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(54) **Title:** METHODS OF ESTABLISHING AND/OR MAINTAINING FLOW OF HYDROCARBONS DURING SUBSEA OPERATIONS

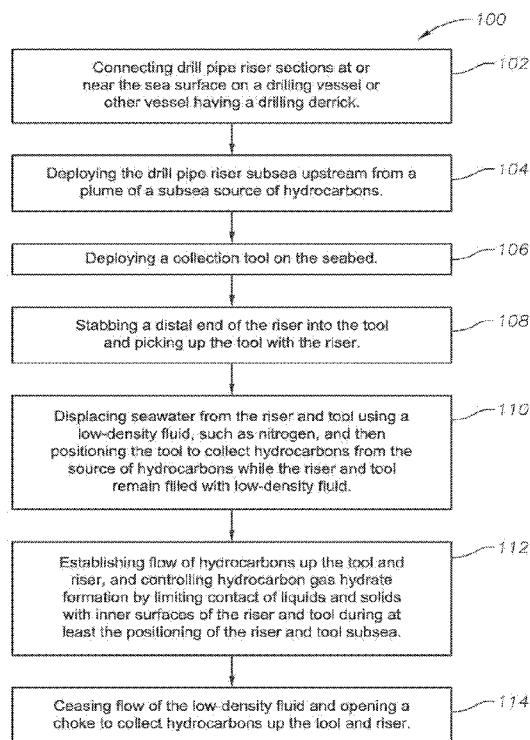


Fig. 1

(57) **Abstract:** Methods are disclosed of establishing and maintaining flow of hydrocarbon-bearing fluid from a subsea source while controlling or limiting hydrocarbon gas hydrate formation in a riser and a collection tool fluidly connected to a distal end of the riser during subsea positioning of the riser and tool. Riser sections are connected at or near the sea surface, and a collection tool may be connected to the distal end of the riser at the surface or picked up subsea by the riser. The riser and tool are deployed subsea near a subsea source of hydrocarbons. A low-density fluid is forced down the riser and tool, and then the riser and tool are positioned to collect hydrocarbons from the subsea source of hydrocarbons. Flow of a low-density fluid is gradually reduced to initiate flow of hydrocarbons up the tool and riser.



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METHODS OF ESTABLISHING AND/OR MAINTAINING FLOW OF HYDROCARBONS DURING SUBSEA OPERATIONS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/479,769 filed April 27, 2011.

[0002] This application is related to assignee's Attorney Docket Nos. 500005-00 corresponding to U.S. Provisional Application No. 61/479,695 filed April 27, 2011 and 500032-00 corresponding to U.S. Provisional Application No. 61/479,704, filed April 27, 2011, both of which are incorporated herein by reference.

BACKGROUND

Field

[0003] The present disclosure relates in general to methods useful in the subsea marine hydrocarbon exploration, production, well drilling, well completion, well intervention, production, and containment and disposal fields.

Related Art

[0004] Nitrogen is typically available on offshore rigs for various uses, one use being remediation of existing hydrocarbon gas hydrates in production wells, water injection wells, in-field lines, export pipelines, and process piping and equipment. See for example assignee's U.S. published patent application number 2009/0111715, published April 30, 2009 (Ballard et al.). In these enumerated situations, flow has been established, and the nitrogen is used to remove a hydrocarbon gas hydrate deposit. However, use of nitrogen or other low-density fluid to establish and/or maintain hydrocarbon flow in a riser from a subsea source to one or more surface vessels during subsea marine operations such as hydrocarbon containment and disposal operations, hydrocarbon exploration, production, well drilling, well completion, and well intervention, is not believed to be known, aside from use as an insulation medium in the annulus of concentric pipe production risers. In the context of non-free-standing risers, Webb et al., *"Dual Activities Without the Second Derrick – A Success Story"*, SPE 112869 (2008) mentions riser annulus dewatering using nitrogen, and discloses a spar platform having a surface nitrogen supply rig and a permanent nitrogen line for annulus dewatering using nitrogen. Webb et al. also mention that early flow assurance work identified a need to

maintain a nitrogen-filled riser annulus at a 100 psi (0.7 MPa) pressure. U.S. Pat. No. 4,234,047 discloses a valve for rapidly evacuating or draining mud from a riser lower segment attached to a subsea blow out preventer (BOP) so as to minimize stress on a free standing riser segment.

[0005] The present methods are directed to uses of low-density fluids to establish and/or maintain hydrocarbon flow in a riser extending from a subsea source to one or more surface vessels. Both the establishment and maintenance of flow may involve preventing, managing, mitigating, and/or controlling hydrocarbon gas hydrate formation directly in the riser hydrocarbon flow passage during deployment and use of the riser and any subsea equipment attached to the riser for containment and disposal operations, as well as other operations, for example production. Patent documents discussing hydrocarbon gas hydrates include U.S. Pat. Nos. 4,422,513; 6,080,704; 6,165,945; 6,571,604; 6,756,021; and 7,093,655, as well as JP10317869 and WO96/04348.

[0006] Marine riser systems have been used during marine drilling, production/injection, completion/workover, and export operations. For a review, see Sparks, C.P., “*Fundamentals of Marine Riser Mechanics*”, 2007, especially the introduction, pp. 1-19. Published U.S. Pat. App. Nos. 20070044972 and 20080223583 disclose marine riser systems and methods of installing same. Other patents that mention further features of marine production risers systems are U.S. Pat. Nos. 4,234,047, 4,646,840, 4,762,180, 6,082,391 and 6,321,844.

[0007] American Petroleum Institute Recommended Practice 2RD, (API-RP-2RD, First Edition June 1998), “*Design of Risers for Floating Production Systems (FPSs) and Tension-Leg Platforms (TLPs)*”, a standard in the subsea oil and gas production industry, notes that nitrogen may be used for leak testing, in buoyancy cans, and in static load testing for internal pressure. Nitrogen is noted as a one of the gases that may form hydrates in Bai et al., *Subsea Engineering Handbook*, page 454, (published December 2010); Bai et al., at page 437 also disclose marine riser systems.

[0008] Assignee's docket number 500005-00, incorporated herein by reference, discloses a riser system to enable closed flow connection from a subsea blowout to a drilling/well test vessel during containment periods, and which may be employed in well test and injection

scenarios during normal production operation. The riser system includes a drill pipe having attached thereto a seal stem that seals with a polished bore receptacle (PBR) anchored to the seabed.

[0009] A need exists for methods to establish and/or maintain hydrocarbon flow in a riser from a subsea source to one or more surface vessels.

SUMMARY

[0010] The present methods are directed to uses of low-density fluids to establish and/or maintain hydrocarbon flow in a riser extending from a subsea source to one or more surface vessels.

[0011] One aspect of the disclosure is a method including deploying a riser and a collection tool subsea upstream from a plume of hydrocarbons emanating from a subsea source of hydrocarbons, displacing seawater from the riser and tool by forcing low-density fluid into the riser and tool, positioning the tool connected to a distal end of the riser to collect hydrocarbons from the source of hydrocarbons while the riser and tool remain filled with the low-density fluid, and establishing flow of hydrocarbons up the tool and riser by ceasing the forcing of the low-density fluid into the riser and tool and collecting hydrocarbons up the tool and riser.

[0012] In certain embodiments, the deploying step can include deploying a riser from a surface vessel subsea upstream from a plume of hydrocarbons from a subsea source of hydrocarbons, deploying a collection tool on the seabed, and stabbing a distal end of the riser into the tool and picking up the tool from the seabed using the riser.

[0013] Another aspect of the disclosure is similar to the first aspect, except that the deployment step includes deploying the riser and a collection tool connected to a distal end of the riser from a surface vessel subsea upstream from a plume of hydrocarbons from a subsea source of hydrocarbons.

[0014] A still further aspect of the disclosure is a method additionally including the step of pumping hydrocarbon gas hydrate inhibitor liquid into the collection tool during at least the collecting step.

[0015] These and other features of the methods of the disclosure will become more apparent upon review of the brief description of the drawings, the detailed description, and the claims that follow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The manner in which the objectives of this disclosure and other desirable characteristics can be obtained is explained in the following description and attached drawings in which:

[0017] FIGS. 1-4 are logic diagrams of four method embodiments in accordance with the present disclosure, and FIG. 5 is a logic diagram of a particular method involving a top hat tool and riser; and

[0018] FIG. 6 is a schematic cross-sectional view of a riser external collection tool (RECT) tool useful in practicing certain methods of this disclosure.

[0019] It is to be noted, however, that the appended drawings are not necessarily to scale and illustrate only typical embodiments of this disclosure, and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

DETAILED DESCRIPTION

[0020] In the following description, numerous details are set forth to provide an understanding of the disclosed methods. However, it will be understood by those skilled in the art that the methods covered by the claims may be practiced without these details and that numerous variations or modifications from the specifically described embodiments may be possible and are deemed within the claims. All U.S. published patent applications and U.S. Patents referenced herein are hereby explicitly incorporated herein by reference. In the event

definitions of terms in the referenced patents and applications conflict with how those terms are defined in the present application, the definitions for those terms that are provided in the present application shall be deemed controlling.

[0021] Methods of this disclosure may be employed for deepwater subsea containment, disposal, production, and well intervention. While many of the methods described herein may be used in the context of containment and disposal, it is explicitly noted that the methods described herein are not restricted to containment and disposal operations, but may be used in conjunction with any “subsea source”, as that term is defined herein. As used herein the term “upstream” when used to describe deployment of a riser and/or collection tool means the riser and/or collection tool is not in the plume of hydrocarbons emanating from a subsea source. As used herein the term “hydrocarbon gas hydrates” means hydrates formed from hydrocarbon gases selected from the group consisting of methane, ethane, propane, butane, isobutene, isobutene and mixtures thereof. The methods may be fully or partially implemented before, during, and after a subsea riser is deployed to collect hydrocarbons from a subsea source (e.g. seafloor seep) or subsea component that has been compromised (for example, but not limited to, a subsea well blowout, damaged subsea blow out preventer (BOP), damaged subsea riser or other subsea conduit, damaged subsea manifold, and the like), and may be used in any marine environment, but are particularly useful in deep and ultra-deep subsea marine environments. The methods may also be used to control, limit, and/or totally prevent hydrocarbon gas hydrate formation during deployment of a subsea riser prior to and during a subsea operation to collect hydrocarbons producing naturally. Methods of the disclosure may also be used to start the flow or enhance the flow rate of source fluids using gas lift principles by injecting nitrogen or other gas, with or without produced gas, near the lower end of the riser.

[0022] In the containment and disposal context, in certain embodiments, the methods described herein may be used in any subsea marine environment to establish and/or maintain flow of material (hydrocarbons, or fluids comprising hydrocarbons) in a riser from a subsea source to one or more surface vessels. As used herein, the phrases “maintain flow” and “maintaining flow” mean controlling, limiting, and/or totally preventing hydrocarbon gas hydrate formation during deployment of a subsea riser and accessory components. Accessory components may include, but are not limited to, collection tools such a top hat fluidly

connected to the riser, a riser insertion tubing tool (RITT) fluidly connected to the riser, a seal stem fluidly connected to the riser, and the like. The terms “establishing flow” and “maintaining flow” may also include using gas lift or subsea pumping methods. Both the establishment and maintenance of flow may involve preventing, managing, mitigating, and/or controlling hydrocarbon gas hydrate formation directly in the riser hydrocarbon flow passage prior to, during deployment, and during use of the riser and any subsea equipment, accessory components, collection tools, and the like attached to the riser for containment and disposal operations, as well as other operations. The methods of this disclosure may not only be used for containment and disposal operations, but may also be used for exploration, production, drilling, completion, and intervention. In certain embodiments, a chamber filled with low-density fluid may be formed in the collection tool, establishing a shielded flow of hydrocarbons from the source of hydrocarbons. By “shielded flow” is meant that the flow of hydrocarbons is shielded from substantial contact with seawater. Since water is a necessary ingredient in formation of hydrocarbon gas hydrates, this advantageously mitigates their formation.

[0023] Certain method embodiments include assembling riser sections at or near the sea surface on one or more surface vessels. Certain embodiments include assembling the riser using high strength steel tubulars coupled with threaded connectors. In certain embodiments the tubulars are vacuum-insulated tubulars. In certain embodiments the riser is constructed of one or more tubulars selected from the group consisting of drill pipe, reel pipe, flexible pipe, composite pipe, and hose. Certain embodiments include controlling hydrocarbon gas hydrate formation by limiting contact of liquids or solids with inner surfaces of the riser and a collection tool during at least the positioning of the riser and tool subsea. In certain embodiments a functional fluid is pumped into the tool, the functional fluid selected from the group consisting of wax inhibitor, asphaltene inhibitor, hydrocarbon gas hydrate inhibitor, and combinations thereof. In certain embodiments, a dispersant chemical may be introduced into any hydrocarbons mixing with seawater. Methods of this disclosure where one or more functional fluids are used in the tool in conjunction with a low-density fluid being forced down the riser, and optionally a dispersant chemical, are deemed methods of preventing hydrocarbon gas hydrates to form, whereas methods of using only a low-density fluid forced down the riser (and tool, if present during deployment) and optionally a dispersant, are deemed methods of controlling hydrocarbon gas hydrate formation. In the latter methods, the

risk of hydrate formation is higher, but the form of the hydrate can be controlled to a manageable level by preventing flakes of hydrates forming drifts, or hard compactions of hydrocarbon gas hydrates.

[0024] As used herein the phrase “on the seabed”, when used to describe location of a tool or other item, is understood to include tools in baskets, or on platforms or manifolds, that are in turn resting directly on (touching) the seabed. As used herein “ceasing the forcing of low-density fluid” means the forcing of the low-density fluid down the riser is gradually reduced and then stopped during the collection step.

[0025] In certain method embodiments the collection tool may be selected from the group consisting of a top hat, a riser insertion tubing tool (RITT), a riser external collection tool (RECT), a cofferdam, and a seal stem. These tools are more fully described herein, and/or in one or more of assignee’s Attorney Docket Nos. 500005-00 and 500032-00, identified above. The RITT and RECT tools are used in embodiments where the subsea source is, for example, a leaking riser or other pipeline laying on the seabed, and similar situations. The RITT tools are designed to be inserted into or seal around the riser or pipeline, while the RECT tools are designed to be positioned over the leaking riser or other equipment. The RECT tools comprise a large diameter lower pipe section, for example a 32 inch (81 cm) diameter pipe, which has U-cuts or equivalent to accommodate a riser or pipeline laying on or above the seabed and a drill pipe (if present) also laying on or above seabed. At its upper end the large diameter pipe has a smaller diameter pipe (for example 10 inches (25 cm) diameter) attached thereto in the form of a chimney. The chimney extends upward into and slidably engages another pipe, for example a pipe having diameter intermediate to the lower and chimney pipes. This tool and its operation are further described herein.

[0026] In certain method embodiments the surface vessel is a drill ship or vessel including a drilling rig and a riser upper end is connected to the drill ship or drilling rig.

[0027] In certain embodiments the low-density fluid is selected from the group consisting of nitrogen, nitrogen-enriched air, helium, chlorine, hydrogen, argon, krypton, neon, dehumidified versions of any of these, and/or any mixture thereof. In certain embodiments the low-density fluid may comprise a gas atmosphere consisting essentially of nitrogen,

where the phrase “consisting essentially of nitrogen” means that the gas atmosphere is mostly nitrogen plus any allowable impurities that would not affect the ability of the nitrogen to limit hydrocarbon gas hydrate formation. The pressure of the low-density fluid in the riser near the distal end of the riser and in the tool attached to the riser should be such as to permit outward flow of the nitrogen (or other gas) during deployment and before start up.

[0028] In certain methods the connecting of the riser sections comprises connecting drill pipe riser sections, or other riser sections, using threaded joints. In certain methods the connecting of riser sections includes connecting sections of insulated pipe using threaded or other joints; in certain embodiments the threaded joints may be vacuum insulated tubing with insulation covers for the threaded connections.

[0029] In certain embodiments the collection tool is a top hat, the vessel is a mobile offshore drilling unit (MODU), and the deploying and positioning include: moving the MODU upstream of a plume of hydrocarbons in the water column emanating from the subsea source (in certain embodiments this is about 800 meters upstream); establishing flow of the low-density fluid inside the riser and top hat until it bubbles out of the lower end of the riser, preventing ingress of water or hydrocarbon gas hydrates into the riser and top hat thus limiting plugging of the riser and top hat; moving the MODU so that the top hat is a few meters above the subsea source, with the top hat in the hydrocarbon plume, and the low-density fluid still bubbling out of the lower end of the top hat and limiting hydrates from forming in inside surfaces of the top hat; landing the top hat on the subsea source, while the top hat remains filled with low-density fluid, keeping seawater out of the top hat; initiating flow of a liquid hydrate inhibitor, and optionally wax and asphaltene inhibitors, through surface control or subsea valves; and optionally initiating flow of a dispersant that mixes with any non- collected hydrocarbons.

[0030] In certain methods the top hat makes no positive seal with the subsea source. In these methods, the method further includes: gradually opening a surface or subsea choke, allowing hydrocarbons to move up the riser as the flow of low-density fluid pressure is gradually reduced and then ceased, and the hydrocarbons and low-density fluid are pushed up by the heavier seawater, controlling the choke opening so that entrance of seawater into the top hat is at least mitigated.

[0031] In certain methods, if flow up the riser is not sufficient, certain methods include providing an auxiliary method to increase flow selected from the group consisting of pumping the hydrocarbon up the riser using a subsea pump, employing gas lift with a non-oxidizing mixture of collected gas (with or without added nitrogen) added through an umbilical or coiled tubing employing a compressor, and employing gas lift using a flue gas (with or without added nitrogen) added through an umbilical or coiled tubing employing a compressor.

[0032] In certain methods when hydrocarbon flow is excessive from the source and would overwhelm the surface processing equipment, the collecting tool such as a top hat may act as a separator and release mainly hydrocarbons through one or more top-mounted release valves. Also, in certain embodiments, the liquid being released from the bottom of the top hat may primarily include produced water. The separation in certain embodiments may be increased using a baffle and spiral-vortex flow.

[0033] In embodiments where the collection tool is a seal stem, the seal stem may include a latch ring near its lower end that allows reduction of travel of the seal stem in a polished bore receptacle (PBR). In certain method embodiments the seal between the PBR and the seal stem is such that the riser and seal stem may be disconnected from the PBR, allowing the PBR and lower riser assembly (LRA) to be disconnected from the surface vessel in an either an emergency or planned event (i.e. drive/drift off or hurricane evacuation).

[0034] In certain method embodiments where the subsea source is a subsea BOP, the method further includes fluidly connecting one or more umbilicals to the BOP, one of the umbilicals fluidly connecting to locations on the subsea BOP selected from the group consisting of a kill line of the BOP, a choke line of the subsea BOP, and both the kill and choke lines of the subsea BOP.

[0035] In certain method embodiments the subsea source may be a subsea BOP, and the method further includes fluidly connecting one or more umbilicals, one of the umbilicals fluidly connected to a subsea BOP stack manifold.

[0036] In certain method embodiments the riser further includes one or more umbilicals, the method fluidly connecting one of the umbilicals to a subsea manifold.

[0037] In certain other system embodiments the riser further includes a modified bumper sub, and may include one or more drill collars in the string near the distal end of a drill pipe riser in order to provide weight to the drill pipe riser during deployment. The modified bumper sub may have one or more splines and/or seals removed.

[0038] In certain method embodiments one or more steps can be performed using a mobile offshore drilling unit (MODU). Certain method embodiments include assisting the MODU or other surface vessel using one or more ROVs.

[0039] As used herein the phrase “subsea source” includes, but is not limited to: 1) production sources such as subsea wellheads, subsea BOPs, other subsea risers, subsea manifolds, subsea piping and pipelines, subsea storage facilities, and the like, whether producing, transporting and/or storing hydrocarbons, liquids or combination thereof, including both organic and inorganic materials; 2) subsea containment sources of all types, including damaged subsea BOPs, risers, manifolds, tanks, and the like; and 3) fissures or openings in the sea floor.

[0040] Certain hydrate inhibition method embodiments include those wherein the hydrate-inhibitor liquid chemical is selected from the group consisting of alcohols (such as methanol, ethanol, and the like) and glycols (such as ethylene glycol, propylene glycol, and the like and mixtures of glycols). An important property of propylene glycol is its ability to lower the freezing point of water. This results in its use in the formulation of antifreeze mixtures. Propylene glycol is almost as efficient as ethylene glycol in antifreeze applications. Solutions of inhibited propylene glycol (propylene glycol containing a corrosion inhibitor) may also be employed.

[0041] In certain method embodiments a hydrocarbon dispersant may be employed, for example pumped around the base of a top hat or cofferdam, or above or around a riser insertion tubing tool. One suitable dispersant may be the chemical known under the trade designation COREXIT®, whose composition is given more fully herein.

[0042] Yet other method embodiments include, in the event of a hurricane or planned disconnect, disconnecting the riser and seal stem from the PBR in a controlled manner using upward force, which force may have a lateral component. Even if not performed in a controlled manner, such as during an unplanned weather event, or ship malfunction event, the system is designed such that the seal stem may disconnect from the PBR without extensive damage to the seal stem, riser, and PBR. In method embodiments where the tool is a top hat, there may either be a positive seal or no seal arrangement. In either situation, in the case of a surface vessel drive off the top hat is just dragged off by the drill pipe. It is preferable to close the upper choke prior to disconnecting to prevent the sucking up of water in the riser. Once disconnected a low-density fluid may be pumped into the riser to mix with or displace the hydrocarbons and permit seawater to fill up the riser prior to retrieving it. An ROV-installable plug or in-line valve near the bottom may facilitate this operation. In embodiments where there is a positive seal of a top hat to a damaged subsea component, the top hat may be deployed with one or more of its venting valves open. In certain embodiments the vent valves may be piped so their end openings are at or near the elevation of the top hat skirt bottom. If the top hat is positively sealed to the subsea source, then a break away coupling, which may be pressure-balanced, may be employed. A modified bumper sub, such as disclosed in assignee's Attorney Docket No. 41001-00, incorporated herein by reference, may be a component of the drill pipe riser, and may be equipped with a break-away coupling device. A modified bumper sub may have some splines and/or some seals removed to reduce friction in the sub.

[0043] In certain embodiments the flow of material from the subsea source may exceed the capacity of the MODU or other surface vessel receiving flow from the riser and collection tool. In certain method embodiments employing a top hat collection tool, advantage may be taken of one or more vent openings on the top hat that may be fitted with quick connect/disconnect low-pressure hose connections. The excess material may then be collected by one or more additional surface vessels or MODUs. For example, a second MODU, again upstream from the hydrocarbon plume, may deploy a second riser having a long, low-pressure hose fluidly connected to its bottom (distal) end. When the lower end of the hose is next to the sea floor, the second MODU moves close to the top hat, while deploying more of the second riser. When the second riser makes contact with the mud, the

second MODU lays away the second riser like a catenary riser. Some protection to prevent hose kinking may be provided at the end of the second riser. In these embodiments, there would then be a second MODU with a second riser catenary to the sea floor forming a flow line on the sea floor, and a hose. The second riser top end is connected to process equipment on the second MODU. Nitrogen or other low-density fluid is forced into the second riser until it bubbles out of the hose. The hose is then connected to one of the top hat venting ports, for example using one or more ROVs. The venting port is opened and a choke opened on the second MODU. The excess material (oil and gas) that could not be processed by the first MODU may then be collected by the second riser and second MODU. The hose may have a pressure-balanced break-away connector for emergency disconnect and reconnect.

[0044] In certain method embodiments, if cooling at the surface or subsea choke is excessive during collection of the hydrocarbons, the hydrocarbon flow may be heated prior to the choke by pumping heated seawater into an annulus between the riser and an external riser, or heating the oil on the deck of the surface vessel.

[0045] The primary features of the methods of the present disclosure will now be described with reference to the drawing figures, after which some of the operational details will be further explained. In accordance with the present disclosure, FIGS. 1-4 are logic diagrams of four method embodiments in accordance with the present disclosure. The method of embodiment 100 of FIG. 1 is a method of establishing flow of material from a subsea source through a collection tool and a riser that ties back to a surface vessel, which may be a drill ship such as a Mobile Offshore Drilling Unit (MODU) equipped with a flare and hydrocarbon processing equipment with or without oil storage and oil transfer equipment to another vessel. In embodiment 100 the method includes connecting riser sections at or near the sea surface (for example some connections may be made underwater near the vessel) to assemble a drill pipe riser, each riser section including, in embodiment 100, a drill pipe riser section, box 102. The drill pipe riser is then deployed subsea, upstream from a plume of a subsea source of hydrocarbons, box 104.

[0046] Still referring to FIG. 1, method embodiment 100 further includes deploying a collection tool on the seabed, box 106. The tool may be deployed before, after, or at substantially the same time as the riser is being deployed. If only one vessel is involved, one

method would be to deploy the collection tool on the seabed using the vessel prior to deploying the riser using the same vessel. This would be one way to limit any damage to the collection tool and its operability before deploying the riser. In other situations it may be preferable to reverse these steps, for example to ensure as far as possible that the drill pipe riser is being properly flushed with the low-density fluid. It should not be necessary to point out that the collection tool may be deployed on a platform or other structure which itself has been previously placed on the seabed. As a short-hand notation, “seabed” is used with this understanding. As noted in box 108, method 100 then includes stabbing a distal end of the riser into the collection tool and picking up the tool from the seabed with the riser. As mentioned herein, this and other steps may require assistance of one or more remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), unmanned undersea vehicles (UUVs) or similar underwater vehicles.

[0047] Once the collection tool is stabbed and picked up from the seabed, method embodiment 100 includes displacing seawater from the riser and tool using a low-density fluid, such as nitrogen, and then positioning the collection tool to collect hydrocarbons from the source of hydrocarbons while the riser and collection tool remain filled with low-density fluid, box 110. Method embodiment 100 then includes establishing flow of hydrocarbons up the collection tool and riser, and controlling hydrocarbon gas hydrate formation by limiting contact of liquids or solids with inner surfaces of the riser and tool during at least the positioning of the riser and tool subsea, box 112. Lastly, method 100 includes ceasing the forcing of the low-density fluid down the riser and tool, and collecting hydrocarbons up the tool and riser, box 114.

[0048] In accordance with the present disclosure, method embodiment 100 includes deploying the riser and picked-up tool subsea upstream of the plume of the subsea hydrocarbon source, and once positioned upstream of the plume, forcing a low-density fluid down the drill pipe riser to displace seawater from the riser and tool until bubbles of the low-density fluid are seen exiting the bottom of the tool. The riser and tool are then moved toward the plume and positioned to establish flow of collected material (primarily hydrocarbons) up the tool and riser, and control hydrocarbon gas hydrate formation by limiting contact of liquids and solids with inner surfaces of the riser and collection tool during at least the positioning of the collection tool subsea near the subsea source. “Forcing” may include

pumping a liquid or using a compressor to force gaseous fluid into the drill pipe riser, depending on the low-density fluid used. Depending on the configuration of equipment available on the surface vessel or vessels, the low-density fluid may be pumped or forced using compression into the drill pipe riser using dedicated pumps or compressors, or pumped or forcibly compressed into the drill pipe riser using a pump or compressor that is part of a unit operation on the vessel. In certain embodiments, the low-density fluid may be a gas such as industrial nitrogen gas pressurized by heating liquid nitrogen (or allowing it to be heated by local ambient temperature) so that it vaporizes. Supplemental compression may be required after such vaporization. In certain embodiments, nitrogen may be produced on a surface vessel using a nitrogen generator (for example, adsorption, membrane, and cryogenic nitrogen generators). In certain embodiments nitrogen may be extracted from the riser flow. In these latter embodiments, this nitrogen may or may not be mixed with collected hydrocarbon gas. In other embodiments, “flue gas” comprising little or no remaining oxygen from a hydrocarbon combustion process may be used.

[0049] Another method of this disclosure is presented in the logic diagram of FIG. 2 as embodiment 200. Embodiment 200 is another method of establishing flow of material from a subsea source through a collection tool and a riser that ties back to a surface vessel, which may be a drill ship such as an MODU. Embodiment 200 differs from embodiment 100 in that the collection tool is connected to the riser at or near the sea surface, rather than the riser stabbing and picking up the tool from the seabed. Similar to embodiment 100, one of the initial steps is connecting riser sections at the sea surface, box 202. The method continues by connecting a collection tool to the distal end of the riser, box 204, and deploying the connected riser sections and tool subsea upstream from the plume of the subsea source of hydrocarbons, box 206. As noted above in connection with embodiment 100, in embodiment 200 one or more ROVs or other underwater vehicles may assist in this step. Nitrogen or other low-density fluid is then forced down the riser and tool, as in embodiment 100, to displace seawater from the riser and tool until bubbles of the low-density fluid are seen exiting the bottom of the collection tool. The riser and tool are then positioned, again using one or more undersea vehicles such as ROVs, to collect hydrocarbons from the subsea source of hydrocarbons, box 208. Method embodiment 200 proceeds by ceasing the injection of low-density fluid at the top of the riser and collecting hydrocarbons up the tool and riser, box 210. In accordance with the present disclosure, method embodiment 200 includes forcing a low-

density fluid down the drill pipe riser at least during positioning of the tool and riser to control hydrocarbon gas hydrate formation by limiting contact of liquids and solids with inner surfaces of the riser and collection tool at least during the positioning of the riser and collection tool subsea near the subsea source. During collection of hydrocarbons, the surface or subsea choke is opened gradually, allowing fluids to travel up the collection tool and riser toward the surface vessel for processing.

[0050] Still another method of this disclosure is presented in the logic diagram of FIG. 3 as embodiment 300. Embodiment 300 is a method of establishing and maintaining flow of material from a subsea source through a collection tool and a riser that ties back to a surface vessel, which may be a drill ship such as an MODU. Method embodiment 300 is similar to method embodiments 100 and 200, with additional features such as the addition of one or more functional fluids to the tool, such as wax inhibitors, asphaltene inhibitors, scale inhibitors, corrosion inhibitors, antideposition agents, and the like, and/or the addition of dispersant chemical in the vicinity of the tool, for example, the skirt of a top hat or directly into a RITT, although dispersant is preferably not mixed with the collected hydrocarbon, as it makes hydrocarbon/water separation difficult. As in method embodiment 100, method embodiment 300 includes connecting riser sections at or near the sea surface, box 302; deploying the riser subsea near a subsea source of hydrocarbons, box 304; deploying a collection tool on the seabed, box 306 (the order of steps in boxes 304 and 306 may be reversed or they may substantially coincide in time, as noted previously); stabbing a distal end of the riser into the tool and picking up the tool with the riser, box 308; positioning the riser and tool upstream of the plume of the hydrocarbon source, displacing seawater from the riser and tool with a low-density fluid, and after observing bubbles of low-density fluid exiting the bottom of the tool, positioning the riser and tool to collect hydrocarbons from the source of hydrocarbons, box 310; ceasing the injection of low-density fluid at the top of the riser and opening a choke and collecting hydrocarbons using the tool and riser, box 312. In addition, method embodiment 300 includes pumping an inhibitor liquid into the tool during at least the collecting step, box 314.

[0051] Yet another method of this disclosure is presented in the logic diagram of FIG. 4 as embodiment 400. Embodiment 400 is a method of establishing and maintaining flow of material from a subsea source through a collection tool and a riser which ties back to a

surface vessel. Method embodiment 400 is similar to method embodiment 200, with additional features such as the addition of one or more functional fluids to the tool, such as a wax inhibitor, asphaltene inhibitor, scale inhibitor, corrosion inhibitor, antideposition agent, and the like, and/or the addition of dispersant chemical in the vicinity of the collection tool in the uncollected hydrocarbons, preferably in the hotter parts of the plume, for example, near the skirt of a top hat and the exhaust of the vent pipes where hydrocarbons may be escaping. As in method embodiment 200, method embodiment 400 includes the steps of connecting riser sections at or near the sea surface to form a riser, box 402; connecting a collection tool to the distal end of the riser, box 404; deploying the riser and tool subsea away from the plume of the hydrocarbon source, then displacing seawater from the riser and tool with a low-density fluid until observing bubbles of low-density fluid exiting the bottom of the tool, 406; positioning the tool to collect hydrocarbons from the subsea source of hydrocarbons, box 408; and ceasing the injection of low-density fluid at the top of the riser and opening a choke and collecting hydrocarbons using the tool and riser, box 410. Method embodiment 400 also includes pumping an inhibitor liquid into the tool during at least the collecting step, box 412.

[0052] FIG. 5 illustrates a particular method embodiment 500 wherein the collection tool is a top hat and the surface vessel is a mobile offshore drilling unit (MODU). Method embodiment 500 includes moving the MODU upstream of a plume of hydrocarbon in the water column emanating from the subsea source, box 502; establishing flow of the low-density fluid inside the drill pipe riser until it bubbles out of the lower end of the top hat, limiting ingress of water or hydrocarbon gas hydrates into the drill pipe riser and top hat and thus limiting plugging of the drill pipe riser and top hat, box 504; moving the MODU so that the top hat is above and a few meters from the subsea source, with the top hat in the hydrocarbon plume, and the low-density fluid still bubbling out and limiting hydrates from forming in the inside surfaces of the top hat, box 506; landing the top hat on the subsea source, while the top hat remains filled with low-density fluid, limiting entrance of seawater, box 508; initiating flow of a liquid hydrate inhibitor, and optionally wax and asphaltene inhibitors, through valves on the roof of the top hat, box 510; ceasing the injection of low-density fluid at the top of the riser and gradually opening a surface or subsea choke, allowing hydrocarbons to move up the drill pipe riser as the low-density fluid pressure is released, and the hydrocarbons and low-density fluid are pushed up by the heavier seawater, controlling the choke opening so that entrance of seawater into the top hat is limited.

[0053] In method embodiments 300 and 400, and optionally in embodiment 500, one or more inhibitor liquids may be introduced into or in the vicinity of the collection tool, the one or more inhibitor liquids selected from the group consisting of wax inhibitors, asphaltene inhibitors, scale inhibitors, corrosion inhibitors, antideposition agents, combinations of two or more thereof, and the like. One or more dispersant chemicals may also be introduced into or in the vicinity of the tool. Suitable corrosion inhibitors include, but are not limited to, compositions selected from the group consisting of amides, quaternary ammonium salts, rosin derivatives, amines, pyridine compounds, trithione compounds, heterocyclic sulfur compounds, alkyl mercaptans, quinoline compounds, polymers of any of these, and mixtures thereof. Suitable scale inhibitors include, but are not limited to, compositions selected from the group consisting of phosphate esters, polyacrylates, phosphonates, polyacrylamides, polysulfonated polycarboxylates, copolymers thereof, and mixtures thereof. These scale and corrosion inhibitors are more fully discussed in U.S. Pat. No. 7,772,160, assigned to Baker Hughes Inc., Houston, Texas, USA. Suitable asphaltene inhibitors include, but are not limited to, ester and ether reaction products, such esters formed from the reaction of polyhydric alcohols with carboxylic acids; ethers formed from the reaction of glycidyl ethers or epoxides with polyhydric alcohols; and esters formed from the reaction of glycidyl ethers or epoxides with carboxylic acids, as described in U.S. Pat. No. 6,313,367 also assigned to Baker Hughes. In certain embodiments, a chemical may contribute more than one of the functions of wax, corrosion, and scale inhibition, and dispersant action. As noted in the '367 patent, some of the compositions taught therein may function as asphaltene deposition inhibitors and dispersants.

[0054] Flow rates of the chemicals depend greatly on the specific situations, and one would not normally use more than required to perform one or more of the intended tasks. In general, the use of hydrate inhibitor is recommended to range from about 0.5 to about 1.0 volumes of inhibitor chemical to volume of water that is expected to mix with hydrocarbon. For embodiments of a RITT tool, flow rate of hydrate inhibitor such as methanol might range from about 2 to about 15 gallons per minute, or from about 6 to about 8 gallons per minute. For embodiments of a top hat tool, flow rate of hydrate inhibitor such as methanol might range from about 2 to about 15 gallons per minute, or from about 2 to about 8 gallons per minute.

[0055] In certain embodiments, the mixing of seawater with hydrocarbons can be reduced or eliminated. There are several options to prevent mixing in a situation such as presented in FIG. 6, discussed below, including inserting a hose with an expanding bladder around it to seal inside pipe 614 (bladders may be off the shelf items, such as used in packers); inserting a hose into pipe 614 and producing a seal with mud or cement (however the created suction may be large and damage the formed seal if pressure is not controlled); and/or plug the drill pipe 604 end with an ROV plug. Dispersants are mixtures of solvents, surfactants and other additives that break up the surface tension of hydrocarbons and make hydrocarbons more soluble in water. Dispersants do not remove hydrocarbons from the water, but break up the hydrocarbons into small droplets. These droplets disperse into the water column (or depths), where they may then break down further in the environment. Examples of dispersants that may be useful in the methods and systems disclosed herein are the chemical compositions known under the trade designations COEXIT 9500 and COREXIT 9527, available from Nalco Company, Naperville, Illinois, USA, the compositions of which are publicly available and found in Table 1.

TABLE 1: Ingredients in COREXIT® brand dispersants

CAS Registry Number	Chemical Name
57-55-6	1,2-Propanediol
111-76-2	Ethanol, 2-butoxy-*
577-11-7	Butanedioic acid, 2-sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt (1:1)
1338-43-8	Sorbitan, mono-(9Z)-9-octadecenoate
9005-65-6	Sorbitan, mono-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs.
9005-70-3	Sorbitan, tri-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs
29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-
64742-47-8	Distillates (petroleum), hydrotreated light
*Note: This chemical component is not included in the composition of COREXIT 9500.	

[0056] FIG. 6 illustrates a schematic cross-sectional view of one embodiment 600 of a riser external collection tool (“RECT”) useful in certain method embodiments. In certain situations, a damaged riser 602 and drill pipe 604 may be laying on the seabed, partially buried below and partially above the mudline 601. Tool 600 includes, in this embodiment, a large diameter lower pipe section 606, for example 32-inch (81cm) diameter pipe, which has

downward U-cuts 608, 610 to accommodate damaged riser 602 and drill pipe 604. At its upper end, large diameter pipe 606 has a smaller diameter pipe 612 (for example 10 inches (25cm) diameter) attached thereto in the form of a chimney. Pipe 612 extends upward into and slidingly engages another pipe 614, for example a pipe having diameter intermediate to lower pipe 606 and chimney pipe 612 (for example 21 inches (53cm)). Pipe 614 fluidly connects to drill pipe riser 616 which ties back to the surface vessel (not illustrated). Flow of leaking material from damaged riser 602 is indicated by arrowed line 628, illustrating the flow traversing up through pipes 606, 612, and 614, and drill pipe riser 616. Hydrocarbons may collect near area 622 in pipe 614 and some hydrate flakes may collect in pipe 614 in a lower area 620, while some hydrates may escape as indicated by the arrow designated 618 (hydrates generally are more dense than hydrocarbons, but less dense than seawater).

[0057] RECT tool 600 and drill pipe riser 616 may be deployed by a surface vessel or MODU that includes facilities for deploying tubulars. During deployment, the RECT tool may be hanging under the vessel, supported by the tubing that, in certain embodiments, is drill pipe for robustness, although the use of drill pipe is not required; for example, vacuum-insulated tubing may be used in certain embodiments if thermal insulation to prevent hydrates is considered. The RECT tool is brought over the end of the leaking riser. The vessel rotates the RECT tool to align the U-cuts with the damaged riser and drill pipe. As the RECT tool is lowered it penetrates the mud as the tubing (drill pipe riser 616) is slackened. Drill collars may be added in the tubing line 616 to increase mud penetration. When installed, pipe 612 inside pipe 614 provides the telescopic stroke required to accommodate vessel heave and riser 616 bowing.

[0058] A polished seal 630 may be employed, for example, a polished bore receptacle or bumper sub with swiveling capabilities. The lateral stability of tool 600 is provided by pipe 606 in contact with the soil. The resistance to rocking or falling over is provided by riser 616 and optional drill collar stiffness, and some by the interface between mud and pipe 606.

[0059] During start-up, if not self-starting, nitrogen or other low-density fluid may be injected into the top of tubing 616 to displace the seawater out of the riser 616 and establish flow of material up the tool and riser. The top of the tubing 616 is opened to the processing equipment in the surface vessel. The oil and gas, having lower density compared to seawater,

induces flow of the produced fluid to the processing equipment. Optionally, gas lift or pumping may be provided. During normal operation, the vessel stays on location. An ROV may be used to monitor the bottom of pipe 614. One or more holes place about 1 inch (2.54cm) from the bottom of pipe 614 may be used as a tell tale and reduce the losses.

[0060] In an emergency disconnect situation, a surface vessel having the capability to lift tool 600 and riser 616 up is used. If the surface vessel cannot lift tool 600 because of a vessel malfunction, weather, or other reason, the bottom part of tool 600 may be dragged on the sea floor. If it snags in the sea floor, nylon lines 624, 626 may be provided that will break.

[0061] The chimney effect in pipe 612 may affect operations, as the venturi effect may induce water to enter through the U-cut openings at the bottom of pipe 606. To offset this, the pressure differential is kept low by a relatively short chimney (pipe 612). Improved sealing around the U-cuts may be provided, for example using flexible fabrics and the like. Gravel bags or just gravel may be dumped on the mud floor around pipe 606 to form a partial seal and help prevent water from mixing with the collected fluids.

[0062] Note that sizes (diameters) of pipes 606, 612, 614, and 616 may be changed from those discussed above, with possible sacrifice in response time. Piping of 21-inch (53cm) and 10-inch (25cm) diameter may be available in 20-foot (6.1m) sections, enough to provide the telescopic stroke of pipe 612 in pipe 614.

[0063] In certain method embodiments a functional fluid is pumped into the collection tool. In certain embodiments the functional fluid may be selected from the group consisting of wax inhibitor, asphaltene inhibitor, hydrocarbon gas hydrate inhibitor, scale inhibitor, corrosion inhibitor and combinations thereof. In certain embodiments, a dispersant chemical may be introduced in the vicinity of hydrocarbons mixing with seawater, and in certain embodiments chemicals marketed as dispersant chemicals may also exhibit hydrate inhibition function. Methods of this disclosure where one or more functional fluids are used in the tool in conjunction with a low-density fluid being forced down the riser, and optionally a dispersant chemical (which may or may not have hydrate inhibition function), may limit formation of hydrocarbon gas hydrates, whereas methods of using only a low-density fluid forced down the riser (and tool, if present during deployment) and optionally a dispersant, may control hydrocarbon gas hydrate formation. In the latter methods, the risk of hydrate formation is

higher, but the form of the hydrate can be controlled to a manageable level by preventing flakes of hydrates forming drifts, or hard compactions of hydrocarbon gas hydrates.

[0064] In certain method embodiments the forcing of the low-density fluid down the riser occurs during the stabbing step. In certain method embodiments the forcing of the low-density fluid down the riser occurs during the positioning step. In certain method embodiments the forcing of the low-density fluid down the riser occurs during the stabbing and positioning steps. In certain method embodiments some of the low-density fluid may be injected from below into the riser or the collecting tool and may be gradually reduced during the collection step.

[0065] In certain method embodiments the collection tool may be selected from the group consisting of a top hat, a riser insertion tubing tool (RITT), a cofferdam, and a seal stem. A top hat includes an essentially an inverted cone attached to the distal end of a riser. The body of the cone may include various features, such as one or more vents, hydrate inhibitor injection points, and dispersant injection options. In certain embodiments, the dispersant may be delivered from a ring positioned near the lower edge of the skirt of the top hat. A weight ring may also be employed, which fits concentrically around the top hat body and provides weight to the structure. The vents may be provided with valves so as to allow adjustment in venting volume. In certain embodiments, one or more vents may allow connection to a flexible hose that is in turn fluidly connected to another riser an accompanying surface collection and processing vessel.

[0066] RITT tools in certain embodiments essentially include a curved or straight piece of pipe or conduit that is stabbed into the interior of a riser or other conduit or equipment laying on or protruding from the sea floor. Embodiments of RITT tools may be straight to allow stabbing into an opening that is pointing straight up. In certain embodiments, RITT tools may seal inside and/or outside the pipe or conduit or other equipment. The RITT conduit may include rubber protrusions extending away from the pipe and that seal against the inner surface of the riser pipeline or other equipment. Other embodiments may include a locking device that prevents or at least mitigates the RITT from pulling out of the equipment once it has been positioned inside the equipment. Hydrate inhibitor chemicals may be introduced into the riser using separate tubing clamped to the exterior of the RITT, and dispersant

chemicals may be delivered as necessary by one or more wands, for example maneuvered by an ROV or by piping preinstalled on the RITT tool.

[0067] When the collection tool is a seal stem, the seal stem may be used in conjunction with a polished bore receptacle (PBR) moored to the sea floor using an inverted wellhead/pile foundation arrangement, wherein the wellhead is specially configured to receive flow from a subsea source through a flexible conduit. As an example, seal stems may presently be purchased from Allamon Tool Company, Inc., Montgomery, Texas, USA. PBRs are available from several sources, including Weatherford International and Baker Hughes. In certain embodiments, wellbore pressure and temperature conditions may be so extreme as to tend to force the seal stem and riser upward, and force the seal stem out of the PBR. In certain embodiments, the seal stem may be modified to include a bottom end plate and one or more orifices to balance the pressure forces as is done on the common ROV hot stabs.

[0068] It should be noted that other vessels may be present during containment and production operations. For example, separate ship-based floating production and storage systems on the sea surface may be present, as well as processing vessels, collection vessels, service vessels, and the like. Other vessels may be provided for subsea installation, operational and ROV assistance, and hydrate prevention and remediation, if needed. A multipurpose intervention vessel may be present, which may include various subsea connector conduits, umbilicals from chemical dispersant and hydrate inhibition system; a hydrate inhibition system service vessel which may also supply power and/or hydraulic assistance through one or more umbilicals; a subsea umbilical distribution box, and electrical power and/or hydraulic umbilical lines.

[0069] Methods of this disclosure may employ a riser positioning system and riser tension monitoring sub-system. A riser positioning system typically includes a riser position clamp and a pair of acoustic sources or beacons. Suitable acoustic beacons are available from Sonardyne International Ltd in the UK, and from Sonardyne Inc., Houston, TX. The riser position clamp with two acoustic beacons may be deployed anywhere on the riser. These beacons may be integrated with the containment vessel dynamic positioning (DP) systems in order to provide relative location of the top of the riser that may be fed directly into the

management of vessel station-keeping limits. The riser tension monitoring unit may be strain-based and may be installed anywhere along the length of the riser, and in multiple locations.

[0070] In certain embodiments, certain connections may be expected to experience heavy fatigue. The teachings of Shilling, et al., “*Development of Fatigue Resistant Heavy Wall Riser Connectors For Deepwater HPHT Dry Tree Riser Systems*”, OMAE2009-79518, may be useful in these embodiments.

[0071] The methods of the present disclosure may be scalable over a wide range of water depths, well pressures and conditions. The riser ideally will be capable of handling over 40,000 bbls per day (about 4800 cubic meters per day) with a 6-inch (15 cm) ID flow path in the riser. The riser joints may for example include 0.563-inch (1.430cm) wall thickness X-80 steel material rated to 6,500 psi (45 MPa). In the past, X-80 material was used in order to successfully weld on premium riser connectors that had external and internal metal to metal seals and met the fatigue performance requirements of the anticipated service life. (X-80, or X80, is a number associated with American Petroleum Institute (API) standard 5L.)

[0072] In general, the riser may have an outer diameter (OD) ranging from about 1 inch up to about 50 inches (2.5 cm to 127cm), or from about 2 inches up to about 40 inches (5cm to 102cm), or from about 4 inches up to about 30 inches (10cm to 76cm), or from about 6 inches up to about 20 inches (15cm to 51cm).

[0073] Over the past several years, BP has participated in development of a comprehensive 15/20Ksi (103/138 MPa) dry tree riser qualification program which focuses on demonstrating the suitability of using high strength steel materials and specially designed thread and coupled (T&C) connections that are machined directly on the riser joints at the mill. See Shilling et al., “*Development of Fatigue Resistant Heavy Wall Riser Connectors for Deepwater HPHT Dry Tree Riser Systems*”, OMAE2009-79518. These connections may eliminate the need for welding and facilitate the use of high strength materials like C-110 and C-125 metallurgies that are NACE qualified. (As used herein, “NACE” refers to the corrosion prevention organization formerly known as the National Association of Corrosion Engineers, now operating under the name NACE International, Houston, Texas.) Use of high strength steel and other high strength materials significantly reduces the wall thickness

required, enabling riser systems to be designed to withstand pressures much greater than can be handled by X-80 materials and installed in much greater water depths due to the reduced weight and hence tension requirements. The T&C connections may eliminate the need for 3rd party forgings and expensive welding processes – considerably improving system delivery time and overall cost. It will be understood, however, that the use of 3rd party forgings and welding is not ruled out for risers described herein, and may actually be preferable in certain situations. Those having knowledge of the particular depth, pressure, temperature, and available materials, will be able design the most cost effective, safe, and operable riser and tool for each particular application without undue experimentation.

[0074] In certain embodiments a source point interface may be required to connect the collection tool to a subsea source. Subsea connectors such as those known under the trade designation OPTIMA mentioned herein may be employed at an interface between a flexjoint and the LMRP. If a PBR is used, a modified bumper sub having both telescoping action as well as swivel action may be employed between the PBR and a surface vessel, such as described in assignee's Attorney Docket No. 41001-00. In certain embodiments the PBR may be designed for balancing the pressure forces using the hot stab principle mentioned herein. The patent applications mentioned in this paragraph are incorporated herein by reference.

[0075] From the foregoing detailed description of specific embodiments, it should be apparent that patentable methods have been described. Although specific embodiments of the disclosure have been described herein in some detail, this has been done solely for the purposes of describing various features and aspects of the methods and certain apparatus used with those methods, and is not intended to be limiting with respect to the scope of the methods and apparatus. It is contemplated that various substitutions, alterations, and/or modifications, including but not limited to those implementation variations which may have been suggested herein, may be made to the described embodiments without departing from the scope of the appended claims.

What is claimed is:

1. A method comprising:

deploying a collection tool connected to the distal end of a riser subsea upstream from a plume of hydrocarbons from a subsea source of hydrocarbons;
displacing seawater from the riser and tool by forcing low-density fluid into the riser and tool;
positioning the tool to collect hydrocarbons from the source of hydrocarbons while the riser and tool remain filled with the low-density fluid;
establishing flow of hydrocarbons up the tool and riser by ceasing the forcing of the low-density fluid into the riser and tool; and
collecting hydrocarbons up the tool and riser.

2. The method according to claim 1, wherein the deploying step comprises:

deploying the riser from a surface vessel subsea upstream from the plume of hydrocarbons from the subsea source of hydrocarbons;
deploying the collection tool on the seabed; and
stabbing a distal end of the riser into the tool and picking up the tool from the seabed using the riser.

3. The method according to claim 1, wherein the ceasing of the forcing of the low-density fluid into the riser and tool comprises gradually reducing the amount of low-density fluid being forced into the riser and tool.

4. The method according to claim 1, further comprising controlling hydrocarbon gas hydrate formation by limiting contact of liquids or solids with inner surfaces of the riser and tool during at least the positioning of the riser and tool subsea.

5. The method according to claim 1, further comprising pumping a functional fluid into the tool, the functional fluid selected from the group consisting of wax inhibitor, asphaltene inhibitor, hydrocarbon gas hydrate inhibitor, and combinations thereof.

6. The method according to claim 1, wherein a dispersant chemical is mixed with hydrocarbons in the subsea source of hydrocarbons before the hydrocarbons escape the subsea source or just after some hydrocarbons escape from the subsea source of hydrocarbons and are not collected by the riser and tool.

7. The method according to claim 2, wherein the tool is a top hat, the vessel is a mobile offshore drilling unit (MODU), and the deploying and positioning comprise:

- moving the MODU upstream of a plume of hydrocarbons emanating from the subsea source;

- establishing flow of the low-density fluid inside the riser and top hat until it bubbles out of the lower end of the top hat, limiting ingress of water or hydrocarbon gas hydrates into the riser and thus limiting plugging of the riser and top hat;

- moving the MODU so that the top hat is a few meters above the subsea source, with the top hat in the hydrocarbon plume, and the low-density fluid still bubbling out of the lower end of the top hat and limiting hydrates from forming in inside surfaces of the top hat;

- landing the top hat on the subsea source, while the top hat remains filled with low-density fluid, keeping seawater out of the top hat;

- initiating flow of a liquid hydrate inhibitor, and optionally wax and asphaltene inhibitors, through surface control or subsea valves; and

- optionally initiating flow of a dispersant that mixes with any non- collected hydrocarbons.

8. The method according to claim 7, wherein the top hat makes no positive seal with the subsea source, the method further comprising:

- wherein the ceasing of flow of the low-density fluid comprises gradually reducing the flow of low-density fluid and gradually opening a choke, causing hydrocarbons to move up the riser as the low-density fluid pressure is pushed up by the heavier seawater and/or by well pressure if a seal with the subsea source has been established, and controlling the choke opening so that entrance of seawater into the top hat is at least mitigated.

9. The method according to claim 1, further comprising an auxiliary method to increase flow through the riser selected from the group consisting of pumping the hydrocarbon up the riser using a subsea pump, employing gas lift with a non oxidizing mixture of collected gas with or without nitrogen added through an umbilical or coiled tubing employing a compressor, and employing gas lift using a flue gas with or without nitrogen added through an umbilical or coiled tubing employing a compressor.
10. The method according to claim 1, comprising flowing a dispersant chemical near and/or into the subsea source of hydrocarbons where hydrocarbons are escaping into seawater.
11. The method according to claim 1, wherein the deploying step comprises:
deploying the riser and the collection tool to a distal end of the riser from a surface vessel subsea upstream from the plume of hydrocarbons emanating from the subsea source of hydrocarbons.
12. The method according to claim 11, wherein the deploying step comprises assembling riser sections at or near the sea surface to form the riser, wherein the riser sections comprise one or more tubulars selected from the group consisting of drill pipe sections, reel pipe, flexible pipe, composite pipe, and hose.
13. The method according to claim 11, wherein the low-density fluid consists essentially of nitrogen.
14. The method according to claim 11, wherein the ceasing of the forcing of the low-density fluid into the riser and tool comprises gradually reducing the amount of low-density fluid being forced into the riser and tool.
15. The method according to claim 11, comprising controlling hydrocarbon gas hydrate formation by limiting contact of liquids and solids with inner surfaces of the riser and collection tool during at least the positioning of the riser and tool subsea.

16. The method according to claim 11, wherein a functional fluid is pumped into the tool, the functional fluid selected from the group consisting of wax inhibitor, asphaltene inhibitor, hydrocarbon gas hydrate inhibitor, and combinations thereof.

17. The method according to claim 11, wherein a dispersant chemical is mixed with hydrocarbons in the subsea source of hydrocarbons before the hydrocarbons escape the subsea source or a dispersant chemical is mixed with hydrocarbons just after some hydrocarbons escape from the subsea source of hydrocarbons and are not collected by the riser and tool.

18. The method according to claim 11, wherein the tool is a top hat, the vessel is a mobile offshore drilling unit (MODU), and the deploying and positioning comprise:

- moving the MODU upstream of a plume of hydrocarbons emanating from the subsea source;

- establishing flow of the low-density fluid inside the riser and top hat until it bubbles out of the lower end of the top hat, limiting ingress of water or hydrocarbon gas hydrates into the riser and thus preventing plugging of the riser and top hat;

- moving the MODU so that the top hat is a few meters above the subsea source, with the top hat in the hydrocarbon plume, and the low-density fluid still bubbling out of the lower end of the top hat and limiting hydrates from forming in inside surfaces of the top hat;

- landing the top hat on the subsea source, while the top hat remains filled with low-density fluid, keeping seawater flow out of the top hat;

- initiating flow of a liquid hydrate inhibitor, and optionally wax and asphaltene inhibitors, through surface control or subsea valves; and

- optionally initiating flow of a dispersant that mixes with any non- collected hydrocarbons.

19. The method according to claim 18, wherein the top hat makes no positive seal with the subsea source, the method further comprising:

- wherein the ceasing of flow of the low-density fluid comprises gradually reducing the flow of low-density fluid and gradually opening a choke, allowing hydrocarbons to move up the riser as the low-density fluid pressure is pushed up by

the heavier seawater and/or well pressure if a seal with the subsea source has been established, controlling the choke opening so that entrance of seawater into the top hat is at least mitigated.

20. The method according to claim 11, further providing an auxiliary method to increase flow selected from the group consisting of pumping the hydrocarbon up the riser using a subsea pump, employing gas lift with a non oxidizing mixture of collected gas with or without added nitrogen added through an umbilical or coiled tubing employing a compressor, and employing gas lift using a flue gas with or without added nitrogen added through an umbilical or coiled tubing employing a compressor.

21. The method according to claim 11, comprising flowing a dispersant chemical near and/or into and/or inside the subsea source of hydrocarbons where hydrocarbons are escaping into seawater.

22. A method comprising:

- connecting riser sections at or near the sea surface to form a riser;
- deploying the riser from a surface vessel subsea upstream from a plume of hydrocarbons from a subsea source of hydrocarbons;
- deploying a collection tool on the seabed;
- stabbing a distal end of the riser into the tool and picking up the tool from the seabed using the riser;
- displacing seawater from the riser and tool by forcing low-density fluid into the riser and tool;
- positioning the tool connected to a distal end of the riser to collect hydrocarbons from the source of hydrocarbons while the riser and tool remain filled with the low-density fluid;
- establishing flow of hydrocarbons up the tool and riser;
- controlling hydrocarbon gas hydrate formation by limiting contact of liquids and solids with inner surfaces of the riser and tool during at least the positioning of the riser and tool subsea;
- ceasing the forcing of the low-density fluid into the riser and tool and collecting hydrocarbons up the tool and riser; and

pumping an inhibitor liquid into the tool during at least the collecting step.

23. A method comprising:

- connecting riser sections at or near the sea surface to form a riser;
- connecting a collection tool to the distal end of the riser;
- deploying the riser and tool from a surface vessel subsea upstream from a plume of hydrocarbons from a subsea source of hydrocarbons;
- displacing seawater from the riser and tool by forcing low-density fluid into the riser and tool;
- positioning the tool connected to a distal end of the riser to collect hydrocarbons from the source of hydrocarbons while the riser and tool remain filled with the low-density fluid;
- establishing flow of hydrocarbons up the tool and riser;
- controlling hydrocarbon gas hydrate formation by limiting contact of liquids and solids with inner surfaces of the riser and tool during at least the positioning of the riser and tool subsea;
- ceasing the forcing of the low-density fluid into the riser and tool and collecting hydrocarbons up the tool and riser; and
- pumping an inhibitor liquid into the tool during at least the collecting step.

24. A method comprising:

- connecting drill pipe riser sections at or near the sea surface to form a drill pipe riser;
- deploying the drill pipe riser from a mobile offshore drilling unit subsea near a subsea source of hydrocarbons;
- positioning a top hat connected to a distal end of the drill pipe riser to collect hydrocarbons from the source of hydrocarbons;
- collecting hydrocarbons using the top hat and drill pipe riser;
- wherein the deploying and positioning comprise:
 - moving the MODU upstream of a plume of hydrocarbon in the water column emanating from the subsea source;
 - displacing seawater from the drill pipe riser and top hat by forcing a gas consisting essentially of nitrogen down the drill pipe riser at least during

the positioning of the top hat and riser until the gas bubbles out of the lower end of the top hat, limiting ingress of seawater or hydrocarbon gas hydrates into the drill pipe riser and top hat thus preventing plugging of the drill pipe riser;

moving the MODU so that the top hat is a few meters above the subsea source, with the top hat in the hydrocarbon plume, and the gas consisting essentially of nitrogen still bubbling out and limiting hydrates from forming in the inside surfaces of the top hat;

landing the top hat on the subsea source, while the top hat remains filled with gas consisting essentially of nitrogen, limiting ingress of seawater into the top hat;

gradually reducing flow of the gas and gradually opening a choke to establish and maintain flow of collected hydrocarbons up the top hat and drill pipe riser; and

pumping an inhibitor liquid into the top hat and optionally wax and asphaltene inhibitors through valves on the roof of the top hat during at least the collecting step, limiting hydrocarbon gas hydrate formation during the collecting of hydrocarbons.

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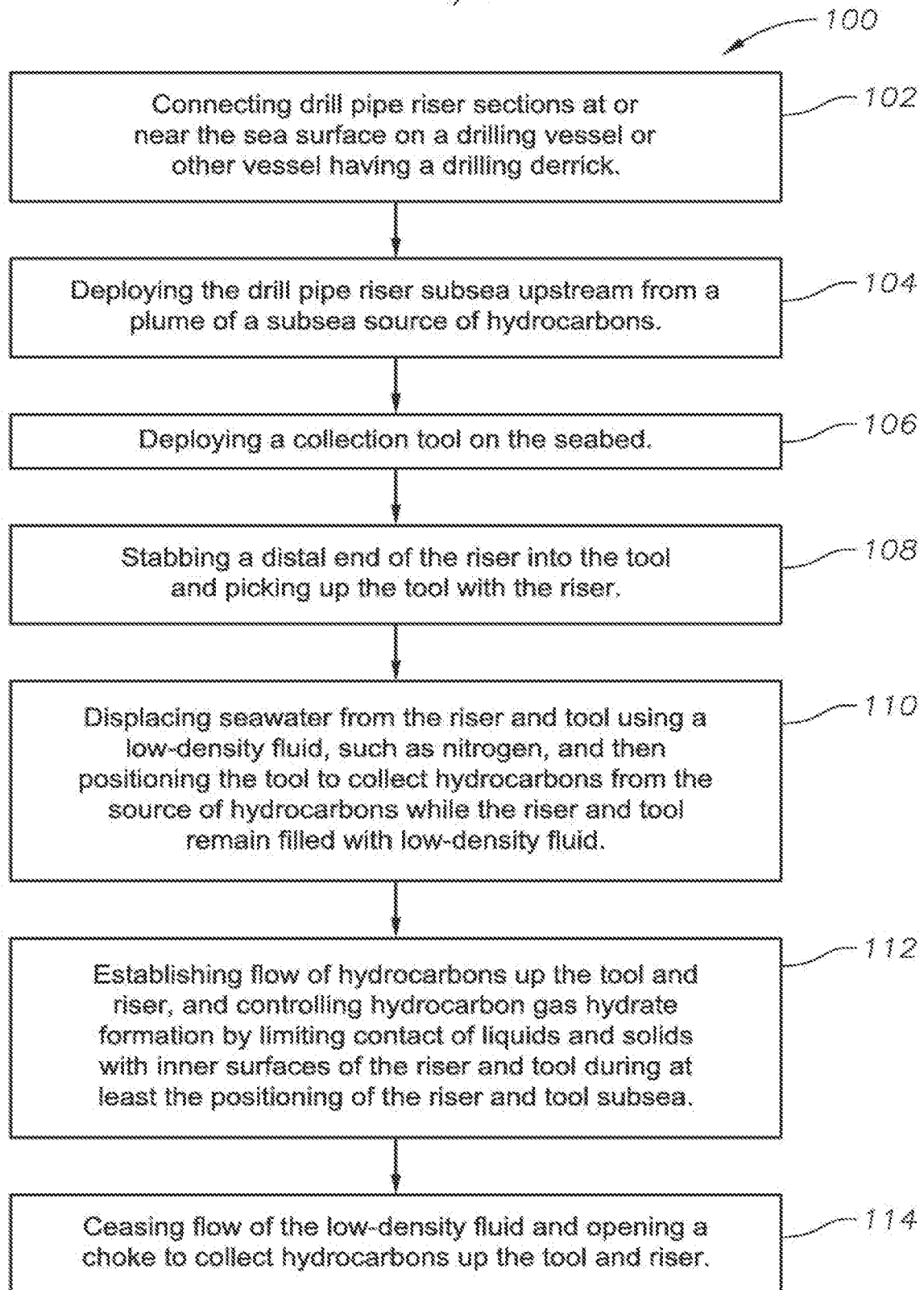


Fig. 1

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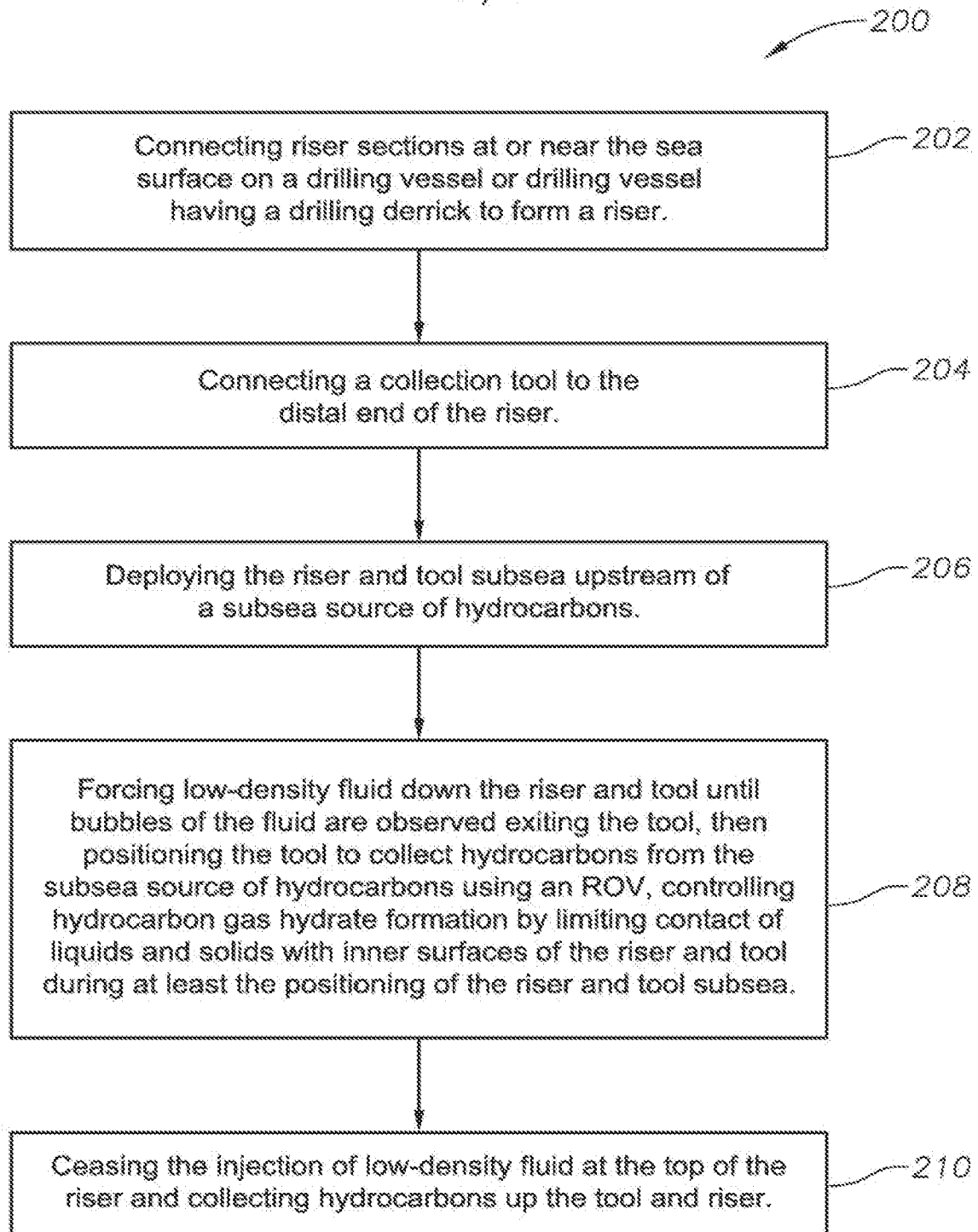


Fig. 2

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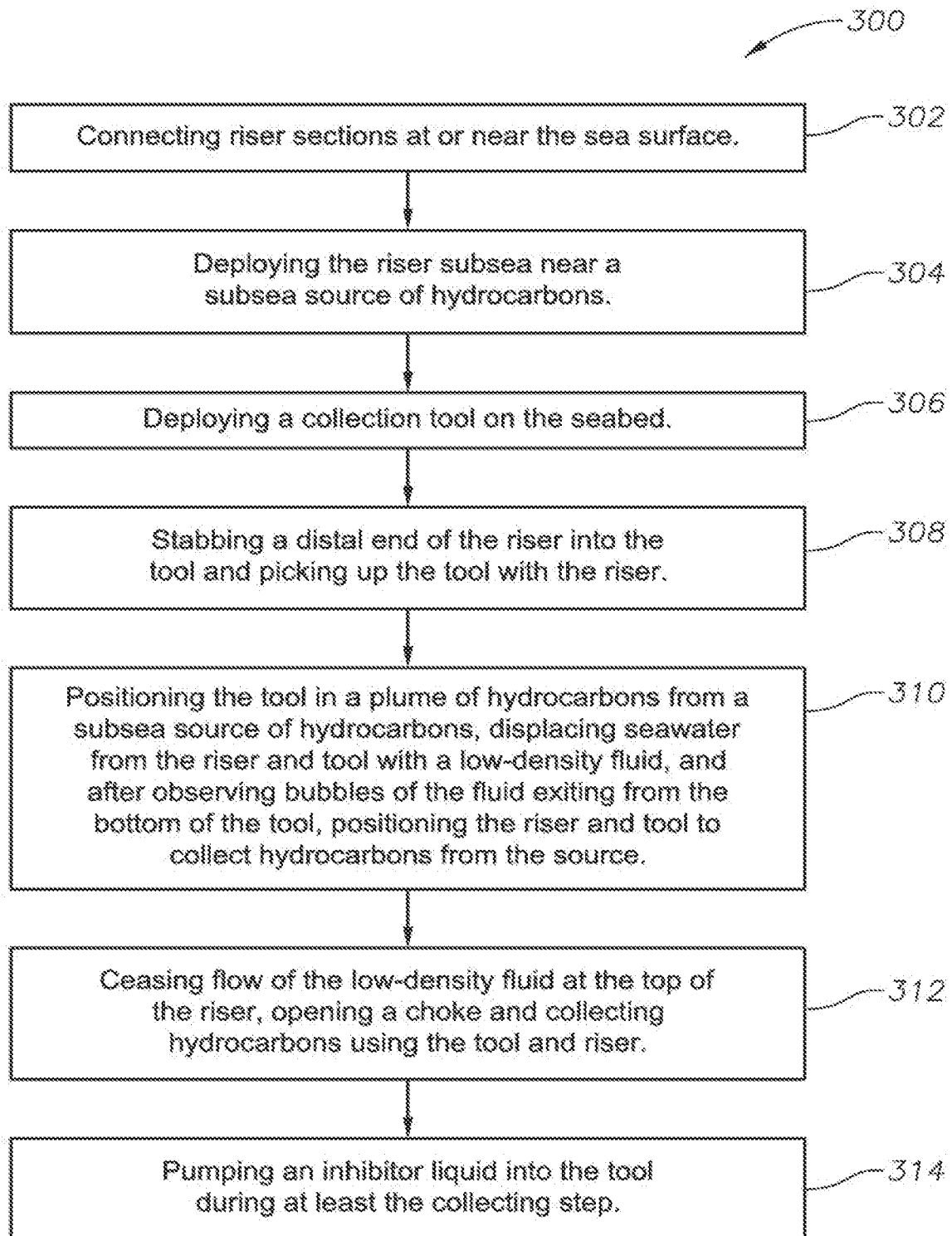


Fig. 3

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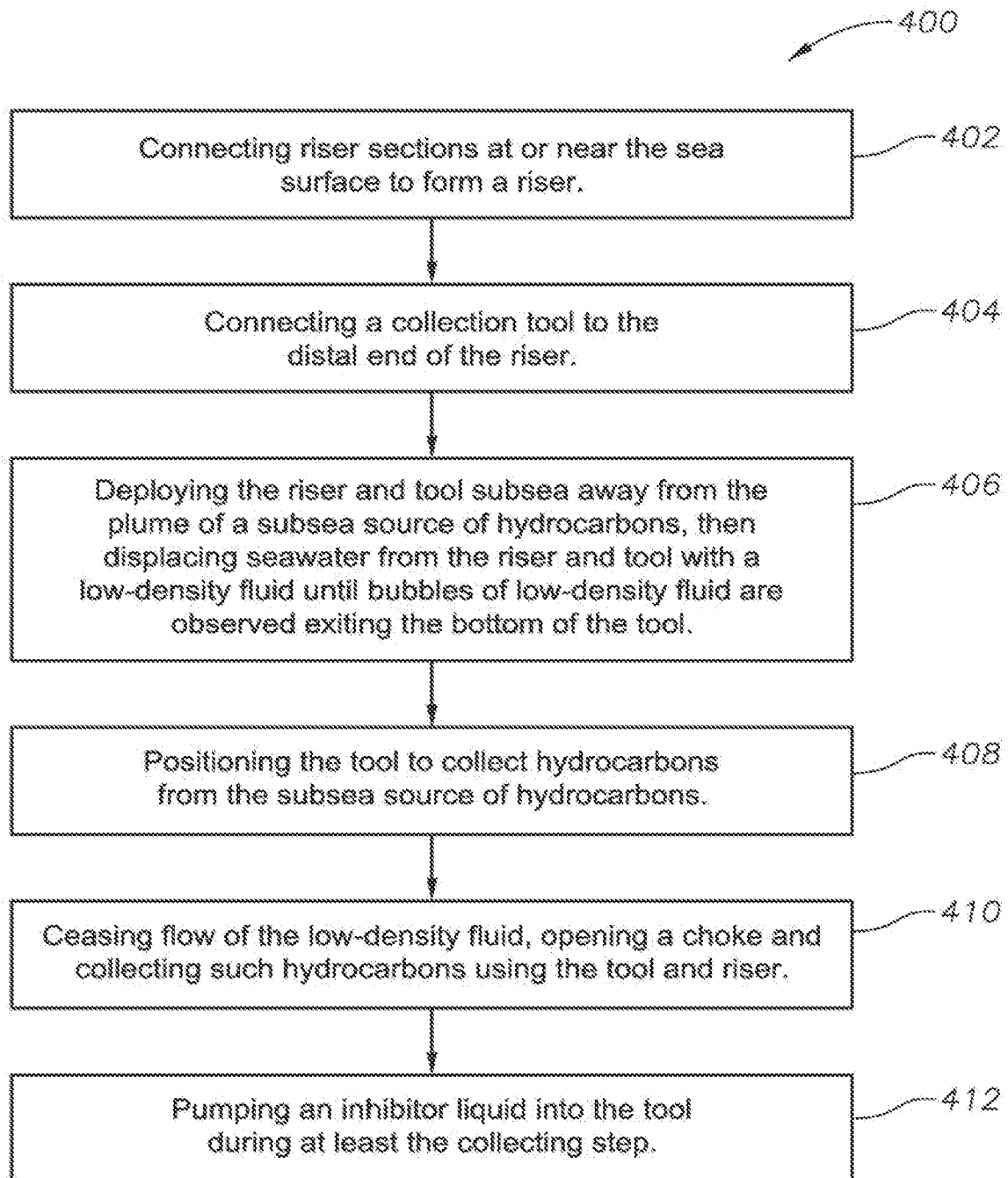


Fig. 4

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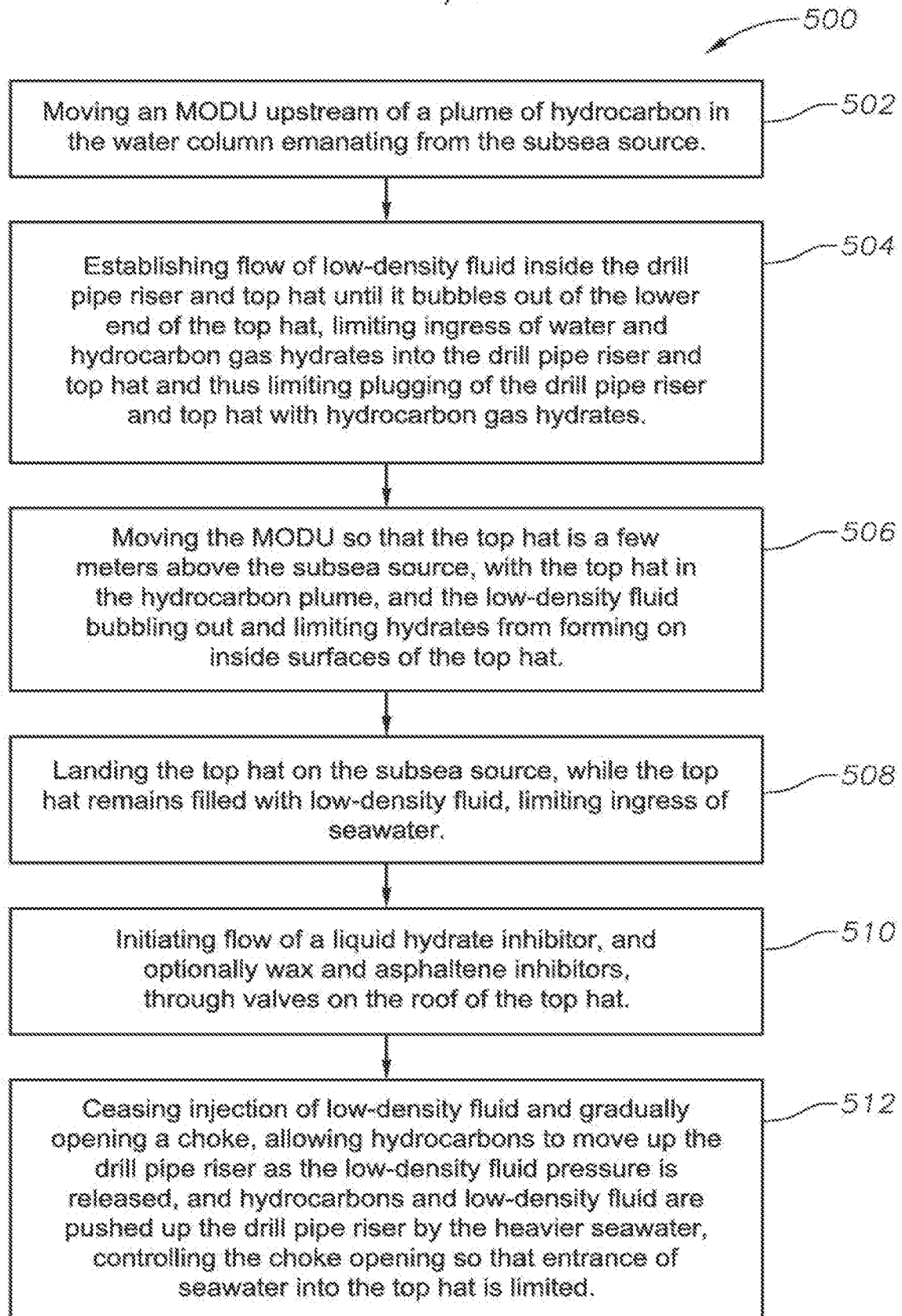


Fig. 5

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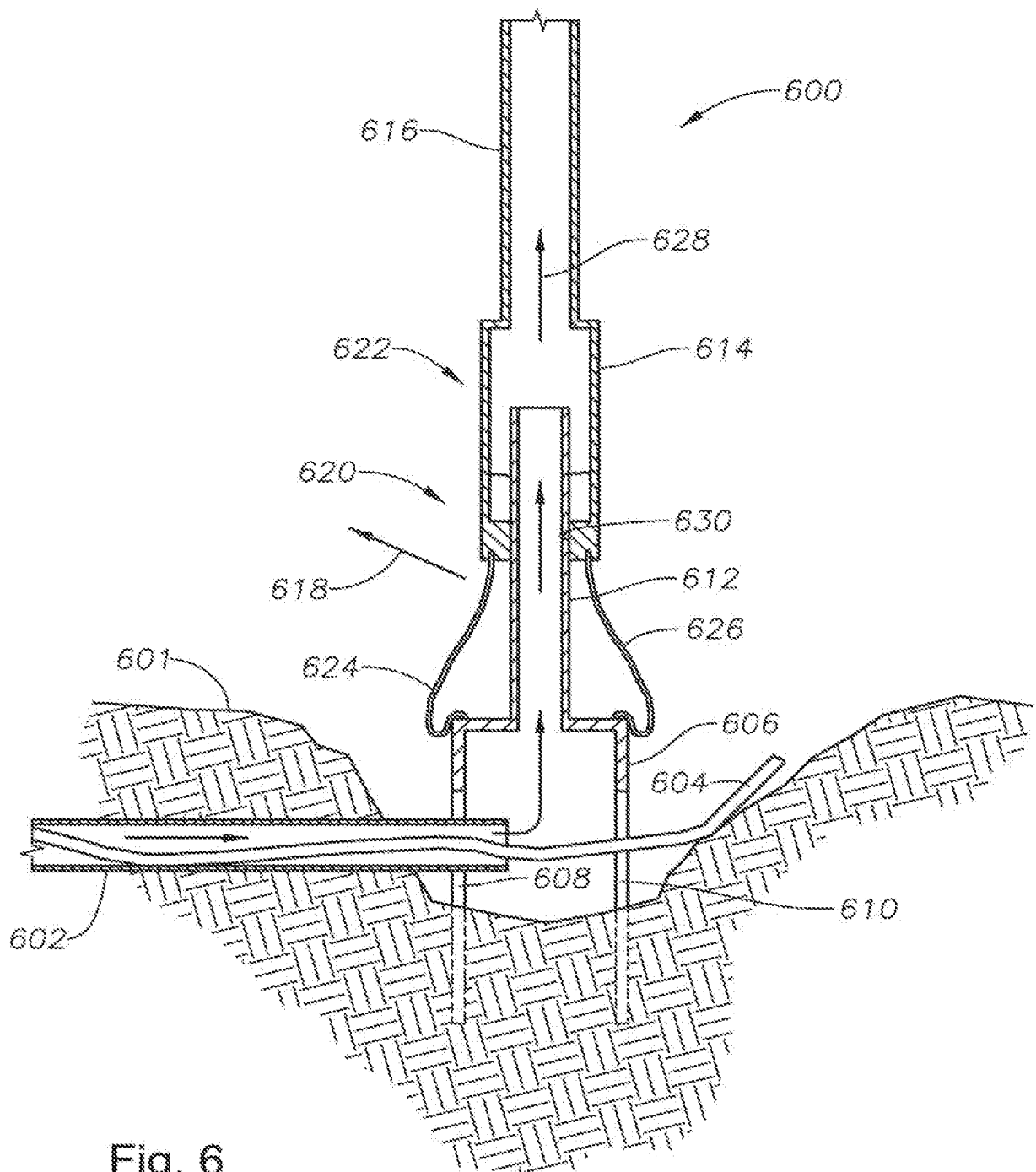


Fig. 6