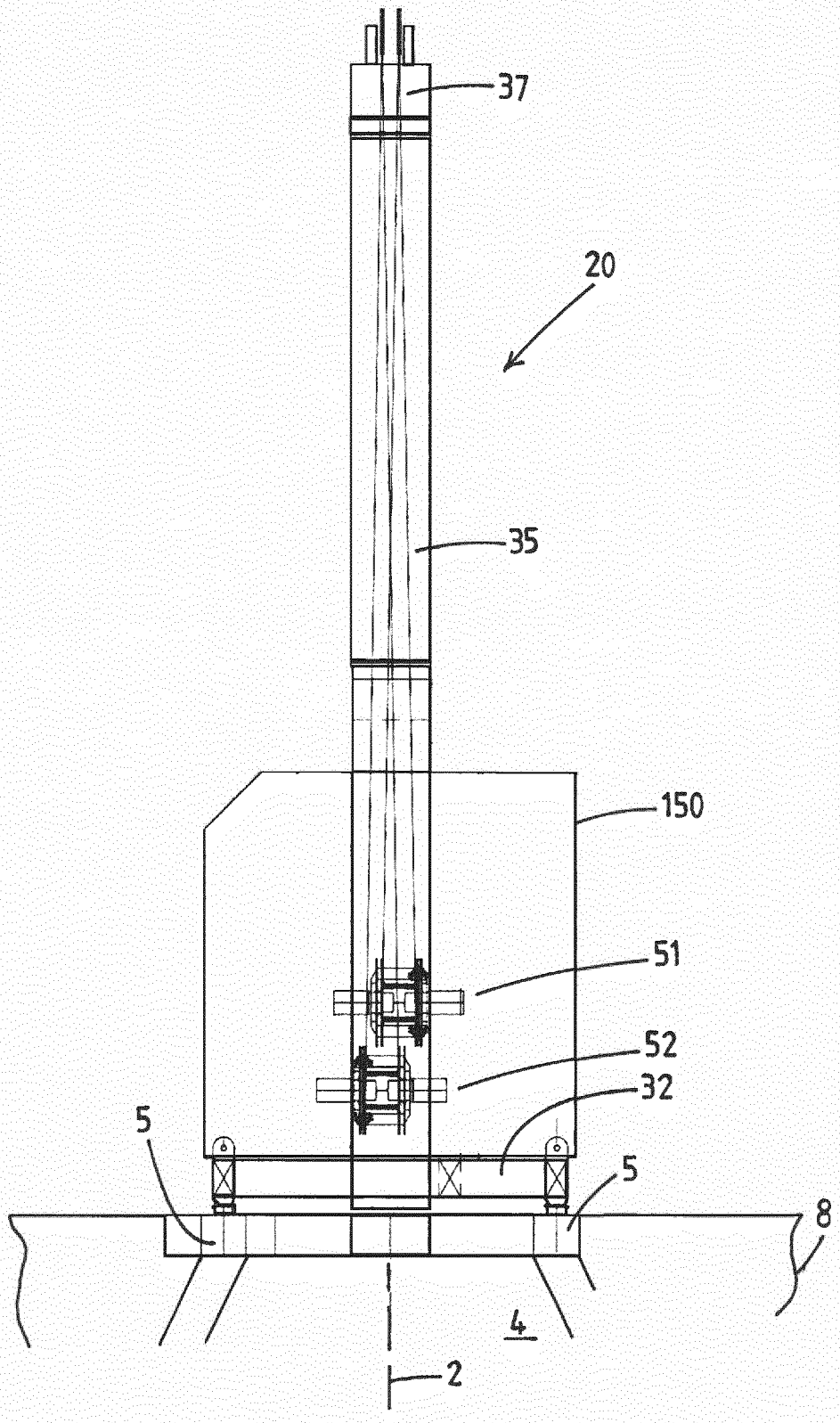


Fig.7

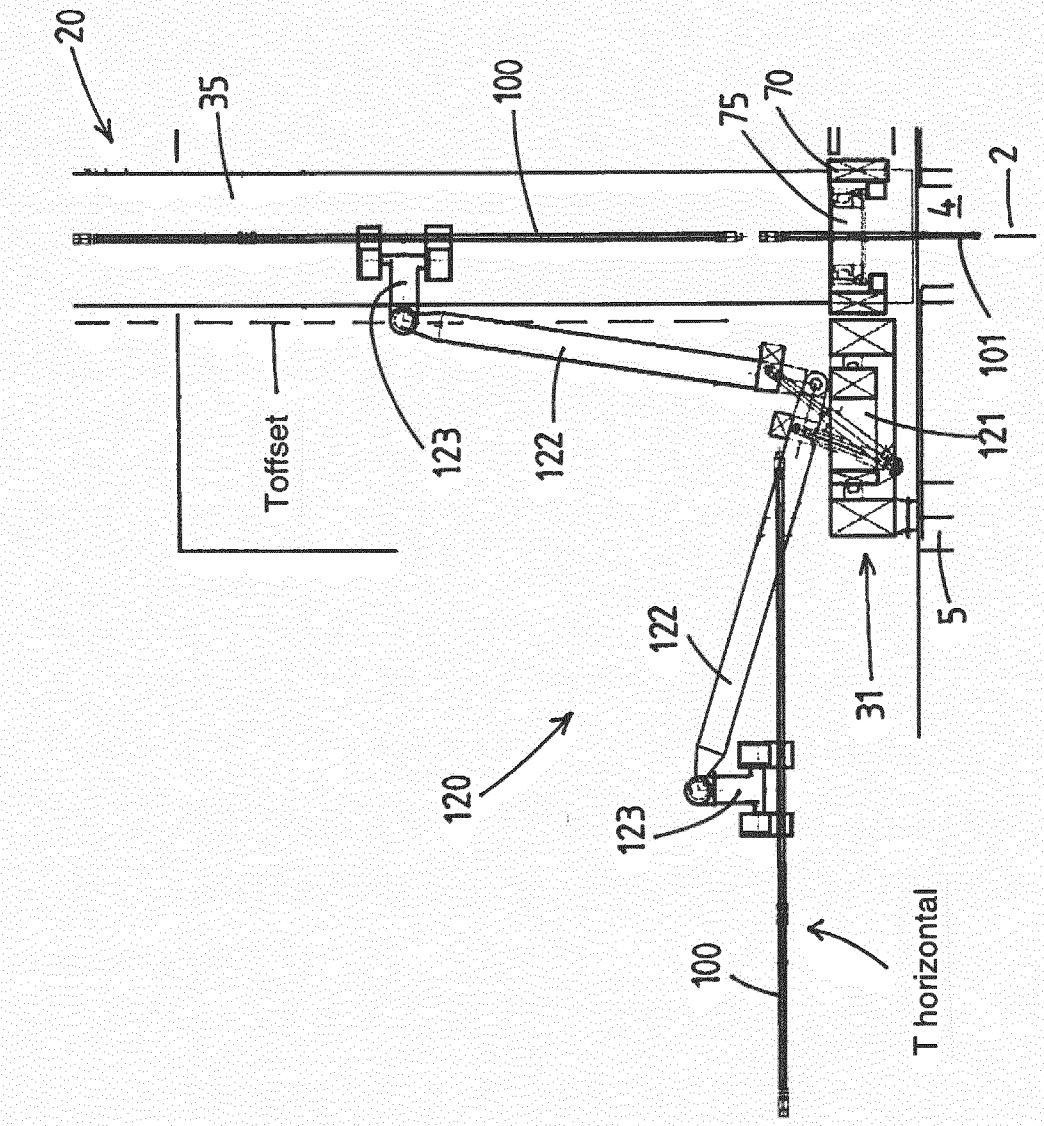

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Fig.8b

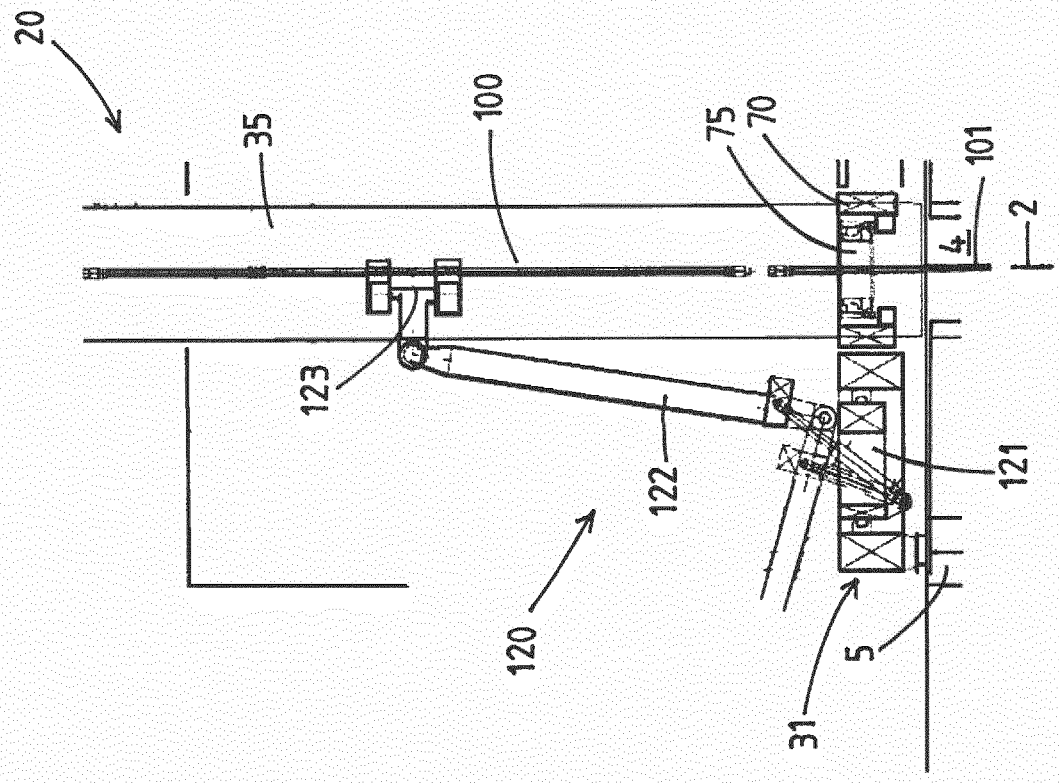

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Fig.8a

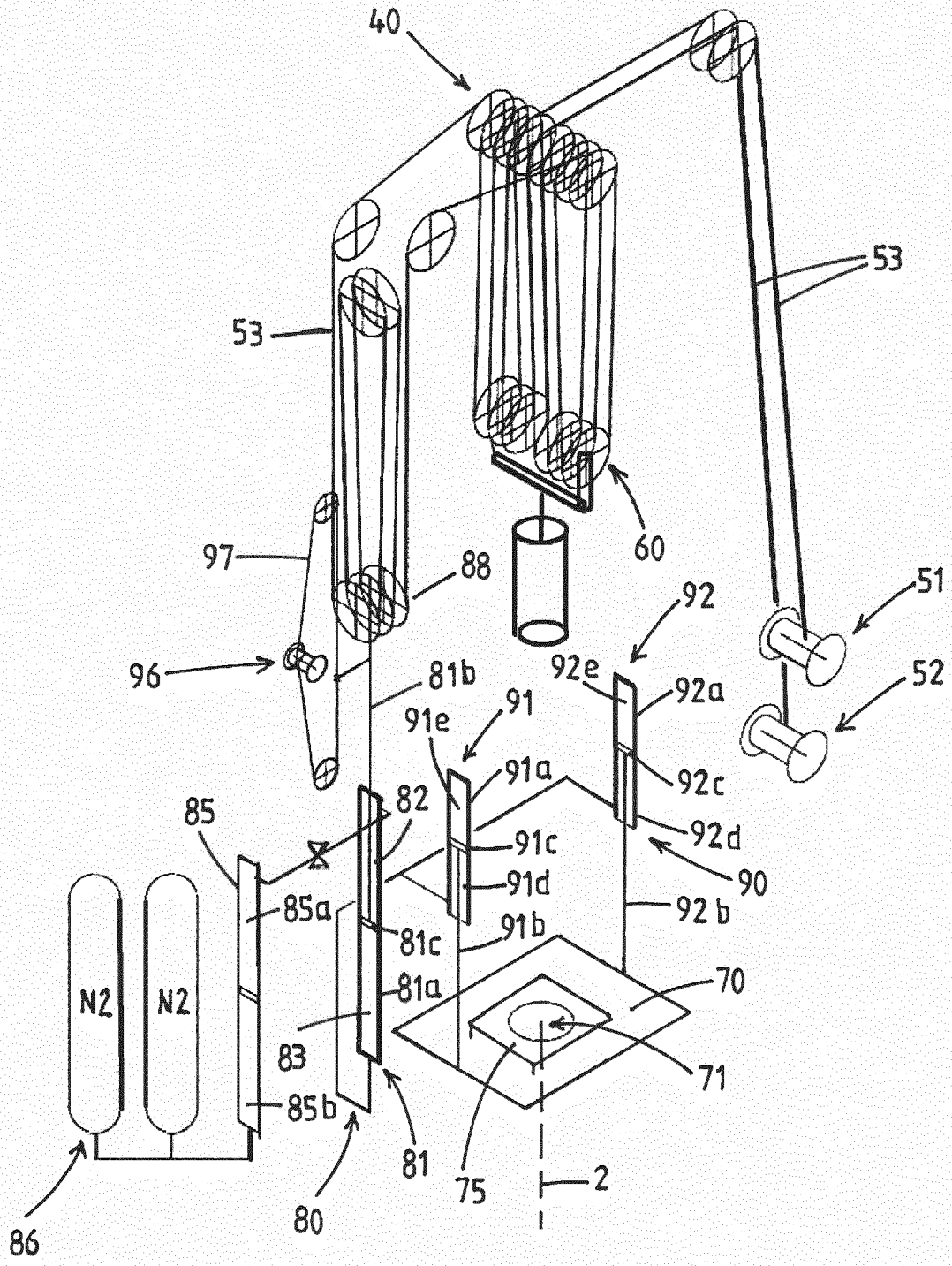

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Fig.9

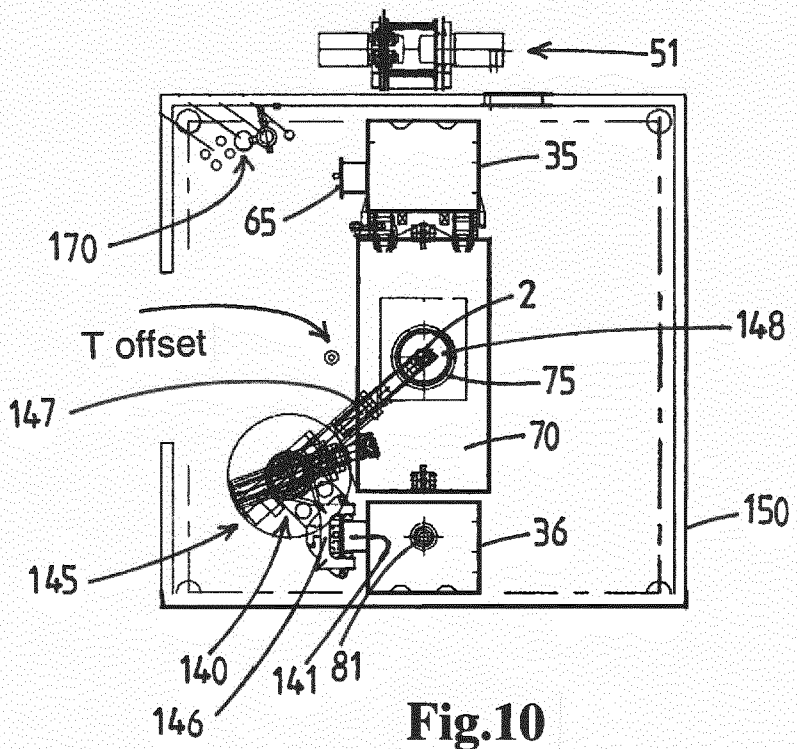

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Fig.10

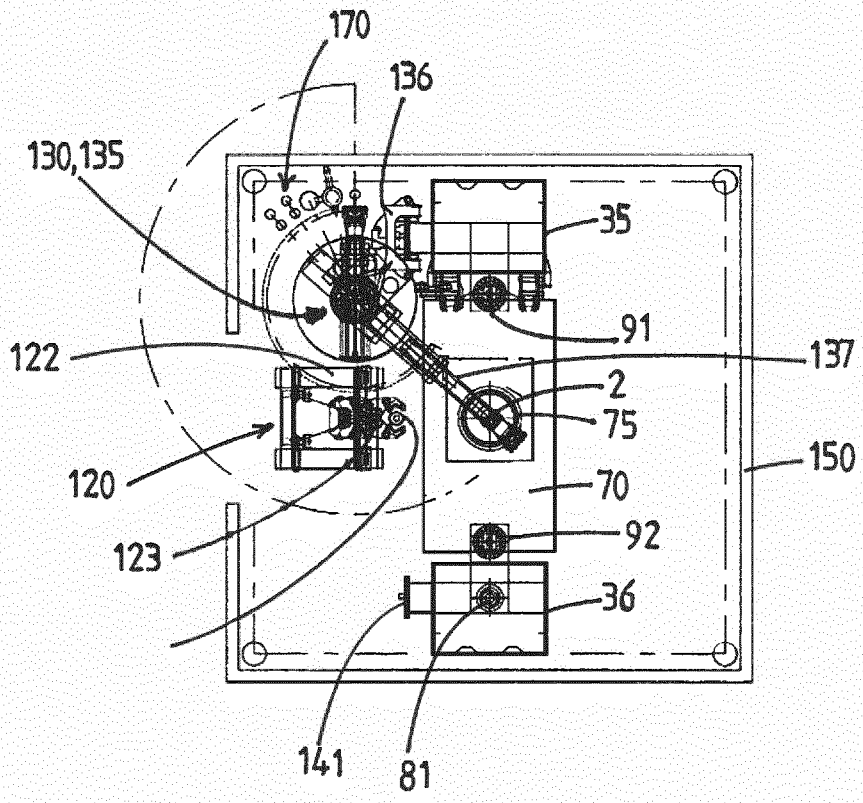

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Fig.11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/065702

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B35/44 B63B83/00 E21B15/02 E21B19/09 E21B7/128
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B B63J E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2016/062812 A1 (ITREC BV [NL]) 28 April 2016 (2016-04-28) cited in the application figures 1-10 page 16, lines 24-25 page 22, lines 20-22	21-23 1-20
Y	US 2017/152716 A1 (ROODENBURG JOOP [NL] ET AL) 1 June 2017 (2017-06-01) figures 1-17 paragraph [0105]	1-20
Y	US 6 000 480 A (EIK GEIR [NO]) 14 December 1999 (1999-12-14) figures 1-4B, 8	10-16
A	CN 105 507 827 A (BAOJI OILFIELD MACHINERY CO) 20 April 2016 (2016-04-20) figure 1	1-23

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 July 2020	29/07/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Freire Gomez, Jon

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/065702

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