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(54) Title: SYSTEMS AND METHODS FOR MECHANICAL HYDROCARBON DISPERSION

(57) Abstract: System and method provide a rapid mobilization and deployment technique for effectively mechanically dispersing marine oil spills that either eliminates or reduces the use of chemical dispersants. The disclosed systems and methods work by mechanically generating finely dispersed oil and gas droplets which may improve the dispersion of the hydrocarbons into the water column which can increase the rate of natural degradation of hydrocarbons in the water column.

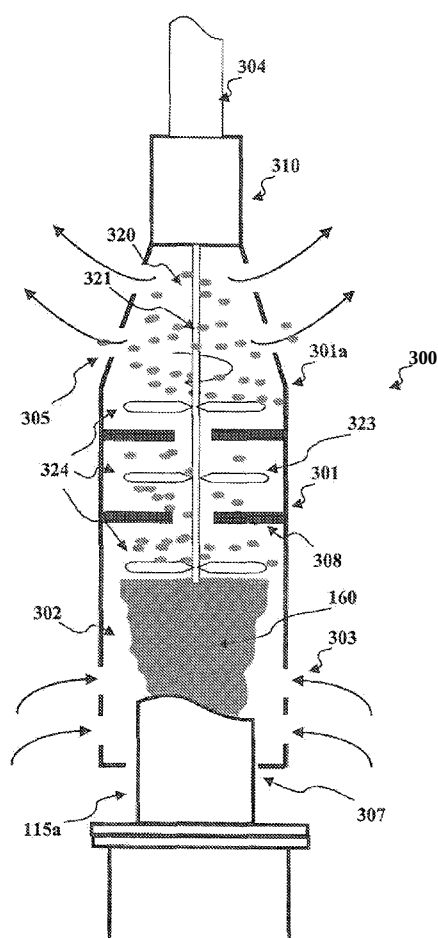


FIG. 3



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SYSTEMS AND METHODS FOR MECHANICAL HYDROCARBON DISPERSIONCross-Reference to Related Applications

[0001] This application claims priority to U.S. Provisional Application No. 61/578,507 filed December 21, 2012, the disclosure of which is incorporated by reference herein in its entirety.

Technical Field

[0002] This disclosure relates generally to the field of the exploration and production of hydrocarbons. More specifically, the disclosure relates to a method and system of dispersing hydrocarbons.

Background

[0003] In offshore drilling and production operations, for example, in the event of a blowout, hydrocarbons may be discharged or vented into the surrounding sea water. Chemical dispersing agents, or simply dispersants, are specially formulated chemical products containing surface-active agents and a solvent. Dispersants aid in breaking up hydrocarbon solids and liquids by reducing the interfacial tension between the oil and water, thereby promoting the migration of finely dispersed water-soluble micelles that are rapidly diluted. As a result, the hydrocarbons are effectively spread throughout a larger volume of water, and the environmental impact may be reduced. In addition, dispersants can facilitate and accelerate the digestion of hydrocarbons by microbes, protozoa, nematodes, and bacteria. Moreover, the use of dispersants can reduce the risk to responders at the surface by minimizing the accumulation of oil, associated volatile organic compounds (VOCs) and hydrocarbon vapors at the surface. Dispersants can also delay the formation of persistent oil-in-water emulsions.

[0004] Traditionally, dispersants have been sprayed onto the oil at the surface of the water. Normally, this process is controlled and delivered from surface vessels or from the air immediately above the oil at the surface. For example, aircraft can be employed to spray oil dispersant over an oil slick on the surface of the sea. For some types of chemical dispersants, the perceived chemical nature of the dispersant itself can present an additional environmental concern. Thus, minimizing the quantity and distribution of dispersants is generally preferred. However, since oil released from a subsea well diffuses and spreads out as it rises to the surface, oil at the surface is often spread out over a relatively large area (e.g., hundreds or thousands of square miles). To sufficiently cover all or substantially all of the oil that reaches the surface, relatively large quantities of dispersant must be distributed over the relatively large area encompassed by the oil slick.

[0005] To minimize "overspray" and limit the application of dispersants to the oil slick itself, distribution at the surface typically involves the visualization of the oil slick at the surface. Accordingly, around the clock surface distribution may not be possible (e.g., at night the location and boundaries of the oil slick at the surface may not be visible). However, there is usually a limited time-frame in which dispersants can be successfully applied at the surface. In particular, certain oil constituents evaporate quickly at the surface, leaving a waxy residue or "weathered" oil that is often unresponsive to dispersants.

[0006] Additionally, some turbulence at the surface (e.g., wave action) is preferred during surface application of dispersants to sufficiently mix the dispersant into the oil and the treated oil into the water. Depending on the weather and sea conditions, surface turbulence may be less than adequate. Moreover, by limiting distribution of dispersants to the surface, only those microbes at or proximal the surface have an opportunity to begin digestion of the oil.

[0007] Chemical dispersants have been applied subsea directly to the source of the leak. However the volume of chemicals required, typically 1% - 2% vol:vol of the leaking oil quantity, and the lead time required to manufacture sufficient inventory and establish a robust supply chain increases the response and reaction time to these unpredictable events. Consequently, there is a need for systems and methods of dispersing hydrocarbons subsea that do not exclusively rely on chemical dispersants.

SUMMARY

[0008] implementations of the present disclosure concern systems and methods that provide a rapid mobilization and deployment technique for effectively mechanically dispersing marine oil spills, which can either eliminate or reduce the use of chemical dispersants. The disclosed systems and methods work by mechanically generating finely dispersed oil and gas droplets which may improve the dispersion of the hydrocarbons into the water column which can increase the rate of natural degradation of hydrocarbons in the water column. Dispersing the oil into the water column also can reduce the risk to responders at the surface by minimizing the accumulation of oil, associated volatile organic compounds (VOCs) and hydrocarbon vapors and can possibly reduce threats of impact to sensitive shoreline habitats and wildlife and increasing the rate of natural degradation of hydrocarbons in the water column. The disclosed methods and systems may be applicable to oil liquid hydrocarbon leakages into the environment including releases of crude oil from tankers, offshore platforms, drilling rigs and wells, however its primary benefit likely is for deepwater well blowouts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Various features of the implementations can be more fully appreciated, as the same become better understood with reference to the following detailed description of the implementations when considered in connection with the accompanying figures, in which:

[0010] FIG. 1 illustrates a schematic view of an example of an offshore system, according to various implementations.

[0011] FIG. 2 illustrates a schematic view of an example of a BOP and a flex joint after substantial removal of the riser after a subsea blowout, according to various implementations.

[0012] FIG. 3 illustrates a cross-sectional view of an example of a mechanical dispersion device, according to various implementations.

[0013] FIGS. 4A and 4B illustrate a cross-sectional view and a bottom view of another example of a mechanical dispersion device using a rotor-stator mixer, according to various implementations.

[0014] FIG. 5A illustrates a cross-sectional view of an example of a mechanical dispersion device using a jet-pump concept, according to various implementations.

[0015] FIG. 5B illustrates a cross-sectional view of an example of a mechanical dispersion device using a carburetor-venturi concept, according to various implementations.

[0016] FIGS. 6A, 6B, and 6C illustrate cross-sectional views of another example of a mechanical dispersion device, according to various implementations.

[0017] FIG. 7A illustrates an example of a deployment of a mechanical dispersion device being installed on a subsea connection, according to various implementations.

[0018] FIG. 7B illustrates a cross-sectional view of an example of a mechanical dispersion device installed on a subsea connection, according to various implementations.

DETAILED DESCRIPTION

[0019] For simplicity and illustrative purposes, the principles of the present teachings are described by referring mainly to examples of various implementations thereof. However, one of ordinary skill in the art would readily recognize that the same principles are equally applicable to, and can be implemented in, all types of information and systems, and that any such variations do not depart from the true spirit and scope of the present teachings. Moreover, in the following detailed description, references are made to the accompanying figures, which illustrate specific examples of various implementations. Electrical, mechanical, logical and structural changes can be made to the examples of the various implementations without departing from the spirit and scope of the present teachings. The following detailed description is, therefore, not to be taken in a limiting sense and the scope of the present teachings is defined by the appended claims and their equivalents,

[0020] 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.

[0021] As used herein, the term "ROV" refers to remotely operated vehicle. Each ROV may include arms having a claw, a subsea camera for viewing the subsea operations (e.g., the relative positions of subsea tools or devices such as the mechanical dispersion

devices described below), and an umbilical. Streaming video and/or images from cameras are communicated to the surface or other remote location via umbilical for viewing on a live or periodic basis. Arms and claws may be controlled via commands sent from the surface or other remote location to the ROV through the umbilical.

[0022] As used herein, the phrase "mechanical dispersion" or "mechanically dispersed" refers to a dispersion or the formation of a dispersion or mixture without the use of chemical agents or compositions.

[0023] FIG. 1 illustrates an example of an offshore system 100 for drilling and/or producing a wellbore 101, according to various implementations. While FIG. 1 illustrates various components contained in the offshore system 100, FIG. 1 is one example of an offshore system and additional components can be added and existing components can be removed.

[0024] As illustrated, the offshore system 100 can include an offshore platform 110 that is located at the sea surface 102. The offshore system 100 can include a subsea blowout preventer (BOP) 120 that is mounted to a wellhead 130 at the sea floor 103. The offshore system 100 can include a subsea connection (e.g. a flex joint) 140. The offshore platform 110 can be equipped with a derrick 111 that supports a hoist. A drilling riser 115 can extend from the platform 110 to the subsea riser connection 140. The riser 115 can be a large-diameter pipe that connects the subsea riser connection 140 to the offshore platform 110. During drilling operations, the riser 115 can take mud returns to the offshore platform 110.

[0025] The BOP 120 can be configured to controllably seal and contain hydrocarbon fluids therein. The BOP 120 can include a plurality of axially stacked sets of opposed rams - opposed blind shear rams or blades 127 for severing a tubular string and sealing off wellbore from the riser 115. The BOP 120 can also include opposed blind rams 128 for sealing off wellbore when no string or tubular extends through main bore 124. The BOP 120 can

include opposed pipe rams 129 for engaging a string and sealing the annulus around a tubular string. Each set of the rams 127, 128, 129 can be equipped with sealing members that engage to prohibit flow through the annulus when rams 127, 128, 129 are closed.

[0026] In implementations, the subsea riser connection 140 can include a riser flex joint 143 that allows the riser 115 to deflect angularly relative to the BOP 120 and the subsea riser connection 140 while hydrocarbon fluids flow from the wellhead 130 and the BOP 120 into the riser 115. The flex joint 143 can include a cylindrical base 144 that is rigidly secured to the BOP 120. The flex joint 143 can also include a riser extension or adapter 145 extending upward from the base 144. A flex element can be disposed within the base 144 that extends between the base 144 and the riser adapter 145. The flex element can sealingly engage both the base 144 and the riser adapter 145. The flex element can allow the riser adapter 145 to pivot and angularly deflect relative to the base 144, the subsea riser connection 140, and the BOP 120. The upper end of the adapter 145 distal the base 144 can include an annular flange 145a. The annular flange 145a can couple the riser adapter 145 to a mating lower riser flange 118 at the lower end of the riser 115 or to alternative devices. Although the subsea connection 140 has been shown and described as being a particular flex joint 143, in general, any suitable riser connection can be employed.

[0027] In some situations, the offshore system 100 can begin leaking hydrocarbon into the environment around the offshore system 100. FIG. 2 illustrates an example of leaking hydrocarbon during a blowout, according to various implementations. While FIG. 2 illustrates one example of a leaking situation in the offshore system 100, the methods and system described herein can be applied to any type of leaking situation in the offshore system 100.

[0028] As illustrated in FIG. 2, during a "kick" or surge of formation fluid pressure in the wellbore, one or more the rams 127, 128, 129 of the BOP 120 and/or the subsea riser

connection 140 can be actuated to seal in the wellbore. In some cases, the rams 127, 128, 129 may not seal off the wellbore, resulting in a blowout. Such a blowout can damage the BOP 120, the subsea riser connection 140, the riser 115, the offshore platform 110, or combinations thereof. Damage to the BOP 120, the subsea riser connection 140, or the riser 115 can compromise the ability to contain the hydrocarbon fluids therein, potentially resulting in the discharge of the hydrocarbon fluids into subsea. The example of the blowout, illustrated in FIG. 2, can be due to failure or malfunction of the rams 127, 128, 129. In example, the BOP 120 has failed and upper portion of the riser 115 has been removed forming severed riser 115a. As a result, hydrocarbon fluids pass through the BOP 120 and the subsea riser connection 140, and are discharged into the surrounding sea water. The emitted hydrocarbon fluids form a subsea hydrocarbon plume 160.

[0029] In implementations, a mechanical dispersion device can be utilized to disperse the subsea hydrocarbon plume 160. FIG. 3 illustrates an example of a mechanical dispersion device 300, which is installed over the severed riser 115a, according to various implementations. While FIG. 3 illustrates various components contained in the mechanical dispersion device 300, FIG. 3 is one example of a mechanical dispersion device and additional components can be added and existing components can be removed,

[0030] As illustrated in FIG. 3, the mechanical dispersion device 300 can include a body 301, a motor 310, and an impeller 320. The body 301 can include inlets 303 through which water enters dispersing chamber 302. The body 301 can include outlets 305 through which a hydrocarbon dispersion or emulsion can exit the dispersing chamber 302. The body 301 can be constructed in any suitable geometry such as without limitation, cylindrical, cubical, frustoconical, or the like. Furthermore, the body 301 can also have an opening 307 through which a flexjoint, subsea connection, or riser can be inserted. In other words, the opening 307 can be adapted or configured to fit over an existing subsea connection or tubular,

such as the severed riser 115a, or to fit over a hydrocarbon leak coming directly through the sea floor.

[0031] The body 301 can include an upper section 301a where the outlets 305 can be disposed, in the example illustrated in FIG. 3, the upper section 301a can be tapered. The upper section 301a can also be configured in any suitable geometry. In the example illustrated in FIG. 3, the body 301 via the motor 310 can be coupled to a riser 304 which can be coupled to a surface vessel. The riser 304 can be any tubular or device to connect the mechanical dispersion device 300 with surface. The riser 304 can provide a conduit for power, whether electrical or hydraulic, to mechanical dispersion device 300.

[0032] The inlets 303 and the outlets 305 can be of any shape and/or size. In some implementations, the inlets 303 and the outlets 305 can have the same shape and size. In some implementations, the inlets 303 and the outlets 305 can have different shapes and/or sizes one another. Likewise, each inlet 303 can be the same or different shape and/or size from one another and each outlet 305 can be the same or different shape and/or size from one another. The mechanical dispersion device 300 can include any number of the inlets 303 and the outlets 305 disposed along the body 301. In some implementations, the outlets 305 can be disposed proximate to the motor 310 or on the upper section 301a, The inlets 303 and the outlets 305 can be disposed in any configuration or position along body 301, In addition, the inlets 303 and the outlets 305 can be adjustable remotely from the surface or locally with remotely operated vehicle (ROV).

[0033]: The motor 310 can be disposed proximate the outlets 305. For example, the motor 310 can be any suitable device which is capable of driving or rotating the impeller 320 with sufficient force and velocity to generate an emulsion of hydrocarbons into the sea water. In other words, the motor 310 can drive or rotate the Impeller 320 with sufficient force and velocity to generate very small droplets of hydrocarbons or bubbles or hydrate crystals in the

sea water matrix. In implementations, the motor 310 can be an electrical motor, a hydraulic motor, and the like.

[0034] The impeller 320 can have a shaft 321 and a plurality of radial members 323. The radial members 323 can be any propellers, blades, turbines, rotating, contra-rotating or stationary or combinations thereof that are known to those of skill in the art. In particular, the impeller 320 can have more than one set 324 of the radial members 323 disposed along the length of the shaft 321. Each set 324 of the members 323 can have the same or different types of the radial members 323. The dispersion device 300 can also have one or more static members 308 which extend radially into the chamber 302. The static members 308 can be interleaved or overlapping with the radial members 323 of the impeller 320. The static members 308 can be of the same shape and size as the radial members 323 or different.

[0035] The impeller 320 can have several functions, although not necessarily limited to these that will be described. The first function can be to suck or force water through the inlets 303 and/or the opening 307 into the chamber 302. Simultaneously or near simultaneously, the second function of the impeller 320 can be to agitate, disperse and/or mix the hydrocarbons 160 that are being emitted from the severed riser 115a such that either a hydrocarbon/water dispersion or emulsion is formed. The impeller 320 can also serve to drive the dispersion and/or emulsion through the outlets 305 into the surrounding water.

[0036] In some implementations, the mechanical dispersion device 300 can include just the impeller 320 and the motor 310 without the body 301. That is, the mechanical dispersion device 300 can comprise the impeller 320 or any other type of agitator known to those skilled in the art and any type of motor to rotate the impeller 320.

[0037] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants can be injected into dispersing chamber of the mechanical dispersion

device 300. In this example, one or more injectors can be located along the interior of the body 301 in the dispersing chamber 302. The injectors can be positioned within and/or outside the mechanical dispersion device to allow the chemical dispersants to be introduced to the hydrocarbon/water mixture. Any chemical dispersants known to those of skill in the art can be used.

[0038] In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the mechanical dispersion devices described above. One or more injectors can be positioned within or around the mechanical dispersion device 300 to deliver hydrate prevention chemicals at any location hydrocarbons can collect. For example, one or more injectors can be positioned in the opening 307, the inlets 303 and the outlets 305. The introduction of the hydrate prevention chemicals can be continuous or intermittent. The hydrate prevention chemicals can include nitrogen and or other hydrate preventions chemicals such as without limitation, methanol.

[0039] In operation of the mechanical dispersion device 300 illustrated in FIG. 3, the mechanical dispersion device 300 can be installed over hydrocarbon plume 160 and the severed riser 115a as will be described in more detail below. The impeller 320 is driven by motor 310 at a rotational speed. The impeller 320 can be driven at rotational speeds ranging from about 1000 rpm to about 4000 rpm, alternatively from about 500 rpm to about 2000 rpm. More particularly, the impeller 320 can be rotated at a tip speed ranging from about 10 m/s to about 30 m/s. Likewise, the impeller 320 can be rotated at any suitable rotational speed. As the impeller 320 is rotated, the impeller 320 can suck hydrocarbons from the hydrocarbon plume 160 emerging from the severed riser 115a into the chamber 302. The concentrated hydrocarbons are cut and sheared into droplets by the rapid rotation of the radial members 323 of the impeller 320 to form a dispersion of hydrocarbons and water. The static

members 307 can also contribute to the shearing and dispersion effect. The hydrocarbon and water dispersion may then be emitted from one or more of the outlets 305 into the environment. Due to the droplet size caused by the mechanical agitation, the mechanically dispersed hydrocarbons may be less likely to reach the surface, thereby reducing the chance of hydrocarbon field (e.g. oil slick) forming on the surface.

[0040] FIGS. 4A and 4B illustrate another example of a mechanical dispersion device 400, which is installed over the severed riser 115a, according to various implementations. While FIGS. 4A and 4B illustrate various components contained in the mechanical dispersion device 400, FIGS. 4A and 4B illustrate one example of a mechanical dispersion device and additional components can be added and existing components can be removed.

[0041] As illustrated in FIG. 4A, the mechanical dispersion device 400 can utilize a rotor stator type mixer. This type of mixer can also be referred to as a high shear mixer. Instead of the impeller 320, as shown in FIG. 3, the mechanical dispersion device 400 can utilize a rotor 402. As illustrated in FIG. 4B, the rotor 402 can have a plurality of slots or openings 404. The rotor 402 can also include blades or teeth optimally configured to shear hydrocarbons. The rotor 402 can have any configuration known to those of skill in the art. In particular, the rotor 402 can be rotatably disposed within stationary stator or body 406. The stator can also have a plurality of slots or openings 408. In operation, the rotor 402 rotates within stator 406 at a speed suitable to shear hydrocarbons. The shearing effect emulsifies and/or disperses the hydrocarbons, which can pass through the opening 408 into the surrounding environment.

[0042] The rotor 402 can be driven by a motor 410. The motor 410 can be coupled to the rotor 402 by a drive shaft 412. The drive shaft 412 can be disposed within a housing 414. The housing 414 can be coupled to the stator 406. The mechanical dispersion device

400 can be coupled to a riser 416. The riser 416 can be any tubular or device to connect the mechanical dispersion device 400 with surface. The riser 416 can provide a conduit for power, whether electrical or hydraulic, to mechanical dispersion device 400.

[0043] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants can be injected into mixing area of the mechanical dispersion device 400. In this example, one or more injectors can be located along the interior or exterior of the rotor 402 and/or the stator 406. The injectors can be positioned within and/or outside the mechanical dispersion device to allow the chemical dispersants to be introduced to the hydrocarbon/water mixture. Any chemical dispersants known to those of skill in the art can be used.

[0044] In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the mechanical dispersion devices described above. One or more injectors can be positioned within or around the mechanical dispersion device 400 to deliver hydrate prevention chemicals at any location hydrocarbons can collect. For example, one or more injectors can be positioned on the interior or exterior of the rotor 402 and/or the stator 406. The introduction of the hydrate prevention chemicals can be continuous or intermittent. The hydrate prevention chemicals can include nitrogen and or other hydrate preventions chemicals such as without limitation, methanol.

[0045] FIGS. 5A and 5B illustrate another example of a mechanical dispersion device 500, which installed over the severed riser 115a, according to various implementations. While FIGS. 5A and 5B illustrate various components contained in the mechanical dispersion device 500, FIGS. 5A and 5B illustrate one example of a mechanical

dispersion device and additional components can be added and existing components can be removed.

[0046] The mechanical dispersion device 500 can be configured utilizing pumping concepts in order to disperse the hydrocarbon. As illustrated in FIG. 5A, in some implementations, the **mechanical** dispersion device 500 can utilize a jet pump or **eductor-type** mechanism. As illustrated in FIG. 5B, in some implementations, the mechanical dispersion device can utilized a carburetor-venturi concept. In particular, the mechanical dispersion device 500 can include a housing 501, a water injection nozzle 510, a mixing chamber 503, a hydrocarbon inlet 502, a throat inlet 530, a throat portion 535, a throat outlet 537, and a device outlet 540. The water injection nozzle 510 can have a convergent geometry. That is, an inlet 510a can have a larger cross-sectional area than an outlet 510b of the injection nozzle 510. The mixing chamber 503 can be disposed in between the water injection nozzle 510 and the throat inlet 530. The hydrocarbon inlet 502 can be in fluid communication with the mixing chamber 503. As shown in FIG. 5A, the hydrocarbon inlet 502 can have a divergent geometry much like a funnel. Likewise, the hydrocarbon inlet 502 can have any suitable configuration or geometry. In addition, the hydrocarbon inlet 502 can be configured or adapted to couple with the severed riser 115a or other subsea conduit or device. Furthermore, the water injection nozzle 510 can be in fluid communication with the mixing chamber 503. The mixing chamber 503 can also be in fluid communication with throat inlet 530.

[0047] Further, as illustrated in FIG. 5A, the throat inlet 530 can have a convergent geometry such that its cross-sectional area decreases as it couples with the throat portion 535. In other words, the throat inlet 530 can be a nozzle. The throat outlet 537 can in fluid communication with the throat portion 535 and can have a diverging geometry. That is, the cross-sectional area of the outlet 537 can increase. As will be described in more detail below, the convergent-divergent geometry of the throat inlet 530 and the outlet 537 utilizes the

Venturi effect to suck in the hydrocarbons from the hydrocarbon plume 160. In some implementations, as illustrated in FIG. 5B, a device 545 can be shaped like a venturi of a carburetor. The hydrocarbons may be sucked through several restrictions distributed around the circumference of a narrow passage in the venturi.

[0048] In implementations, as illustrated in FIGS. 5A and 5B, the mechanical dispersion device 500 can include one or more dispersion structures 540. The dispersion structures 550 can serve to further break up or disperse the hydrocarbon mixture emitted from throat outlet 537. The dispersion structures 550 can include without limitation dispersion screens, filters, grates or irapeller-like devices. The dispersion structures 550 can be disposed in between the throat outlet 537 and the device outlet 540. As illustrated in FIGS. 5A and 5B, the device outlet 540 can have divergent geometry. Likewise, the device outlet 540 can have any suitable geometry.

[0049] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants can be injected into dispersing chamber of the mechanical dispersion device 500. In this example, one or more injectors can be located along the interior of the housing 50.1 and/or the device outlet 540. The injectors can be positioned within and/or outside the mechanical dispersion device to allow the chemical dispersants to be introduced to the hydrocarbon/water mixture. Any chemical dispersants known to those of skill in the art can be used.

[0050] In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the mechanical dispersion devices described above. One or more injectors can be positioned within or around the mechanical dispersion device 500 to deliver hydrate prevention chemicals at any location hydrocarbons can collect. For example, one or more injectors can

be positioned ~~irs~~ the hydrocarbon inlet 502. The introduction of the hydrate prevention chemicals can be continuous or **intermittent**. The hydrate prevention chemicals can include nitrogen and or other hydrate preventions chemicals such as without limitation, methanol.

[0051] In operation of the mechanical dispersion device 500, water from the surrounding environment can be pumped at high pressure through the housing 501. The mechanical dispersion device can utilize the Venturi effect of a converging-diverging nozzle to convert the pressure energy of a motive fluid, in this case, water, to **velocity energy** which creates a low pressure zone that draws **in** and entrains a suction fluid, the hydrocarbons from the hydrocarbon **plume** 160 emitted from the severed riser 115a. The low pressure zone may be created in the mixing chamber 503 where hydrocarbons can be sucked into the mixing chamber 503 through the hydrocarbon inlet 502. Accordingly, water (e.g. seawater) can be injected through the housing 501 by a pump. Water can be injected at a pressure ranging from 100 psi to about 10,000 psi, alternatively from about 200 psi to about 5000 psi, alternatively from about 500 psi to about 3000 psi. The hydrocarbons and water can be mixed together in the mixing chamber 503 and then enter the throat inlet 530. Due to the convergent geometry of the throat inlet 530, the pressure **of** the hydrocarbon/water mixture can be increased. After passing through the throat portion 535 portion and out the throat outlet 537, the mixed water/hydrocarbon fluid expands at the throat outlet 537 and the velocity is reduced which results in recompressing the mixed water/hydrocarbon **fluid** by converting velocity energy back into pressure energy. The hydrocarbon/water mixture then passes through the dispersion structure 550 causing a dispersion 570 to be formed. The dispersion 570 can then be expelled through the device outlet 540.

[0052] FIGS. 6A, 6B, and 6C illustrate another example of a mechanical dispersion device 600, according to various implementations. While FIGS. 6A, 6B, and 6C illustrate various components contained **in** the mechanical dispersion device 600, FIGS. 6A, 6B, and

6C illustrate one example of a mechanical dispersion device and additional components can be added and existing components can be removed,

[0053] FIG. 6A illustrates the mechanical dispersion device 600 being positioned in proximity to the severed riser 115a, according to various implementations. As illustrated in FIG. 6A, the mechanical dispersion device 600 can include an enclosed body 602, a motor 604, and an impeller 606 that is located in a dispersing chamber 608. The body 602 can include one or more intake hoses 610 through which water and/or hydrocarbons can enter the dispersing chamber 608. The body 602 can include one or more output hoses 612 through which a hydrocarbon dispersion or emulsion can exit the dispersing chamber 602. The body 602 can be constructed in any suitable geometry such as without limitation, cylindrical, cubical, frustoconical, or the like.

[0054] The body 602 can include an upper section 602a where the output hoses 612 can be disposed. In the example illustrated in FIG. 6A, the upper section 602a can be tapered. The upper section 602a can also be configured in any suitable geometry. In the example illustrated in FIG. 6A, the body 602 via the motor 604 can be coupled to a riser 614 which can be coupled to a surface vessel. The riser 614 can be any tubular or device to connect the mechanical dispersion device 600 with surface. The riser 614 can provide a conduit for power, whether electrical or hydraulic, to mechanical dispersion device 600.

[0055] The intake hoses 610 can be coupled to the body 602 by throttling valves 616. The throttling valves 616 can be configured to control the amount of water and/or hydrocarbons that are entering the dispersion chamber 608. As such, the throttling valves 616 can be utilized to control the ratio of hydrocarbons and water within the dispersion chamber 608. The output hoses 612 can be coupled to the body 602 by throttling valves 618. The throttling valves 618 can be configured to control the amount of hydrocarbon dispersion or emulsion that exits the dispersion chamber 608. As such, the throttling valves 618 can be

utilized to control the amount of time the hydrocarbon dispersion or emulsion remains in the dispersion chamber 608. The throttling valves 616 and the throttling valves 618 can be any type of valves that can open and close to control the flow of fluids into and out of the dispersion chamber 608, such as mechanical valves, electro-mechanical valves, hydraulic valves, and the like.

[0056] The intake hoses 610 and the output hoses 612 can be of any shape, length and/or size, in some implementations, the intake hoses 610 and the output hoses 612 can have the same shape, length, and size. In some implementations, the intake hoses 610 and the output hoses 612 can have different shapes, lengths, and/or sizes one another. For example, as illustrated in FIG. 6A, the intake hoses 610 can be of different lengths in order to address multiple hydrocarbon leaks. Likewise, each intake hoses 610 can be the same or different shape, length, and/or size from one another and each the output hose 612 can be the same or different shape and/or size from one another.

[0057] The mechanical dispersion device 600 can include any number of the intake hoses 610 and the output hoses 612 disposed along the body 602. In some implementations, the output hoses 612 can be disposed proximate to the motor 604 or on the upper section 602a. The intake hoses 610 and the output hoses 612 can be disposed in any configuration or position along body 602. In addition, the intake hoses 610 and the output hoses 612 can be adjusted and positioned remotely from the surface or locally with remotely operated vehicle (ROV).

[0058] The motor 604 can be any suitable device which is capable of driving or rotating the impeller 606 with sufficient force and velocity to generate an emulsion of hydrocarbons into the sea water. In other words, the motor 604 can drive or rotate the impeller 606 with sufficient force and velocity to generate very small droplets of

hydrocarbons or bubbles or hydrate crystals in the sea water matrix, In implementations, the motor 604 can be an electrical motor, a hydraulic motor, and the like,

[0059] The impeller 606 can have a shaft and a plurality of radial members 620. The radial members 620 can be any propellers, blades, turbines, rotating, contra-rotating or stationary or combinations thereof that are known to those of skill in the art. In particular, the impeller 606 can have more than one set of the radial members 620 disposed along the length of the shaft. Each set of the radial members 620 can have the same or different types of the radial members 620. The mechanical dispersion device 600 can also have one or more static-members 622 which extend radially into the chamber 608. The static members 622 can be interleaved or overlapping with the radial members 620 of the impeller 606. The static members 622 can be of the same shape and size as the radial members 620 or different,

(0060] The impeller 606 can have several functions, although not necessarily limited to these that will be described. The first function can be to suck or force water through the intake hoses 610 into the dispersion chamber 608. Simultaneously or near simultaneously, the second function of the impeller 606 can be to agitate, disperse and/or mix the hydrocarbons of the hydrocarbon plumes 160 that are being emitted from the severed riser 115a or the BOP 120 such that either a hydrocarbon/water dispersion or emulsion is formed. The impeller 606 can also serve to drive the dispersion and/or emulsion through the output hoses 612 into the surrounding water,

[0061] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants can be injected into dispersing chamber 608 of the mechanical dispersion device 600. In this example, one or more injectors can be located along the interior of the body 602 in the dispersing chamber 608; within or around the throttling valves 618; and/or within or around the output hoses 612. The injectors can be positioned within

and/or outside the mechanical dispersion device to allow the chemical dispersants to be introduced to the hydrocarbon/water mixture. Any chemical dispersants known to those of skill in the art can be used.

[0062] In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the **mechanical** dispersion devices described above. One or more injectors can be positioned within or around the mechanical dispersion device 600 to deliver hydrate prevention chemicals at any location hydrocarbons cars collect. For example, one or more injectors can be positioned within or around the intake hoses 610 and/or within or around the throttling valves 618. The introduction of the hydrate prevention chemicals can be continuous or intermittent. The hydrate prevention chemicals can include nitrogen and or other hydrate preventions chemicals such as without limitation, methanol.

[0063] In operation of the mechanical dispersion device 600 illustrated in FIG. 6A, the mechanical dispersion device 600 can installed near the severed riser 115a as will be described in more detail below. One or more of the intake hoses 610 can then be positioned near the hydrocarbon plumes 160 in order to suck hydrocarbons into the dispersion chamber 608. Likewise, one or more of the intake hoses 610 can be positioned away from the hydrocarbon plumes in order to suck water into the dispersion chamber. The impeller 606 can be driven by motor 310 at a rotational speed. For example, the impeller 606 can be driven at rotational speeds ranging from about 1000 rpm to about 4000 rpm, alternatively from about 500 rpm to about 2000 rpm. More particularly, for example, the impeller 606 can be rotated a tip speed ranging from about 10 m/s to about 30 m/s. Likewise, the impeller 606 can be rotated at any suitable rotational speed. As the impeller 606 is rotated, the impeller 606 can suck hydrocarbons from the hydrocarbon plumes 160 into the dispersion chamber 608. The concentrated hydrocarbons are cut and sheared into droplets by the rapid rotation of

the radial members 620 of the impeller 606 to form a dispersion of hydrocarbons and water. The static members 622 can also contribute to the shearing and dispersion effect. The hydrocarbon and water dispersion may then be emitted from one or more of the output hoses 612 into the environment. Due to the droplet size caused by the mechanical agitation, the mechanically dispersed hydrocarbons may be less likely to reach the surface, thereby reducing the chance of hydrocarbon field (e.g. oil slick) forming on the surface.

[0064] As mentioned above, the mechanical dispersion device 600 can be placed in proximity of the severed riser 115a. FIG. 6B illustrates another example of the mechanical dispersion device 600 being placed on the seafloor near a hydrocarbon plume 160 leaking from the seafloor, according to various implementations. As illustrated, the mechanical dispersion device 600 can be placed on the seafloor. One or more of the intake hoses 610 can be positioned within the proximity of the hydrocarbon plume 160 in order to suck the hydrocarbons into the mechanical dispersion device 600. While FIG. 6B illustrates the mechanical dispersion device 600 being placed on the seafloor, the mechanical dispersion device 600 can be positioned on any structure near the hydrocarbon plume 160.

[0065] In some implementations, as illustrated, a collection device 650 can be positioned over the hydrocarbon plume 160. The collection device 650 can be configured in a concave shape or similar shape to create a hydrocarbon collection area 652. One or more of the intake hoses 610 can be placed within or near the hydrocarbon collection area 652 in order to suck the hydrocarbons into the mechanical dispersion device 600. The collection device 650 can be constructed of any material that is capable of collecting the hydrocarbons in the hydrocarbon collection area 652. For example, the collection device 650 can be formed of fabric, metals, metal alloys, plastic, and the like. As illustrated, the collection device 650 can be shaped in a substantially concave shape. Likewise, the collection device 650 can be formed in an irregular concave shape. For example, the collection device 650 can

be formed in an irregular concave shape that funnels the hydrocarbons towards the hydrocarbon collection area 652.

[0066] The collection device 650 can be coupled to one or more weights 656 by one or more tethers 654. The weights 656 can be configured to rest on the seafloor in order to hold the collection device 650 in position over the hydrocarbon plume 160. The tethers 654 can be any type of device that attaches to the weights 656 such as cables, chains, and the like. While FIG. 6B illustrates the collection device 650 being maintained in position by tethers 654 and weights 656, any type of **coupling** system can be utilized to maintain the position of the collection device 650.

[0067] FIG. 6C illustrates another example of the mechanical dispersion device 600 being utilized with the collection device 650, according to various implementations. As illustrated in this example, the collection device 650 can be placed over the hydrocarbon plume 160 in order to cover or "blanket" the hydrocarbon plume 160. For example, as illustrated, the collection device 650 can be formed of a flexible material, for example, one or more fabrics. In this example, the collection device 650 can be secured in place by the one or more weights 656 being placed on the perimeter of the collection device 650. As the hydrocarbon plume 160 exits the seafloor and contacts the collection device 650, the hydrocarbon collection area 652 can be formed. While FIG. 6C illustrates the collection device 650 can be maintained in position over the hydrocarbon plume 160 by the one or more weights 656, any type of coupling system and/or weighting system can be utilized to maintain the position of the collection device 650.

[0068] In implementations, one or more of the intake hoses 610 can be positioned within or near the hydrocarbon collection area 652 in order to suck the hydrocarbons into the mechanical dispersion device 600. For example, as illustrated, one or more of the intake hoses 610 can be coupled or can pass-through holes or ports in the collection device 650,

Likewise, one or more of the intake hoses 610 can be passed under the perimeter of the collection device 650 in order to be positioned within or near the hydrocarbon collection area 652.

[0069] While the collection device 650 can be a flexible material, for example, one or more fabrics, as illustrated in FIG. 6C, the collection device 650 can be constructed of any material that is capable of collecting the hydrocarbons in the hydrocarbon collection area 652. For example, the collection device 650 can be formed of one or more metals, metal alloys, and/or plastics. In this example, the collection device 650 can be formed in a concave shape, such as a dome, in order to form the hydrocarbon collection area 652. Further, in this example, the collection device 650 can be maintained in position over the hydrocarbon plume 160 by the one or more weights 656, the weight of the collection device 650, and/or any type of coupling system and/or weighting system.

[0070] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants can be injected into dispersing chamber 608 of the mechanical dispersion device 600 and/or the hydrocarbon collection area 652. In this example, one or more injectors can be located along the interior of the body 602 in the dispersing chamber 608; within or around the throttling valves 618; and/or within or around the output hoses 612. The injectors can be positioned within and/or around the collection device 650 to allow the chemical dispersants to be introduced to the hydrocarbon collection area 652. Any chemical dispersants known to those of skill in the art can be used.

[0071] In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the mechanical dispersion devices described above and/or within or around the hydrocarbon collection area 652. One or more injectors can be positioned within or around the mechanical

dispersion device 600 and/or within or around the collection device 650 to deliver hydrate prevention chemicals at any location hydrocarbons can collect. The introduction of the hydrate prevention chemicals can be continuous or intermittent. The hydrate prevention chemicals can include nitrogen and or other hydrate preventions chemicals such as without limitation, methanol.

[0072] In implementations, any of the mechanical dispersion device illustrated in FIGS. 3, 4A, 5A, 5B, 6A, and 6B can be used in combination in order to provide multiple devices to break-up hydrocarbons. For example, the mechanical dispersion device 300 and the mechanical dispersion device 500 can be combined for a synergistic dispersion effect where the water/hydrocarbon mixture coming from the device outlet 540 can be routed by way of a conduit or other means to mechanical dispersion device 300. For instance, the mechanical dispersion device 300 can be coupled directly to the device outlet 540. Likewise, for example, the mechanical dispersion device 400 can be positioned near the device outlet 540 for a synergistic dispersion effect where the water/hydrocarbon mixture coming from the device outlet 540 is further processed by the mechanical dispersion device 400. Further, for example, the mechanical dispersion device 600 and the mechanical dispersion device 500 can be combined for a synergistic dispersion effect where the **water/hydrocarbon** mixture coming from the device outlet 540 can be routed by way of a conduit or other means to mechanical dispersion device 300. For instance, the mechanical dispersion device 600 can be coupled directly to the device outlet 540.

[0073] In implementations, for example as illustrated in FIG. 3, the mechanical dispersion device 300 can be controllably lowered subsea with a riser 304 secured to mechanical dispersion device 300 and extending to a surface vessel. Due to the weight of mechanical dispersion device 300, the riser 304 can be preferably relatively strong (e.g., steel cables) capable of withstanding the anticipated tensile loads. A winch or crane mounted to a

surface vessel can be employed to support and lower the mechanical dispersion device 300 on the riser 304. Although the riser 304 can be employed to position the mechanical dispersion device 300, in other implementations, the mechanical dispersion device 300 can be deployed subsea on a cable, pipe, drill string, and the like.

[0074] FIGS. 7A and 7B illustrate an example of a process by which the mechanical dispersion device 300 can be lowered adjacent or laterally offset to the hydrocarbon plume 160 and the subsea riser connection 140 in order to avoid formation of hydrates. More particularly, using riser 304, the mechanical dispersion device 300 can be lowered subsea under its own weight from a location generally above and laterally offset from the subsea riser connection 140. More specifically, during deployment, the mechanical dispersion device 300 can be positioned outside of plume 160 of hydrocarbon fluids. One or more ROVs 700 can be used to assist in deploying and/or the mechanical dispersion device 300 around hydrocarbon plume 160 and/or subsea riser connection 140,

[0075] As illustrated in FIG. 7B, once the mechanical dispersion device 300 has been lowered adjacent to the hydrocarbon plume 160, the mechanical dispersion device 300 can be moved laterally over the hydrocarbon plume 160 and over the severed riser 115a. The mechanical dispersion device 300 can then be activated to begin dispersion of the hydrocarbon plume 160. Likewise, the mechanical dispersion device 300 can be activated prior to engagement of the mechanical dispersion device 300 with severed riser 115a so as to facilitate suction of hydrocarbons into the mechanical dispersion device 300. The mechanical dispersion device 300 can remain suspended or deployed over the hydrocarbon plume 160 to disperse hydrocarbons until a permanent capping system or collecting device can be deployed.

[0076] In implementations, the deployment of the mechanical dispersion device 400, the mechanical dispersion device 500, and/or the mechanical dispersion device 600 can

substantially mirror that of the mechanical dispersion device 300. In addition, although examples of the mechanical dispersion device and processes have been described with respect to the mechanical dispersion device being positioned with respect to a severed riser 115a, any of the mechanical dispersion devices or combinations of the mechanical dispersion devices can be positioned proximate or adjacent any subsea structure that emits hydrocarbons such as without limitation, a wellhead, a BOP, a sea floor leak, and the like.

[0077] In some implementations, chemical dispersants can be used in conjunction with the examples of the mechanical dispersion devices described above. For example, chemical dispersants may be injected into mixing chamber 503 of the mechanical dispersion device 500. Likewise, chemical dispersants can be the mechanical dispersion device 300 injected into the chamber 302 of the mechanical dispersion device 300. Any chemical dispersants known to those of skill in the art can be used. In some implementations, hydrate prevention measures can be implemented. For example, hydrate prevention chemicals can be introduced into or around any of the mechanical dispersion devices described above. The introduction of the hydrate prevention chemicals can be continuous or intermittent. The hydrate prevention chemicals can include nitrogen and or other hydrate prevention chemicals such as without limitation, methanol.

[0078] While the teachings have been described with reference to examples of the implementations thereof, those skilled in the art will be able to make various modifications to the described implementations without departing from the true spirit and scope. The terms and descriptions used herein are set forth by way of illustration only and are not meant as limitations. In particular, although the method has been described by examples, the steps of the method may be performed in a different order than illustrated or simultaneously.

Furthermore, to the extent that the terms "including", "includes", "having", "has", "with", or variants thereof are used in either the detailed description and the claims, such terms are

intended to be inclusive in a manner **similar** to the term "comprising." As used herein, the terms "one or more of" and "at least one of" with respect to a listing of items such as, for example, A and B, means A alone, B alone, or A and B. Further, unless specified otherwise, the term "set." should be interpreted as "one or more." Those skilled in the art will recognize that these and other variations are possible within the spirit and scope as defined in the following claims and their equivalents.

WHAT IS CLAIMED IS:

1. A method for dispersing hydrocarbons subsea, the method comprising:
positioning a mechanical device proximate a subsea structure, the subsea structure emitting a volume of hydrocarbons; and
mechanically agitating the hydrocarbons with the mechanical device to form a dispersion or an emulsion.
2. The method of claim 1, wherein the mechanical device comprises an impeller.
3. The method of claim 2, the method further comprising rotating the impeller at a rotational speed ranging from about 1000 rpm to about 4000 rpm.
4. The method of claim 1, wherein the mechanical device comprises a jet pump.
5. The method of claim 1, wherein the mechanical device is a carburetor.
6. The method of claim 1, wherein positioning the mechanical device comprises:
positioning the mechanical device adjacent the subsea structure;
moving the mechanical device laterally over the subsea structure; and
guiding the mechanical device into engagement with the subsea structure,
7. The method of claim 6, the method further comprising activating the mechanical device to begin dispersion of the hydrocarbons after guiding the mechanical device into engagement with the subsea structure.

8. The method of claim 1, wherein the subsea structure comprises at least one of a lower marine riser package, a blowout preventer, a flexjoint connection, a riser segment, a subsea connection, a pipeline, a wellhead, and a portion of a seafloor.
9. A system for dispersing hydrocarbons subsea comprising:
 - a body comprising a chamber, one or more inlets, one or more outlets, and an opening configured to fit over a subsea structure;
 - an impeller rotatably disposed within the chamber, the impeller comprising a plurality of radial members; and
 - a motor coupled to the impeller for rotating the impeller.
10. The system of claim 9, wherein the impeller comprises a shaft and wherein the plurality of radial members coupled to the shaft,
11. The system of claim 9, wherein the impeller comprises one or more sets of radial members disposed axially along a shaft.
12. The system of claim 9, wherein the body comprises one or more static members extending radially into the chamber.
13. The system of claim 9, wherein the radial members comprise blades, vanes, helical members, propellers, or combinations thereof.
14. The system of claim 9, wherein the body is cylindrical.

15. The system of claim 9, wherein the subsea structure comprises at least one of a lower marine riser package, a blowout preventer, a flex joint connection, a riser segment, a subsea connection, a pipeline, a wellhead, and a portion of a seafloor.

16. The system of claim 9, further comprising:

a riser coupled to the motor; and

a power source coupled to the motor.

17. A system for dispersing hydrocarbons subsea, comprising:

a housing comprising a hydrocarbon inlet, a water inlet, and an outlet, the hydrocarbon inlet configured to engage with a subsea structure;

a water injection nozzle disposed within the housing;

a throat portion comprising a convergent throat inlet and a divergent throat outlet, the throat portion disposed within the housing; and

a mixing chamber disposed within the housing and in between the water injection nozzle and the throat portion, the mixing chamber in direct fluid communication with the hydrocarbon inlet.

18. The system of claim 17, further comprising one or more dispersion structures disposed within the housing and adjacent to the outlet.

19. The system of claim 18 wherein the dispersion structures comprise screens, filters, grates, impeller-like devices, or combinations thereof.

20. The system of claim 17, wherein the subsea structure comprises at least one of a lower marine riser package, a blowout preventer, a flex joint connection, a riser segment, a subsea connection, a pipeline, a wellhead, and a portion of a seafloor.

21. The system of claim 17, wherein the outlet is divergent.

22. The system of claim 17, further comprising a pump coupled to the housing for injecting water into the housing.

23. A system for dispersing hydrocarbons subsea comprising:
a body comprising a chamber, one or more inlets, one or more outlets, and an opening configured to fit over a subsea structure;
a rotor rotatably disposed within the chamber; and
a motor coupled to the rotor for rotating the rotor.

24. The system of claim 23, wherein the body is cylindrical and the rotor is cylindrical

25. A system for dispersing hydrocarbons subsea comprising:
a body comprising a chamber, one or more intake hoses, and one or more output hoses;
an impeller rotatably disposed within the chamber, the impeller comprising a plurality of radial members; and
a motor coupled to the impeller for rotating the impeller.

26. The system of claim 25, wherein the impeller comprises a shaft and wherein the plurality of radial members coupled to the shaft.

27. The system of claim 25, wherein the impeller comprises one or more sets of radial members disposed axially along the shaft.

28. The system of claim 25, wherein the body comprises one or more static members extending radially into the chamber,

29. The system of claim 25, wherein the radial members comprise blades, vanes, helical members, propellers, or combinations thereof.

30. The system of claim 25, further comprising:
one or more valves disposed between the one or more intake hoses and the chamber;
and
one or more valves disposed between the one or more output hoses and the chamber,

31. The system of claim 25, wherein the subsea structure comprises at least one of a lower marine riser package, a blowout preventer, a flex joint connection, a riser segment, a subsea connection, a pipeline, a wellhead, and a portion of the seafloor,

32. The system of claim 25, further comprising:
a riser coupled to the motor; and
a power source coupled to the motor.

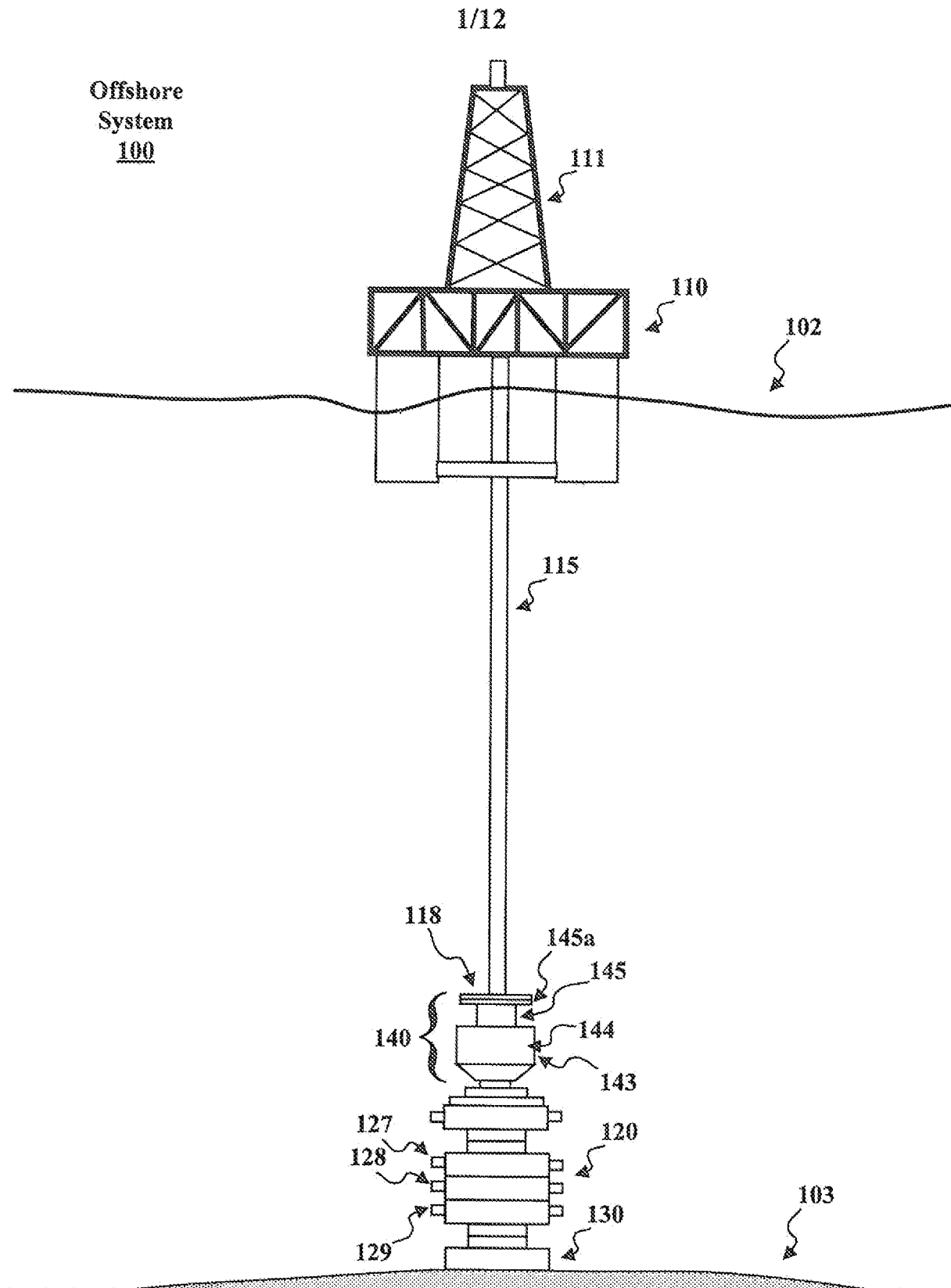


FIG. 1

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Offshore
System
100

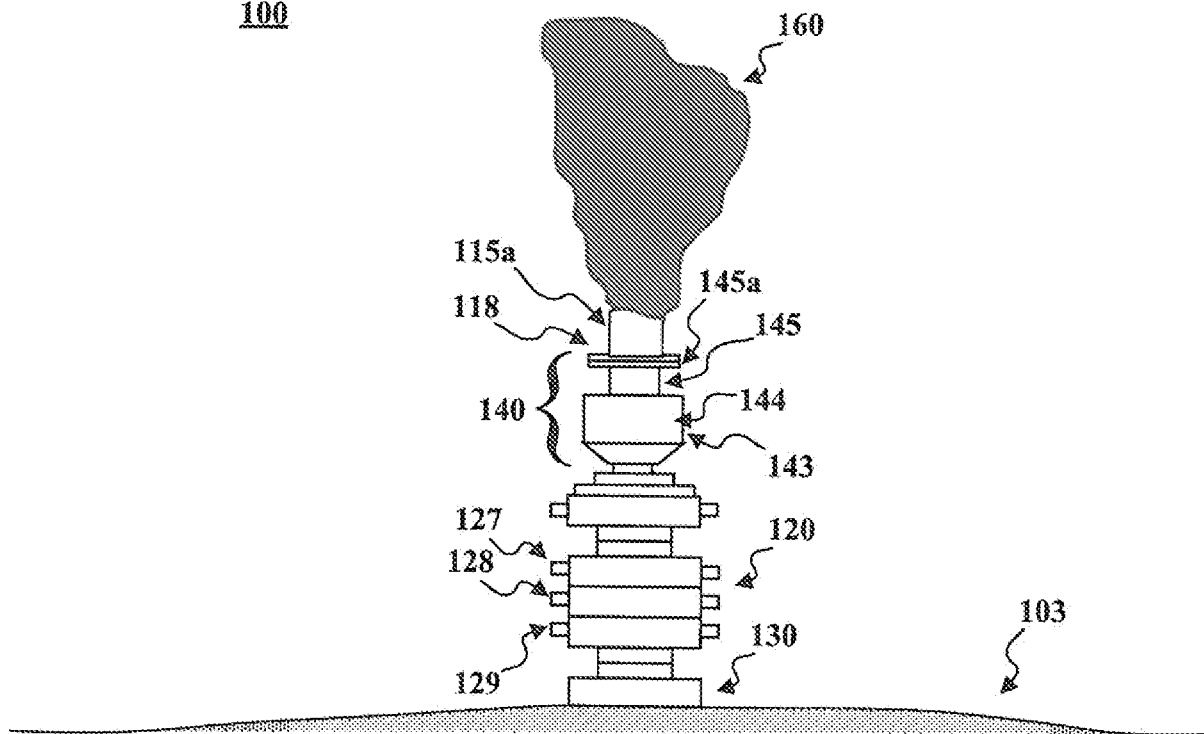


FIG. 2

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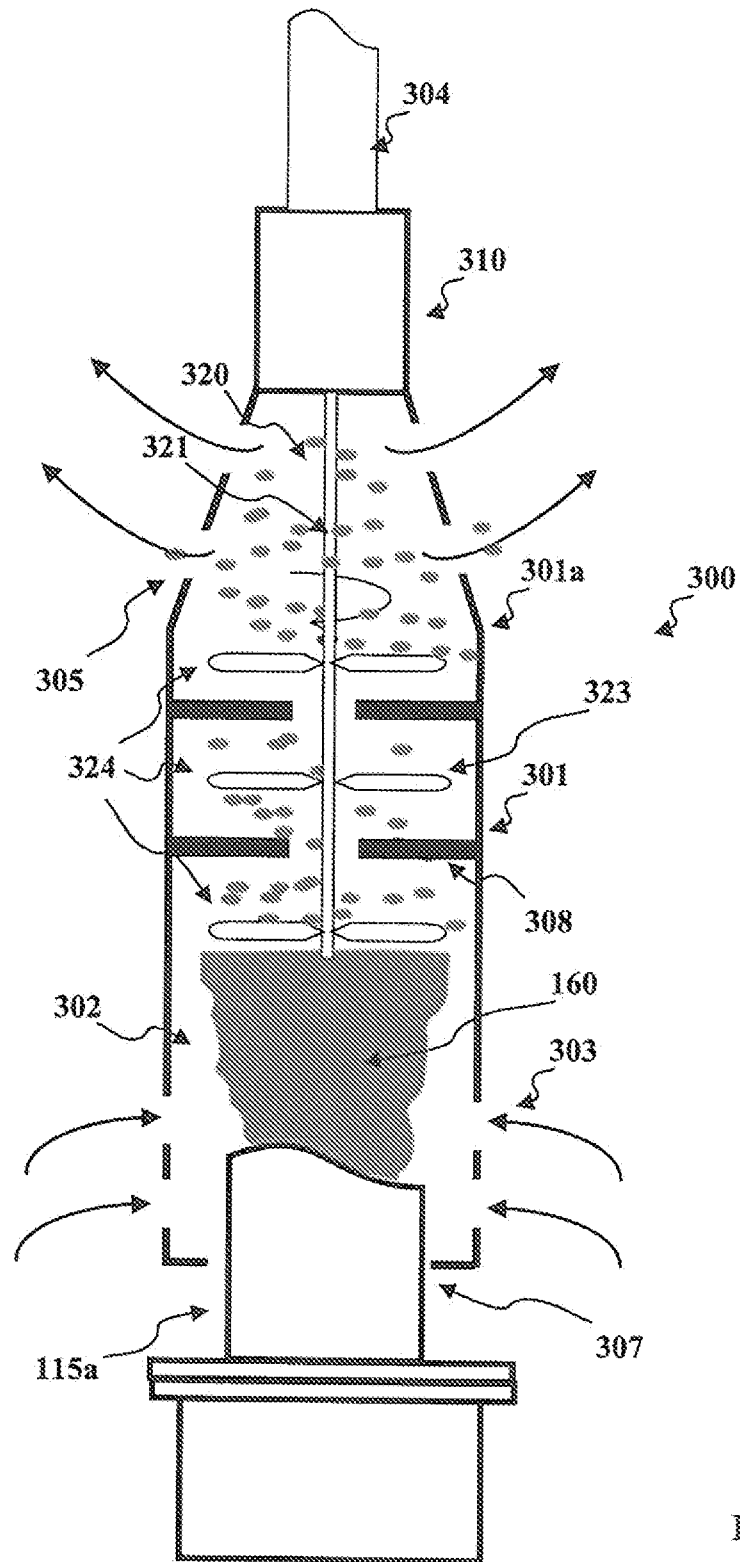


FIG. 3

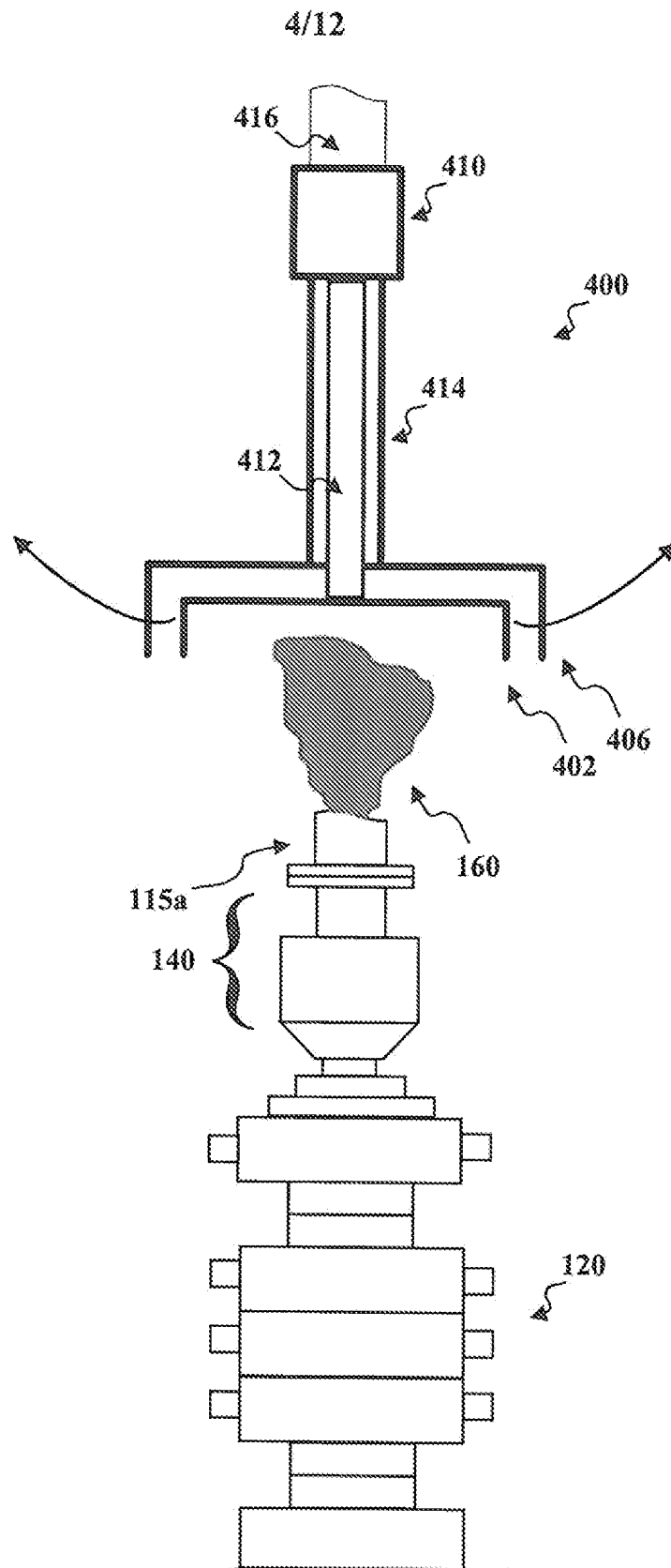


FIG. 4A

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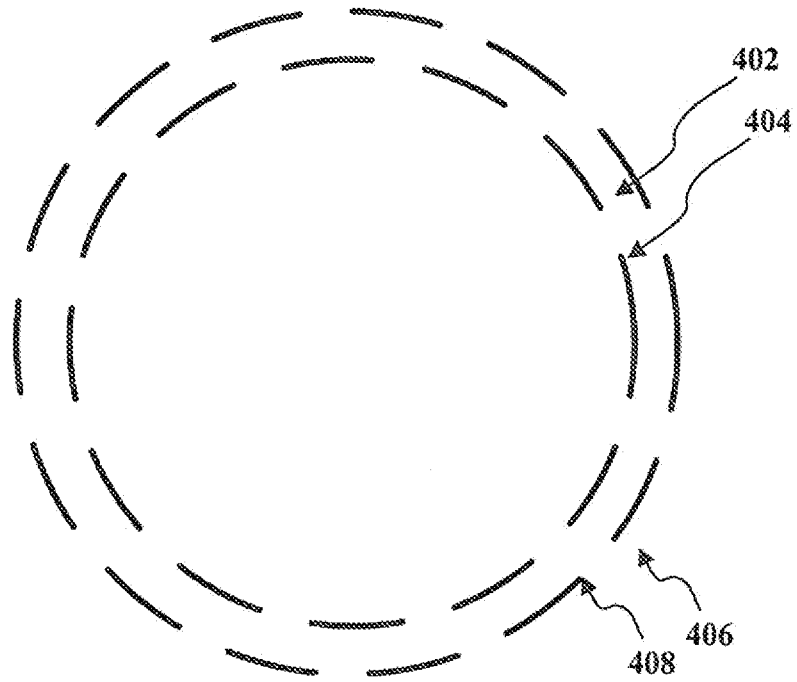


FIG. 4B

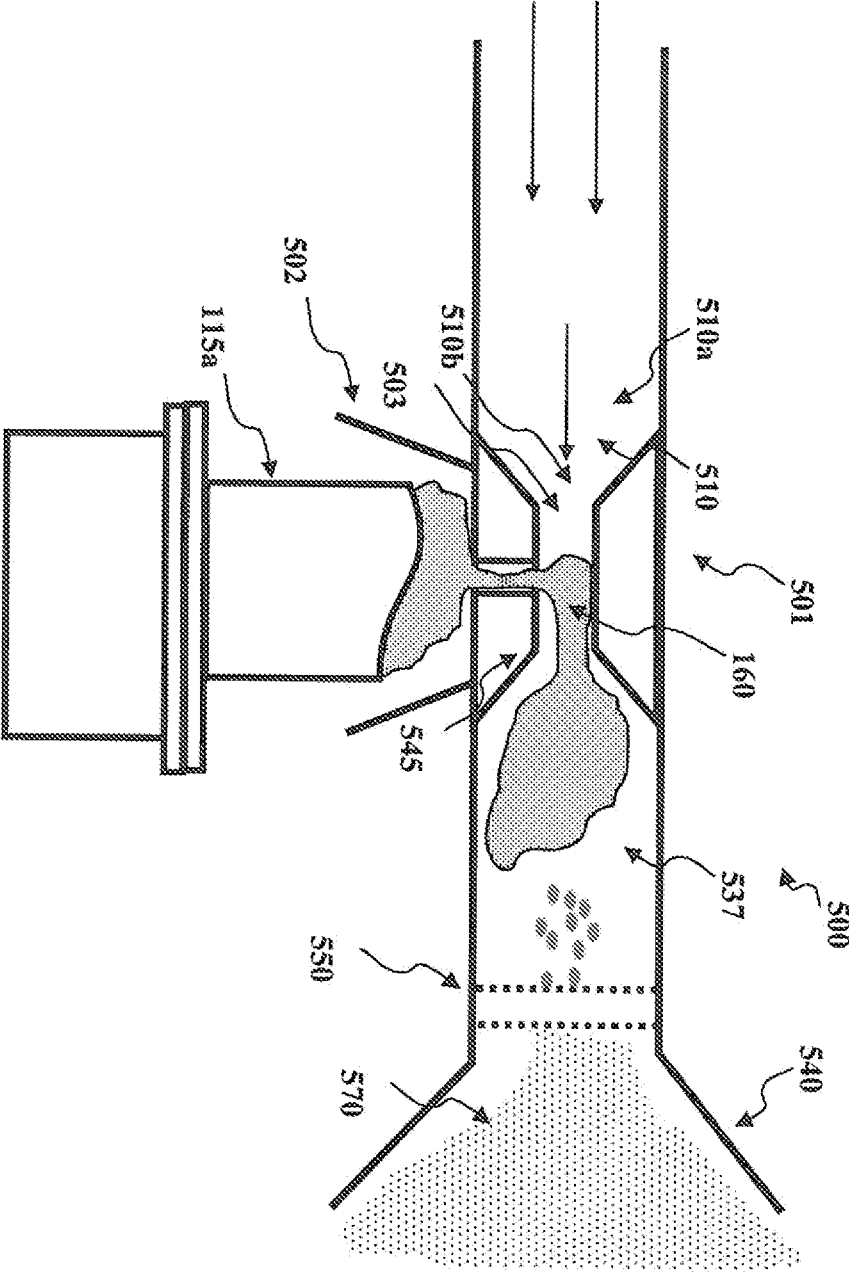


FIG. 5B

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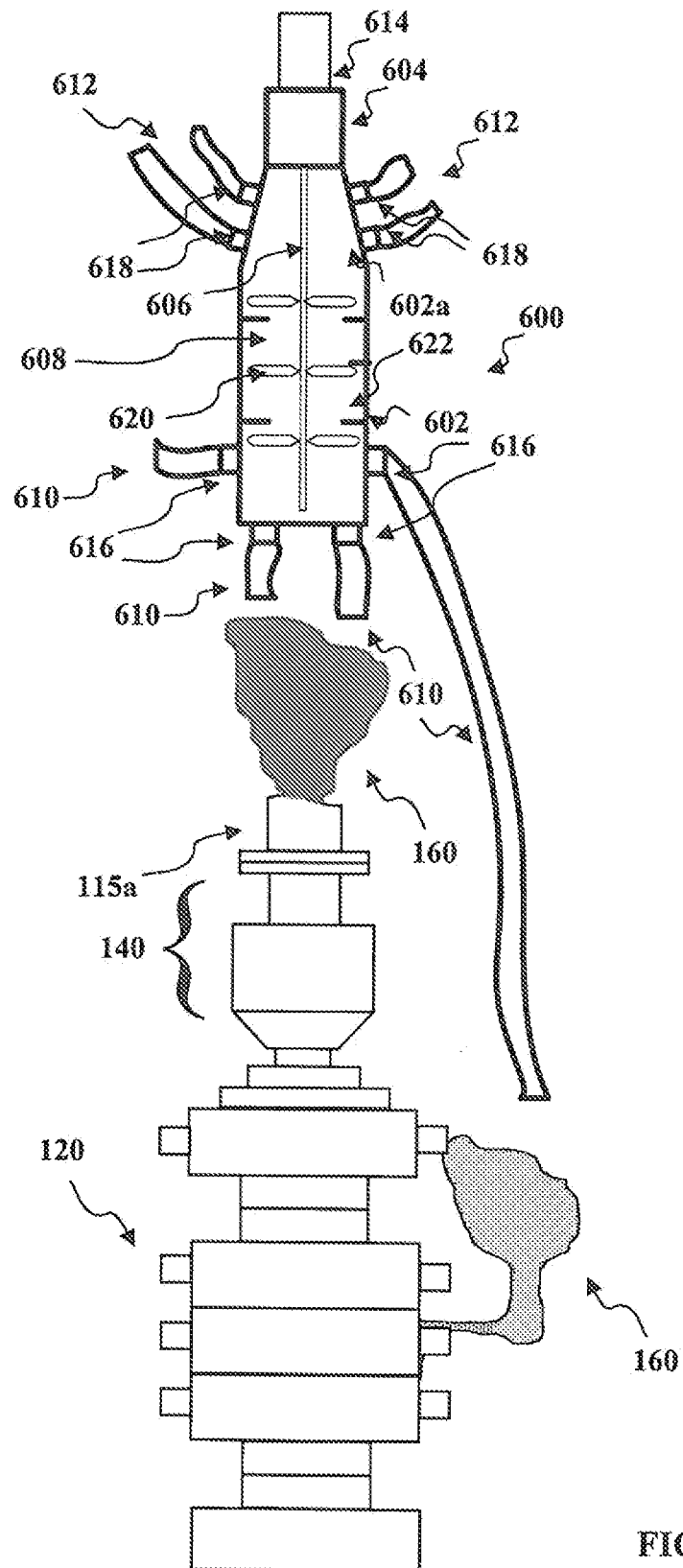
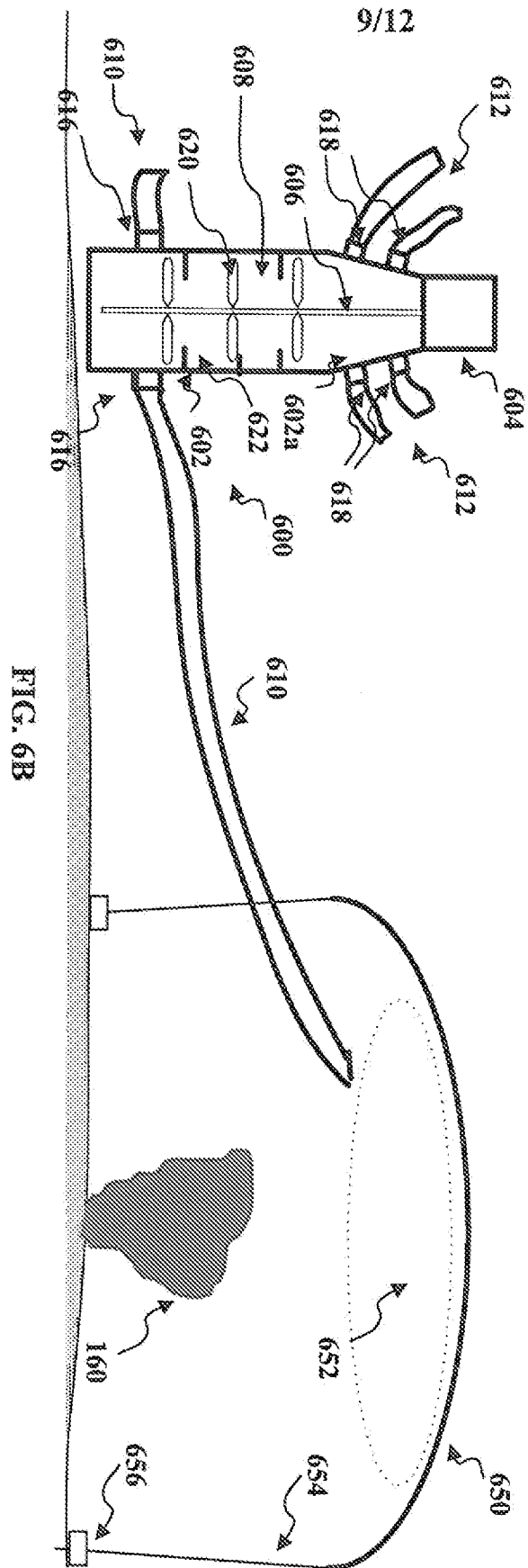


FIG. 6A



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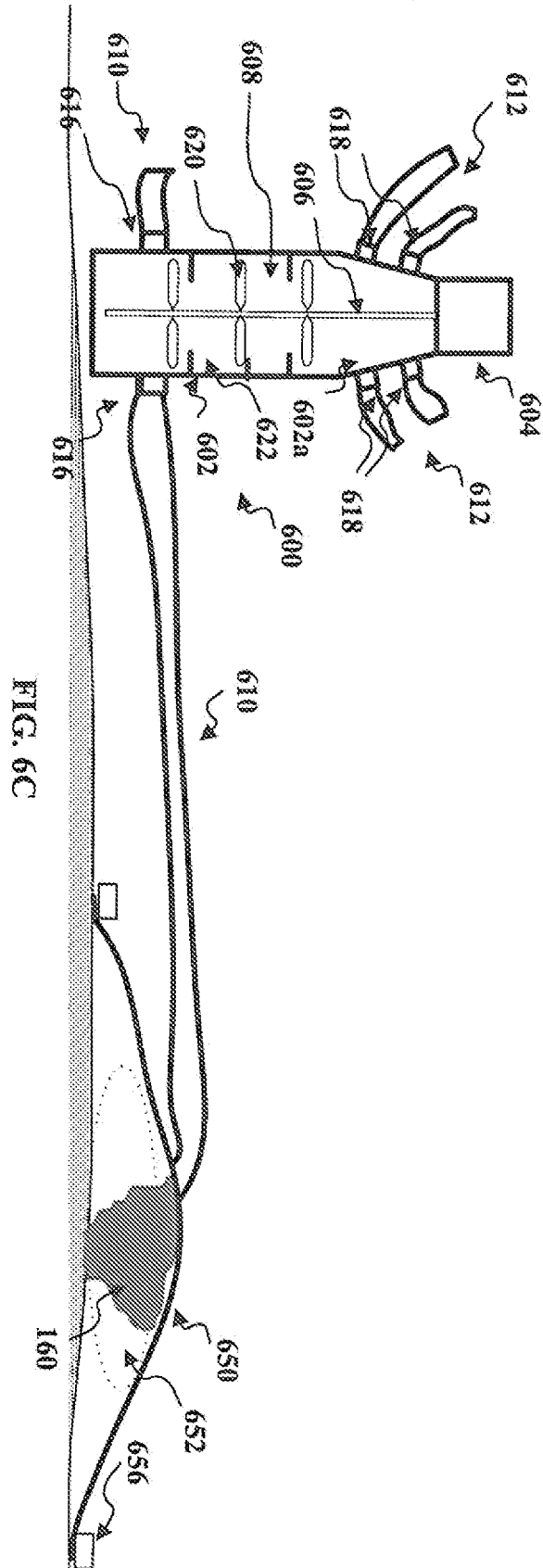
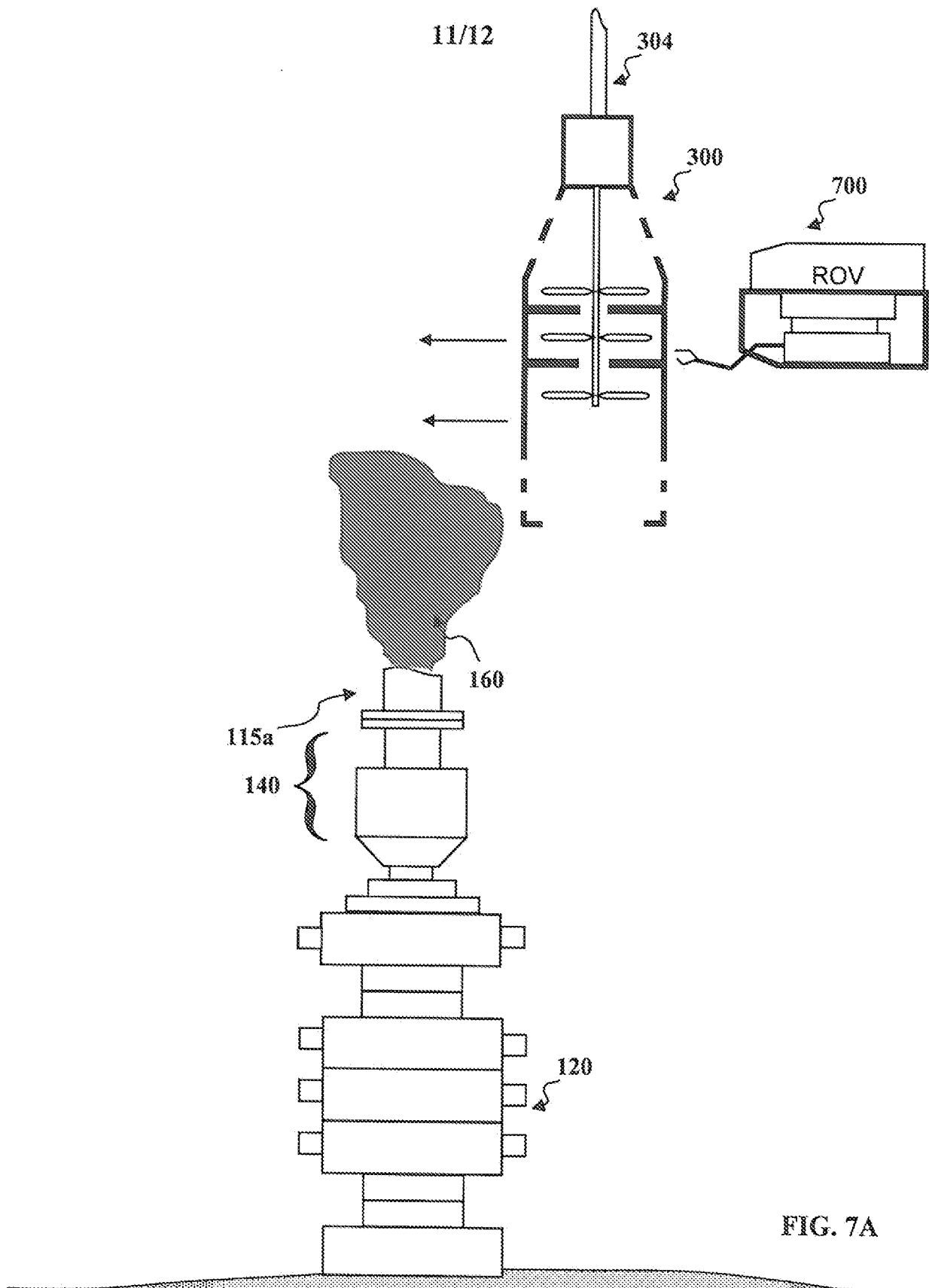


FIG. 6C



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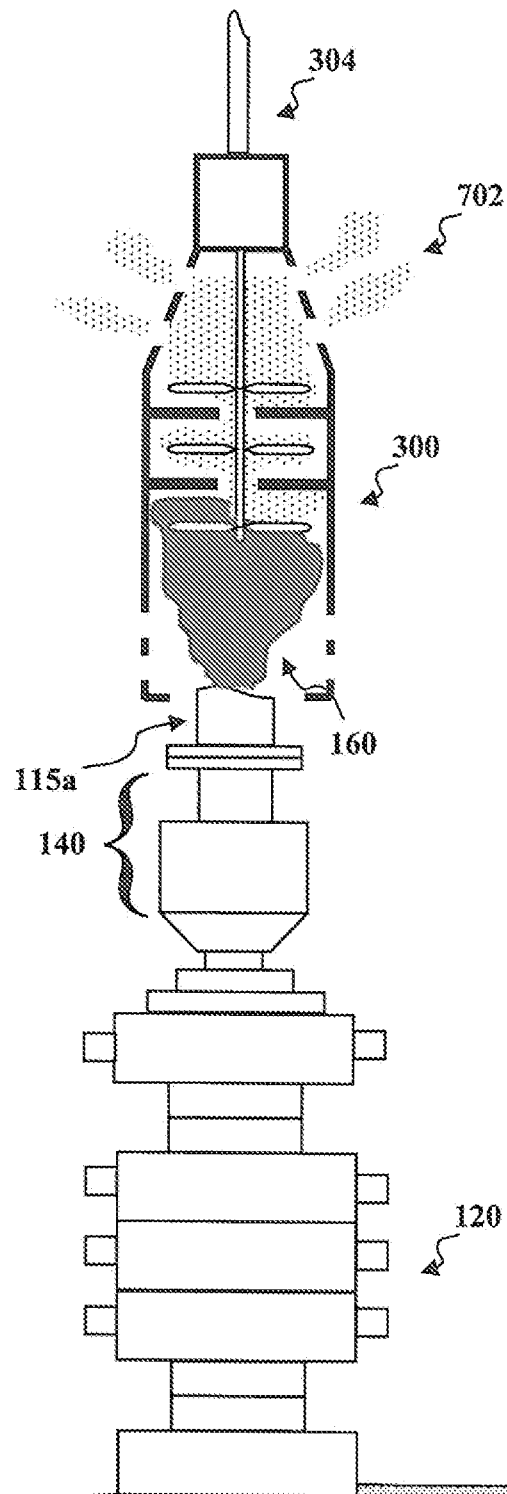


FIG. 7B