US 20170191334A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2017/0191334 A1

(43) Pub. Date: Jul. 6, 2017

JAFFREY

(54) SYSTEMS AND METHODS FOR ENGAGING SUBSEA EQUIPMENT

(71) Applicant: CAMERON INTERNATIONAL CORPORATION, Houston, TX (US)

(72) Inventor: Andrew JAFFREY, Oldmeldrum (GB)

(73) Assignee: CAMERON INTERNATIONAL CORPORATION, Houston, TX (US)

(21) Appl. No.: 14/986,004

(22) Filed: Dec. 31, 2015

Publication Classification

(51) Int. Cl.

E21B 33/038 (2006.01)

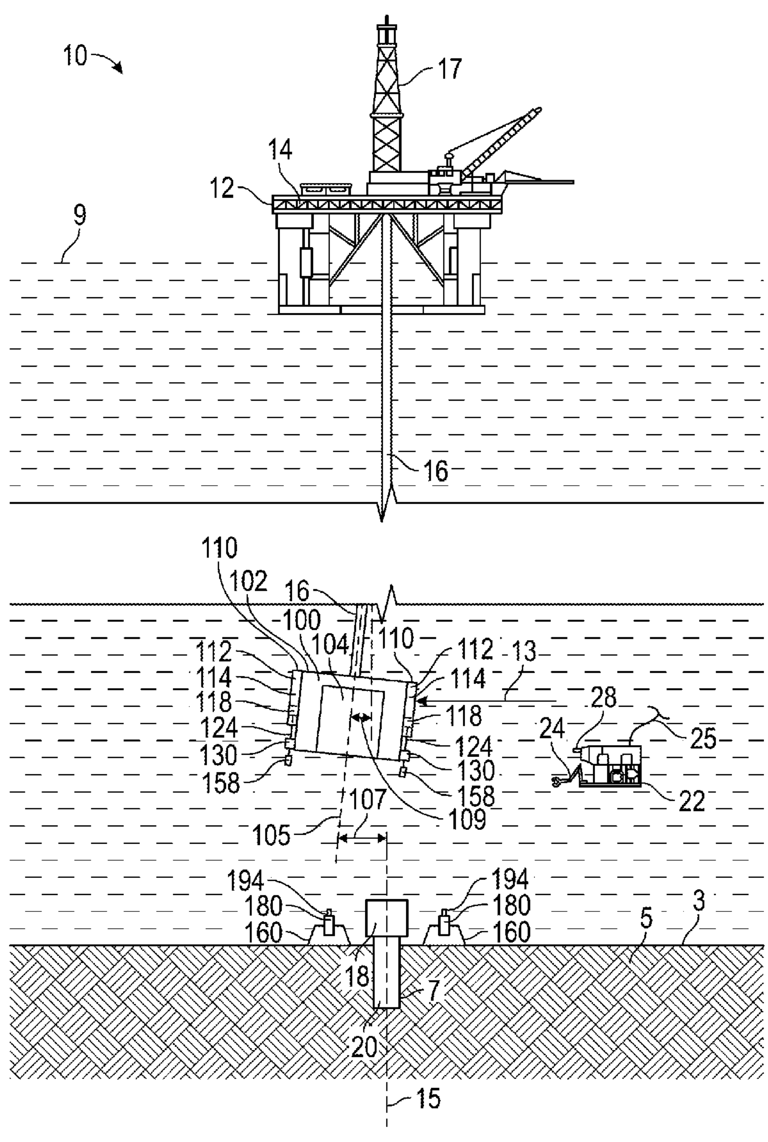
E21B 43/013 (2006.01)

(52) U.S. Cl.

CPC *E21B 33/038* (2013.01); *E21B 43/0135* (2013.01); *E21B 43/013* (2013.01)

(57) ABSTRACT

A system for landing a subsea component includes a retention assembly configured to be coupled to the subsea component, the retention assembly including a first connector, a cable extending between the connector and a tensioning assembly, and a releasable lock configured to selectably actuate the tensioning assembly between a locked position and an unlocked position, wherein, when the tensioning assembly is in the unlocked position, a tensioning force is applied to the cable, and an anchoring assembly configured to anchor to a sea floor, the anchoring assembly including a second connector configured to be coupled to the first connector of the retention assembly.



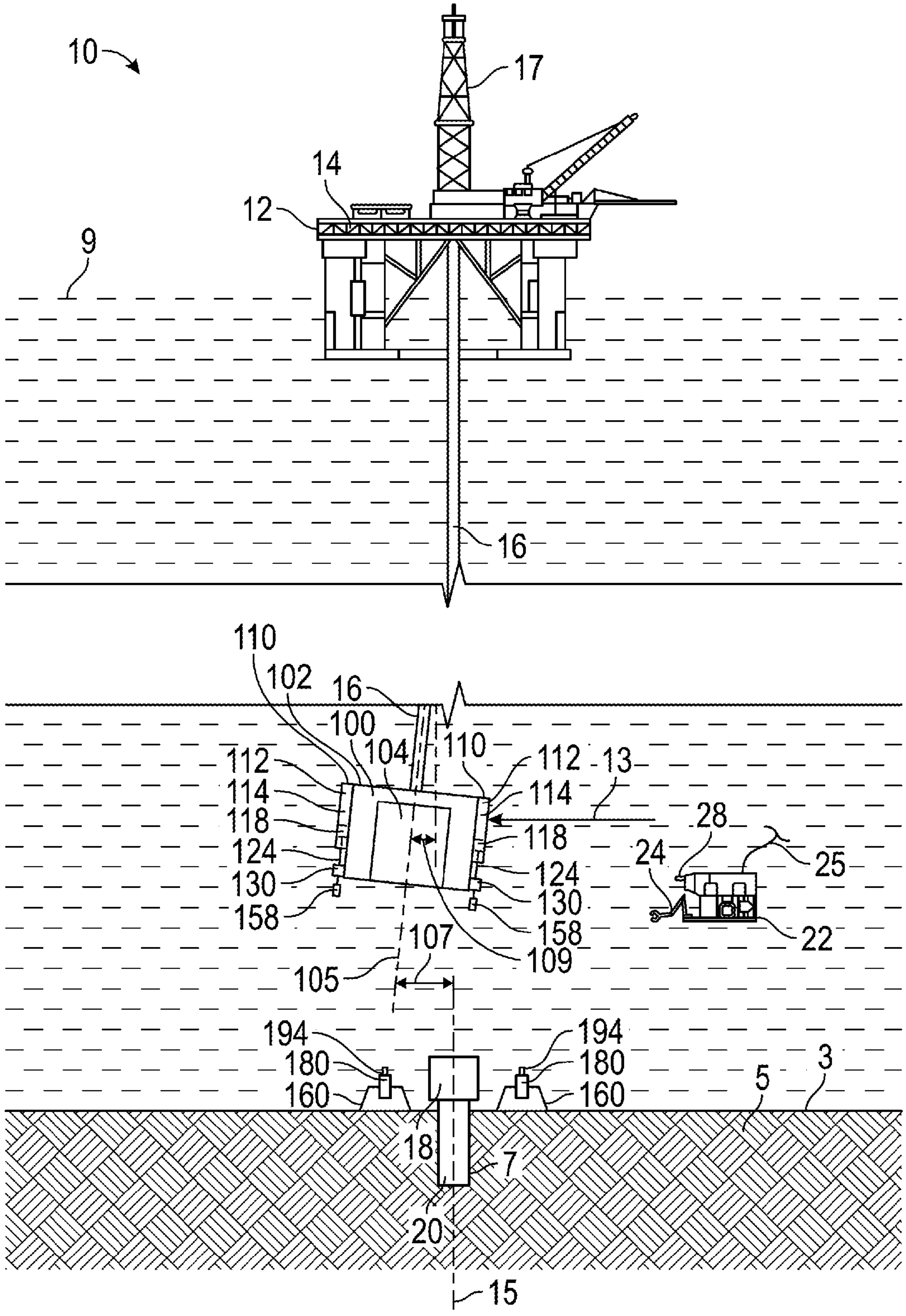

10
17
14
12
9
16
110
102
16
100
104
110
112
13
112
114
114
118
118
124
124
130
130
158
158
28
24
25
22
107
109
105
194
194
180
180
160
160
3
5
18
7
20
15

FIG. 1

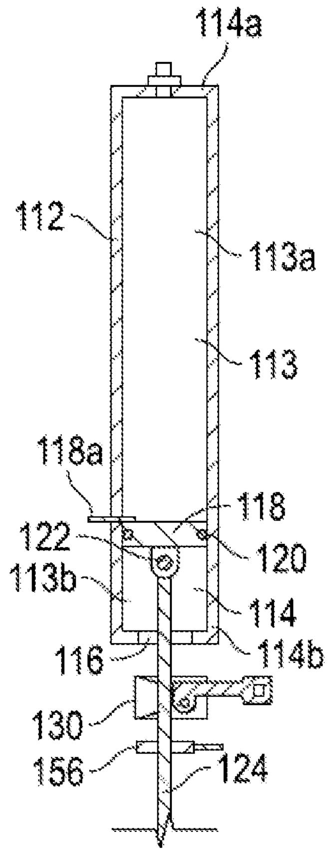


FIG. 2

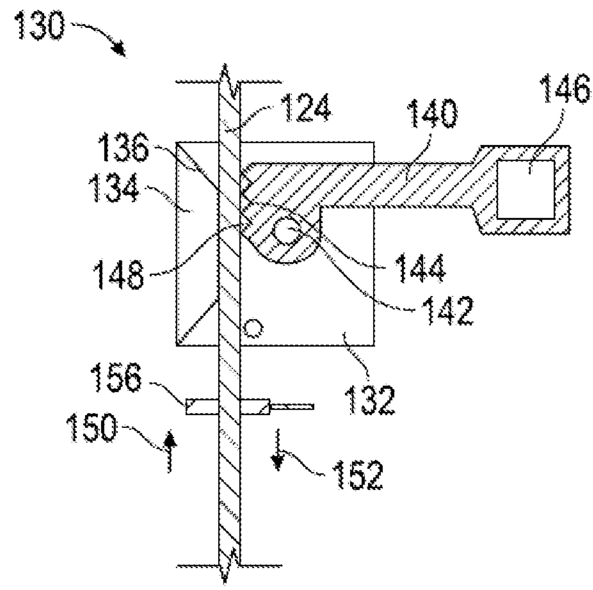


FIG. 3A

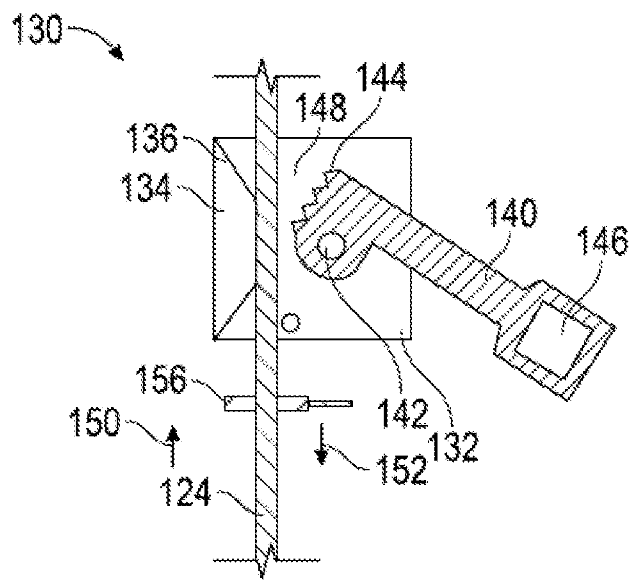


FIG. 3B

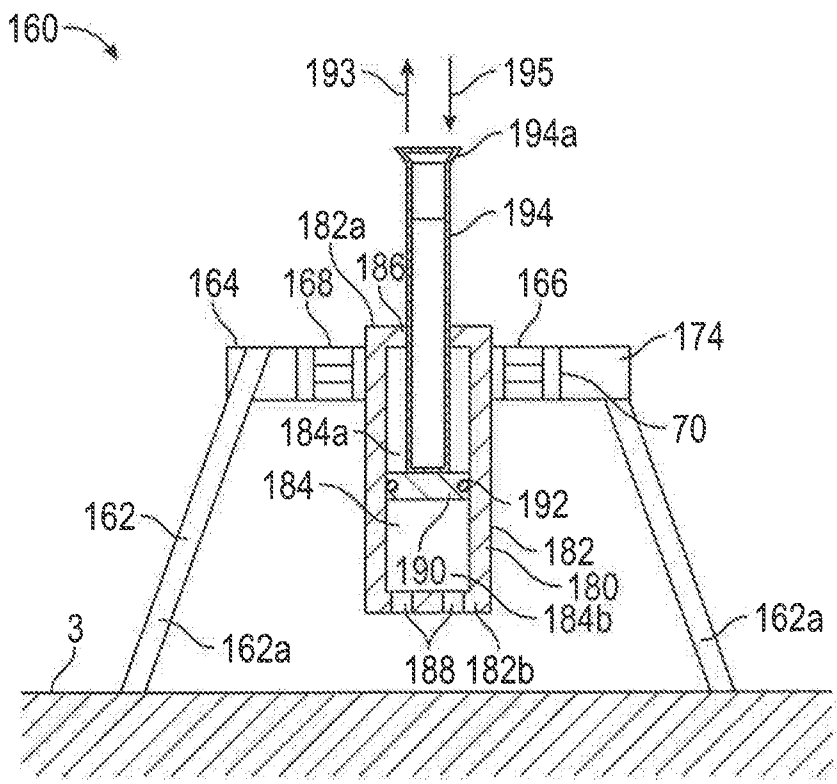

160
193
195
194a
194
182a
186
164
168
166
174
70
184a
184
192
162
182
190
180
184b
162a
3
162a
188
182b

FIG. 4A

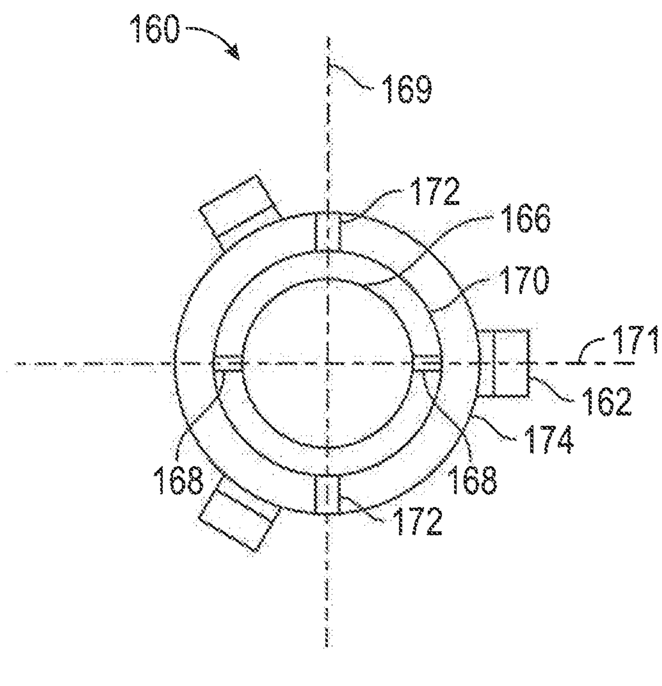

160
169
172
166
170
171
162
174
168
168
172

FIG. 4B

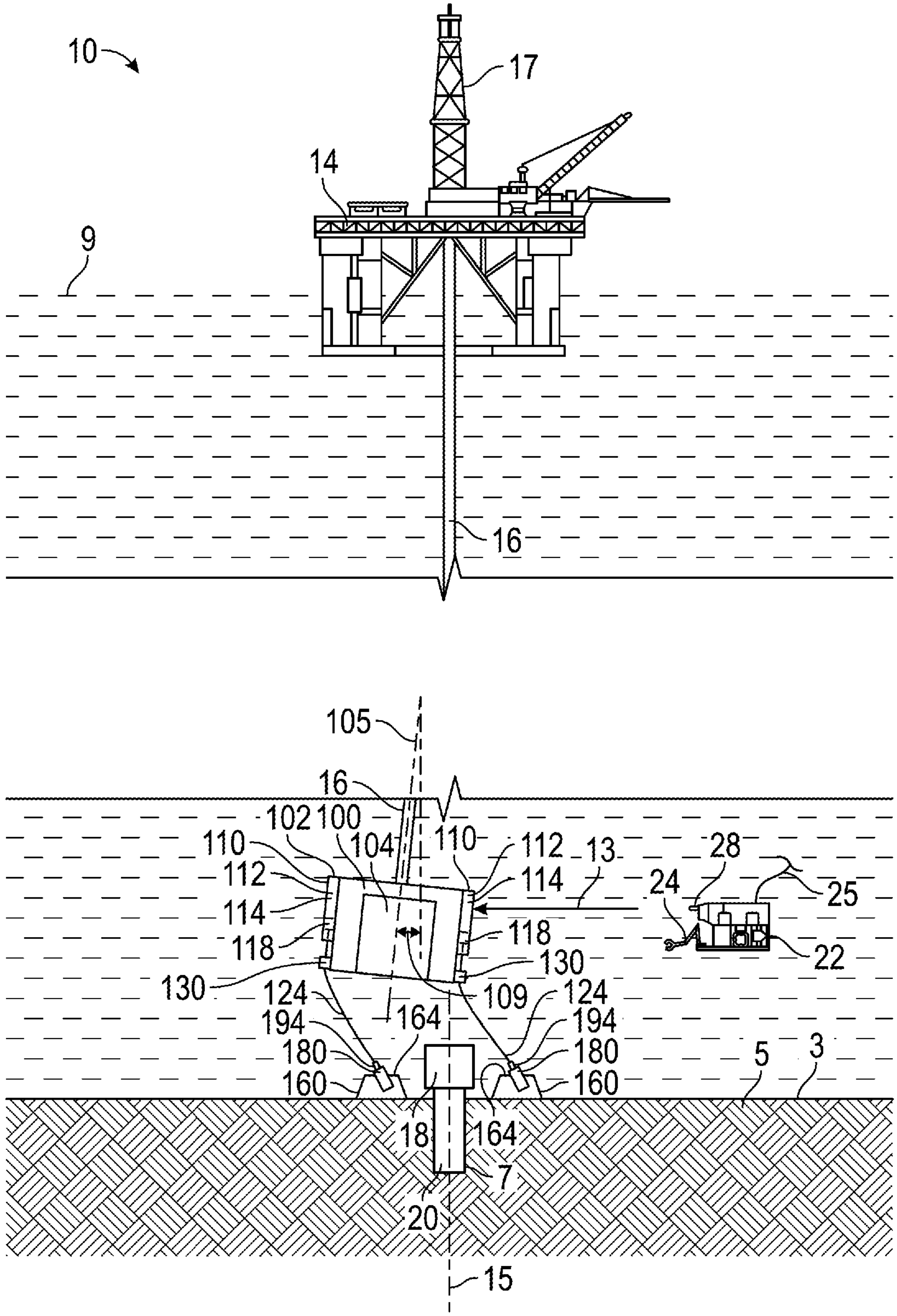

10
17
14
9
16
105
16
102
100
110
104
110
112
13
28
112
114
24
25
114
118
118
22
130
130
124
109
124
194
164
194
180
180
160
160
5
3
18
164
7
20
15

FIG. 5

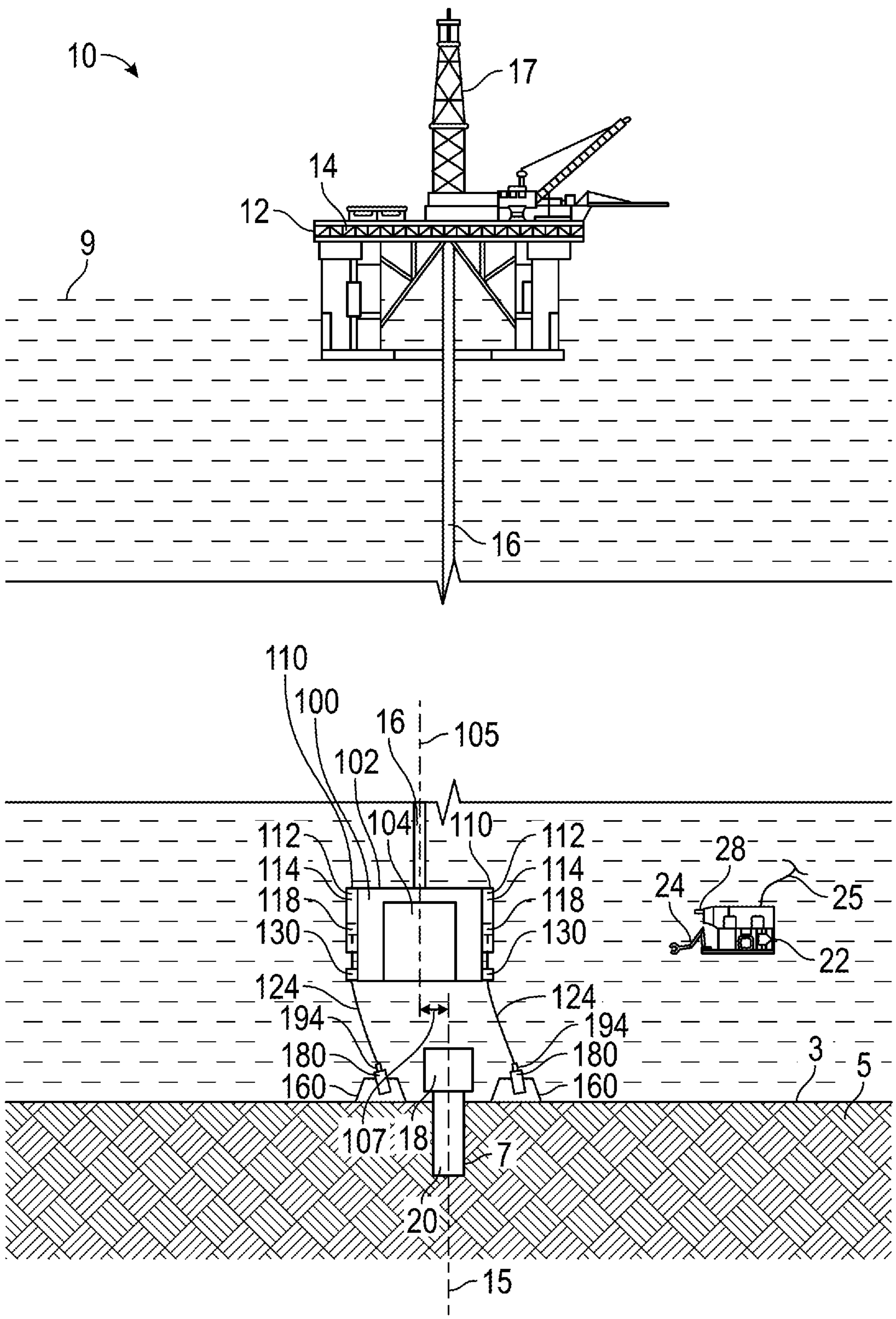

10
17
14
12
9
16
110
100
16
105
102
104
110
112
114
118
130
124
194
180
160
107
18
7
20
3
5
15
28
24
25
22

FIG. 6

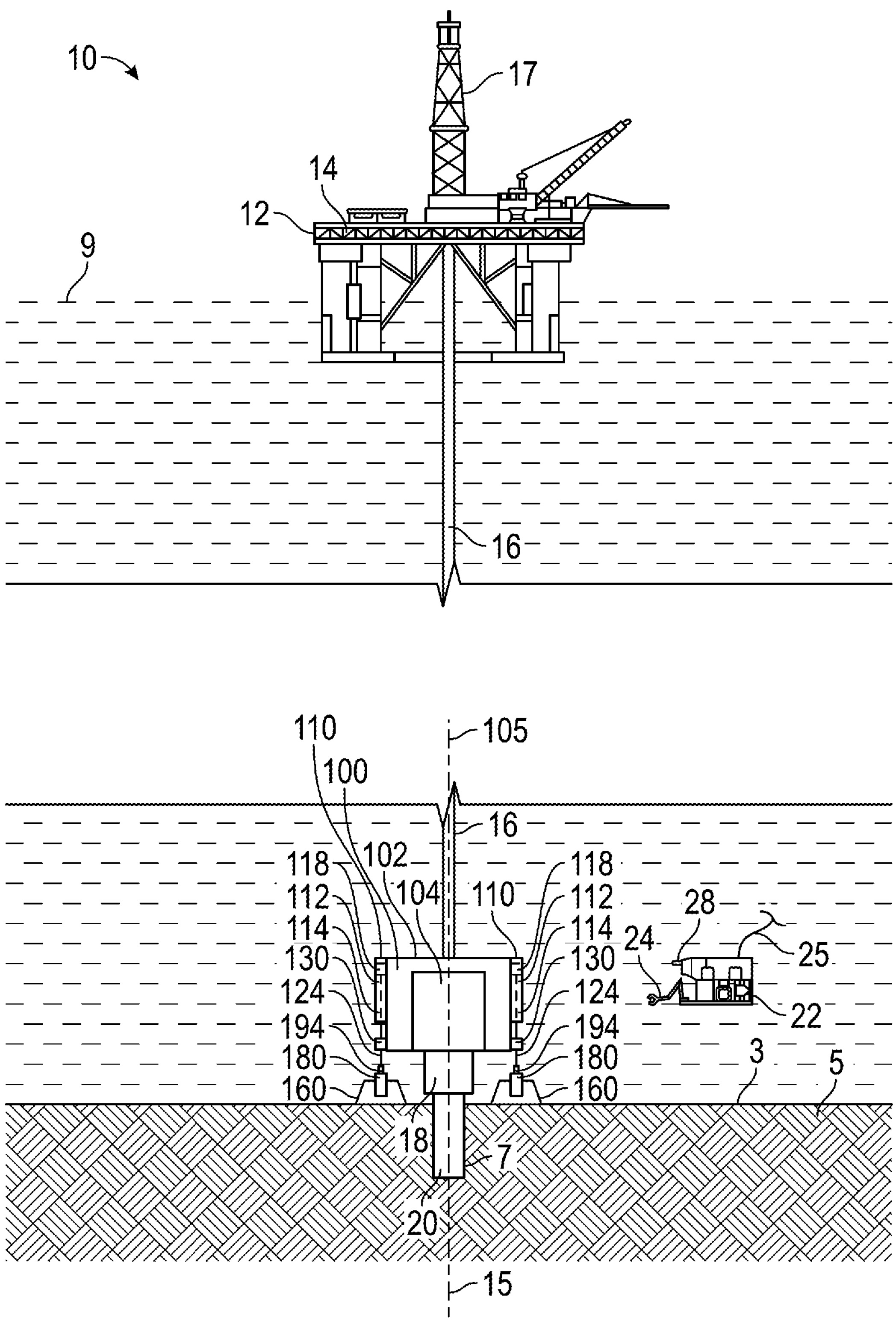

10
17
14
12
9
16
110
105
100
16
118
102
118
112
104
110
112
114
114
28
130
130
24
25
124
124
22
194
194
180
180
3
5
160
160
18
7
20
15

FIG. 7

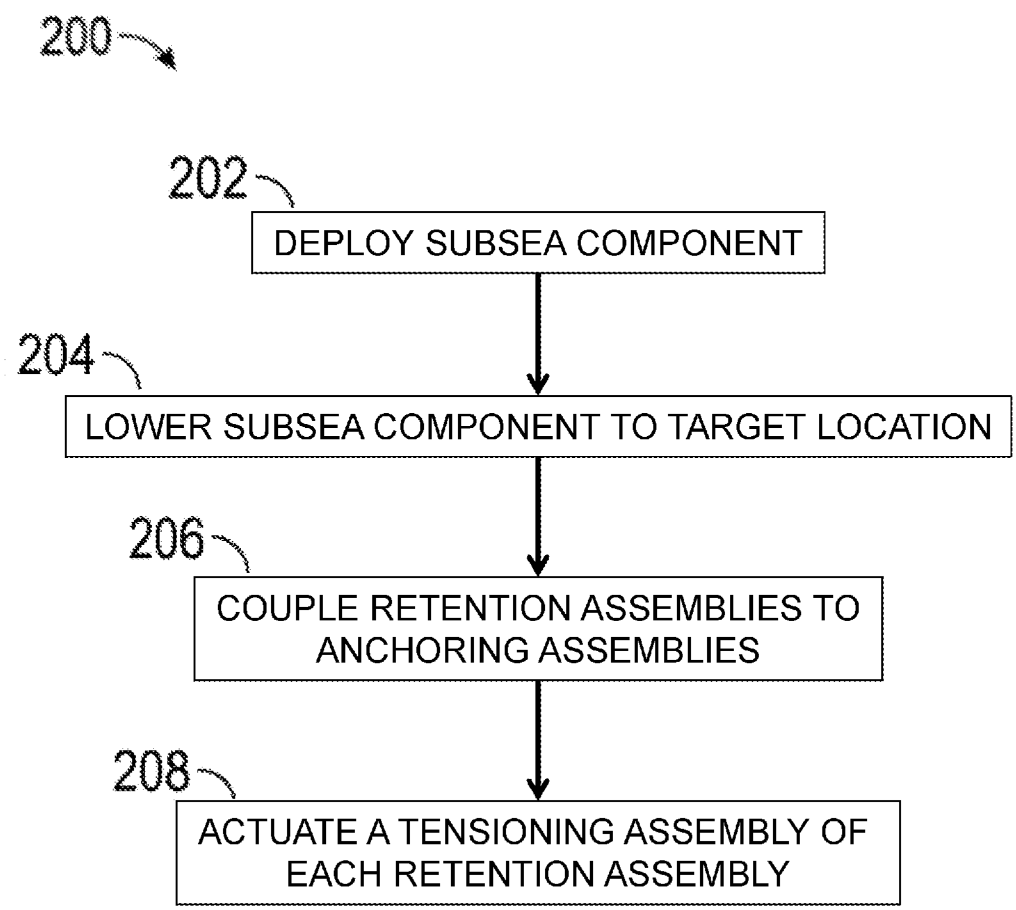

200
202
DEPLOY SUBSEA COMPONENT
204
LOWER SUBSEA COMPONENT TO TARGET LOCATION
206
COUPLE RETENTION ASSEMBLIES TO ANCHORING ASSEMBLIES
208
ACTUATE A TENSIONING ASSEMBLY OF EACH RETENTION ASSEMBLY

FIG. 8

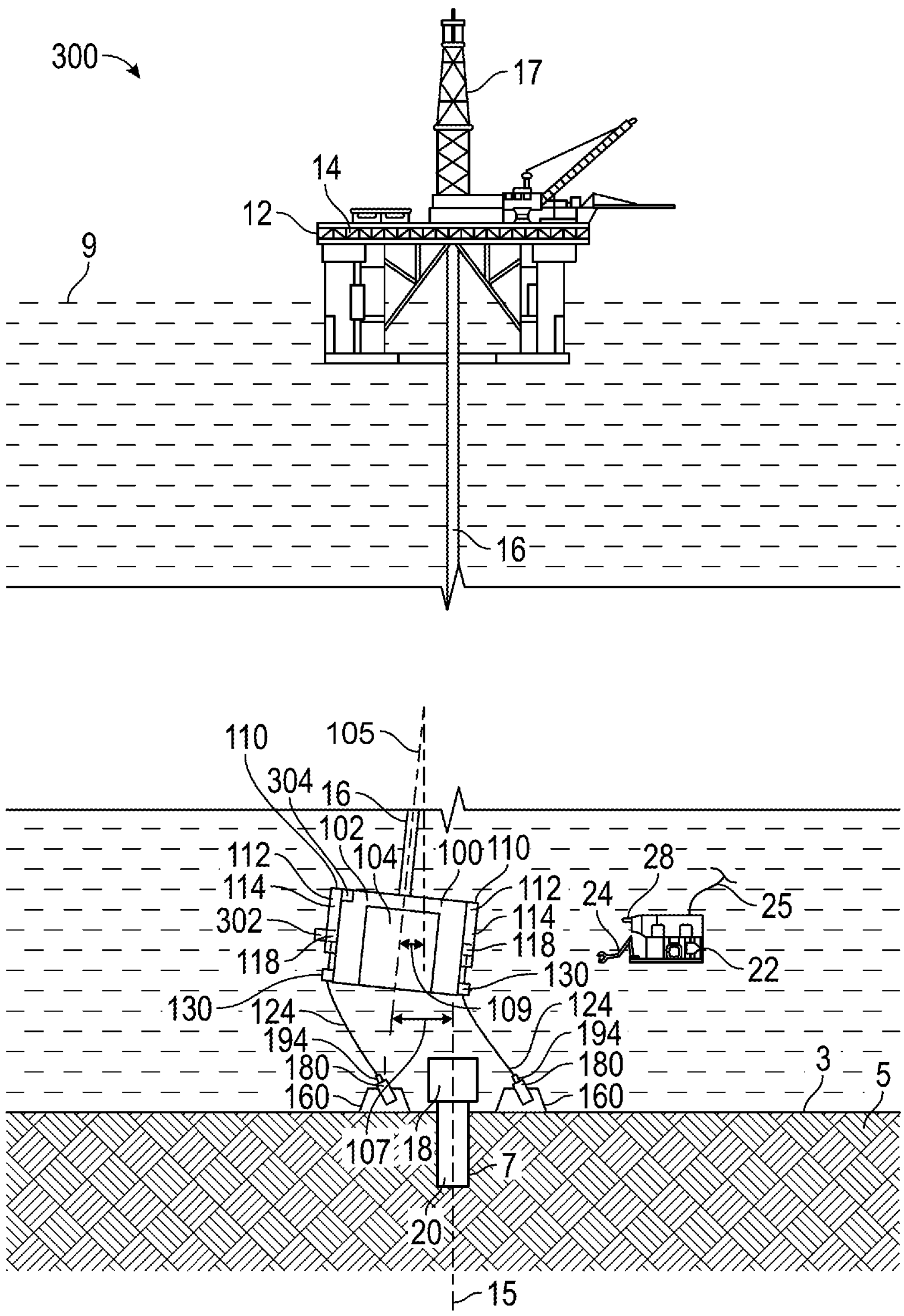

300
17
14
12
9
16
110
105
304
16
102
104
100
110
112
114
302
118
112
114
118
28
24
25
22
130
130
109
124
124
194
194
180
180
160
160
3
5
107
18
7
20
15

FIG. 9

SYSTEMS AND METHODS FOR ENGAGING SUBSEA EQUIPMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND

[0003] Hydrocarbon drilling systems utilize drilling fluid or mud for drilling a wellbore in a subterranean earthen formation. In some offshore applications, a conductor housing is installed through a temporary guidebase disposed on the sea floor, where the conductor housing is coupled to casing conductor that extends into the sea floor. A permanent guidebase follows the installation of the conductor housing in the sea floor, and a wellhead housing is then installed within the conductor housing disposed on the sea floor. Once the conductor and wellhead housings are secured on the sea floor, a blowout preventer (BOP) stack is secured to the wellhead housing for controlling the flow of fluid into and out of the wellbore. Following the installation of the BOP stack, a lower marine riser package (LMRP) is secured to the BOP stack for providing a conduit for drilling fluids between a drilling vessel at the surface and the wellhead disposed on the sea floor. Each of the components described above, including the BOP stack and LMRP, may be installed at the sea floor by lowering the components from a drilling vessel or semi-submersible drilling rig disposed at the surface. Specifically, the components may be suspended from a marine riser, cable, or other component and lowered towards the sea floor. In some applications, the drilling vessel includes a heave compensation system for maintaining the vertical position (e.g., the vertical distance to the sea floor) of the suspended component as the drilling vessel is displaced vertically at the surface due to waves or other turbulence.

SUMMARY

[0004] An embodiment of a system for landing a subsea component comprises a retention assembly configured to be coupled to the subsea component, the retention assembly comprising a first connector, a cable extending between the connector and a tensioning assembly, and a releasable lock configured to selectably actuate the tensioning assembly between a locked position and an unlocked position, wherein, when the tensioning assembly is in the unlocked position, a tensioning force is applied to the cable, and an anchoring assembly configured to anchor to a sea floor, the anchoring assembly comprising a second connector configured to be coupled to the first connector of the retention assembly. In some embodiments, the retention assembly further comprises a locking assembly configured to allow the passage of the cable through the locking assembly in a first direction towards the retention assembly, and restrict passage of the cable through the locking assembly in a second direction away from the retention assembly. In some embodiments, the tensioning assembly comprises a cylinder configured to couple to the subsea component, and a piston slidably disposed in the cylinder and coupled to an end of the cable, wherein the cylinder includes an open end for providing fluid communication between a first end of the piston and the subsea environment. In certain embodiments, when the tensioning assembly is in the locked position, the releasable lock physically engages the piston to restrict the piston from being displaced through the cylinder, and when the tensioning assembly is in the unlocked position, the piston is displaced through the cylinder in response to fluid pressure acting against the first end of the piston. In some embodiments, in response to the piston being displaced through the cylinder, the cable is passed through the locking assembly to reduce slack in the cable. In some embodiments, the anchoring assembly comprises a first ring concentrically disposed in a second ring, and a third ring, wherein the first and second rings are each concentrically disposed in the third ring, wherein the first ring is pivotally coupled to the second ring such that the first ring is configured to pivot about a first axis relative to the second ring, and wherein the second ring is pivotally coupled to the third ring such that the second ring is configured to pivot about a second axis relative to the third ring. In certain embodiments, the anchoring assembly comprises a damper configured to damp forces applied to the subsea component when the first connector is coupled to the second connector.

[0005] An embodiment of a system for landing a subsea component comprises a first subsea component, a retention assembly coupled to the first subsea component, the retention assembly comprising a first connector, a cable extending between the connector and a tensioning assembly, wherein the tensioning assembly is configured to apply a tensioning force to the cable, a locking assembly configured to allow the passage of the cable through the locking assembly in a first direction towards the retention assembly, and restrict passage of the cable through the locking assembly in a second direction away from the retention assembly, and an anchoring assembly configured to anchor to a sea floor, the anchoring assembly comprising a second connector for coupling with the first connector of the retention assembly. In some embodiments, the retention assembly further comprises a releasable lock configured to selectably actuate the tensioning assembly between a locked position and an unlocked position, wherein, when the tensioning assembly is in the unlocked position, a tensioning force is applied to the cable in response to a pressure force applied against the tensioning assembly from the surrounding environment. In some embodiments, the tensioning assembly comprises a cylinder coupled to the subsea component, and a piston slidably disposed in the cylinder and coupled to an end of the cable, wherein the cylinder has an open end for providing fluid communication between a first end of the piston and the subsea environment. In certain embodiments, when the tensioning assembly is in the locked position, the releasable lock physically engages the piston to restrict the piston from being displaced through the cylinder, and when the tensioning assembly is in the unlocked position, the piston is displaced through the cylinder in response to fluid pressure acting against the first end of the piston. In certain embodiments, in response to the piston being displaced through the cylinder, the cable is passed through the locking assembly to reduce slack in the cable. In some embodiments, the anchoring assembly comprises a first ring concentrically disposed in a second ring, and a third ring, wherein the first ring and the second ring are each concentrically disposed in the third ring, wherein the first ring is pivotally coupled to

the second ring such that the first ring is configured to pivot about a first axis relative to the second ring, and wherein the second ring is pivotally coupled to the third ring such that the second ring is configured to pivot about a second axis relative to the third ring. In some embodiments, the system further comprises a detector configured to detect a distance between the first subsea component and a second subsea component, and a controller in signal communication with the detector, wherein the controller is configured to adjust a tensioning force applied to the cable in response to a signal transmitted to the controller from the detector.

[0006] An embodiment of a method of landing a subsea component comprises deploying a subsea component in a subsea environment, lowering the subsea component to a target location near a sea floor, coupling a cable extending from a retention assembly coupled to the subsea component to an anchoring assembly, and actuating a tensioning assembly of the retention assembly to apply a tensioning force to the cable to guide the subsea component towards the anchoring assembly. In some embodiments, the method further comprises passing the cable through a locking assembly to reduce slack in the cable. In some embodiments, the method further comprises restricting passing the cable through the locking assembly in the second direction in response to a force applied against the subsea component. In certain embodiments, the method further comprises damping a force applied against the subsea component after coupling the cable. In certain embodiments, the method further comprises rotating a connector of the anchoring assembly in a gimbal assembly. In some embodiments, the method further comprises utilizing a controller to automatically adjust a tensioning force to the cable in response to a threshold level of lateral gap between the subsea component and the target location.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For a detailed description of exemplary embodiments, reference will now be made to the accompanying drawings in which:

[0008] FIG. **1** is a schematic view of an embodiment of a drilling system showing a BOP stack in a first position in accordance with principles disclosed herein;

[0009] FIG. **2** is a cross-sectional view of a retention assembly of the drilling system of FIG. **1** in accordance with principles disclosed herein;

[0010] FIG. **3**A is a schematic view of a locking assembly of the drilling system of FIG. **1** in a first position in accordance with principles disclosed herein;

[0011] FIG. **3**B is a schematic view of the locking assembly of FIG. **3**A in a second position;

[0012] FIG. **4**A is a schematic view of an anchoring assembly in accordance with principles disclosed herein;

[0013] FIG. **4**B is a top view of the anchoring assembly of FIG. **4**A;

[0014] FIG. **5** is a schematic view of the drilling system of FIG. **1** in a second position;

[0015] FIG. **6** is a schematic view of the drilling system of FIG. **1** in a third position;

[0016] FIG. **7** is a schematic view of the drilling system of FIG. **1** in a fourth position;

[0017] FIG. **8** is an embodiment of a method for landing a subsea component in accordance with principles disclosed herein; and

[0018] FIG. **9** is a schematic view of another embodiment of a drilling system including a BOP stack in accordance with principles disclosed herein.

DETAILED DESCRIPTION

[0019] In the drawings and description that follow, like parts are typically marked throughout the specification and drawings with the same reference numerals. The drawing figures are not necessarily to scale. Certain features of the disclosed embodiments may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in the interest of clarity and conciseness. The present disclosure is susceptible to embodiments of different forms. Specific embodiments are described in detail and are shown in the drawings, with the understanding that the present disclosure is to be considered an exemplification of the principles of the disclosure, and is not intended to limit the disclosure to that illustrated and described herein. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce desired results.

[0020] Unless otherwise specified, in the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . ". Any use of any form of the terms "connect", "engage", "couple", "attach", or any other term describing an interaction between elements is not meant to limit the interaction to direct interaction between the elements and may also include indirect interaction between the elements described. The various characteristics mentioned above, as well as other features and characteristics described in more detail below, will be readily apparent to those skilled in the art upon reading the following detailed description of the embodiments, and by referring to the accompanying drawings.

[0021] FIG. **1** is a schematic diagram illustrating an embodiment of a drilling system **10**. In an embodiment, drilling system **10** comprises a system for landing a subsea component. The drilling system **10** can be configured to extract various minerals and natural resources, including hydrocarbons (e.g., oil and/or natural gas), or configured to inject substances into a sea floor **3** and a subterranean earthen formation **5** via a well or wellbore **7**. In this embodiment, drilling system **10** generally includes a semi-submersible drilling rig **12** disposed at a surface or waterline **9**, a wellhead **18** secured to the sea floor **3** via a casing conductor **20** that extends into the formation **5**, a remotely operated underwater vehicle (ROV) **22** disposed below the waterline **9** and including an actuatable arm or gripper **24** and a camera or image sensor **28**, a subsea component or blowout preventer (BOP) assembly **100** disposed beneath the waterline **9**, and a plurality of anchoring assemblies **160** anchored to the sea floor **3** and disposed about the wellhead **18**. In FIG. **1** BOP assembly **100** is disposed near the waterline **9** after being lowered through the waterline **9** as BOP assembly **100** descends towards the sea floor **3**. In this embodiment, ROV **22** is connected to the drilling rig **12** via a cable **25** that supplies power and real-time signal communication between ROV **22** and drilling rig **12**. However, in other embodiments, ROV **22** may be untethered from drilling rig **12** and comprising an internal power supply and an antenna for wirelessly transmitting signals to the drilling rig

12. In still further embodiments, ROV **22** may comprise an autonomous or semi-autonomous vehicle.

[0022] In this embodiment, drilling rig **12** includes a rig floor **14** and a derrick **17** extending from floor **14** that supports a marine riser **16** coupled to the BOP assembly **100** as the riser **16** and BOP assembly **100** are lowered from the waterline **9** to the wellhead **18** disposed at the sea floor **3**. In this embodiment, BOP assembly **100** has a central or longitudinal axis **105** and generally includes a BOP frame **102** coupled to a lower end of riser **16**, a BOP **104** disposed within BOP frame **102**, and a plurality of retention assemblies **110** coupled to the BOP frame **110**. As BOP assembly **100** is lowered towards sea floor **3**, transient forces **13** are applied to BOP assembly **100** from subsea currents, jerks or transient forces from riser **16**, and other forces, which cause BOP assembly **100** to sway or move laterally and angularly as BOP assembly **100** is lowered vertically towards sea floor **3**. Although in this embodiment drilling system **10** includes drilling rig **12** and marine riser **16**, in other embodiments, drilling system **10** may include a mono-hull drilling vessel including a crane supporting a cable from which BOP assembly **100** is suspended, or other drilling vessels or rig systems.

[0023] In an embodiment, drilling vessel **12** includes a heave compensating system for controlling the vertical position respective sea floor **3** of BOP assembly **100**. Specifically, the heave compensating system of drilling rig **12** maintains the vertical position of BOP assembly **100** as the vertical position of drilling rig **12** rises and falls in response to wave action at the waterline **9**. Although the heave compensating system of drilling rig **12** is configured to maintain the vertical position of BOP assembly **100** relative sea floor **3**, the heave compensating system is not configured to maintain the lateral and angular position of BOP assembly **100** as transient forces act against BOP assembly **100**. Thus, transient forces applied to BOP assembly **100** cause longitudinal axis **105** of BOP assembly **100** to become laterally misaligned with a longitudinal axis **15** of wellhead **18**, resulting in a lateral gap **107** between longitudinal axis **105** and longitudinal axis **15**.

[0024] Retention assemblies **110** are configured to releasably couple with anchoring assemblies **160** and thereby guide BOP assembly **100** into engagement with wellhead **18** such that BOP **104** may couple with wellhead **18** to provide a sealed flowpath between an internal throughbore of BOP **104** and a throughbore of casing conductor **20**. Particularly, retention assemblies **110** are configured to releasably couple with anchoring assemblies **160** to align longitudinal axis **105** of BOP assembly **100** with longitudinal axis **15** of wellhead **18** such that longitudinal axis **105** is disposed substantially coaxial with longitudinal axis **15**. In this embodiment, each retention assembly **110** generally includes a tensioning or cylinder assembly **112**, a locking assembly **130**, and a first or male connector **158**. In this embodiment, four retention assemblies **110** are included in BOP assembly **100** with a retention assembly **110** coupled to each corner of BOP frame **102**. However, in other embodiments varying numbers of retention assemblies **110** may be coupled to BOP frame **102** or other components of BOP assembly **100** in various configurations.

[0025] Referring to FIGS. **1** and **2**, cylinder assembly **112** includes an elongate cylinder **114** having a first or upper end **114***a* and a second or lower end **114***b*, where lower end **114***b* is disposed vertically (relative sea floor **3**) below upper end **114***a*. Lower end **114***b* of cylinder **114** includes a port **116** providing for fluid communication between an internal volume **113** of cylinder **114** and the surrounding subsea environment. Cylinder assembly **112** also includes a piston **118** slidably disposed within cylinder **114** and includes an annular seal **120** that is disposed in an outer surface thereof for sealably engaging an inner surface of cylinder **114**. Sealing engagement between annular seal **120** and the inner surface of cylinder **114** divides volume **113** into an upper volume or chamber **113***a* extending between the upper end **114***a* of cylinder **114** and piston **118**, and a lower volume or chamber **113***b* extending between piston **118** and the lower end **114***b*.

[0026] In this embodiment, upper chamber **113***a* is filled with a compressible fluid or gas (e.g., air), while lower chamber **113***b* is in fluid communication with the surrounding subsea environment. A releasable lock **118***a* extends through cylinder **114** and into upper chamber **113***a* to physically engage an upper end of piston **118** to releasably lock piston **118** in a lower or first position proximal lower end **114***b* of cylinder **114**. In this embodiment, releasable lock **118***a* comprises a release pin; however, in other embodiments, releasable lock may comprise other types of releasable locks known in the art. In this configuration, hydrostatic pressure of the sea water acts against a lower end of piston **118** while lock **118***a* holds piston **118** into the first position and prevents piston **118** from being displaced upwards through cylinder **114**, compressing the fluid disposed in upper chamber **113***a*. Also, the lower end of piston **118** includes a connector **122** coupled to an upper end of a cable or hawser **124** that extends through port **116**.

[0027] Disposed directly beneath the lower end **114***b* of each cylinder **114** is a locking assembly **130**. Each locking assembly **130** is configured to allow for the passage of hawser **124** therethrough in a first direction, while selectably restricting the passage of hawser **124** through locking assembly **130** in a second or opposing direction. Particularly, each locking assembly **130** is configured to allow for the passage of hawser **124** in an upwards direction towards cylinder **114** while restricting the passage of hawser **124** in a downwards direction away from cylinder **114**.

[0028] Referring to FIGS. **1**-**3**B, in this embodiment each locking assembly **130** generally includes a mounting member **132**, a clamping block **134** affixed to the mounting member **132**, a pivot arm **140** pivotally coupled to mounting member **132**, and a guide member **156**. Mounting member **132** is mounted or coupled to BOP frame **102** of BOP assembly **100** such that locking assembly **130** is disposed directly beneath the lower end **114***b* of cylinder **114**. Clamping block **134** is affixed to mounting member **132** and includes a curved or convex engagement surface **136** for frictionally engaging hawser **124**. Pivot arm **140** is pivotally coupled to mounting member **132** at pivot joint **142** and includes an engagement surface **144** configured to frictionally engage hawser **124** and a handle **146** distal engagement surface **144** and configured to be actuatable by the gripper **24** of ROV **22**. In this arrangement, a passage or pathway **148** is formed between the engagement surface **136** of clamping block **134** and the engagement surface **144** of pivot arm **140**.

[0029] Pivot arm **140** includes a first or locked position shown in FIG. **3**A that allows the passage of hawser **124** in a first or upward direction **150** (i.e., towards cylinder **114**) through passage **148** and restricts the passage of hawser **124** in a second or downward direction **152** (i.e., away from cylinder **114**) through passage **148**. Passage of hawser **124** is allowed in the upward direction **150** while restricted in the downward direction **152** due to the offset position of pivot joint **142** relative engagement surface **144**. Particularly, when hawser **124** passes in the upward direction **150**, frictional engagement between hawser **124** and engagement surface **144** causes pivot arm **140** to pivot in a first or clockwise direction, expanding the width of passage **148**. However, when hawser **124** passes in the downward direction **152**, frictional engagement between hawser **124** and engagement surface **144** causes pivot arm **140** to pivot in a second or counterclockwise direction, reducing the width of passage **148** and thereby causing engagement surfaces **136** and **144** to grapple or grab hawser **124**, restricting further passage of hawser **124** in the downward direction **152**. While in this embodiment pivot arm **140** is actuated via gripper **24** of ROV **22**, in other embodiments, pivot arm **140** may be actuated between the locked and unlocked positions via the transmission of a remote signal transmitted from the surface to an antenna in signal communication with an electronically, hydraulically, pneumatically or otherwise actuatable pivot arm of locking device **130**.

[0030] Pivot arm **140** also includes a second or unlocked position shown in FIG. **3**B where engagement surface **144** is disposed distal hawser **124**, thereby allowing the passage of hawser **124** in both the upward direction **150** and the downward direction **152**. In this embodiment, pivot arm **140** is biased into the first position via a biasing member (not shown). In this arrangement, pivot arm **140** may be actuated from the locked position shown in FIG. **3**A to the unlocked position shown in FIG. **3**B via the grabber **24** of ROV **22**. In this embodiment, each locking assembly **130** also includes a guide member **156** affixed to BOP housing **102** and disposed directly beneath mounting member **132**, where guide member **156** includes an aperture extending therethrough to guide hawser **124** towards passage **148**. In this configuration, guide member **156** restricts hawser **124** from becoming tangled within or slipping free from passage **148**. Although in the embodiment of FIGS. **3**A and **3**B, locking devices **130** comprise base plate **132** and pivot arm **140**, in other embodiments, locking devices **130** may comprise other mechanisms configured for allowing the passage of hawser **124** in the upwards direction **150** while restricting the passage of hawser **150** in the downwards direction **152**.

[0031] As shown particularly in FIG. **1**, the lower end of hawser **124** is coupled to male connector **158**. As will be discussed further herein, male connector **158** is configured to releasably connect to a female connector of a corresponding anchoring assembly **160**, forming a releasable connection between each retention assembly **110** and corresponding anchoring assembly **160**. In this embodiment, male connector **158** comprises the male connector of a subsea mooring or ball and taper connector, such as the Ballgrab® Subsea mooring Connector (SMC) provided by First Subsea Ltd located at Lune Industrial Estate, New Quay Road, Lancaster, Lancashire, LA1 5QP, United Kingdom. However, in other embodiments, male connector **158** may comprise other types of male connectors known in the art configured for usage in subsea environments, such as the quick release lifting pins offered by Automotion Components Ltd., Alexia House, Little Mead Industrial Estate, Cranleigh, Surrey, GU6 8NE, UK, or other components known in the art such as shackles that may be secured to eyes in the hawsers **124**. Also, as BOP assembly **100** is lowered towards sea floor **3**, the length of hawser **124** may be coiled to prevent hawser **124** from becoming tangled with other components of BOP assembly **100**. Prior to connecting male connector **158** with a corresponding female connector of anchoring assembly **160**, as will be discussed further herein, grabber **24** of ROV **22** may release or uncoil the length of hawser **124** from BOP assembly **100**.

[0032] Referring to FIGS. **1**, **4**A, and **4**B, each anchoring assembly **160** is configured to releasably couple with a corresponding retention assembly **110** to couple BOP assembly **100** to the sea floor **3** and guide BOP assembly **100** into engagement with wellhead **18**. Particularly, in this embodiment, four anchoring assemblies **160** are disposed about wellhead **18** corresponding with the four retention assemblies **110** coupled to BOP frame **102**. However, in other embodiments, BOP assembly **100** may only include a single retention assembly **110**. In this arrangement, when longitudinal axis **105** of BOP assembly **100** aligns with longitudinal axis **15** of wellhead **18**, each anchoring assembly **160** longitudinally or vertically aligns with a corresponding retention assembly **110**, as will be discussed further herein. In this embodiment, each anchoring assembly **160** generally includes a support frame **162**, a gimbal assembly **164** physically supported by support frame **162**, and a female connector assembly **180** coupled to gimbal assembly **164**. Support frame **162** is anchored or coupled to the sea floor **3** and is configured to physically support gimbal assembly **164** and female connector assembly **180**. In this embodiment, support frame **162** comprises a plurality of legs **162***a* extending from gimbal assembly **180** to the sea floor **3**.

[0033] Gimbal assembly **164** of anchoring assembly **160** is configured to provide for the rotation of female connector assembly **180** about multiple independent axes relative support frame **162**. In this arrangement, female connector assembly **180** may axially align with tension forces applied to hawser **124** once male connector **158** has been inserted into and coupled with female connector assembly **180**. In this embodiment, the gimbal assembly **164** of each anchoring assembly **160** generally includes a first or inner ring **166**, a pair of first or inner coupling pins **168**, a second or intermediate ring **170**, a pair of second or outer coupling pins **172**, and a third or outer ring **174** coupled to an upper end of support frame **162**. Inner coupling pins **168** pivotally couple inner ring **166** with intermediate ring **170**, providing for rotation of inner ring **166** about a first axis **169** relative intermediate ring **170**. Also, outer coupling pins **172** pivotally couple intermediate ring **170** with outer ring **174**, providing for rotation of intermediate ring **170** about a second axis **171** relative outer ring **174**. In this arrangement, inner ring **166** is pivotal about both first axis **169** and second axis **171** relative outer ring **174** and support frame **162**. Further, first axis **169** is disposed orthogonal to second axis **171**.

[0034] Female connector assembly **180** is coupled to inner ring **166**, thus allowing female connector assembly **180** to pivot about first axis **169** and second axis **171** relative support frame **162**. The female connector assembly **180** of each anchoring assembly **160** is configured to releasably couple with a male connector **158** of a corresponding retention assembly **110**. Female connector assembly **180** is also configured to dampen forces transmitted to BOP support assembly **100** from anchoring assemblies **160** once BOP assembly **100** has been coupled to anchoring assemblies **160**.

[0035] In this embodiment, each female connector assembly **180** generally includes a cylinder **182**, a piston **190** disposed in cylinder **182**, and a female connector **194** coupled to an upper end of piston **190**. Cylinder **182** has a first or upper end **182***a*, a second or lower end **182***b*, and an internal volume **184** disposed therein. The upper end **182***a* of cylinder **182** includes a centrally disposed aperture **186** and the lower end **182***b* includes a plurality of tuned ports **188**. Piston **190** includes an annular seal **192** disposed in an outer surface thereof for sealingly engaging an inner surface of cylinder **182**. The sealing engagement provided by annular seal **192** divides internal volume **184** into a first or upper chamber **184***a* extending between upper end **182***a* and the upper end of piston **190**, and a second or lower chamber **184***b* extending between a lower end of piston **190** and the lower end **182***b* of cylinder **182**. Female connector **194** couples to the upper end of piston **190** and extends through aperture **186** at the upper end **182***a* of cylinder **182**. An inner surface of aperture **186** for sealingly engaging an outer surface of female connector **194**, thereby restricting fluid communication between upper chamber **184***a* and the surrounding subsea environment. In this embodiment, upper chamber **184***a* is filled with a compressible fluid, such as air. Lower chamber **184***b* of cylinder **182** is in fluid communication with the surrounding subsea environment via ports **188**, and is thus filled with sea water.

[0036] In this embodiment, female connector **194** comprises the corresponding female connector of a subsea mooring or ball and taper connector, such as the Ballgrab® Subsea mooring Connector (SMC) provided by First Subsea Ltd located at Lune Industrial Estate, New Quay Road, Lancaster, Lancashire, LA1 5QP, United Kingdom. However, in other embodiments, female connector **194** may comprise other types of male connectors known in the art configured for usage in subsea environments, such as the quick release lifting pins and/or shackles described above with respect to male connector **158**. Also, female connector **194** includes a radially flanged guided member **194***a* at an upper end thereof for guiding the male connector **158** of a corresponding retention assembly **110** into engagement with female connector **194**. In this embodiment, male connector **158** may be releasably coupled or secured to female connector **194** by axially inserting male connector **158** into female connector **194** regardless of the angular orientation between male connector **158** and female connector **194**. Once male connector **158** is inserted into female connector **194**, male connector **158** is restricted from being released from female connector **194** when an upwards tension force is applied against male connector **158**.

[0037] In the configuration described above, female connector assembly **180** is configured to act as a dampener when a force is applied in either a first or upper (relative sea floor **3**) direction **193** or a second or downwards (relative sea floor **3**) direction **195**. Specifically, when a force is applied against female connector **194** in a first or upwards (relative sea floor **3**) direction **193**, the fluid disposed in upper chamber **184***a* of cylinder **182** is compressed, thereby absorbing shock and dissipating energy from the upwards force **193**. Also, when a force is applied against female connector **194** in a second or downwards (relative sea floor **3**) direction **195**, sea water disposed in lower chamber **184***b* is ejected from volume **184** via ports **188** at the lower end **182***b* of cylinder **182**. Ports **188** are tuned to optimize the flow of the ejected sea water so as to absorb shock and dissipate energy from the downwards force **195**. In this manner, female connector assembly **180** is configured to reduce shocks and dissipate energy in response to forces applied to BOP assembly **100** once BOP assembly **100** couples with anchoring assemblies **160** via hawsers **124**.

[0038] Referring to FIG. **5**, as BOP assembly **100** is lowered towards sea floor **3**, BOP assembly **100** will enter a target location disposed proximal sea floor **3**. Once BOP assembly **100** is disposed in the target location, the gripper **24** of ROV **22** releases or uncoils hawsers **124** from BOP frame **102**, thereby allowing male connectors **158** to descend further towards the sea floor **3**. Once male connectors **158** have been released and are disposed at or near the sea floor **3**, ROV **22** inserts each male connector **158** into the female connector **194** of a corresponding anchoring assembly **160** using gripper **24**, thereby coupling BOP assembly **100** to anchoring assemblies **160**, and in turn, the sea floor **3**.

[0039] During this process, BOP assembly **100** is continuously displaced laterally, vertically, and angularly in response to transient forces **13**, causing the longitudinal axis **105** to be disposed at an angular misalignment or angle **109** relative a vertical axis (i.e., extending parallel longitudinal axis **15** of wellhead **18**) extending from the sea floor **3**. Due to the lateral gap **107** and angular misalignment **109**, the female connector assembly **180** of each anchoring assembly **160** rotates within its respective gimbal assembly **164** such that each female connector assembly **180** is axially aligned with the tension force applied by the coupled hawser **124**, which is placed in tension by the moving BOP assembly **100**. In this arrangement, the only substantial forces applied to female connector assemblies **180** are axial, thus limiting or eliminating the shear forces applied against female connector assemblies **180** and anchoring assemblies **160** by hawsers **124**.

[0040] Further, in this arrangement female connector assemblies **180** act to damp the shock to BOP assembly **100** and anchoring assemblies **160** produced by the moving BOP assembly **100**. For instance, a lull in transient forces **13** on BOP assembly **100** may allow hawsers **124** to slacken, followed by a resumption of transient forces **13** thereby causing BOP assembly **100** to be displaced away from anchoring assemblies **160** until hawsers **124** are rapidly drawn taut in response to locking devices **130** gripping hawsers **124**, imparting a shock or force to both BOP assembly **100** and the anchoring assemblies **160** coupled thereto by taut hawsers **124**. In this instance, the cylinders **182** and corresponding pistons **190** described above and shown in FIG. **4**A damp the shock imparted to BOP assembly **100** and anchoring assemblies **160** via compressing the gas disposed in upper chamber **184***a* of cylinder **182**.

[0041] Referring to FIG. **6**, once the male connector **158** of each retention assembly **110** is connected with the female connector **194** of a corresponding anchoring assembly **160**, gripper **24** of ROV **22** is used to release the lock **118***a* of each retention assembly **110**, allowing each piston **118** to displace upwards towards the upper end **112***a* (shown in FIG. **2**) of the corresponding cylinder **112** in response to the relatively high pressure sea water acting on the lower end of each piston **118**, as shown schematically in FIG. **6**. Although in this embodiment releasable locks **118***a* are used to release pistons **118** via gripper **24** of ROV **22**, in other embodiments, pistons **118** may be released through other mechanisms, such as by transmitting a remote signal transmitted from the surface to an antenna coupled to an electronically actuated mechanism configured to release pistons **118**. Further, while in this embodiment the displacement of pistons **118** through cylinders **112** tensions hawsers **124**, in other embodiments, another tensioning mechanism may be used to tension hawsers **124** following the connection of male connectors **158** with female connectors **194**. For instance, in an embodiment, lift bags are coupled to hawsers **124** including energetic materials for generating gas within the lift bags to provide buoyancy for tensioning hawsers **124** following the connection of male connectors **158** with female connectors **194**. Alternatively, buoys may be coupled to hawsers **124** and BOP frame **102**, and following the connection of male connectors **158** with female connectors **194**, the buoys are released from BOP frame **102** to tension hawsers **124**.

[0042] In response to the upwards displacement of pistons **118**, hawsers **124** coupled to pistons **118** are also displaced upwards through cylinders **112** and locking devices **130**. The displacement of hawsers **124** through cylinders **112** guides BOP assembly **100** towards anchoring assemblies **160**, reducing the extent of lateral gap **107** between the longitudinal axis **105** of BOP assembly **100** and the longitudinal axis **15** of wellhead **18**. In this embodiment, hawsers **124** do not necessarily pull BOP assembly **100** towards wellhead **18**, and instead, guide BOP assembly **100** towards wellhead **18** while locking devices **130** restrict BOP assembly **100** from being displaced away from wellhead **18** in response to the application of transient forces **13**. Particularly, locking devices **130** grip hawsers **124**, restricting hawsers **124** from passing in the downwards direction **152** (shown in FIGS. **3**A and **3**B), in response to transient forces **13** applied against BOP assembly **100** in a direction away from anchoring assemblies **160**, thereby restricting BOP assembly **100** from being displaced away from anchoring assemblies **160**. However, in other embodiments, retention assemblies **110** and/or anchoring assemblies **160** include powered winches for actively pulling BOP assembly **100** towards wellhead **18** by actively retracting hawsers **124**.

[0043] Referring to FIG. **7**, following the release of locks **118***a* of retention assemblies **110**, pistons **118** continue to travel upwards through cylinders **112**, thereby guiding or directing BOP assembly **100** towards well head **18** until BOP assembly **100** engages wellhead **18** and the longitudinal axis **105** of BOP assembly **100** is substantially aligned with the longitudinal axis **15** of wellhead **18**. In this position, the pistons **118** of each retention assembly **110** are disposed proximal the upper end **112***a* (shown in FIG. **2**) of a corresponding cylinder **112**. Once BOP assembly **100** has successfully landed against wellhead **18**, BOP **104** is coupled or secured to wellhead **18**. Following the coupling of BOP **104** to wellhead **18**, the gripper **24** of ROV **22** is used to disconnect the male connector **158** of each retention assembly **110** from the female connector **194** of each corresponding anchoring assembly **160**. Additional anchoring assemblies **160** mounted to BOP frame **102** (not shown) can be subsequently used to anchor and guide other components of drilling system **10** into engagement with BOP **104** in a manner similar to the guiding of BOP assembly **100** described above. For instance, in an embodiment an LMRP assembly (not shown) is guided and landed against BOP **104** in a manner similar to the guiding of BOP assembly **100** described above. In this embodiment, the LMRP assembly includes one or more retention assemblies **110** each having a male connector **158** for releasably coupling with the female connector **194** of the anchoring assemblies **160** mounted to BOP frame **102**.

[0044] Referring to FIGS. **1** and **8**, an embodiment of a method **200** of guiding and engaging a subsea component is shown. Starting at block **202**, a subsea component is deployed below the waterline **9** in an offshore, subsea environment. In certain embodiments, prior to the subsea component being deployed below the waterline **9**, anchoring assemblies are installed or coupled to the sea floor **3**. In some embodiments, the process of installing anchoring assemblies at the sea floor **3** comprises coupling the frame **162** (shown in FIGS. **4**A and **4**B) to the sea floor **3** about wellhead **18**, which is coupled to casing conductor **20** that extends through the sea floor **3**. In an embodiment, block **202** comprises deploying BOP assembly **100** from drilling rig **12**, where BOP assembly **100** is suspended from riser **16** that extends from drilling rig **12**. At block **204**, the subsea component is lowered to a target location proximal the sea floor **3**. In an embodiment, block **204** comprises lowering BOP assembly **100** towards the target location proximal sea floor **3** by extending riser **16** from drilling rig **12**.

[0045] At block **206**, retention assemblies coupled to the subsea component are coupled to the anchoring assemblies installed at the sea floor **3**. In an embodiment, block **206** comprises coupling retention assemblies **110** to anchoring assemblies **160** anchored to the sea floor **3** using the gripper **24** of ROV **22**, as described above and illustrated in FIG. **5**. At block **208**, one or more pistons of each retention assembly is released to guide the subsea component towards the sea floor **3**, and into engagement with another subsea component disposed at or near the sea floor **3**. In an embodiment, block **208** comprises using the gripper **24** of ROV **22** to release the lock **118***a* of each retention assembly **110**, thereby releasing the piston **118** of each retention assembly **110**, as described above and illustrated in FIGS. **6** and **7**. In this embodiment, once BOP assembly **100** has landed against wellhead **18**, BOP **104** of BOP assembly **100** is coupled to wellhead **18**.

[0046] Referring to FIGS. **1**, **8**, and **9**, block **208** of method **200** may include releasing or unlocking the locking assembly **130** of each retention assembly **110** when the lateral gap **107** between longitudinal axis **105** of BOP assembly **100** and the longitudinal axis **15** of wellhead **18** extends beyond a threshold level to allow BOP assembly **100** to become aligned with wellhead **18**. Particularly, if the lateral gap **107** increases past a threshold level, the piston **118** of the retention assembly **110** in closest alignment with its corresponding anchoring assembly **160** may be displaced an unequal distance through its corresponding cylinder **114** with respect to the pistons **118** of the retention assemblies **110** further out of alignment of their corresponding anchoring assemblies **160**, thereby inhibiting the alignment of the BOP assembly **100** with the wellhead **18**. For instance, such a relative misalignment between retention assemblies **110** may result in an increased angular misalignment **109**. In an embodiment, the lateral gap **107** may be monitored by personnel of drilling rig **12** utilizing the camera **28** of ROV **22**, and in the event of an undesirable lateral offset **107**, may utilize the gripper **24** of the ROV **22** to actuate the handle **146** of the locking device of the locking device **130** of the retention assembly **110** in greatest relative alignment with its corresponding anchoring assembly **160**, thereby allowing the passage of hawser **124** therethrough in the upward direction **150**.

[0047] Alternatively, a control system may be utilized to automatically unlock one or more of the locking devices **130** of the retention assemblies **110** in the event of a threshold level of lateral gap **107**. Particularly, FIG. **9** illustrates an embodiment of a drilling system **300** including a control system for automatically releasing one or more retention assemblies **110** in response to a threshold level of lateral gap **107** between the longitudinal axis **105** of BOP assembly **100** and the longitudinal axis **15** of wellhead **18**. Drilling system **300** includes features similar to those of drilling system **10**, and shared features are numbered similarly. In this embodiment, the BOP assembly **100** a detector **302** in signal communication with a controller **304**, where the detector is configured to actively detect or measure the extent of the lateral gap **107** between the BOP assembly **100** and the wellhead **18**. In certain embodiments, detector **302** may also be configured to detect the angular misalignment **109** between the BOP assembly **100** and the wellhead **18**. In this embodiment, the detector **302** comprises an optical detector; however, in other embodiments, detector **302** may comprise an acoustic, radio-frequency, or other types of detectors known in the art. In this embodiment, the detector **302** communicates with the controller **304** in real-time the extent of lateral gap **107**, and in response to the lateral gap **107** exceeding a predetermined threshold level, the controller **304** is configured to adjust the tension in one or more of the hawsers **124** to optimize the placement of the BOP assembly **100** and the wellhead **18**. Particularly, in this embodiment the controller **304** is configured to selectably release and/or lock one or more locking assemblies **130** in response to the lateral gap **107** exceeding a predetermined threshold level to allow the BOP assembly **100** to become re-centered with the wellhead **18**. In certain embodiments, the controller **304** is further configured to displace the piston **118** of one or more retention assemblies **110** in response to the lateral gap **107** exceeding a threshold level in order to optimize placement of the BOP assembly **100** with respect to the wellhead **18**.

[0048] The above discussion is meant to be illustrative of the principles and various embodiments of the present disclosure. While certain embodiments have been shown and described, modifications thereof can be made by one skilled in the art without departing from the spirit and teachings of the disclosure. The embodiments described herein are exemplary only, and are not limiting. Accordingly, the scope of protection is not limited by the description set out above, but is only limited by the claims which follow, that scope including all equivalents of the subject matter of the claims.

1. A system for landing a subsea component, comprising:

a retention assembly configured to be coupled to the subsea component, the retention assembly comprising:

a first connector;

a cable extending between the connector and a tensioning assembly; and

a releasable lock configured to selectably actuate the tensioning assembly between a locked position and an unlocked position;

wherein, when the retention assembly is disposed subsea and the tensioning assembly is in the unlocked position, a tensioning force is applied to the cable in response to a hydraulic pressure force applied against the tensioning assembly by sea water from the surrounding environment; and

an anchoring assembly configured to anchor to a sea floor, the anchoring assembly comprising a second connector configured to be coupled to the first connector of the retention assembly.

2. The system of claim **1**, wherein the retention assembly further comprises a locking assembly configured to allow the passage of the cable through the locking assembly in a first direction towards the retention assembly, and restrict passage of the cable through the locking assembly in a second direction away from the retention assembly.

3. The system of claim **2**, wherein the tensioning assembly comprises:

a cylinder configured to couple to the subsea component; and

a piston slidably disposed in the cylinder and coupled to an end of the cable;

wherein the cylinder includes an open end for providing fluid communication between a first end of the piston and the subsea environment.

4. The system of claim **3**, wherein:

when the tensioning assembly is in the locked position, the releasable lock physically engages the piston to restrict the piston from being displaced through the cylinder; and

when the tensioning assembly is in the unlocked position, the piston is displaced through the cylinder in response to fluid pressure acting against the first end of the piston.

5. The system of claim **4**, wherein, in response to the piston being displaced through the cylinder, the cable is passed through the locking assembly to reduce slack in the cable.

6. The system of claim **1**, wherein the anchoring assembly comprises:

a first ring concentrically disposed in a second ring, and a third ring, wherein the first and second rings are each concentrically disposed in the third ring;

wherein the first ring is pivotally coupled to the second ring such that the first ring is configured to pivot about a first axis relative to the second ring; and

wherein the second ring is pivotally coupled to the third ring such that the second ring is configured to pivot about a second axis relative to the third ring.

7. The system of claim **1**, wherein the anchoring assembly comprises a damper configured to damp forces applied to the subsea component when the first connector is coupled to the second connector.

8. A system for landing a subsea component, comprising:

a first subsea component;

a retention assembly coupled to the first subsea component, the retention assembly comprising:

a first connector;

a cable extending between the connector and a tensioning assembly, wherein the tensioning assembly is configured to apply a tensioning force to the cable;

a locking assembly configured to allow the passage of the cable through the locking assembly in a first direction towards the retention assembly, and restrict passage of the cable through the locking assembly in a second direction away from the retention assembly; and an anchoring assembly configured to anchor to a sea floor, the anchoring assembly comprising a second connector for coupling with the first connector of the retention assembly.

9. The system of claim **8**, wherein the retention assembly further comprises:

a releasable lock configured to selectably actuate the tensioning assembly between a locked position and an unlocked position;

wherein, when the tensioning assembly is in the unlocked position, a tensioning force is applied to the cable.

10. The system of claim **9**, wherein the tensioning assembly comprises:

a cylinder coupled to the subsea component; and

a piston slidably disposed in the cylinder and coupled to an end of the cable;

wherein the cylinder has an open end for providing fluid communication between a first end of the piston and the subsea environment.

11. The system of claim **10**, wherein:

when the tensioning assembly is in the locked position, the releasable lock physically engages the piston to restrict the piston from being displaced through the cylinder; and

when the tensioning assembly is in the unlocked position, the piston is displaced through the cylinder in response to fluid pressure acting against the first end of the piston.

12. The system of claim **11**, wherein, in response to the piston being displaced through the cylinder, the cable is passed through the locking assembly to reduce slack in the cable.

13. The system of claim **8**, wherein the anchoring assembly comprises:

a first ring concentrically disposed in a second ring, and a third ring, wherein the first ring and the second ring are each concentrically disposed in the third ring;

wherein the first ring is pivotally coupled to the second ring such that the first ring is configured to pivot about a first axis relative to the second ring; and

wherein the second ring is pivotally coupled to the third ring such that the second ring is configured to pivot about a second axis relative to the third ring.

14. The system of **8**, further comprising a detector configured to detect a distance between the first subsea component and a second subsea component, and a controller in signal communication with the detector, wherein the controller is configured to adjust a tensioning force applied to the cable in response to a signal transmitted to the controller from the detector.

15. A method of landing a subsea component, comprising:

deploying a subsea component in a subsea environment;

lowering the subsea component to a target location near a sea floor;

coupling a cable extending from a retention assembly coupled to the subsea component to an anchoring assembly;

actuating a tensioning assembly of the retention assembly to apply a tensioning force to the cable to guide the subsea component towards the anchoring assembly; and

passing the cable through a locking assembly to reduce slack in the cable.

16. (canceled)

17. The method of claim **15**, further comprising restricting passing the cable through the locking assembly in the second direction in response to a force applied against the subsea component.

18. The method of claim **15**, further comprising damping a force applied against the subsea component after coupling the cable.

19. The method of claim **15**, further comprising rotating a connector of the anchoring assembly in a gimbal assembly.

20. The method of claim **15**, further comprising utilizing a controller to automatically adjust a tensioning force to the cable in response to a threshold level of lateral gap between the subsea component and the target location.

* * * * *