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(71) **Applicant (for SM only): SHELL OIL COMPANY**
[US/US]; One Shell Plaza, P.O. Box 2463, Houston,
Texas 77252-2463 (US).

(71) **Applicant (for all designated States except US): SHELL
INTERNATIONALE RESEARCH MAATSCHAPPIJ
B.V.** [NL/NL]; Carel van Bylandtlaan 30, NL-2596 The
Hague (NL).

(72) **Inventors; and**

(75) **Inventors/Applicants (for US only): CHEN, Tom X**
[US/US]; 2934 Apple Forest Court, Kingwood, Texas
77345 (US). **LI, You Sun** [US/US]; 1323 Moorwick
Lane, Houston, Texas 77043 (US). **ZHANG, Heping**
[US/US]; 20215 Silverwood Trail, Cypress, Texas 77433
(US). **ZHANG, Jane Qing** [US/US]; 7610 Wellford
Trail, Sugarland, Texas 77479 (US).

(74) **Agent: HICKMAN, William, E.;** Shell Oil Company,
One Shell Plaza, P.O. Box 2463, Houston, Texas
77252-2463 (US).

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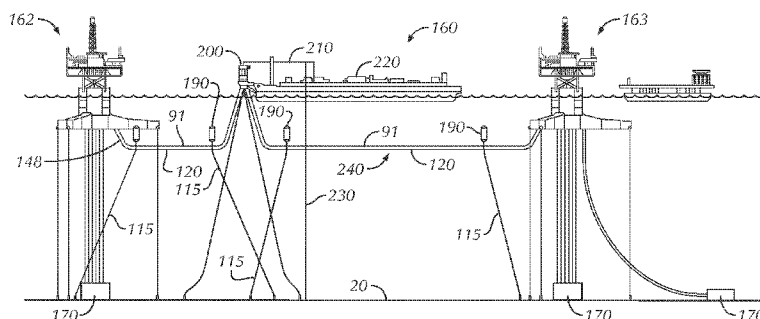


FIG. 2A

- (57) Abstract:** A hydrocarbon production system comprising a first structure comprising a hydrocarbon production apparatus, the first structure located in a body of water having a depth of at least 1000 feet; a second structure comprising a hydrocarbon storage apparatus or a second hydrocarbon production apparatus, the second structure located in the body of water; and a mid-water transfer line connecting the first structure and the second structure, the mid-water transfer line located at a depth of 50 feet to 250 feet.

MID-WATER TRANSFER LINE

Field of the Invention

Embodiments disclosed herein generally relate to transfer lines located between the sea floor and the sea surface.

Background of the Invention

International Publication WO 01/40695 discloses a submerged pipeline for transporting fluids such as oil and/or gas. The pipeline floats for all or at least part of its length. The buoyancy is provided by floating elements and/or floating material arranged at intervals and in a mainly uniform layer around the pipeline, possibly in combination with weights or sinker material. The pipeline is anchored to the seabed by stays or anchor lines arranged at intervals. It is expedient for tension to be applied to the pipeline in a longitudinal direction and for the distance between the anchor points to vary. International Publication WO 01/40695 is herein incorporated by reference in its entirety.

U.S. Patent number 3,849,997 discloses a submarine pipeline formed from lengths of pipe joined together in end to end relationship on shore. The pipeline has an overall positive buoyancy and is propelled seawards from the shore as a continuous length for laying in a desired location relative to the sea bed. The pipeline includes variable buoyancy supporting structure including at least one buoyancy chamber connected to the barge and connected to the leading end of the pipeline. The supporting structure permits anchors progressively applied to the supporting structure to be progressively anchored to the sea bed according to the contour of the sea bed by varying the buoyancy of the support structure by operation of controls located on the barge. The pipeline progressively engages the anchors and maintains itself clear of the sea bed by virtue of its buoyancy. The anchors impart a negative buoyancy to the pipeline to locate the pipeline relative to the sea bed and each anchor includes an anchor weight and rollers spaced above the anchor weight. The rollers engage the pipeline whereby the pipeline can be propelled seawards past the applied anchors. The controls comprise controls for the buoyancy chamber arranged to selectively vary the degree of buoyancy of the chamber. Finally, a propellant is located on the shore and is connected to the pipeline to provide a continuous thrust against the supporting structure to move the supporting structure

and the pipeline seawards. U.S. Patent number 3,849,997 is herein incorporated by reference in its entirety.

U.S. Patent number 4,056,944 discloses that for laying a submarine pipeline, hauling of the same is exerted by means of a force distribution cable which extends over the full length of the submerged part of the pipeline and which is attached to it by hangers, preferably in conjunction with heavy chains acting as guide ropes and anchoring blocks. U.S. Patent number 4,056,944 is herein incorporated by reference in its entirety.

U.S. Patent number 6,508,311 discloses a string of pipe formed by the connection together of multiple joints of shorter pipe segments is stored in the water space adjacent an offshore drilling rig. The pipe string bends from the drilling rig floor in a semicircular arc and enters the water adjacent the drilling rig. A curving guide is used to direct the pipe string movement. A platform extension from the corner of the drilling rig is provided to position a work area above the point at which the pipe enters the water. Multiple guides may be employed for simultaneously running two strings of pipe. The string may be stored in one or more long sections or in a single continuous string. The major portions of the string or long pipe sections may be stored below the surface of the water. Provision is made for pumping fluids through the pipe string, and/or the pipe sections, to the well. The string may be stored in a sleeve. A flexible hose attached to the end of the drill string permits pumping of fluids into the well through the string while the string is in the sleeve. An air supply to the sleeve assists in maintaining the buoyancy of the sleeve and its contents. A pulling system is provided to assist in pulling the drill string through the sleeve. U.S. Patent number 6,508,311 is herein incorporated by reference in its entirety.

U.S. Published Patent Application number 2006/0056918 discloses A riser system for connecting two subsea installations to a floating surface unit. In a preferred embodiment, each of the two subsea installations comprises a flexible pipe arranged in a first catenary and extending between the surface unit and a submerged buoy. Each buoy is anchored to the seabed by a tether device comprising at least two taut tethers. A riser arranged in a second catenary extends between the buoy and being fixed at the seabed. At least one weighted return line in a third catenary connects the two buoys. U.S. Published Patent Application number 2006/0056918 is herein incorporated by reference in its entirety.

There are needs in the art for one or more of the following: pipelines to connect multiple structures in an offshore environment, such as floating structures; pipelines to connect multiple floating structures in a deepwater environment; and/or pipelines to connect floating structures to an FPSO vessel in an offshore environment.

5 Summary of Invention

One aspect of the invention provides a hydrocarbon production system comprising a first structure comprising a hydrocarbon production apparatus, the first structure located in a body of water having a depth of at least 1000 feet; a second structure comprising a hydrocarbon storage apparatus or a second hydrocarbon production apparatus, the second
10 structure located in the body of water; and a mid-water transfer line connecting the first structure and the second structure, the mid-water transfer line located at a depth of 50 feet to 250 feet.

Another aspect of the invention provides a method of installing a mid-water transfer line in a body of water, comprising laying the line on a floor of the body of water; anchoring
15 the line to the floor with a plurality of anchors; attaching a plurality of buoyancy members to the line; and floating the line by removing the water from the line.

Brief Description of Drawings

Figure 1 shows a hydrocarbon transfer system in accordance with embodiments disclosed herein.

20 Figures 2A-2B show a cable suspended mid-water transfer line in accordance with embodiments disclosed herein.

Figure 3 shows a mid-water transfer line installation method in accordance with embodiments disclosed herein.

25 Figure 4 shows a “W” shaped pipeline configuration in accordance with embodiments disclosed herein.

Detailed Description of the Invention

In one aspect, embodiments disclosed herein relate generally to methods and offshore structures for deploying a subsea hydrocarbon transfer system. More specifically, embodiments disclosed herein relate to a production transfer system configured to receive,
30 support, and transport hydrocarbons to a storage transport vessel from a floating production platform, fixed structure, or subsea wellhead. More specifically still, the production transfer

system includes a substantially horizontal, submerged mid-water transfer line interconnecting the storage transport vessel and production platform, or between multiple platforms.

In accordance with embodiments disclosed herein a mid-water transfer line may refer to a cable suspended mid-water transfer line for transporting hydrocarbons, specifically, an oil and/or gas production stream from a production platform to a storage transport system (*e.g.*, a spread-moored floating production, storage, and offloading vessel). Moreover, embodiments disclosed herein relate to a deepwater wellhead coupled or “tied-back” to a storage transport vessel by a cable suspended steel pipe mid-water transfer line. In another aspect, embodiments disclosed herein relate to a method of installing a deepwater cable suspended mid-water transfer line to tie-back a wellbore system that is currently in place.

A storage transport vessel, as disclosed herein, refers to a vessel used to receive, store, and transport produced hydrocarbons. Further, the storage transport vessel may be a specific structure such as a floating production storage unit, a ship, or tanker. Examples as used herein, may include a “Floating Production Storage Off-loading Vessel,” (“FPSO”), “barge unit,” “production ship,” “floating LNG production vessel,” floating LNG ship,” “floating tanker,” “storage processing vessel,” or simply an “offloading vessel.” A floating production structure or production hull, as disclosed herein, refers to an offshore hull used to transfer hydrocarbons from below the subsea floor to a storage transport vessel or unit for transport to a land facility for refining or processing. Moreover, the offshore hull may be a specific structure such as an offshore production rig or floating platform used to recover petroleum reserves. Examples as used herein, may include a “floating platform,” “subsea platform,” “FPSO,” “TLP,” “spar,” “floater,” “offshore rig,” “production structure,” “semi-submersible,” “spar-buoys,” “tension leg platform,” “barge,” “ship,” or simply “production platform.”

A mid-water transfer line, as disclosed herein, refers to a continuous steel pipe used to transport produced hydrocarbons received from a subsea well or manifold and a production platform to a storage transport vessel. Examples as used herein, may include a “transfer line,” “carrier pipeline,” “flowline,” “bridge,” or simply “pipeline.” Further, as used herein, a “mid-water horizontal transfer section” refers to a horizontal section between the storage transport vessel and the production platform which includes a floating steel pipe, buoyancy members, anchor lines, tensioning cables, and strapping members, each suspended between end sections of the horizontal section. A storage transport system, used in accordance with embodiments

disclosed herein, may be provided to tie-back a borehole into an existing line. As used herein, a “tie-back” refers to the tie-back or connection of a subsea wellhead or manifold to a processing facility, such as, for example, a FPSO.

Furthermore, a “pig,” as used herein, refers to a generally cylindrical device having blades or brushes that is pushed through a pipeline to clean and/or remove rust, wax, scale, and debris during the installation of a section of pipe. Lastly, as disclosed herein, “ROV” refers to a remotely operated vehicle.

Figure 1:

Referring to Figure 1, a prospective view of a hydrocarbon transfer system 101 according to embodiments of the present disclosure is shown. In this embodiment, hydrocarbon transfer system 101 is configured to transport a hydrocarbon production stream from a well 170 located on seafloor 20 to a storage transport vessel 160 located on the surface of the ocean 10. One of ordinary skill in the art will appreciate that hydrocarbon transfer system 101 may be used in offshore deep and ultra deep waters, where water depths of the hydrocarbon transfer system 101 may exceed 1000 feet, 3000 feet, or 5000 feet. In an alternate embodiment, the hydrocarbon transfer system 101 may further include more than one storage transport vessel 160 for transporting produced hydrocarbons to shore.

As illustrated, hydrocarbon transfer system 101 includes a storage transport vessel 160, which may be anchored to the seafloor 20 or may be held in place by thrusters and/or other propulsion systems on the ship, a first production hull 162, anchored to the sea floor 20, and a second production hull 163, also anchored to sea floor 20. The first production hull 162 may be connected to one or more riser sections 30 and one or more subsea wells 170, and the second production hull 163 also may be connected to one or more riser sections 30 and to other subsea wells 170.

Before produced hydrocarbons may be transferred to storage transport vessel 160, the first, second, or both production hulls 162, 163 are connected to the storage transport vessel 160 by a horizontal mid-section transfer system 240. More specifically, horizontal mid-section transfer system 240 is installed between storage transport vessel 160 and production hull 162, and a second horizontal mid-section transfer system 240 may also be installed between storage transport vessel 160 and production hull 163.

In addition, horizontal mid-section transfer system (not shown) may be installed between production hull 162 and production hull 163.

One of ordinary skill in the art will appreciate that one or more horizontal mid-section transfer systems 240 may be used to connect one or more production hulls to a storage transport vessel without departing from the scope of embodiments disclosed herein. Furthermore, horizontal mid-section transfer system 240, as further described herein, may also include a continuous rigid steel pipe which may be anchored to the seafloor 20 with buoyancy members 190 attached at select distances along mid-water transfer lines 120, 121.

Generally, hydrocarbon transfer between floating systems, such as production hulls 162, 163, in deep and ultra deep waters are typically more efficient if handled at minimal water depths by the horizontal mid-section transfer system 240. One of ordinary skill in the art will appreciate that the horizontal mid-section transfer system 240 may be suspended at a water level below the surface of the water line, such as, for example, 100 feet to 1000 feet, such as 200 to 400 ft below the surface. Such water levels are generally required to render seabed temperature and pressure variations less relevant on the horizontal mid-section transfer system 240.

Still referring to Figure 1, production hulls 162, 163 may be selected from those commonly used in the art for wellbore production. Production hulls 162, 163 generally include at least one hydraulic manifold to control the volume and flow of hydrocarbons flowing by way of subsea risers 30. In another embodiment, subsea risers 30 may be, alternatively, in fluid communication with transfer lines 120, 121 transferring produced hydrocarbons to storage transport vessel 160. Transfer lines 120, 121 may include at least two end sections, a first end section 125 and a second end section 130. One of ordinary skill in the art will appreciate that while end sections 125, 130 may be referred to as 'first' and 'second' end sections for ease of understanding the figures, a transfer line may have more than two end sections that may be sectioned about any distance without departing from the scope of the embodiments disclosed herein.

Transfer lines 120, 121 of horizontal mid-section transfer system 240 include end sections 125, 130, wherein first end section 125 is connected to a subsea riser 30, and the second end section 130 is connected to storage transport vessel 160. In an alternate embodiment, first end section 125 of transfer lines 120, 121 may be connected to a central

connection (not shown) on production hulls 162, 163. First and second end sections 125, 130 of the transfer lines 120, 121 may include flexible jumper hoses 148, 150 attached to production hulls 162, 163.

First end section 125 and second end section 130 of transfer lines 120, 121 may include jumpers 148, 150 configured to engage transfer line 120, 121. In one embodiment, straps or clamps may be disposed on a surface of the mid-water transfer lines 120, 121 for coupling tensioning cable 91 along the transfer line 120, 121, as discussed in more detail below with reference to Figure 2B.

The horizontal mid-section transfer system 240 of the present disclosure is advantageously configured to be significantly shorter in length than conventional transfer systems. Conventional horizontal mid-section transfer systems are generally longer in interval length and require the use of flexible pipe and/or flexible joints at the mid-point of the transfer line for support. Additionally, the conventional design is typically fitted with buoyancy elements at select locations along transfer lines, and as a result often takes on a “W” shape, also known as a sag configuration (as shown in Figure 4). Such sag configurations are a result of an uneven distribution of the weight of the continuous pipe along the length of the suspended system. In contrast, embodiments of the present disclosure provide a buoyant and shortened interval length of the horizontal mid-section transfer system 240 to maintain a substantially horizontal configuration.

The horizontal mid-section transfer system 240 of the present disclosure is advantageously configured to be significantly shorter in length than conventional transfer systems. Other conventional horizontal mid-section transfer systems are generally longer in length as they go from a floating structure to the sea floor and then come back up to another floating structure. When operating in 1000 feet or more of water, a much shorter transfer system can be provided by running a pipe from about 100 to about 200 feet below the water surface.

Traditionally, in conventional systems it is often difficult to connect the end section of a transfer pipe directly to a buoyant member or structure, due to the continuous movement of the buoyancy member with the movement of the sea current. Additionally, the end section of the pipe moves with the buoyancy members, and as a result is subjected to fatigue failure. In contrast, the present disclosure provides a hydrocarbon transfer system that may be quickly

coupled, or alternatively, decoupled by suspending end section 125, 130 of the transfer line 120 by an anchor line 115 from a buoy 190 and connecting a flexible jumper 148, 150 to the end of the transfer line 120 below the turbulence or heave zone of the sea. Thus, each component of the hydrocarbon transfer system may be connected individually, such that, in the case of an emergency, any one component or components may be disconnected or detached from the transfer system. The components of the hydrocarbon transfer system 101 are fully decoupled from the storage transport vessel 160, production hull 162, and production hull 163, to advantageously minimize dynamic loads on the transfer system.

Embodiments disclosed herein relate to a cable suspended mid-water transfer line capable of connecting to a wellhead via a riser section with maximum operating pressures of up to about 3,000 psi and in up to about 10,000 fsw (feet of seawater). Mid-water transfer lines in accordance with embodiments disclosed herein may be installed and actuated by a ROV. Further, embodiments disclosed herein, also relate to the cable suspended mid-water transfer line connected to a floating system, and as such, the transfer line is capable of sustaining pressures of up to about 3,000 psi in water depths up to about 1,000 fsw (feet of seawater), and further configured, to be neutrally buoyant in its normal flow density mode.

Figures 2A & 2B

Referring to Figure 2A, during production of a field of wells 170, the production stream from each wellbore is extracted, transported up risers 30, and transported through transfer lines 120 extending horizontally to a storage transport vessel 160 anchored to the seafloor via anchor lines 115. Transfer lines 120 may extend distances of about 1 km to about 50 km, for example from about 2 to about 25 km, or from about 3 to about 10 km at water depths of about 10 m to about 200 m, for example from about 20m to about 100m, or from about 25m to about 50m below the water surface.

The production stream may contain fluids and/or small particles that may need to be separated. As such, the storage transport vessel 160 may include a separation system 200 that is configured to separate fluids (*e.g.*, water) and small particles (*e.g.*, waxes and crystals) from the production stream before it is transferred into a storage tank 220 on storage transport vessel 160. Such a separation system may be used to transform the production stream into a transportable slurry. Once the production stream flows through the separator system 200, the production stream is then transferred through a first pipe line 210 to a metering device.

Further, the fluid and/or small particles that have been separated from the production stream are transferred through a second line 230 for disposal (*e.g.*, into the ocean or into a disposal well).

Buoyancy element 190 may be connected to an end section 125, 130 (Figure 1) of the mid-water transfer line 120 with a tensioning cable 91 that generates an axial tension along mid-water transfer line 120. Along the length of the tensioning cable 91, straps 117 may be used to attach tensioning cable 91 to the mid-water transfer line 120, and the tensioning cable 91 is attached to anchor line 115 at an inclined angle proximate buoyancy member 190. One of ordinary skill in the art will appreciate that the tension imposed on the mid-water transfer line may be adjusted by the angle of extension of the tensioning cable to the buoyancy member to provide a selected or desired tension of the mid-water transfer line. Further, as used herein, anchor lines 115 and tensioning cable 91 may be formed from a polyester rope, a steel wire, a steel chain, or combinations thereof.

End sections 125, 130 of transfer pipe 120 may be coupled to the storage transport vessel 160 and the production hulls 162, 163 by tensioning cables 91 extending upward at an inclined angle. The straps 117 may allow expansion and contraction of the mid-water transfer line 120. Straps 117 are also attached at the end sections of the mid-water transfer line. The straps 117 act on the tensioning cable 91 and provide suitable tension. The tension may also maintain the mid-water transfer line's hog/sag deflections within acceptable limits, should variations occur in density of the transported fluids or the distance between the two platforms. Thus, the hog/sag deflections due to wave loading on the floating vessel deck may be reduced. As known in the art, inertia loads and hog/sag impose significant deflections on topside structures and piping. As disclosed in the present application, tensioning of the mid-water transfer line 120 controls or reduces lateral deflections of the transfer line induced by transverse currents to reduce or prevent the "W" or sag shaped configuration (shown in Figure 4).

Figure 3:

With reference to Figure 3, a method, in accordance with embodiments disclosed herein, for installing a cable suspended mid-water transfer line may generally proceed as follows. Initially, a location 1102 for installation of the transfer line is identified. Next, the mid-water transfer line 1104 must be prepared for installment with the storage transport vessel

and production hulls. Preparation of the mid-water transfer line 1104 may include laying down the mid-water transfer line 1104 on the seabed to allow access to the mid-water transfer line 1104, flooding of the mid-water transfer line with seawater, and attachment of buoyancy members 190, 191. The process for accessing the mid-water transfer line from its end sections
5 may be limited by subsea conditions such as water currents.

Preparation of the pipe further includes removing coatings, debris, or other material from the inside surface of the pipe where the production fluids are to be transferred to the storage transport vessel. Further, anchoring lines and the buoyancy members 190, 191 may be attached to the transfer line 1101 by a ROV along the location where the transfer line is to be
10 installed, for ease of installation of the mid-water transfer line with the storage transport vessel. Next, a “pig” 1006 may be deployed and the end section of the mid-water transfer line is sealed or closed, to prevent seawater from filling the transfer line as the pig travels through the line pushing seawater to the open end. Each of the end sections of the transfer line may be sealed, for example, using a connection valve, which may be in the opened or closed position,
15 depending on the operation. The pig is actuated to mechanically slide through the transfer line to displace seawater. Once the pig has traveled at least a $\frac{1}{4}$ of the length of the transfer line, which may be approximately 15 km along the mid-water transfer line, the transfer line begins to float to its installed pre-determined location between the seafloor 20 and water surface 15. The buoyancy members 190, 191 begin to float upward in the direction of the water surface 15 as the pig 1006 travels through towards the open end of the transfer line. Buoyancy members
20 190, 191 suspend the transfer line above the seabed 20 and a tensioning cable may be attached to apply approximately 200 kip of tension to the transfer line. Finally, a jumper hose which may extend from the storage transport vessel and/or the production hull may be attached to the end sections of the horizontal transfer line, so that production of the hydrocarbons may begin.

25 Alternatively, the transfer line may be sealed and then pumped full of a low density gas such as air, carbon dioxide, or nitrogen to displace the water, in order to provide buoyancy to and float the transfer line.

In further embodiments, one skilled in the art will appreciate that software tools and suites exist that perform engineering design analysis on mechanical problems such as
30 structural, thermal, computational fluid dynamics, acoustic, and various other mechanical issues. One such tool is ANSYS™ (commercially available from ANSYS Inc. (Canonsburg,

PA)). ANSYS™ can perform static/dynamic, linear/nonlinear structural finite element analysis that address structural design concepts. Further, ANSYS™ tools and suites may be implemented on virtually any type of computer system that may run software tools and suites that perform structural analysis in accordance with embodiments of the present disclosure.

5 Advantageously, embodiments described herein may provide a horizontal mid-water transfer system that is lighter and easier for transporting hydrocarbons to a floating production system. Additionally, embodiments described herein may provide a mid-water transfer system, including continuous steel pipes, anchor lines, cables, straps, buoyancy members, and an anchor assembly, that is more cost effective, more efficient, and easier to use. Further,
10 embodiments described herein may provide a mid-water transfer line system that may be installed and operated by a ROV.

Advantageously, embodiments described herein may also provide for a mid-water transfer line having tensioning cables that may assist in generating horizontal tension, and flexible jumpers that may connect the continuous steel pipe to an offshore structure. The
15 inventors of the present application have discovered that this new design resolves issues associated with hog/sag deflections which creates sagging of the transfer line when no production fluids are being transferred to production and/or storage units. The present design results in a mid-water transfer line being substantially horizontal under conditions of hydrocarbon transfer and during periods of little or no hydrocarbon transfer.

20 Illustrative Embodiments:

In one embodiment, there is disclosed a hydrocarbon production system comprising a first structure comprising a hydrocarbon production apparatus, the first structure located in a body of water having a depth of at least 1000 feet; a second structure comprising a hydrocarbon storage apparatus or a second hydrocarbon production apparatus, the second
25 structure located in the body of water; and a mid-water transfer line connecting the first structure and the second structure, the mid-water transfer line located at a depth of 50 feet to 250 feet. In some embodiments, the system also includes a plurality of anchors connected to the mid-water transfer line. In some embodiments, the system also includes a plurality of buoyancy members connected to the mid-water transfer line. In some embodiments, the
30 system also includes a cable between the first structure and the second structure, and a plurality of strap members to connect the mid-water transfer line to the cable. In some

embodiments, the mid-water transfer line comprises a first end, further comprising a first flexible hose connecting the first end to the first structure. In some embodiments, the mid-water transfer line comprises a second end, further comprising a second flexible hose connecting the second end to the second structure. In some embodiments, the first structure is selected from the group consisting of tension leg platforms, spars, and semi-submersibles. In some embodiments, the second structure is selected from the group consisting of tension leg platforms, spars, and semi-submersibles. In some embodiments, the second structure comprises a floating production storage and offloading vessel (FPSO). In some embodiments, the second structure comprises a hydrocarbon storage apparatus, further comprising a third structure comprising a hydrocarbon production apparatus, the third structure located in the body of water, further comprising a second mid-water transfer line connecting the third structure and the second structure, the second mid-water transfer line located at a depth of 50 feet to 250 feet. In some embodiments, the system also includes at least one well and at least one riser, the at least one well connected to the first structure by the at least one riser.

In one embodiment, there is disclosed a method of installing a mid-water transfer line in a body of water, comprising laying the line on a floor of the body of water; anchoring the line to the floor with a plurality of anchors; attaching a plurality of buoyancy members to the line; and floating the line by removing the water from the line. In some embodiments, removing the water from the line comprises passing one or more pigs through the line. In some embodiments, removing the water from the line comprises pumping a gas into the line to displace the water.

While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

C L A I M S

1. A hydrocarbon production system comprising:

5 a first structure comprising a hydrocarbon production apparatus, the first structure located in a body of water having a depth of at least 1000 feet;

a second structure comprising a hydrocarbon storage apparatus or a second hydrocarbon production apparatus, the second structure located in the body of water; and

a mid-water transfer line connecting the first structure and the second structure, the mid-water transfer line located at a depth of 50 feet to 250 feet.

10

2. The system of claim 1, further comprising a plurality of anchors connected to the mid-water transfer line.

3. The system of one or more of claims 1-2, further comprising a plurality of buoyancy
15 members connected to the mid-water transfer line.

4. The system of one or more of claims 1-3, further comprising a cable between the first structure and the second structure, and a plurality of strap members to connect the mid-water transfer line to the cable.

20

5. The system of one or more of claims 1-4, wherein the mid-water transfer line comprises a first end, further comprising a first flexible hose connecting the first end to the first structure.

6. The system of claim 5, wherein the mid-water transfer line comprises a second end, further
25 comprising a second flexible hose connecting the second end to the second structure.

7. The system of one or more of claims 1-6, wherein the first structure is selected from the group consisting of tension leg platforms, spars, and semi-submersibles.

8. The system of one or more of claims 1-7, wherein the second structure is selected from the group consisting of tension leg platforms, spars, and semi-submersibles.

30

9. The system of one or more of claims 1-8, wherein the second structure comprises a floating production storage and offloading vessel (FPSO).

10. The system of one or more of claims 1-9, wherein the second structure comprises a hydrocarbon storage apparatus;

5 further comprising a third structure comprising a hydrocarbon production apparatus, the third structure located in the body of water;

10 further comprising a second mid-water transfer line connecting the third structure and the second structure, the second mid-water transfer line located at a depth of 50 feet to 250 feet.

11. The system of one or more of claims 1-10, further comprising at least one well and at least one riser, the at least one well connected to the first structure by the at least one riser.

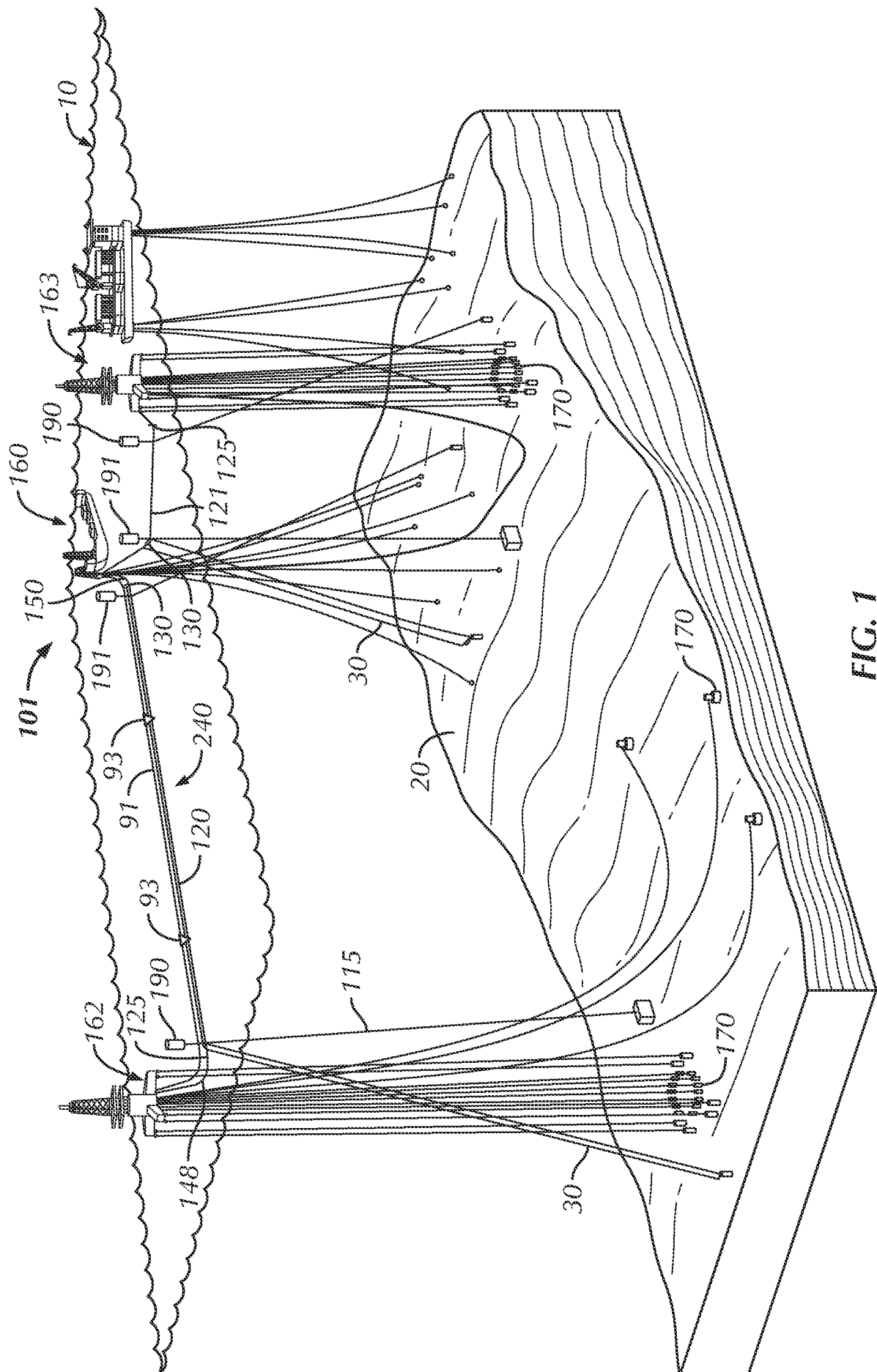
12. A method of installing a mid-water transfer line in a body of water, comprising:

laying the line on a floor of the body of water;
anchoring the line to the floor with a plurality of anchors;
attaching a plurality of buoyancy members to the line; and
floating the line by removing the water from the line.

13. The method of claim 12, wherein removing the water from the line comprises passing one or more pigs through the line.

14. The method of claim 12, wherein removing the water from the line comprises pumping a gas into the line to displace the water.

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1000

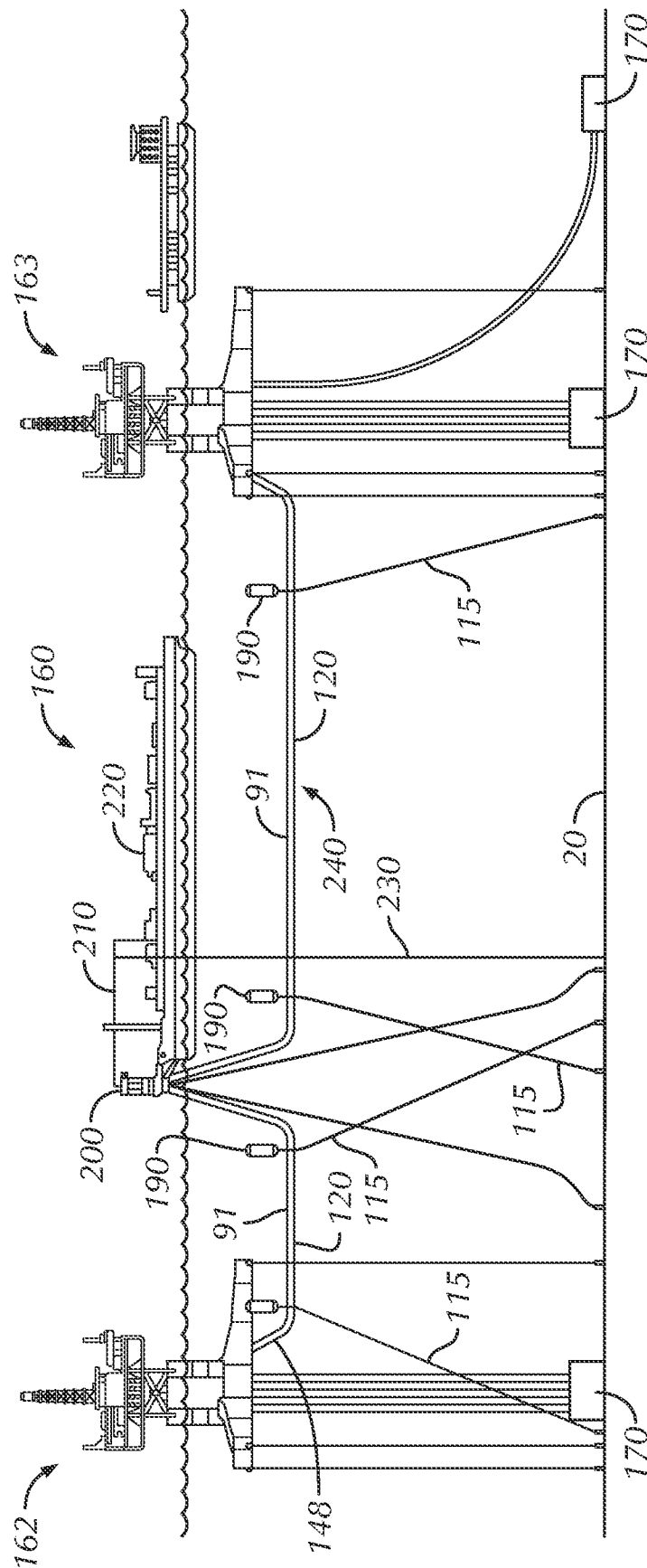
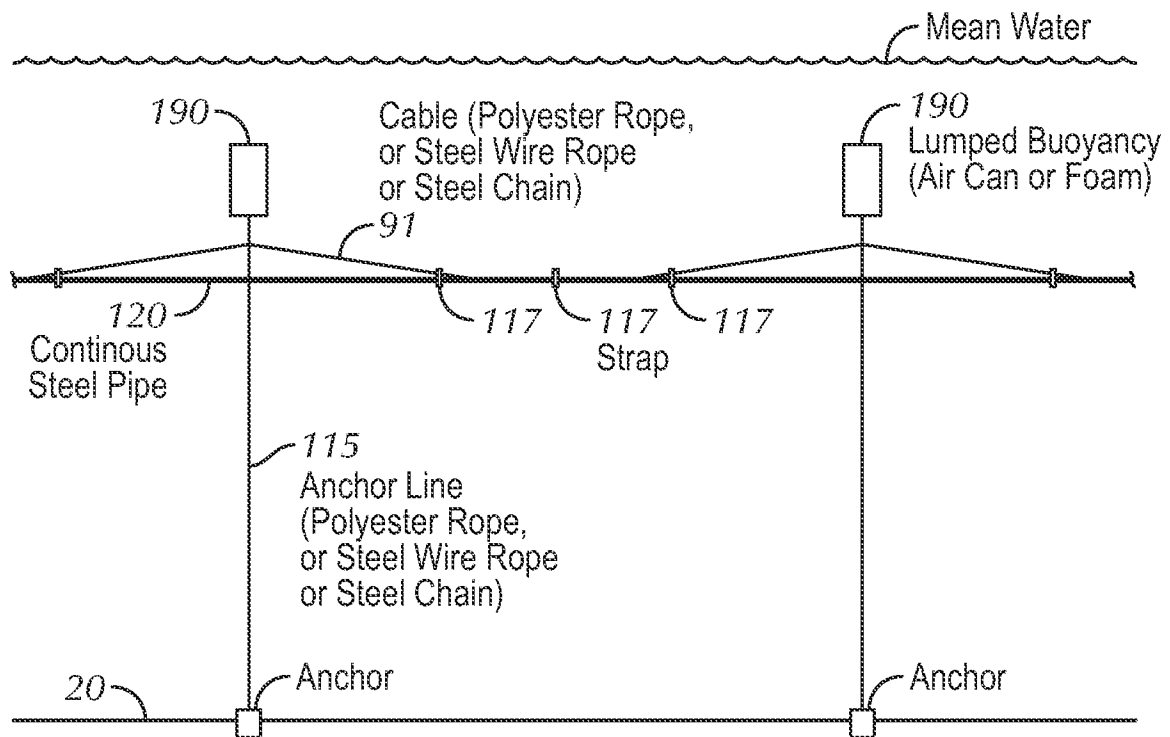
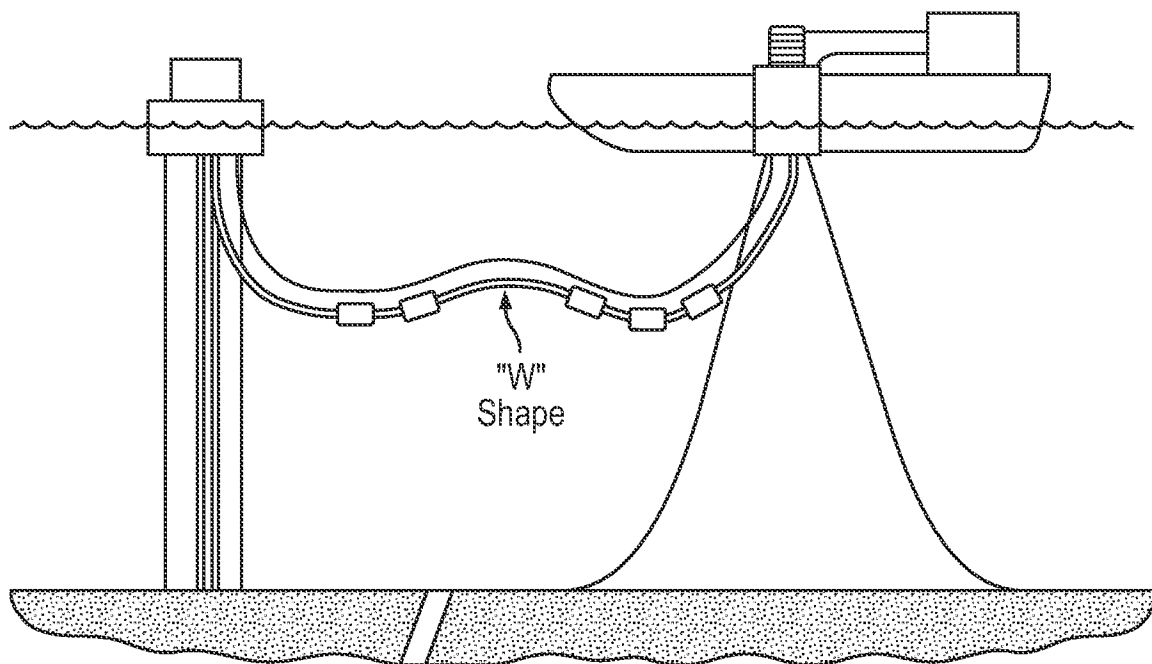


FIG. 2A

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**FIG. 2B****FIG. 4**
(Prior Art)

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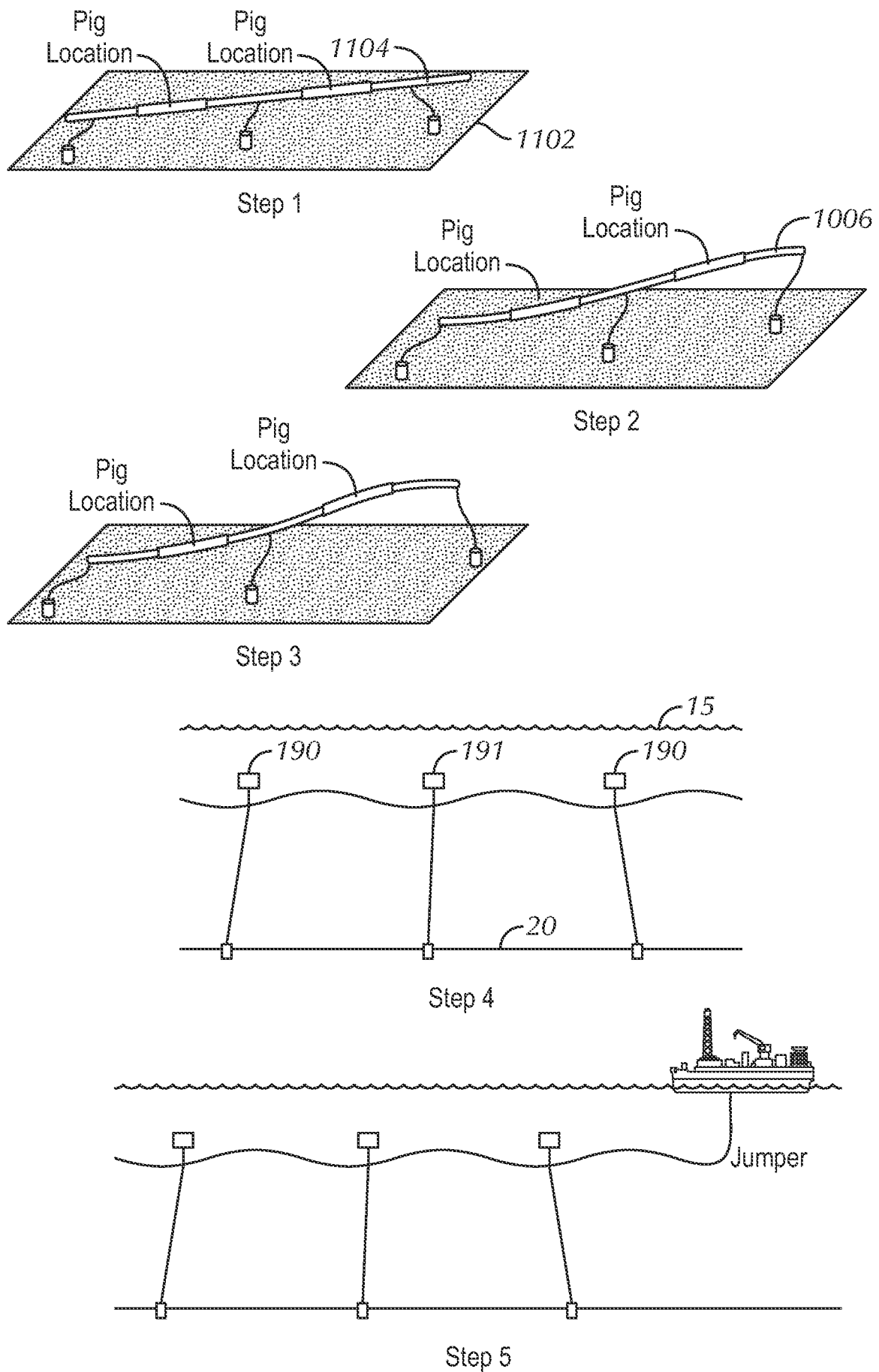


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/41054

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F16L 1/036 (2010.01)

USPC - 405/184.5

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

PC(8): F16L 1/036 (2010.01)

USPC: 405/184.5

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

IPC(8): F16L 1/036 (2010.01)

USPC: 405/154.1, 184.5, 184.4, 184.5, 158, 169, 195.1

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

Electronic Databases Searched: Google Scholar; Google Patent; PubWest (US Patents full-text, US PGPubs full-text, EPO Abstracts, and JPO Abstracts) Search Terms Used: hydrocarbon, hydrocarbons, oil, petroleum, pipe, pipes, pipeline, pipelines, conduit, conduits, install, installs, installing, installed, lay, laying, water, sea, seas, ocean, oceans

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0223582 A1 (WILLE) 18 September 2008 (18.09.2008) entire document especially Fig. 1, Fig. 2; abstract, para [0024], para [0027]	1-2, 3/(1-2)
Y		12-14
Y	US 3,940,942 A (GOWER) 02 March 1976 (02.03.1976) Fig. 2, Fig. 3, Fig. 5, Fig. 11; col 2, ln 59 to col 3, ln 15; col 3, ln 29-57	12-14
Y	US 3,961,493 A (NOLAN, JR. et al.) 08 June 1976 (08.06.1976) Fig. 2, Fig. 3, Fig. 6, Fig. 7; col 5, ln 62 to col 6, ln 17; col 8, ln 42 to col 9, ln 8	13-14
A	US 6,371,693 B1 (KOPP et al.) 16 April 2002 (16.04.2002) entire document generally	1-3, 12-14
A	US 5,007,482 A (FORSYTH et al.) 16 April 1991 (16.04.1991) entire document generally	1-3, 12-14
A	US 4,474,507 A (MORTON) 02 October 1984 (02.10.1984) entire document generally	1-3, 12-14
A	US 4,056,944 A (LAMMY) 08 November 1977 (08.11.1977) entire document generally	1-3, 12-14

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


* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

19 August 2010 (19.08.2010)

Date of mailing of the international search report

01 SEP 2010

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 10/41054

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-11
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.