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**(54) PLUG AND ABANDONMENT OF ONE OR MORE OFFSHORE PLATFORM WELLBORES OF AN OFFSHORE PLATFORM USING A MARINE JACK-UP TYPE VESSEL**

VERSCHLIESSEN UND AUFLASSEN EINES ODER MEHRERER BOHRLÖCHER EINER OFFSHORE-PLATTFORM UNTER VERWENDUNG EINES HUBSCHIFFS

OBTURATION ET ABANDON D'UN OU DE PLUSIEURS Puits DE FORAGE À PLATEFORME EN MER D'UNE PLATE-FORME EN MER À L'AIDE D'UN NAVIRE MARIN À VÉRIN

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(56) References cited:  
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**US-A- 4 269 542**

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## Description

**[0001]** The present invention relates to the field of decommissioning of offshore platforms and the associated subsea wellbores. Generally such decommissioning is required at the end of life of a subsea hydrocarbon field. International and national legislation exist that mandates decommissioning. For example some legislation demands a full removal of platforms in less than 100 meters water depth, whereas in deeper water a part of the jacket may remain on the seabed. The decommissioning further often involves the (partial) removal of flowlines, mattresses, piling, etc.

**[0002]** By some estimates around 7000 of such platforms exist, with a majority thereof in rather shallow water on the continental shelf, for example in the North Sea. The decommissioning also involves the plug and abandonment (P&A) of the subsea wells associated with the platform. Sometimes P&A is done (many) years before the removal of the platform, sometimes it is done just prior to said removal. Even when done years before the removal of the platform it may sometimes be required to perform some additional P&A work to achieve permanent plugging of the wells.

**[0003]** WO2012/144952 discloses a marine jack-up vessel for decommissioning an offshore platform. Parts of the topside, referred to as superstructure, are moved to the jack-up or a supply vessel. This is carried out by the crane at the cantilever. In the process of 'top sides removal' scraped parts that are placed in containers and moved to the deck using the crane. The containers are ultimately transported to supply ships for disposal using pedestal cranes.

**[0004]** The marine jack-up vessel of WO2017/142938 is provided with a cantilever comprising a crane. During well plugging and platform deconstruction operations the cantilever is extended from the marine jack-up vessel to allow the crane, which is on top of the cantilever, to move components of the offshore platform to a transport vessel or to the deck of the marine jack-up vessel depending on the deck load capacity.

**[0005]** The present invention aims to propose measures that allow for a more efficient and economical decommissioning of offshore platforms.

**[0006]** The invention proposes a method for permanent plug and abandonment according to claim 1.

**[0007]** Preferred embodiments of the invention are defined by claims 2 to 5.

**[0008]** Compared to present day approaches this method obviates the need to use a separate dedicated heavy lift crane vessel to lift the topsides from the jacket and to transport the topside to a remote location, e.g. to a shore based disposal site or an offshore location where the topsides is transferred onto another vessel for transport to an onshore disposal site.

**[0009]** It is noted that the advantage of the invention is not merely that a heavy lift crane vessel is not needed for at least the removal of the topsides, so avoiding costs

incurred by use of such a crane vessel. Also time is saved as even the task of properly anchoring and positioning such a crane vessel near the platform is time consuming as live producing flowlines may be present on the seabed and in view of the often reduced structural integrity of the platform. This activity is now avoided as the jack-up type vessel is used also for the removal of the topsides. It is noted for completeness that between the steps of performing plug and abandonment and lifting the topsides, according to the invention, the marine jack-up type vessel is not displaced or moved.

**[0010]** The inventive approach also avoids the use of a barge to place the topsides thereon once lifted from the jacket as is often done in conjunction with the use of a heavy lift crane vessel in the prior art approach to decommissioning. This avoids any issues related to the potential that such a barge might collide with one or more legs of the jack-up type vessel that is still in its jacked-up operative position.

**[0011]** It will be appreciated that the applicability of the method of the invention is limited by the hoisting capacity of the one or more cranes of the marine jack-up type vessel that are capable or configured, in view of location onboard the vessel and hoisting capabilities, to serve in the process of lifting and handling the topsides.

**[0012]** In a preferred embodiment each crane of the vessel is capable, in view of location onboard the vessel and hoisting capabilities, to serve in the process of lifting and handling the topsides. For example, a crane has a lifting capacity of at least 600 tonnes (600.000 kg) at a reach or radius of 20 meters from the slew axis, e.g. a capacity of about 1000 tonnes (1.000.000 kg) at said reach or radius of 20 meters from the slew axis.

**[0013]** In a preferred embodiment the vessel has, at the cantilever deployment side of the hull, two cranes capable or configured, in view of location onboard the vessel and hoisting capabilities, to serve in the process of lifting and handling the topsides, preferably two the same cranes.

**[0014]** Advantageously, said one or more cranes has a reach beyond said cantilever deployment side and over a portion of said main deck.

**[0015]** In a preferred embodiment each crane of the vessel involved in the lifting and handling of the topsides is a leg encircling crane having a slew bearing extending about a respective jack-up leg of the vessel. It is conceivable that a topside has a weight of 800 tonnes (800.000 kg), in particular over 1000 tonnes (1.000.000 kg), or possibly even over 1300 tonnes (1.300.000 kg).

**[0016]** In another embodiment each crane of the vessel involved in the lifting and handling of the topsides is fixed to the hull in proximity of a jack-up leg of the vessel, e.g. on a foot that is structurally combined with a housing for the respective elevating unit for the jack-up leg.

**[0017]** The offshore platform comprises a jacket and a topsides. Herein the term jacket not only encompasses the common design of a platform substructure as a structural steel framework, but also other seabed mounted

substructures, like concrete substructures.

**[0018]** It is preferred to lift the entire topsides in a single-lift by means of the one or more cranes of the jack-up type vessel. However, in embodiments, a topsides may be separated into parts that are handled in multiple lifts. The latter is e.g. less preferred in view of costs associated with the separation but may be needed in case the structure of the topsides has become too weak to lift the topsides as a unit.

**[0019]** Generally, the cantilever is movable to a retracted position to allow the lowering of the vessel in order to make the vessel buoyant again.

**[0020]** In an embodiment it is envisaged that the cantilever is not just retracted to allow for the later lifting of the topsides, but the cantilever is moved into a deck clearing position wherein an area of the deck is cleared and the topsides is landed by the one or more cranes on said clear deck area. Innovative embodiments of a marine jack-up type vessel that provide such deck clearing capabilities are discussed herein below as said vessel may also be applicable to other methods and even distinct fields of use, e.g. offshore wellbore drilling activities, e.g. for hydrocarbons but also for CO<sub>2</sub> storage, etc., thermal energy well drilling, offshore wellbore intervention and/or workover activities to be performed on existing wellbores, or even offshore wind farm installation and/or maintenance activities, etc..

**[0021]** In an embodiment the cantilever motion assembly is not only adapted to move the cantilever relative to the hull between a retracted position and extended positions wherein the operational end of the cantilever structure extends beyond one of said sides of the hull, but also to move the cantilever into said deck clearing position so that sufficient area of the deck is cleared to receive at least the topsides thereon. So, in an embodiment the method of the invention comprises the step of operating the cantilever motion assembly to move the cantilever into said deck clearing position.

**[0022]** In an alternative embodiment, it is envisaged that the one or more cranes of the vessel are employed to lift the cantilever, e.g. once returned into the retracted position, and move said cantilever into the deck clearing position to clear sufficient deck space for the topsides.

**[0023]** In yet another embodiment it is envisaged that the cantilever is used as support of the removed topsides and that the topsides is placed by means of the one or more cranes of the vessel onto the cantilever, preferably said cantilever then being in its retracted position when the topsides is placed thereon.

**[0024]** As explained decommissioning generally also requires the removal of the jacket on which the topsides is supported, e.g. as a whole, in parts, or just an upper part with a lower part remaining on the seabed. In embodiments it is envisaged that the one or more cranes of the jack-up type vessel are also employed for the, at least partial, removal of the jacket. For example the one or more cranes involved in the lifting of the jacket have a maximum operative height in said lifting process of the

crane hook above the design waterline of the buoyant hull that exceeds 55 meters, preferably exceeds 75 meters, e.g. between 75 and 110 meters.

**[0025]** In an embodiment it is envisaged that the lifted jacket or part thereof is also placed onboard the vessel, e.g. on the main deck. In another embodiment the jacket or part thereof remains suspended from the one or more cranes as the vessel is sailed away from the site of the decommissioned platform. Or a barge or other transport vessel is brought into, onto which the jacket or part thereof is transferred, preferably said transfer taking place once the jack-up vessel has been lowered so as to become buoyant again, thereby avoiding issues related to the potential of collision between the barge and the legs.

**[0026]** In embodiments, as known in the art, the method may comprise - after removal of the topsides, the step of lowering an internal cutting tool into a leg of the jacket and operating said cutting tool to cut the leg, e.g. the steel leg, preferably in proximity of the seabed, possibly some distance below the seabed. The lowering of such a tool may for example be done using one of the cranes of the vessel.

**[0027]** In embodiments, as known in the art, one or more buoyancy modules are connected to the jacket or part thereof, e.g. the modules having clamps that secure the module onto a leg of the platform, prior to lifting by means of the one or more cranes of the vessel, e.g. to reduce the load on the cranes and so expand the capability of the vessel to deal with heavier jackets.

**[0028]** In an embodiment it is envisaged that the jacket is lifted by the one or more cranes of the vessel and then disposed of on the seabed, e.g. tilted horizontally, at the same or another site to serve as the basis for an artificial reef. The latter approach may e.g. be envisaged for sites in the Gulf of Mexico.

**[0029]** A marine jack-up type vessel that is envisaged as beneficial for use in the method of the invention may also be of benefit for other applications, other methods and even distinct fields of use, e.g. offshore wellbore drilling activities, e.g. for hydrocarbons but also for CO<sub>2</sub> storage, etc., thermal energy well drilling, offshore wellbore intervention and/or workover activities to be performed on existing wellbores, or even offshore wind farm installation and/or maintenance activities, etc..

**[0030]** Such a more versatile marine jack-up type vessel, e.g. allowing a more efficient and economical decommissioning of offshore platforms, comprises:

- a buoyant hull with a main deck, said hull having sides,
- at least three jack-up legs,
- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level,
- a cantilever having a cantilever structure with an op-

erational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longitudinally opposite the operational end, wherein the cantilever is movably mounted on the main deck of the hull,

- a cantilever motion assembly adapted to move the cantilever relative to the hull at least in longitudinal direction thereof between a retracted position and extended positions wherein the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull,
- a crane fixed to the hull and having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis.

**[0031]** In embodiments, the cantilever motion assembly and/or the crane is adapted to move the cantilever into a deck clearing position wherein a deck area of the main deck is cleared to form a clear deck area.

**[0032]** In embodiments, the clear deck area of the main deck is present between said cantilever and the cantilever deployment side, and measures at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction. Advantageously, the clear deck area measures at least 25x25 meters. The clear deck area e.g. allows for placing a topsides on said clear deck area according to the method of the invention, using said crane.

**[0033]** The cantilever motion assembly is adapted to move the cantilever relative to the hull at least in longitudinal direction thereof. Embodiments are conceivable wherein the cantilever is adapted to move also in a transverse direction, e.g. as disclosed in US6729804 of the same applicant, or wherein the cantilever is rotatable, e.g. as disclosed in US2004151549, or alternatively as disclosed in EP2823105 of the same applicant.

**[0034]** The crane advantageously has a reach beyond said cantilever deployment side and over a portion of said main deck, in particular over the clear deck area between the cantilever and the cantilever deployment side.

**[0035]** In embodiments, the cantilever motion assembly comprises one or more rails mounted on said main deck, e.g. in a axial direction of the hull perpendicular to the second axial side. Said one or more rails extend towards or to a side of the hull opposite the cantilever deployment side, so as to allow for the cantilever motion assembly to move the cantilever relative to the vessel at least in said longitudinal direction thereof, between extended positions wherein the operational end of the cantilever structure extends beyond the cantilever deployment side of the hull, and a retracted position.

**[0036]** Advantageously, said operational end of the cantilever structure is positioned above the hull, before the sides of the hull and the entire cantilever is within the contour of the hull. For example, the cantilever being with-

in a contour delimited by said jack-up legs.

**[0037]** Possibly, the cantilever in said deck clearing position is positioned further towards a side of the hull than said retracted position. E.g. a clear deck area of the main deck is present between said cantilever and the cantilever deployment side, for example a clear deck area of at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction, e.g. to allow for placing a topsides on said clear deck area according to the method of the invention, using said crane.

**[0038]** In embodiments, the vessel has an axially extending docking space, e.g. an open ended axially extending docking space, that is present between a first superstructure, e.g. accommodation superstructure, of the vessel at the first lateral side of the vessel, proximate a first axial end, and a second superstructure, e.g. accommodation superstructure, of the vessel at the second lateral side of the vessel, proximate said first axial end, allowing to receive therein at least a part of the cantilever when in said deck clearing position thereof. It is conceivable that a third superstructure extends above the docking space, bridging the first and second superstructure. This third superstructure e.g. comprises a helicopter landing space.

**[0039]** In embodiments the inner end of the cantilever structure is forked, formed by transversely spaced first and second cantilever inner end extension parts. Possibly, said first and second cantilever inner end extension parts are mobile relative to the cantilever structure when in said deck clearing position thereof, e.g. foldable about a vertical axis, or removable from the cantilever structure so as to reduce the length of the cantilever, allowing to move the cantilever further away from the cantilever deployment side than in said retracted position and into said deck clearing position.

**[0040]** In embodiments, the cantilever structure has a reducible length with a reduced length when in said deck clearing position thereof, so as to reduce the length of the cantilever, allowing to move the cantilever further away from the cantilever deployment side than in said retracted position and into said deck clearing position. Examples of how the length of the cantilever structure can be reduced is by providing foldable or removable parts of the cantilever structure, or by providing a telescopic structure of the cantilever.

**[0041]** In embodiments, the cantilever motion assembly and/or the crane is adapted to move the cantilever into a deck clearing position wherein a clear deck area of the main deck is present between said cantilever and the cantilever deployment side of at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction, e.g. to allow for placing a topsides on said clear deck area according to the method of any of claims 1 - 6 using said crane.

**[0042]** Such a marine jack-up type vessel allows wellbore activities wherein use is made of the cantilever in

the extended position. In addition, the vessel provides a clear deck area of at least 20x10 metres in the deck clearing position of the cantilever. This clear deck area can e.g. be used for placing a topsides, but other purposes are also conceivable.

**[0043]** In embodiments, use is made of a marine jack-up type vessel comprising

- a buoyant hull with a main deck, wherein the hull has an axial direction and first and second axial sides, and wherein the hull has a lateral direction and first and second lateral sides,
- a first pair of jack-up legs which are spaced apart in said transverse direction from one another,
- a second pair of jack-up legs which are spaced apart in said transverse direction from one another, wherein said first and second pairs are spaced from one another in said axial direction, the first pair of jack-up legs being closest to the first axial side of the hull and the second pair of jack-up legs being closest to the second axial side of the hull,
- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is essentially above water level,
- a cantilever having a cantilever structure with an operational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longitudinally opposite the operational end, wherein the cantilever is movably mounted on the main deck of the hull,
- a cantilever motion assembly adapted to move the cantilever relative to the hull at least in longitudinal direction thereof between a retracted position and extended positions wherein the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull, wherein the cantilever deployment side is the second axial side;
- a crane fixed to the hull and having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

wherein the cantilever motion assembly and/or the crane is adapted to move the cantilever into a deck clearing position wherein a deck area of the main deck is cleared and wherein:

- the inner end of the cantilever structure extends beyond said first axial side of the hull of the vessel, and/or
- the operational end of the cantilever structure is arranged between the legs of the first pair of jack-up legs and the rest of the cantilever extends towards and possibly beyond the first axial side of the hull, and/or
- the centre of gravity of the cantilever is arranged, in side view, between the first pair of jack-up legs and the first axial side of the hull or beyond the first pair of jack-up legs relative to the second pair of jack-up legs; and/or
- at least a part of the cantilever is received in an axially extending docking space, e.g. an open ended axially extending docking space, that is present between a first superstructure, e.g. accommodation superstructure, of the vessel at the first lateral side of the vessel, proximate the first axial end, and a second superstructure, e.g. accommodation superstructure, of the vessel at the second lateral side of the vessel, proximate said first axial end.

**[0044]** Such a marine jack-up type vessel allows wellbore activities wherein use is made of the cantilever in the extended position. In addition, the vessel provides a clear deck area in the deck clearing position of the cantilever. This clear deck area can e.g. be used for placing a topsides, but other purposes are also conceivable.

**[0045]** Such a vessel covers alternative deck clearing positions of the cantilever. In particular, in an operational position, the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull. In the vessel, the cantilever deployment side is the second axial side. Upon retraction in the longitudinal direction thereof the operational end is retracted to a position above deck, no longer extending beyond the deployment side of the hull. In particular, the cantilever is moved into a deck clearing position wherein a deck area of the main deck is cleared.

**[0046]** In embodiments, this is achieved by moving the cantilever to a position wherein the inner end of the cantilever structure extends beyond said first axial side of the hull of the vessel. Hence, from extending beyond the second axial end, the cantilever is allowed to move to a position extending beyond the first axial end. In this position, the inner end of the cantilever structure extends beyond the hull, the operation end is preferably still positioned above the hull.

**[0047]** In addition thereto, or alternatively, this is achieved by moving the cantilever to a position wherein the operational end of the cantilever structure is arranged between the legs of the first pair of jack-up legs, and the rest of the cantilever extends towards and possibly beyond the first axial side of the hull. In this position, the deck area between the first pair of jack-up legs and the second axial side of the hull is cleared. The inner end of the cantilever structure may still be positioned above the

hull, or extend beyond the first axial side of the hull.

**[0048]** In addition thereto, or alternatively, this is achieved by moving the cantilever to a position wherein the centre of gravity of the cantilever is arranged, in side view, beyond the first pair of jack-up legs relative to the second pair of jack-up legs, preferably between the first pair of jack-up legs and the first axial side of the hull or. With the wellbore activities station supported on the operational end of the cantilever structure, the centre of gravity of the cantilever is located relatively close to this operational end. In view of stability of the jack-up type vessel, it is advantageous to position this centre of gravity opposite the second axial side of the hull, e.g. in the vicinity of the first pair of jack-up legs, in particular between the first pair of jack-up legs and the first axial side of the hull or beyond the first pair of jack-up legs relative to the second pair of jack-up legs.

**[0049]** In addition thereto, or alternatively, this is achieved by moving the cantilever to a position wherein at least a part of the cantilever is received in an axially extending docking space. For example, the docking space is an open ended axially extending docking space, that is present between a first superstructure, e.g. accommodation superstructure, of the vessel at the first lateral side of the vessel, proximate the first axial end, and a second superstructure, e.g. accommodation superstructure, of the vessel at the second lateral side of the vessel, proximate said first axial end. It is conceivable that a third superstructure extends above the docking space, bridging the first and second superstructure. This third superstructure e.g. comprises a helicopter landing space.

**[0050]** In embodiments, said crane is a first leg encircling crane comprising:

- a foot fixed to the hull,
- a slew bearing supported on the foot and extending about a jack-up leg of the second pair of jack-up legs of the vessel,
- a slewable crane member which is supported by said slew bearing, and
- a boom pivotally mounted to said slewable crane member about a horizontal boom pivot axis so that the boom is pivotal up and down.

Such leg encircling cranes are well known and commercially available from the applicant.

**[0051]** Advantageously, said vessel further comprises a second leg encircling crane comprising a foot fixed to the hull, a slew bearing supported on the foot and extending about the other jack-up leg of the second pair of jack-up legs of the vessel, a slewable crane member which is supported by said slew bearing, and a boom pivotally mounted to said slewable crane member about a horizontal boom pivot axis so that the boom is pivotal up and down.

**[0052]** In embodiments, the cantilever motion assembly comprises one or more rails mounted on said main

deck, e.g. in a axial direction of the hull perpendicular to the second axial side. Said one or more rails extend towards or to the first axial side of the hull so as to allow for the cantilever motion assembly to move the cantilever relative to the vessel at least in said longitudinal direction between extended positions wherein the operational end of the cantilever structure extends beyond the second axial side of the hull and a retracted position wherein said operational end is before the second axial side of the hull and the entire cantilever is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs. In embodiments, the cantilever in said deck clearing position is positioned further towards the first axial side than said retracted position wherein a clear deck area of the main deck is present between said cantilever and said second axial side, for example a clear deck area of at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction, e.g. to allow for placing a topsides on said clear deck area according to the invention using said crane.

**[0053]** In embodiments, the vessel has an axially extending docking space, e.g. an open ended axially extending docking space, that is present between a first superstructure, e.g. accommodation superstructure, of the vessel at the first lateral side of the vessel, proximate the first axial end, and a second superstructure, e.g. accommodation superstructure, of the vessel at the second lateral side of the vessel, proximate said first axial end, allowing to receive therein at least a part of the cantilever when in said deck clearing position thereof.

**[0054]** In embodiments, use is made of a three jack-up legs marine jack-up type vessel comprising:

- a substantially triangular buoyant hull with a main deck, said hull having a longitudinal axis and having sides,
- a single jack-up leg closest to a first apex of said triangular hull on said longitudinal axis thereof,
- a pair of jack-up legs, each closest to another apex of said triangular hull, which jack-up legs of said pair are spaced apart in a transverse direction from one another that is perpendicular to said longitudinal axis,
- three elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is essentially above water level,
- a cantilever having a cantilever structure with an operational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station

thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longitudinally opposite the operational end, wherein the cantilever is movably mounted on the main deck of the hull,

- a cantilever motion assembly adapted to move the cantilever relative to the hull at least in longitudinal direction thereof, in the direction of said longitudinal axis of the hull, between a retracted position and extended positions wherein the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull, opposite said single jack-up leg closest to said first apex,
- a crane fixed to the hull and having a boom that is slewable about a vertical slew axis and pivotal up and down about a horizontal boom pivot axis,

wherein the cantilever motion assembly and/or the crane is adapted to move the cantilever into a deck clearing position wherein a deck area of the main deck is cleared and wherein:

- a clear deck area of the main deck is present between said cantilever and said cantilever deployment side, for example a clear deck area of at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction, e.g. to allow for placing a topsides on said clear deck area according to the method of any of claims 1 - 6 using said crane, and/or
- the inner end of the cantilever structure is forked, formed by transversely spaced first and second cantilever inner end extension parts, wherein in said deck clearing position said first and second cantilever inner end extension parts are received on transversely opposite locations relative to said single jack-up leg closest to a first apex of said triangular hull on said longitudinal axis thereof, or wherein said first and second cantilever inner end extension parts are mobile relative to the cantilever structure when in said retracted position thereof, e.g. foldable about a vertical axis, or removable from the cantilever structure so as to reduce the length of the cantilever, allowing to move the cantilever further towards said first apex than in said retracted position and into said deck clearing position.

**[0055]** Such a vessel covers alternative deck clearing positions of the cantilever on a three jack-up leg marine jack-up type vessel. In particular, in an operational position, the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull. In embodiments, the cantilever deployment side is the side opposite said single jack-up leg closest to said first apex.

**[0056]** Upon retraction in the longitudinal direction thereof the operational end is retracted to a position

above deck, no longer extending beyond the deployment side of the hull. In particular, the cantilever is moved into a deck clearing position wherein a deck area of the main deck is cleared.

5 **[0057]** In embodiments, a deck area of the main deck is cleared between said cantilever and said cantilever deployment side, for example a clear deck area of at least 20 meters in a direction perpendicular to said cantilever deployment side and at least 10 meters transverse to said direction, e.g. to allow for placing a topsides on said clear deck area according to the method of the invention using said crane.

10 **[0058]** In embodiments, the inner end of the cantilever structure is forked, formed by transversely spaced first and second cantilever inner end extension parts.

15 **[0059]** In such embodiments, clearing of the main deck is possibly achieved by moving the cantilever into a deck clearing position wherein said first and second cantilever inner end extension parts are received on transversely opposite locations relative to said single jack-up leg closest to a first apex of said triangular hull on said longitudinal axis thereof.

20 **[0060]** Possibly, in embodiments, said first and second cantilever inner end extension parts are mobile relative to the cantilever structure when in said retracted position thereof, e.g. foldable about a vertical axis, or removable from the cantilever structure so as to reduce the length of the cantilever.

25 **[0061]** In such embodiments, clearing of the main deck is possibly achieved by allowing to move the cantilever further towards said first apex than in said retracted position and into said deck clearing position.

30 **[0062]** The cantilever system that is used in combination with the invention described herein may be embodied as disclosed in WO2013/133694, e.g. in order to have an envelope for the wellbore activities station that allows to treat a grid of wellbores on an offshore platform, e.g. a two-dimensional grid of wellbores as is known in the art.

35 **[0063]** Alternative designs of the cantilever system and associated rail layout on the deck of the vessel are also envisaged, e.g. including an X-Y grid of pairs of rails on the deck to achieve a suitable operational envelope for the wellbore activities.

40 **[0064]** In some designs the wellbore activities station may be movable relative to the cantilever, e.g. movable transverse relative to the cantilever structure, to achieve a suitable envelope, e.g. the cantilever structure merely being movable in its longitudinal direction relative to the hull.

45 **[0065]** In embodiments, the invention may make use of a marine jack-up type vessel, e.g. as disclosed in WO2013/133694, comprising:

- a buoyant hull with a main deck, said hull having sides including a cantilever deployment side,
- at least three jack-up legs,

- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level,
  - a cantilever system comprising an elongated cantilever structure with a longitudinal axis and with an operational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longitudinally opposite the operational end,
- wherein the cantilever structure has one or more cantilever beams in the longitudinal direction of the cantilever,
- wherein the hull is provided with a first support rail which extends along said cantilever deployment side of the hull,
- wherein one or more travelling and swivelling assemblies are arranged between said first support rail and the one or more cantilever beams, each assembly having a lower member which travels over the first support rail, an upper member over which the one or more cantilever beams travel in their longitudinal direction, and a vertical pivot axis swivel between said lower and upper member of the assembly,
- and wherein the hull is provided with one or more second support rails that extend over the main deck in a direction perpendicular to the first support rail,
- wherein the cantilever system further comprises a cantilever inner end carrier device which travels over and engages on said one or more second support rails,
- wherein cantilever inner end carrier device is connected via a vertical pivot axis swivel to the cantilever structure at or near its inner end to provide a rotation axis at a fixed location relative to the cantilever structure for the rotational motion of the cantilever, the cantilever inner end carrier device holding the cantilever inner end relative to the main deck,
- so that the cantilever is mounted on the main deck so as to be movable in longitudinal direction of the cantilever, in a rotational direction (A,B), and in combinations thereof, allowing to move the cantilever between a retracted position and extended positions wherein the operational end of the cantilever extends over said cantilever deployment side.

**[0066]** In embodiments, the invention makes use of a marine jack-up type vessel, e.g. as disclosed in WO2013/133694, comprising:

- 5 - a buoyant hull with a main deck, said hull having sides including a cantilever deployment side,
- at least three jack-up legs,
- 10 - a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level,
- 15 - a cantilever system comprising an elongated cantilever structure with a longitudinal axis and with an operational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longitudinally opposite the operational end,
- 20 wherein the cantilever structure has one or more cantilever beams in the longitudinal direction of the cantilever,
- 25 wherein the hull is provided with a first support rail which extends along said cantilever deployment side of the hull,
- 30 wherein one or more travelling and swivelling assemblies are arranged between said first support rail and the one or more cantilever beams, each assembly having a lower member which travels over the first support rail, an upper member over which the one or more cantilever beams travel in their longitudinal direction, and a vertical pivot axis swivel between said lower and upper member of the assembly,
- 35 and wherein the hull is provided with one or more second support rails that extend over the main deck in a direction perpendicular to the first support rail,
- 40 wherein the cantilever system further comprises a cantilever inner end carrier device which travels over and engages on said one or more second support rails,
- 45 wherein cantilever inner end carrier device is connected via a vertical pivot axis swivel to the cantilever structure at or near its inner end to provide a rotation axis at a fixed location relative to the cantilever structure for the rotational motion of the cantilever, the cantilever inner end carrier device holding the can-
- 50
- 55

tilever inner end relative to the main deck,

so that the cantilever is mounted on the main deck so as to be movable in longitudinal direction of the cantilever, in a rotational direction (A,B), and in combinations thereof, allowing to move the cantilever between a retracted position and extended positions wherein the operational end of the cantilever extends over said cantilever deployment side,

that is characterized in that the elongated cantilever structure comprises:

- a rigid operational end module that supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said rigid operation end module being provided with said one or more cantilever beams, and
- one more mobile or removable cantilever structure extender members which are configured to extend in an operative state of the cantilever system longitudinally from the rigid operational end module towards the cantilever inner end carrier device that is connected to said one or more mobile or removable cantilever structure extender members at a location longitudinally spaced from the rigid operational end module in said operative state of the cantilever system,

and wherein:

- a) said one or more cantilever structure extender members are configured to be removed from the rigid operational end module in a non-operative, e.g. main deck clearing, state of the cantilever system, or
- b) said one or more cantilever structure extender members are configured to be moved into a storage position relative to the rigid operational end module, e.g. said one or more cantilever structure extender members being telescopic and/or foldable relative to the rigid operational end module.

**[0067]** Optionally the cantilever inner end carrier device is disconnectable from said one or more cantilever structure extender members for the purpose of said removal or motion into said storage position of said one or more cantilever structure extender members.

**[0068]** In embodiment, use is made of a cantilever system comprising an elongated cantilever structure with a longitudinal axis and with an operational end, wherein said operational end supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end longi-

tudinally opposite the operational end,

wherein the cantilever system further comprises a cantilever inner end carrier device which travels over and engages on one or more support rails,

wherein, preferably, the cantilever inner end carrier device is connected via a vertical pivot axis swivel to the cantilever structure at or near its inner end to provide a rotation axis at a fixed location relative to the cantilever structure for the rotational motion of the cantilever, the cantilever inner end carrier device holding the cantilever inner end relative to the deck,

wherein the elongated cantilever structure comprises:

- a rigid operational end module that supports a wellbore activities station, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said rigid operation end module being provided with said one or more cantilever beams, and
- one more mobile or removable cantilever structure extender members which are configured to extend in an operative state of the cantilever system longitudinally from the rigid operational end module towards the cantilever inner end carrier device that is connected to said one or more mobile or removable cantilever structure extender members at a location longitudinally spaced from the rigid operational end module in said operative state of the cantilever system.

**[0069]** The cantilever system may have a rigid operational end module which has opposed lateral side walls, and the cantilever structure preferably comprises two folding cantilever structure extender members, that are each hinged about a vertical axis relative to an inner end of a respective lateral side wall of the rigid operational end module so as to each be pivotal between a longitudinally extended position wherein each folding cantilever structure extender member extends generally in line with the respective side wall of the rigid operational end module, and a folded position wherein each folding cantilever structure extender member generally is located alongside the respective side wall of the rigid operational end module,

and wherein said cantilever inner end carrier device is disconnectable from said cantilever structure extender members for the purpose of said folding into said storage position of said cantilever structure extender members.

**[0070]** The invention is further elucidated in relation to the drawings, in which:

Fig. 1 represents a side view of a marine jack-up type vessel, adjacent an offshore platform;

Figs. 2a and 2b show the marine jack-up type vessel of fig. 1 in a top view in distinct operations situations; Fig. 3a represents a side view of a marine jack-up type vessel adjacent an offshore platform similar to fig. 1, in a distinct operational situation; Fig. 3b represents a detail of the offshore platform of fig. 3a in side view; Fig. 3c represents the detail of the offshore platform of fig. 3b in a top view; Figs. 4a and 4b represent a side view and top view respectively of a marine jack-up type vessel with a topsides on board the vessel; Fig. 5 represents a side view of a marine jack-up type vessel adjacent an offshore platform similar to fig. 1, in a distinct operational situation; Figs. 6a and 6b show a different type of offshore platform in a side view and top view respectively; Fig. 7 shows in plain view and schematically marine jack-up type vessel and associated cantilever, with a part of the cantilever structure stored in a docking space between two superstructures of the vessel, Figs. 8a,b show in plain view and in side schematically the cantilever structure with module, folding members, and carrier in the state of storage of the cantilever structure, Fig. 9 shows the cantilever having been moved towards the cantilever deployment side of the hull, Fig. 10 illustrates the unfolding of the folding members to obtain the full operational length of the cantilever, Fig. 11a,b,c shows the deployed cantilever system in side view, in top view, and the unfolding of the folding members of the cantilever structure respectively, in schematic form, Fig. 12 illustrates the functionality of the exemplary cantilever system, Fig. 13 shows the marine jack-up type vessel and associated cantilever of figure 7, Fig. 14a shows in plain view the cantilever of figure 13 in retracted position, Fig. 14b shows in side view the cantilever of figure 13 in retracted position, Fig. 15 shows in plain view the cantilever of figure 13 having been moved towards the cantilever deployment side of the hull, Fig. 16 shows in side view the cantilever of figure 13 deployed over the side of the hull, Fig. 17 illustrates the functionality of the exemplary cantilever system of figure 13.

**[0071]** In fig. 1 a marine jack-up type vessel 1 is shown, suitable for performing the method according to the invention.

**[0072]** The vessel 1 is shown has been arranged adjacent an offshore platform 50, comprising a topsides 51 and a jacket 52. The offshore platform is provide above one or more offshore platform wellbores 55, provided at the bottom of the sea B. The water level W of the sea is

also indicated, as well as the waterline WW of the buoyant hull of the vessel, when the vessel is afloat.

**[0073]** In figs. 2a and 2b the marine jack-up type vessel 1 in shown in a top view.

5 **[0074]** The marine jack-up type vessel 1 comprises a buoyant hull 2 with a main deck 3, said hull having sides. In the shown embodiment the buoyant hull 2 has an axial direction A and a first axial side 2a, and a second axial side 2b. The hull 2 has a lateral direction L, and a first lateral side 2c and a second lateral side 2d.

10 **[0075]** The vessel has at least three jack-up legs. In the shown embodiment, the vessel 1 comprises a first pair of jack-up legs 4a, 4b which are spaced apart in said transverse direction from one another. A second pair of jack-up legs 4c, 4d are also spaced apart in said transverse direction from one another. Said first and second pairs are spaced from one another in said axial direction A. The first pair of jack-up legs 4a, 4b being closest to the first axial side 2a of the hull 2 and the second pair of jack-up legs 4c, 4d being closest to the second axial side 2b of the hull 2.

20 **[0076]** The vessel further comprises a plurality of elevating units, not shown in detail, each associated with a respective jack-up leg, adapted to move the respective jack-up leg 4a, 4b, 4c, 4d vertically relative to the hull 2 and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level.

25 **[0077]** In the situation of fig. 1 the elevating units have been operated and brought the vessel 1 in an operational position wherein the vessel is not afloat but wherein the jack-up legs 4a, 4b, 4c, 4d engage the seabed B. In the shown embodiment, the feet of the jack-up legs are partly buried in the bottom of the sea B. The hull 2 is above water level W at a height such that a cantilever 10 is movable in an extended position above the topsides 51 of the offshore platform 50.

30 **[0078]** The vessel further comprises a cantilever 10 having a cantilever structure 11 with an operational end 11a, wherein said operational end supports a wellbore activities station 12, e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure 11 having an inner end 11b longitudinally opposite the operational end 11a, wherein the cantilever is movably mounted on the main deck 3 of the hull.

35 **[0079]** A cantilever motion assembly 13 is provided and adapted to move the cantilever relative to the hull 3 at least in longitudinal direction CL thereof between a retracted position and extended positions wherein the operational end 11a of the cantilever extends beyond a cantilever deployment side of said sides of the hull. In the vessel of fig. 1, the cantilever deployment side of the hull is the second axial side 2b.

40 **[0080]** In fig. 1, the cantilever motion assembly has moved the cantilever 10 into an extended position wherein the operational end 11a of the cantilever extends beyond the cantilever deployment side 2, and above the

topsides 51. The wellbore activities station 12 is aligned with a wellbore 55 of the offshore platform 50.

**[0081]** This configuration of fig. 1 allows the performance of wellbore activities such as drilling and plug and abandonment operations, involving the use of the wellbore activities station.

**[0082]** In fig. 2a, the cantilever 10 is shown in a retracted position. In the shown position, the operational end 11a of the cantilever no longer extends beyond the hull of the vessel.

**[0083]** Here, the cantilever motion assembly comprises two parallel rails 13, mounted on the main deck 3 allowing movement of the cantilever 10. The rails 13 are mounted in an axial direction A of the hull, perpendicular to the second axial side 2b, and extend in the longitudinal direction CL of the cantilever.

**[0084]** Said one or more rails 13 extend towards or to the first axial side 2a of the hull so as to allow for the cantilever motion assembly to move the cantilever 10 relative to the vessel at least in said longitudinal direction CL between extended positions wherein the operational end 11a of the cantilever extends beyond the second axial side 2b of the hull, a retracted position wherein said operational end 11a is before the second axial side of the hull 2b and the entire cantilever 10 is within the contour of the hull, e.g. the cantilever being within a contour delimited by said jack-up legs.

**[0085]** In addition, also a rail 14 is mounted on said main deck 3 in the lateral direction L of the hull, parallel to and adjacent the second axial side, allowing a lateral movement of the cantilever between multiple extended positions.

**[0086]** Two cranes 20, 21 are fixed to the hull and having a boom 20b, 21b that is slewable about a vertical slew axis 20s, 21s and pivotal up and down about a horizontal boom pivot axis 20h, 21h.

**[0087]** In particular, crane 20 is a first leg encircling crane comprising a foot 20f fixed to the hull, a slew bearing supported on the foot and extending about a jack-up leg 4c of the second pair of jack-up legs of the vessel, a slewable crane member 20sb which is supported by said slew bearing, a boom 20b pivotally mounted to said slewable crane member 20sb about a horizontal boom pivot axis 20h so that the boom is pivotal up and down. The slewable crane member 20sb comprises a protruding superstructure 20c.

**[0088]** Analogously, crane 21 is a second leg encircling crane comprising a foot fixed to the hull, a slew bearing supported on the foot and extending about the other jack-up leg 4d of the second pair of jack-up legs of the vessel, a slewable crane member which is supported by said slew bearing, a boom 21b pivotally mounted to said slewable crane member about a horizontal boom pivot axis 21h so that the boom is pivotal up and down.

**[0089]** In fig. 2b, and in fig. 3a, the cantilever 10 has moved into a deck clearing position wherein a deck area of the main deck is cleared to form a clear deck area 3C between said cantilever 10 and said second axial side 2b.

**[0090]** Fig. 3a is a side view of the operational situation of fig. 2b, with the cantilever 10 in the deck clearing position.

**[0091]** Advantageously the clear deck area 3C measures at least 20 meters in a direction perpendicular to said cantilever deployment side 2b, here the axial direction A of the vessel, and at least 10 meters transverse to said direction, here the longitudinal direction L of the vessel, e.g. to allow for placing a topsides on said clear deck area according to the method of the invention using said cranes 20, 21.

**[0092]** In particular, in the shown configuration, the inner end 11b of the cantilever structure extends to, but not yet beyond said first axial side 2a of the hull of the vessel. It is also conceivable that the inner end 11b does extend beyond this first axial side 2a.

**[0093]** In the shown configuration, the operational end 11a of the cantilever structure 11 is arranged between the legs of the first pair of jack-up legs 4a, 4b, and the rest of the cantilever extends towards the first axial side 2a of the hull.

**[0094]** Furthermore, the centre of gravity G of the cantilever is arranged, in side view, between or beyond the first pair of jack-up legs 4a, 4b (shown is beyond). Preferably, the centre of gravity G of the cantilever is arranged, in side view, beyond the first pair of jack-up legs 4a, 4b, relative to the second pair of jack-up legs 4c, 4d, preferably between the first pair of jack-up legs 4a, 4b and the first axial side 2a of the hull.

**[0095]** In the shown embodiment, in the deck clearing position, at least a part of the cantilever 10 is received in an axially extending docking space 15, shown in fig. 1. The axially extending docking space 15 is e.g. an open ended axially extending docking space, that is present between a first superstructure 16a, e.g. accommodation superstructure, of the vessel at the first lateral side 2c of the vessel, proximate the first axial end 2a, and a second superstructure 16b, e.g. accommodation superstructure, of the vessel at a second lateral side 2d of the vessel, proximate said first axial end 2a. Here, a third superstructure 16c extends above the docking space 15, bridging the first and second superstructure 16a, 16b. This third superstructure e.g. comprises a helicopter landing space 16d.

**[0096]** In the operational situation shown in fig. 3a the topsides 51 has been disconnected from the jacket 52, and the topsides 51 is being lifted from the jacket 52 by means of the cranes 20, 21 of the vessel. Advantageously, an entire topsides 51 is lifted in a single-lift by means of the cranes 20, 21 of the jack-up type vessel.

**[0097]** In the detailed view of fig. 3b, it is indicated in striped lines LL how close the jack-up vessel 1 can be positioned adjacent the offshore platform 50. This allows both wellbore operations involving the use of the wellbore activities station 12 on the cantilever 10, as well as lifting operations of the cranes 20, 21. In fig. 3c, the detail of the offshore platform 50 is shown in a top view.

**[0098]** In figs. 6a and 6b, a different type of offshore

platform 150 is shown in a side view and top view respectively. Here also striped lines LL indicate how close the jack-up vessel 1 can be positioned adjacent the offshore platform 150, both for wellbore operations and for lifting operations, e.g. involving the removal of the topsides.

**[0099]** In fig. 3a, the lifting of the topsides 51 by means of the cranes 20, 21 of the vessel is shown.

**[0100]** In figs. 4a and 4b, a side view and top view respectively of a marine jack-up type vessel 1 is shown with the topsides 51 placed on board the vessel by means of said crane 20, 21. Here, the topsides 51 is positioned on the clear deck area 3C created by a retracted cantilever, here in the deck clearing position of the cantilever 10. In particular is the topsides 51 positioned above the rails 13 of the cantilever motion assembly. It is also conceivable and within the scope of the invention that the topsides is positioned on board the vessel at any available deck area, e.g. on top of a (part of the) cantilever.

**[0101]** The situation of figs. 4a and 4b is possibly followed by operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward. With the vessel 1 afloat, the topsides 51 can be brought to any desired location.

**[0102]** It is also conceivable that the situation of figs. 4a and 4b is followed by lifting the jacket 52, as shown in fig. 5. Advantageously, the one or more cranes 20, 21 of the jack-up type vessel are also employed for the, at least partial, removal of the jacket 52. Possibly this jacket 52 is also positioned on board the vessel 1, or alternatively on board another vessel or barge.

**[0103]** With reference to figures 7 - 12 an example of a cantilever system will be discussed. This system is beneficial in combination with any aspect of the disclosure.

**[0104]** The cantilever system may be readily combined with any marine jack-up type vessel comprising:

- a buoyant hull with a main deck, said hull having sides including a cantilever deployment side,
- at least three jack-up legs,
- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level.

**[0105]** The cantilever could also be mounted on the main deck of some other vessel, e.g. a floating vessel, e.g. a semi-submersible vessel, a monohull vessel lacking jack-up capability, etc.

**[0106]** By way of example the inventive cantilever system is here shown in combination with a four legged marine jack-up vessel, but the system may for example also be combined with a three legs jack-up vessel.

**[0107]** Figure 7 and figure 13 show in plan view the

vessel 500 having a buoyant hull 501 with a main deck 502. The hull 501 has a first axial side 503, a second axial side, also called cantilever deployment side 504, and lateral sides 505, 506.

**[0108]** The vessel 500 has a first pair of jack-up legs 510, 511 closest to the first axial side 503, with the legs 510, 511 being spaced in transverse direction of the hull.

**[0109]** The vessel 500 has a second pair of jack-up legs 512, 513 closest to the cantilever deployment side 504, the legs 512, 513 also be spaced in transverse direction of the hull.

**[0110]** Preferably, not shown here, a leg encircling crane is provide around one or each of the jack-up legs 512, 513 near the deployment side 504 of the hull, e.g. in view of the lifting and handling of a topsides as discussed herein.

**[0111]** Optionally the vessel 500 may be a six legged vessel, with an intermediate or third pair of jack-up legs located centrally between the first and second pairs of legs. However a four legged vessel 500 is preferred in view of costs, handling, etc.

**[0112]** Not depicted here but common in the art, is the presence of elevating units, e.g. with a rack-and-pinion or a hydraulic stepping mechanism. Each elevating unit is associated with a respective jack-up leg and is adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level. Such elevating units may be housed in respective housings or frames on the main deck and/or recessed in the hull of the vessel.

**[0113]** Depicted here is, as preferred, that the jack-up legs are latticed jack-up legs, here of a triangular cross-section.

**[0114]** The hull 501 has a longitudinal axis, here parallel to the lateral sides 505, 506 of the hull.

**[0115]** As illustrated herein at least a first support rail 520 for a cantilever system extends along the cantilever deployment side 504 of the hull, e.g. over the main deck 502 of the vessel 500.

**[0116]** As illustrated herein, one or more, herein a pair of, second support rails 521, 522 extend over the main deck 502 in a direction perpendicular to the first support rail 520, here in longitudinal direction of the hull.

**[0117]** As can be seen here the second support rails 521, 522 extend, as preferred, from an end thereof proximate the first support rail 520 and/or the cantilever deployment side 504 of the hull, to an end thereof that lies beyond the first pair of jack-up legs 510, 511, e.g. to an end in proximity of the first axial side 503 of the hull.

**[0118]** As can be seen here, the vessel is provided with a first superstructure 530 and a second superstructure 535 at the first lateral side 503 of the vessel, so at the port and starboard corner region of the hull at said side, here between the respective leg of the first pair of legs and said first axial side.

**[0119]** These superstructures 530, 535 may for example be embodied as housing for crew members, work

spaces, bridge, control rooms, storage of tools and supplies, etc.

**[0120]** The superstructures 530, 535 at said first axial side 503 are laterally spaced apart, at least in a region thereof in line with the main deck 502 and over a height to accommodate therein a part of the cantilever of the vessel in a deck clearing position thereof. So the lateral spacing between the superstructures 530, 535 forms an axially extending docking space 540 or garage for a part of the cantilever 600.

**[0121]** It is shown that the one or more second support rails 521, 522 extend into this lateral spacing, or docking space 540, between the superstructures 530, 535.

**[0122]** Figure 7 and figure 13 show schematically that an inventive cantilever system is provided on the vessel 500.

**[0123]** The cantilever system generally has an elongated cantilever structure 600 with a longitudinal axis and with an operational end 601 and an inner end 602 that is longitudinally opposite the operational end, see e.g. figure 11a.

**[0124]** The operational end 601 supports a wellbore activities station 610, here a drilling station with a tower, mast or derrick, and with a draw works, etc. For example the drilling station is embodied with one or more of the features as disclosed in WO2016/204608, herein incorporated by reference. The drilling station 610 may be fixed to the cantilever or be a mobile drilling station that is placed on a deck of the cantilever structure 600.

**[0125]** It is illustrated that the wellbore activities station 610 on the operational end of the cantilever structure has a single firing line 610a that is to be aligned with a wellbore to perform wellbore related activities, e.g. plug and abandonment activities of a platform that is to be decommissioned. In other embodiments there may be two stations, to allow for dual activity operation, so one two wellbores at the same time, or a single station having two firing lines.

**[0126]** The innovative elongated cantilever structure 600 comprises:

- a rigid operational end module 620 that supports the wellbore activities station 610, and
- one more, here two, mobile cantilever structure extender members 630, 635 which are configured to extend in an operative state of the cantilever system longitudinally from the rigid operational end module 620 towards a cantilever inner end carrier device 650 that is connected or connectable to the one or more mobile cantilever structure extender members 630, 635 at a location longitudinally spaced from the rigid operational end module 610 in the operative state of the cantilever system 600.

**[0127]** In more detail figure 7 and figure 13 show the deck clearing position of the cantilever system, wherein the cantilever structure 600 is stored or parked proximate the first axial side 502 of the hull, e.g. in one or more of the positions discussed herein.

**[0128]** In more detail figure 7 and figure 13 show a rigid module 620 having opposed lateral side walls 611, 612, preferably bending load absorbing vertical walls.

**[0129]** A working deck 613 may extend, as here, between these side walls 611, 612, and a head wall may be present to close the rigid module 610 at the operational end.

**[0130]** The rigid module 620 may include floors, rooms, as well as further strengthening walls or members, etc. in order to absorb the loads when the cantilever is deployed over the respective side of the hull and used to perform activities.

**[0131]** At the bottom, preferably at the lower end of each lateral side wall 611, 612, the rigid module 620 is provided with a longitudinally extending cantilever beam 614 (only one visible here).

**[0132]** The lateral side walls 611, 612 of the module 620 do not extend over the whole length of the cantilever structure 600 when in its operative state. To make up the remainder of the required length of the cantilever structure 600 the cantilever structure extender members 630, 635 are provided. Here, as preferred, these members are foldable relative to the module 620.

**[0133]** Here the two folding cantilever structure extender members 630, 635 are each hinged about a respective vertical axis 636, 637 relative to an inner end of a respective lateral side wall 611, 612 of the rigid operational end module 620. This allows for each member 630, 635 to be pivoted between a longitudinally extended position, wherein each folding cantilever structure extender member 630, 635 extends generally in line with the respective side wall 611, 612 of the rigid operational end module 620, and a folded position, wherein each folding cantilever structure extender member 630, 635 generally is located alongside the respective side wall 611, 612 of the rigid operational end module 620.

**[0134]** Figure 7 and figure 13 show the folded position of the members 630, 635.

**[0135]** For the clearing of the main deck 502 as discussed herein, the foldability - or mobility in other form - of these members 630, 635 allows for a significant shortening of the length of the cantilever structure 600 compared to the length thereof when in operative state. For example said reduction in length is at least 30% of the length when in operative state, which allows for a clearing of deck space on the main deck 502 in combination with a relatively short design of the hull 501.

**[0136]** Figure 7 and figure 13 also depict the presence of a cantilever inner end carrier device 650 which travels over and engages the one or more second support rails 520.

**[0137]** In the depicted embodiment it is illustrated that the cantilever system has the main properties of the cantilever system disclosed in WO2013/133694 with the added functionality of shortening the cantilever structure for storage, e.g. in view of optimizing deck clearing, e.g. in view of the described plug and abandonment of wellbores and the decommissioning of offshore platforms.

**[0138]** As schematically shown here the cantilever inner end carrier device 650 is disconnectable from each of the cantilever structure extender members 630, 635 for the purpose of the folding into the storage position of the cantilever structure extender members 630,635.

**[0139]** As shown schematically the cantilever inner end carrier device 650 is connected or connectable via a vertical pivot axis swivel 651 to the cantilever structure 600 at or near its inner end to provide a rotation axis at a fixed location relative to the cantilever structure 600 for the rotational motion of the cantilever, the cantilever inner end carrier device holding the cantilever inner end relative to the deck.

**[0140]** Figures 8a, 8b and figures 14a, 14b show in plain view and in side schematically the cantilever structure with module 620, folding members 630, 635, and carrier 650 in the state of storage of the cantilever structure. Figure 8b and figure 14b, show this cantilever structure being parked in the docking spaced 540, e.g. an overhead part 538 of the superstructure being present bridging the docking space 540. As can be seen the members 630, 635 are folded alongside the lateral side walls of the rigid module 610.

**[0141]** It is also shown that the operational end sticks out of the docking space 540 allowing for the wellbore activities station 620, e.g. the tower of station 610 thereof, to remain erected and on said module in the stored position of the cantilever.

**[0142]** Between the cantilever beams on the module 620 and the second rails 521,522 skid systems can be arranged to support the cantilever structure on the rails 521, 522 and to provide a motion device that allows to move the cantilever structure over the rails. Other arrangement can also be envisaged, e.g. the cantilever structure being supported via wheeled bogies on the rails 521, 522.

**[0143]** In Figure 9 the situation is depicted wherein the cantilever structure 600 has been moved out of the docking space 540 at the first axial side 502 of the hull, by moving the structure 600 over the rails 521, 522 towards the other end of said rails. Here ends of the cantilever beams 514 of the module 610 may be mated with respective travelling and swivelling assemblies 660 that have remained on the first support rails.

**[0144]** These assemblies 660 may, as disclosed in WO2013/133694, each have a lower member which travels over the first support rail, an upper member over which the respective cantilever beam travels in its longitudinal direction, and a vertical pivot axis swivel between said lower and upper member of the assembly.

**[0145]** In another approach these assemblies 660 remain connected to the respective cantilever beam of the module 610 for the storage of the cantilever.

**[0146]** Figure 10 illustrates the unfolding of the cantilever structure extender members 630, 635 so that they finally reach a longitudinally extended position, wherein each folding cantilever structure extender member extends generally in line with the respective side wall 611,

612 of the rigid operational end module 620. It will be appreciated that in said extended position each member 630, 635 is fixated to the rigid module, e.g. by one or more locking devices, bolts, etc.

**[0147]** Figure 10 also depicts that the cantilever inner end carrier device 650 has been connected to these folding cantilever structure extender members 630, 635. This situation is also depicted in figure 15.

**[0148]** It will be appreciated that instead of a folding design, which is preferred, the cantilever structure extender members 630, 635 could also be embodied as telescopic members that slide horizontally relative to the respective side wall 611, 612 of the rigid operational end module 620. Or, in another embodiment, for these cantilever structure extender members 630, 635 to be readily removable from the module 910 in case a shortening of the cantilever is desired, e.g. for the mentioned deck clearing as discussed herein.

**[0149]** It will be appreciated that figure 10 shows the folded as well as the operative position of the members 630, 635 as well as an intermediate position during the unfolding.

**[0150]** Once the members 630, 635 have been unfolded and fixated, and the carrier device 650 being connected, the cantilever can be deployed. This is schematically illustrated in figure 11a and figure 16, where the rigid module 610 is over the side 504 of the hull, e.g. above an offshore platform of which the one or more wellbores are to be plugged, etc.. The assemblies 660 support the module 610 on the first rail 520. The device 650 retains the inner end of the cantilever structure.

**[0151]** Figure 11b shows the cantilever structure at full length from above, and figure 11c shows the folding members 630, 635 both in folded and in longitudinally extended state.

**[0152]** Figure 12 then illustrates the functionality of the exemplary cantilever system, namely that the cantilever is mounted on the main deck 502 so as to be movable in longitudinal direction of the cantilever, in a rotational direction (A,B), and in combinations thereof, allowing to move the cantilever between a retracted position and extended positions wherein the operational end of the cantilever extends over said cantilever deployment side. Figure 17 gives a close up of the cantilever positioned with a displacement in a rotational direction (A,B). This is further explained in WO2013/133694.

**[0153]** It will be appreciated that the described solutions to allow for a shortening of the length of the cantilever structure for storage are highly beneficial in combination with the method of the invention. The invention is defined by the appended claims.

## Claims

1. Method for permanent plug and abandonment of one or more offshore platform wellbores (55) of an offshore platform (50) and for decommissioning of said

offshore platform, wherein said platform has a jacket (52) and a topsides (51),

wherein use is made of a marine jack-up type vessel (1) comprising:

- a buoyant hull (2) with a main deck (3), said hull having sides (2a, 2b, 2c, 2d),
- at least three jack-up legs (4a, 4b, 4c, 4d),
- a plurality of elevating units, each associated with a respective jack-up leg, adapted to move the respective jack-up leg vertically relative to the hull and to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level,
- a cantilever (10) having a cantilever structure (11) with an operational end (11a), wherein said operational end supports a wellbore activities station (12), e.g. a drilling station, or is adapted to support a wellbore activities station thereon, e.g. a mobile drilling station, said cantilever structure having an inner end (11b) longitudinally opposite the operational end,

wherein the cantilever is movably mounted on the main deck of the hull,

- a cantilever motion assembly (13) adapted to move the cantilever relative to the hull at least in longitudinal direction thereof between a retracted position and extended positions wherein the operational end of the cantilever structure extends beyond a cantilever deployment side of said sides of the hull,
- a crane (20, 21) fixed to the hull and having a boom (20b, 21b) that is slewable about a vertical slew axis (20s, 21s) and pivotal up and down about a horizontal boom pivot axis (20h, 21h),

wherein the method comprises:

- arranging the vessel adjacent the offshore platform and operating the elevating units to bring the vessel in an operational position wherein the legs engage the seabed and the hull is above water level at a height such that the cantilever is movable in an extended position above the topsides of the offshore platform,
- moving by means of the cantilever motion assembly the cantilever into said extended position above the topsides and aligning the wellbore activities station with a wellbore of the offshore platform,

- performing a plug and abandonment operation on said wellbore involving the use of the wellbore activities station,
- retracting the cantilever (10) into a retracted position,
- disconnecting the topsides (51) from the jacket (52),
- lifting the topsides (51) from the jacket (52) by means of the crane (20, 21) of the vessel and placing said topsides by means of said crane onboard the vessel with the cantilever (10) in the retracted position,
- operating the elevating units so as to lower the hull of the vessel into the sea and to retract the jack-up legs upward.

2. Method according to claim 1, wherein an entire topsides (51) is lifted in a single-lift by means of the one or more cranes (20, 21) of the jack-up type vessel.

3. Method according to claim 1 or 2, wherein the cantilever is moved into a deck clearing position wherein a deck area of the main deck is cleared and the topsides is landed by the one or more cranes on said clear deck area (3C).

4. Method according to any one of claims 1 - 3, wherein the one or more cranes (20, 21) of the jack-up type vessel are also employed for the, at least partial, removal of the jacket (52).

5. Method according to claim 4, wherein the one or more cranes involved in the lifting of the jacket have a maximum operative height in said lifting process of the crane hook above the design waterline of the buoyant hull that exceeds 55 meters, preferably exceeds 75 meters, e.g. between 75 and 110 meters.

#### Patentansprüche

1. Verfahren zum dauerhaften Verschließen und Aufgeben von einem oder mehreren Offshore-Plattform-Bohrlöchern (55) einer Offshore-Plattform (50) und zur Stilllegung der Offshore-Plattform, wobei die Plattform ein Jacket (52) und eine Oberseite (51) aufweist,

wobei ein Schiff (1) vom marinen Jack Up typ (1) verwendet wird, das umfasst:

- einen schwimmfähigen Rumpf (2) mit einem Hauptdeck (3), wobei der Rumpf Seiten (2a, 2b, 2c, 2d) aufweist,
- mindestens drei Jack Up Beine (4a, 4b, 4c, 4d),
- eine Vielzahl von Hebeeinheiten, die jeweils einem entsprechenden Jack Up Bein

zugeordnet sind und dazu geeignet sind, das entsprechende Jack Up Bein vertikal relativ zu dem Rumpf zu bewegen und das Schiff in eine Betriebsposition zu bringen, in der sich die Beine mit dem Meeresboden in Eingriff befinden und sich der Rumpf über dem Wasserspiegel befindet,

- einen Ausleger (10) mit einer Auslegerstruktur (11) mit einem Betriebsende (11a), wobei das Betriebsende eine Bohrlocharbeitsstation (12), z.B. eine Bohrstation, hält oder dafür ausgelegt ist, eine Bohrlocharbeitsstation, z.B. eine mobile Bohrstation, darauf zu halten, wobei die Auslegerstruktur ein inneres Ende (11b) aufweist, das dem Betriebsende in Längsrichtung gegenüberliegt, wobei der Ausleger beweglich auf dem Hauptdeck des Rumpfs montiert ist,

- eine Auslegerbewegungsanordnung (13), die geeignet ist, den Ausleger relativ zu dem Rumpf zumindest in dessen Längsrichtung zwischen einer eingefahrenen Position und ausgefahrenen Positionen zu bewegen, wobei sich das Betriebsende der Auslegerstruktur über eine Ausleger-Einsatzseite der Seiten des Rumpfs hinaus erstreckt,

- einen Kran (20, 21), der an dem Rumpf befestigt ist und einen Kranausleger (20b, 21b) aufweist, der um eine vertikale Schwenkachse (20s, 21s) schwenkbar ist und um eine horizontale Kranausleger-schwenkachse (20h, 21h) auf und ab schwenkbar ist,

wobei das Verfahren umfasst:

- Anordnen des Schiffes neben der Offshore-Plattform und Betätigen der Hebeeinheiten, um das Schiff in eine Betriebsposition zu bringen, in der sich die Beine mit dem Meeresboden in Eingriff befinden und der Rumpf sich in einer solchen Höhe über dem Wasserspiegel befindet, dass der Ausleger in einer ausgefahrenen Position über den Oberseiten der Offshore-Plattform bewegbar ist,

- Bewegen des Auslegers mittels der Auslegerbewegungsanordnung in die ausgefahrene Position über der Oberseite und Ausrichten der Bohrlocharbeitsstation mit einem Bohrloch der Offshore-Plattform,

- Durchführen eines Verschluss- und Aufgabevorgangs an dem Bohrloch unter Verwendung der Bohrlocharbeitsstation,

- Einfahren des Auslegers (10) in eine eingefahrene Position,

- Trennen der Oberseiten (51) von dem Jacket (52),

- Anheben der Oberseiten (51) von dem Jacket (52) mittels des Krans (20, 21) des Schiffes und Anordnen der Oberseiten mit dem Kran an Bord des Schiffes, wobei sich der Ausleger (10) in der eingefahrenen Position befindet,

- Betätigen der Hebeeinheiten, um den Rumpf des Schiffes ins Meer abzusenken und die Jack Up Beine nach oben einzuziehen.

2. Verfahren nach Anspruch 1, wobei eine gesamte Oberseite (51) in einem einzigen Hub mittels des einen oder der mehreren Kräne (20, 21) des Jack Up typ Schiffs angehoben wird.
3. Verfahren nach Anspruch 1 oder 2, wobei der Ausleger in eine Deckkräumungsposition bewegt wird, in der ein Deckbereich des Hauptdecks geräumt ist und die Oberseite von dem einen oder den mehreren Kränen auf dem geräumten Deckbereich (3C) abgesetzt ist.
4. Verfahren nach einem der Ansprüche 1 bis 3, wobei der eine oder die mehreren Kräne (20, 21) des Jack Up typ Schiffs auch für das zumindest teilweise Entfernen des Jackets (52) eingesetzt werden.
5. Verfahren nach Anspruch 4, wobei der eine oder die mehreren Kräne, die an dem Anheben des Jackets beteiligt sind, eine maximale Arbeitshöhe bei dem Anhebeverfahren des Kranhakens über der Konstruktionswasserlinie des schwimmfähigen Rumpfes haben, die 55 Meter, vorzugsweise 75 Meter, z.B. zwischen 75 und 110 Metern, überschreitet.

## Revendications

1. Procédé pour obturation et abandon permanents d'un ou plusieurs puits de forage à plateforme en mer (55) d'une plateforme en mer (50) et pour mise hors service de ladite plateforme en mer, dans lequel ladite plateforme a une chemise (52) et des côtés supérieurs (51),

dans lequel est utilisé un navire marin à vérin (1), comprenant :

- une coque flottante (2) avec un pont principal (3), ladite coque ayant des côtés (2a, 2b, 2c, 2d),

- au moins trois pieds de vérin (4a, 4b, 4c, 4d),

- une pluralité d'unités d'élévation, chacune associée à un pied de vérin respectif, adaptées pour déplacer le pied de vérin respectif verticalement par rapport à la coque et pour

amener le navire dans une position fonctionnelle dans laquelle les pieds se mettent en prise avec le fond marin et la coque est au-dessus du niveau de l'eau,

- un porte-à-faux (10) ayant une structure en porte-à-faux (11) avec une extrémité fonctionnelle (11a), dans lequel ladite extrémité fonctionnelle supporte une station d'activités de puits de forage (12), par exemple une station de forage, ou est adapté pour supporter une station d'activités de puits de forage sur celui-ci, par exemple une station de forage mobile, ladite structure en porte-à-faux ayant une extrémité interne (11b) opposée longitudinalement à l'extrémité fonctionnelle, dans lequel le porte-à-faux est monté de manière amovible sur le pont principal de la coque,
- un ensemble de déplacement de porte-à-faux (13) adapté pour déplacer le porte-à-faux par rapport à la coque au moins dans la direction longitudinale de celle-ci entre une position rétractée et des positions étendues dans lequel l'extrémité fonctionnelle de la structure en porte-à-faux s'étend au-delà d'un côté de déploiement de porte-à-faux desdits côtés de la coque,
- une grue (20, 21) fixée à la coque et ayant une flèche (20b, 21b) qui est orientable autour d'un axe d'orientation vertical (20s, 21s) et pivotante vers le haut et vers le bas autour d'un axe de pivotement de flèche horizontal (20h, 21h).

dans lequel le procédé comprend :

- l'agencement du navire de manière adjacente à la plateforme en mer et l'actionnement des unités d'élévation pour amener le navire dans une position fonctionnelle dans laquelle les pieds se mettent en prise avec le fond marin et la coque est au-dessus du niveau de l'eau à une hauteur telle que le porte-à-faux est mobile dans une position étendue au-dessus des côtés supérieurs de la plateforme en mer,
- le déplacement au moyen de l'ensemble de déplacement de porte-à-faux du porte-à-faux dans ladite position étendue au-dessus des côtés supérieurs et l'alignement de la station d'activités de puits de forage avec un puits de forage de la plateforme en mer,
- la réalisation d'une opération d'obturation et d'abandon sur ledit puits de forage impliquant l'utilisation de la station d'activités de puits de forage,
- la rétraction du porte-à-faux (10) dans une position rétractée,

- la séparation des côtés supérieurs (51) de la chemise (52),

- le levage des côtés supérieurs (51) à partir de la chemise (52) au moyen de la grue (20, 21) du navire et le placement desdits côtés supérieurs au moyen de ladite grue à bord du navire avec le porte-à-faux (10) dans la position rétractée,

- l'actionnement des unités d'élévation de sorte à abaisser la coque du navire dans la mer et à rétracter les pieds de vérin vers le haut.

2. Procédé selon la revendication 1, dans lequel une totalité des côtés supérieurs (51) est levée en un seul levage au moyen des une ou plusieurs grues (20, 21) du navire à vérin.
3. Procédé selon la revendication 1 ou 2, dans lequel le porte-à-faux est déplacé dans une position de dégagement de pont dans lequel une zone de pont du pont principal est dégagée et les côtés supérieurs sont débarqués par les une ou plusieurs grues sur ladite zone de pont dégagée (3C).
4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel les une ou plusieurs grues (20, 21) du navire à vérin sont également utilisées pour le retrait, au moins partiel, de la chemise (52).
5. Procédé selon la revendication 4, dans lequel les une ou plusieurs grues impliquées dans le levage de la chemise ont une hauteur fonctionnelle maximale dans ledit processus du crochet de grue au-dessus de la ligne de flottaison prévue de la coque flottante qui dépasse 55 mètres, de préférence dépasse 75 mètres, par exemple, entre 75 et 110 mètres.



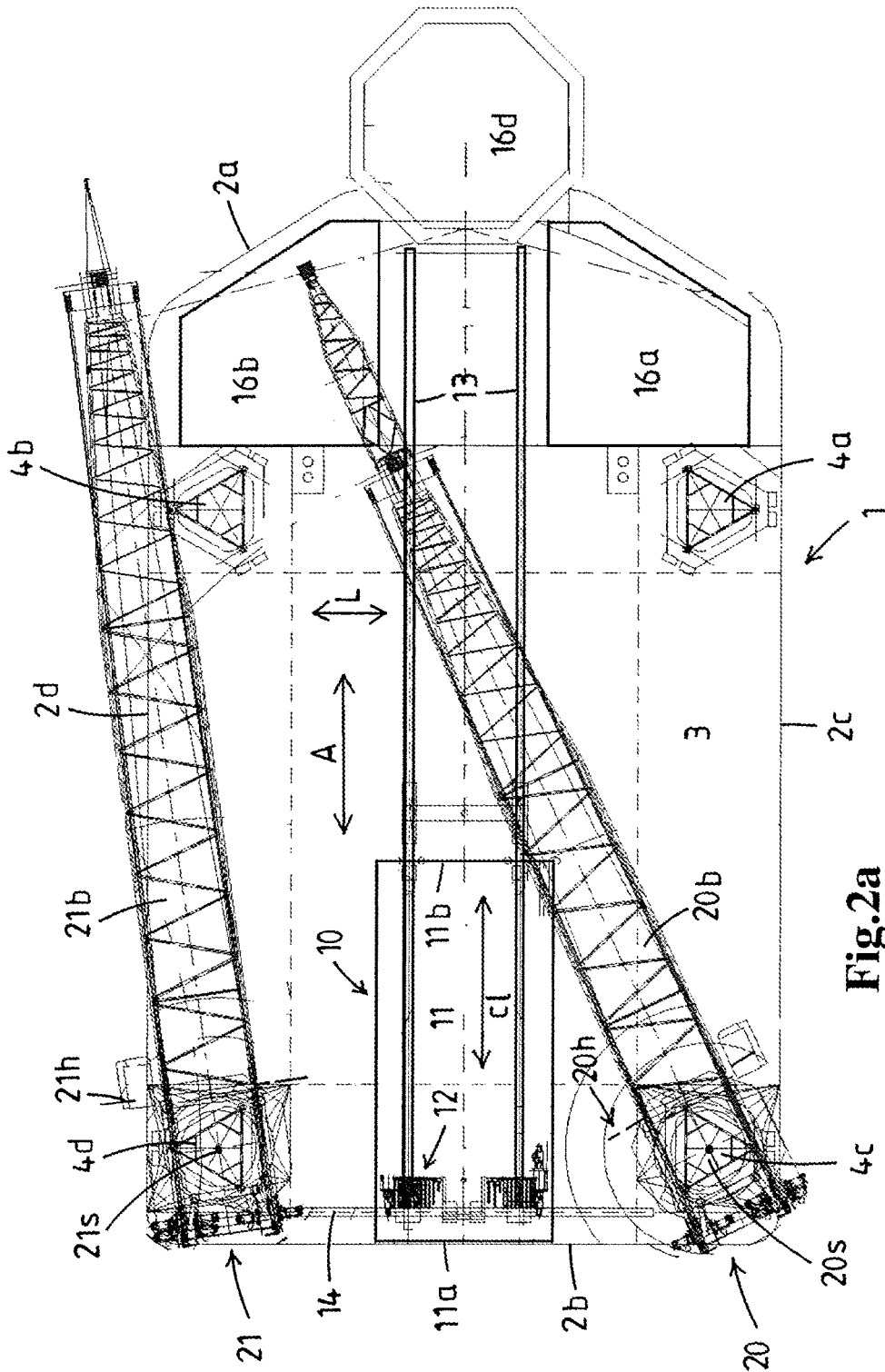


Fig. 2a



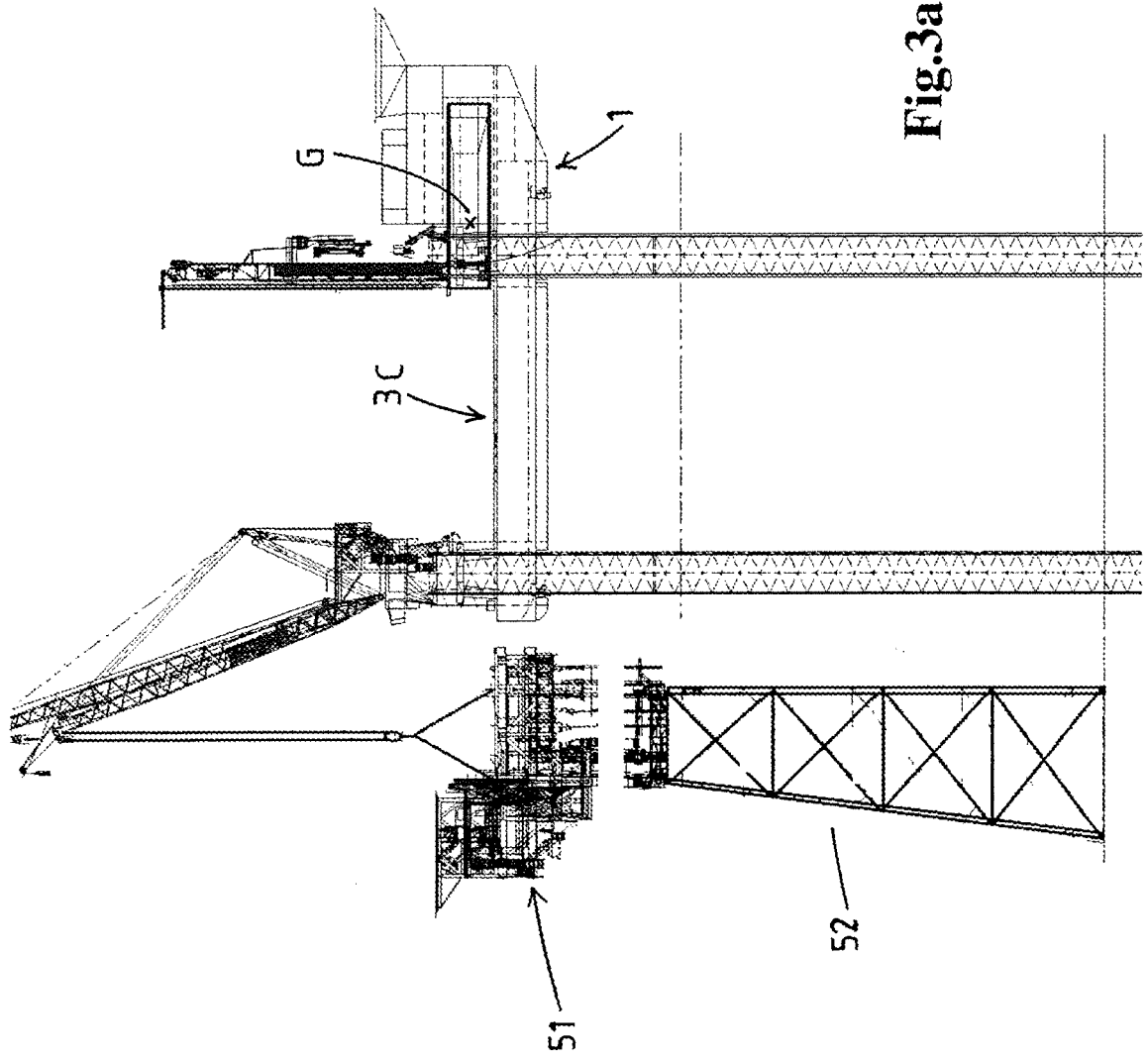
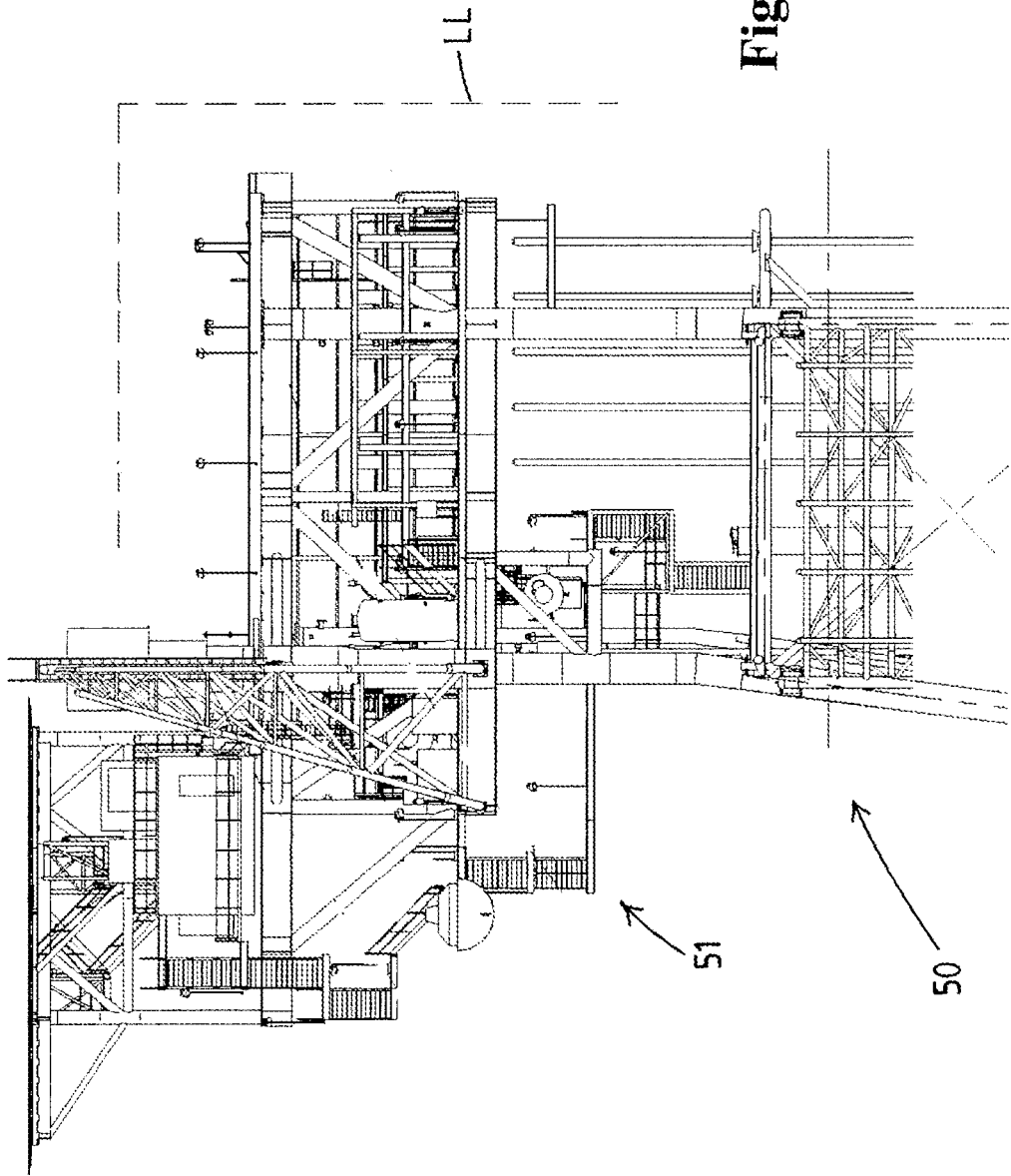


Fig.3a



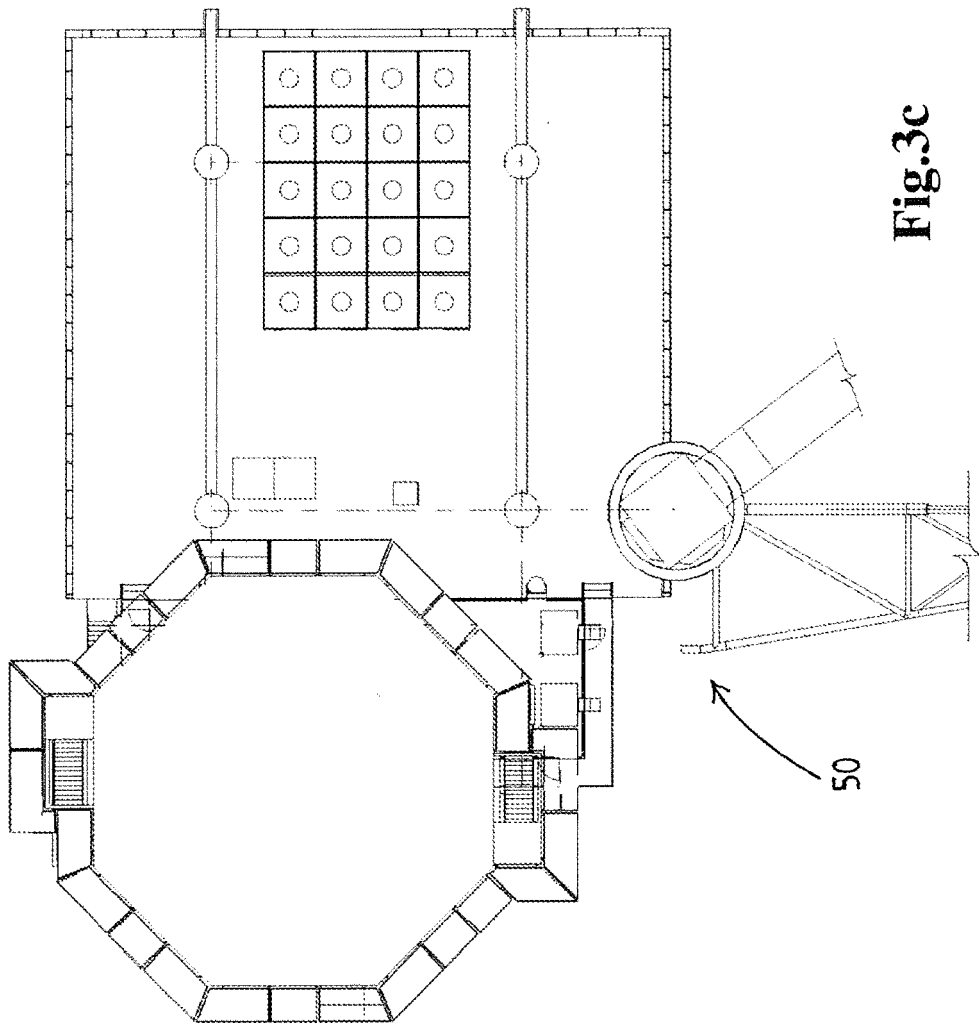


Fig.3c

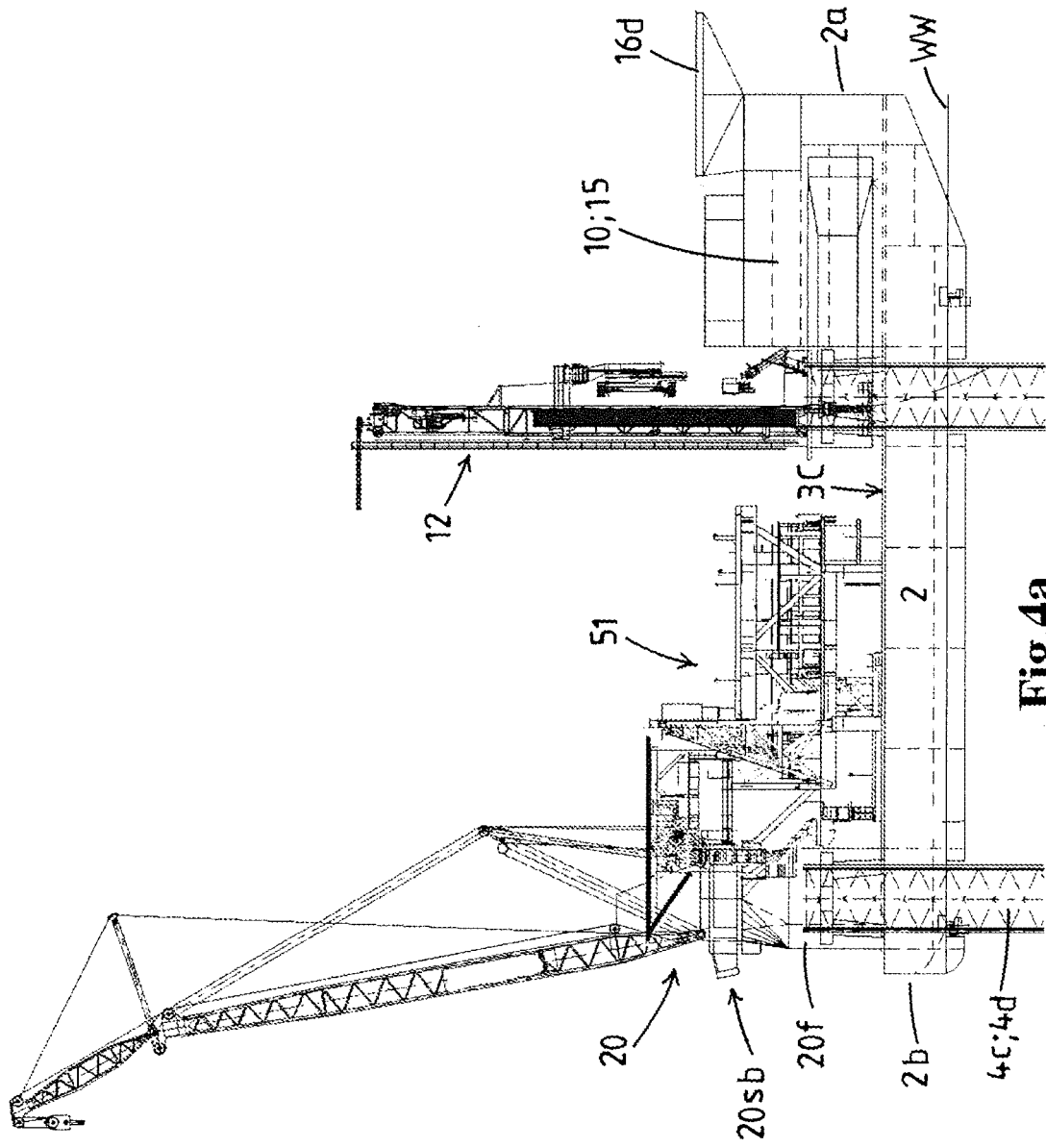


Fig.4a

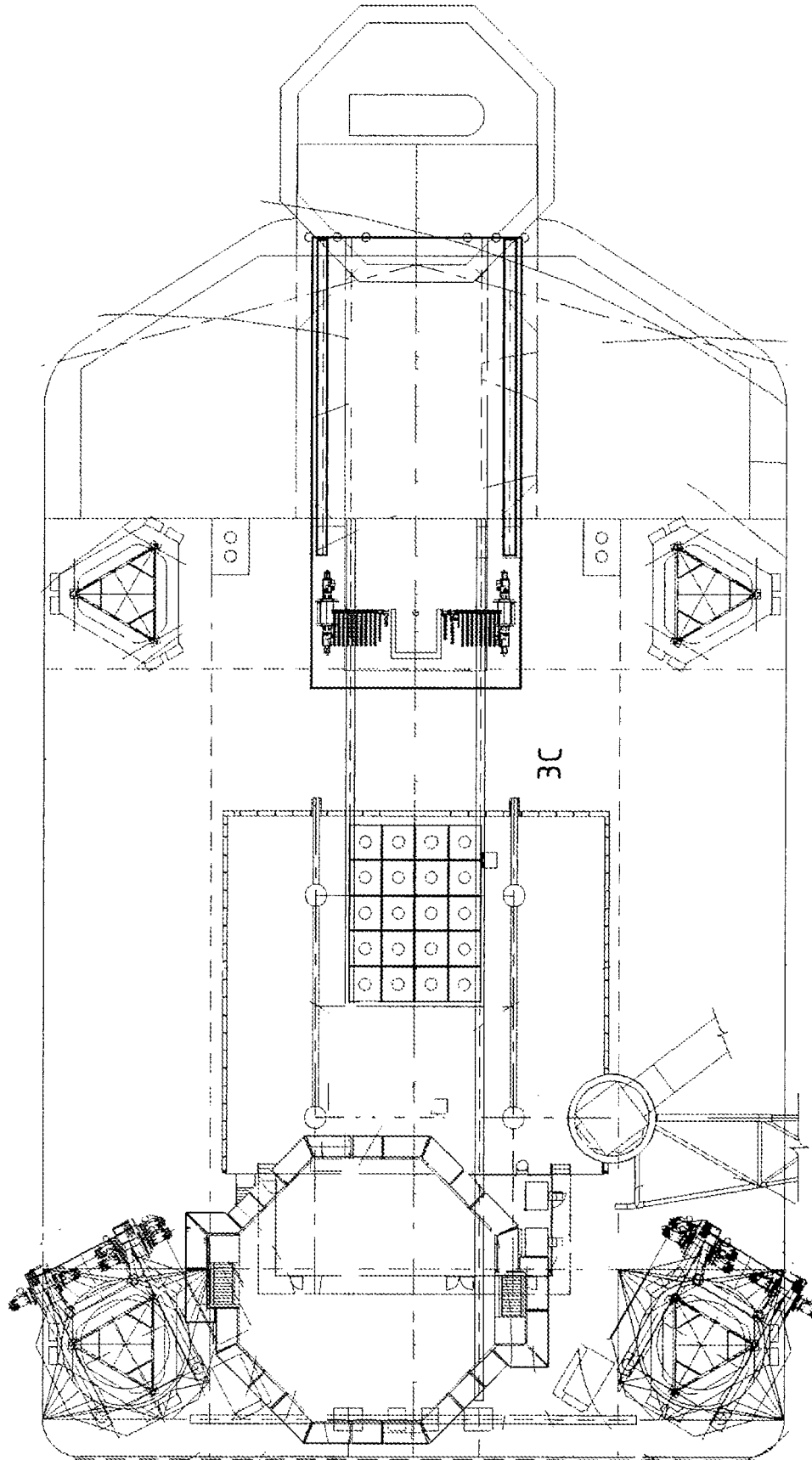


Fig.4b

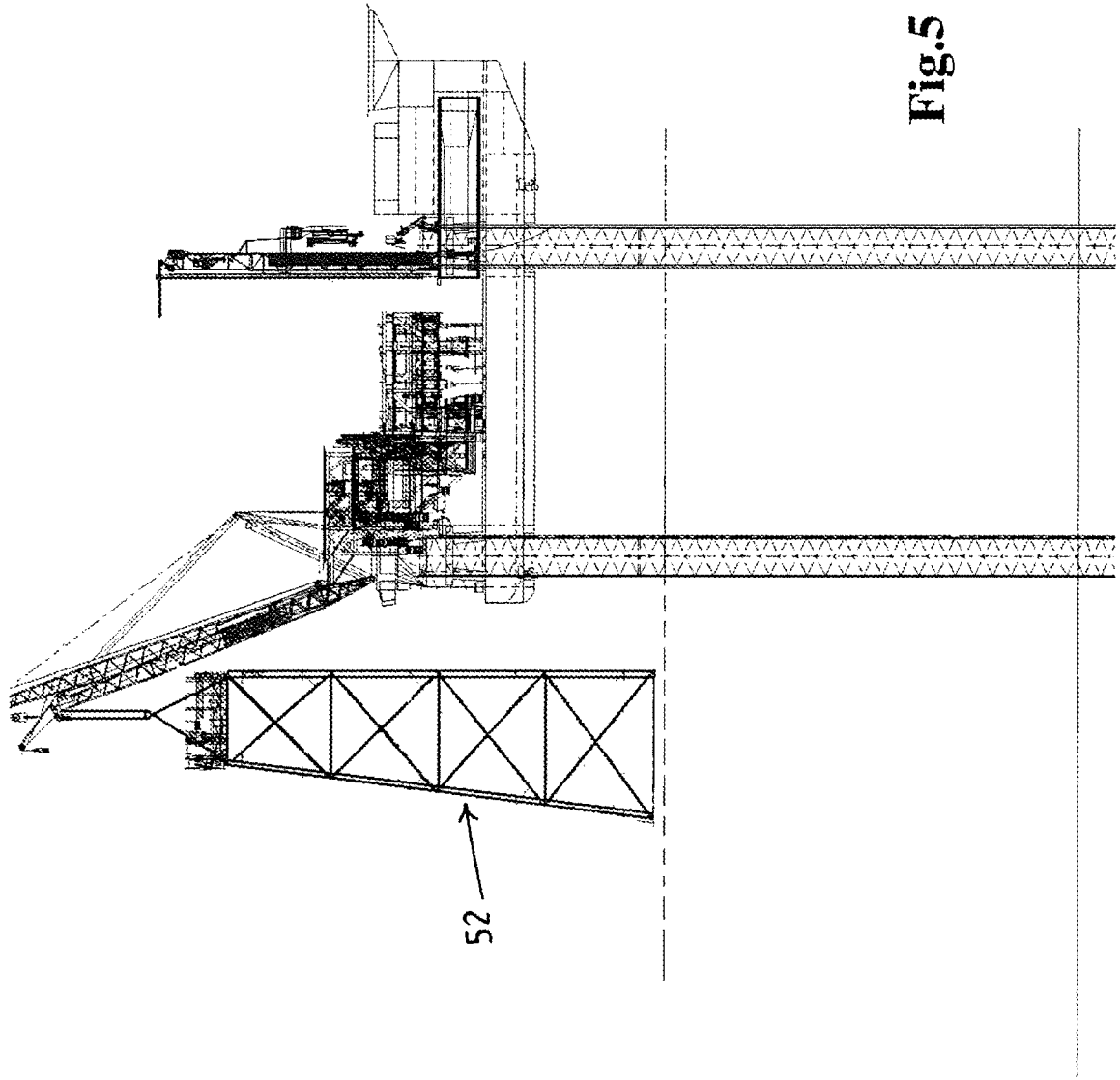


Fig.5

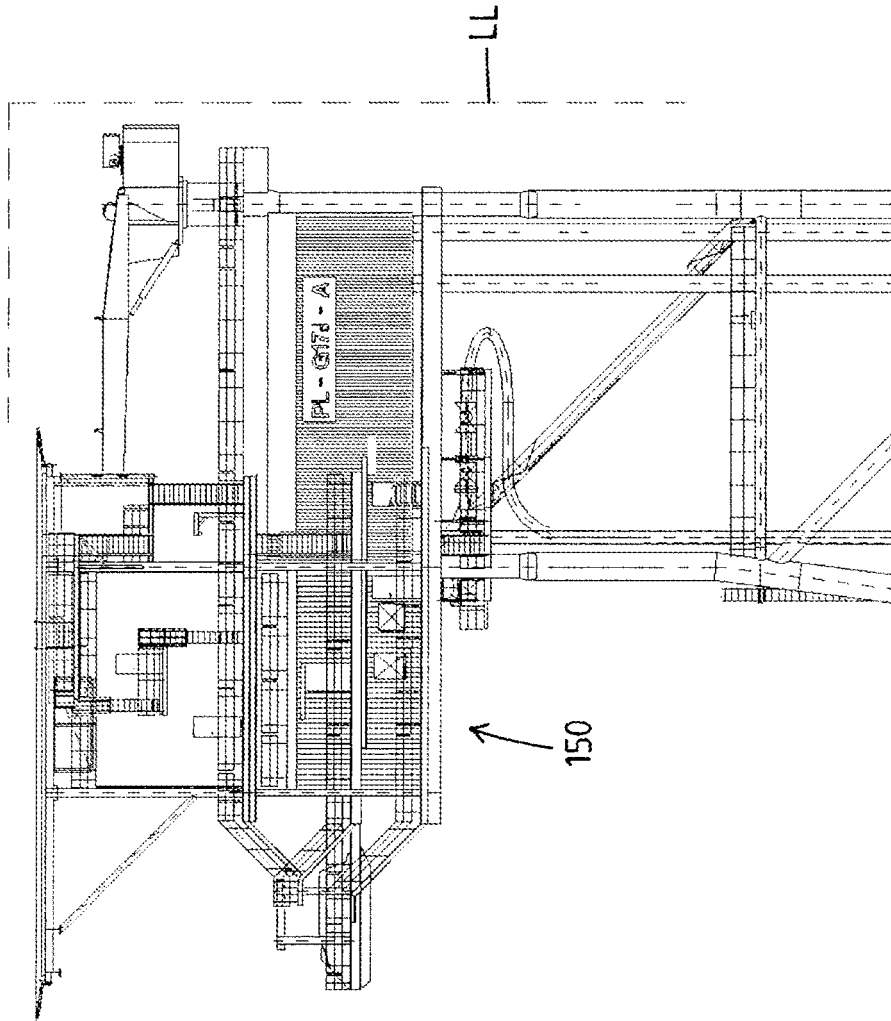
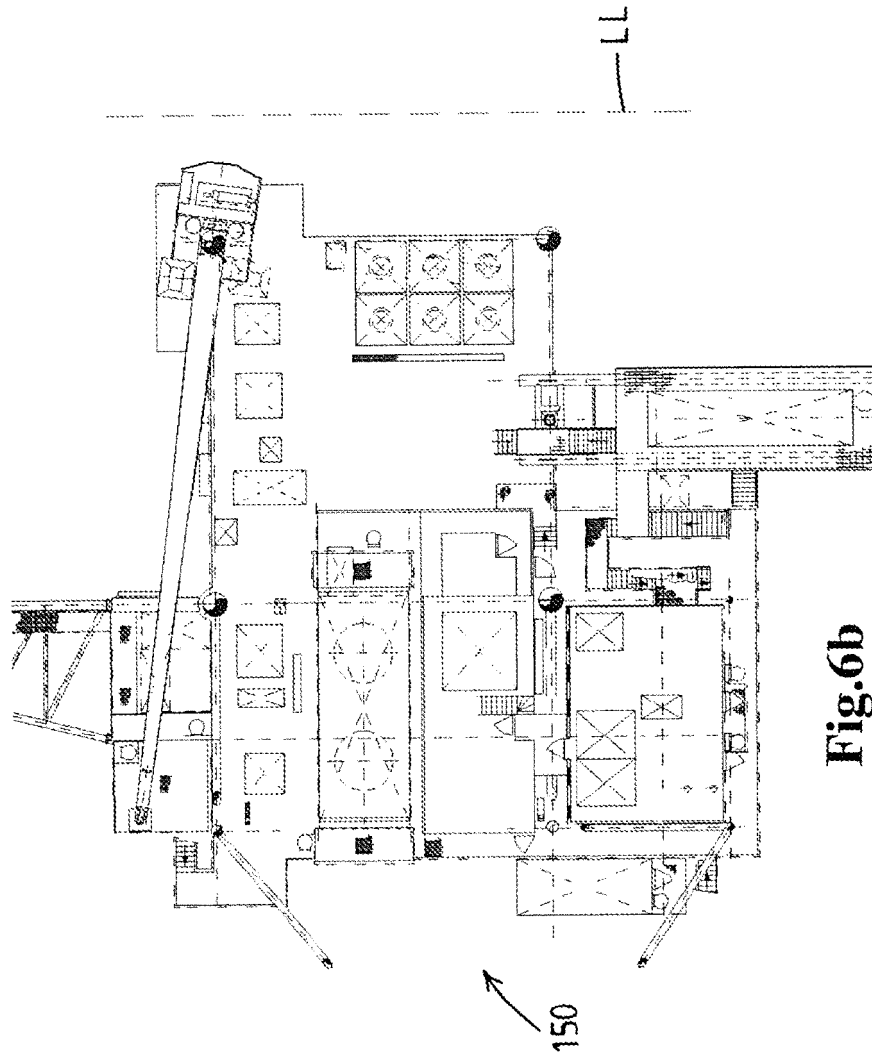


Fig.6a



**Fig.6b**

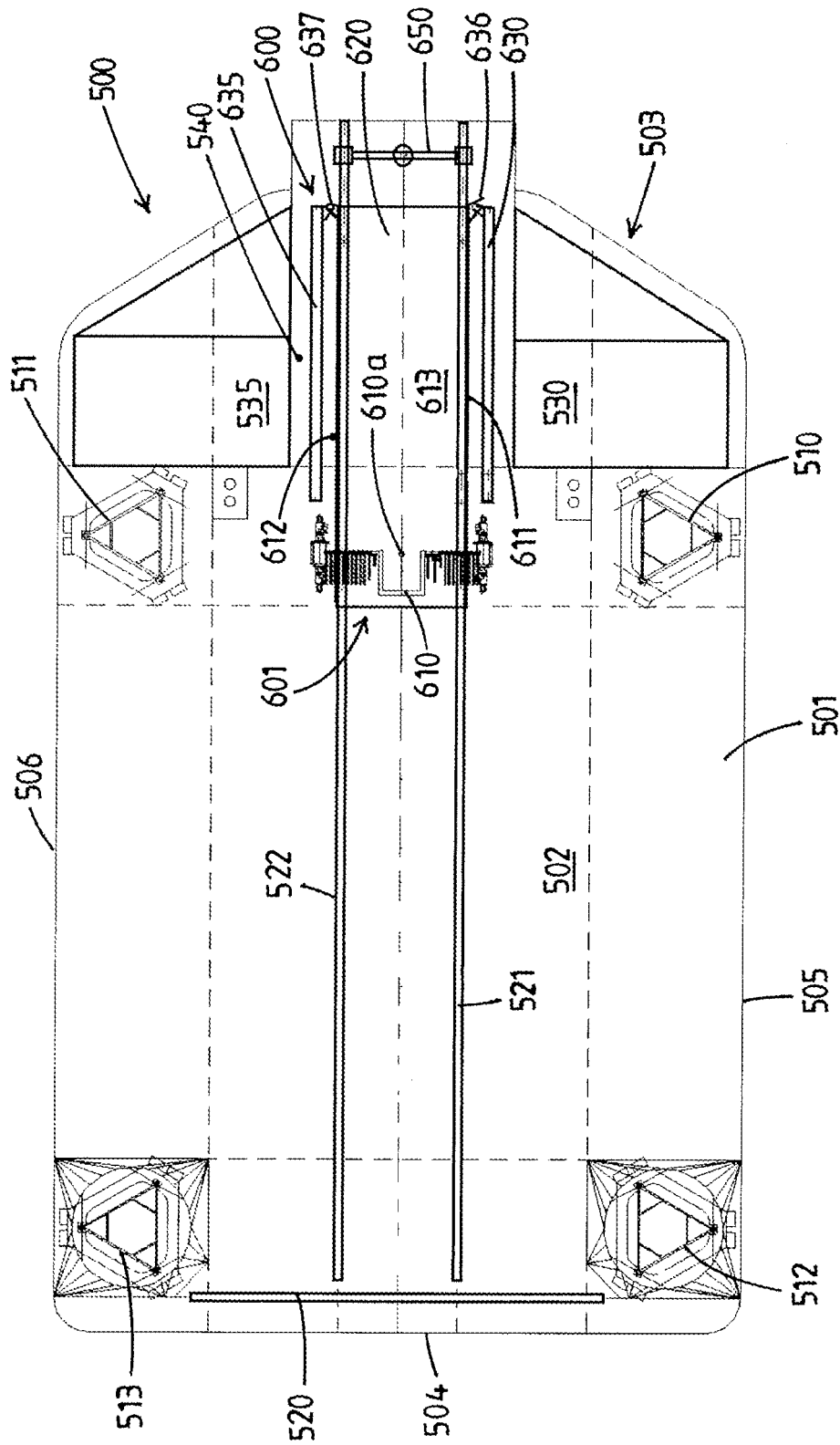
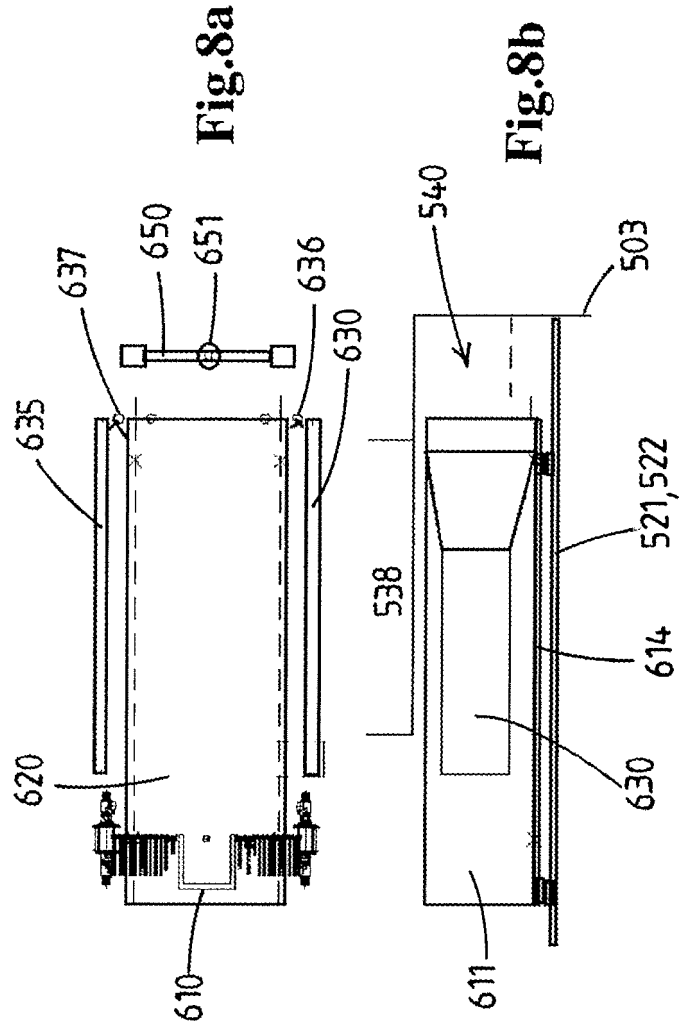


Fig. 7



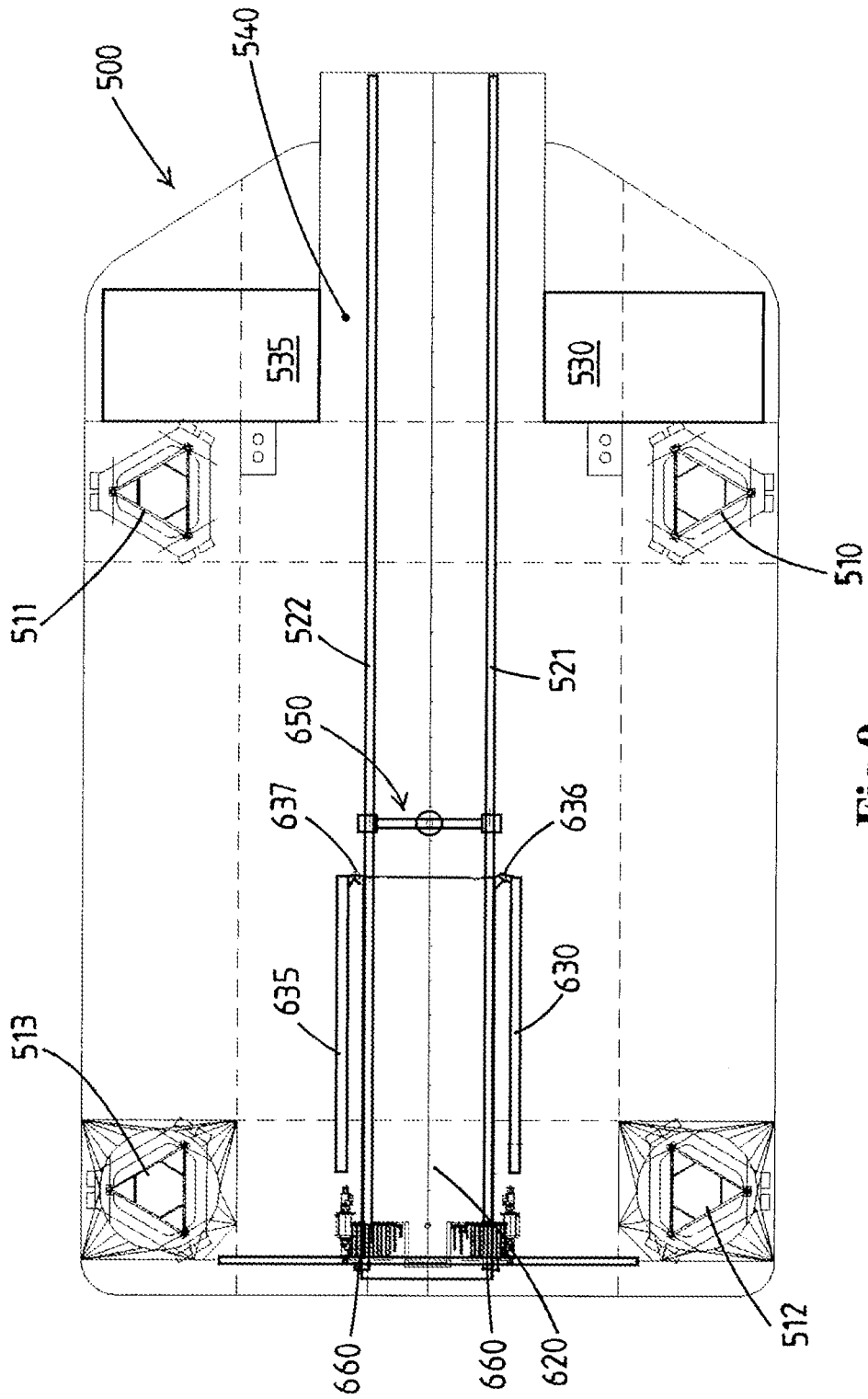
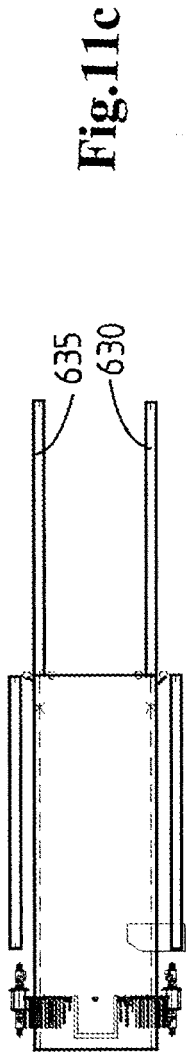
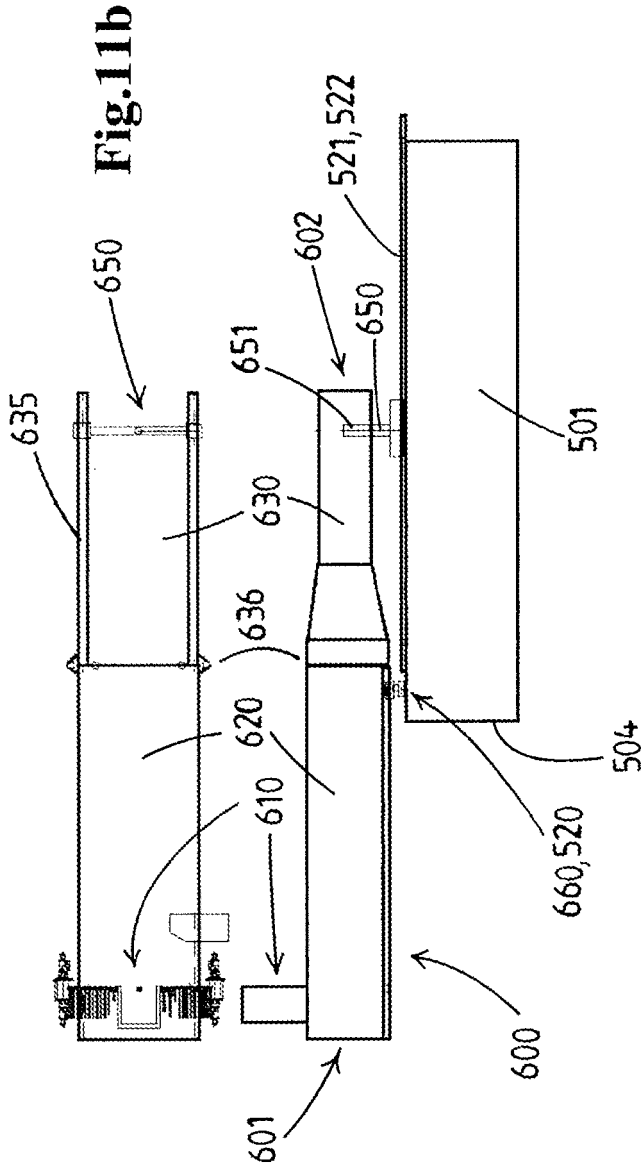


Fig.9





**Fig.11c**



**Fig.11b**

**Fig.11a**

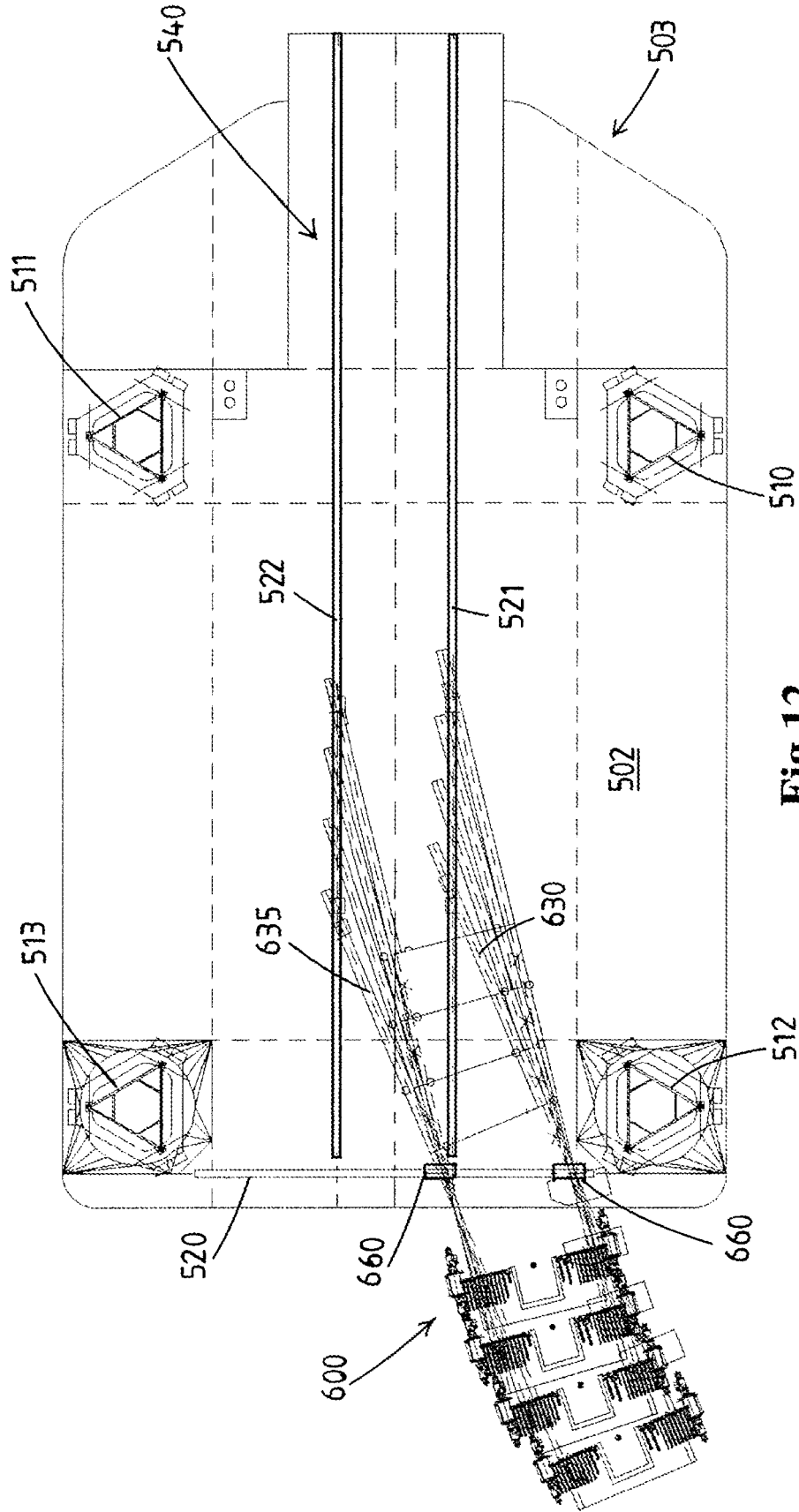


Fig.12



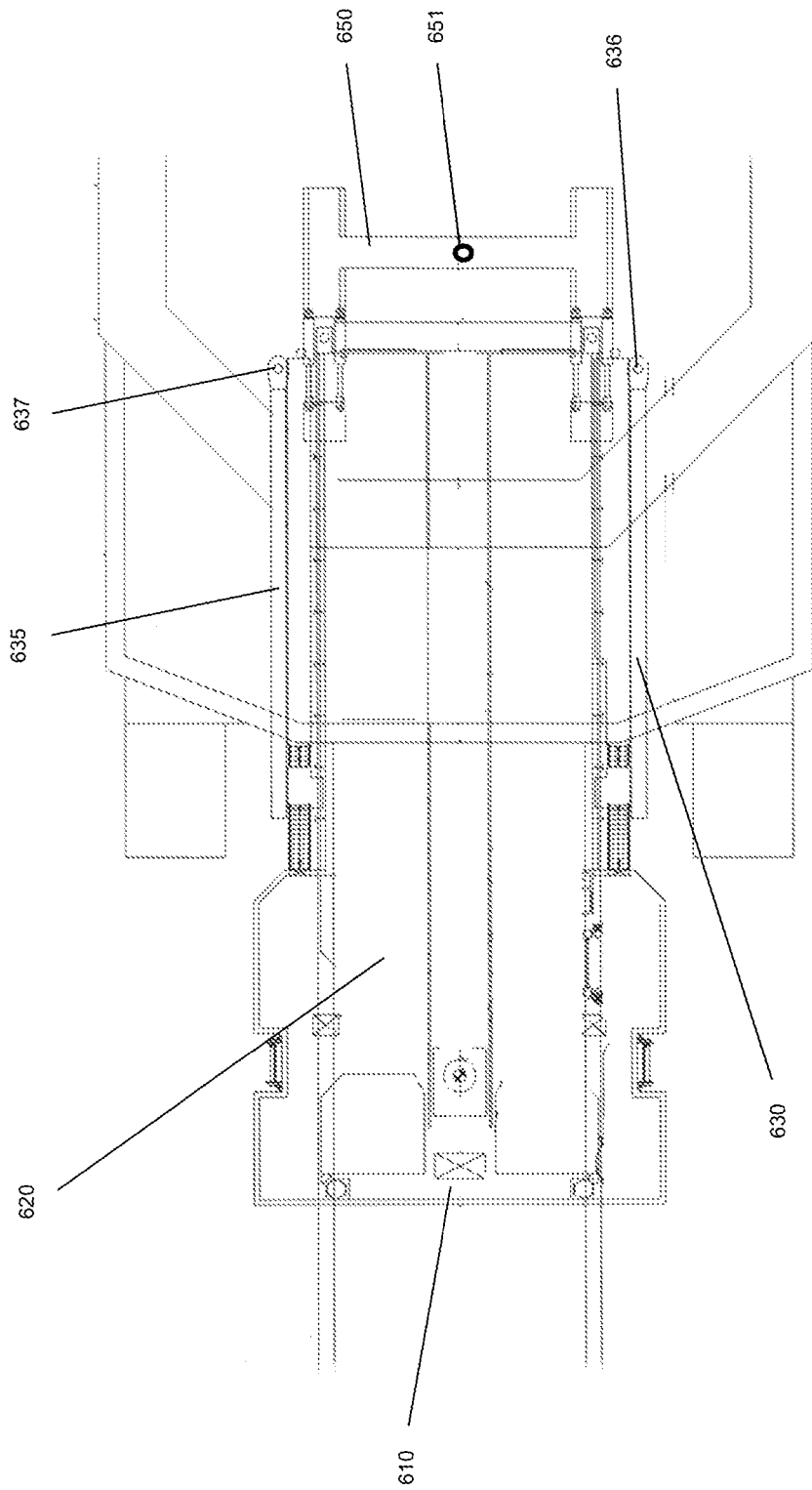


Fig. 14a

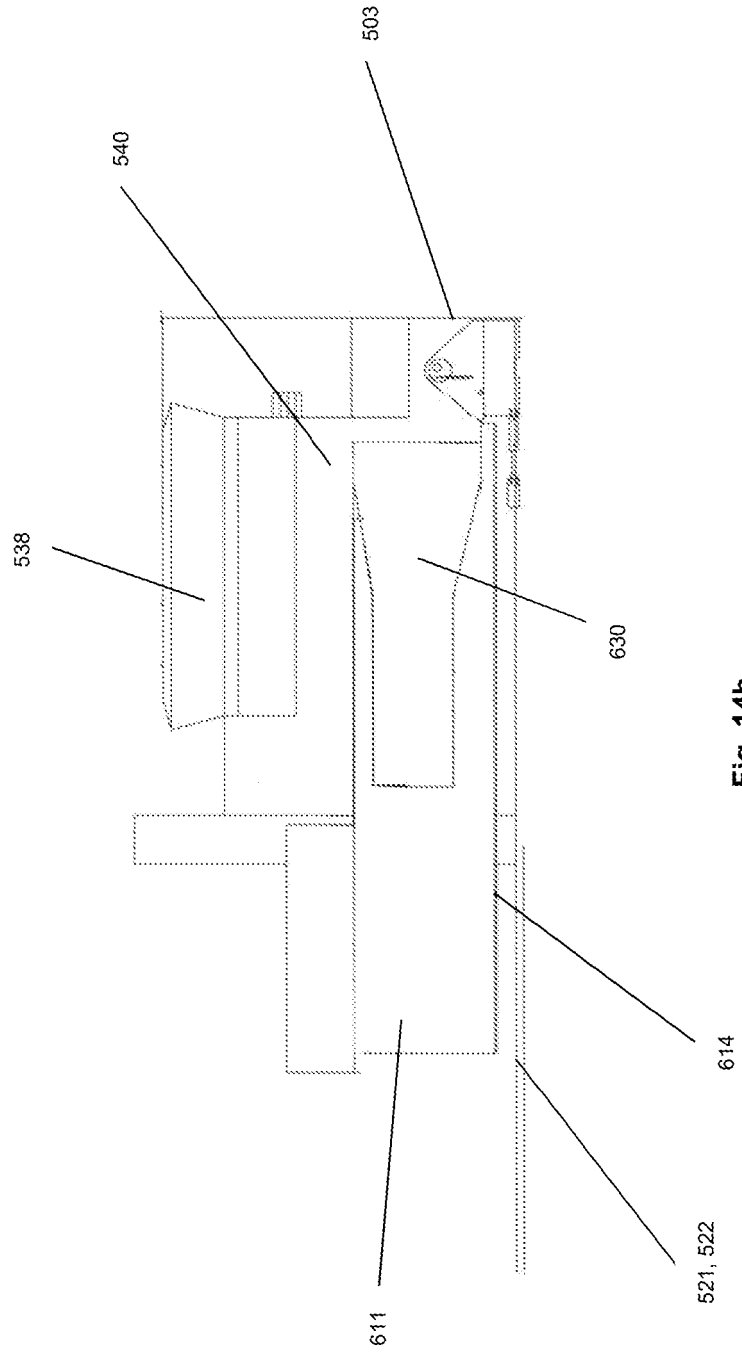


Fig. 14b

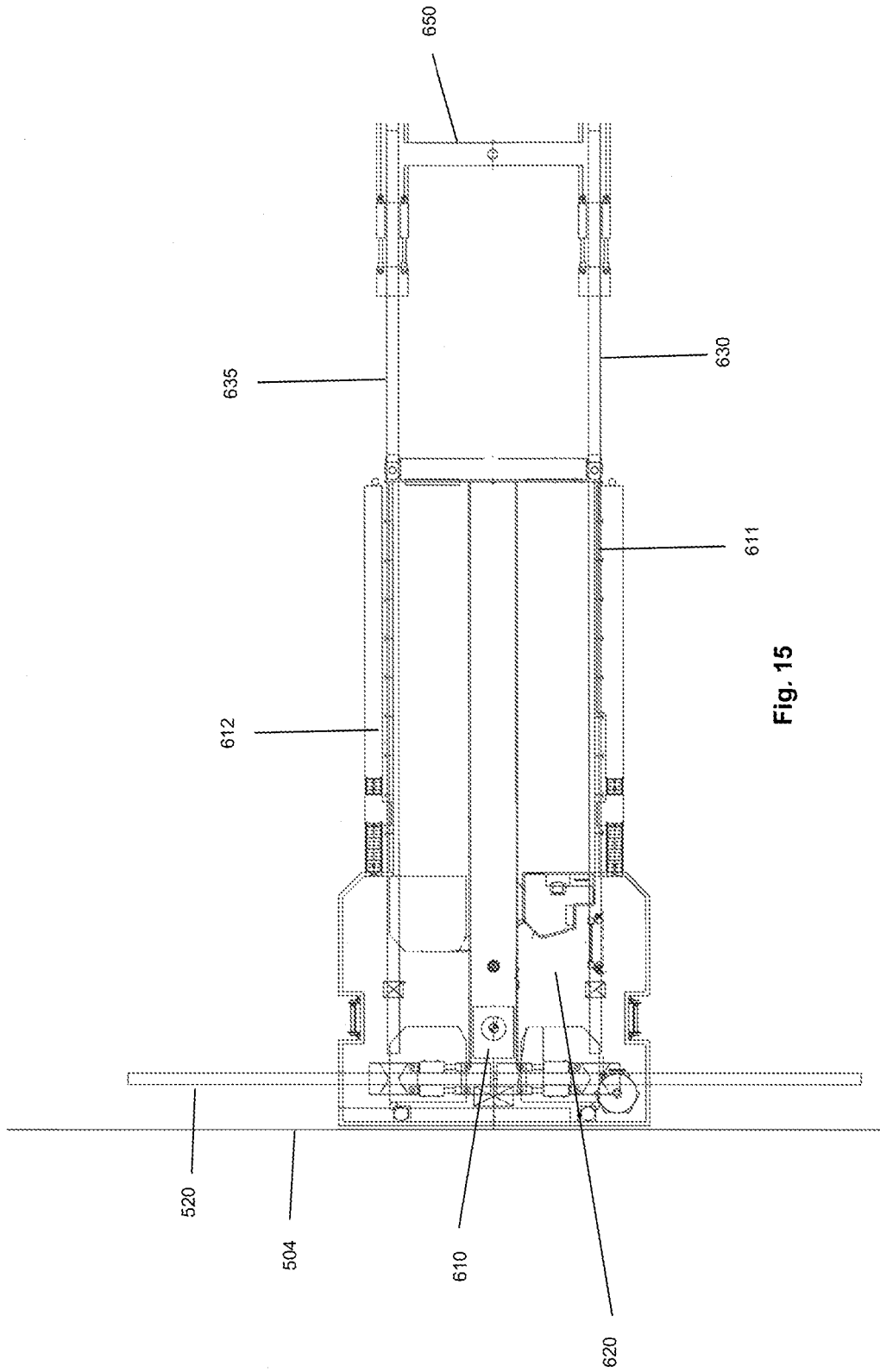


Fig. 15

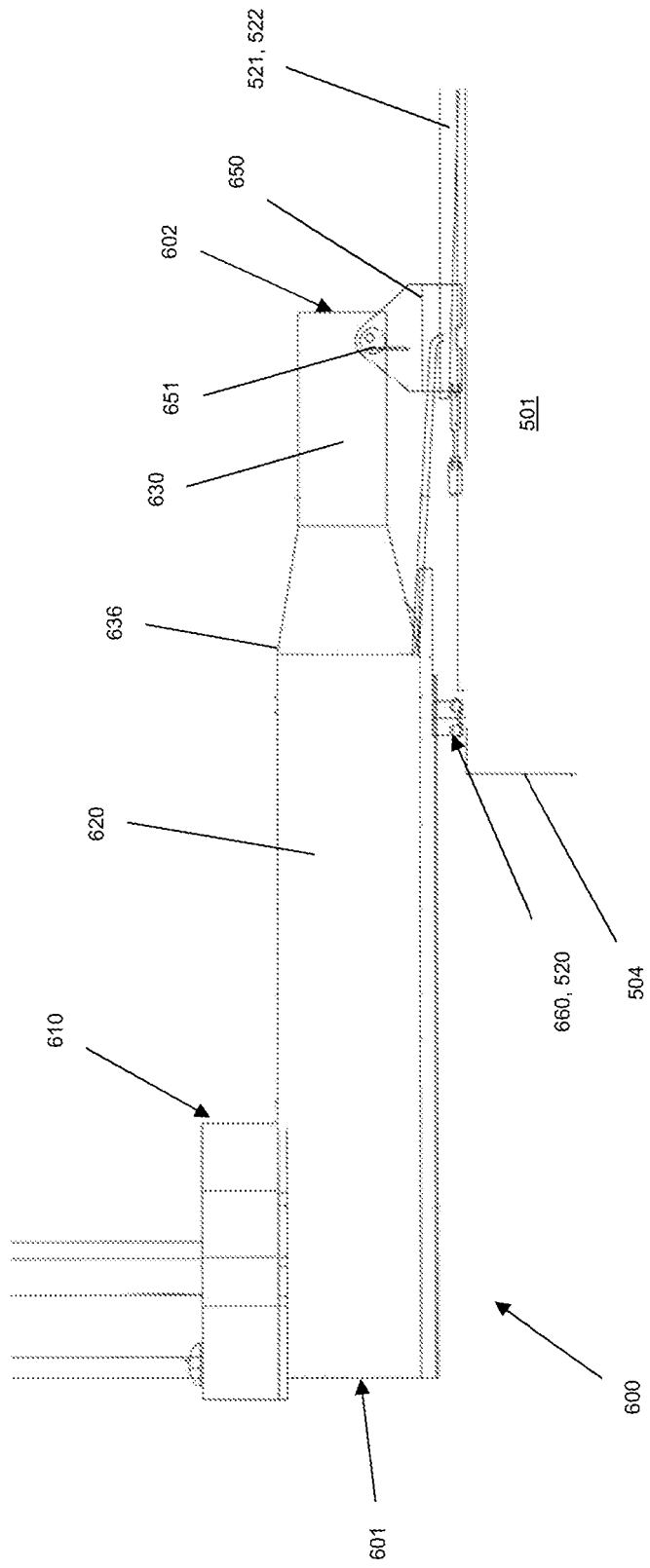


Fig. 16

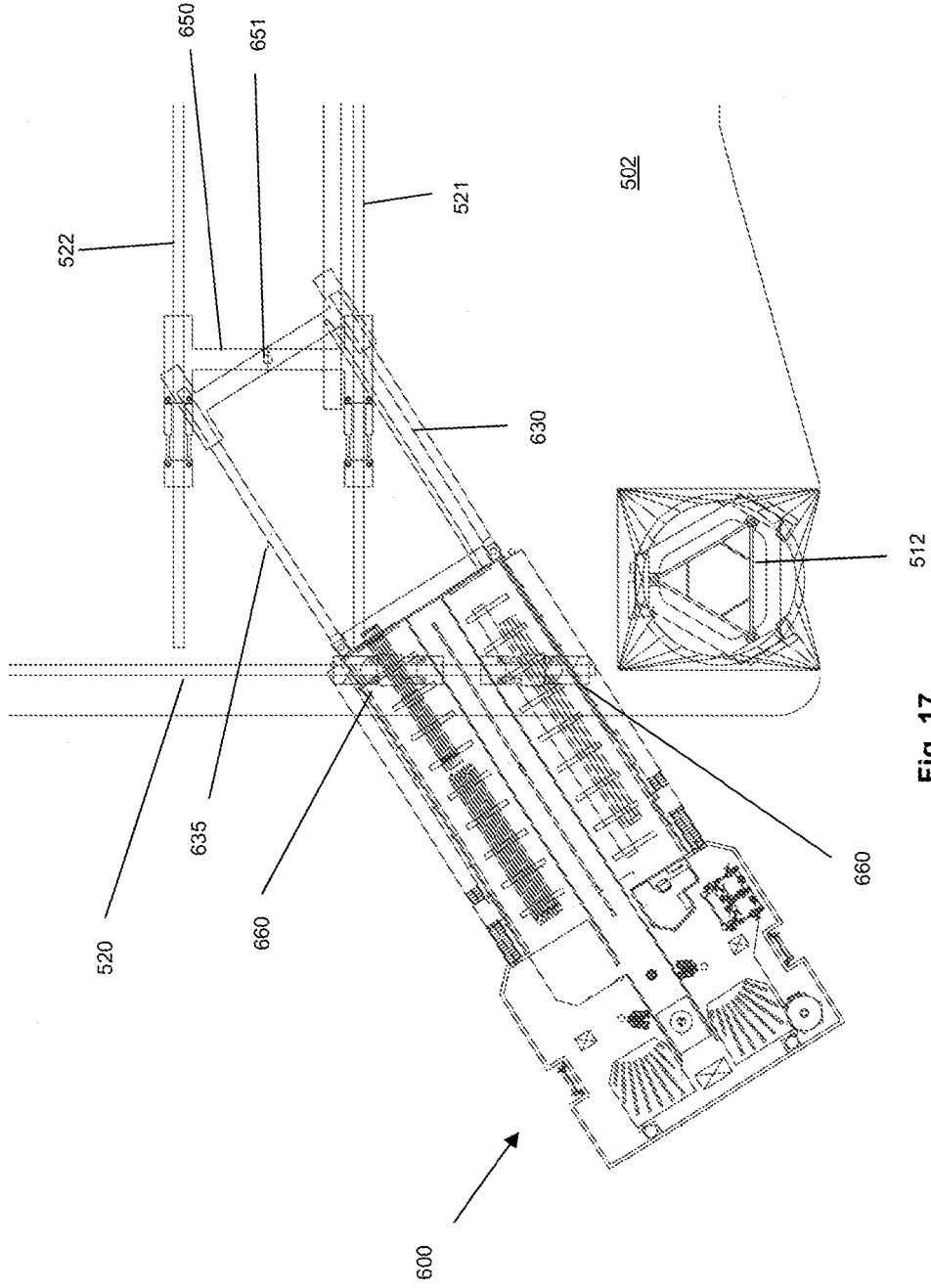


Fig. 17

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- WO 2012144952 A [0003]
- WO 2017142938 A [0004]
- US 6729804 B [0033]
- US 2004151549 A [0033]
- EP 2823105 A [0033]
- WO 2013133694 A [0062] [0065] [0066] [0137]  
[0144] [0152]
- WO 2016204608 A [0124]