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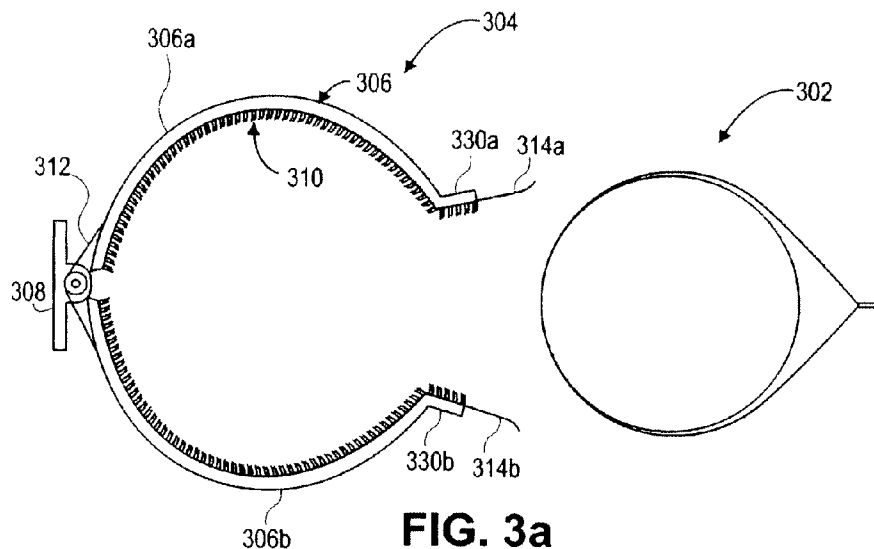


FIG. 3a

(57) Abstract: An offshore structure cleaning system comprising a frame, at least one set of clamps supported by the frame, a cleaning mechanism on an interior of the set of clamps, the cleaning mechanism adapted to clean an offshore structure.



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METHODS AND SYSTEMS FOR CLEANING SUBSEA STRUCTURES

Field of the Invention

The present invention is directed to methods and devices for cleaning
5 subsea structures.

Background of the Invention

Whenever a bluff body in a fluid environment, such as a cylinder, is
subjected to a current in the fluid, it is possible for the body to experience vortex-
10 induced vibrations (VIV). These vibrations may be caused by oscillating
hydrodynamic forces on the surface which can cause substantial vibrations of the
structure, especially if the forcing frequency is at or near a structural natural
frequency.

Drilling for and/or producing hydrocarbons or the like from subterranean
15 deposits which exist under a body of water exposes underwater drilling and
production equipment to water currents and the possibility of VIV. Equipment
exposed to VIV may include structures ranging from the smaller tubes of a riser
system, anchoring tendons, or lateral pipelines to the larger underwater cylinders
of the hull of a minispar or spar floating production system (a "spar").

20 Risers as used herein are defined to be a non-exclusive example of a
marine element subject to VIV. Generally a riser system is used for establishing
fluid communication between the surface and the bottom of a water body. The
principal purpose of the riser is to provide a fluid flow path between a drilling
vessel and a well bore and to guide a drill string to the well bore.

25 A typical riser system may include one or more fluid-conducting conduits
that extend from the surface to a structure (e.g., wellhead) on the bottom of a
water body. For example, in the drilling of a submerged well, a drilling riser usually
consists of a main conduit through which the drill string is lowered and through
which the drilling mud is circulated from the lower end of the drill string back to the
30 surface. In addition to the main conduit, there may be provided auxiliary conduits
such as, for example, choke and kill lines, pressurized fluid lines, hard pipes, and
electrical lines, which extend relatively parallel to the main conduit. These

auxiliary conduits and lines are commonly referred to as umbilical elements and/or umbilicals.

There are generally two kinds of water current induced stresses to which elements of a riser system may be exposed. The first kind of stress as mentioned
5 above is caused by vortex-induced alternating forces that vibrate the underwater structure in a direction perpendicular to the direction of the current. These are referred to as vortex-induced vibrations (VIV). When water flows past the structure, vortices are alternately shed from each side of the structure. This produces a fluctuating force on the structure transverse to the current. These
10 vibrations can, depending on the stiffness and the strength of the structure and any welds, lead to unacceptably short fatigue lives. In fact, stresses caused by high current conditions have been known to cause structures such as risers to break apart and fall to the ocean floor. The second type of stress is caused by drag forces which push the structure in the direction of the current due to the
15 structure's resistance to fluid flow. The drag forces may be amplified by vortex induced vibrations of the structure. For instance, a riser pipe that is vibrating due to vortex shedding will disrupt the flow of water around it more so than a stationary riser. This results in greater energy transfer from the current to the riser, and hence more drag.

20 Many methods have been developed to reduce vibrations of sub sea structures. Some of these methods to reduce vibrations caused by vortex shedding from subsea structures operate by stabilization of the wake. These methods include streamlined fairings, wake splitters and flags. Streamlined or teardrop shaped, fairings that swivel around a structure have been developed that
25 almost eliminate the shedding or vortexes. Other conventional methods to reduce vibrations caused by vortex shedding from sub sea structures operate by modifying the boundary layer of the flow around the structure to prevent the correlation of vortex shedding along the length of the structure. Examples of such methods include the use of helical strakes around a structure, or axial rod shrouds
30 and perforated shrouds.

Over time, devices such as fairings and strakes and other devices, and subsea structures such as risers and tendons may have marine growth such as barnacles and seaweed build up on them. Such marine growth may increase drag

on structures and affect the performance of devices, and otherwise interfere with the normal functioning of such structures and devices, for example not allowing fairings to weathervane. Various coatings, films, and paints have been proposed to retard marine growth. In addition, electric currents have been proposed to
5 retard marine growth.

U.S. Patent 5,026,212 discloses an apparatus for removing marine growth from offshore marine structures, said apparatus comprising flexible multi-component floating rings and submerged rings being adapted to surround a structural support member of the offshore marine structure, the apparatus being
10 powered by the utilization of ocean forces in the form of waves, swells, tides and currents so that marine growth is removed from the structural support member by means of the reciprocating motion of the apparatus about the structural support member. U.S. Patent 5,026,212 is herein incorporated by reference in its entirety.

There is a need in the art for improved apparatus and methods for cleaning
15 offshore structures and devices.

There is a need in the art for apparatus and methods for cleaning offshore structures and devices that do not suffer from the disadvantages of the prior art.

These and other needs will become apparent to those of skill in the art upon review of this specification, including its drawings and claims.

20

Summary of the Invention

In one aspect, the invention provides an offshore structure cleaning system comprising a frame, at least one set of clamps supported by the frame, a cleaning mechanism on an interior of the set of clamps, the cleaning mechanism adapted to
25 clean an offshore structure.

In another aspect, the invention provides a method of cleaning an offshore structure, the method comprising positioning a clamshell tool adjacent to the structure, wherein the clamshell tool carries a cleaning mechanism, moving the clamshell tool in an open configuration to position the clamshell device around the
30 structure, closing the clamshell tool from the open configuration to a closed configuration to close the clamshell device around the structure, and cleaning at least a portion of the structure with the cleaning mechanism.

Advantages of the invention may include one or more of the following:

improved apparatus and methods for cleaning offshore structures and devices; and

apparatus and methods for cleaning offshore structures and devices that do not suffer from the disadvantages of the prior art.

5

Brief Description of the Figures

Figure 1a illustrates a subsea system.

Figure 1b illustrates a cross-sectional view of a riser with a fairing attached.

Figure 2a illustrates a top view of a cleaning device.

10 Figure 2b illustrates a perspective view of a cleaning device.

Figure 3a illustrates a top view of a cleaning unit in an open position.

Figure 3b illustrates a top view of the cleaning unit of Figure 3a in a closed position.

15 Figure 3c illustrates a perspective view of the cleaning unit of Figures 3a and 3b.

Figure 4 illustrates a perspective view of a cleaning unit.

Figure 5 illustrates a perspective view of a cleaning unit.

Figure 6 illustrates a top view of a cleaning unit.

Figure 7 illustrates a perspective view of a cleaning unit.

20 Figure 8a illustrates a top view of a cleaning unit in an open position.

Figure 8b illustrates a top view of the cleaning unit of Figure 8a in a closed position.

Figure 9 illustrates a top view of a cleaning unit in a closed position.

25 Figure 10a illustrates a cross sectional view along a length of a cleaning unit.

Figure 10b illustrates a cross sectional view along a length of a cleaning unit.

Figure 11 illustrates a top view of a cleaning unit.

30 Figure 12 illustrates a side view of a remotely operated vehicle (ROV) and subsea system.

Detailed Description

Referring now to Figure 1a, there is illustrated a subsea system. Subsea system 100 includes surface structure 102 near a water surface. Surface structure 102 is connected to subsurface structure 103 adjacent to seafloor 108 by a tubular structure 104. In some embodiments, tubular structure 104 may be a riser. Exterior to riser 104 may be buoyancy material 106, such as foam, which may serve to insulate and/or provide buoyancy to riser 104. The water has current 110, which may cause vortex-induced vibration (VIV) of riser 104. To counter VIV, fairings 114a, 114b, 114c and 114d may be installed along the length of riser 104. Fairings 114a, 114b, 114c and 114d swivel around riser 104 to counteract VIV. Collars 112a, 112b, 112c and 112c exterior to buoyancy material 106 are used to keep fairings 114a, 114b, 114c and 114d from moving along the length of riser 104.

Referring now to Figure 1b, a cross-sectional view of the subsea system of Figure 1a is illustrated. Buoyancy material 106 is shown positioned external to riser 104. Collar 112 is further shown external to buoyancy material 106. Fairing 114 is positioned around foam 106. Figure 1b illustrates a tear drop shaped fairing 114, however, it is contemplated that fairing 114 may have any shape suitable for countering VIV. It is further contemplated that in some embodiments, other suitable VIV suppression devices (e.g. strakes, shrouds, wake splitters, etc.) may be used in place of, or in addition to, fairing 114 to counter VIV.

Over time, the marine environment causes marine growth on subsea components such as collars 112a, 112b, 112c, 112d and fairings 114a, 114b, 114c, 114d, thereby inhibiting their performance. For example, excess marine growth may cause rotation of fairings 114a, 114b, 114c and 114d to be hindered or stopped all together. A non-rotating fairing subjected to a crosscurrent may result in vortex shredding that induces greater vibration than tubular structure 104 would incur alone. The components of subsea system 100 may be cleaned periodically to remove marine growth and remain effective.

Figure 2a illustrates a top view of a cleaning device. Cleaning device 200 includes support plate 202 connected to cleaning unit 204. Support plate 202 and its associated components may provide a support mechanism for various lines and devices used to control cleaning unit 204. Representatively, support plate 202

may include ports through which power and/or fluid lines from a surface structure (as will be discussed more fully below) are inserted to keep the lines from tangling during cleaning of a desired subsea structure.

Support plate 202 may be attached to brace 206. Brace 206 may include
5 any number of lateral braces 208 extending from a center of brace 206 to its edges to provide support to support plate 202 and cleaning unit 204 attached thereto. Representatively, in the illustrated embodiment, support plate 202 is a six sided polygon having six lateral braces 208 extending from a center of brace 206 to each corner. In other embodiments, support plate 202 may be a three sided polygon
10 having three lateral braces 208 extending from the center to each corner. In still further embodiments, it is contemplated that support plate 202 may have any shape (e.g. polygon, circular, etc) and any number of lateral braces 208, and in some embodiments no lateral braces. Support plate 202 and brace 206 may be integrally formed or separate components attached together by, for example, bolts.
15 Support plate 202 and brace 206 may be made of a metal material such as copper, aluminum, or steel or any other similarly rigid material such as, for example, thermoplastics or fiberglass.

Cleaning unit 204 may be connected to and extend from an edge of support plate 202. Cleaning unit 204 may be connected to support plate 202 by, for
20 example, a pin or bolt threaded through an end portion of cleaning unit 204 and a frame (see Figure 2b) connected to support plate 202. Cleaning unit 204 may be dimensioned to wrap around and clean regular and irregularly shaped tubulars (e.g. a collar, etc.) or a VIV suppression structure (e.g. fairings, strakes, shrouds, sleeves, wake splitters, etc.). Although one cleaning unit 204 is shown connected
25 to support plate 202, it is contemplated that any number of cleaning units 204 may be connected to support plate 202. Representatively, in embodiments where support plate 202 is a six sided polygon, six cleaning units 204 may be connected to support plate 202 at its corners. Each of the six cleaning units may be identical, or they may each be different to serve different purposes and designed for
30 different uses.

Figure 2b illustrates a perspective view of a cleaning device. Cleaning device 200 includes support plate 202 and brace 206. Connector 210 is further shown extending from the center of brace 206. Connector 210 is dimensioned to

attach to a line extending from surface structure 102 for lowering and raising cleaning device 200. In this aspect, connector 210 may be a ring shaped structure extending from brace 206 which is dimensioned to receive a hook attached to an end of the line.

5 Support plate 202 may further include frame assembly 212 connected to an edge of support plate 202. Frame assembly 212 may provide an attachment point for cleaning unit 204 as well as a handle for manipulation of cleaning device 200 by a remotely operated vehicle (ROV) or diver. Representatively, frame assembly 212 may be made of tubular members to which cleaning unit 204 and/or an arm of
10 ROV may be attached or a diver may grasp. Connector 210 and frame assembly 212 may be made of the same or different material to that of support plate 202 and brace 206. It is further contemplated that in some embodiments, ends of lateral braces 208 may be connected directly to frame assembly 212 and support plate 202 omitted to reduce drag during manipulation of the device in the water, like a
15 wagon wheel with a hub and spokes.

 In some embodiments, cleaning device 200 may have a lateral dimension greater than its longitudinal dimension as shown in Figure 2b. In other embodiments, cleaning device 200 may have a longitudinal dimension greater than its lateral dimension. Representatively, cleaning device 200 may have a first
20 upper support plate and a second lower support plate (not shown) connected by a longitudinal framework in between (not shown). A distance between the support plates may be substantially equivalent to a height of cleaning unit 204. For example, in embodiments where cleaning unit 204 has a height of 3 feet, a distance between support plates may be about 3 feet such that cleaning unit 204 is
25 attached along its length to the support plate framework to provide added support to cleaning unit 204. In this aspect, cleaning unit 204 may be connected at one end to the first upper support plate and at another end to the second lower support plate. In other embodiments, a first cleaning unit 204 may be connected to the upper support plate and another cleaning unit 204 may be connected to the
30 second lower support plate to provide a dual cleaning action. Representatively, the cleaning units 204 may be vertically aligned such that when cleaning device 200 is run down the VIV suppression device (e.g. fairing), the lower cleaning unit

204 may provide a first cleaning of the VIV suppression device and the upper cleaning unit 204 may follow with a secondary cleaning of the device.

In some embodiments, buoyancy foam, cans, or other buoyant elements could be attached to one or more elements of cleaning device 200 to lower the
5 water weight of cleaning device 200.

Figure 3a illustrates a top view of a cleaning unit in an open position. Cleaning unit 304 is shown in an open position ready to receive fairing 302. Cleaning unit 304 includes body 306 having a clamshell configuration with first section 306a and second section 306b. First section 306a and second section
10 306b are connected at one end by hinge 308. Hinge 308 may have a set of arms 312 that extend from the joint of hinge 308 and pivot relative to one another. A free end of each of arms 312 may be attached to first section 306a and second section 306b such that first section 306a and second section 306b pivot between open and closed positions. It is further contemplated that in some embodiments, a
15 tensioning device such as a v-spring attached at its peak to hinge 308 with its free ends contacting first section 306a and second section 306b, may be used to provide additional lateral forces to cleaning unit 304.

Although in this embodiment, body 306 has two sections it is further contemplated that body 306 may be made of a single piece and hinge 308 omitted.
20 In this alternative embodiment, for example, body 306 may be made of a compliant material and shaped such that when positioned around a structure to be cleaned, it provides a lateral force which holds cleaning device 304 around the structure. Representatively, an inner diameter of body 306 may be smaller than an outer diameter of the structure to be cleaned. Body 306 may be made of a compliant
25 material that can be expanded to fit around the structure. Once body 306 is in position and the force used to expand body 306 is removed, body 306 contracts back to its original shape thereby tightening around the underlying structure.

Body 306 may be dimensioned such that its inner surface conforms to the VIV suppression device, collar, smooth sleeve, tubular or other device cleaning
30 unit 304 is designed to clean when in a closed position. Representatively, in a closed position body 306 may have a substantially cylindrical shape with flared free ends 330a and 330b to accommodate a shape of fairing 302. In still further embodiments, body 306 may have a triangular or square shape to clean irregularly

shaped VIV suppression devices. Body 306 may be made of a metal material, such as aluminum, steel or copper, a plastic material, a fiberglass material or any other similarly suitable material. Body 306 and its sections may be extruded from the desired material or molded (e.g., and extruded or molded plastic).

5 Guide members 314a and 314b may be connected to and extend from flared ends 330a and 330b, respectively. Guide members 314a and 314b may help to orient fairing 302 relative to cleaning unit 304 and ROV during cleaning. In this aspect, guide members 314a and 314b may be substantially straight with outwardly curved ends. The curved ends may be used to tap and rotate fairing
10 302 until a nose, as opposed to a tail, of fairing 302 is positioned within the opening of body 306 of cleaning unit 304. In this aspect, when cleaning unit 304 is inserted around fairing 302, fairing 302 is properly positioned within cleaning unit 304. Guide members 314a and 314b may have a wire like structure or a sheet like structure which extends from and/or along a length of flared ends 330a and 330b.

15 Guide members 314a and 314b may be made of a metal material, such as aluminum, steel or copper, a plastic material, a fiberglass material or any other similarly suitable material for guiding fairing 302 into cleaning unit 304. It is contemplated that guide members 314a and 314b may be integrally formed with body 306 or attached by, for example, bolting or fusing (e.g., welding) them to
20 flared ends 330a and 330b of body 306. Although two guide members 314a and 314b are described, additional guide members may be provided along a length of flared ends 330a and 330b. Representatively, a first set of guide members 314a and 314b may extend from a top portion of flared ends 330a and 330b and a second set of guide members may extend from a bottom portion of flared ends
25 330a and 330b to provide additional guidance along the length of fairing 302.

 An inner surface of body 306 of cleaning unit 304 shown in Figure 3a includes bristles 310. Bristles 310 facilitate cleaning of VIV suppression device, collar, sleeve, tubular or other device cleaning unit 304 is designed to clean when in a closed position. Bristles 310 may be made of any material suitable for
30 cleaning marine growth from a subsea device when passed along a surface of the device. Representatively, bristles 310 may be made of a plastic or metal material. Bristles 310 may be attached to body 306 by any suitable connecting mechanism. Representatively, bristles 310 may be anchored in superficial holes of an inner

surface of body 306 by, for example, inserting barbed ends of bristles 310 into the holes. Once within the holes, the barbed ends expand beneath the surface of body 306 and hold bristles 310 thereto. Alternatively, bristles 310 may be attached to the surface of body by, for example, soldering metal bristles 310 to the surface of a metal body 306. Bristles 310 may be randomly positioned along body 306 or in columns, rows or any other similarly suitable pattern for cleaning an underlying device.

Figure 3b illustrates a top view of the cleaning unit of Figure 3a in a closed position. Cleaning unit 304 of Figure 3b is substantially the same as the cleaning unit of Figure 3a and therefore includes the same components. As illustrated in Figure 3b, when cleaning unit 304 is in a closed position around fairing 302, cleaning unit 304 conforms to the shape of fairing 302 and bristles 310 are positioned along the outer surface of fairing 302. Cleaning unit 304 may then be moved along a length dimension of fairing 302 so that bristles 310 scrape along an outer surface of fairing 302 thereby removing marine growth. Representatively, cleaning unit 304 may be moved by an ROV or diver up and/or down along a length of fairing 302. Still further, in embodiments where cleaning unit 304 is used to clean a cylindrical structure such as a collar, cleaning unit 304 may be moved up and down and/or rotated around the collar.

Figure 3c illustrates a perspective view of the cleaning unit of Figures 3a and 3b. As can be seen from Figure 3c, body 306 of cleaning unit 304 has a substantially cylindrical shape with flared ends 330a and 330b to conform to the dimensions of fairing 302 when in a closed position. A height "h" of cleaning unit 304 may vary depending upon a height of the structure it is designed to clean. Representatively, when cleaning unit 304 is used to clean a six foot tall fairing, cleaning unit 304 may have a height of six feet or less. It is contemplated that in embodiments where cleaning unit 304 is rotated around an underlying structure (e.g. collar or sleeve), a height of cleaning unit 304 may be substantially the same height as the structure so that an entire surface of the structure may be cleaned by rotating the device (e.g. upward and downward movement along the structure are not necessary). Alternatively, in embodiments where upward and downward movement of cleaning unit 304 is used to clean the structure (e.g. a fairing), a height of cleaning unit 304 may be the same as or less than that of the structure.

Although exemplary dimensions are disclosed, it is contemplated that cleaning unit 304 may have any height sufficient for cleaning an underlying structure. It is further contemplated that both rotation and upward/downward movement of cleaning unit 304 may be used to clean a desired structure.

5 First section 306a and second section 306b of body 306 are dimensioned to accommodate a diameter of the structure cleaning unit 304 is designed to clean. Representatively, where a diameter of a tubular to be cleaned is about twelve inches, an inner diameter of body 306 may be slightly larger than twelve inches (e.g. fourteen inches) when in the closed position. In this aspect, bristles 310
10 extending from body 306 may be about an inch long such that they contact an outer surface of the tubular when body 306 is closed around the tubular. Although exemplary dimensions are described, it is contemplated that a height, diameter and bristle length may vary. For example, a height of body 306 may be proportional to a diameter of the fairing, tubular, etc. to be cleaned.
15 Representatively, a height of body 306 of cleaning unit 304 for cleaning a thirty-two inch diameter tubular may be greater than the height of body 306 of cleaning unit 304 for cleaning a tubular having a fourteen inch diameter.

In one embodiment, a biasing mechanism such as a spring or gas cylinder may be used to bias first section 306a and second section 306b of body 306 in an
20 open position. One or more cam members (not shown) may be provided on the inside of body 306, adjacent hinge 308, so that when cleaning unit 304 is pushed towards a structure to be cleaned, the cam members act to close first section 306a and second section 306b and overcome biasing mechanism. When the cleaning operation is completed, cleaning unit 304 may be pulled off of the structure and the
25 biasing mechanism acts to open first section 306a and second section 306b of body 306. One suitable clamshell tool with cam members is disclosed in co-pending U.S. Patent Application Publication 2007/0140797, published June 21, 2007, and having attorney docket number TH2875. U.S. Patent Application Publication 2007/0140797 is herein incorporated by reference in its entirety.

30 Figure 4 is a perspective view of a cleaning unit. Cleaning unit 404 is substantially the same as cleaning unit 304 discussed in reference to Figures 3a, 3b and 3c except that bristles 410 are arranged in groups as shown. Cleaning unit 404 includes body 406 having first section 406a and second section 406b attached

to one another by hinge 408. Hinge 408 may have a set of arms 412 which extend from the joint of hinge 408 and pivot relative to one another. A free end of each of arms 412 may be attached to first section 406a and second section 406b such that first section 406a and second section 406b pivot between open and closed
5 positions. Guide members 414a and 414b extend from flared ends 430a and 430b, respectively, of body 406.

Groups of bristles 410 may be rotated during cleaning to provide an enhanced cleaning action. In this aspect, groups of bristles 410 may extend from support disks 411 rotatably connected to an inner surface of body 406. Groups of
10 bristles 410 and disks 411 may be randomly position along the surface of body 406 or in a pattern (e.g. rows, columns, etc.). Disks 411 may be rotatably connected to body 406 by, for example, pins through body 406 and an opening in the center of each of disks 411. As cleaning unit 404 is moved over a surface of, for example, a fairing, the friction on bristles 410 causes bristles 410 coupled to
15 disks 411 to rotate. It is noted that although groups of rotating bristles are described, the bristles may also rotate individually. In still further embodiments, rotation of disks 411 may be controlled by, for example, a motor assembly coupled to disks 411. In other embodiments, bristles 410 can be rotated with hydraulic or pneumatic pressure applied by a line from a structure at the water surface, for
20 example a vessel, boat, ship, or fixed or floating production platform.

It is further contemplated that in some embodiments, cleaning unit 404, and in turn bristles 410, may be vibrated to facilitate cleaning of a desired structure. Representatively, a cam device having a rotating wheel may be attached to an outer surface of body 406 and strike levers extending from body 406 which in turn
25 vibrates body 406. Although a cam device is described, it is further contemplated that another type of actuators and drive systems may be used to vibrate cleaning unit 404. In another embodiment, a hydraulic or pneumatic pressure may be pulsated from a structure at the water surface to cause the bristles to vibrate.

Figure 5 is a perspective view of a cleaning unit. Cleaning unit 504 is
30 substantially the same as cleaning unit 304 discussed in reference to Figures 3a, 3b and 3c except that bristles 510 extend from both an inner surface and upper and lower edges of body 506. Cleaning unit 504 includes body 506 having first section 506a and second section 506b attached to one another by hinge 508.

Hinge 508 may have a set of arms 512 which extend from the joint of hinge 508 and pivot relative to one another. A free end of each of arms 512 may be attached to first section 506a and second section 506b such that first section 506a and second section 506b pivot between open and closed positions. Guide members
5 514a and 514b extend from flared ends 530a and 530b, respectively, of body 506.

Bristles 510 extending from the upper and lower edges of body 506 may be used to clean structures (e.g. collars or sleeves) above and below the structure cleaning unit 504 is positioned around (e.g. fairing). Bristles 510 along an inner surface and edges of body 506 may have substantially the same dimensions and
10 be made of the same material (e.g. plastic or metal). Alternatively, bristles 510 along edges of body 506 may be made of a different material and have a different length than that of bristles 510 along an inner surface of body 506 depending upon the types of structures to be cleaned. For example, bristles 510 along edges of body 506 may be longer and made of a stiffer material (e.g. metal) than bristles
15 510 along an inner surface of body 506 so that they have a sufficient length and are stiff enough to contact and clean structures above and below cleaning unit 504. Although bristles 510 are shown extending from both upper and lower edges of body 506, it is contemplated that bristles 510 may extend from either the upper edge or the lower edge of body 506.

20 Figure 6 is a top view of a cleaning unit. Cleaning unit 604 is substantially the same as cleaning unit 304 discussed in reference to Figures 3a, 3b and 3c except that water outlets 616 are provided along an inner surface of body 606. Cleaning unit 604 includes body 606 having first section 606a and second section 606b attached to one another by hinge 608. Hinge 608 may have a set of arms
25 612 which extend from the joint of hinge 608 and pivot relative to one another. A free end of each of arms 612 may be attached to first section 606a and second section 606b such that first section 606a and second section 606b pivot between open and closed positions. Guide members 614a and 614b extend from flared ends 630a and 630b, respectively, of body 606.

30 Water outlets 616 may be provided in addition to or in place of bristles. In embodiments where both water outlets 616 and bristles are used, bristles may extend from portions of body 606 between outlets 616. Water outlets 616 may be openings formed along an inner surface of body 606 with nozzles 617 positioned

around each outlet 616 to regulate fluid flow. Nozzles 617 may be dimensioned to discharge a fluid at a sufficient rate to clean marine growth off of a surface of, for example, a fairing, around which cleaning unit 604 is positioned. Representatively, a size of an opening of nozzle 617 may be increased (to increase flow rate) or
5 decreased (to decrease flow rate) depending upon the desired flow rate. Cleaning unit 604 may be rotated or moved up and down the fairing during cleaning. It is contemplated, however, that when cleaning unit 604 has substantially the same height as the fairing or other underlying structure to be cleaned, movement of cleaning unit 604 may not be necessary to clean the structure. In addition to
10 cleaning the underlying device, fluid flowing from water outlets 616 and nozzles 617 may help to remove marine growth which may collect between cleaning unit 604 and the structure during cleaning.

In between nozzles 617, there may be located perforations (not shown) which allow water and marine growth to exit from within cleaning unit 604.
15 Perforations may comprise from about 10% to about 90% of the area of body 606, for example from about 20% to about 60%, or from about 30% to about 50%.

Water may be delivered from surface structure 102 described in reference to Figure 1a to water outlets 616 and out nozzles 617 via conduit 618. Conduit 618 may be, for example, a rubber tube, which extends from surface structure 102
20 and splits into two separate ends which terminate within first section 606a and second section 606b of body 606. First section 606a and second section 606b of body 606 may be hollow or have channels between the outer surfaces to accommodate delivery of water from conduit 618 to each of outlets 616 and nozzles 617. A pump mechanism (not shown) may be provided on surface
25 structure 102 to pump water from a water source on the surface structure or directly from the sea and through conduit 618 to nozzles 617. The pump mechanism may be any suitable pumping mechanism capable of pumping water through conduit 618 to nozzles 617. Alternatively, a pump mechanism may be attached directly to cleaning unit 604 and conduit 618 which may pump water from
30 the sea into conduit 618 and out nozzles 617 of cleaning unit 604.

Figure 7 is a perspective view of a cleaning unit. Cleaning unit 704 is substantially the same as cleaning unit 304 discussed in reference to Figures 3a, 3b and 3c except that water outlets 716 having nozzles 717a are provided along

upper and lower edges of body 706 and water outlets 716 having nozzles 717b are provided along an inner surface of body 706. Water outlets 716 and nozzles 717a and 717b are substantially the same as those previously discussed. Nozzles 717a and 717b are represented by circular members in Figure 7. Cleaning unit 704
5 includes body 706 having first section 706a and second section 706b attached to one another by hinge 708. Hinge 708 may have a set of arms 712 which extend from the joint of hinge 708 and pivot relative to one another. A free end of each of arms 712 may be attached to first section 706a and second section 706b such that first section 706a and second section 706b pivot between open and closed
10 positions. Guide members 714a and 714b extend from flared ends 730a and 730b, respectively, of body 706.

Bristles 710 may extend from body 706 between nozzles 717a and/or 717b to provide additional cleaning capabilities.

Figure 8a illustrates a top view of a cleaning unit in an open position.
15 Cleaning unit 804 is shown prior to positioning of cleaning unit 804 around tubular 801. Similar to the previously discussed cleaning units, cleaning unit 804 includes body 806 made up of first section 806a and second section 806b connected by hinge 808. Hinge 808 may have a set of arms 812 which extend from the joint of hinge 808 and pivot relative to one another. A free end of each of arms 812 may
20 be attached to first section 806a and second section 806b such that first section 806a and second section 806b pivot between open and closed positions. Although not shown, it is contemplated that body 806 may further include flared ends and guide members extending therefrom as previously discussed.

Tubular 801 may be a riser with strakes 802a, 802b and 802c helically
25 wrapped around the riser. To accommodate a profile of tubular 801 with strakes 802a, 802b and 802c coupled thereto, body 806 of cleaning unit 804 may have a substantially round profile when in a closed position. Ribs 818a, 818b and 818c may extend from an inner surface of body 806 forming channels there between. Ribs 818a, 818b and 818c may be spaced around the inner surface of body 306
30 such that the channels formed in between adjacent ribs 818a, 818b and 818c may be aligned with each of strakes 802a, 802b and 802c when cleaning unit 804 is positioned around tubular 801 as shown in Figure 8b. Ribs 818a, 818b and 818c may be made of substantially the same material as body 806 and may be formed

as separate pieces and attached to an inner surface of body 806 or integrally formed with body 806. A width "w" of each of ribs 818a, 818b and 818c may be less than or equal to a distance between adjacent strakes 802a, 802b and 802c. Ribs 818a, 818b and 818c may be spaced a distance apart at least as wide as
5 strakes 802a, 802b and 802c such that each of ribs 818a, 818b and 818c fits between two adjacent strakes. Ribs 818a, 818b and 818c may extend a distance from the inner surface of body 806 greater than or equal to a distance strakes 802a, 802b and 802c extend from a surface of tubular 801. In this aspect, body 806 and bristles 810 extending from the inner surface of body 806 and ribs 818a,
10 818b, 818c substantially conform to the dimensions of tubular 801 with strakes 802a, 802b and 802c attached.

As previously discussed, body 806 of cleaning unit 804 may have a length dimension. Ribs 818a, 818b and 818c may further have a length dimension and extend along the length of body 806. Since helical strakes 802a, 802b and 802c
15 are coiled around tubular 801, however, ribs 818a, 818b and 818c must be dimensioned such that cleaning unit 804 may move smoothly along a length of tubular 801 without getting stuck between turns of helically wound strakes 802a, 802b and 802c. Representatively, it is contemplated that during cleaning of tubular 801 and strakes 802a, 802b and 802c, cleaning unit will be closed around
20 tubular 801 and wound down tubular 801 along strakes 802a, 802b and 802c. In this aspect, where body 806 and ribs 818a, 818b and 818c have a length equal to that of strakes 802a, 802b and 802c, ribs 818a, 818b and 818c may be helically wound along the inner surface of body 802 so that cleaning unit 804 can follow turns of strakes 802a, 802b, 802c along tubular 801. Alternatively, body 806 may
25 have a length equal to one helical turn of strakes 802a, 802b and 802c and ribs 818a, 818b and 818c may have a length equal to or less than that of body 806. In this aspect, cleaning unit 804 with ribs 818a, 818b, 818c positioned between strakes 802a, 802b, 802c may be wound down a length of tubular 801 without getting stuck between each turn of strakes 802a, 802b, 802c. Alternatively, a
30 width of ribs 818a, 818b and 818c may be modified to accommodate the helical turns of strakes 802a, 802b and 802c around tubular 801. Representatively, it is contemplated that the greater the distance between edges of ribs 818a, 818b and 818c positioned between strakes 802a, 802b and 802c and that of the strakes, the

more freedom to rotate around turns of strakes 802a, 802b and 802c cleaning unit 804 will have.

Figure 8b illustrates a top view of the cleaning unit of Figure 8a in a closed position. Cleaning unit 804 is shown in Figure 8b closed around tubular 801
5 having strakes 802a, 802b and 802c attached thereto. As can be seen in Figure 8b, strakes 802a, 802b and 802c fit within channels formed between ribs 818a, 818b and 818c of body 806. Bristles 810 extending from body 806 and ribs 818a, 818b and 818c contact tubular 801 and strakes 802a, 802b and 802c. A diver or ROV may be used to attach cleaning unit 804 to tubular 801 and strakes 802a,
10 802b and 802c and rotate cleaning unit 804 down tubular along the helical pattern of strakes 802a, 802b and 802c.

Figure 9 illustrates a top view of a cleaning unit in a closed position. Cleaning unit 904 is substantially similar to cleaning unit 804 discussed in reference to Figures 8a and 8b. In this aspect, cleaning unit 904 includes body
15 906 having first section 906a and second section 906b attached to one another by hinge 908. Hinge 908 may have a set of arms 912 which extend from the joint of hinge 908 and pivot relative to one another. A free end of each of arms 912 may be attached to first section 906a and second section 906b such that first section 906a and second section 906b pivot between open and closed positions. Ribs
20 918a, 918b and 918c extend from an inner surface of body 906. Cleaning unit 904 is shown in Figure 9 positioned around tubular 901 having strakes 902a, 902b and 902c attached thereto. Bristles 910 extend from the inner surface of body 906 and ribs 918a, 918b and 918c to clean tubular 901 and strakes 902a, 902b and 902c.

As previously discussed, cleaning is accomplished by rotating cleaning unit
25 904 down tubular 901 along strakes 902a, 902b and 902c using an ROV or diver. In this embodiment, cleaning unit 904 may rotate within a non-rotating housing 920 when housing 920 is moved along a length of tubular 901. In this aspect, ROV need only move housing 920 up or down tubular 901 and does not need to rotate around tubular 901 along with cleaning unit 904.

30 Housing 920 may have a substantially cylindrical shape dimensioned to fit around cleaning device 904. Housing 920 may be made of the same or different material to that of cleaning unit 904. Similar to the underlying cleaning unit 904, housing 920 may have first portion 920a and second portion 920b attached to one

another by hinge 922. Similar to hinge 908, hinge 922 may have a set of arms 924 which extend from the joint of hinge 922 and pivot relative to one another. A free end of each of arms 924 may be attached to first section 920a and second section 920b such that first section 920a and second section 920b pivot between open and closed positions. Ledges 926a and 926b may extend inwardly from upper and lower edges of housing sections 920a and 920b, respectively, to retain cleaning device 904 therein. Cleaning unit 904 and housing 920 may be assembled around tubular 901 by closing cleaning unit 904 around tubular 901 followed by housing 920. Alternatively, cleaning unit 904 and housing 920 may initially be attached together such that they may be closed around tubular 901 simultaneously. Once assembled, the ROV or diver may remove, for example, a pin, holding cleaning unit 904 and housing 920 together so that cleaning unit 904 may rotate within housing 920. Since cleaning unit 904 is free to rotate within housing 920, ROV need only move housing 920 up or down along the length of tubular 920 to rotate cleaning unit 904 along strakes 902a, 902b and 902c.

Figure 10a illustrates a cross sectional view along a length of a cleaning unit. Cleaning unit 1004 may have body 1006 and other components similar to those previously discussed. In addition to, or in place of, brushes and water outlets, scrapers 1008a, 1008b and 1008c may extend from body 1006. Scrapers 1008a, 1008b and 1008c may extend from body 1006 to form an acute angle with respect to body 1006. Scrapers 1008a, 1008b and 1008c may be attached to body 1006 by, for example, a hinge mechanism, so that scrapers 1008a, 1008b and 1008c may adjust along the contours of the device being cleaned. Tensioning devices 1010a, 1010b and 1010c may further be provided between body 1006 and scrapers 1008a, 1008b and 1008c, respectively, to bias scrapers 1008a, 1008b and 1008c in a direction of the tubular during cleaning. Representatively, as cleaning unit 1004 is moved down a length of, for example, a tubular having fairings and collars attached thereto in the direction of the illustrated arrow, scrapers 1008a, 1008b and 1008c can pivot with respect to body 1006 and adjust according to the changing surface dimensions thereby scraping marine growth from a surface of each structure.

Figure 10b illustrates a cross sectional view along a length of a cleaning unit. Cleaning unit 1004 may have body 1006 and other components similar to

those previously discussed. Scrapers 1008a, 1008b and 1008c having tensioning devices 1010a, 1010b and 1010c, respectively, may extend from body 1006 as previously discussed in connection with Figure 10a. In this embodiment, barbs 1012a, 1012b and 1012c may extend from ends of scrapers 1008a, 1008b and 1008c, respectively, to provide added cleaning capabilities. Representatively, when cleaning unit 1004 is moved along a length of a tubular as illustrated by the arrow, barbs 1012a, 1012b and 1012c will scrape along the tubular surface thereby removing marine growth attached thereto. Tensioning devices 1010a, 1010b and 1010c bias scrapers 1008a, 1008b and 1008c, respectively, against the tubular surface to maximize marine growth removal.

Figure 11 illustrates a top view of a cleaning unit. Similar to the previously described cleaning units, cleaning unit 1104 has a body 1106 with bristles 1110 extending from an inner surface of body 1106. It is contemplated that in some cases, it is not necessary for the cleaning unit to wrap entirely around the structure it is used to clean (e.g. fairing). For example, in the case of fairings, marine growth is often greater at the fairing nose than the tail. In this aspect, body 1106 may have a "U" shape dimensioned to fit around the nose of the fairing. Since body 1106 need not open and close around the entire fairing, body 1106 is formed of a single, integral piece rather than hinged sections as previously disclosed. It is contemplated, however, that in some embodiments, body 1106 may have first and second sections hinged at their ends as previously disclosed. Body 1106 may be made from the same materials of a cleaning unit body as discussed in reference to the previous embodiments.

Attachment mechanism 1108 may be connected to an outer surface of body 1106 to attach cleaning unit 1104 to a support member. Attachment mechanism 1108 may be, for example, a bracket extending from cleaning unit 1104 which is bolted or screwed to the framework illustrated in Figure 2b. Cleaning of a fairing, collar, tubular, etc. may be accomplished by inserting the fairing, collar, tubular, etc within the opening of body 1106 such that it contacts bristles 1110 extending from the inner surface and moving cleaning unit 1104 up, down and/or around the underlying structure.

Figure 12 illustrates a remotely operated vehicle (ROV) manipulating a cleaning device. ROV 1200 includes arm 1204 extending therefrom for

manipulation of cleaning device 200. Cleaning device 200 is suspended by line 1206 extending from surface structure 102. Similar to the system described in reference to Figure 1a, surface structure 102 is connected to subsurface structure 103 adjacent to seafloor 108 by tubular structure 104 (e.g. a riser). Fairing 114 is
5 installed along the length of riser 104 to counteract VIV. Collars 112a and 112b are further provided exterior to tubular structure 104 to keep fairing 114 from moving along the length of tubular structure 104.

Line 1206 may extend from surface structure 102 to cleaning device 200 to raise or lower cleaning device 200 within the water. Line 1206 may be made of any
10 material suitable for supporting cleaning device 200. Representatively, line 1206 may be made of any suitable synthetic material. In other embodiments, line 1206 may be made of a metal or metal alloy which is resistant to extreme temperatures and corrosion (e.g. Inconel®, a nickel-based superalloy). Line 1206 may be wound around a spring mounted spool attached to surface structure 102 to control
15 slack in line 1206 when cleaning device 200 is moved up and down along the structure being cleaned. In still further embodiments, other mechanisms and/or techniques may be used to control line 1206.

Line 1206 may be secured to cleaning device 200 by connector 210 extending from brace 206 of support plate 202. In addition to supporting cleaning
20 device 200, line 1206 may carry or be coupled to additional lines (not shown) that extend from surface structure 102 (e.g. a vessel or production platform) into cleaning device 200 for the purpose of operating various components of cleaning device 200. Representatively, a conduit for delivering water to nozzles within cleaning unit 204 or power lines to provide power to rotating bristles within
25 cleaning unit 204 may be run along an outer surface of line 1206. Additional conduits and lines may be attached to the outer surface of line 1206 by, for example, bands, clamps or by helically wrapping the additional lines around line 1206.

During operation, cleaning device 200 having cleaning unit 204 attached
30 thereto is lowered from surface structure 102 by line 1206. Arm 1204 of ROV 1200 attaches to cleaning device 200 (e.g. clamps to a portion of device 200) and is used to move cleaning device 200 toward fairing 114. Once cleaning unit 204 of cleaning device 200 contacts fairing 114, ROV 1200 may rotate cleaning device

200 and in turn cleaning unit 204 until cleaning unit 204 is properly positioned against fairing 114 and then push cleaning unit 204 around fairing 114. The lateral tension created on the first and second sections of cleaning unit 204 by, for example, the hinge, a tensioning device (e.g. spring) or the shape of the body
5 itself, as previously discussed, holds cleaning unit 204 around fairing 114. Once in position, arm 1204 of ROV 1200 may be used to move cleaning device 200, and in turn, cleaning unit 204 up or down along a length of fairing 114. Once a fairing 114 is cleaned, cleaning unit 204 may be released from fairing 114 by pulling cleaning unit 204 in a direction away from fairing 114 using arm 1204. The
10 process may then be repeated on the next fairing.

In still further embodiments where cleaning unit 204 is dimensioned to clean, for example, collars 112a and 112b or tubulars with strakes as previously discussed, arm 1204 of ROV 1200 may rotate cleaning unit 204 around the structure to be cleaned. Representatively, ROV 1200 may rotate cleaning device
15 200 around the structure a few feet or turns, release cleaning device 200 and then reattach cleaning device 200 to another portion of the structure or another structure all together to achieve the desired cleaning effect.

It is further contemplated that although only one cleaning unit 204 is shown, a plurality of cleaning units may be connected to the framework of support plate
20 202. The cleaning units may have the same or different dimensions. Representatively, in one embodiment, the cleaning units have different dimensions so that different types of structures (e.g. fairings, collars, tubulars, etc.) of different dimensions may be cleaned without having to raise cleaning device 200 back up to surface structure 102 to replace cleaning units. In still further embodiments,
25 support plate 202 may be omitted and cleaning unit 204 attached directly to ROV 1204 or held by a diver.

As previously discussed, fairings may be replaced with strakes, shrouds, wake splitters, tail fairings, buoyancy modules, or other devices as are known in the art. Suitable sleeves, suitable collars, and suitable devices for installation
30 exterior to structures, and methods of their installation are disclosed in U.S. Patent Application Number 10/839,781, having attorney docket number TH1433; U.S. Patent Application Number 11/400,365, having attorney docket number TH0541; U.S. Patent Application Number 11/419,964, having attorney docket number

TH2508; U.S. Patent Application Number 11/420,838, having attorney docket number TH2876; U.S. Patent Application Number 60/781,846 having attorney docket number TH2969; U.S. Patent Application Number 60/805,136, having attorney docket number TH1500; U.S. Patent Application Number 60/866,968, 5 having attorney docket number TH3112; U.S. Patent Application Number 60/866,972, having attorney docket number TH3190; U.S. Patent Number 5,410,979; U.S. Patent Number 5,410,979; U.S. Patent Number 5,421,413; U.S. Patent Number 6,179,524; U.S. Patent Number 6,223,672; U.S. Patent Number 6,561,734; U.S. Patent Number 6,565,287; U.S. Patent Number 6,571,878; U.S. 10 Patent Number 6,685,394; U.S. Patent Number 6,702,026; U.S. Patent Number 7,017,666; and U.S. Patent Number 7,070,361, which are herein incorporated by reference in their entirety.

Suitable methods for installing fairings, collars, and other devices installed exterior to structures, are disclosed in U.S. Patent Application Number 10/784,536, 15 having attorney docket number TH1853.04; U.S. Patent Application Number 10/848,547, having attorney docket number TH2463; U.S. Patent Application Number 11/596,437, having attorney docket number TH2900; U.S. Patent Application Number 11/468,690, having attorney docket number TH2926; U.S. Patent Application Number 11/612,203, having attorney docket number TH2875; 20 U.S. Patent Application Number 60/806,882, having attorney docket number TH2879; U.S. Patent Application Number 60/826,553, having attorney docket number TH2842; U.S. Patent Number 6,695,539; U.S. Patent Number 6,928,709; and U.S. Patent Number 6,994,492; which are herein incorporated by reference in their entirety.

25 The fairings may be installed on the tubular member (e.g. buoyancy material and riser) before or after the tubular member is placed in a body of water.

The fairings and/or other devices exterior to the structure may have a clamshell configuration, and may be hinged with a closing mechanism opposite the hinge, for example a mechanism that can be operated with an ROV.

30 Fairings may be provided with copper plates on their ends to allow them to weathervane with adjacent fairings or collars.

Fairings may be partially manufactured from copper.

Illustrative Embodiments:

In one embodiment, there is disclosed an offshore structure cleaning system comprising a frame, at least one set of clamps supported by the frame, a cleaning mechanism on an interior of the set of clamps, the cleaning mechanism adapted to clean an offshore structure. In some embodiments, the cleaning mechanism comprises at least one of brushes, bristles, rotating brushes, moving brushes, scrapers, and spray nozzles. In some embodiments, the clamps are moveable from an open position to a closed position. In some embodiments, the system also includes at least one cam, wherein the clamps are adapted to move from an open position to a closed position when the cam engages an offshore structure. In some embodiments, the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a fairing when in a closed position. In some embodiments, the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a strake when in a closed position. In some embodiments, the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a pipe when in a closed position. In some embodiments, the frame is adapted to interface with a remotely operated vehicle (ROV). In some embodiments, the system is adapted to move longitudinally along a length of the structure in order to clean the structure. In some embodiments, the system is adapted to be rotated about a circumference of the structure in order to clean the structure. In some embodiments, there are at least two sets of clamps supported by the frame. In some embodiments, each set of clamps comprises a different cleaning mechanism. In some embodiments, a first clamp and a second clamp each comprise at least one cleaning mechanism.

In one embodiment, there is disclosed a method of cleaning an offshore structure, the method comprising positioning a clamshell tool adjacent to the structure, wherein the clamshell tool carries a cleaning mechanism, moving the clamshell tool in an open configuration to position the clamshell device around the structure, closing the clamshell tool from the open configuration to a closed configuration to close the clamshell device around the structure, and cleaning at least a portion of the structure with the cleaning mechanism. In some embodiments, the clamshell tool covers from about 50% to about 100% of the circumference of the structure. In some embodiments, the structure comprises a

fairing. In some embodiments, the structure comprises a helical strake. In some
embodiments, the structure comprises a pipe. In some embodiments, the tool is
operated underwater with a remotely operated vehicle. In some embodiments, the
cleaning mechanism comprises a brush, wherein cleaning at least a portion of the
5 structure comprises moving the tool along a length of the structure. In some
embodiments, the cleaning mechanism comprises a brush, wherein cleaning at
least a portion of the structure comprises rotating the tool about a circumference of
the structure. In some embodiments, the cleaning mechanism comprises a brush,
further comprising rotating the brush. In some embodiments, the cleaning
10 mechanism comprises a nozzle, further comprising spraying a fluid through the
nozzle. In some embodiments, the cleaning mechanism comprises a scraper,
wherein cleaning at least a portion of the structure comprises moving the tool
along a length of the structure.

Those of skill in the art will appreciate that many modifications and
15 variations are possible in terms of the disclosed embodiments, configurations,
materials and methods without departing from their spirit and scope. Accordingly,
the scope of the claims appended hereafter and their functional equivalents should
not be limited by particular embodiments described and illustrated herein, as these
are merely exemplary in nature.

20

C L A I M S

1. An offshore structure cleaning system comprising:
 - a frame;
 - 5 at least one set of clamps supported by the frame;
 - a cleaning mechanism on an interior of the set of clamps, the cleaning mechanism adapted to clean an offshore structure.
- 10 2. The system of claim 1, wherein the cleaning mechanism comprises at least one of brushes, bristles, rotating brushes, moving brushes, scrapers, and spray nozzles.
3. The system of one or more of claims 1-2, wherein the clamps are moveable from an open position to a closed position.
- 15 4. The system of one or more of claims 1-3, further comprising at least one cam, wherein the clamps are adapted to move from an open position to a closed position when the cam engages an offshore structure.
- 20 5. The system of one or more of claims 1-4, wherein the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a fairing when in a closed position.
- 25 6. The system of one or more of claims 1-5, wherein the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a strake when in a closed position.
- 30 7. The system of one or more of claims 1-6, wherein the clamps are adapted to cover from about 270 to about 360 degrees about the exterior of a pipe when in a closed position.
8. The system of one or more of claims 1-7, wherein the frame is adapted to interface with a remotely operated vehicle (ROV).

9. The system of one or more of claims 1-8, wherein the system is adapted to move longitudinally along a length of the structure in order to clean the structure.
10. The system of one or more of claims 1-9, wherein the system is adapted to be
5 rotated about a circumference of the structure in order to clean the structure.
11. The system of one or more of claims 1-10, wherein there are at least two sets of clamps supported by the frame.
- 10 12. The system of claim 11, wherein each set of clamps comprises a different cleaning mechanism.
13. The system of one or more of claims 1-12, wherein a first clamp and a second clamp each comprise at least one cleaning mechanism.
- 15 14. The system of one or more of claims 1-13, wherein at least one of a first clamp and a second clamp comprise perforations.
15. The system of claim 14, wherein at least one of the first clamp and the second
20 comprise from about 20% to about 70% perforations by area, wherein the perforations allow debris to exit a cleaning area.
16. The system of one or more of claims 1-15, further comprising a line connected at a first end to the frame and a second end to a structure at a water surface.
- 25 17. The system of claim 16, wherein the line comprises one or more hydraulic lines from the water surface to the frame.
18. The system of one or more of claims 1-17, further comprising a vibration
30 causing apparatus connected to the frame, and adapted to vibrate the cleaning mechanism.

19. The system of claim 18, wherein the vibration causing apparatus is selected from a motor, a rotary, and a propeller.
20. A method of cleaning an offshore structure, the method comprising:
- 5 positioning a clamshell tool adjacent to the structure, wherein the clamshell tool carries a cleaning mechanism;
- moving the clamshell tool in an open configuration to position the clamshell device around the structure;
- closing the clamshell tool from the open configuration to a closed
- 10 configuration to close the clamshell device around the structure; and
- cleaning at least a portion of the structure with the cleaning mechanism.
21. The method of claim 20, wherein the clamshell tool covers from about 50% to about 100% of the circumference of the structure.
- 15
22. The method of one or more of claims 20-21, wherein the structure comprises a fairing.
23. The method of one or more of claims 20-22, wherein the structure comprises
- 20 a helical strake.
24. The method of one or more of claims 20-23, wherein the structure comprises a pipe.
- 25
25. The method of one or more of claims 20-24, wherein the tool is operated underwater with a remotely operated vehicle.
26. The method of one or more of claims 20-25, wherein the cleaning mechanism comprises a brush, wherein cleaning at least a portion of the structure comprises
- 30 moving the tool along a length of the structure.

27. The method of one or more of claims 20-26, wherein the cleaning mechanism comprises a brush, wherein cleaning at least a portion of the structure comprises rotating the tool about a circumference of the structure.

5 28. The method of one or more of claims 20-27, wherein the cleaning mechanism comprises a brush, further comprising rotating the brush.

29. The method of one or more of claims 20-28, wherein the cleaning mechanism comprises a nozzle, further comprising spraying a fluid through the nozzle.

10

30. The method of one or more of claims 20-29, wherein the cleaning mechanism comprises a scraper, wherein cleaning at least a portion of the structure comprises moving the tool along a length of the structure.

15

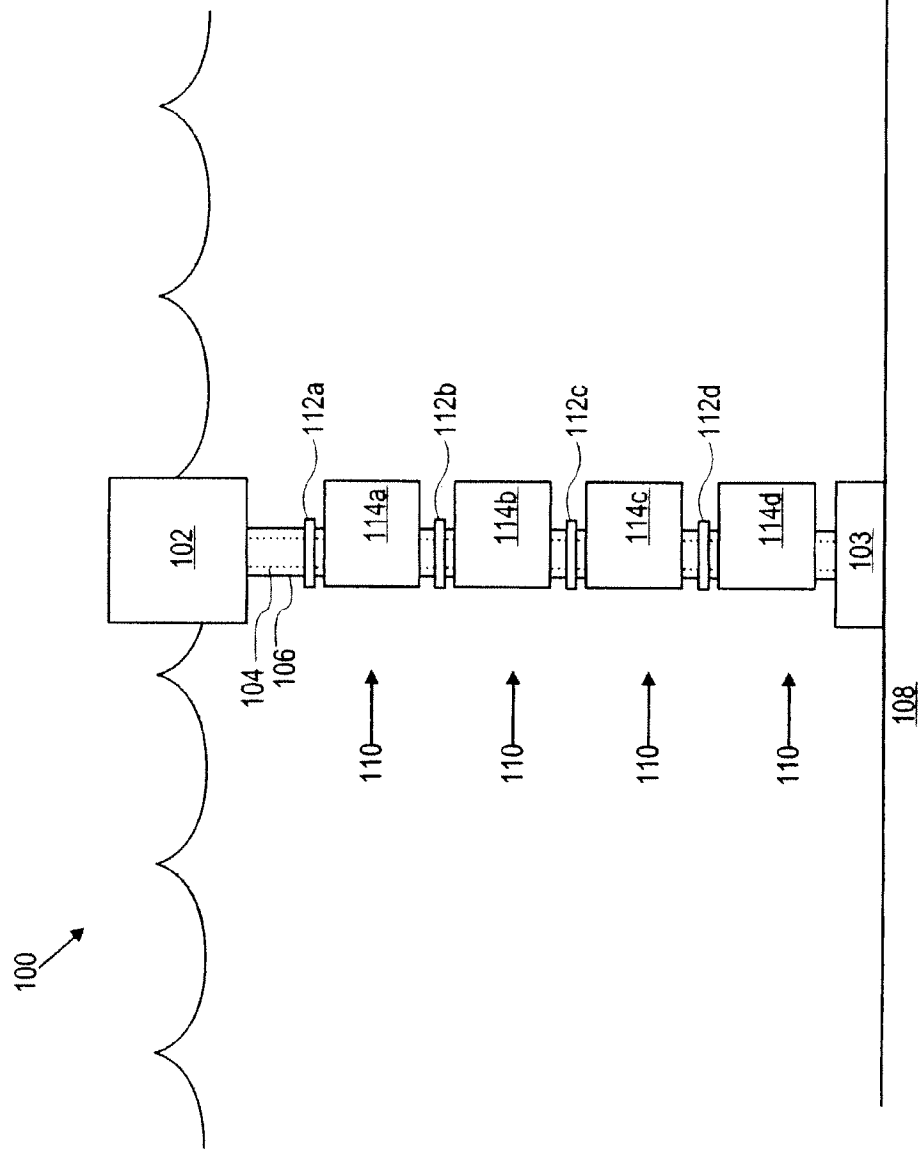


FIG. 1a

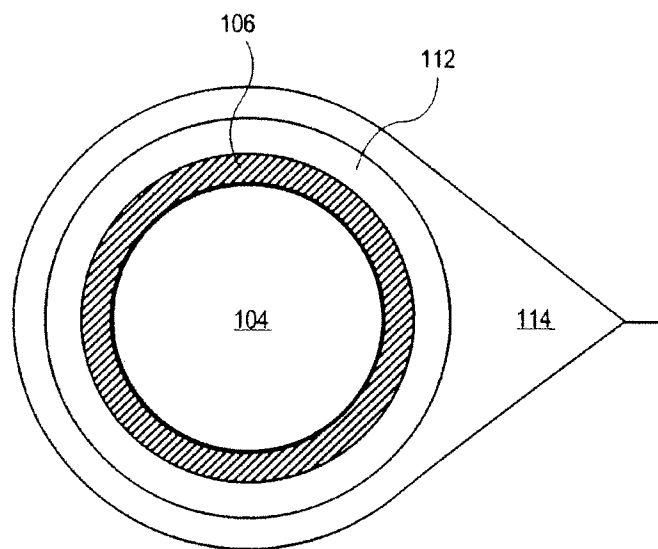


FIG. 1b

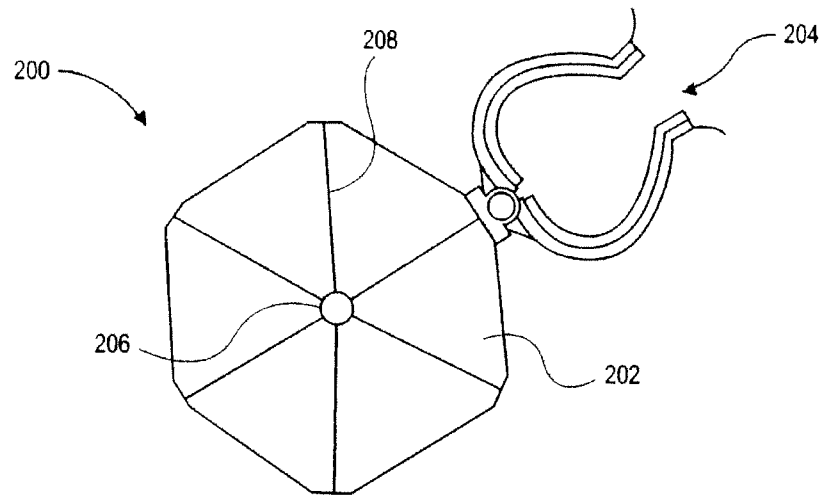


FIG. 2a

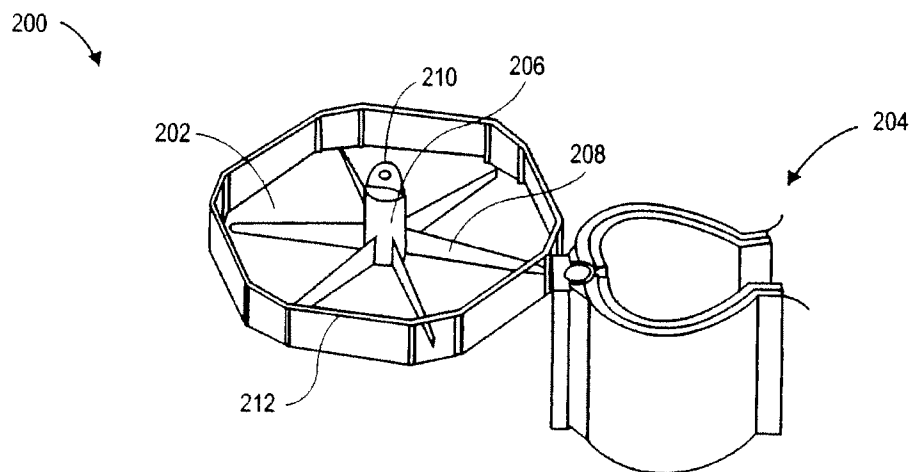
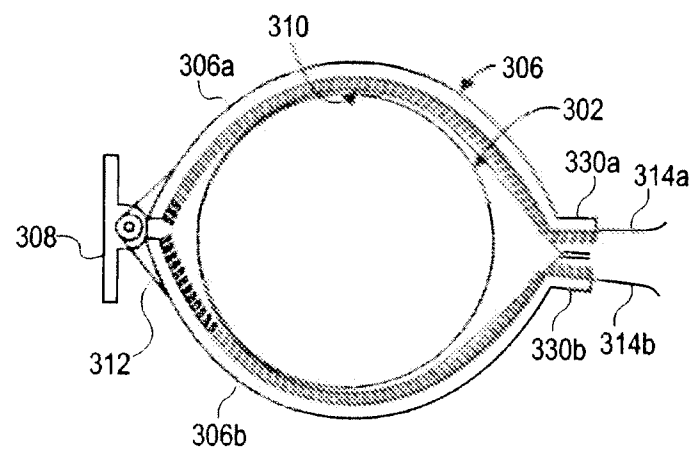
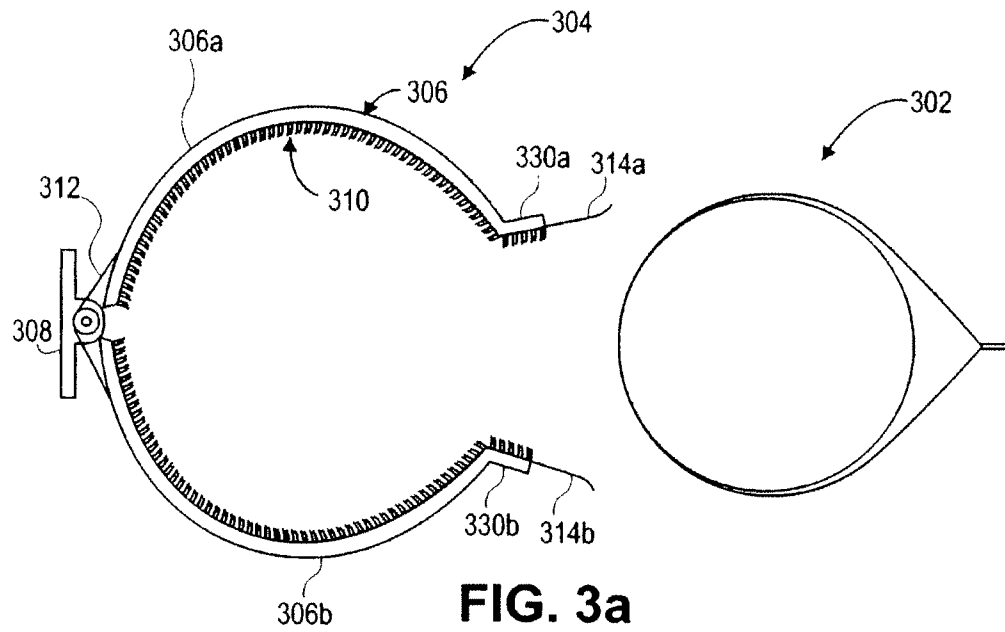
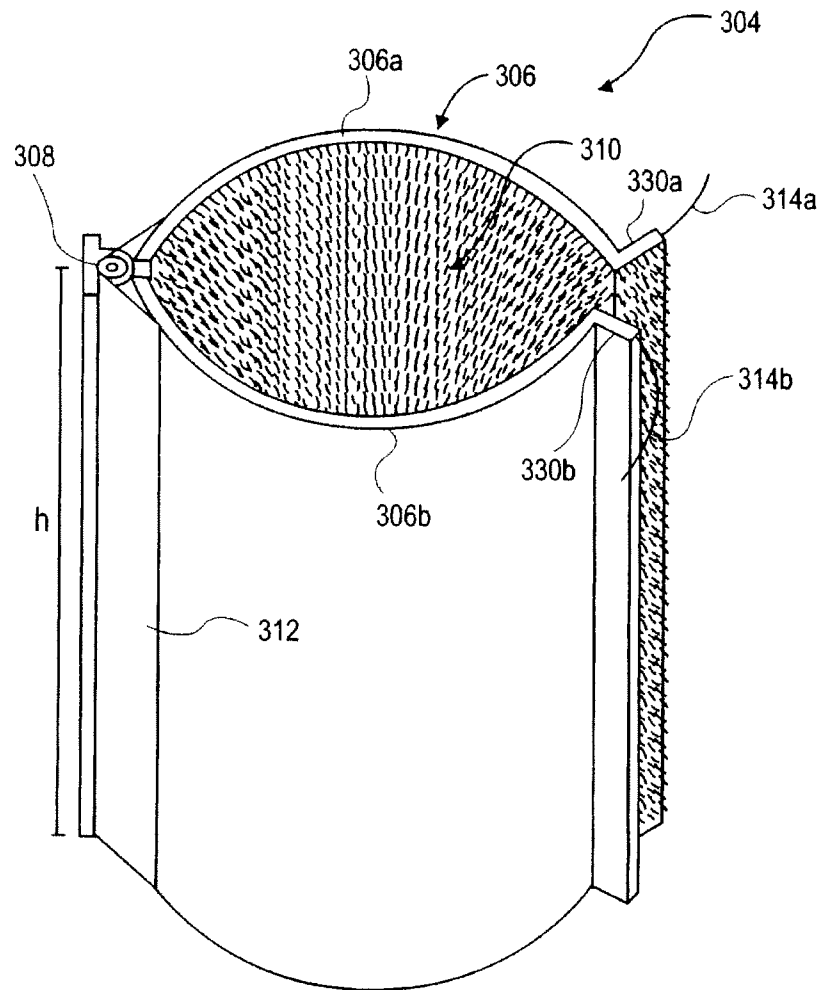
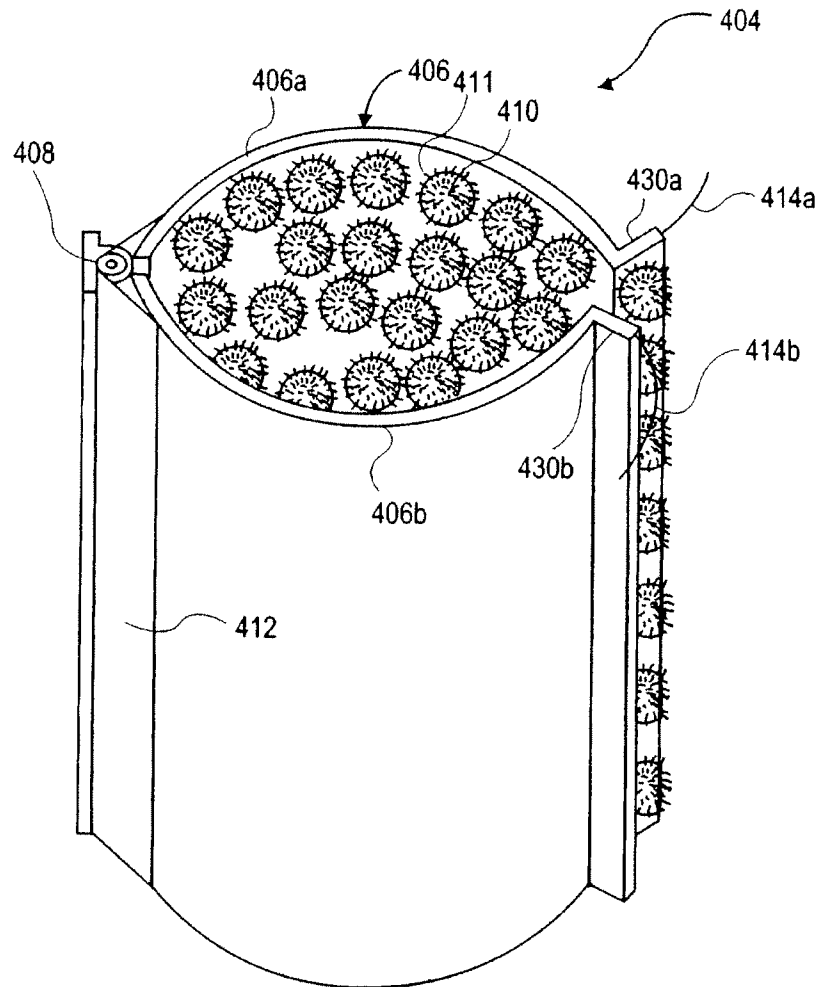
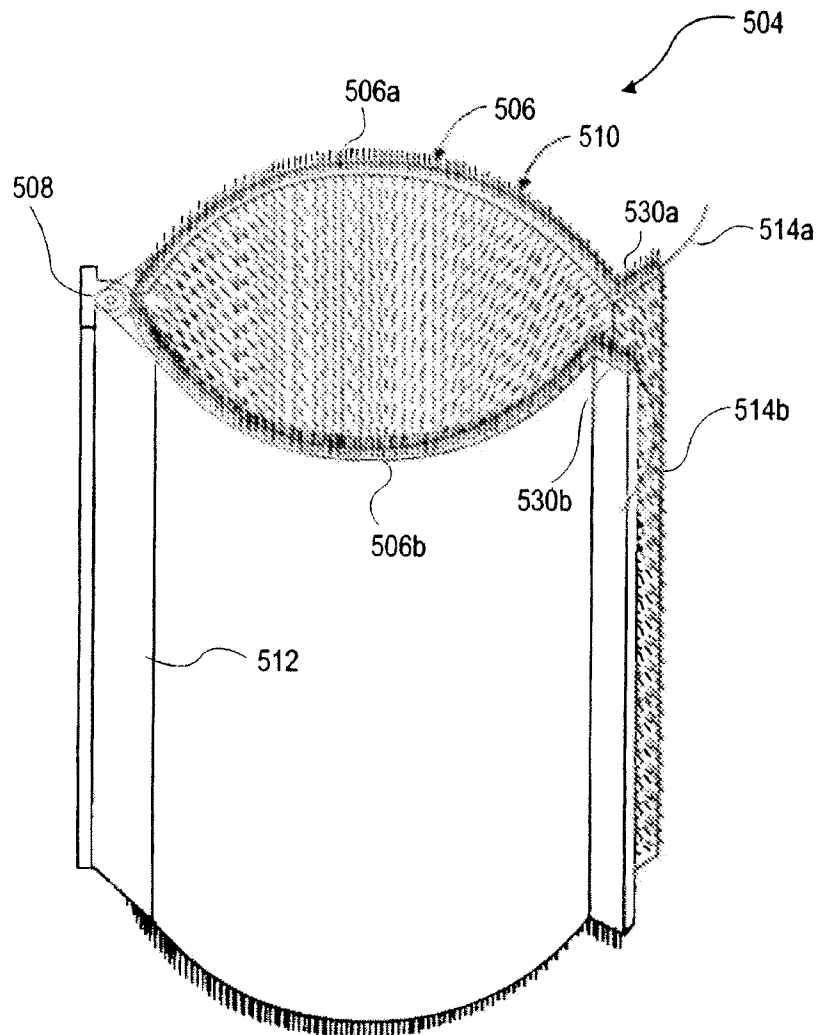


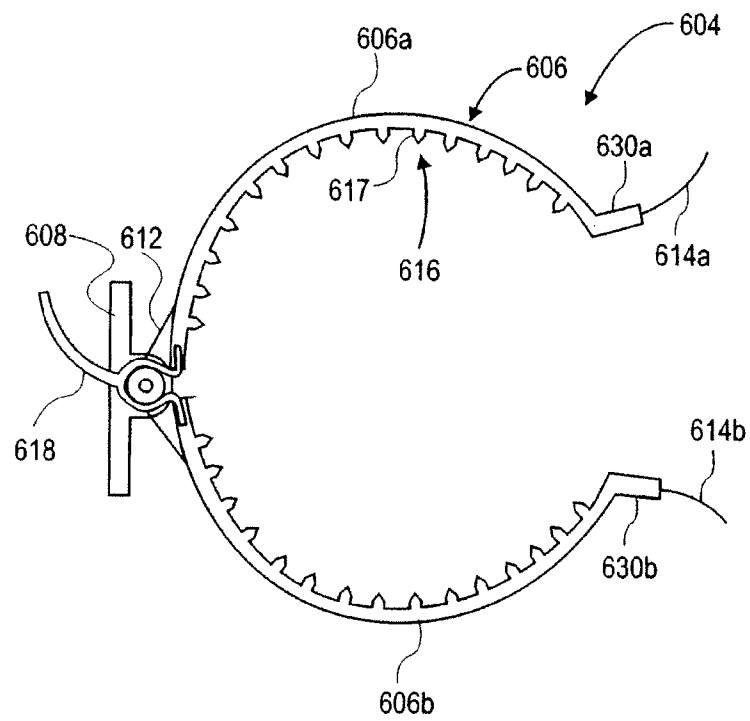
FIG. 2b



**FIG. 3c**

**FIG. 4**

**FIG. 5**

**FIG. 6**

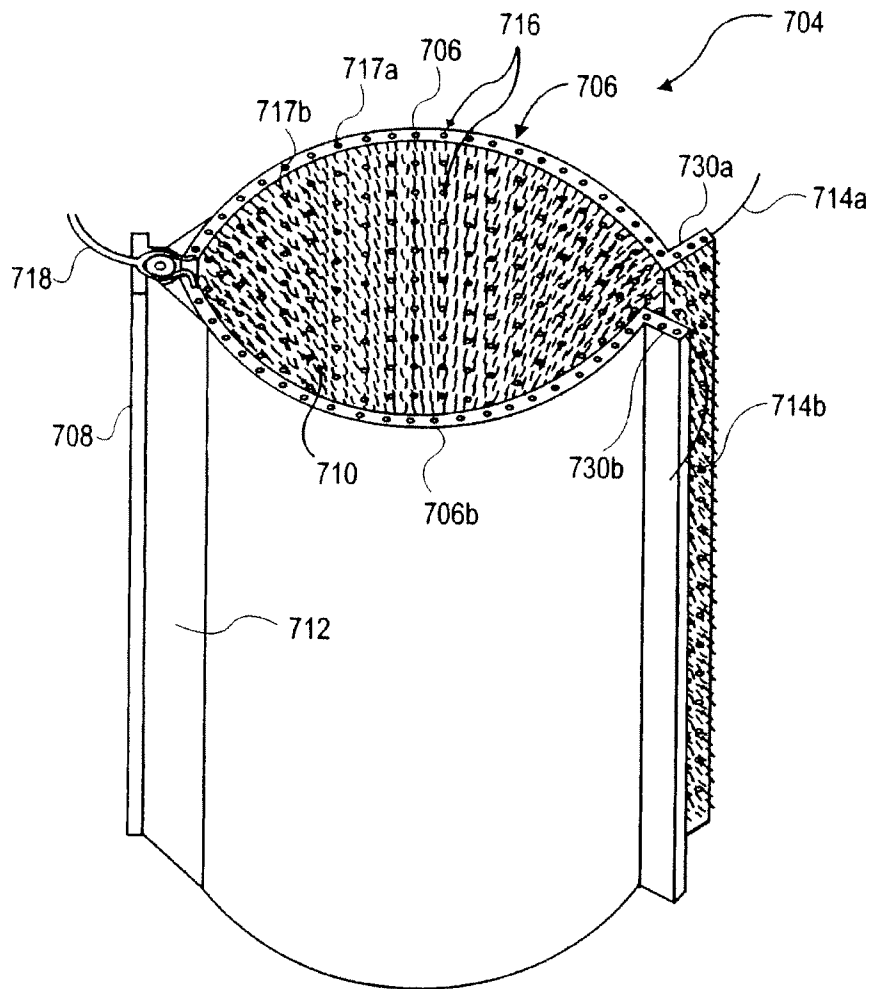
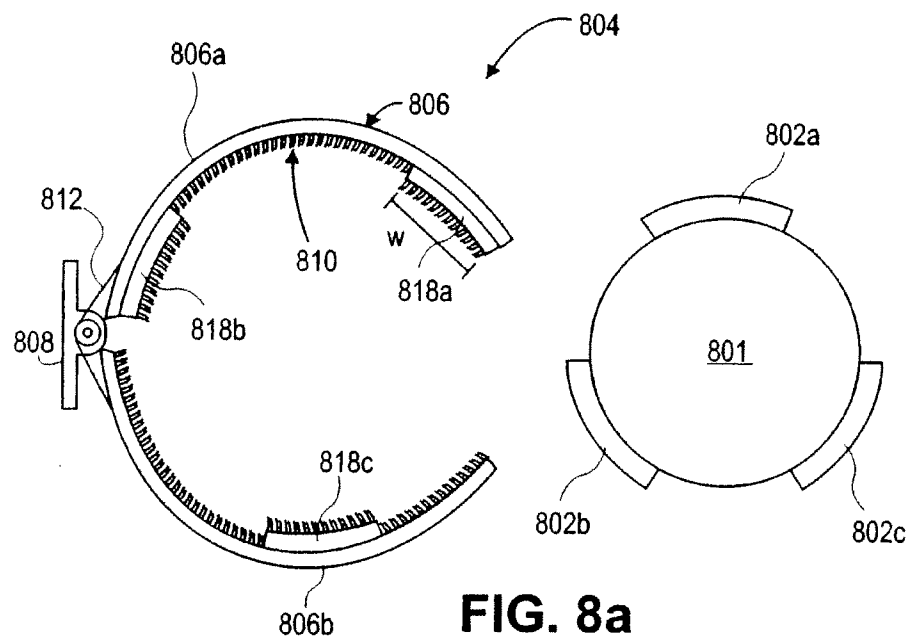


FIG. 7



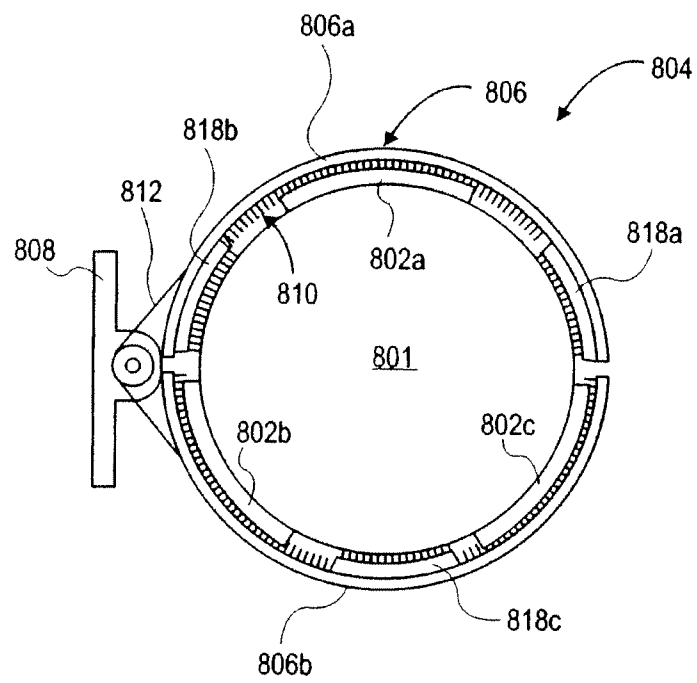
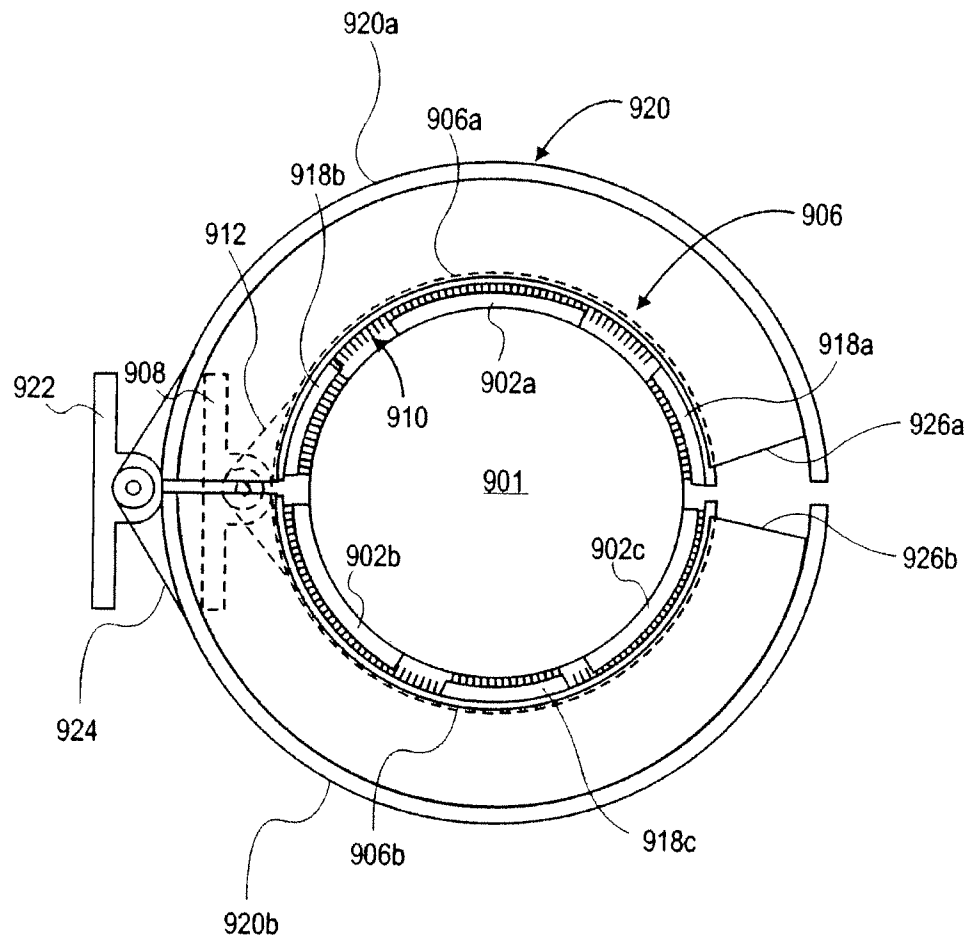


FIG. 8b

**FIG. 9**

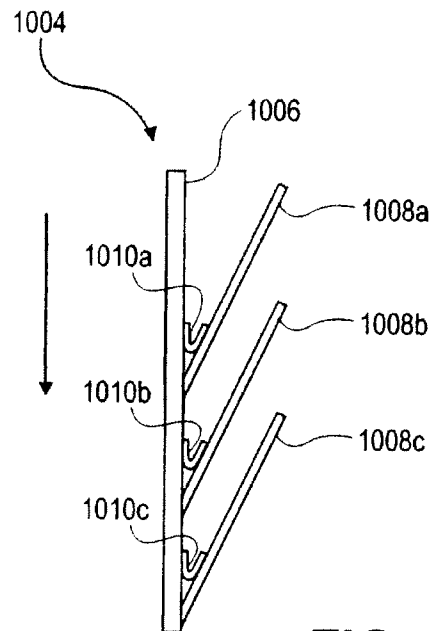


FIG. 10a

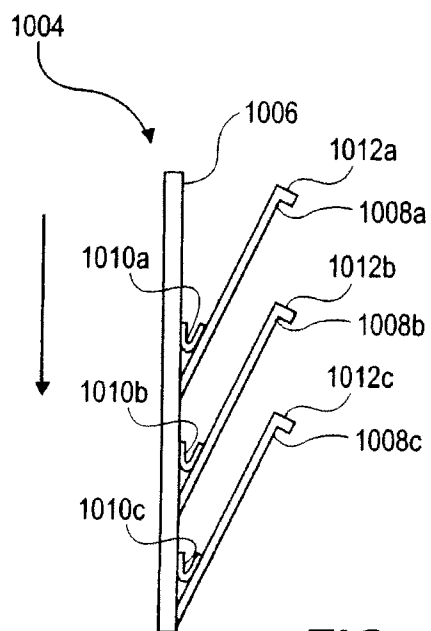


FIG. 10b

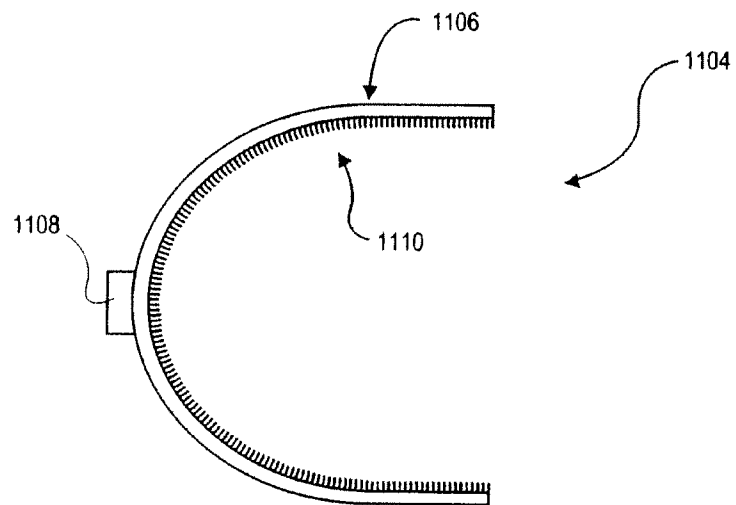


FIG. 11

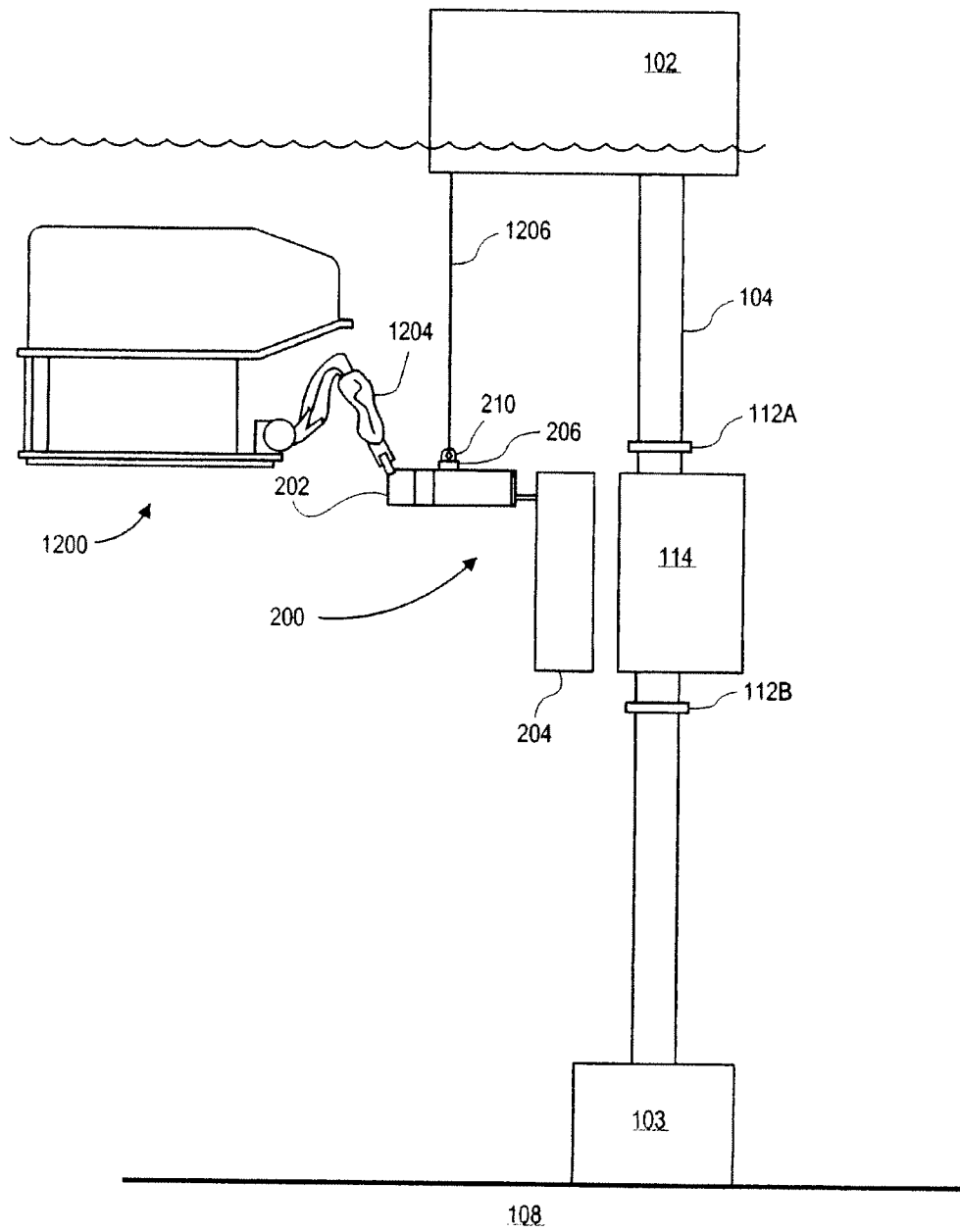


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 09/31508

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E02D 5/60 (2009.01)

USPC - 405/211

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): E02D 5/60 (2009.01)

USPC: 405/211

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

IPC(8): E02D 5/60 (2009.01) - see search terms below

USPC: 405/211, 195, 224.2 - see search terms below

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

PubWEST(USPT,PGPB,EPAB,JPAB); DialogPRO(Engineering); GoogleScholar

Search Terms: Subsea, structure, riser, fairing, vortex, induced, vibration, growth, marine, barnacle, seaweed, clean, scrub, polish, scour, rub, polish, descale, brush, bristle, scrape, nozzle, jet, offshore, remove, clamp, pipe

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,205,694 A (THOMPSON et al.) 03 June 1980 (03.06.1980), entire document especially Fig 1-3a, col 2, ln 41-42, col 2, ln 45-49, col 6, ln 20-22	1-2 and 20-21
Y	US 5,765,968 A (LEE) 16 June 1998 (16.06.1998), Fig 3a	1-2 and 20-21
A	US 5,722,340 A (SWEETMAN) 03 March 1998 (08.03.1998), Fig 1	22
A	US 5,026,212 A (DO) 25 June 1991 (25.06.1991), entire document	1-2 and 20-21

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


* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

23 February 2009 (23.02.2009)

Date of mailing of the international search report

10 MAR 2009

Name and mailing address of the ISA/US

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

Facsimile No. 571-273-3201

Authorized officer:

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 09/31508

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 3-19, 22-30
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

Remark on Protest

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