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(71) Applicant (for all designated States except US): **BP CORPORATION NORTH AMERICA INC.** [US/US]; 501 Westlake Park Boulevard, Houston, TX 77079 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **BEYNET, Pierre, Albert** [US/US]; 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US). **DEVERS, Kevin, James** [US/US]; 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US). **BLALOCK, Douglas, Paul** [US/US]; 150 W. Warrenville Road, MC 200-1W,

Naperville, IL 60563 (US). **FLEECE, Trent, James** [CA/US]; 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US). **WALIGURA, Jason, Edward** [US/US]; 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US). **LAWLER, Kinton** [US/US]; 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US).

(74) Agent: **PIANA, Jayne, C.**; BP America Inc., 150 W. Warrenville Road, MC 200-1W, Naperville, IL 60563 (US).

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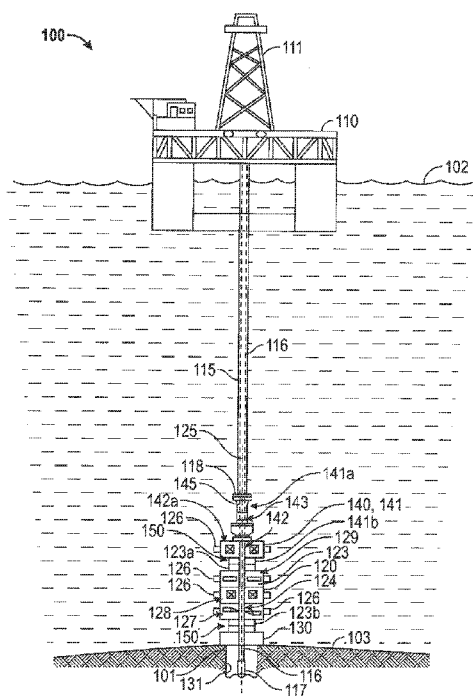


FIG. 1

(57) Abstract: A device for capturing hydrocarbons discharged from a sub-sea flow passage comprises an elongate tubular structure having a central axis, a first end, and a second end opposite the first end. The second end is open and in fluid communication with the first end. The tubular structure includes a rigid stabbing member extending axially from the second end and configured to be inserted into the flow passage. In addition, the device comprises an annular flexible skirt disposed about the stabbing member. The skirt is secured to the stabbing member and extends radially outward from the stabbing member. The skirt is configured to flex from an unflexed position to a flexed position upon insertion of the stabbing member into the flow passage. The skirt is biased to the unflexed position and has an outer diameter in the unflexed position that is greater than the inner diameter of the flow passage.



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

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. provisional patent application Serial No. 61/479,704 filed April 27, 2011, and entitled "Apparatus for Use In Establishing and/or Maintaining Controlled Flow of Hydrocarbons During Subsea Operations," which is hereby incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND

Field of the Invention

[0003] The invention relates generally to apparatus and methods for flowing hydrocarbons from a subsea conduit to the surface. More particularly, the invention relates to apparatus and methods for intervening in subsea conduits such as risers to flow hydrocarbons to the surface while minimizing the formation of hydrocarbon gas hydrates.

Background of the Technology

[0004] In offshore drilling operations, a blowout preventer (BOP) is installed on a wellhead at the sea floor and a lower marine riser package (LMRP) is mounted to the BOP. In addition, a drilling riser extends from a flex joint at the upper end of LMRP to a drilling vessel or rig at the sea surface. A drill string is then suspended from the rig through the drilling riser, LMRP, and the BOP into the well bore. A choke line and a kill line are also suspended from the rig and coupled to the BOP, usually as part of the drilling riser assembly.

[0005] During drilling operations, drilling fluid (also referred to as "mud") is delivered through the drill string, and returned up an annulus between the drill string and tubular casing that lines the well bore. In the event of a rapid influx of formation fluid into the annulus, commonly known as a "kick," the BOP and/or LMRP may actuate to seal the annulus and control the well. In particular, BOPs and LMRPs comprise closure members capable of sealing and closing the well in order to prevent the release of high-pressure gas or liquids from the well. Thus, the BOP and LMRP are used as safety devices that close, isolate, and seal the wellbore. Heavier drilling mud may be delivered through the drill string, forcing

fluid from the annulus through the choke line or kill line to protect the well equipment disposed above the BOP and LMRP from the high pressures associated with the formation fluid. Assuming the structural integrity of the well has not been compromised, drilling operations may resume. However, if drilling operations cannot be resumed, cement or heavier drilling mud is delivered into the well bore to kill the well.

[0006] In the event that the BOP and LMRP fail to actuate or insufficiently actuate in response to a surge of formation fluid pressure in the annulus, a blowout may occur. The blowout may damage subsea well equipment and hardware such as the BOP, LMRP, or drilling riser. This can be especially problematic if it results in the discharge of hydrocarbons into the surrounding sea water. In addition, it may be challenging to remedy the situation remotely, as the damage may be hundreds or thousands of feet below the sea surface.

[0007] In the event that a subsea blowout results in the discharge of hydrocarbons into the surrounding sea, it is important to capture the emitted hydrocarbons at the subsea source as quickly as possible in order to minimize the volume of hydrocarbons discharged in the sea water. One approach is to cap and shut-in the subsea well by lowering a containment cap and connecting it to the upper end of the equipment stack that is connected to the well bore (e.g., LMRP or BOP). However, this procedure may take time to complete, especially if it requires the removal of a damaged subsea riser before landing the cap. During such time, hydrocarbons may be discharged into the surrounding sea from the damaged subsea riser.

[0008] Accordingly, there is a need in the art for apparatus and methods to capture hydrocarbons from a damaged subsea riser or conduit. Such apparatus and methods would be particularly well-received if they offered the potential to capture hydrocarbons discharged from a subsea riser or conduit, and flow the captured hydrocarbons to the surface while minimizing the formation of hydrates.

BRIEF SUMMARY OF THE DISCLOSURE

[0009] These and other needs in the art are addressed in one embodiment by a device for capturing hydrocarbons discharged from a subsea flow passage. In an embodiment, the device comprises an elongate tubular structure having a central axis, a first end, and a second end opposite the first end. The second end is open and in fluid communication with the first end. The tubular structure includes a rigid stabbing member extending axially from the second end and configured to be inserted into the flow passage. In addition, the device comprises an annular flexible skirt disposed about the stabbing member. The skirt is secured to the stabbing member and extends radially outward from the stabbing member. The skirt is configured to flex from an unflexed position to a flexed position upon insertion of the

stabbing member into the flow passage. The skirt is biased to the unflexed position and has an outer diameter in the unflexed position that is greater than the inner diameter of the flow passage.

[0010] These and other needs in the art are addressed in another embodiment by a method for capturing hydrocarbons discharged from a subsea flow passage. In an embodiment, the method comprises (a) lowering a hydrocarbon collection tool subsea, the collection tool comprising a tubular structure having a central axis, a first end, a second end, and a stabbing member extending axially from the second end. The second end is open and in fluid communication with the first end. In addition, the method comprises (b) coupling a tie-back conduit to the first end of the collection tool. Further, the method comprises (c) inserting the stabbing member into the subsea flow passage. Still further, the method comprises (d) flowing the hydrocarbons into the collection tool at the second end. Moreover, the method comprises (e) flowing the hydrocarbons through the collection tool and the tie-back conduit to the surface.

[0011] These and other needs in the art are addressed in another embodiment by a device for capturing hydrocarbons discharged from a subsea flow passage. In an embodiment, the device comprises an elongate tubular structure having a central axis, a first end, and a second end opposite the first end. The second end is open and in fluid communication with the first end. The tubular structure includes a rigid stabbing member extending axially from the second end and configured to be inserted into the flow passage. In addition, the device comprises an annular packer disposed about the stabbing member. The packer is secured to the stabbing member and extends radially outward from the stabbing member. The packer is configured to radially expand from a retracted position to an expanded position upon insertion of the stabbing member into the flow passage. The packer has an outer diameter in the retracted position that is less than the inner diameter of the flow passage.

[0012] Embodiments described herein comprise a combination of features and advantages intended to address various shortcomings associated with certain prior devices, systems, and methods. The various characteristics described above, as well as other features, will be readily apparent to those skilled in the art upon reading the following detailed description, and by referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] For a detailed description of the preferred embodiments of the invention, reference will now be made to the accompanying drawings in which:

- [0014] Figure 1 is a schematic view of an embodiment of an offshore drilling system;
- [0015] Figure 2 is a schematic view of the offshore drilling system of Figure 1 damaged by a subsea blowout;
- [0016] Figure 3 is a side view of an embodiment of a tool for capturing hydrocarbons from a subsea conduit;
- [0017] Figure 4 is an enlarged partial side perspective view of the tool of Figure 3;
- [0018] Figure 5 is an enlarged cross-sectional view of the cross-over member of Figure 3;
- [0019] Figure 6 is a front view of the ROV access panel of the tool of Figure 3;
- [0020] Figure 7 is a cross-sectional view of the first elbow of Figure 3 illustrating the position of two flow lines along the inside the tool of Figure 3;
- [0021] Figures 8A and 8B are partial perspective views of the tool of Figure 3 mounted in an embodiment of a support frame;
- [0022] Figure 9 is a side view of an embodiment of a tool for capturing hydrocarbons from a subsea conduit;
- [0023] Figures 10A-10E are partial perspective views of the tool of Figure 9 mounted in an embodiment of a support frame;
- [0024] Figure 11 is a side view of an embodiment of a tool for capturing hydrocarbons from a subsea conduit;
- [0025] Figure 12 is a rear view of the tool of Figure 11;
- [0026] Figures 13A-13H are sequential schematic illustrations of an embodiment of a method for deploying the tool of Figure 3, Figure 9, or Figure 11;
- [0027] Figures 14A-14F are schematic illustrations of alternative applications of embodiments disclosed herein;
- [0028] Figure 15 is a side view of an embodiment of a tool for capturing hydrocarbons from a subsea conduit;
- [0029] Figures 16A-16D are sequential schematic illustrations of an embodiment of a method for deploying the tool of Figure 15; and
- [0030] Figure 17 is a side view of an embodiment of a tool for capturing hydrocarbons from a subsea conduit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] The following discussion is directed to various exemplary embodiments. However, one skilled in the art will understand that the examples disclosed herein have broad application, and that the discussion of any embodiment is meant only to be exemplary of that

embodiment, and not intended to suggest that the scope of the disclosure, including the claims, is limited to that embodiment.

[0032] Certain terms are used throughout the following description and claims to refer to particular features or components. As one skilled in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but not function. The drawing figures are not necessarily to scale. Certain features and components herein may be shown exaggerated in scale or in somewhat schematic form and some details of conventional elements may not be shown in interest of clarity and conciseness.

[0033] In the following discussion and in the claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to..." Also, the term "couple" or "couples" is intended to mean either an indirect or direct connection. Thus, if a first device couples to a second device, that connection may be through a direct connection, or through an indirect connection via other devices, components, and connections. In addition, as used herein, the terms "axial" and "axially" generally mean along or parallel to a central axis (e.g., central axis of a body or a port), while the terms "radial" and "radially" generally mean perpendicular to the central axis. For instance, an axial distance refers to a distance measured along or parallel to the central axis, and a radial distance means a distance measured perpendicular to the central axis. Still further, as used herein the terms "hydrocarbon gas hydrates," "hydrates," and "hydrocarbon hydrates" refer to hydrates formed from hydrocarbon gases selected from the group consisting of methane, ethane, propane, butane, isobutane, isobutene and mixtures thereof.

[0034] Referring now to Figure 1, an embodiment of an offshore system 100 for drilling and/or producing a wellbore 101 is shown. In this embodiment, system 100 includes an offshore platform 110 at the sea surface 102, a subsea blowout preventer (BOP) 120 mounted to a wellhead 130 at the sea floor 103, and a lower marine riser package (LMRP) 140. Platform 110 is equipped with a derrick 111 that supports a hoist (not shown). A drilling riser 115 extends from platform 110 to LMRP 140. In general, riser 115 is a large-diameter pipe that connects LMRP 140 to the floating platform 110. During drilling operations, riser 115 takes mud returns to the platform 110. Casing 131 extends from wellhead 130 into subterranean wellbore 101.

[0035] Downhole operations are carried out by a tubular string 116 (e.g., drillstring, production tubing string, coiled tubing, etc.) that is supported by derrick 111 and extends from platform 110 through riser 115, LMRP 140, BOP 120, and into cased wellbore 101. A

downhole tool 117 is connected to the lower end of tubular string 116. In general, downhole tool 117 may comprise any suitable downhole tool(s) for drilling, completing, evaluating and/or producing wellbore 101 including, without limitation, drill bits, packers, testing equipment, perforating guns, and the like. During downhole operations, string 116, and hence tool 117 coupled thereto, may move axially, radially, and/or rotationally relative to riser 115, LMRP 140, BOP 120, and casing 131.

[0036] BOP 120 and LMRP 140 are configured to controllably seal wellbore 101 and contain hydrocarbon fluids therein. Specifically, BOP 120 has a central or longitudinal axis 125 and includes a body 123 with an upper end 123a releasably secured to LMRP 140, a lower end 123b releasably secured to wellhead 130, and a main bore 124 extending axially between upper and lower ends 123a, b. Main bore 124 is coaxially aligned with wellbore 101, thereby allowing fluid communication between wellbore 101 and main bore 124. In this embodiment, BOP 120 is releasably coupled to LMRP 140 and wellhead 130 with hydraulically actuated, mechanical wellhead-type connections 150. In general, connections 150 may comprise any suitable releasable wellhead-type mechanical connection such as the H-4® profile subsea system available from VetcoGray Inc. of Houston, Texas, the DWHC profile subsea system available from Cameron International Corporation of Houston, Texas, and the HC profile subsea system available from Cameron International Corporation of Houston, Texas. Typically, such wellhead-type mechanical connections (e.g., connections 150) comprise an upward-facing male connector or “hub,” labeled with reference numeral 150a herein, that is received by and releasably engages a complementary, downward-facing mating female connector or receptacle, labeled with reference numeral 150b herein. In addition, BOP 120 includes a plurality of axially stacked sets of opposed rams - opposed blind shear rams or blades 127 for severing tubular string 116 and sealing off wellbore 101 from riser 115 and opposed pipe rams 129 for engaging string 116 and sealing the annulus around tubular string 116, and may include opposed blind rams 128 for sealing off wellbore 101 when no string (e.g., string 116) or tubular extends through main bore 124,. Each set of rams 127, 128, 129 is equipped with sealing members that engage to prohibit flow through the annulus around string 116 and/or main bore 124 when rams 127, 128, 129 is closed.

[0037] Opposed rams 127, 128, 129 are disposed in cavities that intersect main bore 124 and support rams 127, 128, 129 as they move into and out of main bore 124. Each set of rams 127, 128, 129 is actuated and transitioned between an open position and a closed position. In the open positions, rams 127, 128, 129 are radially withdrawn from main bore 124 and do not interfere with tubular string 116 or other hardware that may extend through main bore 124.

However, in the closed positions, rams 127, 128, 129 are radially advanced into main bore 124 to close off and seal main bore 124 (e.g., rams 127) or the annulus around tubular string 116 (e.g., rams 128, 129). Each set of rams 127, 128, 129 is actuated and transitioned between the open and closed positions by a pair of actuators 126. In particular, each actuator 126 hydraulically moves a piston within a cylinder to move a drive rod coupled to one ram 127, 128, 129.

[0038] Referring still to Figure 1, LMRP 140 has a body 141 with an upper end 141a connected to the lower end of riser 115, a lower end 141b releasably secured to upper end 123a with connector 150, and a throughbore 142 extending between upper and lower ends 141a, b. Throughbore 142 is coaxially aligned with main bore 124 of BOP 110, thereby allowing fluid communication between throughbore 142 and main bore 124. LMRP 140 also includes an annular blowout preventer 142a comprising an annular elastomeric sealing element that is mechanically squeezed radially inward to seal on a tubular extending through bore 142 (e.g., string 116, casing, drillpipe, drill collar, etc.) or seal off bore 142. Thus, annular BOP 142a has the ability to seal on a variety of pipe sizes and seal off bore 142 when no tubular is extending therethrough. Upper end 141a of LMRP 140 comprises a riser flex joint 143 that allows riser 115 to deflect angularly relative to BOP 120 and LMRP 140 while hydrocarbon fluids flow from wellbore 101, BOP 120 and LMRP 140 into riser 115.

[0039] Referring now to Figure 2, during a “kick” or surge of formation fluid pressure in wellbore 101, one or more rams 127, 128, 129 of BOP 120 and/or LMRP 140 are normally actuated to seal in wellbore 101. If wellbore 101 is not sealed, a blowout may result. Such a blowout may result in the discharge of such hydrocarbon fluids subsea. In Figure 2, system 100 is shown after a subsea blowout. In the exemplary blowout scenario shown in Figure 2, riser 115 and drillstring 116 have been severed subsea and bent over proximal flex joint 143. As a result, hydrocarbon fluids flowing upward in wellbore 101 pass through BOP 120 and LMRP 140, and are discharged into the surrounding sea water through the end of riser 115 disposed along the sea floor 103. The emitted hydrocarbon fluids form a subsea hydrocarbon plume 160. Embodiments of hydrocarbon capture apparatus and methods described in more detail below are designed to capture the hydrocarbons flowing through riser 115, thereby reducing the subsea discharge of hydrocarbon fluids.

[0040] Referring now to Figure 3, an embodiment of a device or tool 200 for capturing hydrocarbons from a subsea conduit is shown. Tool 200 is an elongate tubular structure or assembly having a central or longitudinal axis 205, an open upper end 200a, and a lower open end 200b in fluid communication with end 200a. Starting at end 200b and moving axially

towards end 200a, in this embodiment, tool 200 includes a stabbing member 210 extending from end 200b, a connector member 220 coupled to stabbing member 210 with a first elbow 270, a recovery member 230 coupled to connector member 220 with a second elbow 275, and an adapter member 250 extending from end 200a and coupled to recovery member 230 with a crossover member 240. Each member 210, 220, 230, 240, 250 and each elbow 270, 275 is a rigid tubular conduit coaxially aligned with tool axis 205, and thus, each may also be referred to as a conduit. Accordingly, a continuous flow passage extends through tool 200 from end 200a to end 200b. In this embodiment, each member 210, 220, 230 has the same inner and outer diameters, however, crossover member 240 provides a transition from recovery member 230 to a larger inner and outer diameter adapter member 250. In other embodiments, the stabbing member (e.g., member 210) has a smaller inner and outer diameter than the remaining conduits of the tool (e.g., connector member 220 and recovery member 230) to facilitate insertion of the stabbing member into a subsea conduit.

[0041] Each tubular member 210, 220, 230 is linear (i.e., straight) between its respective ends, however, members 210, 220, 230 are not collinear (i.e., members 210, 220, 230 do not extend along the same straight line). Consequently, central axis 205 is linear along each respective member 210, 220, 230, but includes bends between members 210, 220, 230. In particular, first elbow 270 orients connector member 220 at an angle α relative to stabbing member 210, and second elbow 275 orients recovery member 230 at an angle β relative to connector member 220. Angle α and angle β are preferably selected so that stabbing member is coaxially aligned with the end of the conduit discharging hydrocarbons when recovery member 230 is vertically oriented. For most applications, angle α is preferably between 30° and 90° and angle β is preferably between 45° and 180° . In this embodiment, angle α is 45° and angle β is 130° . Thus, recovery member 230 is generally oriented perpendicular to stabbing member 210.

[0042] To enhance visibility subsea, any one or more of members 210, 220, 230, 240, 250 and elbows 270, 275 may be painted a color that contrasts with the color of the surrounding water, which is usually very dark (black) at subsea depths. For example, these components may be painted white or yellow. Reflective tape or other light-reflective element(s) may also be provided on one or more of these components.

[0043] Referring now to Figures 3 and 4, stabbing member 210 extends axially from end 200b to elbow 270. A plurality of axially spaced annular diaphragms or skirts 211 are disposed about stabbing member 210 between end 200b and elbow 270. Skirts 211 are fixed to stabbing member 210 such that skirts 211 do not move axially along stabbing member 210

or rotate about stabbing member 210. Each skirt 211 extends radially outward from stabbing member 210 and comprises a flexible, resilient material. Examples of suitable materials for skirts 211 include natural or synthetic rubber (e.g., thermoplastic elastomers), which may be filled with fillers (e.g., carbon black) and/or other additives to improve flexibility, elastic properties, resistance to erosion or saltwater attack, and the like. As will be described in more detail below, stabbing member 210 is inserted into a conduit or flow passage discharging hydrocarbons subsea to capture the hydrocarbons before they reach the surrounding sea. Upon insertion of stabbing member 210 into the subsea conduit or passage, skirts 211 slidingly engage and conform to the inner surface of the conduit as well as the outer surfaces of any other components disposed within the conduit (e.g., a drillpipe disposed within a riser), thereby forming a barrier that restricts and/or prevents the discharge of the hydrocarbons into the surrounding sea and directing the hydrocarbons into stabbing member 210 and tool 200 at end 200b. Thus, each skirt 211 has an unflexed position prior to insertion into the subsea conduit or passage and a flexed position after insertion into the subsea conduit or passage. The resilient material(s) from which skirts 211 are made causes skirts 211 to be biased to the unflexed position shown in Figures 3 and 4. In the unflexed position, each skirt 211 has an outer diameter greater than the inner diameter of the subsea conduit or passage, and in the flex position, each skirt 211 has an outer diameter equal to the inner diameter of the subsea conduit or passage as the skirt slidingly engages the inner surface of the conduit or passage upon insertion therein.

[0044] In the embodiment shown in Figures 3 and 4, each skirt 211 comprises a pair of axially adjacent, annular discs 212 secured to stabbing member 210. Each disc 212 comprises a plurality of circumferentially adjacent strips or flaps 213 defined by radial slits or cuts 214. Inclusion of slits 214 enhances the flexibility of discs 212 and skirts 211. Discs 212 of each skirt 211 are preferably oriented such that slits 214 are circumferentially misaligned (i.e., out of alignment) to minimize the flow of fluids through slits 214. Although each skirt 211 includes two discs 212 in this embodiment, in general, each skirt (e.g., skirt 211) may comprise any suitable number of discs (e.g., discs 212) such as one, two, three, or more discs.

[0045] Stabbing member 210 has a stabbing tip 217 at end 200b. In this embodiment, tip 217 is generally perpendicular to axis 205. However, in other embodiments, the tip of the stabbing member (e.g., tip 217 of stabbing member 210) may be tapered or comprise a muleshoe to facilitate its insertion into a subsea conduit.

[0046] Referring still to Figures 3 and 4, a stop plate 215 extends between stabbing member 210 and connector member 220 along the inside of elbow 270 and a mud cutting plate 271 extends along the outside of elbow 271 generally away from stabbing member 210. Each plate 215, 271 lies in a plane containing axis 205.

[0047] Stop plate 215 functions as webbing that adds rigidity and structural support to members 210, 220 by restricting and/or preventing tool 200 from flexing at elbow member 270 under load. In addition, when stabbing member 210 is inserted into an end of a conduit discharging hydrocarbons subsea, stop plate 215 provides a rigid buffer between any sharp edges on the end of the conduit being serviced and elbow 270, thereby reducing and/or eliminating the potential for the end of the conduit to impact and puncture or damage elbow 270. In this embodiment, stop plate 215 includes a notch or recess 216 configured to receive the end of the conduit being serviced with tool 200. Seating of the end of the conduit in notch 216 offers the potential to stabilize the position of stabbing member 210 within the conduit by limiting relative movement of stabbing member 210 and tool 200 relative to the conduit.

[0048] Mud plate 271 enhances the ability of tool 200 and elbow 270 to penetrate the sea floor as necessary during subsea hydrocarbon capture operations. In addition, once penetrated into the seafloor, mud plate 271 provides lateral stability to tool 200 by resisting lateral movement of tool 200 relative to the sea floor.

[0049] Referring still to Figures 3 and 4, connector member 220 extends axially between elbows 270, 275. A support or stabilizer arm 221 is pivotally coupled to connector member 220 between elbows 270, 275. In particular, arm 221 has a first or pivot end 221a rotatably coupled to connector member 220 and a second or free end 221b opposite end 221a. End 221a is coupled to connector member 220 with a mounting bracket 222 welded to connector member 220 and a pin 223 extending through end 221a and bracket 222. Pin 223 is oriented perpendicular to the plane containing tool axis 205. Thus, arm 221 pivots about pin 223 within a plane that contains or is parallel to tool axis 205. In this embodiment, a conduit engagement plate or member 224 is pivotally coupled to end 221b and is configured to engage and grip the outer surface of the subsea conduit being serviced when stabbing member 210 is inserted therein, thereby providing additional support and stability to tool 200 during subsea hydrocarbon capture operations. For example, engagement of plate 224 with the subsea conduit offers the potential to resist forces seeking to push tool 200 out of the conduit.

[0050] As best shown in Figure 4, a stopper or bumper 225 is secured to connector member 220 between bracket 222 and elbow 270 to prevent arm 221 and conduit engagement member

224 from unintentionally impinging and damaging connector member 220. In addition, a lifting eye 226 is welded to connector member 220 proximal elbow 270 to facilitate transport and deployment of tool 200.

[0051] Referring now to Figures 3 and 5, crossover member 240 rotatably connects recovery member 230 and adapter member 250. In other words, crossover member 240 allows adapter member 250 to rotate relative to recovery member 230 about axis 205. In addition, crossover member 240 provides a transition from recovery member 230 and adapter member 250, which has a larger inner and outer diameter than recovery member 230. For example, crossover member 240 may provide a connection between a 4-inch (10 cm) diameter recovery member 230 and a 6 5/8-inch (17 cm) adapter member 250.

[0052] As best shown in Figure 5, in this embodiment, crossover member 240 includes an annular adapter sleeve 241 secured to the upper end of recovery member 230 and a coupling member 242 rotatably coupled to sleeve 241. In particular, sleeve 241 is threaded onto the upper end of recovery member 230 and has a radially outer cylindrical surface 243 including an annular recess or groove 244. Coupling member 242 has a first or upper end 242a and a second or lower end 242b. In addition, coupling member 242 includes a counterbore 245 extending axially from lower end 242b and an internally threaded box end connector 246 at upper end 242a. Counterbore 245 defines a radially inner surface 247 that slidingly engages surface 243 of sleeve 241. In addition, a plurality of circumferentially spaced head caps 248 extend radially through coupling member 242 and into sliding engagement with recess 244. In this embodiment, head caps 248 are threaded through radial bores in coupling member 242. Connector 246 threadably receives a mating pin end connector at the lower end of adapter member 250, thereby rotatably coupling adapter member 230 to recover member 250.

[0053] A pair of axially spaced annular seal assemblies 248 are provided between sleeve 241 and coupling member 242 to restrict and/or prevent fluid flow between sleeve 241 and coupling member 242. In this embodiment, each seal assembly 248 includes an annular recess or seal gland 249a in outer surface 243 and an annular seal member 249b (e.g., O-ring) disposed therein. Thus, seal member 249b forms an annular static seal with sleeve 241 and an annular dynamic seal with coupling member 242.

[0054] Referring again to Figure 3, adapter member 250 functions to connect tool 200 to a deployment tool, a retrieval tool, a tie back system of fluid conduit (e.g., pipestring extending from the surface), or combinations thereof. In this embodiment, adapter member 250 comprises a J-slot connector for releasably coupling tool 200 to a lower end of such tools or conduits. As is known in the art, a J-slot connector is a releasable connection that allows the

transfer of rotational torque. In general, the J-slot connector in adapter member 250 may be a right-hand or left hand J-slot connector. In addition, the J-slot connector in adapter member 250 may include a shear pin for disconnecting in an emergency situation, such as a surface vessel drive-off. Although member 250 comprises a J-slot connector in this embodiment, in general, the adapter member (e.g., member 250) may comprise any suitable releasable subsea connector for connecting the hydrocarbon capture tool (e.g., tool 200) to the lower end of another tool or conduit such as a connector that attaches and releases through only relative vertical movement. Another example of a suitable subsea connector that may be employed for the adapter member is an OPTIMA connector available from Vector Subsea, Inc. of Houston, Texas.

[0055] Referring now to Figures 3 and 6, hydrocarbon capture tool 200 also includes an ROV access panel 280 mounted to recovery member 230 between crossover member 240 and elbow 275. The face of panel 280 is oriented at an angle between 30° and 90° relative to horizontal to enhance visualization of and access to panel 280 with a subsea ROV. In this embodiment, panel 280 includes U-shaped handles 281, a plurality of control handles 282a, b, c and a plurality of receptacles 283a, b, c (e.g., hot stabs) associated with handles 282a, b, c, respectively. Handles 281 facilitate the positioning of tool 200 by personnel at the surface and by ROVs subsea. Each paddle 282a, b, c operates a corresponding valve (disposed behind panel 280) to control the flow of fluids through flow lines 284a, b, c, respectively. As shown in Figures 4 and 6, flow lines 284a, b extend from panel 280 along the outside of recovery member 230 and connector member 220 to elbow 270, and flow line 284c extends from panel 280 along the outside of recovery member 230, connector member 220, elbow 270, and stabbing member 210 to end 200b. As best shown in Figure 4, along stabbing member 210, flow line 284c may extend under skirts 211 in route to end 200b. Flow lines 284a, b, c can be secured to recovery member 230, connector member 220, elbow 275, elbow 270, stabbing member 210, or combinations thereof with retainers 285.

[0056] The end of each flow line 284a, b distal panel 280 extends through the sidewall of elbow 270 into the interior of tool 200 as shown in Figure 7, and the end of flow line 284c distal panel 280 extends through the sidewall of stabbing member 210 into the interior of tool 200 proximal end 200b. During subsea hydrocarbon capture operations, flow lines 284a, b, c may be used to inject a functional fluid (e.g., hydrate inhibitors) into tool 200 and the captured hydrocarbons flowing therethrough.

[0057] In this embodiment, panel 280 includes a receptacle 283a, b, c for each paddle 282a, b, c, respectively, and flow line 284a, b, c, respectively. Receptacles 283a, b, c may comprise any

suitable connection for coupling a fluid line to panel 280 including, without limitation, API 17H hot stab connectors. The valves in panel 280 controlled by paddles 281a, b, c control the flow of fluids between receptacles 283a, b, c, respectively, and lines 284a, b, c. Thus, fluids can be supplied to lines 284a, b, c through receptacles 283a, b, c, respectively, and the corresponding valves.

[0058] Referring now to Figures 8A and 8B, a support structure or frame 290 for supporting tool 200 during transport of tool 200 is shown. For purposes of clarity, one skirt 211 is not shown in Figure 8A. Support frame 290 includes a horizontal foundation or base platform 291 and an elongate pipe stand 292 extending vertically therefrom. Platform 291 includes a plurality of lifting handles 293 and a plurality of support stanchions or brackets 294. Stabbing member 210 is seated in a semi-circular notch in each bracket 294, recovery member 230 is seated in a clamp 295 mounted to stand 292, and adapter member 250 is seated in a clamp 295 mounted to stand 292. Brackets 294 and clamps 295 help support and maintain the position of tool 200 within frame 290.

[0059] Referring now to Figures 9 and 10A-10E, another embodiment of a device or tool 300 for capturing hydrocarbons from a subsea conduit is shown. In Figures 10A-10E, tool 300 is shown supported by support structure 290 previously described during transport of tool 300.

[0060] Tool 300 is substantially the same as tool 200 previously described. Namely, tool 300 includes members 210, 220, 230, 240, 250 and elbows 270, 275, each as previously described. However, in this embodiment, the inner and outer diameters of members 220, 230 and elbows 270, 275 are increased relative to stabbing member 210. For example, in tool 200 previously described, the nominal pipe size of each member 210, 220, 230, and elbows 270, 275 is 4.0" (~ 10 cm). However, in tool 300, member 210 has a nominal pipe size of 4.0" (~ 10 cm), but members 220, 230 and elbows 270, 275 have a nominal pipe size of 6.0" (~ 15 cm). In general, increasing the diameters of members 220, 230 and elbows 270, 275 increases strength and rigidity of tool 300 in that tool 300 can resist large vertical forces up or down. However, in this embodiment, tip 217 is tapered or mule-shoe shaped, a support plate 327 is provided between connector member 220 and recovery member 230, and a vertical support assembly 331 is provided.

[0061] Support plate 327 lies in a plane containing axis 205 and functions as webbing that adds rigidity and structural support to members 220, 230 by restricting and/or preventing tool 300 from flexing at elbow member 275 under load. In addition, support plate 327 provides a surface for assisting in routing flow lines 284a, b, c. Tapered tip 217 facilitates the insertion of stabbing member 210 into a subsea conduit.

[0062] Support assembly 331 includes a base frame 332 mounted to elbow 275 and connector member 220 and a support leg 333 removably coupled to frame 332 with a pin 334. Frame 332 and leg 333 extend vertically downward from elbow 275 and member 220 and are generally vertically aligned with recovery member 240. The lower end of leg 333 comprises a saddle 335, which is sized and shaped to engage and rest on the outside of the subsea conduit being serviced, thereby providing a direct support path for vertical loads on tool 300. By removing pin 334, different sized legs 333 may be provided in assembly 331 to accommodate differently sized subsea conduits.

[0063] Referring now to Figures 11 and 12, another embodiment of a device or tool 400 for capturing hydrocarbons from a subsea conduit is shown. Tool 400 is substantially the same as tool 300 previously described. Namely, tool 400 includes members 210, 220, 230, 240, 250 and elbows 270, 275, each as previously described. However, in this embodiment, stabilizer arm 221 is eliminated and support assembly 331 has been replaced with a different vertical support assembly 431.

[0064] Support assembly 431 includes a frame 432 mounted to elbow 275 and connector member 220 and a hoop clamp 435 mounted to frame 432. Frame 432 comprises a vertical member 433a extending downward from elbow 275 and vertically aligned with recovery member 240 and a horizontal member 433b extending from member 433a to connector member 220. The lower end of member 433a comprises a saddle 335 as previously described. Hoop clamp 435 is coupled to member 433b and hangs downward therefrom. Clamp 435 is hydraulically actuated to engage and grip the subsea conduit being serviced following insertion of stabbing member 210. More specifically, clamp 435 is open to receive the conduit as stabbing member 210 is inserted and advanced into the conduit. After insertion of stabbing member 210, clamp 435 is hydraulically actuated (e.g., with a subsea ROV) to close around and engage the outside of the conduit, thereby securing tool 400 to the conduit. Clamp 435 is preferably positioned a few feet from the end of the subsea conduit. With stabbing member 210 disposed within the conduit, saddle 335 resting atop the conduit, and clamp 435 secured about the conduit, tool 400 may be left alone for an extended period of time. In general, clamp 435 may be any clamp known in the art for grasping the outside of tubulars such as are used in pipeline applications to grip and align pipe segments for splicing and/or repairs.

[0065] Referring now to Figures 13A-13I, the deployment of a tool 200' to capture hydrocarbons discharged from a subsea riser 115 previously described is schematically shown. Tool 200' is the same as tool 200 previously described except that tool 200' includes

a tapered muleshoe at tip 217 and only two axially spaced skirts 211. The open end of severed riser 115 is disposed along the sea floor 103 with severed drillstring 116 extending therethrough.

[0066] For subsea deployment and implementation of tool 200', one or more remote operated vehicles (ROVs) are preferably employed to aid in positioning the tool (e.g., tool 200'), monitoring the tool and the conduit, and actuating subsea hardware (e.g., handles 282a, b, c, clamp 435, etc.). In this embodiment, ROVs 170 are employed to perform these functions. Each ROV 170 includes an arm 171 having a claw 172, a subsea camera 173 for viewing the subsea operations. Streaming video and/or images from cameras 173 are communicated to the surface or other remote location via umbilical 174 for viewing on a live or periodic basis. Arms 171 and claws 172 are controlled via commands sent from the surface or other remote location to ROV 170 through umbilical 174.

[0067] Referring first to Figures 13A and 13B, tool 200' is controllably lowered subsea. In general, tool 200' may be lowered on the end of a pipe string (e.g., drillstring or riser) or with wireline. One or more buoyancy devices (e.g., buoyancy tanks) may be coupled to tool 200' during deployment to counteract the weight of tool 200', thereby decreasing the loads applied to the wireline or pipe string and facilitating easier manipulation of tool 200' with ROVs 170. During deployment, tool 200' is preferably maintained outside of plume 160 of hydrocarbon fluids emitted from wellbore 101 to enhance visibility and reduce the potential for the formation of hydrates within tool 200'. As tool 200' approaches riser 115, it is oriented such that stabbing member 210 is positioned above and aligned parallel to riser 115 as shown in Figure 13B.

[0068] Moving now to Figures 13C and 13D, with stabbing member 210 just above and aligned with riser 115, tool 200' is moved parallel to riser 115 until tip 217 is about 3 ft. (~90cm) beyond the end of riser 115, and then lowered such that stabbing member 210 is generally coaxially aligned with riser 115 but radially spaced from string 116. Next, as shown in Figures 13E and 13F, tool 200' is moved towards the end of riser 115 to insert tip 217 into the severed end of riser 115 and axially advance stabbing member 210 therein. As best shown in Figures 13E and 13H, as stabbing member 210 is advanced into riser 115, flexible skirts 211 conform to inside surface of riser 115 and the outside surface of string 116, thereby restricting and/or preventing the flow of hydrocarbons from riser 115 into the surrounding sea. Thus, skirts 211 block the flow of hydrocarbons out of the end of riser 115, and direct the hydrocarbons to flow into end 200b and through tool 200 to end 200a. With stabbing member 210 sufficiently seated within riser 115, locking arm 221 may be pivoted to

bring engagement plate 224 into engagement with the outside of riser 115 to help secure tool 200' thereto.

[0069] Moving now to Figure 13G, to maintain the position of tool 200' and reduce the potential for seawater external riser 115 to mix with hydrocarbons flowing through riser 115 into tool 200', one or more barriers 190 may be placed over and around the end of riser 115 and tool 200. For example, sandbags, rocks, chert, berms, tarps, or combinations thereof may be placed around tool 200' and the end of riser 115. As best shown in the cross-sectional end view of tool 200 disposed within riser 115 of Figure 13H, any one or more of fluid lines 284a, b, c may be used to inject various fluids and chemicals (e.g., hydrate inhibitors, wax inhibitors, asphaltene inhibitors, scale inhibitors, corrosion inhibitors, antideposition agents, and combinations thereof) into the hydrocarbons flowing through tool 200'.

[0070] Referring now to Figure 13I, the hydrocarbons flowing through tool 200' are produced to the surface via a tie-back conduit 180 that extends from tool 200' to a surface vessel 181, which may be a drill ship such as an MODU or other vessel such as a drilling rig. The hydrocarbons may be temporarily stored before being offloaded and shipped to a designated oil terminal onshore. In general, tie-back conduit 180 may be the pipe string used to deploy tool 200', a pipe string coupled to tool 200' (via adapter member 250) after deployment, or other conduit (e.g., flexible hose) coupled to tool 200' (via adapter member 250) before or after deployment.

[0071] As previously described, tool 200' may be lowered subsea with wireline or with a pipe string (e.g., drillstring, riser, etc.). During deployment with a pipe string, a low-density fluid (e.g., nitrogen) is preferably pumped down the pipe string and through tool 200' to limit the formation of hydrates within tool 200' and the pipe string. Following insertion of stabbing member 210 into the subsea conduit (e.g., riser 115), the flow of hydrocarbons up tool 200' and the pipe string are established by gradually reducing the flow of the low-density fluid through tool 200'.

[0072] If tool 200' is deployed with wireline, the tie-back conduit is coupled to tool 200' subsea. In such a scenario, tool 200' may be deployed before, after, or at substantially the same time as the tie-back conduit. Further, once tool 200' and the tie-back conduit are coupled subsea, the tie-back conduit can be used to pick up and manipulate the position of tool 200. Seawater in the tie-back conduit and tool 200' is preferably flushed with a low-density fluid such as nitrogen, and once the low-density flushing fluid is observed bubbling of tip 217, the installation of tool 200 may continue as previously described.

[0073] Although the deployment of an exemplary tool 200' is shown in Figures 13A-13I and described above, the embodiments of hydrocarbon capture tools described herein (e.g., tools 200, 300, 400) are deployed in the same manner. Further, the methods described above for deploying tool 200' with a pipe string or wireline and utilizing a low-density fluid to reduce the potential for the hydrate formations may be used with any of the embodiments disclosed herein (e.g., tools 200, 300, 400).

[0074] Referring still to Figure 13I, in one exemplary deployment of tool 200', stabbing member 210 of tool 200' has a 4.0 in. (~ 10 cm) diameter and a 5 ft. length (~ 150 cm). Riser 115 has a 21.0 in. diameter (~ 53 cm) and is disposed on the sea floor 103 at a depth of 5,000 ft. (~ 1500 m). The severed end of riser 115 is about 600 ft. (~ 180 m) from wellhead 130 and BOP 120. Tie-back conduit 180 is a new riser connected to tool 200', and flows hydrocarbons from tool 200' to surface vessel 181 for processing. Thus, tie-back conduit 180 has a length of about 5,000 ft. (~ 1500 m). The system is designed to minimize the formation of gas hydrates at the 5,000 ft. (~ 1500 m) depth. In particular, flow lines 284a, b inject methanol into tool 200' to limit the formation of gas hydrates in the ultra-deep water. Tie-back conduit 180 conveys hydrocarbons to surface vessel 181, which is configured to process 15,000 barrels of oil per day (~ 2400 m³/day) and store 139,000 barrels (~ 22,000 m³). A support barge may be deployed with a capacity to store 137,000 barrels of oil (~ 22,000 m³).

[0075] In the manner previously described, embodiments of tools described herein (e.g., tools 200, 200', 300, 400) may be employed to capture hydrocarbons discharged from a damaged subsea riser 115 containing a severed drillstring 116. However, embodiments described herein may also be used to capture hydrocarbons flowing through/from other subsea conduits, pipes, and flow lines. Figures 14A-14F schematically illustrate other exemplary applications of tools described herein. The tools shown in Figures 14A-14F are deployed in substantially the same manner previously described, but are used to capture hydrocarbons discharged from subsea components other than severed risers. In particular, Figure 14A schematically illustrates an embodiment of a tool 500 in accordance with the principles described herein inserted into a subsea pipeline 500 to collect and capture hydrocarbons flowing therethrough.

[0076] In Figure 14B, an embodiment of a tool 500' in accordance with the principles described herein is shown capturing hydrocarbons flowing through a flexible gooseneck 501 coupled to a subsea wellhead 130'. Gooseneck 501 supplies hydrocarbons from wellhead 130' to a subsea manifold (not shown), but in this case, has a leaking area 502 that is discharging hydrocarbons into the surrounding sea water. To capture hydrocarbons from

gooseneck 501 and reduce and/or eliminate the discharge of hydrocarbons into the sea water, stabbing member 210 of tool 500' is stabbed into area 502 until skirt 211 engages the outside of gooseneck 501, thereby forming a partial seal that restricts the discharge of hydrocarbons from leaking area 502.

[0077] In Figure 14C, an embodiment of a tool 500" in accordance with the principles described herein is shown capturing hydrocarbons flowing through a surface vessel 505 from a damaged area 506 disposed below the sea surface 102. To capture hydrocarbons from area 506 and reduce and/or eliminate the discharge of hydrocarbons into the sea water, stabbing member 210 of tool 500" is stabbed into area 506 until skirt 211 engages the outside of vessel 505, thereby forming a partial seal that restricts the discharge of hydrocarbons from area 506. Tool 500" is fluidly connected to processing equipment 507 on vessel 505.

[0078] In Figure 14D, an embodiment of a tool 500'" in accordance with the principles described herein is inserted into a subsea riser access conduit 510 extending from a riser 511, which has been obstructed by a hydrate plug 512. With tool 500'" sufficiently seated in conduit 510, a valve 513 in conduit is opened to allow tool 500'" to collect and capture hydrocarbons flowing through conduit 510. In Figure 14E, an embodiment of a tool 500"" in accordance with the principles described herein is inserted into a riser 515 through an access port 516, which may be cut into riser 515 or result from damage to riser 515. Again, in this embodiment, skirt 211 forms at least a partial seal against the external surface of riser 515.

[0079] In Figure 14F, an embodiment of a tool 500"" in accordance with the principles described herein is shown capturing hydrocarbons flowing through a subsea manifold 520 that has suffered a leak in an area 521 of a conduit 522. Leaking area 521 may be the result of damage or corrosion. If there is no valve in header 523 to isolate the leaking conduit 522, tool 500"" may be employed in a similar manner as was previously described with respect to Figure 14E. Namely, stabbing member 210 is inserted through the leaking area 521 into conduit 522 until skirt 211 engages the outside of conduit 522 and forms at least a partial seal against the external surface of conduit 522.

[0080] In the alternative applications shown in Figures 14A-14F and described above, the portion of stabbing member 210 inserted into the hydrocarbon discharge site may be varied as appropriate (e.g., only a short length of stabbing member 210 may be inserted). In addition, the diameter of stabbing member 210 and skirts 211 may be varied depending on size of the discharge site (e.g., leaking area or damage).

[0081] As previously described, one or more small diameter flow lines (e.g., flow lines 284a, b, c) may be used to deliver one or more functional fluids into the interior of the tool (e.g.,

tool 200, 200', 300, 400, etc.) or exterior of the tool. Such functional fluids may include, without limitation, hydrate inhibitors, wax inhibitors, asphaltene inhibitors, scale inhibitors, corrosion inhibitors, antideposition agents, combinations of two or more thereof, and the like. Suitable hydrate inhibitors include, without limitation, 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. Solutions of inhibited propylene glycol (propylene glycol containing a corrosion inhibitor) may also be employed. Suitable corrosion inhibitors include, without limitation, 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, without limitation, phosphate esters, polyacrylates, phosphonates, polyacrylamides, polysulfonated polycarboxylates, copolymers thereof, and mixtures thereof. Examples of scale and corrosion inhibitors are described in U.S. Patent No. 7,772,160, which is hereby incorporated herein by reference in its entirety. Suitable asphaltene inhibitors include, without limitation, 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. Patent No. 6,313,367, which is hereby incorporated herein by reference in its entirety. In certain embodiments, a chemical may contribute more than one of the functions of wax, corrosion, and scale inhibition, and dispersant action. For example, U.S. Patent No. 6,313,367 discloses compositions that may function as asphaltene deposition inhibitors and dispersants.

[0082] The flow rate of the injected chemical(s) depends on the specific situations. In general, the flow rate of an injected hydrate inhibitor is preferably in the range of 0.5 to about 1.0 volumetric units of inhibitor chemical to volumetric units of water that is expected to mix with the hydrocarbons. For example, the flow rate of hydrate inhibitor such as methanol may range from about 2.0 to about 15.0 gallons per minute, or from about 6.0 to about 8.0 gallons per minute.

[0083] Another approach to reduce the potential for hydrate formation is to reduce and/or eliminate contact between the hydrocarbons and the sea water. Skirts 211 provide a barrier between the hydrocarbons and the seawater, but may not form a perfect annular seal (i.e., some hydrocarbons and/or water may flow past skirts 211). Accordingly, in some embodiments, one or more radially expanding bladder (e.g., packer) may be included on the

stabbing member (e.g., stabbing member 210) to form an annular seal between the stabbing member and conduit into which the stabbing member is inserted. Use of an expanding bladder is particularly suited to subsea conduits that do not include other objects or structures (e.g., pipes) that may obstruct or impact the ability of the expanding bladder to form an annular seal with the inside of the conduit. In addition, such packers offer the potential for a high pressure seal and can function as anchors that maintain the position of the stabbing member within the subsea conduit. A hydraulic supply line extending from the ROV panel along the device can provide hydraulic pressure to actuate the packer. In other embodiments, an annular seal between the stabbing member and conduit may be formed with a plug (e.g., mud or cement) inserted into the annulus between the stabbing member and conduit rearward of the stabbing tip (e.g., tip 217) and at least one skirt (e.g., skirt 211).

[0084] Following insertion of the stabbing member (e.g., stabbing member 210) into the conduit discharging hydrocarbons, a chemical dispersant may be introduced in the vicinity of any escaping (non-captured) hydrocarbons mixing with seawater. Dispersants, if used, are preferably mixed only with oil that is not captured, since adding dispersant to oil that is captured may be counter-productive, making oil/water separation very difficult. Examples of suitable chemical dispersants are listed in Table 1 below and are available from Nalco Company, Naperville, Illinois, USA.

TABLE 1: Ingredients in COREXIT® 9500 and 9527 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.	

[0085] Embodiments of tools previously described (e.g., tools 200, 200', 300, 400, etc.) are generally designed for insertion into a horizontal or substantially horizontal subsea conduit (i.e., oriented at an angle between 0° and about 45° from horizontal). However, embodiments

described herein may be configured for insertion into a subsea conduit that is vertical or substantially vertical (i.e., oriented at an angle between about 45° and 90° from horizontal). Referring now to Figure 15, an embodiment of a device or tool 600 for capturing hydrocarbons from a vertical or substantially vertical subsea conduit is shown. Tool 600 is an elongate tubular structure or assembly having a central or longitudinal axis 605, an open upper end 600a, and an open lower end 600b in fluid communication with end 600a. Starting at end 600b and moving axially towards end 600a, in this embodiment, tool 600 includes a stabbing member 610 extending from end 600b, and an adapter member 250 coupled to the upper end of stabbing member 610 with a crossover member 240. Adapter member 250 and crossover member 240 are each as previously described. In this embodiment, axis 605 is generally vertical and linear between ends 600a, b.

[0086] Each member 610, 240, 250 is a tubular conduit coaxially aligned with tool axis 605. Thus, a continuous flow passage extends through tool 600 from end 600a to end 600b. Crossover member 240 provides a transition from member 610 to a larger inner and outer diameter adapter member 250. To enhance visibility subsea, any one or more of members 610, 240, 250 may be painted a color that contrasts with the color of the surrounding water, which is usually very dark (black) at subsea depths. For example, these components may be painted white or yellow. Reflective tape or other light-reflective element(s) may also be provided on one or more of these components.

[0087] Referring still to Figure 15, stabbing member 610 extends axially from end 600b to crossover member 240 and is rotatably coupled to crossover member 240 as previously described. A rigid annular landing plate 611 is mounted to stabbing member 610 and a plurality of axially spaced annular diaphragms or skirts 211 as previously described are disposed about stabbing member 610 between end 600b and plate 611. Skirts 211 and plate 611 are fixed to stabbing member 610 such that skirts 211 and plate 611 do not move axially along stabbing member 610 or rotate about stabbing member 610. Skirts 211 are designed to slidably engage and conform to the inner surface of the conduit being serviced as previously described. However, plate 611 is landed upon and engages the upper end of the conduit being serviced to prevent tool 600 from falling therethrough and providing an additional barrier to the discharge of hydrocarbons from the conduit and influx of sea water into the conduit. Stabbing member 610 has a stabbing tip 617 at end 600b. In this embodiment, tip 617 is a tapered muleshoe to facilitate insertion into a subsea conduit.

[0088] Hydrocarbon capture tool 600 also includes an ROV access panel 280 as previously described coupled to stabbing member 610 between plate 611 and crossover member 240.

However, in this embodiment, panel 280 is radially spaced away from stabbing member 610 and axis 605 to position panel 280 outside the hydrocarbon plume during insertion of stabbing member 610 into a vertical or substantially vertical conduit. Flow lines 284a, b, c (not shown in Figure 15) extend from panel 280 to stabbing member 610, downward along the outside of stabbing member 610, and through the sidewall of member 610 into the interior of tool 600 between plate 611 and tip 617. During subsea hydrocarbon capture operations, flow lines 284a, b, c may be used to inject a functional fluid (e.g., hydrate inhibitors) into tool 600 and the captured hydrocarbons flowing therethrough.

[0089] Referring now to Figures 16A-16D, the deployment of tool 600 to capture hydrocarbons discharged from a vertical subsea conduit 650 is schematically shown. For subsea deployment and implementation of tool 600, one or more ROVs 170 as previously described are preferably employed to aid in positioning tool 600, monitoring tool 600 and conduit 650, and actuating subsea hardware (e.g., handles 282a, b, c, etc.).

[0090] Referring first to Figures 16A and 16B, tool 600 is controllably lowered subsea. In general, tool 600 may be lowed on the end of a pipe string (e.g., drillstring or riser) or with wireline. During deployment, tool 600 is preferably maintained outside of plume 160 of hydrocarbon fluids emitted from conduit 650 to enhance visibility and reduce the potential for the formation of hydrates within tool 600. Tool 600 is lowered laterally offset from conduit 650 until tip 617 is immediately above the upper end of conduit 650.

[0091] Moving now to Figure 16C, tool 600 is moved laterally over conduit 650 with stabbing member 610 substantially coaxially aligned with conduit 650. Next, as shown in Figure 16D, tool 600 is lowered to insert tip 617 into the end of conduit 650 and axially advance stabbing member 610 therein. Tool 600 is lowered under its own weight until plate 611 axially abuts and engages the upper end of conduit 650, thereby preventing further advancement of stabbing member into conduit 650. As stabbing member 610 is advanced into conduit 650, flexible skirts 211 conform to inside surface of conduit 650 and any structures therein (e.g., a drillpipe, etc.), thereby restricting and/or preventing the flow of hydrocarbons from conduit 650 into the surrounding sea. In addition, plate 611 forms an additional barrier at the upper end of conduit 650. Thus, skirts 211 and plate 611 at least partially block the flow of hydrocarbons out of the end of conduit 650, and direct the hydrocarbons to flow into end 600b and through tool 600 to end 600a.

[0092] The hydrocarbons flowing through tool 600 are produced to the surface via a tie-back conduit in the manner previously described. In addition, a low-density fluid such as nitrogen

may be pumped through tool 600 in the manner previously described to reduce the potential for hydrate formations during deployment of tool 600.

[0093] Referring now to Figure 17, another embodiment of a device or tool 700 for capturing hydrocarbons from a vertical or substantially vertical subsea conduit is shown. Tool 700 is the same as tool 600 previously described except that tool 700 does not include plate 611 or skirts 211 disposed about stabbing member 610. Rather, in this embodiment, an annular packer 710 is mounted to stabbing member 610 and a plurality of circumferentially-spaced ribs 730 are disposed about stabbing member 610 between packer 720 and tip 617.

[0094] In general, packer 710 may be any annular packer known in the art that is hydraulically actuated to expand radially outward into sealing engagement with a tubular within which it is disposed (e.g., BOP throughbore, riser, pipeline, etc.). In Figure 17, packer 710 is shown in the radially retracted "run in" position (solid line) and the radially expanded "sealing" position (dashed line). Packer 710 may be actuated via a hydraulic line extending from control panel 280 or other subsea hydraulic power source.

[0095] Ribs 730 function to protect packer 710 during insertion and advancement of stabbing member 610 and packer 710 into a subsea conduit. In this embodiment, four uniformly circumferentially spaced ribs 730 are disposed about stabbing member 610. Each rib 730 extends to an outer radius that is greater than the outer radius of packer 710 in the retracted position, but less than the outer radius of packer 710 in the expanded position.

[0096] Tool 700 is deployed in the same manner as tool 600 previously described except that tool 700 relies on packer 710 to anchor it to the subsea conduit and seal between stabbing member 610 and the conduit. In particular, tool 700 is lowered subsea and inserted into the subsea conduit with packer 710 in the retracted position. Ribs 720 precede and shield packer 710 during insertion of stabbing member 610 into the conduit being serviced. With packer 710 sufficiently disposed within the conduit, it is actuated to expand radially outward into sealing engagement with the conduit, thereby directing hydrocarbons flowing through the conduit into tool 700 at tip 617.

[0097] In the manner described, embodiments described herein provide means for capturing hydrocarbons discharged subsea. In general, embodiments of tools described herein may be used for insertion into and collection of hydrocarbons emanating subsea from any of a variety of subsea components or devices, such as risers, drill pipes, a BOP, wellheads or connections thereto, manifolds, transfer pipelines, lower marine riser packages (LMRP), lower riser assemblies (LRA), upper riser assemblies (URA), goosenecks or wing valve assemblies, underwater portions of surface vessels, underwater vessels, underwater containers (such

tanks), and the like. Such tools include features (e.g., skirts, diaphragms, packers, etc.) that provide a barrier to the undesirable subsea contact of hydrocarbons and sea water. Since water is a necessary ingredient in formation of hydrates, this offers the potential to mitigate hydrate formation. In addition, the releasable connection of a tie-back conduit to embodiments described herein enables the captured hydrocarbons to be flowed to a surface vessel.

[0098] While preferred embodiments have been shown and described, modifications thereof can be made by one skilled in the art without departing from the scope or teachings herein. The embodiments described herein are exemplary only and are not limiting. Many variations and modifications of the systems, apparatus, and processes described herein are possible and are within the scope of the invention. For example, the relative dimensions of various parts, the materials from which the various parts are made, and other parameters can be varied. Accordingly, the scope of protection is not limited to the embodiments described herein, but is only limited by the claims that follow, the scope of which shall include all equivalents of the subject matter of the claims. Unless expressly stated otherwise, the steps in a method claim may be performed in any order. The recitation of identifiers such as (a), (b), (c) or (1), (2), (3) before steps in a method claim are not intended to and do not specify a particular order to the steps, but rather are used to simplify subsequent reference to such steps.

CLAIMS

What is claimed is:

1. A device for capturing hydrocarbons discharged from a subsea flow passage having an inner diameter, the device comprising:
 - an elongate tubular structure having a central axis, a first end, and a second end opposite the first end, wherein the second end is open and in fluid communication with the first end;
 - wherein the tubular structure includes a rigid stabbing member extending axially from the second end and configured to be inserted into the flow passage; and
 - an annular flexible skirt disposed about the stabbing member, wherein the skirt is secured to the stabbing member and extends radially outward from the stabbing member;
 - wherein the skirt is configured to flex from an unflexed position to a flexed position upon insertion of the stabbing member into the flow passage, wherein the skirt is biased to the unflexed position and has an outer diameter in the unflexed position that is greater than the inner diameter of the flow passage.
2. The device of claim 1, wherein the skirt is configured to slidingly engage an inner surface defining the flow passage upon insertion of the stabbing member into the flow passage and at least partially block the flow of hydrocarbons from the flow passage.
3. The device of claim 2, wherein the tubular structure further comprises a crossover member coupled to the stabbing member configured to rotate about the central axis relative to the stabbing member.
4. The device of claim 3, wherein the tubular structure further comprises an adapter member extending from the first end to the crossover member, wherein the adapter member includes a J-slot connector configured to releasably engage the tie-back conduit.
5. The device of claim 2, wherein the second end comprises a tapered mule-shoe.

6. The device of claim 2, further comprising a plurality of axially spaced annular skirts disposed about the stabbing member, wherein each skirt is secured to the stabbing member and extends radially outward from the stabbing member;

wherein each skirt is configured to flex from an unflexed position to a flexed position upon insertion of the stabbing member into the flow passage, wherein each skirt is biased to the unflexed position and has an outer diameter in the unflexed position that is greater than the inner diameter of the flow passage.

7. The device of claim 6, wherein at least one skirt includes a pair of axially adjacent annular discs secured to the stabbing member, wherein each disc comprises a plurality of circumferentially adjacent flaps defined by a plurality of circumferentially spaced radial slits.

8. The device of claim 7, wherein the radial slits in each disc are circumferentially misaligned.

9. The device of claim 2, and wherein the first end is configured to be coupled to a lower end of a tie-back conduit extending subsea.

10. The device of claim 9, wherein the tie-back conduit is a riser or pipe string extending from the surface.

11. The device of claim 2, further comprising an ROV control panel coupled to the tubular structure, and a plurality of flow lines extending from the ROV control panel to the stabbing member;

wherein the flow lines are configured to inject a fluid into the tubular structure.

12. The device of claim 2, wherein the tubular structure further comprises:

a connector member coupled to the stabbing member with a first elbow; and

a recovery member coupled to the connector member with a second elbow;

wherein the connector member is oriented at a first angle α relative to the stabbing member and the recovery member is oriented at a second angle β relative to the connector member, wherein angle α is between 30° and 90° and angle β is between 45° and 180° .

13. The device of claim 12, wherein the recovery member is oriented perpendicular to the stabbing member.

14. The device of claim 12, further comprising a stop plate extending between the stabbing member and the connector member, wherein the stop plate is configured to prevent impingement of the tubular structure upon insertion of the stabbing member into the flow passage.

15. The device of claim 12, further comprising a support arm coupled to the connector member, wherein the support arm is oriented parallel to the recovery member and is configured to support vertical loads upon insertion of the stabbing member into the flow passage.

16. The device of claim 15, wherein the support arm is pivotally coupled to the connector member.

17. The device of claim 12, further comprising a clamp coupled to the connector member and disposed about the stabbing member.

18. The device of claim 2, further comprising a landing plate disposed about the stabbing member, wherein the landing plate is secured to the stabbing member and extends radially outward from the stabbing member;

wherein the skirt is axially positioned between the landing plate and the second end, and wherein the landing plate has an outer diameter greater than the outer diameter of the skirt in the flexed position.

19. A method for capturing hydrocarbons discharged from a subsea flow passage, the method comprising

(a) lowering a hydrocarbon collection tool subsea, the collection tool comprising a tubular structure having a central axis, a first end, a second end, and a stabbing member extending axially from the second end, wherein the second end is open and in fluid communication with the first end;

(b) coupling a tie-back conduit to the first end of the collection tool;

(c) inserting the stabbing member into the subsea flow passage;

(d) flowing the hydrocarbons into the collection tool at the second end; and
(e) flowing the hydrocarbons through the collection tool and the tie-back conduit to the surface.

20. The method of claim 19, further comprising:
at least partially blocking the flow of the hydrocarbons through the flow passage during (d).

21. The method of claim 20, wherein the collection tool includes a plurality of annular flexible skirts disposed about the stabbing member, wherein each skirt is secured to the stabbing member and extends radially outward from the stabbing member;
wherein (c) further comprises slidably engaging an inner surface defining the flow passage with the skirts.

22. The method of claim 21, wherein the skirts at least partially block the flow of hydrocarbons through the flow passage during (d).

23. The method of claim 19, further comprising:
injecting a fluid into the hydrocarbons flowing through the collection tool.

24. The method of claim 23, wherein the injected fluid is a hydrate inhibitor, a wax inhibitor, an asphaltene inhibitor, a scale inhibitors, a corrosion inhibitors, or an antideposition agent.

25. The method of claim 20, wherein (a) comprises lowering the collection tool subsea from a surface vessel with the tie-back conduit.

26. The method of claim 20, further comprising:
lowering the collection tool subsea outside of a plume formed by the discharged hydrocarbons;
aligning the collection tool with the flow passage;
moving the collection tool in a first direction beyond an outlet of the flow passage;
and

moving the collection tool in a second direction opposite the first direction to insert the stabbing member into the flow passage.

27. The method of claim 20, wherein the flow of the hydrocarbons through the flow passage during (d) is at least partially blocked by an annular packer disposed about the stabbing member.

28. The method of claim 27, further comprising:

radially expanding the annular packer into engagement with an inner surface defining the flow passage after (c).

29. A device for capturing hydrocarbons discharged from a subsea flow passage having an inner diameter, the device comprising:

an elongate tubular structure having a central axis, a first end, and a second end opposite the first end, wherein the second end is open and in fluid communication with the first end;

wherein the tubular structure includes a rigid stabbing member extending axially from the second end and configured to be inserted into the flow passage; and

an annular packer disposed about the stabbing member, wherein the packer is secured to the stabbing member and extends radially outward from the stabbing member;

wherein the packer is configured to radially expand from a retracted position to an expanded position upon insertion of the stabbing member into the flow passage, wherein the packer has an outer diameter in the retracted position that is less than the inner diameter of the flow passage.

30. The device of claim 29, wherein the packer is configured to sealingly engage an inner surface defining the flow passage and at least partially block the flow of hydrocarbons from the flow passage.

31. The device of claim 30, wherein the tubular structure further comprises a crossover member coupled to the stabbing member and configured to rotate about the central axis relative to the stabbing member.

32. The device of claim 31, wherein the tubular structure further comprises an adapter member extending from the first end to the crossover member, wherein the adapter member includes a J-slot connector configured to releasably engage the tie-back conduit.
33. The device of claim 30, wherein the second end comprises a tapered mule-shoe.
34. The device of claim 30, and wherein the first end is configured to be coupled to a lower end of a tie-back conduit extending subsea.
35. The device of claim 30, wherein the tie-back conduit is a riser or pipe string extending from the surface.
36. The device of claim 30, further comprising an ROV control panel coupled to the tubular structure, and a plurality of flow lines extending from the ROV control panel to the stabbing member;
wherein the flow lines are configured to inject a fluid into the tubular structure.
37. The device of claim 30, further comprising a plurality of circumferentially spaced ribs coupled to the stabbing member, wherein the ribs are axially positioned between the second end and the packer, and wherein the ribs extend radially outward from the stabbing member to an outer diameter that is greater than the outer diameter of the packer in the retracted position and less than the inner diameter of the flow passage.

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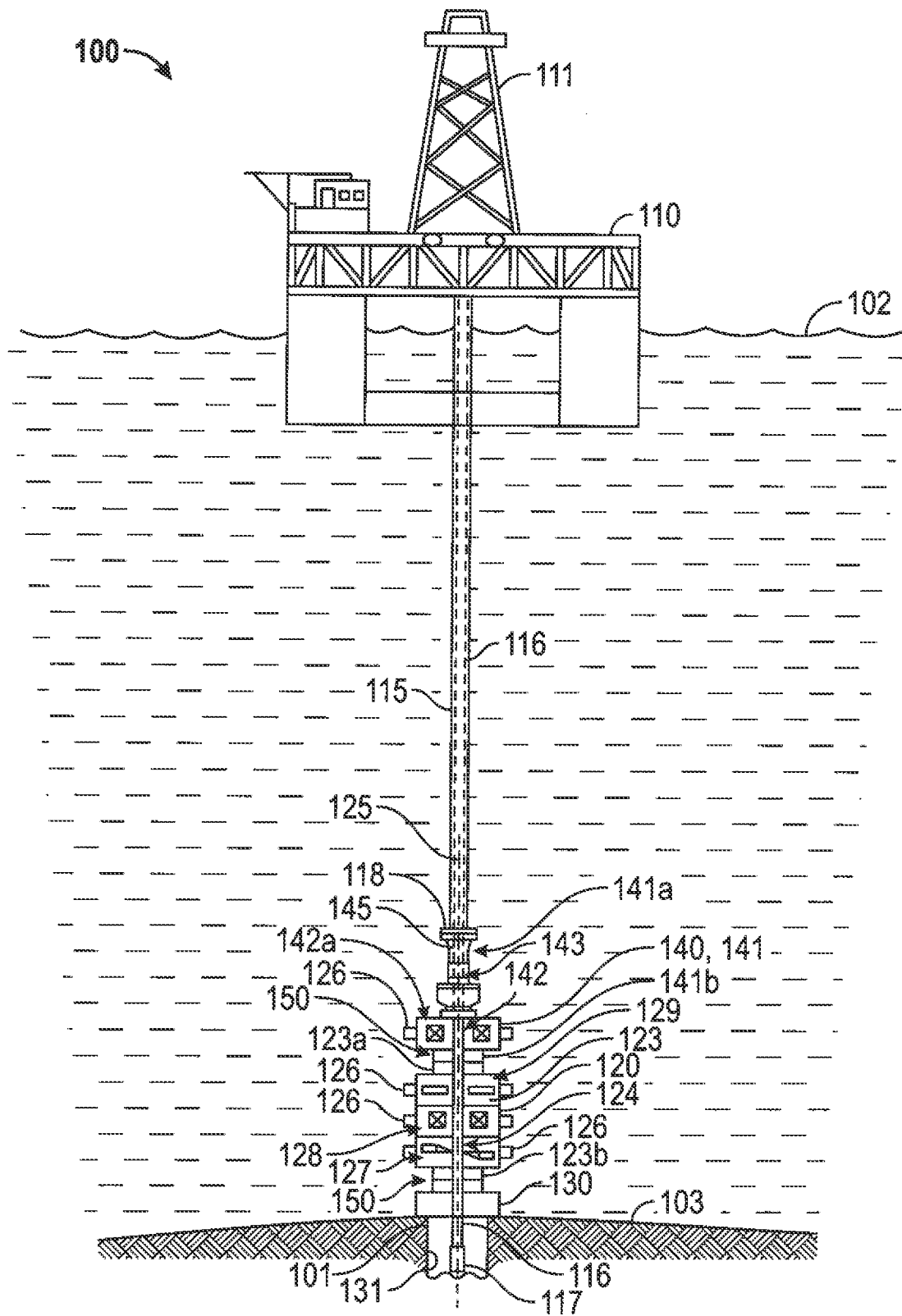


FIG. 1

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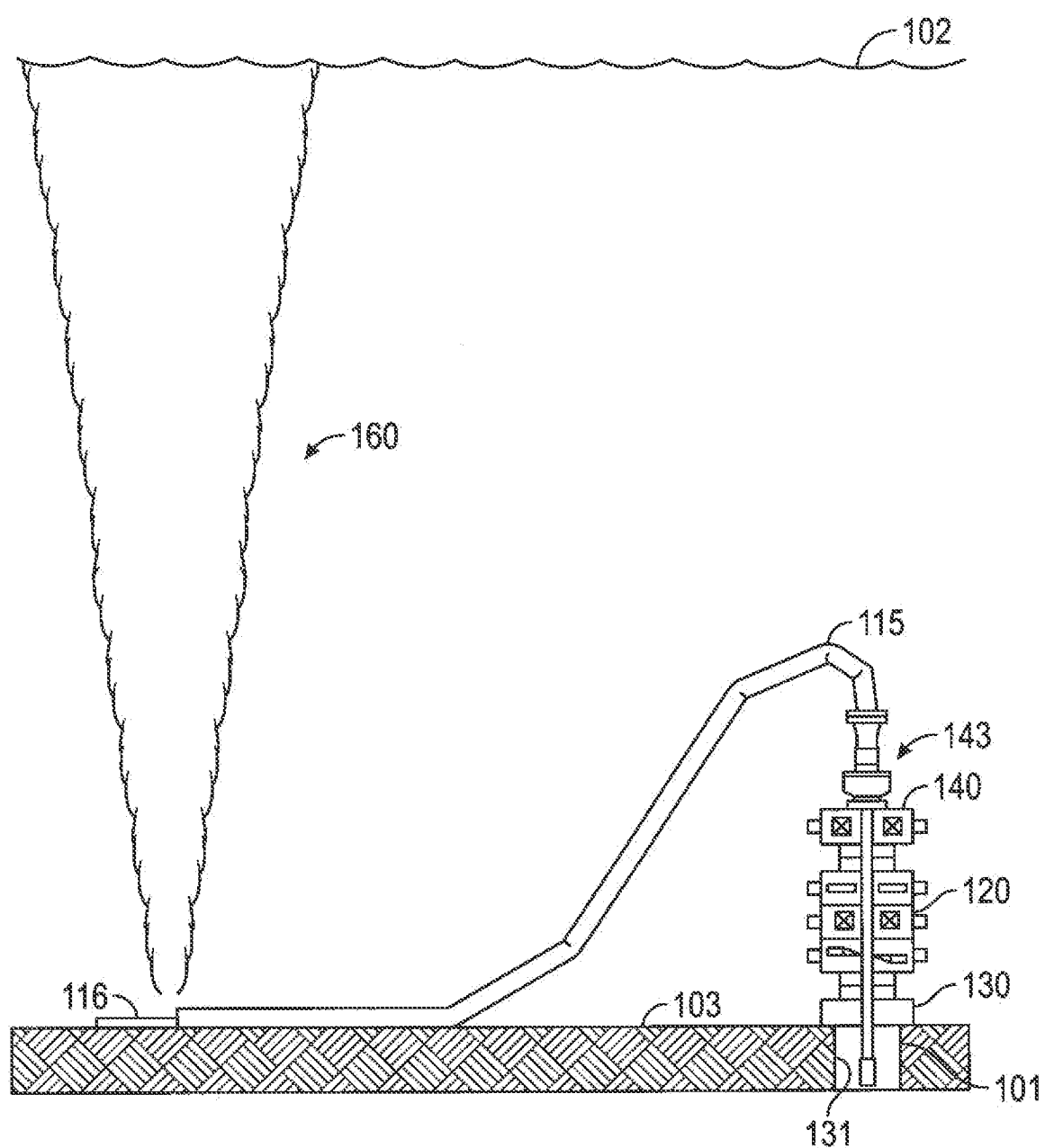


FIG. 2

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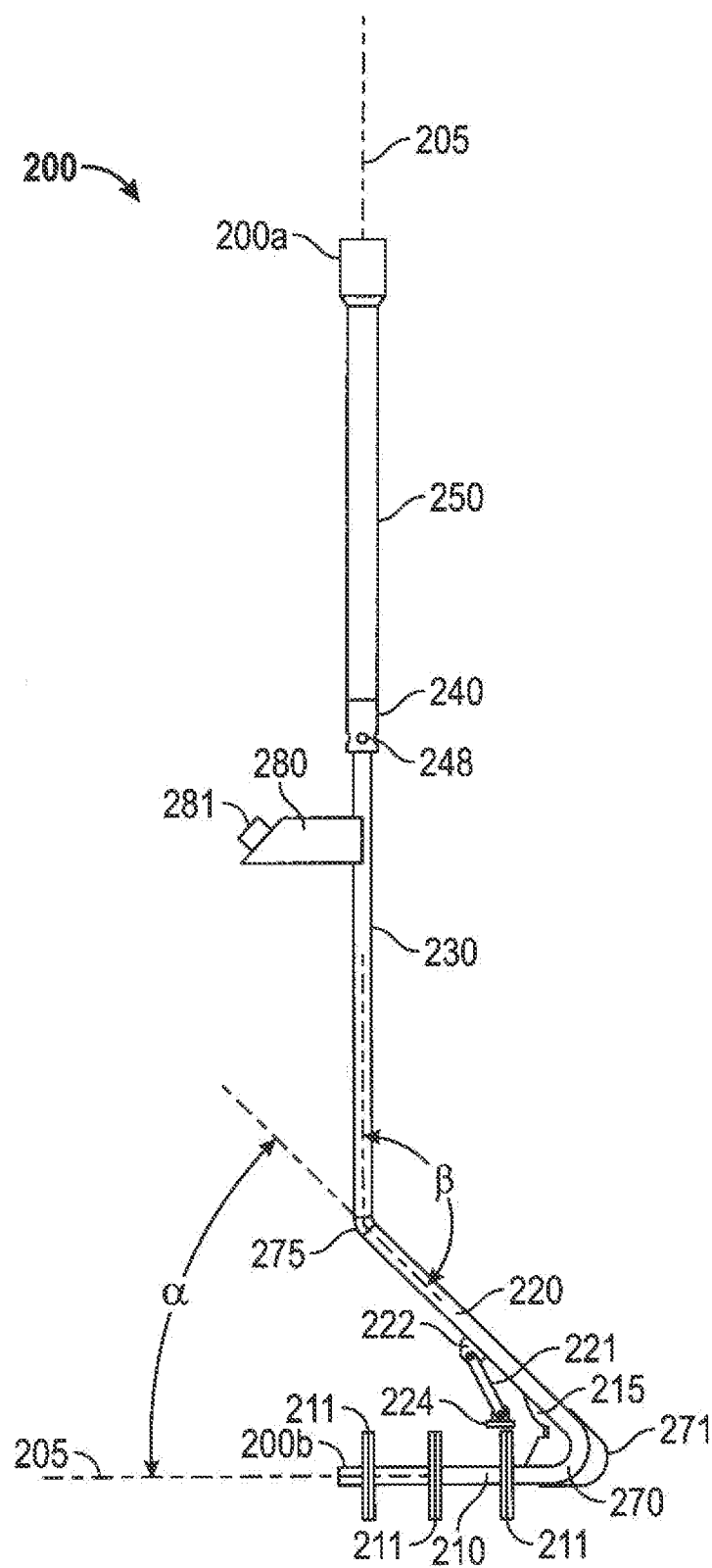
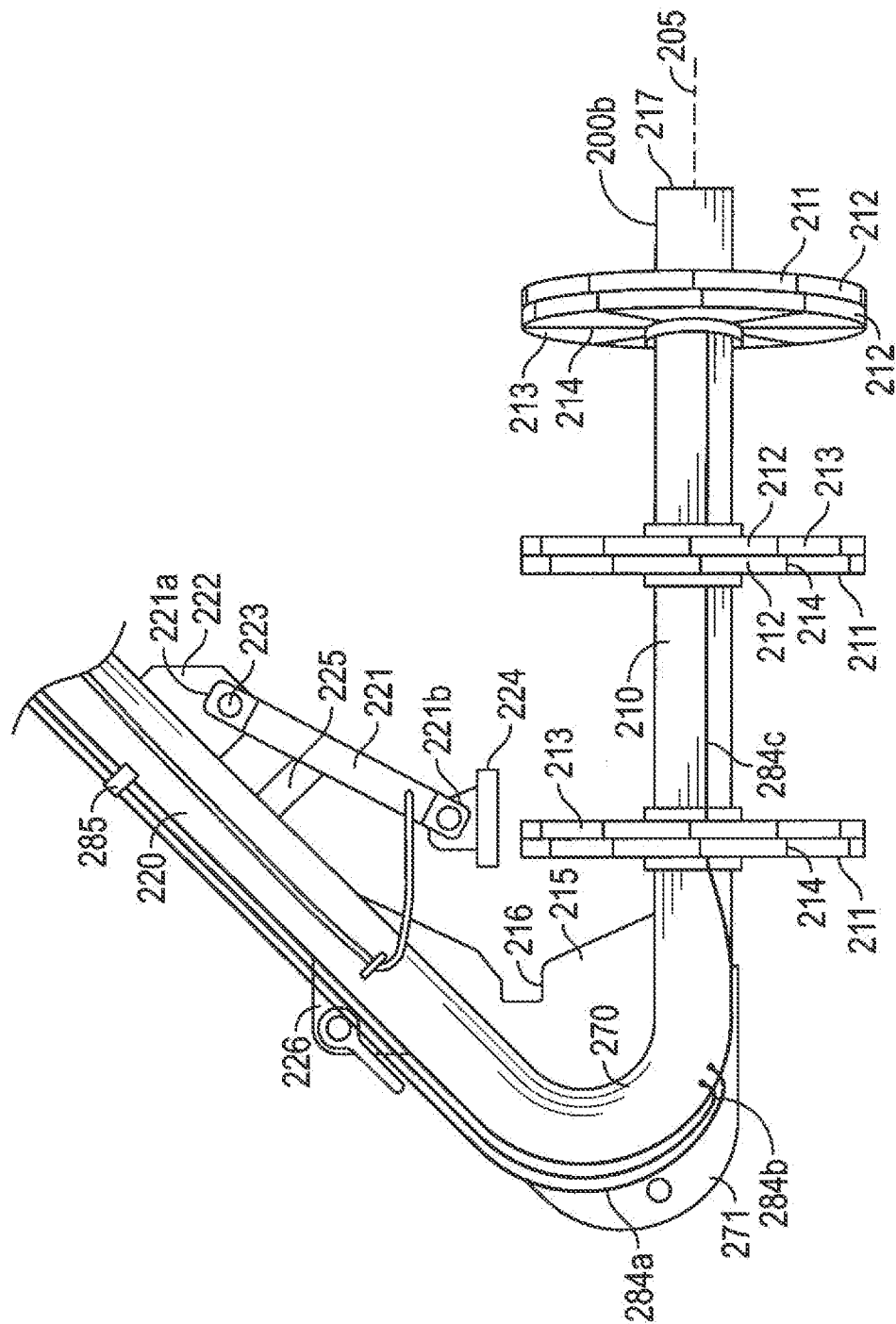


FIG. 3



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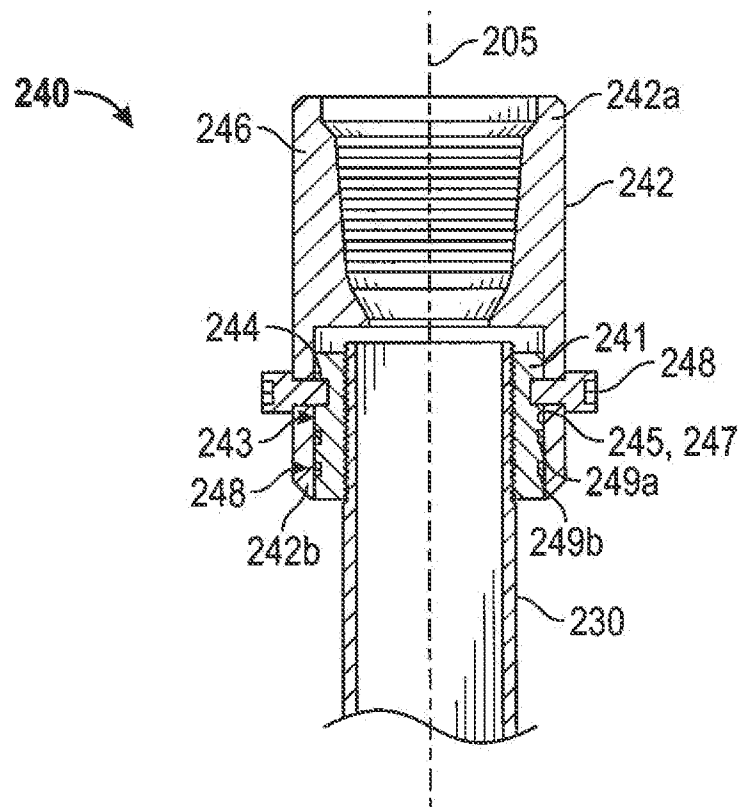


FIG. 5

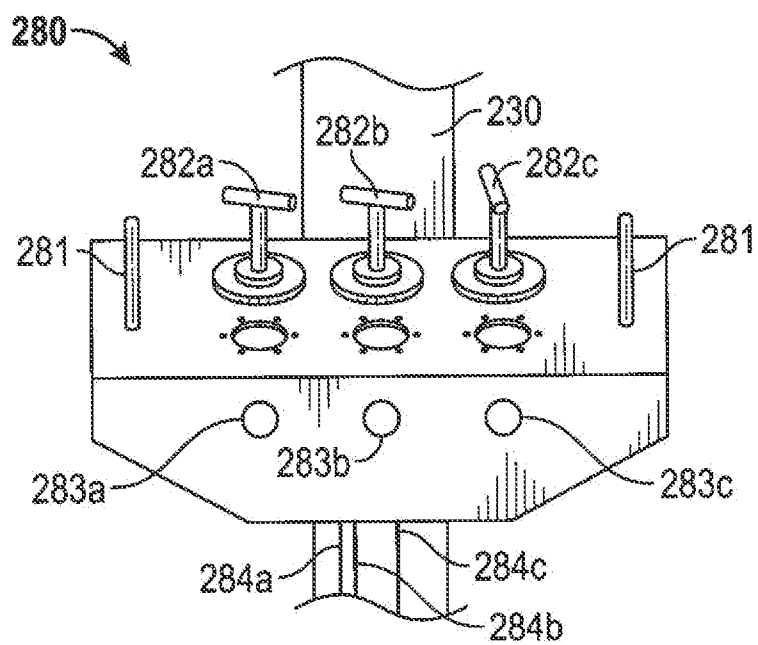


FIG. 6

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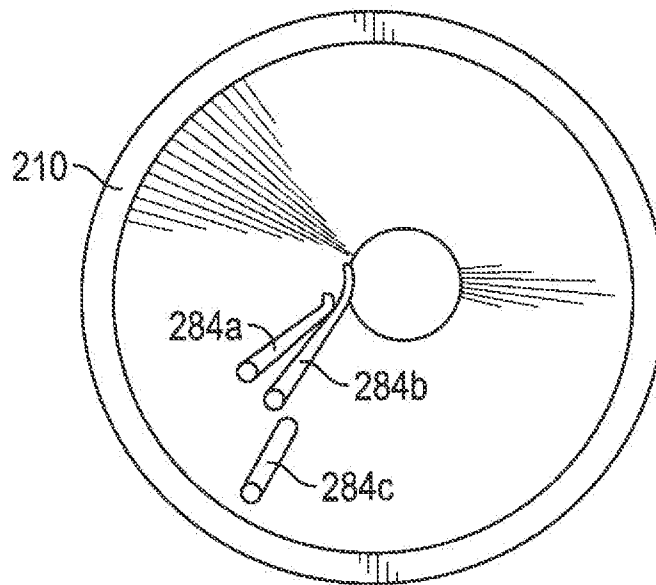


FIG. 7

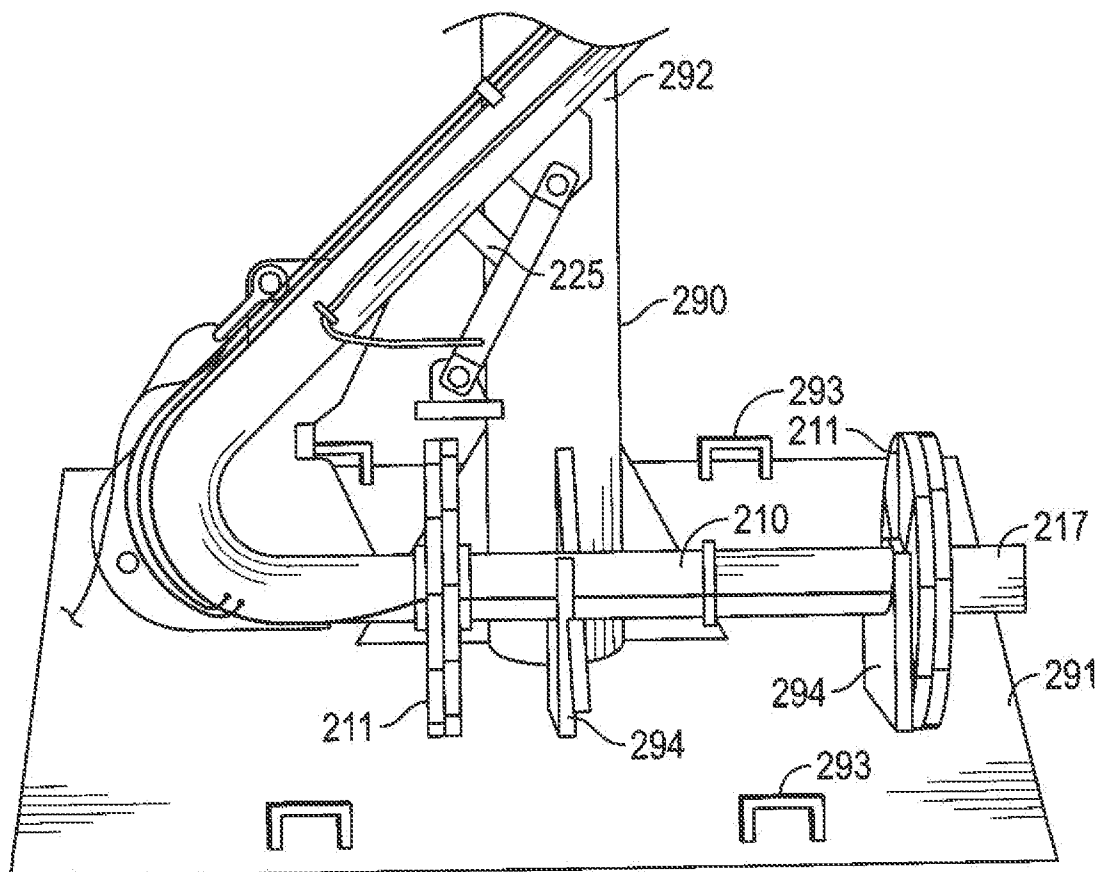


FIG. 8A

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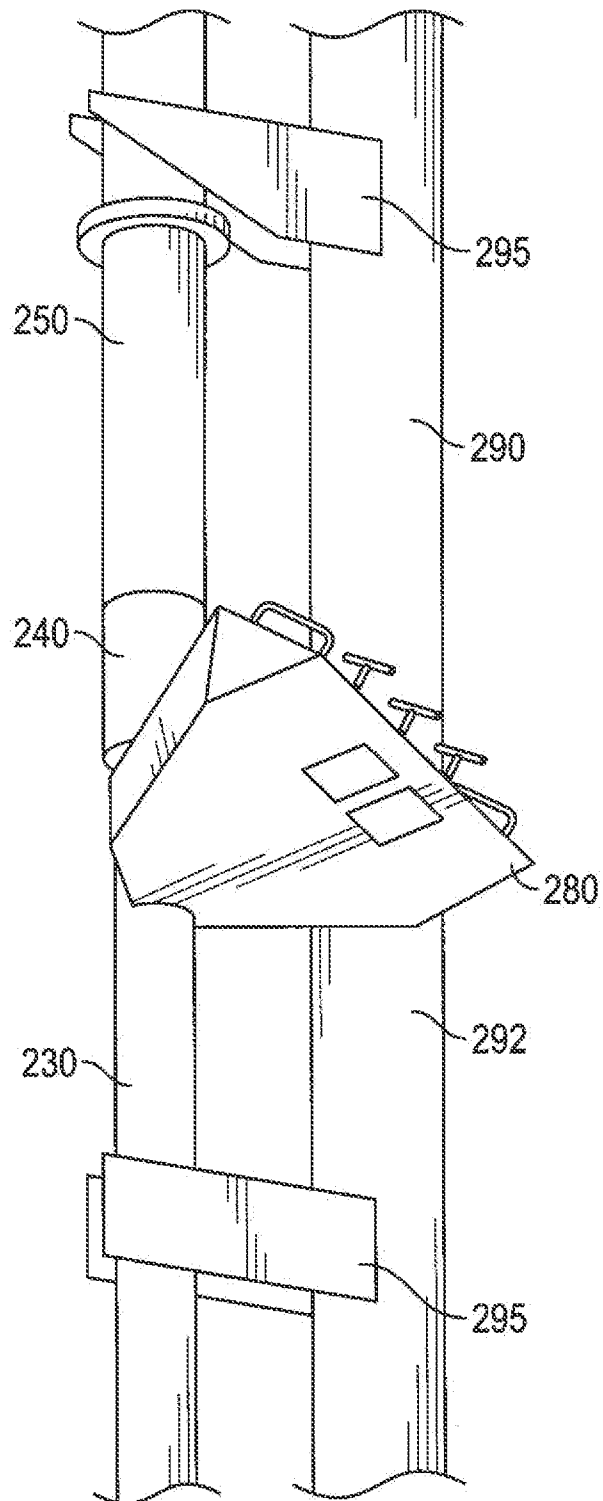


FIG. 8B

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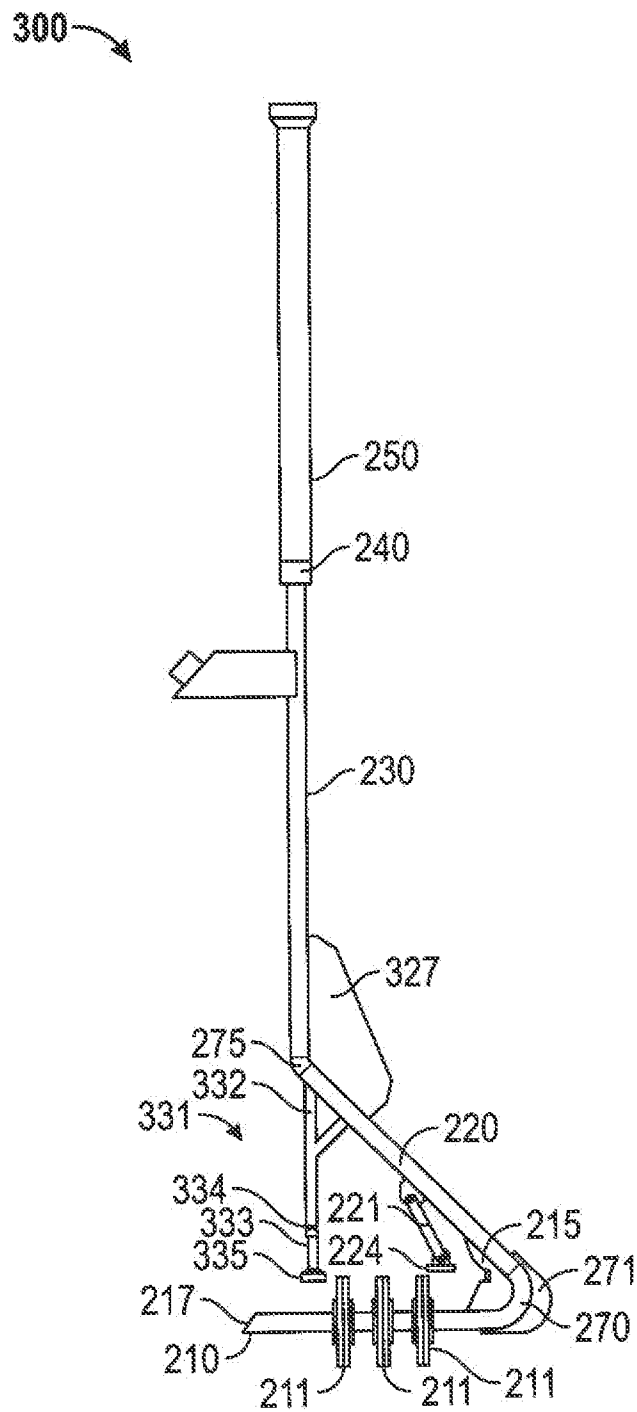


FIG. 9

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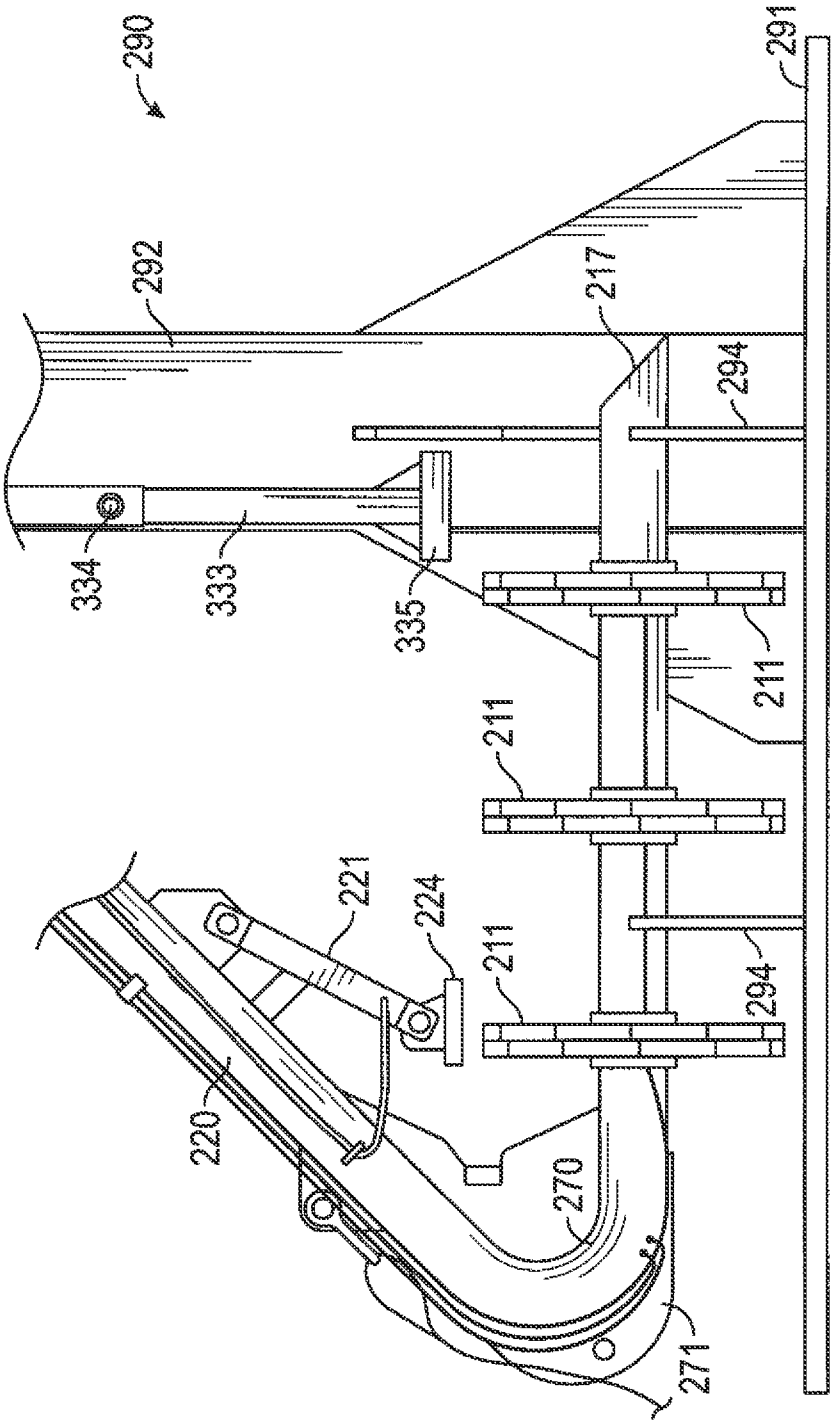


FIG. 10A

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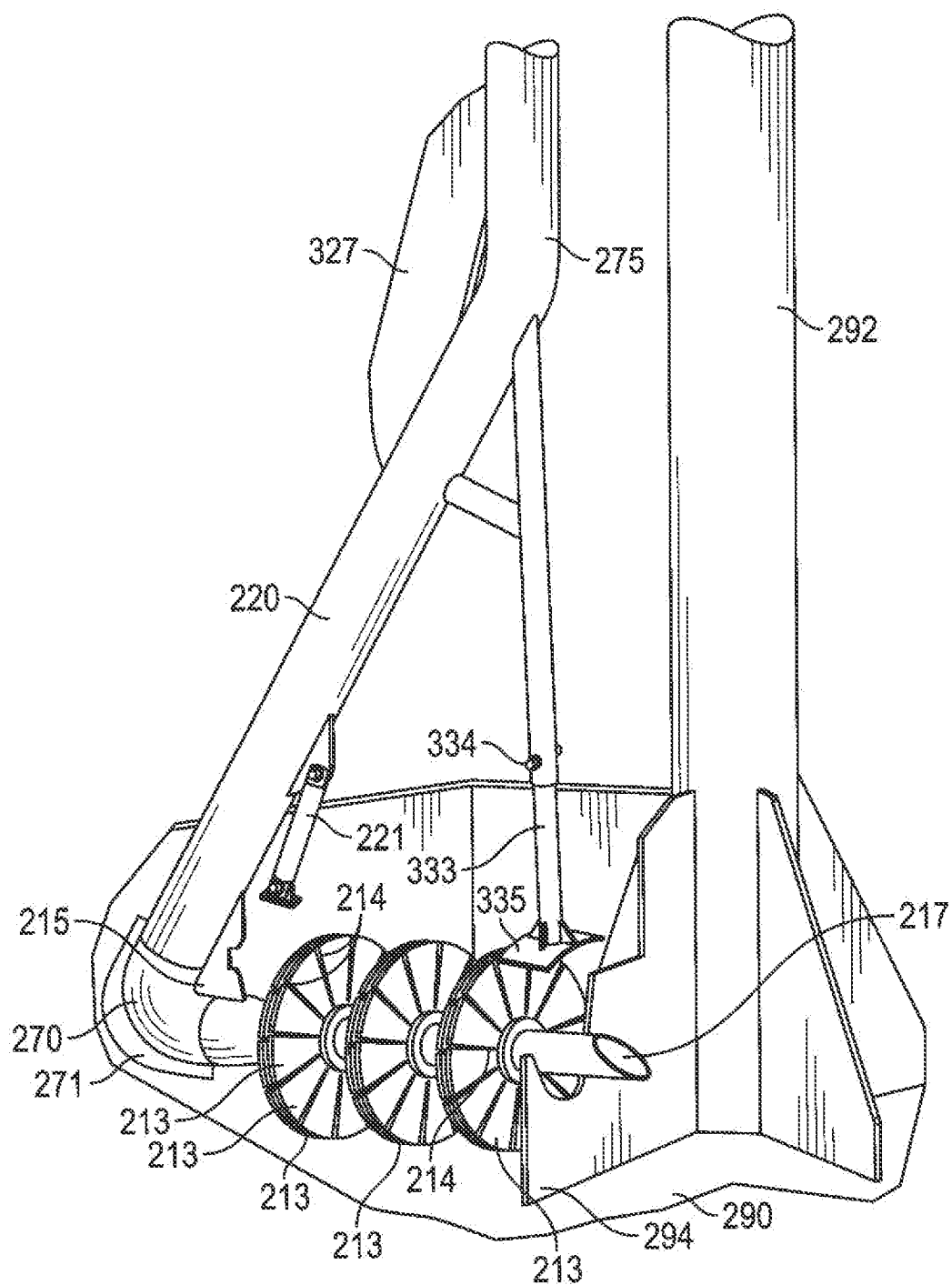


FIG. 10B

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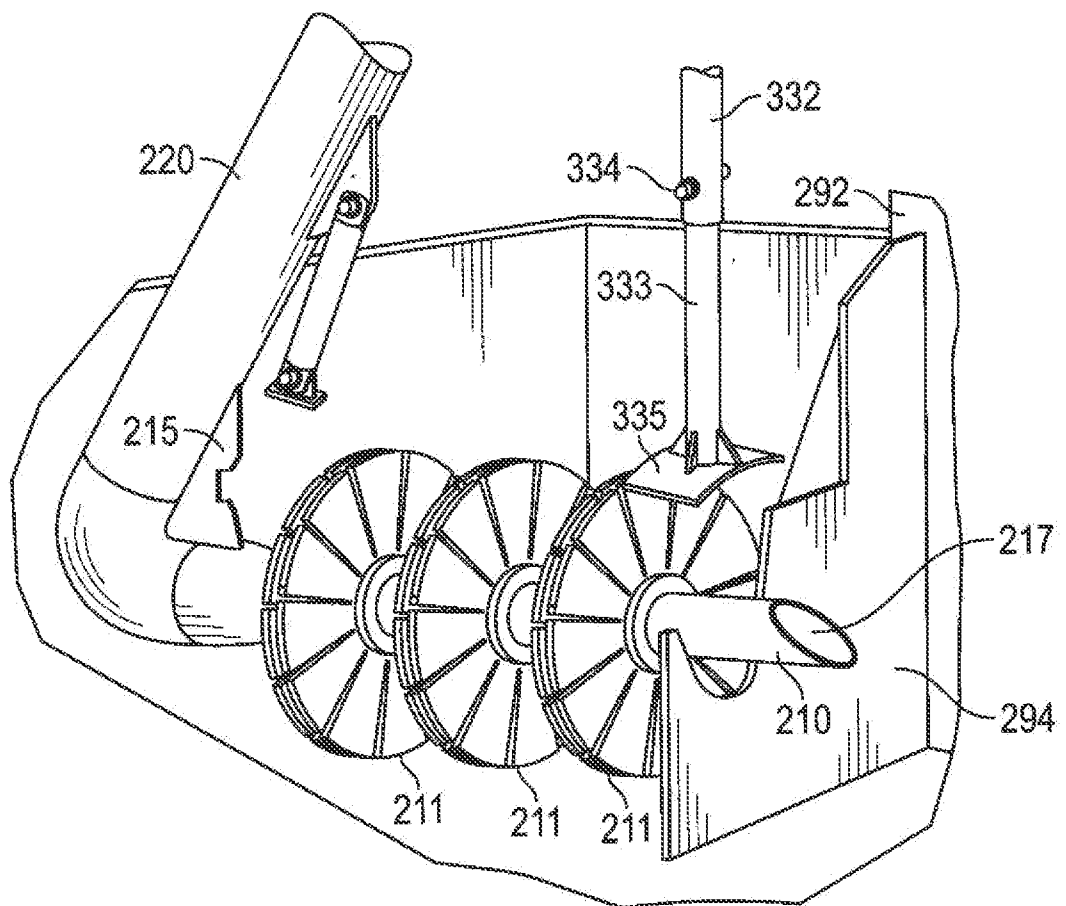


FIG. 10C

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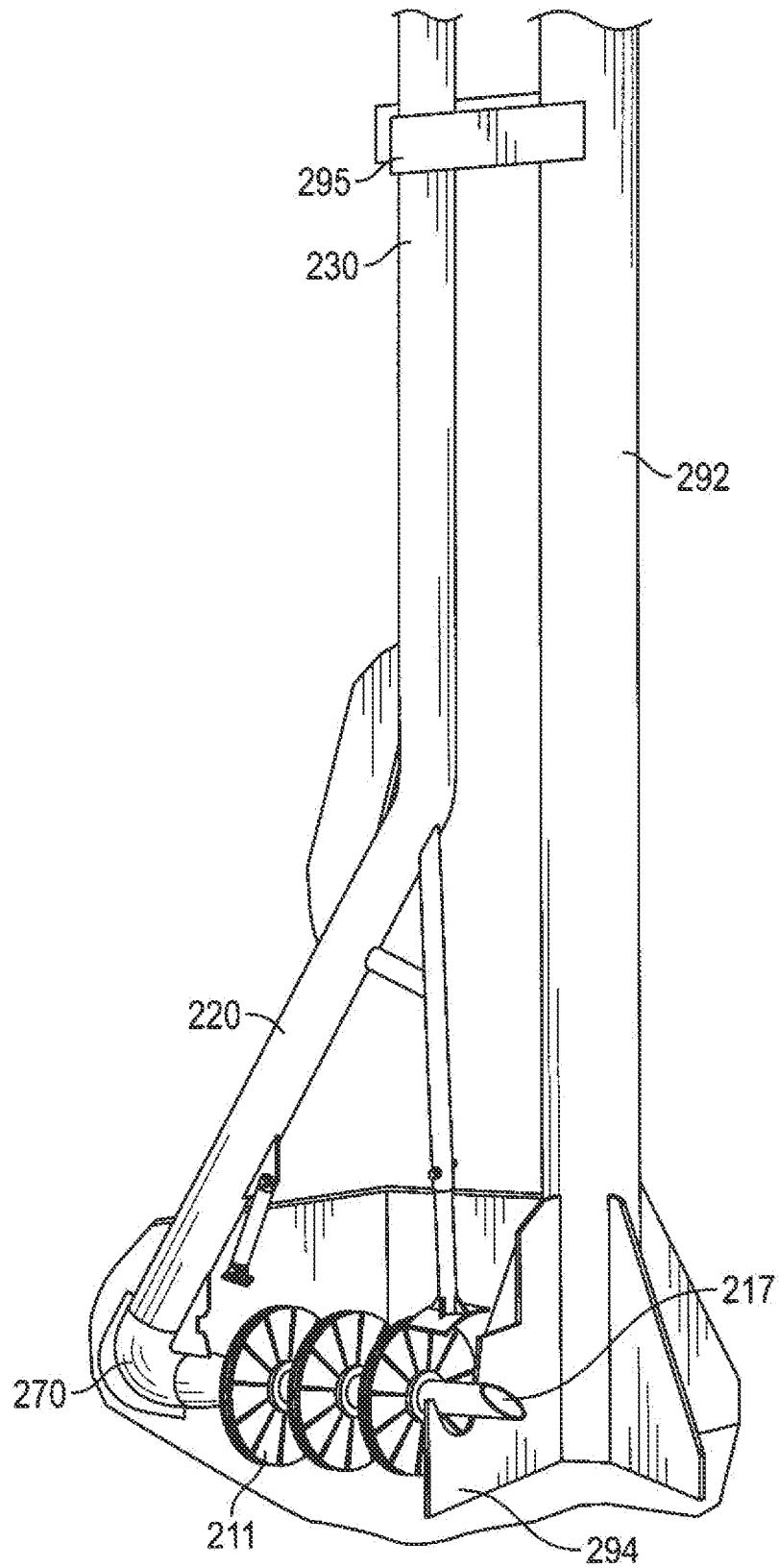


FIG. 10D

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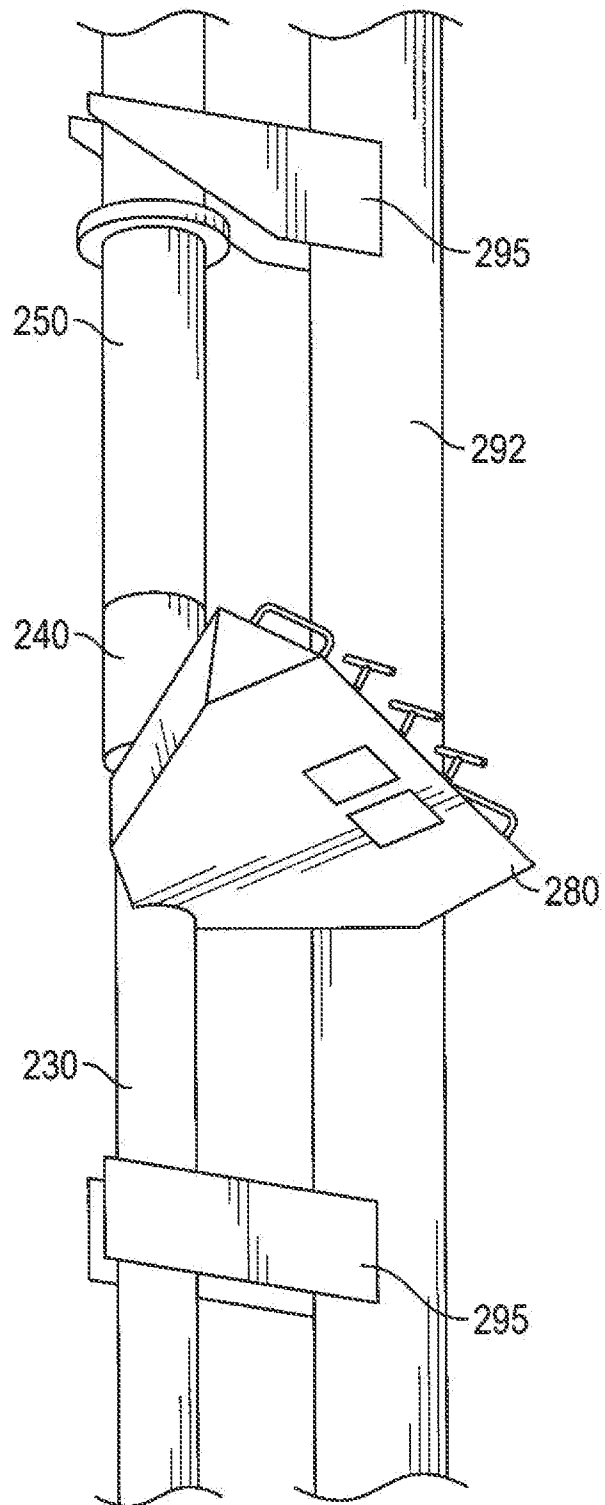


FIG. 10E

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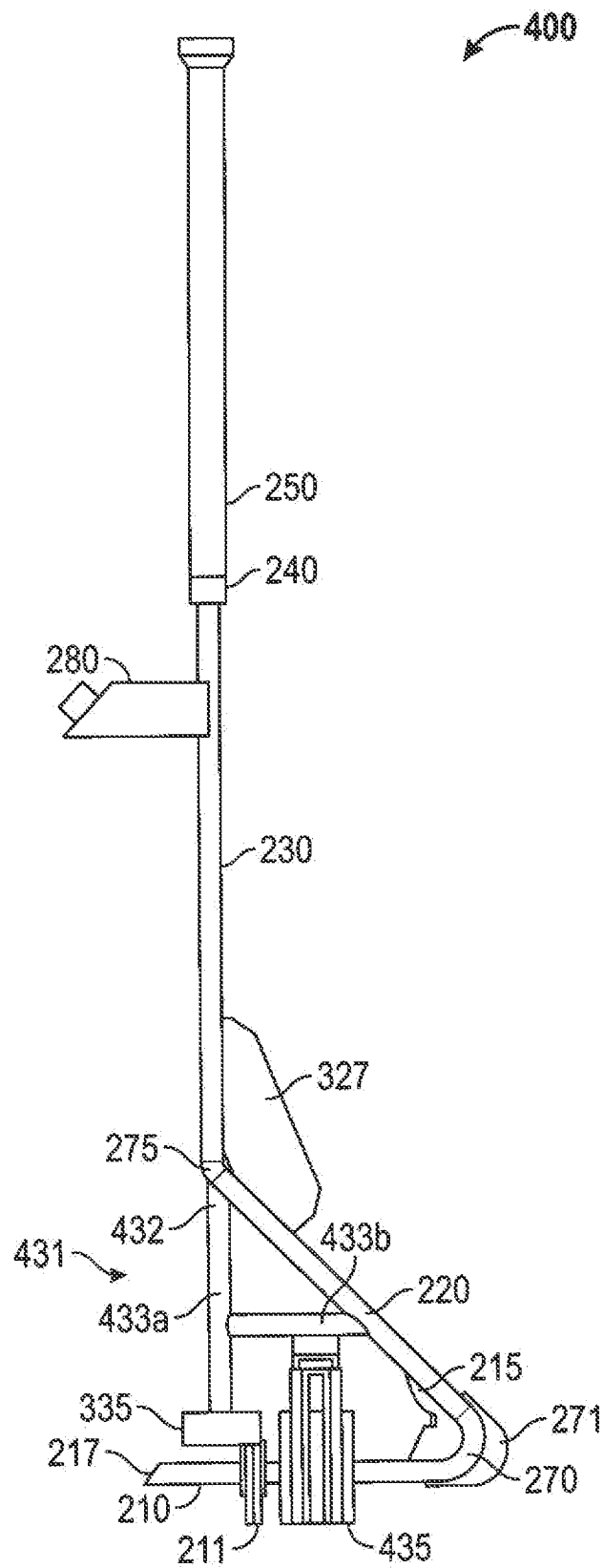


FIG. 11

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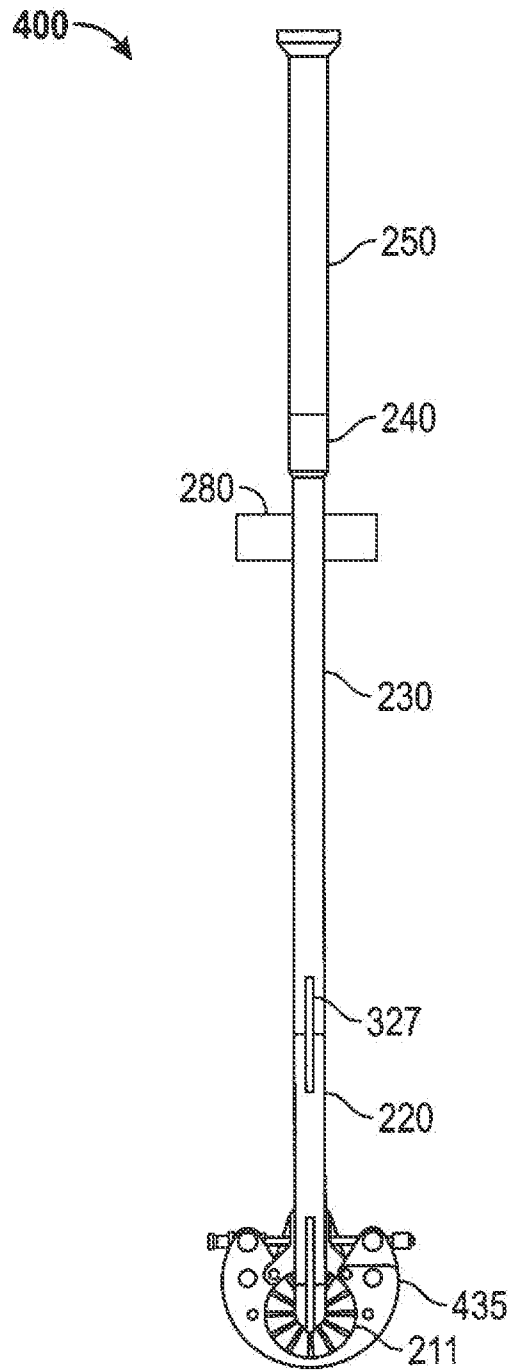


FIG. 12

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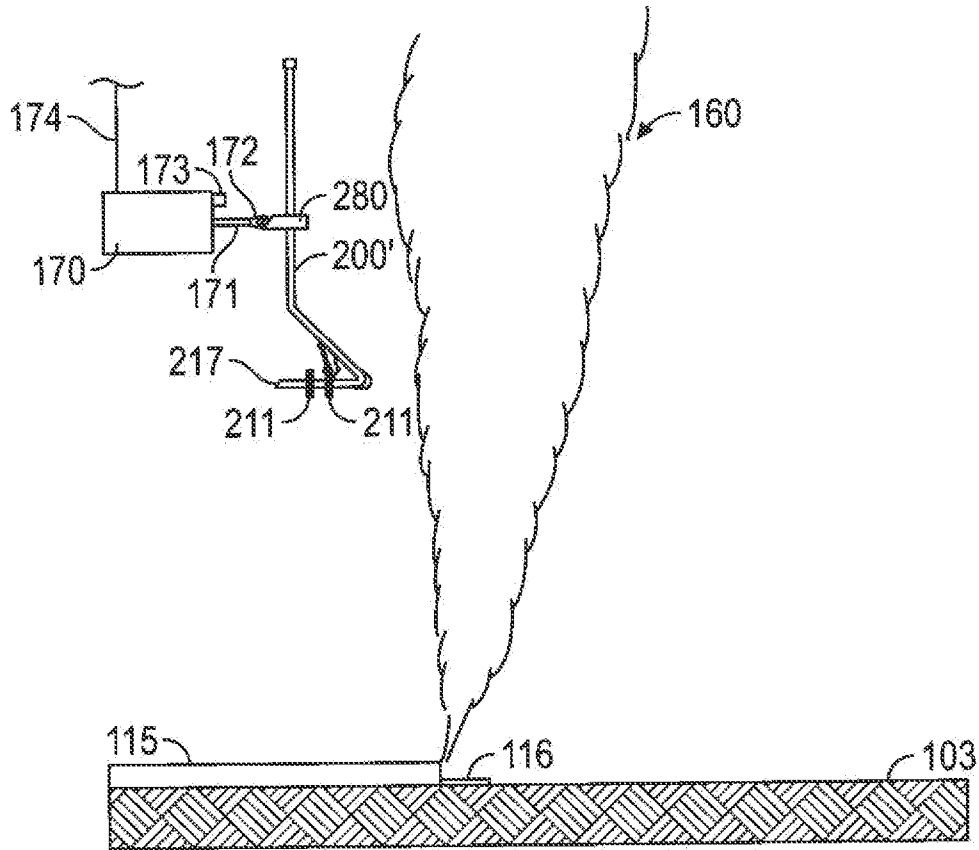


FIG. 13A

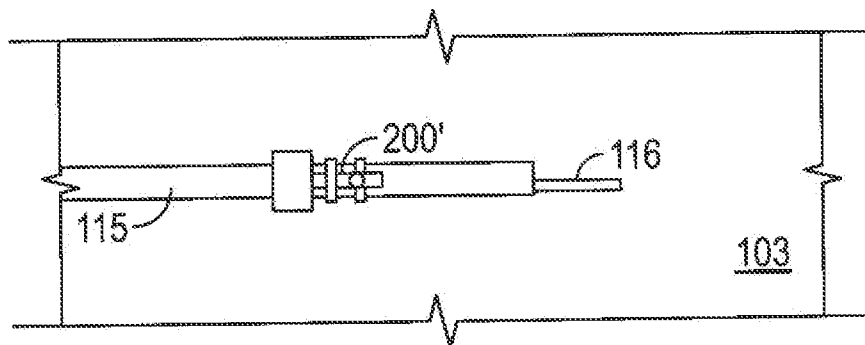


FIG. 13B

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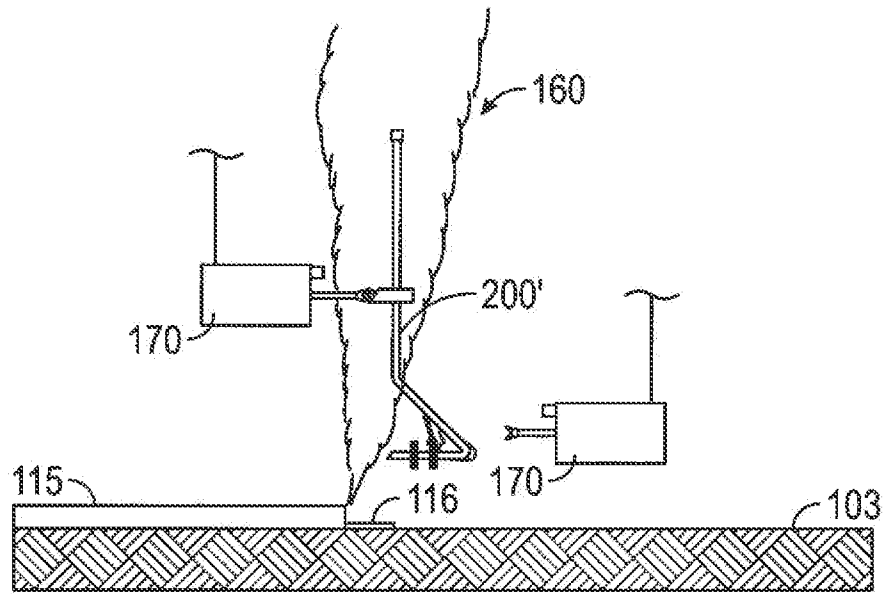


FIG. 13C

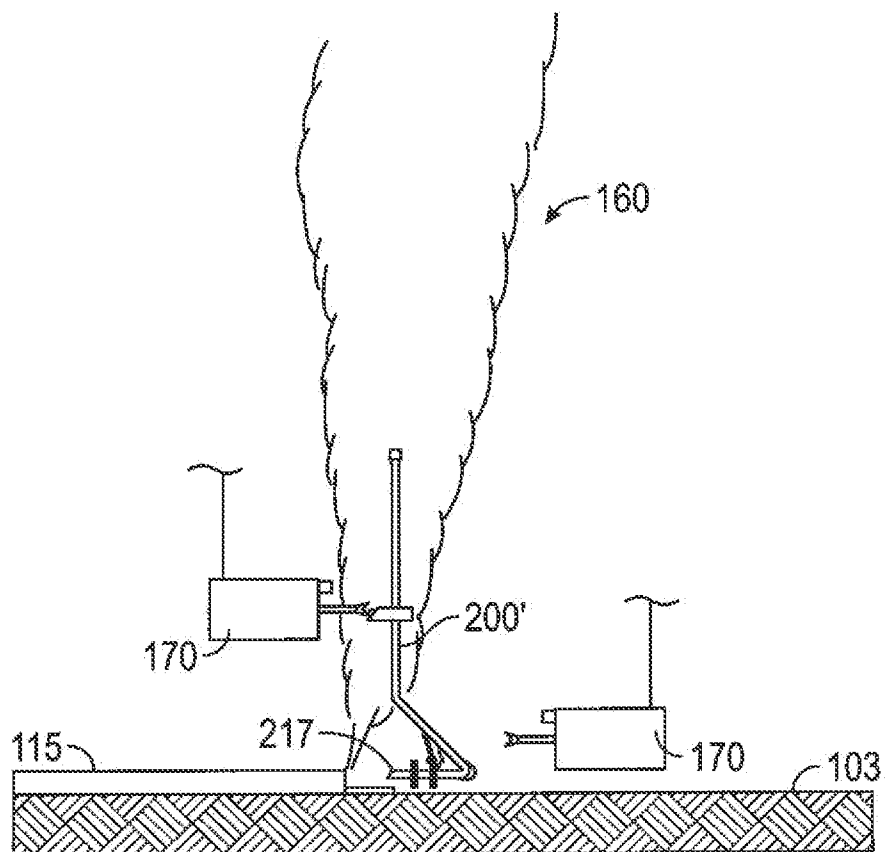


FIG. 13D

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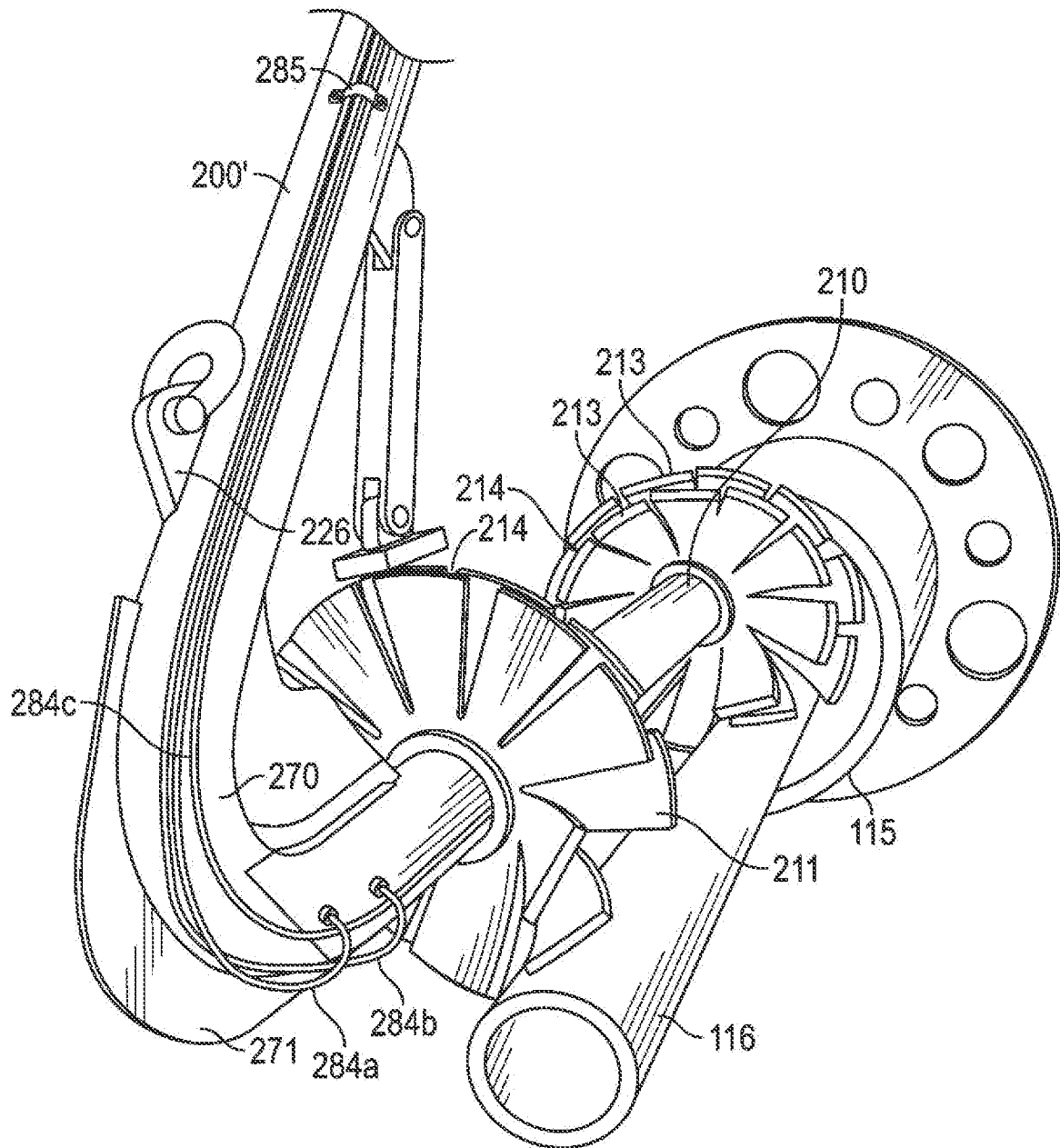


FIG. 13E

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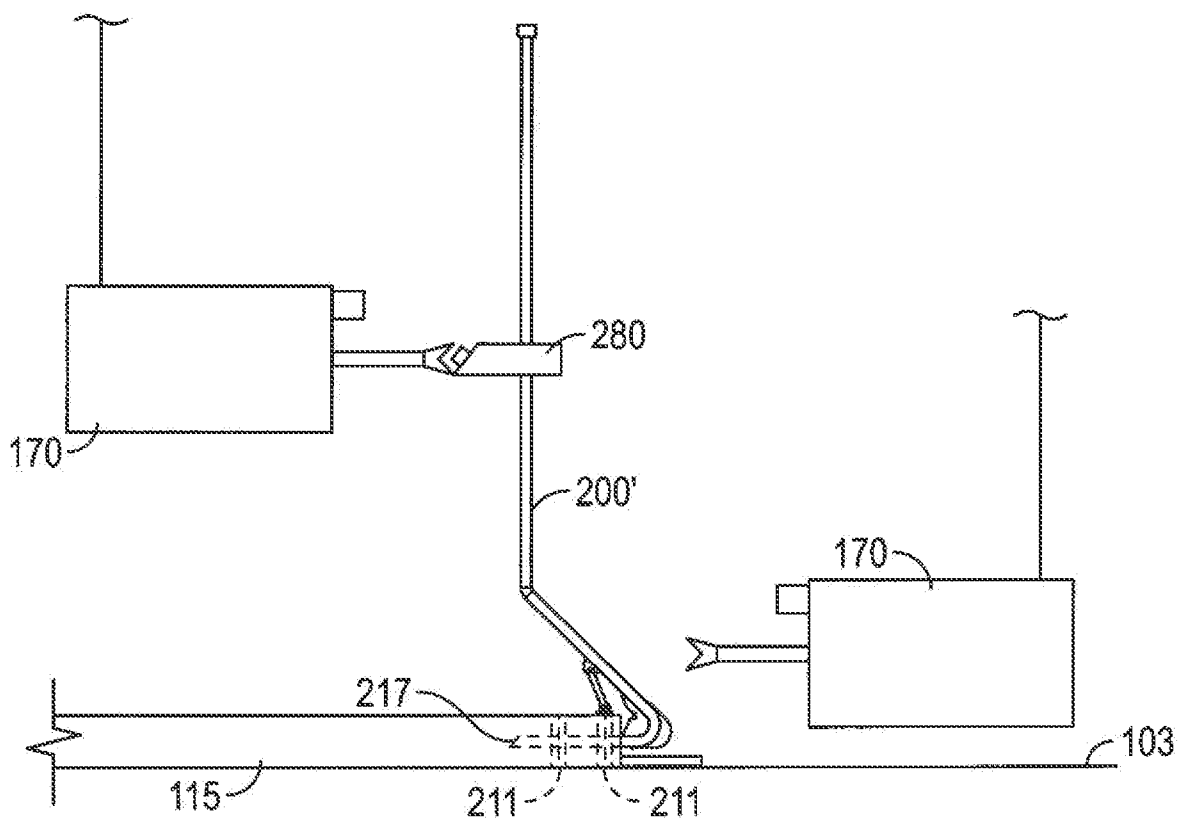


FIG. 13F

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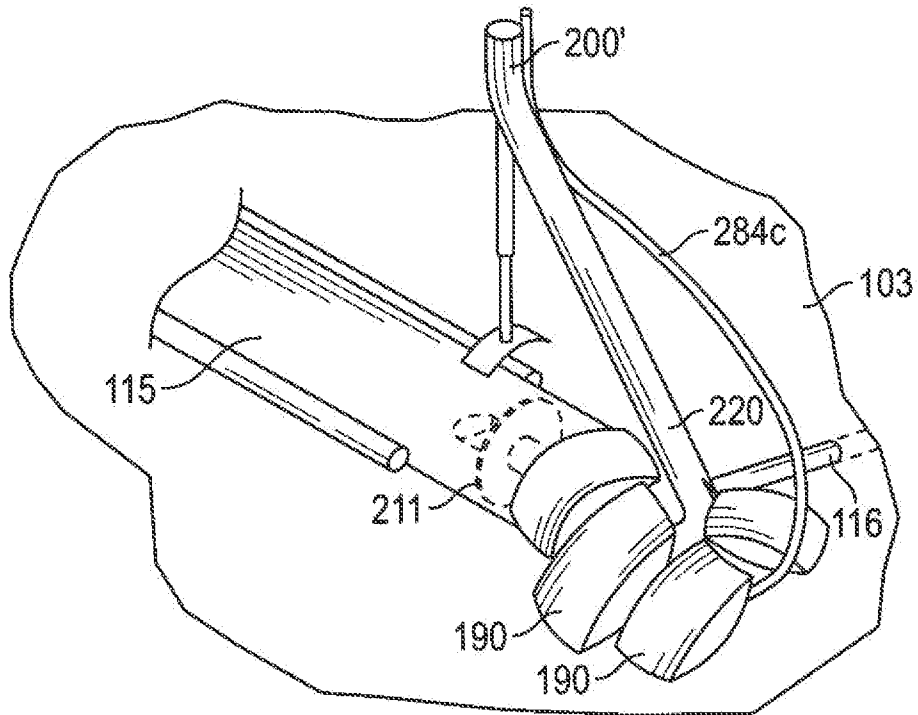


FIG. 13G

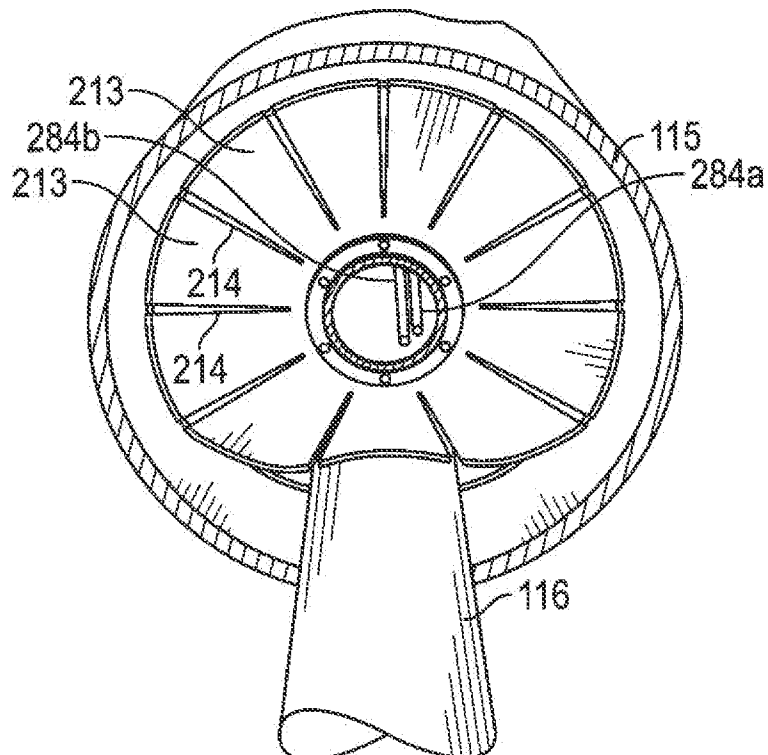


FIG. 13H

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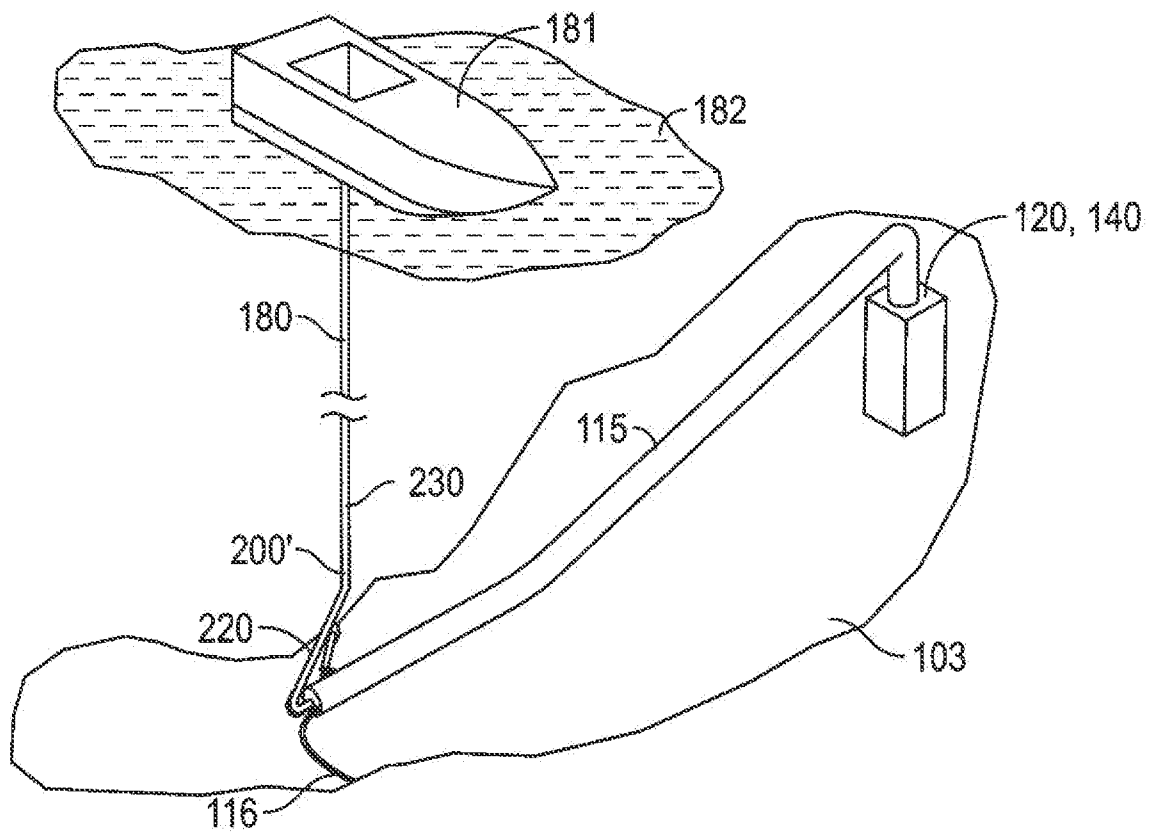


FIG. 13I

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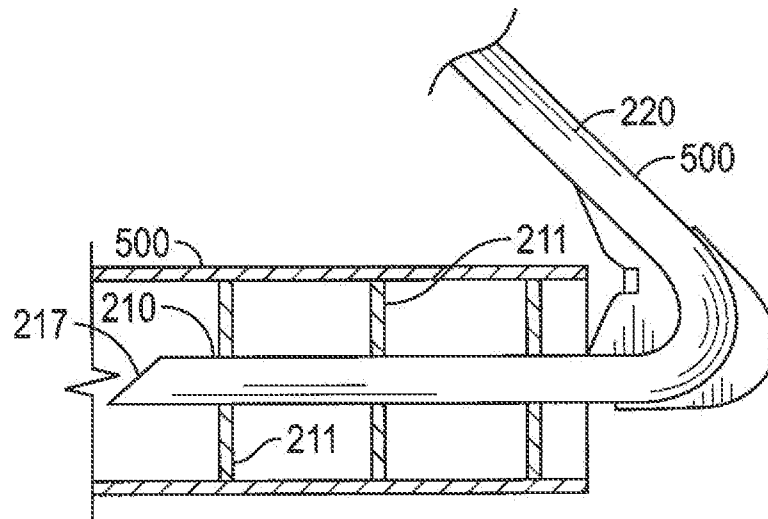


FIG. 14A

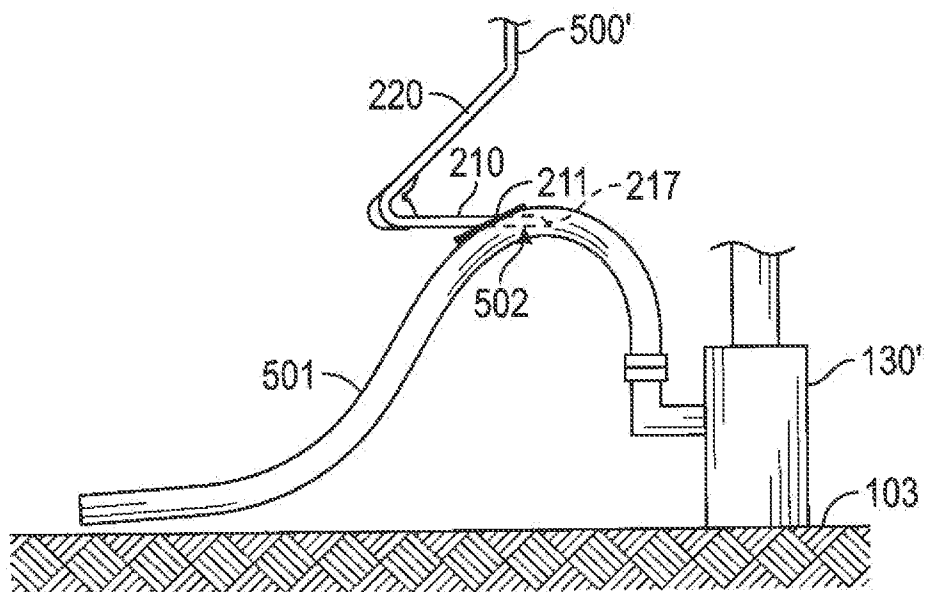


FIG. 14B

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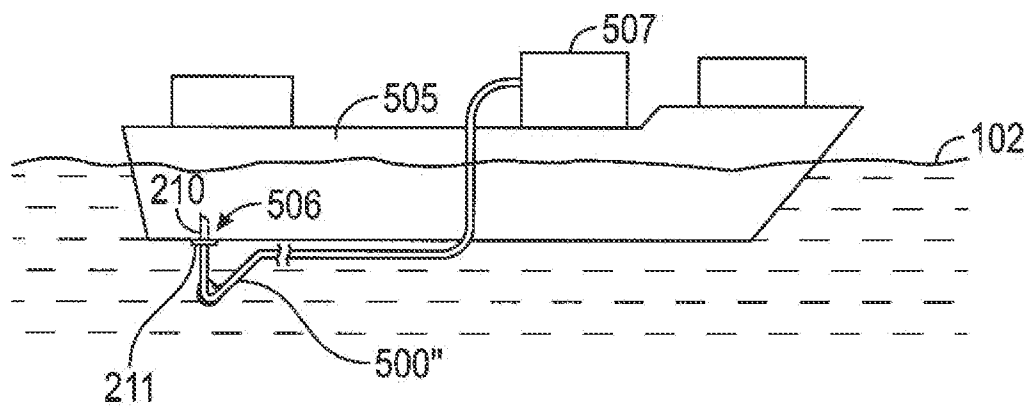


FIG. 14C

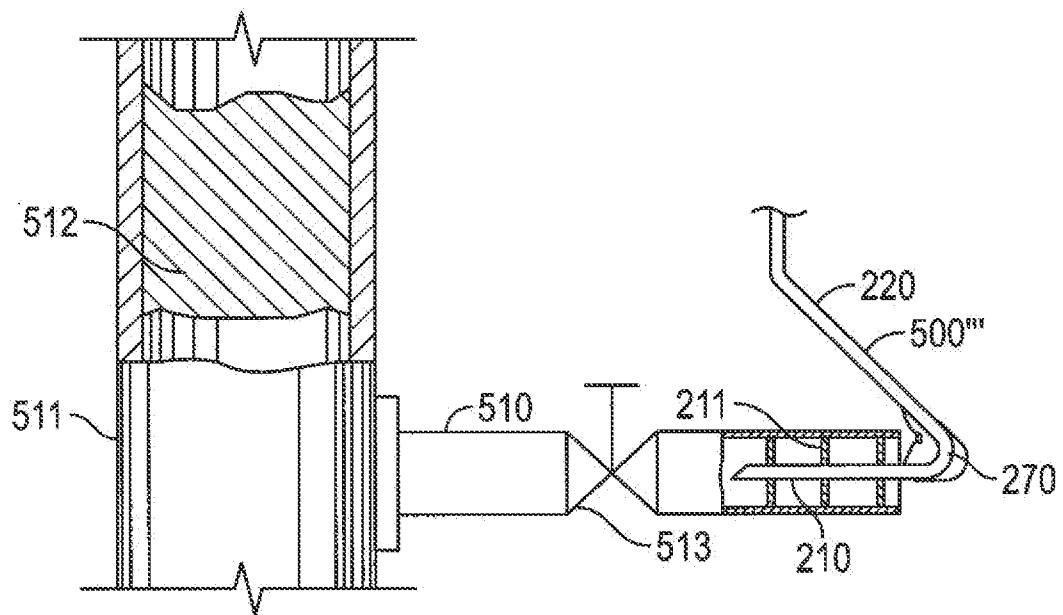


FIG. 14D

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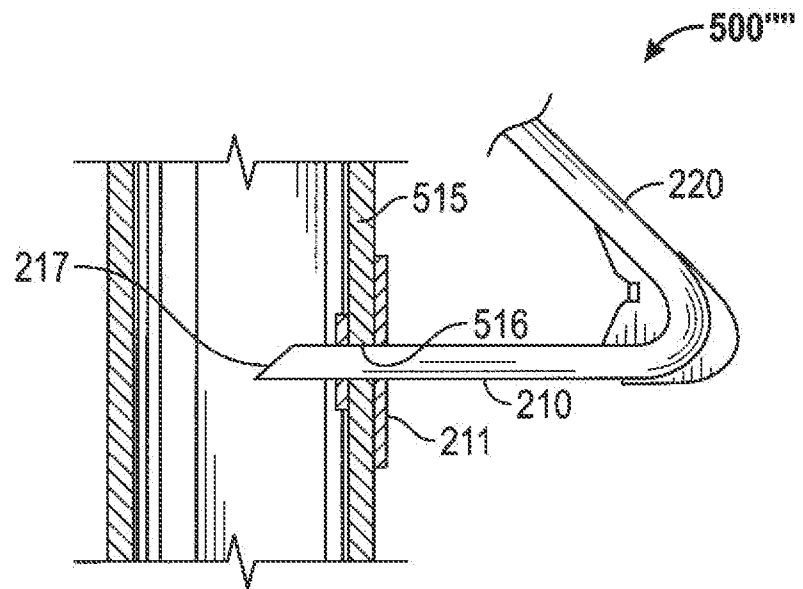


FIG. 14E

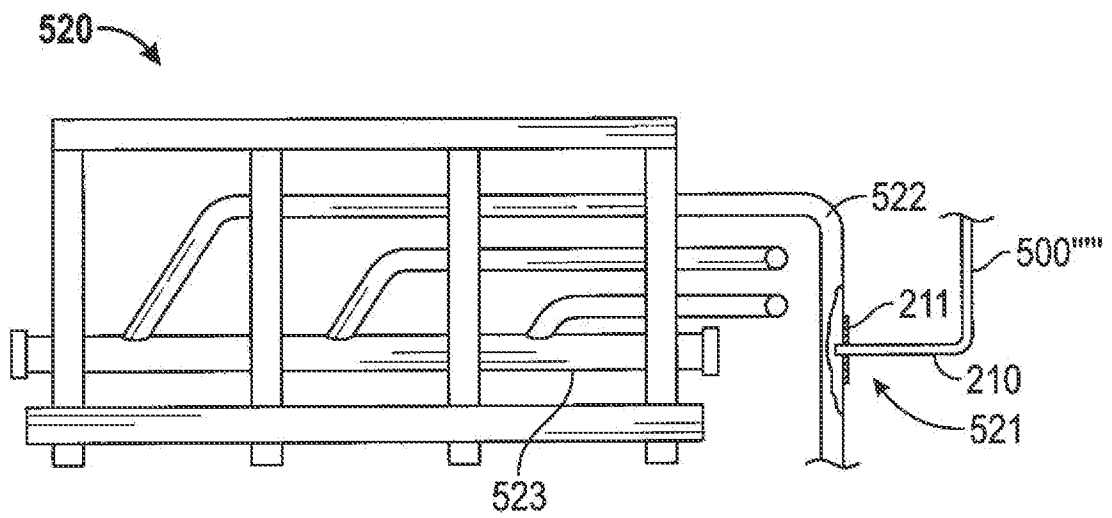


FIG. 14F

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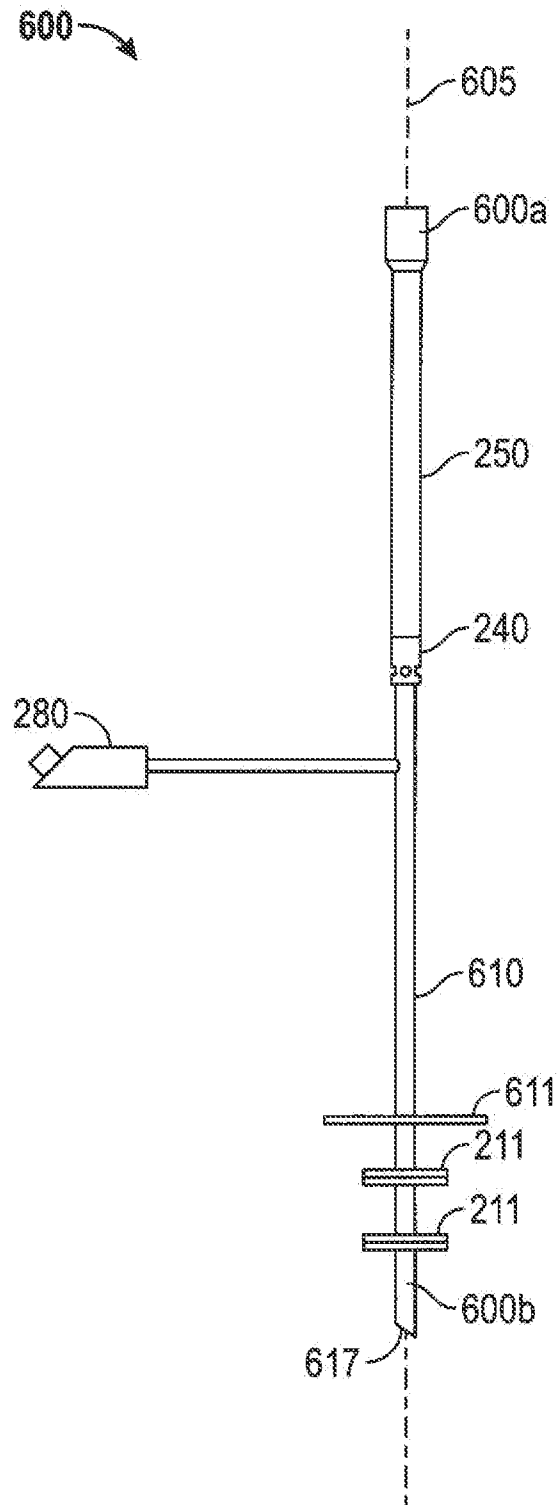


FIG. 15

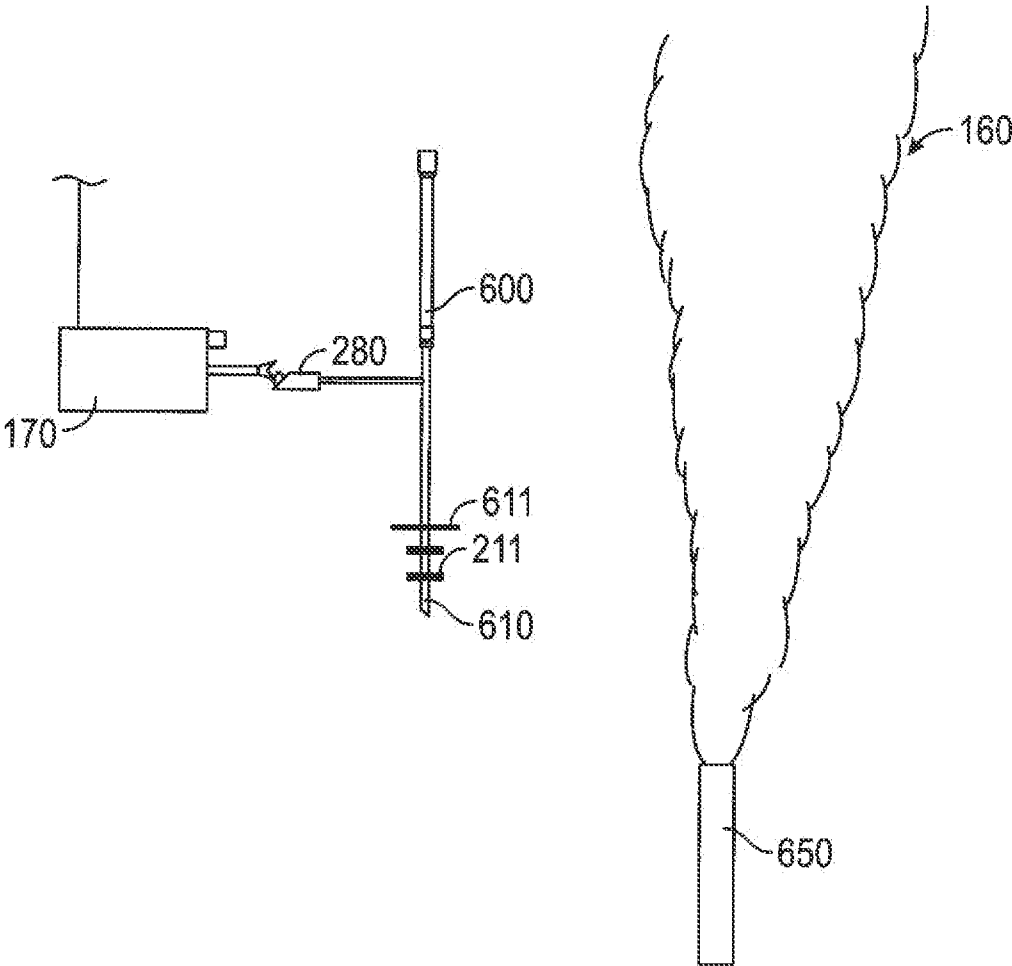


FIG. 16A

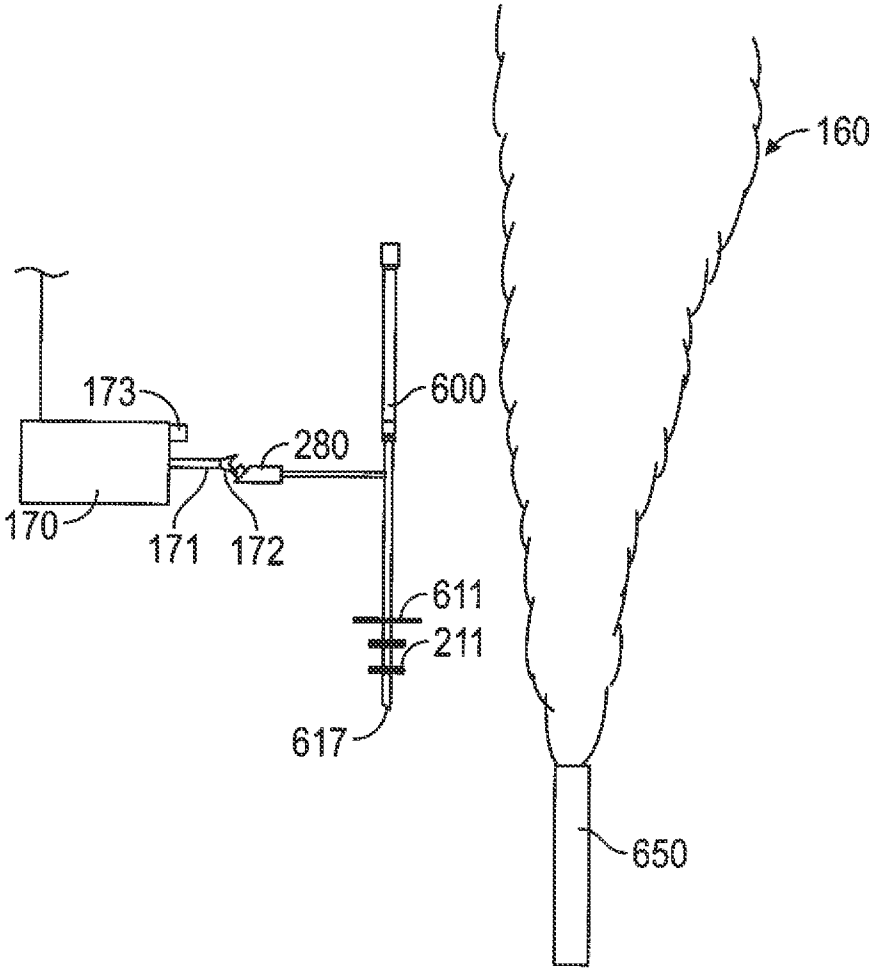


FIG. 16B

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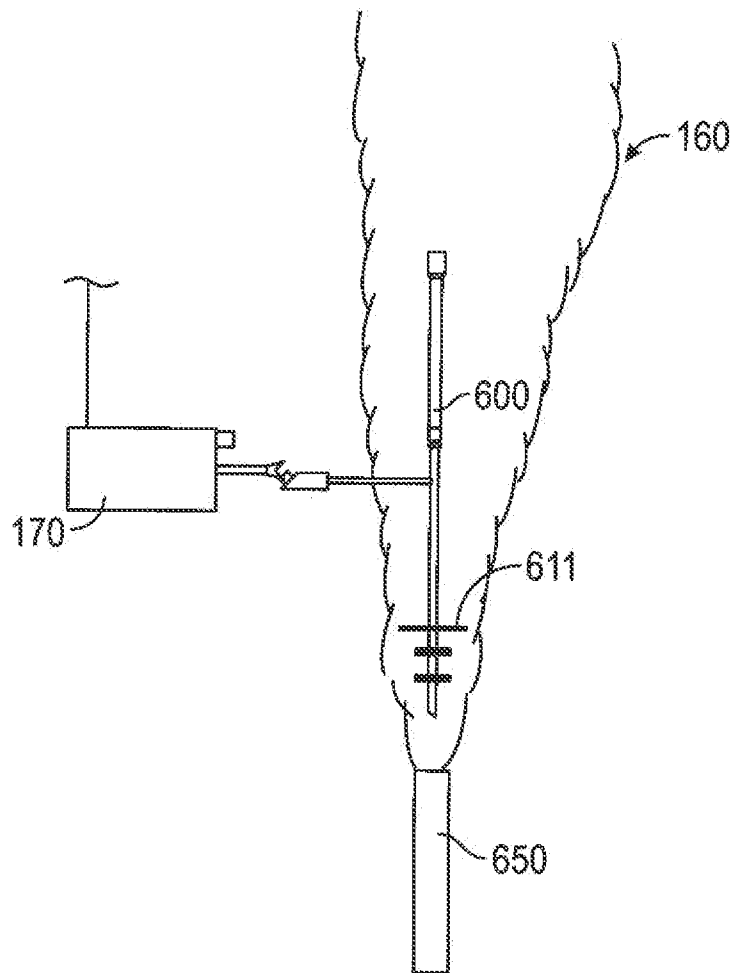


FIG. 16C

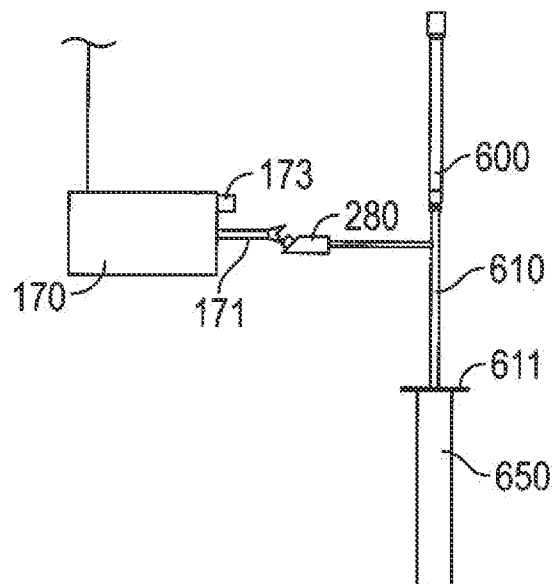


FIG. 16D

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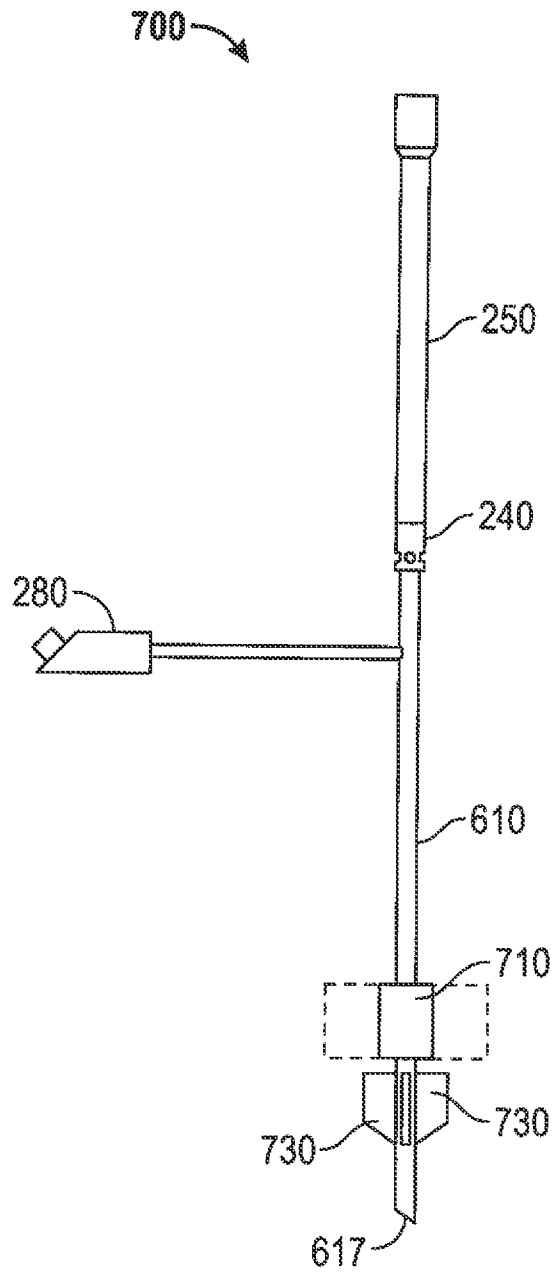


FIG. 17