Vessel and crane with full dynamic compensation for vessel and wave motions.

The invention relates to vessel (10) comprising a crane (12) for positioning diver transfer equipment (36) and/or diver equipment (38) overboard the vessel (10) into a body of water (2). The crane (12) comprises:
- a crane base (24) connected to the vessel (10);
- a crane arm (14) with a suspension point (16) that is movably connected to the crane base (24);
- control means (26) for controlling the crane arm (14) configuration;
The control means (26) are configured for:
- determining a change in position and/or orientation of the crane (12) resulting from vessel motion,
- dynamically adjusting the crane arm configuration to change the position of the suspension point (16) with respect to the crane base (24) so as to at least partially compensate for the change in position and/or orientation of the crane (12).
Vessel and crane with full dynamic compensation for vessel and wave motions

TECHNICAL FIELD

The invention relates to a vessel comprising a crane for positioning diver transfer equipment and/or diver equipment overboard the vessel into a body of water.

Furthermore, the invention relates to a crane, and to a method for positioning diver transfer equipment and/or diver equipment overboard a vessel and into a body of water, using the crane.

BACKGROUND

The “equipment” refers herein to various objects involved in diving operations, like diver transfer equipment (e.g. a diving bell, chamber, or basket, preferably carrying diving personnel inside the transfer equipment), and diver equipment (e.g. tooling, supplies, or spare gear, optionally carried in a workbasket). According to known diver deployment methods, the diver transfer equipment and/or diver equipment is placed overboard a diving support vessel and into a body of water by either deployment over the side of the vessel hull, or by deployment through a moon pool. A small crane with a single heave arm and a winch may be used for lowering and hoisting the diver equipment into and out of the water body. The load is carried by the cable at a connection point, and is repositionable by controlling the winch and/or by vertically adjusting the heave arm. Deployment of diver transfer equipment commonly involves the use of a dedicated launch and recovery system (LARS) incorporating a winch carrying a cable for suspending the diver transfer equipment. The diver transfer equipment is thus deployed either through the moon pool or over the side of the vessel.

Often, this deployment further involves a known method of cross-hauling using a small crane with a single heave arm and a winch carrying a further cable for suspending the diver transfer equipment. During cross-hauling, the submerged diver transfer equipment is horizontally transferred towards the work site, while the crane gradually takes over the suspension function from the LARS.

A disadvantage of the known methods is that the diver transfer equipment and/or diver equipment are positioned into the body of water at a relatively small projected horizontal distance away from the vessel, which in the case of diving operations in which the vessel is not able or allowed to be positioned nearby the target, results in
significant swimming times required for the divers to commute between their bell and equipment, and the work site. This may be the case during diving operations for sea platform construction or Inspection Repair and Maintenance (IRM), wherein the platform’s construction prohibits the vessel from approaching the platform base. The unfavourably long swimming distances incur additional costs, and form a limiting factor in planning and finding a suitable operational window in the ever changing environmental conditions. Positioning a load at a larger horizontal distance away from the vessel using a crane is difficult and dangerous, because relatively small movements of the vessel, such as heave and rotational movements like yaw, pitch and roll, will result in relatively large movements of the crane’s suspension point, especially under rough environmental conditions.

Patent applications US2010/0230370 and WO2009/036456 disclose floating vessels with a crane for lifting loads, in which the crane system is provided with (vertical) heave compensation for wind and wave induced vessel motion. The disclosed heave compensation employs automatic control of the winch that carries the load line, based on to heave moment measurements. Consequently, only vertical heave motion is compensated for in the described crane systems.

Patent application GB2252295 discloses a control system for an offshore crane on a floating vessel. The disclosed system provides vessel motion compensation by automatic slew (rotational) motor control of the crane base with respect to the vessel hull. As a result, the disclosed system helps reducing swinging motion of the load suspended above the water surface.

SUMMARY

It is an object to provide a device and method for positioning and suspending diver transfer equipment and/or diver equipment overboard a floating vessel and into a body of water, with increased accuracy and safety, in particular under rough environmental conditions.

Therefore, according to a first aspect, there is provided a vessel comprising a crane for positioning diver transfer equipment and/or diver equipment overboard the vessel into a body of water, whereby the crane comprises: - a crane base that is connected to the vessel; - a crane arm with a suspension point that is movably
connected to the crane base; control means for controlling the crane arm configuration to place the suspension point at a position with respect to the crane base; whereby the control means are configured for:

- determining a change in position and/or orientation of the crane resulting from vessel motion, and
- dynamically adjusting the crane arm configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane.

The described vessel allows for positioning a diving chamber (possibly carrying diver personnel) and/or equipment overboard the vessel in a safe and accurate way, for example by cross-hauling, even when the vessel moves up and down due to waves (heave) and in case of vessel orientation changes such as yaw, pitch and roll movements. The control means may be arranged to compensate for lateral movements of the vessel (sway and surge), although such movements may also be compensated by a known dynamic positioning system present on the vessel. Such a vessel could be used to position the load to an underwater position and keeping it relatively steady despite movements of the vessel. This makes it for instance possible for divers to work while the diver transfer equipment and diver operational equipment is being held nearby and readily accessible in a steady position by the crane. The crane arm may comprise a number of actuators to move the crane arm and to thereby position the suspension point at a desired position. The configuration of the crane may be three-dimensionally adjustable, based on a change in a position or orientation of the crane, and by cooperation of one or several of the motion compensation systems described below, in such a way that objects suspended from the crane (e.g. diving transfer equipment) are kept at least partially steady irrespective of environmental influences. The term “position” is herein identified with a set of location parameters (e.g. x-y-z), and distinguished from the term “orientation”, which refers to a set of rotational parameters (e.g. pitch-yaw-roll). If it is required to deploy the load at a significant horizontal distance away from the vessel hull, then without further measures, the deflection of the load attached at or near the suspension point of the crane would be greatly enhanced by environmentally induced vessel motion, the enhancement being attributable to the lever effect on the free end of the crane arm. By dynamically adjusting the crane configuration and in response to a change in position of the vessel (i.e. the crane base), the suspension point can be kept at least partially steady. Thus, swinging of the load
carried at the suspension point and above the water line due to sudden vessel
movements is compensated for. Also, wave forces acting on the load while traversing
the splash-zone may be reduced by actively adapting the crane tip motion parallel to the
wave motion.

According to an embodiment, the crane arm comprises a plurality of
interconnected arm segments, the control means being configured for controlling
relative orientations of the arm segments in response to the determined change in
position and/or orientation of the crane.

A crane arm having two or more interconnected arm segments that are
repositionable with respect to each other and the crane base (which requires at least two
movable interconnections) has sufficient motional degrees of freedom to provide on its
own all vessel/crane motion compensation capacity required for keeping the suspension
point steady. The arm segments may be interconnected by for example hingeable,
telescoping, and/or axially rotatable arm joints. The crane may comprise actuators, such
as hydraulic actuators, which can move the different arm segments with respect to each
other and keep the arm segments in desired relative orientations. Controlling the
relative orientation of the arm segments may be advantageous to compensate for lateral
movements of a vessel (sway and surge) in a direction parallel to the horizontal
direction of the crane arm.

According to an embodiment, the crane arm is movably attached to the crane base
with hydraulic repositioning means controllable by the control means for adjusting a
pitch-and-roll configuration of the crane arm in response to the determined change in
position and/or orientation of the crane.

Advantageously, the hydraulic repositioning means enables dynamic
compensation of the crane configuration with respect to pitch and/or roll changes in the
orientation of the vessel (and consequently in the orientation of the fixed crane base).
Consequently, suspension point adjustment is enabled in response to wave induced
vessel motion.

According to an embodiment, the crane arm comprises a telescoping arm portion,
the control means being configured for controlling the extension and/or retraction of
the telescoping arm portion, thereby adjusting a projected arm length in response to the
determined change in position and/or orientation of the vessel or crane base.
The crane may comprise actuators, such as hydraulic actuators, which can extend or retract the telescoping arm portion or arm segments. Controlling such extendable and retractable arm segments may be advantageous to compensate for lateral movements of a vessel (sway and surge) in a direction parallel to the horizontal direction of the crane arm, but also for compensation of lateral movements of the crane tip resulting from a rolling motion of the vessel.

According to a further embodiment, the crane arm is rotatably connected to the crane base, the control means being configured for rotating the crane arm with respect to the crane base in response to the determined change in position and/or orientation of the vessel or crane base.

According to yet a further embodiment, the crane arm is rotatable about a vertical rotation axis.

Rotating the crane arm with respect to the crane base about a vertical rotational axis may be advantageous to compensate for a rotational change of orientation of the vessel about a vertical axis (yaw), or for compensation of lateral movements of the crane tip resulting from pitching of the vessel.

According to another further embodiment, the crane arm is rotatable about at least two horizontal rotation axes.

Rotating the crane arm about two or more horizontal rotational axes may be advantageous to compensate for pitch-and-roll movements of the vessel, while holding the suspension point at a fixed projected horizontal distance from the vessel hull.

According to an embodiment, the vessel comprises a crane kinematics sensor for determining the change in position and/or orientation of the crane.

The crane kinematic sensor may for instance be mounted on the crane, such as on the base or on/close to the suspension point to directly measure changes in position and/or orientation of the crane. The kinematic sensor may be formed as part of the control means, and may comprise one or more of an acceleration sensor, a gyroscope and a global positioning system. According to a further embodiment, the crane kinematics sensor is positioned on or close to the suspension point. By providing the kinematic sensor on or close to the suspension point of the crane, feedback can be obtained about the dynamic compensation and corrections may be made to further improve the dynamic compensation.
According to an embodiment, the vessel comprises a vessel kinematics sensor for determining a change in position and/or orientation of the vessel, whereby the control means are configured for dynamically adjusting the crane arm configuration to change the position of the suspension point based on the determined change in position and/or orientation of the vessel.

The vessel kinematics sensor may be provided alternatively or in addition to the crane kinematics sensor described herein above. Furthermore, the vessel kinematics sensor may be formed as part of the crane control means, and may also comprise one or more of an acceleration sensor, a gyroscope and a global positioning system.

Alternatively, the vessel kinematics sensor may be already installed on the vessel as part of the vessel positioning and motion reference system, e.g. navigation control or dynamic positioning (DP) system. If the DP-system is active, the planar motion of the vessel can be already (at least partially) compensated for by the DP thrusters, and the crane arm configuration need only be dynamically adjusted to compensate for the remaining vessel motion components. The vessel motion data measured by the vessel kinematics sensor may in any case be used as input for the crane control means.

According to yet a further embodiment, the control means are configured for determining a change in height of the crane due to a heave movement of the vessel, and for controlling the crane arm to change the height of the suspension point with respect to the base in an opposite direction.

Such an embodiment has the advantages that the load is not constantly moving up and down with the vessel, which could cause damage, especially when the diving bell or equipment is closely above the water surface above a rising wave while the vessel performs a downward movement. Controlled height adjustment of the crane suspension point may be supplemented by control of the winch in order to increase or reduce hoisting wire length.

According to another further embodiment, the control means are configured for determining a change in orientation of the crane due to a rotational movement of the vessel, and for controlling the crane arm to change the orientation of the suspension point with respect to the base to compensate for the determined change in orientation.

Often, the crane is attached to the vessel near an edge of the deck, and not in the vessel’s centre of rotational motion. Consequently, the position of the entire crane will change during rotational (i.e. pitch-roll-yaw) movement of the vessel. This embodiment
has the advantage that the diver personnel and or diver equipment is not subjected to relatively large swaying motions resulting from wave induced vessel rotation, which could cause seasickness or damage. Furthermore, impact with the water surface is, especially when the diver personnel or diver equipment is closely above the water surface and hits the water surface with great force because of the swaying motions.

According to a second aspect, and in accordance with the advantages and effects described herein above, a crane is provided for positioning and suspending diver transfer equipment and/or diver equipment overboard a vessel into a body of water, whereby the crane comprises: - a crane base, a moveable crane arm and a suspension point, - control means for controlling the crane arm to position the suspension point at a relative position with respect to the crane base, characterized in that the control means are configured for: - determining a change in position and/or orientation of the crane base, and - dynamically adjusting the crane configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane base.

The crane base may be configured for mounting to the deck of a floating vessel.

According to a third aspect, and in accordance with the advantages and effects described herein above, a method is provided for positioning and suspending diver transfer equipment and/or diver equipment overboard a vessel and into a body of water, using a crane positioned on the vessel, the crane comprising a crane base, a moveable crane arm and a suspension point, the method comprising: a) controlling the crane arm to position the suspension point at a relative position with respect to the crane base; b) determining a change in position and/or orientation of the crane resulting from the vessel motion, and c) dynamically adjusting the crane configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane.

According to an embodiment, the method comprises: - determining a local vertical motion of the body of water with respect to the vessel, and - dynamically adjusting the crane arm configuration to change the position of the suspension point
with respect to the crane base so as to at least partially compensate for the local vertical motion of the body of water.

The local vertical motion of the body of water refers to local wave motion at or near the location of the water surface coinciding with the vertical projection of the suspension point. Such wave motion may for example be measured by a floating buoy with a vertical position detector, from which local wave motion measurement data is received by the crane control means and used as input for the dynamic crane arm configuration adjustment. Advantageously, by compensating for the local wave motion, the impact of the suspended diver equipment upon traversing the water surface into the water body (i.e. the “splash-zone”) will be significantly diminished.

According to an embodiment, the method comprises: - determining a target position of the suspension point, wherein action a) comprises positioning the suspension point at the target position, wherein action b) comprises determining a current position of the suspension point and determining a change in position of the suspension point. The target position is defined with respect to an earth (global) coordinate system.

According to another embodiment, the method comprises: using distinct cranes for separately positioning each of the diver transfer equipment and the diver equipment overboard the vessel and into the body of water, whereby the respective cranes are positioned on the vessel, and comprise respective crane bases, respective moveable crane arms and respective suspension points, the method comprising: - controlling the respective crane arms to position the respective suspension points at relative positions with respect to the respective crane bases; - determining changes in positions and/or orientations of the respective cranes; - dynamically controlling the respective crane arms to change the relative positions of the respective suspension points with respect to the respective crane bases to at least partially compensate for the determined changes in positions and/or orientations of the respective crane bases; - keeping the respective suspension points at least partially steady with respect to each other.

Advantageously, the diver transfer equipment and diver equipment can be freely suspended in the body of water by means of the pair of dynamically compensated cranes, and kept relatively steady with respect to the (earth fixed) operational target as well as each other.
According to an embodiment, the method comprises: - suspending the diver transfer equipment and/or diver equipment in the body of water below a water surface while dynamically adjusting the crane arm configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane resulting from vessel motion. The proposed method is thus employed during diving operations, with the result of keeping the diver and tool deployment location steady for the divers and close to the target.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Embodiments will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

FIG. 1 schematically shows a schematic rear view of a diving support vessel according to an embodiment;

The figures are meant for illustrative purposes only, and do not serve as restriction of the scope or the protection as laid down by the claims.

DETAILED DESCRIPTION

Fig.1 schematically shows a rear view of a diving support vessel 10 that is floating in a body of seawater 2 bounded from above by a water surface 4 and from below by a seafloor 6. The vessel 10 is floating in the proximity of a platform 8 that is supported by the seafloor 6, the vessel 10 being located at a sufficient distance for avoiding accidental collision with a support structure of the platform 8. The vessel 10 as shown in Fig. 1 has two cranes 12, one of which is used for positioning diver transfer equipment 36 (here, a diver bell) and the other for positioning diver equipment 38 (here, a repair tool basket or working basket) overboard the vessel 10 into the water body 2. Each crane 12 comprises a crane base 24 that is connected to the vessel 10 at a top side of its hull. Each crane 12 further comprises a crane arm 14 with a load suspension point 16 at a remote end of the crane arm 14. Each suspension point 16 carries a cable 30 that is attached at a connection point 34 to a load, in this case the diver bell 36 or diver equipment 38. By moving the crane 12 and changing a length of the cable 30, the load 36, 38 can be hoisted into and out of the water body 2. The diver bell 36 and/or diver equipment 38 are supplied with required resources (e.g. power,
communication, etc) through an umbilical 32 connected to resource units on the vessel 10.

The crane arms 14 are rotatably connected to respective crane bases 24. A first one of the crane arms 14 comprises a plurality of hingably interconnected arm segments 21, which are mutually repositionable by linear arm actuators or pistons 23, allowing the crane 12 to be vertically raised and lowered and horizontally extended and retracted. A typical length for the arm segments 21 for a crane 12 used for the purpose described herein is 5 – 15 metres, resulting in a typical horizontal projected hoisting distance D1 of 10 to 30 meters away from the vessel hull.

The second crane arm 14 has a telescoping arm portion 20, which is extendable and retractable with respect to an arm segment 21 that is hingably connected to its crane base 24. Furthermore, the second crane arm 14 is at a lower end of the arm segment 21 movably attached to the crane base 24 by means of hydraulic repositioning means 27. Both crane arms 14 are rotatably connected to their crane bases 24 about vertical rotation axes. Rotatability about horizontal rotation axes is also provided for each crane arm 14 by means of the arm joints 22.

The vessel 10 has a known dynamic positioning system 28 including a vessel kinematics sensor 18 for determining a change in position and/or orientation of the vessel 10. Alternatively or in addition, each crane arm 14 has near its suspension point 16 a crane kinematics sensor 19 for determining the change in position and/or orientation of the crane 12 at the suspension point 16.

Control means 26 are provided for controlling the configuration of each crane arm 14 to move the corresponding suspension point 16 to a desired position with respect to the crane base 24. The control means 26 are configured for determining a change in position and/or orientation of the crane suspension point 16 resulting from vessel motion. This change in position of the suspension point 16 is determined from measurements by vessel kinematics sensor 18 and/or the crane kinematics sensor 19. The position of the crane base 24 may for instance be derived from positional measurement data for the vessel 10, which are collected by the vessel kinematics sensor 18.

The crane configuration control means 26 control the dynamic adjustment of the configurations of both crane arms 14 to change the positions of the respective suspension points 16 with respect to their crane bases 24, so as to at least partially
compensate for the change in position and/or orientation of the cranes 12 as measured by the crane kinematics sensors 19, and supplemented or substituted by the change in position and/or orientation of the vessel 10 as measured by the vessel kinematics sensor 18. The control means 26 is configured for rotating each of the crane arms 14 with respect to the crane bases 24 in response to the determined change in position and/or orientation of the crane 12 or vessel 10. The control means 26 is thus arranged to receive measurement data from the kinematics sensors 18, 19, process this information to compute a change in position of the suspension points 16 and control the actuators 23 to compensate for this change.

The control means 26 is configured for dynamically adjusting the relative orientations of the arm segments 21 and arm joints 22 for the first crane 12, in response to the determined changes in position and/or orientation, by controlling the arm actuators 23. Furthermore, the control means 26 is configured for controlling the extension and retraction of the telescoping arm portion 20 for the second crane 12, thereby adjusting a projected arm length in response to the determined change in position and/or orientation of the crane 12 or vessel 10.

A wave measurement system may be installed, for instance formed by a floating buoy 40 which is located in the water body 2 at or near a location in which the suspension cables 30 intersect the water surface 4. The buoy 40 is provided with a sensor configured for measuring a local vertical wave motion with respect to the vessel 10. Measurement data of the local water level executed by the buoy 40 sensor is transmitted to and interpreted by the crane configuration control unit 26, which data is utilised for adjusting the configurations of the crane arms 14 to change the positions of the suspension points 16 with respect to the respective crane bases 24 so as to at least partially compensate for the local vertical motion of the body of water 2.

The diver bell 36 and equipment 38 are preferably deployed at a significant horizontal distance D1 away from the vessel hull, a significant distance herein corresponding with a range of 5 to 50 meters, and preferably 10 to 20 meters. Without further measures, the deflection of the loads 36, 38 attached at or near the suspension points 16 would be greatly enhanced by environmentally induced vessel motion, the enhancement being attributable to the lever effect on the free end of the crane arms 14. By dynamically adjusting the configurations of the crane arms 14 in at least two dimensions, and in response to a change in position and/or orientation of the vessel 10
or the crane 12, the suspension points 16 are kept at least partially steady. Thus, swinging of the bell 36 and equipment 38 hoisted at the suspension points 16 and above the water surface 4 due to (sudden) vessel movements is compensated for.

So, the control means 26 may be arranged to receive measurement data from the kinematics sensors 18, 19 and the wave measurement system 40, process this information to control the actuators 23 to compensate for wave motions to reduce the impact of the positioning diver transfer equipment 36 (e.g. diving bell) and/or diver equipment 38 when hitting the water surface 4 and after having passed the water surface 4, receive measurement data from the kinematics sensors 18, 19, process this information to compute a change in position of the suspension points 16 and control the actuators 23 to compensate for this change. Once the water surface has been passed, the waves will no longer be able to hit the diver transfer equipment 36 (e.g. diving bell) and/or diver equipment 38. Of course, the wave measurement system 40 may cooperate with the vessel kinematics sensor 18 to predict vessel motion.

According to embodiments, there is provided a method for positioning diver transfer equipment 36 (e.g. diving bell) and/or diver equipment 38 overboard a side of a vessel 10 and into a body of water 2, using a crane 12 that is movably connected to the vessel 10 as described herein above. The method comprises: controlling the crane arm 14 to place the suspension point 16 at a relative position with respect to the crane base 24; determining a change in position and/or orientation of the crane 12 resulting from vessel motion, and dynamically adjusting the crane arm configuration to change the position of the suspension point 16 with respect to the crane 12 so as to at least partially compensate for the change in position and/or orientation of the crane 14 resulting from vessel motion.

The method may involve hoisting the bell 36 and/or diver equipment 38 from the suspension point 16 at a projected horizontal distance D1 from the vessel 10, while the configuration of the crane arm 14 is dynamically adjusted in three dimensions to at least partially compensate for the change in position and/or orientation of the crane 12 (or the vessel 10), so as to keep the suspension point 16 at least partially steady.

According to the embodiments, the configuration of the crane 12 is (three-dimensionally) adjusted based on a determined change of the vessel position and/or orientation, and by cooperation of some or all of the various motion compensation systems described herein above, in such a way that objects suspended from the crane 12
(e.g. diving bells 36, diver baskets, or equipment 38) are kept at least partially steady irrespective of environmental influences. The position and/or orientation of the vessel 10 refer to its position and/or orientation with respect to an earth fixed (global) coordinate system. The suspension point 16 is kept steady with respect to the same earth fixed coordinate system.

The diver transfer equipment 36 and diver equipment 38 can be suspended in the body of water 2 below the water surface 4, while the configurations of both crane arms 14 are jointly dynamically adjusted so as to change the positions of the respective suspension points 16 with respect to their crane bases 24.

A buoy 40 with water motion sensor may be used in the method for determining a local vertical motion of the water body 2 and with respect to the vessel 10 at or near the location in which the suspension cables 30 intersect the water surface 4. Based on measurement data of the local vertical wave motion, the configurations of the crane arms 14 are dynamically adjusted to change the position of the suspension points 16 with respect to the crane base 24 so as to at least partially compensate for the local vertical motion of the body of water 2.

According to a further embodiment a method is provided for positioning diver transfer equipment 36 and/or diver equipment 38 overboard a vessel 10 and into a body of water 2, using a crane 12 positioned on the vessel 10, the crane 12 comprising a crane base 24, a moveable crane arm 14 and a suspension point 16, the method comprising:
- determining a local vertical motion of the body of water 2 with respect to the vessel 10, and
- dynamically adjusting the crane arm configuration to change the position of the suspension point 16 with respect to the crane base 24 so as to at least partially compensate for the local vertical motion of the body of water 2 when transferring the diver transfer equipment 36 and/or diver equipment 38 through the water surface 4.

The descriptions above are intended to be illustrative, not limiting. It will be apparent to the person skilled in the art that alternative and equivalent embodiments of the invention can be conceived and reduced to practice, without departing from the scope of the claims set out below.
LIST OF FIGURE ELEMENTS

2 water body
4 water surface
6 seabed
5 8 platform
10 vessel
12 crane
14 crane arm
16 suspension point
10 18 vessel kinematics sensor
19 crane kinematics sensor
20 telescoping arm portion
21 arm segment
22 arm joint
15 23 arm actuator
24 crane base
26 control means
27 hydraulic repositioning means
28 dynamic positioning system
20 30 cable
32 umbilical and guide wires
34 connection point
36 diver transfer equipment
38 diver equipment
25 40 measurement buoy
D1 projected horizontal distance
CONCLUSIES

1. Vaartuig (10) omvattende een kraan (12) voor het overboord van het vaartuig (10) positioneren van duikerverplaatsingsuitrusting (36) en/of duikeruitrusting (38) in een waterlichaam (2), waarbij de kraan (12) omvat:
   - een kraanbasis (24) dat verbonden is met het vaartuig (10);
   - een kraanarm (14) met een ophangpunt (16) die beweegbaar verbonden is met de kraanbasis (24);
   - besturingsmiddelen (26) voor het besturen van de kraanarm (14) configuratie om het ophangpunt (16) op een positie ten opzichte van de kraanbasis (24) te plaatsen; waarbij de besturingsmiddelen (26) geconfigureerd zijn voor:
     - het bepalen van een verandering in positie en/of oriëntatie van de kraan (12) als gevolg van vaartuigbeweging, en
     - het dynamisch aanpassen van de kraanarmconfiguratie om de positie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om ten minste gedeeltelijk te compenseren voor de verandering in positie en/of oriëntatie van de kraan (12).

2. Vaartuig (10) volgens een van de voorgaande conclusies, waarbij de kraanarm (14) een aantal onderling verbonden armsegmenten (21) omvat, waarbij de besturingsmiddelen (26) geconfigureerd zijn voor het besturen van relatieve oriëntaties van de armsegmenten (21) in reactie op de bepaalde verandering in positie en/of oriëntatie van de kraan (12).

3. Vaartuig (10) volgens een van de conclusies 1 - 2, waarbij de kraanarm (14) beweegbaar verbonden is met de kraanbasis (24) via hydraulische verplaatsingsmiddelen (27), welke aanstuurbaar zijn door de besturingsmiddelen (26) voor het aanpassen van een pitch-en-roll configuratie van de kraanarm (14) in reactie op de bepaalde verandering in positie en/of oriëntatie van de kraan (12).

4. Vaartuig (10) volgens een van de conclusies 1 - 3, waarbij de kraanarm (14) een uitschuifbaar armgedeelte (20) omvat, waarbij de besturingsmiddelen (26) geconfigureerd zijn voor het besturen van de verlenging en/of intrekking van het
uitschuifbare armgedeelte (20), en daarmee aanpassen van een geprojecteerde
armlengte in reactie op de bepaalde verandering in positie en/of oriëntatie van de kraan
(12).

5. Vaartuig (10) volgens een van de conclusies 2 - 4, waarbij de kraanarm (14)
roteerbaar verbonden is met de kraanbasis (24), waarbij de besturingsmiddelen (26)
geconfigureerd zijn voor het roteren van de kraanarm (14) ten opzichte van de
kraanbasis (24) in reactie op de bepaalde verandering in positie en/of oriëntatie van de
kraan (12).

6. Vaartuig (1) volgens conclusie 5, waarbij de kraanarm (14) roterbaar is rondom
een verticale rotatie-as.

7. Vaartuig (10) volgens een van de conclusies 5 – 6, waar bij de kraanarm (14)
roteerbaar is rondom ten minste twee horizontale rotatieassen.

8. Vaartuig (10) volgens een van de voorgaande conclusies, omvattende een
kraankinematicsensor (19) voor het bepalen van een verandering in positie en/of
oriëntatie van de kraan (12).

9. Vaartuig (10) volgens een van de voorgaande conclusies, omvattende een
vaartuigkinematicsensor (18) voor het bepalen van een verandering in positie en/of
oriëntatie van het vaartuig (10), waarbij de besturingsmiddelen (26) gecombineerd zijn
voor het dynamisch aanpassen van de kraanarmconfiguratie om de positie van het
ophangpunt (16) te veranderen gebaseerd op de bepaalde verandering in positie en/of
oriëntatie van het vaartuig (10).

10. Vaartuig (10) volgens een van de conclusies 8 - 9, waarbij de besturingsmiddelen
(26) gecombineerd zijn voor het bepalen van een verandering in hoogte van de kraan
(12) ten gevolge van een bij beweging van het vaartuig, en voor het aanpassen van de
kraanarmconfiguratie om de hoogte van het ophangpunt (16) ten opzichte van de
kraanbasis (24) in een tegengestelde richting te veranderen.
11. Vaartuig (10) volgens een van de conclusies 8 - 10, waarbij de besturingsmiddelen (26) geconfigureerd zijn voor het bepalen van een verandering in oriëntatie van de kraan (12) ten gevolge van een draaibeweging van het vaartuig, en voor het aanpassen van de kraanarmconfiguratie om de oriëntatie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om te compenseren voor de bepaalde verandering in oriëntatie.

12. Kraan (12) voor het overboord van een vaartuig (10) positioneren van duikerverplaatsingsuitrusting (36) en/of duikeruitrusting (38) in een waterlichaam (2), waarbij de kraan (12) omvat:
- een kraanbasis (24), een beweegbare kraanarm (14) en een ophangpunt (16),
- besturingsmiddelen (26) voor het besturen van de kraanarm (14) om het ophangpunt (16) op een relatieve positie ten opzichte van de kraanbasis (24) te plaatsen, waarbij de besturingsmiddelen (26) geconfigureerd zijn voor:
- het bepalen van een verandering in positie en/of oriëntatie van de kraan (14) ten gevolge van vaartuigbeweging, en
- het dynamisch aanpassen van de kraanarm (14) configuratie om de positie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om ten minste gedeeltelijk te compenseren voor de verandering in positie en/of oriëntatie van de kraan (14).

13. Werkwijze voor het overboord van een vaartuig (10) positioneren van duikerverplaatsingsuitrusting (36) en/of duikeruitrusting (38) in een waterlichaam (2), met behulp van een kraan (12) geplaatst op het vaartuig (10), waarbij de kraan (12) een kraanbasis (24), een beweegbare kraanarm (14), en een ophangpunt (16) omvat, waarbij de werkwijze omvat:
- a) het besturen van de kraanarm (14) om het ophangpunt (16) op een relatieve positie ten opzichte van de kraanbasis (24) te plaatsen;
- b) het bepalen van een verandering in positie en/of oriëntatie van de kraan (14) ten gevolge van vaartuigbeweging, en
- c) het dynamisch aanpassen van de kraanarmconfiguratie om de positie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om ten minste
gedeeltelijk te compenseren voor de verandering in positie en/of oriëntatie van de kraan (14).

14. Werkwijze volgens conclusie 13, omvattende:
- het bepalen van een lokale verticale beweging van het waterlichaam (2) ten opzichte van het vaartuig (10), en
- het dynamisch aanpassen van de kraanarmconfiguratie om de positie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om ten minste gedeeltelijk te compenseren voor de lokale verticale beweging van het waterlichaam (2).

15. Werkwijze volgens conclusie 13 of 14, omvattende:
- het bepalen van een doelpositie van het ophangpunt (16), waarbij actie a) het positioneren van het ophangpunt (16) op de doelpositie omvat, waarbij actie b) het bepalen van een huidige positie van het ophangpunt (16) en het bepalen van een verandering in positie van het ophangpunt (16) omvat.

16. Werkwijze volgens een van de conclusies 13 - 15, omvattende:
- het gebruiken van afzonderlijke kranen (12) voor het individueel overboord van het vaartuig (10) positioneren van elk van de duikerverplaatsingsuitrusting (36) en de duikerveruitrusting (38) in het waterlichaam (2), waarbij de respectieve kranen (12) geplaatst zijn op het vaartuig (10), en respectieve kraanbases (24), respectieve beweegbare kraanarmen (14) en respectieve ophangpunten (16) omvatten, waarbij de werkwijze omvat:
- het besturen van de respectieve kraanarmen (14) om de respectieve ophangpunten (16) op relatieve posities ten opzichte van de respectieve kraanbases (24) te plaatsen;
- het bepalen van veranderingen in posities en/of oriëntaties van de respectieve kranen (12);
- het dynamisch besturen van de respectieve kraanarmen (14) om de relatieve posities van de respectieve ophangpunten (16) ten opzichte van respectieve kraanbases (24) te veranderen om ten minste gedeeltelijk te compenseren voor de bepaalde veranderingen in posities en/of oriëntaties van de respectieve kraanbases (24);
het ten minste gedeeltelijk onbeweeglijk ten opzichte van elkaar houden van de respectieve ophangpunten (16).

17. Werkwijze volgens een van de conclusies 13 - 16, omvattende:
- het hangen van de duikerverplaatsingsuitrusting (36) en/of duikeruitrusting (38) in het waterlichaam (2) onder een wateroppervlak (4) en tegelijkertijd het dynamisch aanpassen van de kraanarmconfiguratie om de positie van het ophangpunt (16) ten opzichte van de kraanbasis (24) te veranderen om ten minste gedeeltelijk te compenseren voor de verandering in positie en/of oriëntatie van de kraan (14) ten gevolge van vaartuigbeweging.
### SAMENWERKINGSVERDRAG (PCT)

**RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE**

<table>
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<tr>
<th>IDENTIFICATIE VAN DE NATIONALE AANVRAGE</th>
<th>KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE</th>
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Aanvrager (Naam)

**IHC Holland IE B.V.**

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<th>Datum van het verzoek voor een onderzoek van internationaal type</th>
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<td>21-01-2012</td>
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**I. CLASSIFICATIE VAN HET ONDERWERP** (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

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<td>B63B27/10</td>
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**II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK**

Onderzochte minimumdocumentatie

Classificatiesysteem: IPC

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Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

**III. GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES** (opmerkingen op aanvullingsblad)

**IV. GEBREK AAN EENHEID VAN UITVINDING** (opmerkingen op aanvullingsblad)

Form PCT/ISA 201 A (11/2000)
**ONDERZOEKRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

|------|------------|------------|------------|-----------|-----------|

**ADD.**
Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

**B. ONDERZOEKTE GEBIEDEN VAN DE TECHNIEK**
Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)

B66C B63B

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

**EPO-Internal**

**C. VAN BELANG GEACHTTE DOCUMENTEN**

<table>
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<tr>
<th>Categorie</th>
<th>Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages</th>
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<td>US 2010/089855 A1 (KJOLSETH PAUL M [US]) 15 april 2010 (2010-04-15) * alineas [0004], [0006], [0018], [0019], [0024], [0025], [0026]; figuren 1, 6, 7 * * alineas [0036] - [0040] * * conclusie 1 * -----</td>
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<td>US 6 496 765 B1 (ROBINETT III RUSH D [US] ET AL) 17 december 2002 (2002-12-17) * figuren 6-14 * * kolom 2, regels 18-32 * * kolom 4, regels 23-32 * * kolom 6, regels 8-15, 65 - kolom 7, regel 38 * * regel 36 - kolom 16, regel 65 * -----</td>
<td>1,5,6,8, 9,12,13</td>
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**Leden van dezelfde octrooifamilie zijn vermeld in een bijlage**

**Speciale categorieën van aangehaalde documenten**

- "A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
- "D" in de octrooianvrage vermeld
- "E" eerdere octrooiaanvrage, gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvoering wordt beschreven
- "L" om andere redenen vermelde literatuur
- "O" niet-schriftelijke stand van de techniek
- "P" tussen de voorrangssdatum en de indieningsdatum gepubliceerd literatuur

**Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltakt**

24 juli 2012

**De bevoegde ambtenaar**

Özsoy, Sevda
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<tr>
<td>X</td>
<td>US 5 961 563 A (OVERTON ROBERT H [US])&lt;br&gt;5 oktober 1999 (1999-10-05)&lt;br&gt;* kolom 1, regels 14-30; figuren 1,2 <em>&lt;br&gt;</em> kolom 3, regels 15-22, 40-55 <em>&lt;br&gt;</em> regel 65 - kolom 5, regel 66; conclusie 1 *</td>
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This opinion contains indications relating to the following items:

- Box No. I  Basis of the opinion
- Box No. II  Priority
- Box No. III  Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV  Lack of unity of invention
- Box No. V  Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- Box No. VI  Certain documents cited
- Box No. VII  Certain defects in the application
- Box No. VIII  Certain observations on the application
**WRITTEN OPINION**

**Box No. I  Basis of this opinion**

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
   
a. type of material:
      - [ ] a sequence listing
      - [ ] table(s) related to the sequence listing
   
b. format of material:
      - [ ] on paper
      - [ ] in electronic form
   
c. time of filing/furnishing:
      - [ ] contained in the application as filed.
      - [ ] filed together with the application in electronic form.
      - [ ] furnished subsequently for the purposes of search.

3. [ ] In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

**Box No. V  Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

   **Novelty**
   - Yes: Claims 4, 10, 11, 13-17
   - No: Claims 1-3, 5-9, 12

   **Inventive step**
   - Yes: Claims
   - No: Claims 1-17

   **Industrial applicability**
   - Yes: Claims
   - No: Claims 1-17

2. Citations and explanations

   see separate sheet

NL237B (July 2006)
Re Item V

1 REFERENCES CITED

Reference is made, at least partially, to the following documents:


D3 US 5 961 563 A (OVERTON ROBERT H [US]) 5 oktober 1999 (1999-10-05)


D6 GB 2 252 295 A (DAVIDSON JAMES DANIEL DAVIDSON JAMES DANIEL [GB]) 5 augustus 1992 (1992-08-05) in de aanvraag genoemd

2 INDEPENDENT CLAIMS 1 AND 12

2.1 Claim Interpretation

2.1.1 It has been observed that independent claims 1 and 12 both include the expression "a crane for positioning a diver transfer equipment and/or diver equipment overboard the vessel into a body of water".

2.1.2 Please note that, in the foregoing analysis, said formulation is construed as meaning a crane which is "suitable" for achieving the objectives of the present invention.

2.1.3 The crane disclosed in documents D1-D3 are suitable for positioning any equipment overboard a vessel into a body of water. Therefore, even though the diver equipment is not explicitly mentioned in those documents, the cranes disclosed therein have been considered to be "suitable for" achieving said purposes as well. Consequently, the disclosure of those documents are considered to be anticipating the subject-matter of claims 1 and 12.
2.2 Independent claim 1

2.2.1 Document D1 discloses (see esp. Figs. 1, 6, 7),
a vessel (OSV; see also paragraph [0018]) comprising a crane (11) for
positioning diver transfer equipment and/or diver equipment overboard
the vessel into a body of water (see paragraph [0018]; Document D1
describes cargo transfer between two vessels/platforms which are both
subject to wave induced motions. Hence it could be used equally well to
position diver equipment into a body of water.), whereby the crane
comprises:

- a crane base (see Fig. 1, the cylindrical part to the left-hand part of the
crane) that is connected to the vessel;

- a crane arm (see Fig. 1: the non-numbered boom, the jib 15 and the
manipulator 10) with a suspension point (13) that is movably connected
to the crane base;

- control means (paragraph [0036]) for controlling the crane arm
configuration to place the suspension point at a position with respect to
the crane base (paragraph [0037]);

whereby the control means are configured for:

- determining a change in position and/or orientation of the crane
resulting from vessel motion (last sentence of paragraph [0040]), and

- dynamically adjusting the crane arm configuration to change the
position of the suspension point with respect to the crane base so as to
at least partially compensate for the change in position and/or orientation
of the crane (paragraphs [0026], [0039] and [0040]).

The subject-matter of claim 1 is therefore not novel.

2.2.2 Please note that, documents D2 and D3 also disclose the subject-matter of
claim 1.

2.3 Independent claim 12

2.3.1 Document D1 discloses (see esp. Figs. 1, 6, 7),
a crane (11) for positioning diver transfer equipment and/or diver
equipment overboard the vessel into a body of water (see paragraph
[0018]; Document D1 describes cargo transfer between two vessels/
platforms which are both subject to wave induced motions. Hence it
could be used equally well to position diver equipment into a body of
water.), whereby the crane comprises:
- a crane base (see Fig. 1, the cylindrical part to the left-hand part of the crane), a moveable crane arm (see Fig. 1: the non-numbered boom, the jib 15 and the manipulator 10) and a suspension point (13);

- control means (paragraph [0036]) for controlling the crane arm to position the suspension point at a relative position with respect to the crane base (paragraph [0037]); whereby the control means are configured for:

- determining a change in position and/or orientation of the crane resulting from vessel motion (last sentence of paragraph [0040]), and

- dynamically adjusting the crane arm configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane (paragraphs [0026], [0039] and [0040]).

The subject-matter of claim 12 is therefore not novel.

2.3.2 Please note that, documents D2 and D3 also disclose the subject-matter of claim 12.

3 INDEPENDENT CLAIM 13

3.1 Document D1 discloses

a method for positioning a load (see claim 1) using a crane (11) positioned on the vessel (OSV), the crane comprising a crane base (see Fig. 1, the cylindrical part to the left-hand part of the crane), a moveable crane arm (see Fig. 1: the non-numbered boom, the jib 15 and the manipulator 10) and a suspension point (13), the method comprising:

a) controlling the crane arm to place the suspension point at a relative position with respect to the crane base (paragraph [0037]);

b) determining a change in position and/or orientation of the crane resulting from vessel motion (last sentence of paragraph [0040]), and

c) dynamically adjusting the crane arm configuration to change the position of the suspension point with respect to the crane base so as to at least partially compensate for the change in position and/or orientation of the crane (paragraphs [0026], [0039] and [0040]).

3.2 The subject-matter of claim 13 differs from this known document in that

the method is for positioning diver transfer equipment and/or diver equipment overboard a vessel into a body of water.
3.3 It is within the general knowledge of the person skilled in the art that the crane of D1 could be used for positioning diver equipment into a body of water. Hence, the subject-matter of claim 13 is not inventive over the available prior art.

3.4 Please note that, the above-mentioned inventive step objection could also be based on document D2 or document D3.

4 DEPENDENT CLAIMS

4.1 Dependent claims do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty and/or inventive step.

4.2 Document D1 discloses, in addition to the subject-matter of claim 1, the subject-matter of claims 2-3, 5-9, and 12. Hence the subject-matter of these claims is not novel over D1.

4.3 The features of claim 15 is also known from D1 (see esp. Fig. 7). Thus, a line of argumentation similar to that presented above (section 3) applies mutatis mutandis to claim 15 as well. The subject-matter of claim 15 is therefore not inventive over D1.

4.4 The subject-matter of claim 4 relates to the application of the control of claim 1 to a crane with a telescopic arm. It would be obvious for the person skilled in the art to apply the control of D1 to a crane with a telescopic crane arm. The subject-matter of claim 4 therefore does not involve an inventive step.

4.5 The features of claims 10, 11, 14 and 16-17 are merely some of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to solve the problems posed. The subject-matters of these claims are therefore not inventive.