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(54) SYSTEMS AND METHODS FOR INSTALLATION OF CLAMSHELL DEVICES AROUND AN ELEMENT

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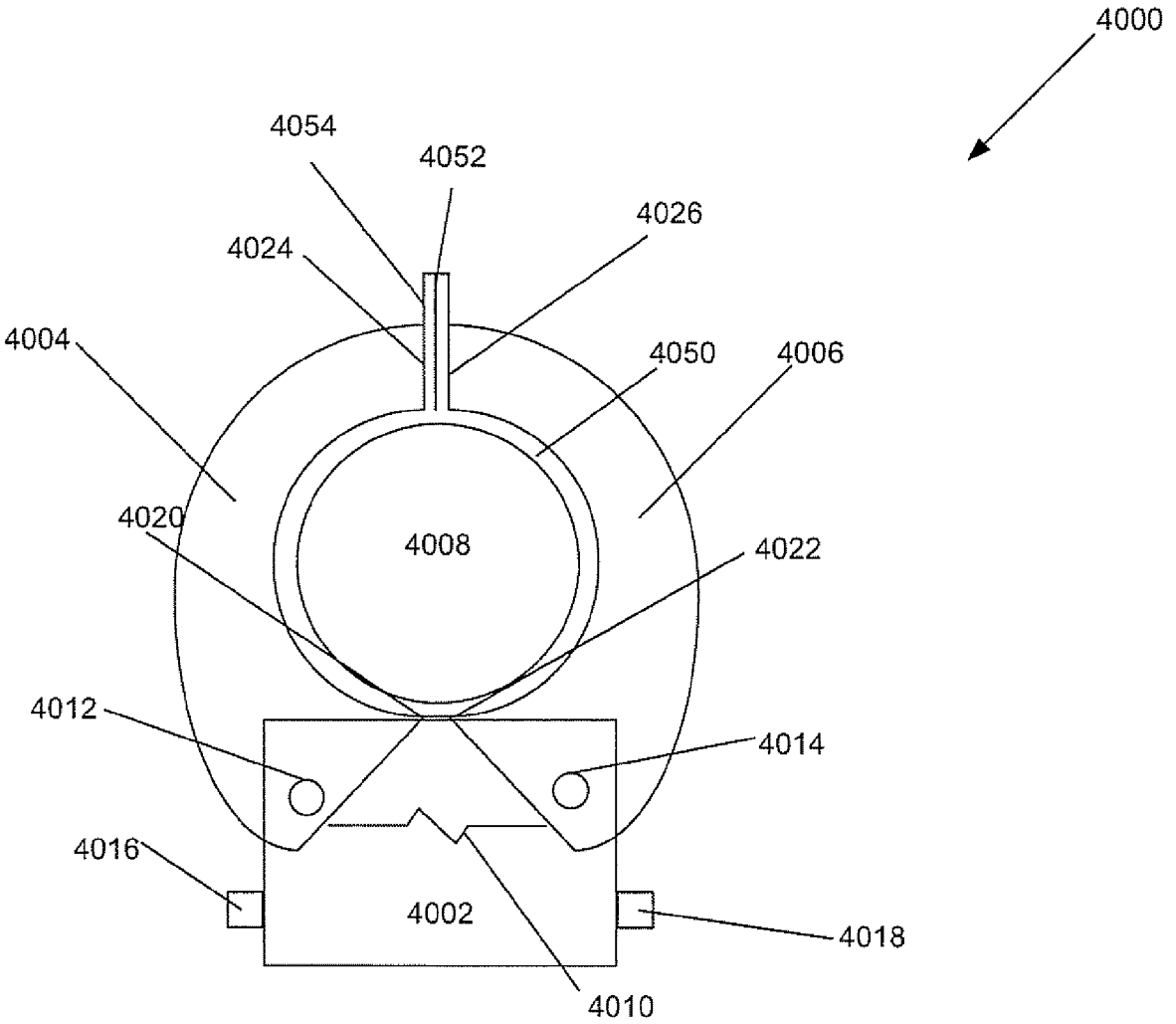
(57) **ABSTRACT**

Systems and methods for remotely installing a clamshell device around an element, the clamp system comprising a body; and at least one set of clamps supported by the body, the set suitable for holding and releasing the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices, wherein at least one clamp comprises a cam surface adapted to engage the element and close the clamp about the element.



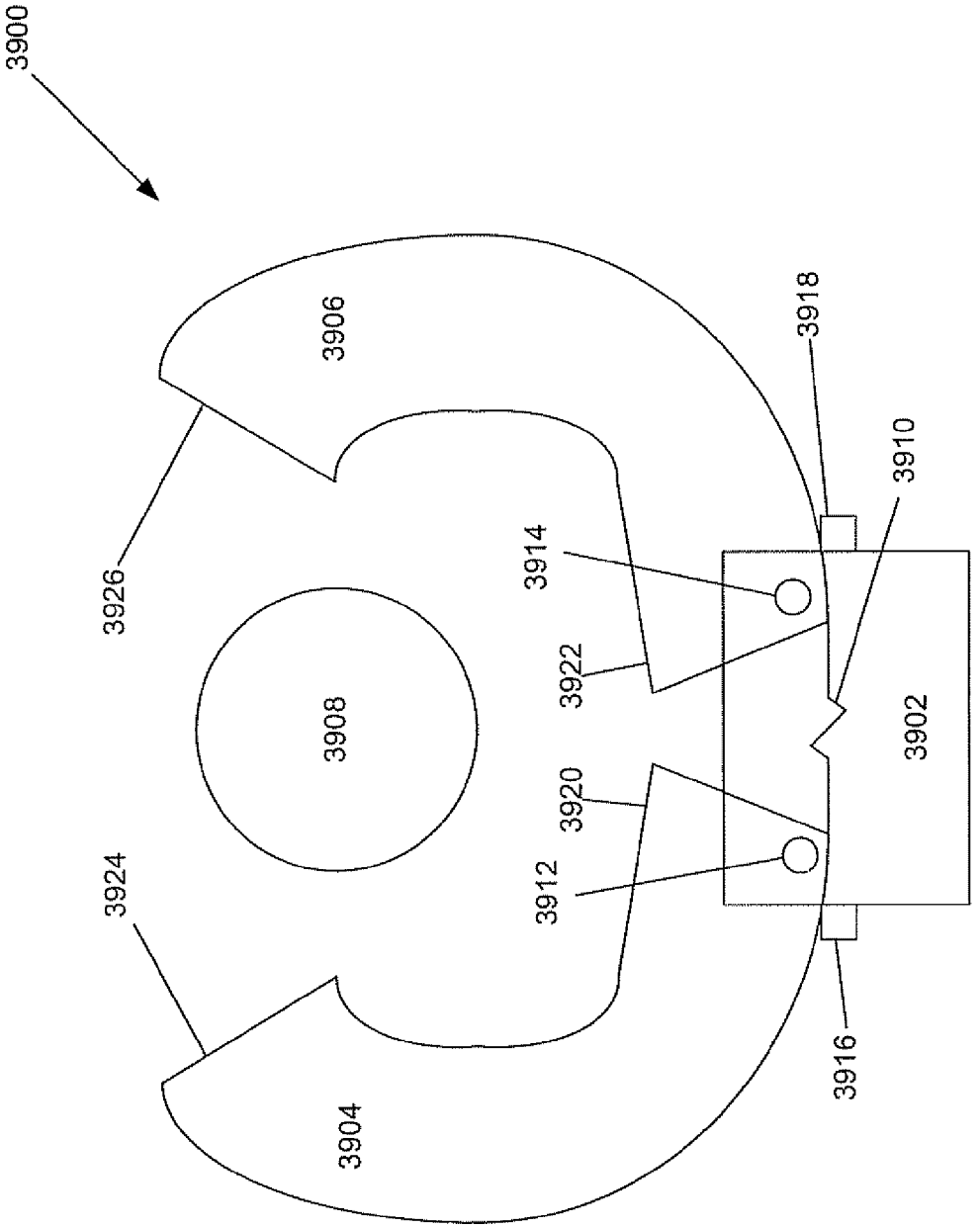

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Figure 1

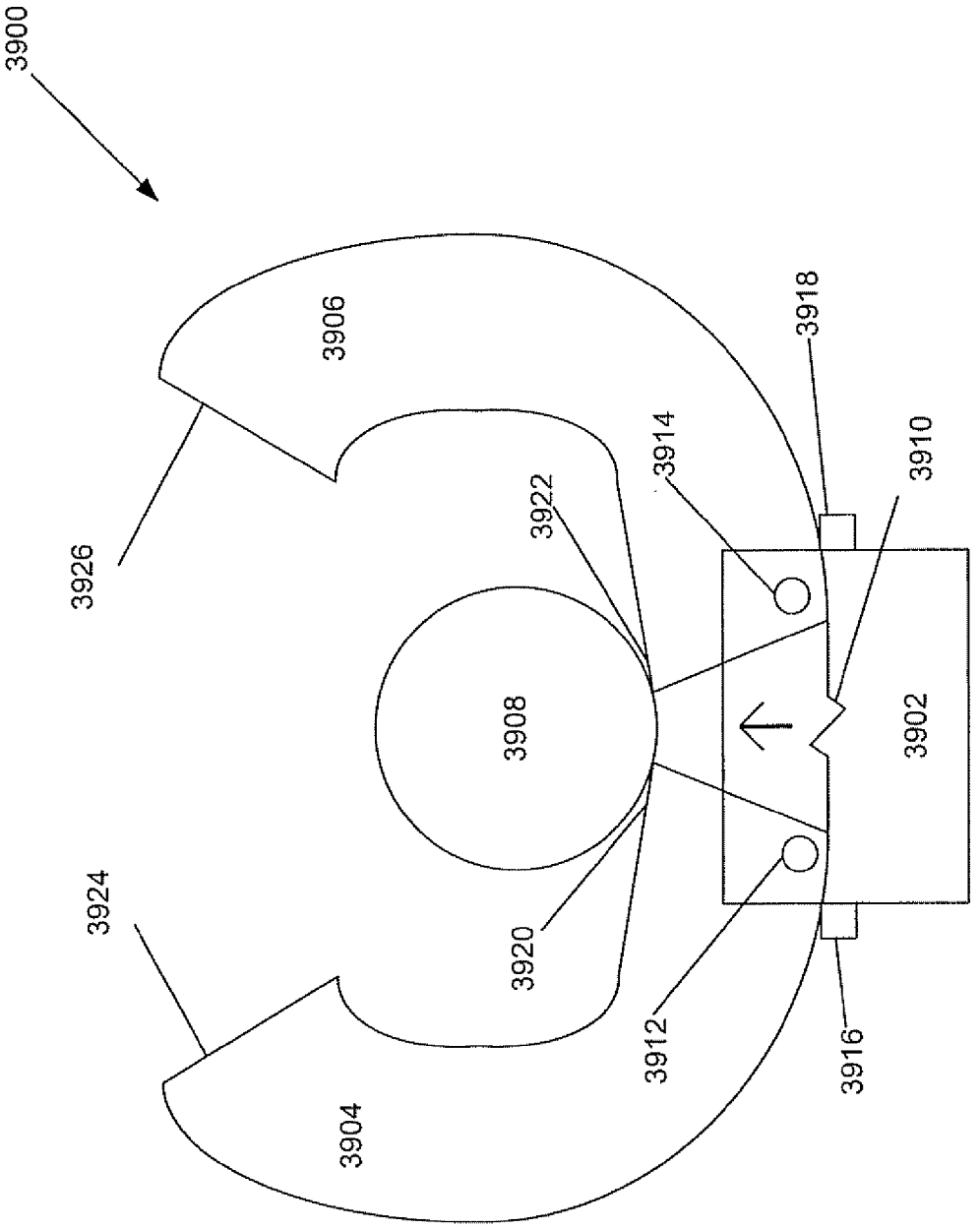
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Figure 2

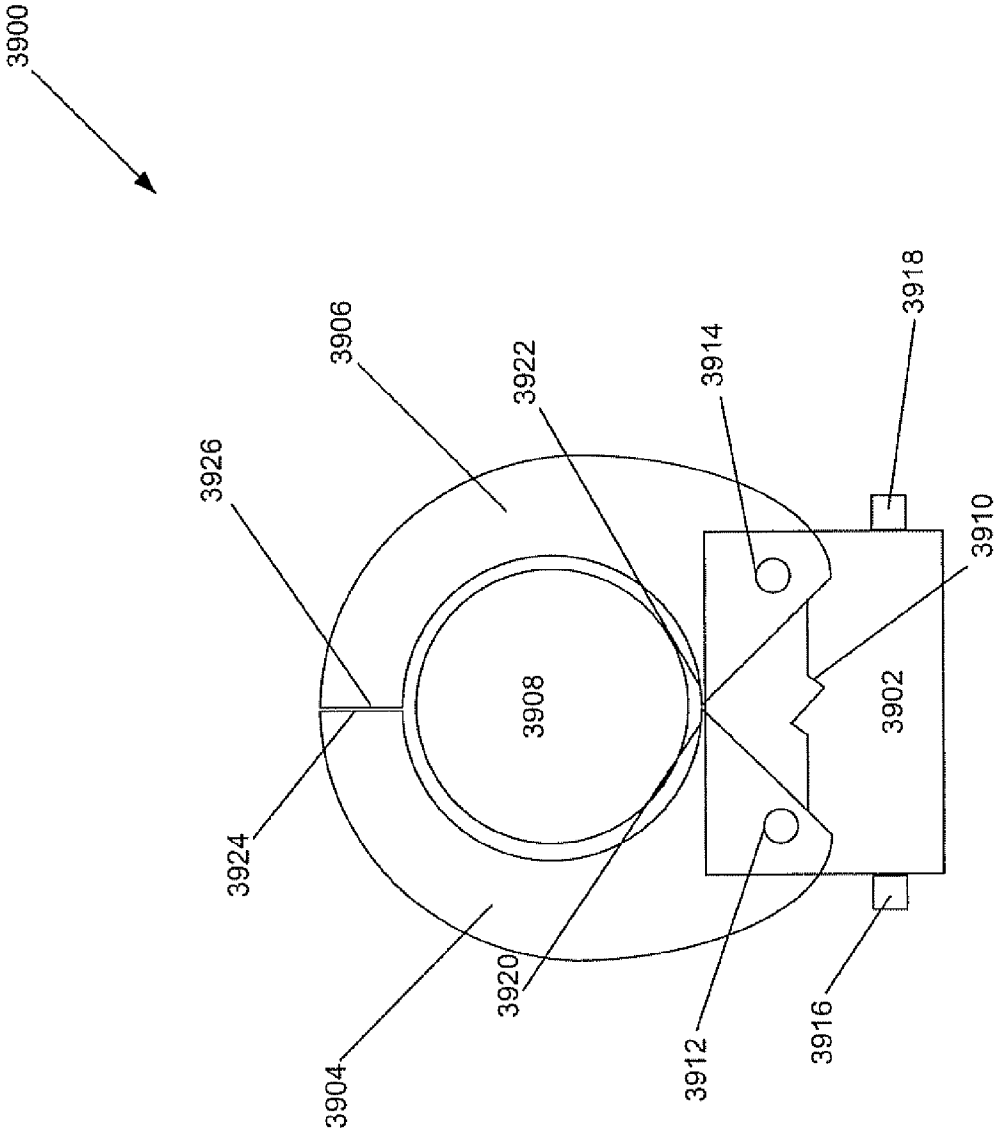
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Figure 3

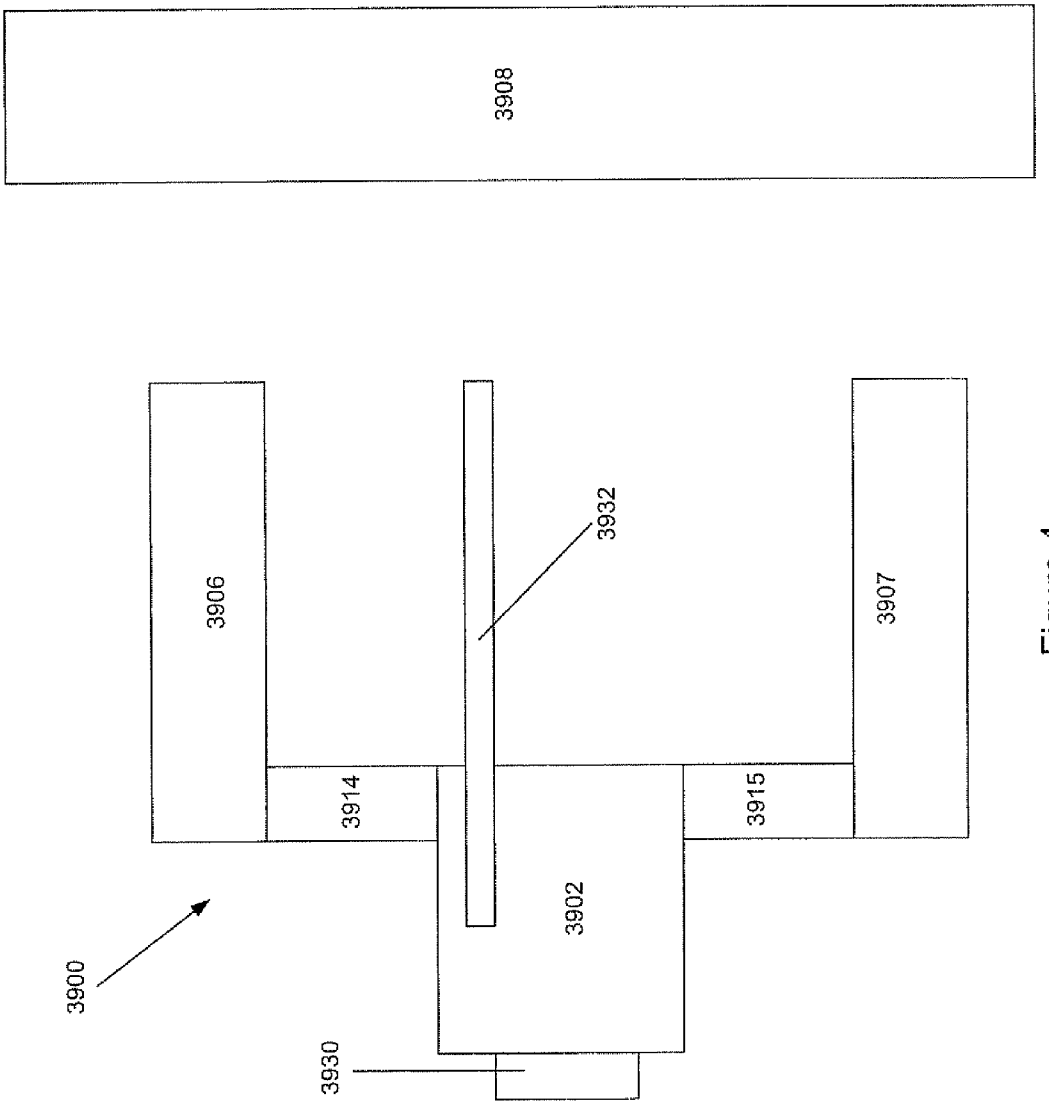

Figure 4

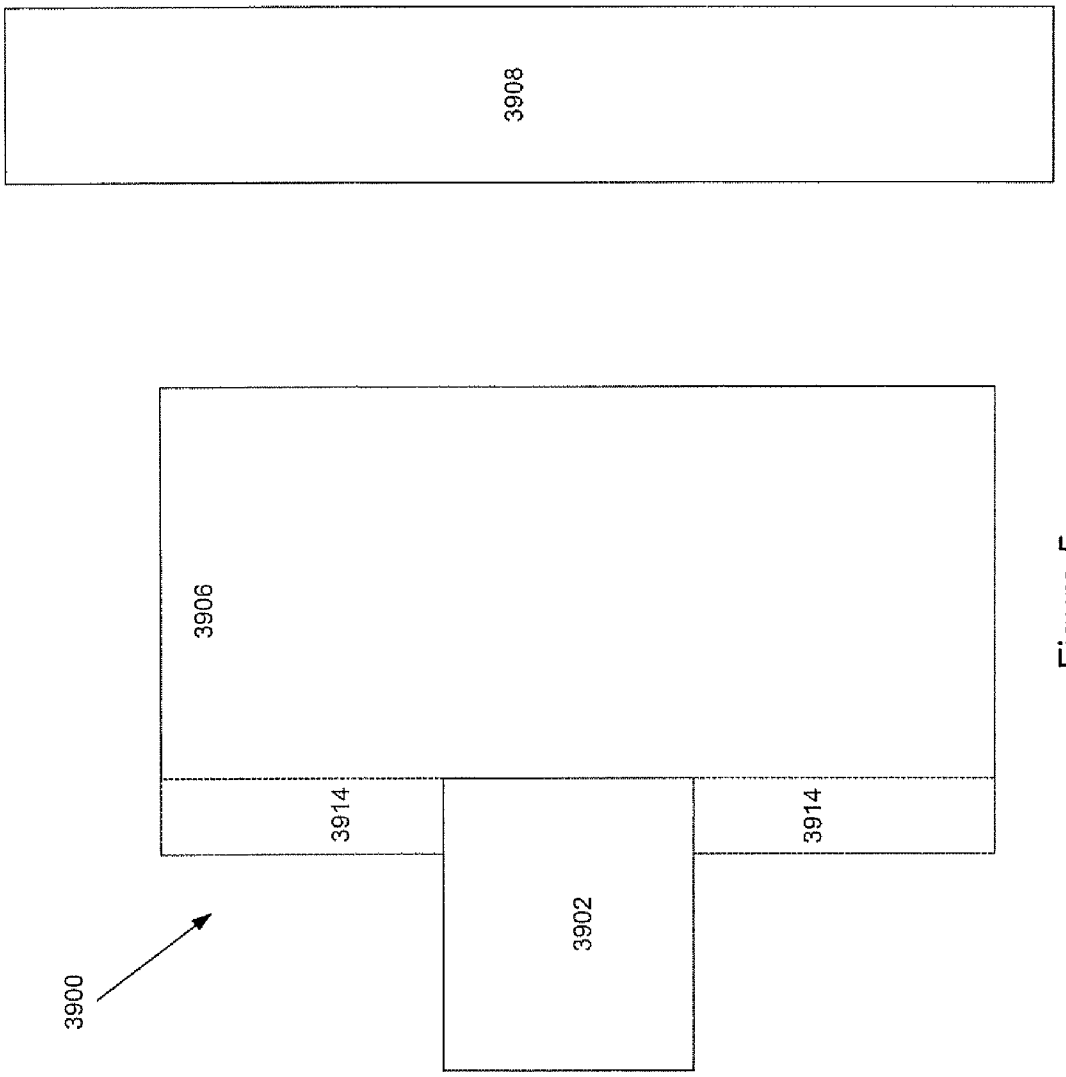

Figure 5

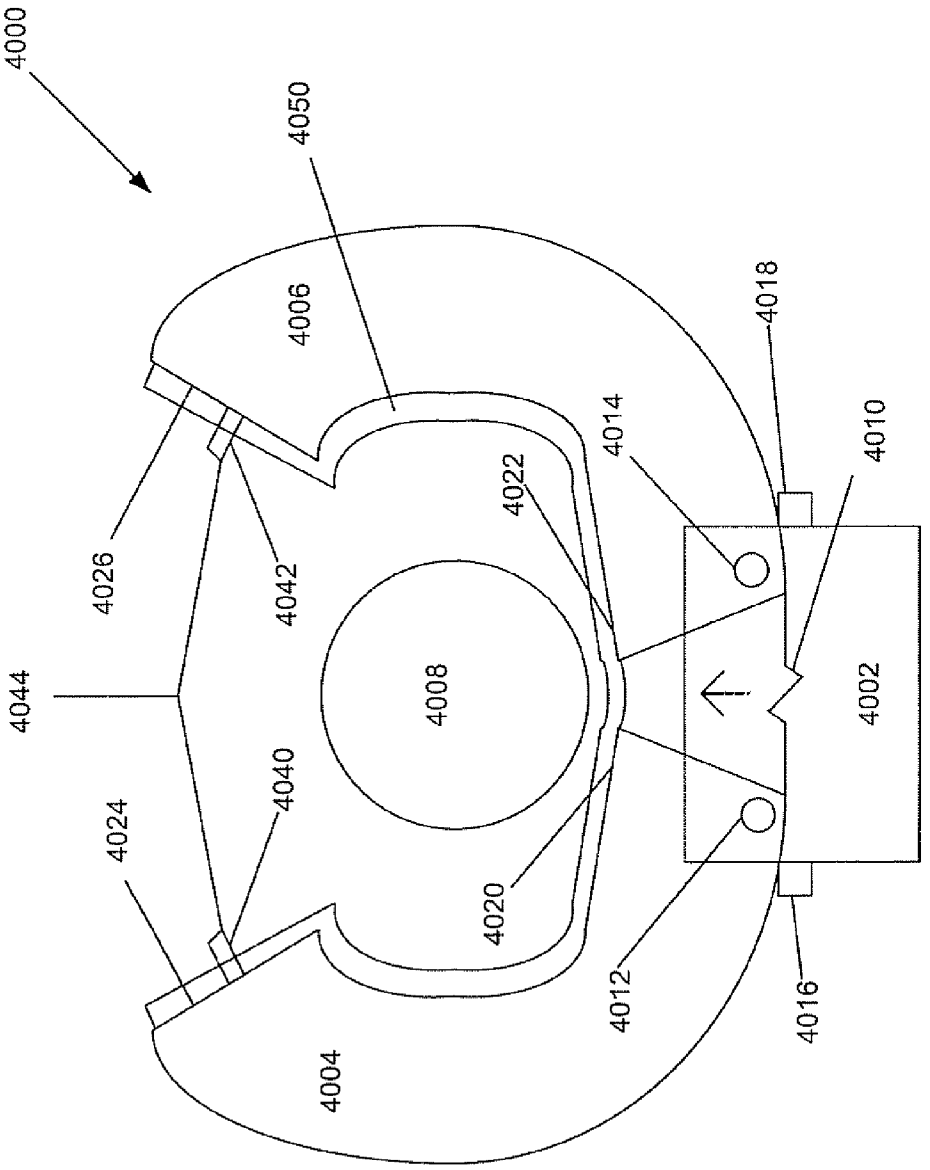
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Figure 6

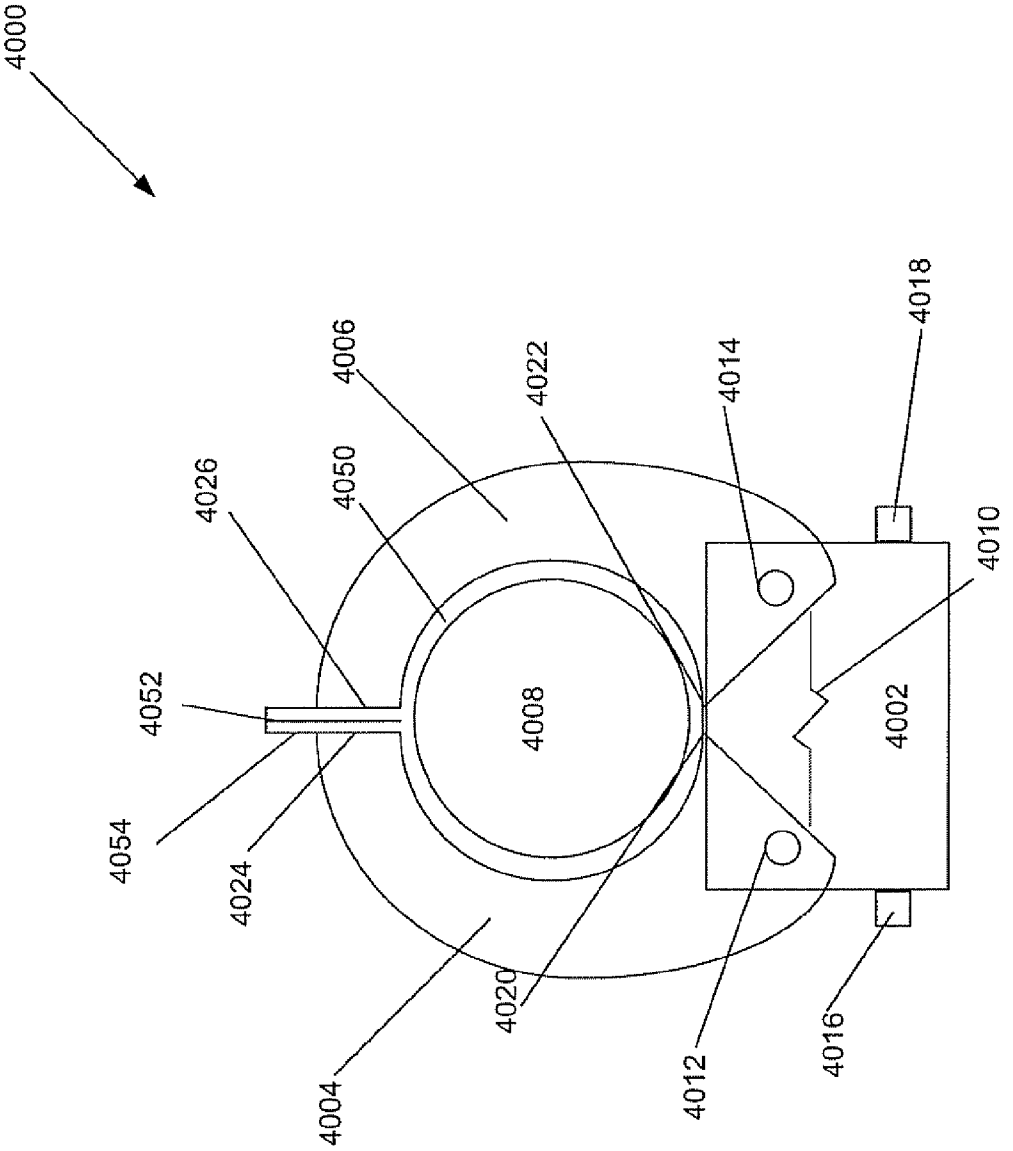
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Figure 7

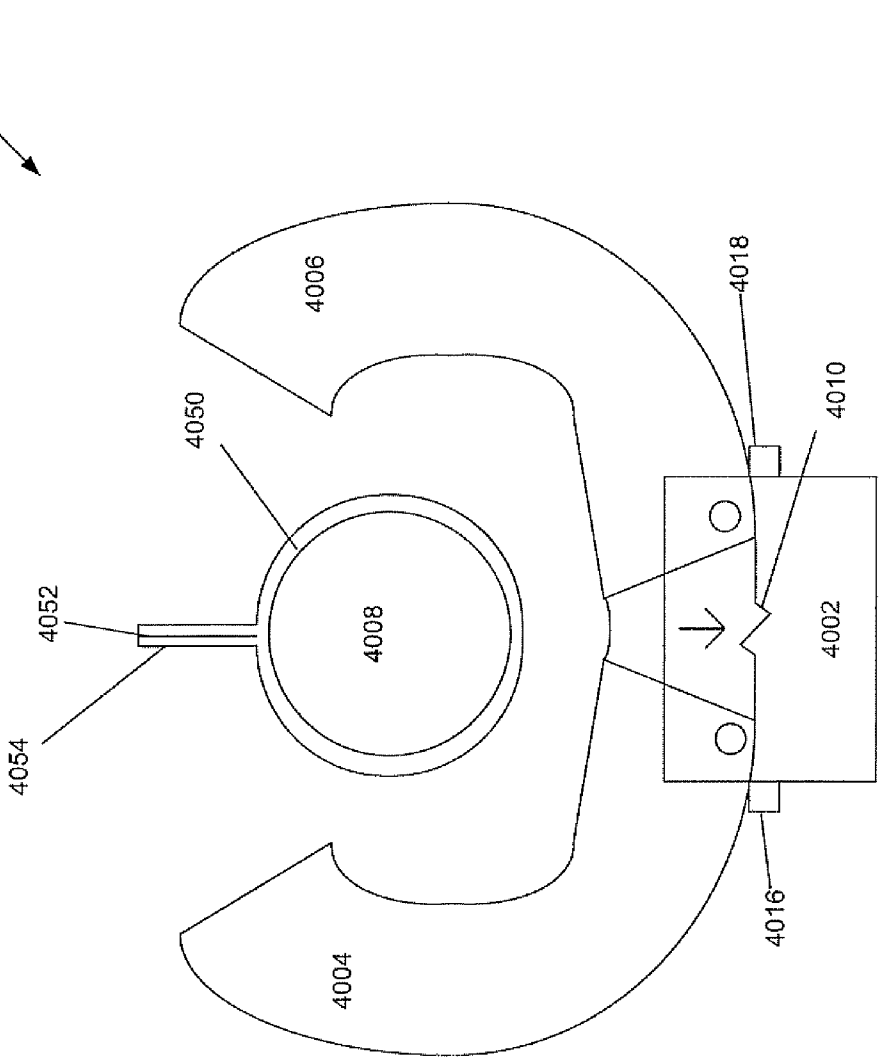

Figure 8

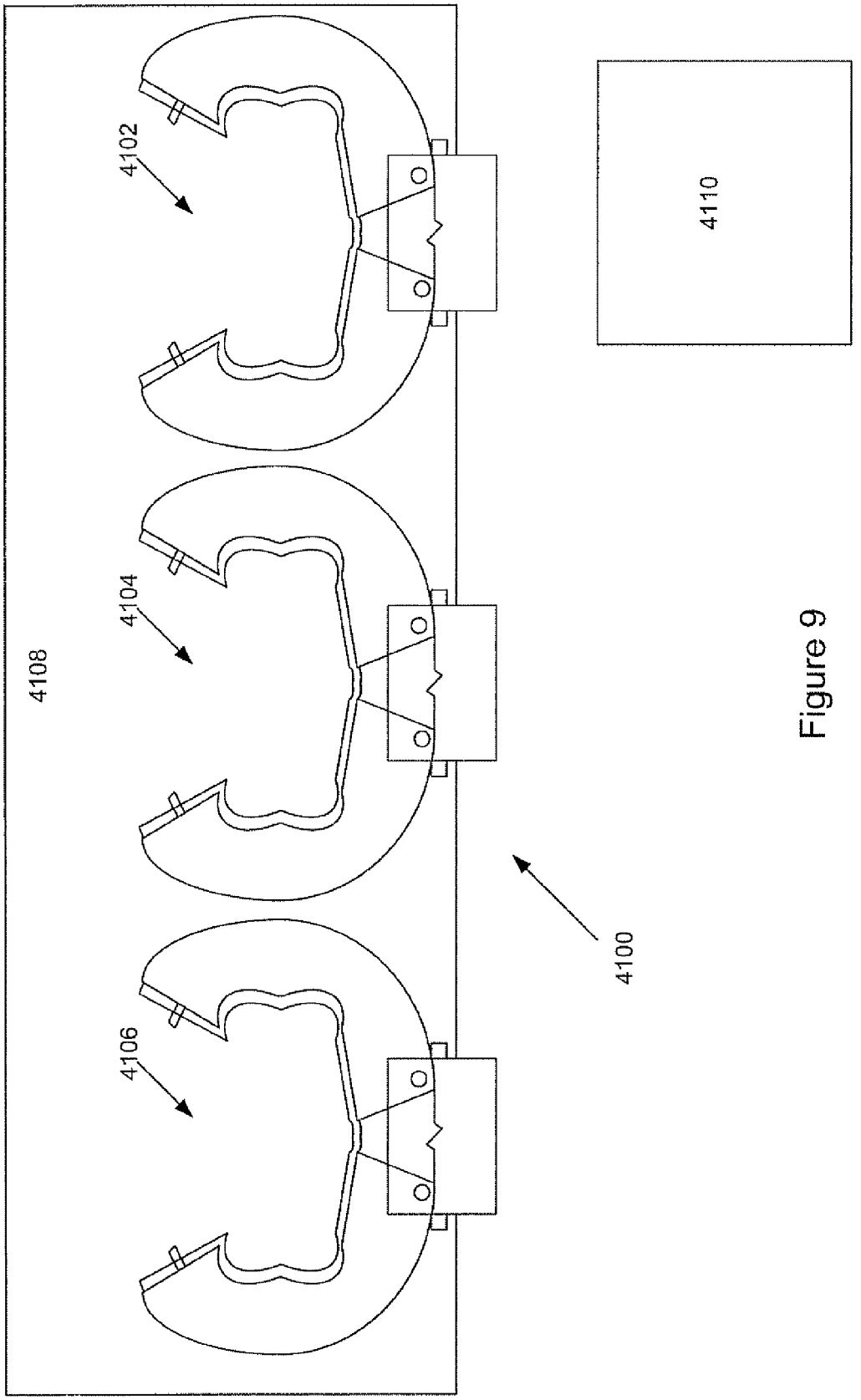

Figure 9

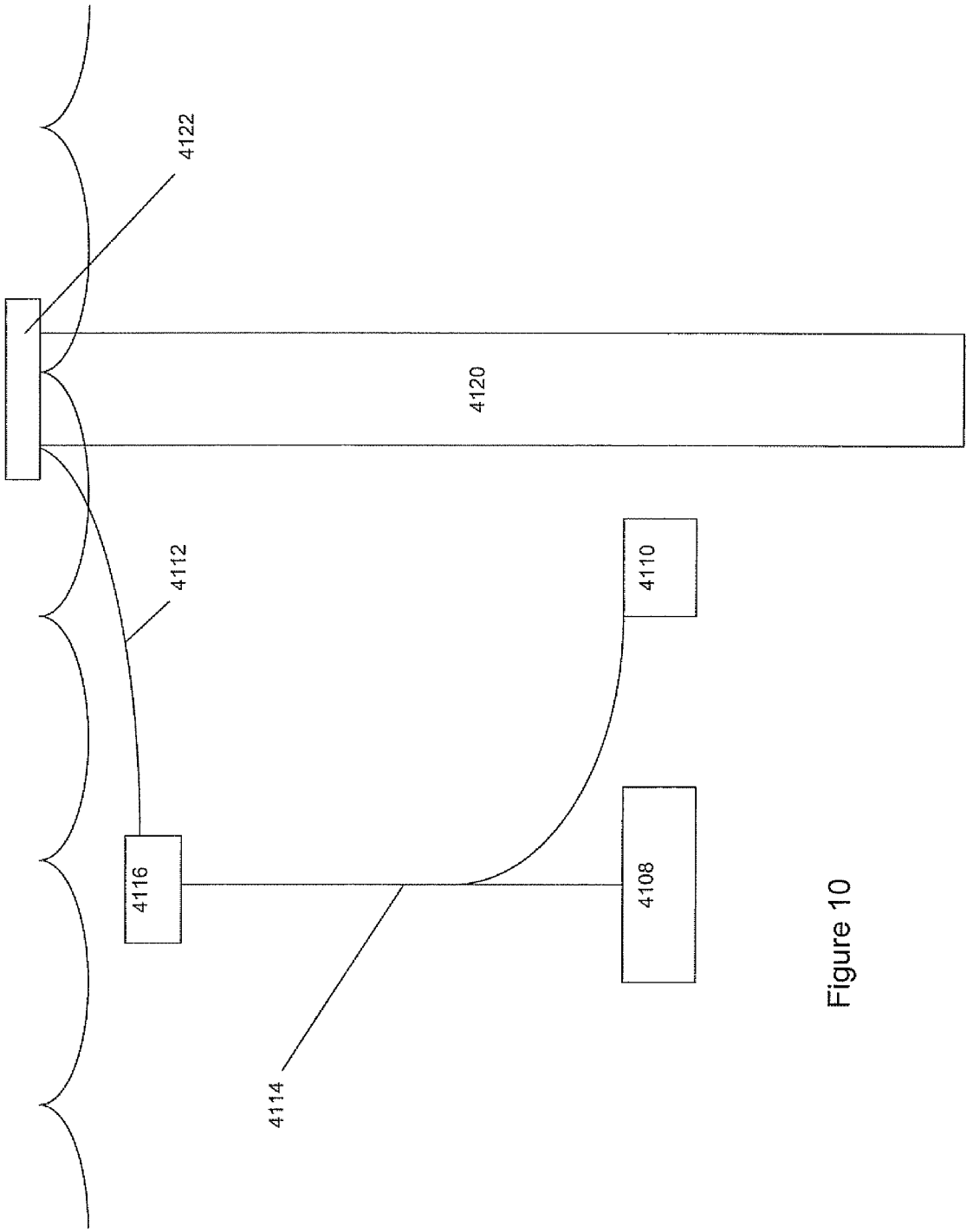

Figure 10

SYSTEMS AND METHODS FOR INSTALLATION OF CLAMSHELL DEVICES AROUND AN ELEMENT

RELATED APPLICATION DATA

[0001] This application claims priority to U.S. Provisional Application 60/751,503, filed Dec. 19, 2005. U.S. Provisional Application 60/751,503 is herein incorporated by reference in its entirety.

[0002] This application is related to U.S. patent application Ser. No. 11/083,833, filed Mar. 18, 2005, having Attorney Docket Number TH1853-03; U.S. patent application Ser. No. 10/383,154, filed Mar. 6, 2003; U.S. patent application Ser. No. 10/032,710, filed Oct. 19, 2001. U.S. patent application Ser. No. 11/083,833, U.S. patent application Ser. No. 10/383,154, and U.S. patent application Ser. No. 10/032,710 are herein incorporated by reference in their entirety.

FIELD OF THE INVENTION

[0003] In one aspect, the invention relates to systems and methods for installing clamshell devices around an element.

DESCRIPTION OF THE RELATED ART

[0004] Whenever a bluff body, such as a cylinder, experiences a current in a flowing fluid environment, it is possible for the body to experience vortex-induced vibrations (VIV). These vibrations are caused by oscillating dynamic 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. The vibrations may be largest in the transverse (to flow) direction; however, in-line vibrations can also cause stresses, which are sometimes larger than those in the transverse direction.

[0005] Drilling for and/or producing hydrocarbons or the like from subterranean 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 includes 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 mini spar or spar floating production system (hereinafter "spar").

[0006] There are generally two kinds of current-induced stresses in flowing fluid environments. The first kind of stress is caused by vortex-induced alternating forces that vibrate the structure ("vortex-induced vibrations") in a direction perpendicular to the direction of the current. When fluid 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. If the frequency of this harmonic load is near the resonant frequency of the structure, large vibrations transverse to the current can occur. These 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 in marine environments have been known to cause structures such as risers to break apart and fall to the ocean floor.

[0007] The second type of stress is caused by drag forces, which push the structure in the direction of the current due to the 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 generally disrupt the flow of water around it more than a stationary riser. This may result in more energy transfer from the current to the riser, and hence more drag.

[0008] Many types of devices have been developed to reduce vibrations of sub sea structures. Some of these devices used to reduce vibrations caused by vortex shedding from sub sea structures operate by stabilization of the wake. These methods include use of streamlined fairings, wake splitters and flags.

[0009] Streamlined or teardrop shaped, fairings that swivel around a structure have been developed that almost eliminate the shedding of vortices. The major drawback to teardrop shaped fairings is the cost of the fairing and the time required to install such fairings.

[0010] Other devices used 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 devices include sleeve-like devices such as helical strakes, shrouds, fairings and substantially cylindrical sleeves.

[0011] Some VIV and/or drag reduction devices can be installed on risers and similar structures before those structures are deployed underwater. Alternatively, VIV and/or drag reduction devices can be installed by divers on structures after those structures are deployed underwater.

[0012] Use of human divers to install VIV and/or drag reduction equipment at shallower depths can be cost effective. However, strong currents can also occur at great depths causing VIV and/or drag of risers and other underwater structures at those greater depths. However, using divers to install VIV and/or drag reduction equipment at greater depths subjects divers to greater risks and the divers cannot work as long as they can at shallower depths. The fees charged, therefore, by diving contractors are much greater for work at greater depths than for shallower depths. Also, the time required by divers to complete work at greater depths is greater than at shallower depths, both because of the shorter work periods for divers working at great depths and the greater travel time for divers working at greater depths. This greater travel time is caused not only by greater distances between an underwater work site and the water surface, but also by the requirement that divers returning from greater depths ascend slowly to the surface. Slow ascent allows gases, such as nitrogen, dissolved in the diver's blood caused by breathing air at greater depths, to slowly return to a gaseous state without forming bubbles in the diver's blood circulation system. Bubbles formed in the blood of a diver who ascends too rapidly cause the diver to experience the debilitating symptoms of the bends.

[0013] Elongated structures in wind in the atmosphere can also encounter VIV and/or drag, comparable to that encountered in aquatic environments. Likewise, elongated structures with excessive VIV and/or drag forces that extend far above the ground can be difficult, expensive and dangerous to reach by human workers to install VIV and/or drag reduction devices.

[0014] U.S. Pat. No. 6,928,709 discloses apparatus and methods for remotely installing vortex-induced vibration

(VIV) reduction and drag reduction devices on elongated structures in flowing fluid environments. The apparatus is a tool for transporting and installing the devices. The devices installed can include clamshell-shaped strakes, shrouds, fairings, sleeves and flotation modules. U.S. Pat. No. 6,928,709 is herein incorporated by reference in its entirety.

[0015] There are needs in the art for apparatus and methods for installing VIV and/or drag reduction devices on structures in flowing fluid environments; for apparatus and methods for installing VIV and/or drag reduction devices on structures in flowing fluid environments, which do not suffer from the disadvantages of the prior art apparatus and methods; for apparatus and methods for installing VIV and/or drag reduction equipment on underwater structures without using human divers; for apparatus and methods for installing VIV and/or drag reduction devices on underwater structures using equipment that can be remotely operated from the surface of the water; for apparatus and methods for installing VIV and/or drag reduction devices on above-ground devices using equipment that can be operated from the surface of the ground; for apparatus and methods for installing VIV and/or drag reduction devices on underwater structures using an ROV; and/or for apparatus and methods for installing various lengths of VIV and/or drag reduction devices.

[0016] These and other needs in the art will become apparent to those of skill in the art upon review of this specification, including its drawings and claims.

SUMMARY OF THE INVENTION

[0017] One aspect of the invention provides a clamp system for remotely installing a clamshell device around an element, the clamp system comprising a body; and at least one set of clamps supported by the body, the set suitable for holding and releasing the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices, wherein at least one clamp comprises a cam surface adapted to engage the element and close the clamp about the element.

[0018] Another aspect of the invention provides a method of remotely installing a clamshell device having a longitudinal axis around an element, using a clamp system comprising at least one clamp with a cam surface, the method comprising positioning the clamp system adjacent to the element wherein the clamp system carries the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices; moving the clamp system to position the clamshell device around the element; moving the clamp system to engage the cam surface with the element to close the clamshell device around the element; and securing the device in position around the element.

[0019] These and other aspects of the invention will become apparent to those of skill in the art upon review of this specification, including its drawings and claims.

[0020] Advantages of the invention may include one or more of the following: simplified systems and methods for closing clamshell devices about an element;

[0021] a system with a self-opening feature;

[0022] a system adapted to be used with an ROV;

[0023] a system adapted to install multiple clamshell devices about an element;

[0024] a system adapted to avoid the effects of heave.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] FIG. **1** is a top view of an apparatus for installing a clamshell device about an element.

[0026] FIG. **2** is the apparatus of FIG. **1** being engaged with the element.

[0027] FIG. **3** is the apparatus of FIG. **1** being engaged with the element.

[0028] FIG. **4** is a side view of a system for installing a clamshell device about an element.

[0029] FIG. **5** is a side view of a system for installing a clamshell device about an element.

[0030] FIG. **6** is a top view of a system installing a clamshell device about an element.

[0031] FIG. **7** is a top view of a system installing a clamshell device about an element.

[0032] FIG. **8** is a top view of a system after having installed a clamshell device about an element.

[0033] FIG. **9** is a system for installing clamshell devices about an element.

[0034] FIG. **10** is a system for installing clamshell devices about an element.

DETAILED DESCRIPTION OF THE INVENTION

[0035] In one embodiment, there is disclosed a clamp system for remotely installing a clamshell device around an element, the clamp system comprising a body; and at least one set of clamps supported by the body, the set suitable for holding and releasing the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices, wherein at least one clamp comprises a cam surface adapted to engage the element and close the clamp about the element. In some embodiments, the at least one set of clamps comprises a first clamp comprising a first cam surface, and a second clamp comprising a second cam surface. In some embodiments, the body has a top and a bottom, wherein the at least one set of clamps is comprised of a first set of clamps and a second set of clamps, wherein the first set of clamps is supported by the top of the body and the second set of clamps is supported by the bottom of the body. In some embodiments, there are at least two sets of clamps. In some embodiments, the at least one set of clamps holds the clamshell device. In some embodiments, the body has a taller first height and is collapsible to a shorter second height for holding shorter devices or for storage of the clamp system. In some embodiments, at least one clamp comprises at least one nipple, pin, screw, bolt, nail, adhesive, or other type of connector for anchoring the clamshell device to the set of clamps. In some embodiments, the clamp system also includes a release adapted to release the at least one nipple, pin, screw, bolt, nail, adhesive, or other type of connector so the clamshell device is not anchored to the set of clamps. In some embodiments, a plurality of clamps comprises a cam sur-

face. In some embodiments, each clamp comprises a cam surface. In some embodiments, the clamp system also includes a spring or other biasing device to hold the at least one set of clamps in an open position. In some embodiments, the clamp system also includes at least one stop to limit the opening of the at least one set of clamps. In some embodiments, the clamp system also includes an ROV connection adapted to connect the body to an ROV. In some embodiments, the clamshell device comprising a fairing. In some embodiments, the clamp system is mounted to a rack with at least one other clamp system. In some embodiments, the clamp system is attached to an umbilical. In some embodiments, the clamp system is attached to an umbilical, the umbilical attached to a subsea buoyancy device, the subsea buoyancy device adapted to isolate the clamp system from surface heave.

[0036] In one embodiment, there is disclosed a method of remotely installing a clamshell device having a longitudinal axis around an element, using a clamp system comprising at least one clamp with a cam surface, the method comprising positioning the clamp system adjacent to the element wherein the clamp system carries the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices; moving the clamp system to position the clamshell device around the element; moving the clamp system to engage the cam surface with the element to close the clamshell device around the element; and securing the device in position around the element. In some embodiments, the clamp system may be mounted on a rack with at least one other clamp system, the method further comprising repeating the positioning, moving, moving and securing with the at least one other clamp system. In some embodiments, the clamshell device installed is selected from a fairing, a shroud, an ultra-smooth sleeve, and a strake. In some embodiments, the clamshell device installed is selected from a flotation module and a collar.

[0037] Referring now to FIG. **1**, in one embodiment of the invention, clamp system **3900** is illustrated, which could be used to install collars, strakes, fairings, shrouds, sleeves, or other devices onto an element, such as a substantially cylindrical member or an I-beam.

[0038] Clamp system **3900** includes clamp **3904**, which is mounted to body **3902** by pivot **3912** and clamp **3906** by pivot **3914**. Body **3902** includes stop **3916** and stop **3918**, which are adapted to keep clamp **3904** and **3906** from opening too wide. Clamp **3904** includes cam surface **3920** and engaging surface **3924**. Clamp **3906** includes cam surface **3922** and engaging surface **3926**. Spring **3910** acts to bias clamp **3904** and clamp **3906** in an open position, as illustrated in FIG. **1**. Spring **3910** could also be a bungee cord, an elastic member, or other arrangement as are known in the art. Element **3908** may be positioned within the opening of clamp **3904** and clamp **3906**.

[0039] Referring now to FIG. **2**, in some embodiments of the invention, body **3902** has been advanced in the direction of the arrow toward element **3908**, so that cam surface **3920** and/or cam surface **3922** engage element **3908**. As body **3902** is further advanced, element **3908** exerts a force on cam surface **3920**, which pivots clamp **3904** towards a closed position about pivot **3912**. Similarly, element **3908** exerts a force on cam surface **3922**, which acts to pivot clamp **3906** towards a closed position about pivot **3914**. This pivoting of clamp **3904** and clamp **3906** acts to close the clamps, and move engaging surface **3924** closer to engaging surface **3926**. A sufficient force must be exerted on body **3902** in the direction of arrow to overcome the biasing force provided by spring **3910** and close clamps **3904** and **3906**.

[0040] Referring now to FIG. **3**, in some embodiments of the invention, body **3902** has been fully advanced towards element **3908**, so that engaging surface **3924** is touching engaging surface **3926**. Clamp **3904** and clamp **3906** are fully closed about element **3908**.

[0041] As body **3902** is withdrawn from element **3908**, spring **3910** acts to open clamps **3904** and **3906**, by pivoting clamp **3904** about pivot **3912**, and by pivoting clamp **3906** about pivot **3914**. This pivoting continues until clamp **3904** encounters stop **3916**, and clamp **3906** encounters stop **3918**.

[0042] Referring now to FIG. **4**, in some embodiments of the invention, there is illustrated a system **3900** for installing an apparatus about element **3908**. System **3900** includes top clamp **3906**, and bottom clamp **3907**, which are pivotally connected to body **3902** by pivot **3914** and pivot **3915**. Support arm **3932** is also pivotally connected to body **3902**. ROV connection **3930** is provided, which may be used to connect body **3902** to an ROV (not shown). In operation, body **3902** is advanced towards element **3908**, for example by an ROV, so that clamp **3906** and clamp **3907** engage element **3908**, clamp **3906** and clamp **3907** close about element **3908**. Similarly support arm **3932** may close about element **3908**.

[0043] Referring now to FIG. **5**, in some embodiments of the invention, a system **3900** for installing an apparatus about element **3908** is illustrated. System **3900** includes body **3902**, which is connected to clamp **3906** by pivot **3914**. In operation, body **3902** may be advanced towards element **3908**, for example with an ROV. As clamp **3906** engages element **3908**, clamp **3906** closes about element **3908**.

[0044] Referring now to FIG. **6**, in some embodiments of the invention, there is illustrated a top view of system **4000** installing clamshell device **4050** about element **4008**. System **4000** includes body **4002** which is connected to clamp **4004** and clamp **4006**. Clamp **4004** is pivotally connected to body **4002** by pivot **4012**. Clamp **4006** is pivotally connected to body **4002** by pivot **4014**. Stop **4016** and stop **4018** keep clamp **4004** and clamp **4006** from opening too far. Spring **4010** acts to bias clamps **4004** and clamp **4006** in the open position, as shown in the figure. As body **4002** is advanced in the direction of the arrow, cam surfaces **4020** and **4022** engage element **4008**, which serve to close clamp **4004** and clamp **4006** about element **4008**, which installs clamshell device **4050** about element **4008**. Connector **4040** and connector **4042** are provided to anchor clamshell device **4050** to engaging surface **4024** and engaging surface **4026**, respectively. Release **4044** is provided to disengage connectors **4040** and **4042**, at the appropriate time, so that clamshell device **4050** may be released from system **4000**. In operation, an ROV may engage release **4042** to release connectors **4040** and **4042**. Suitable connectors **4040** and **4042** include pins, bolts, male-female connectors, groves, and other connectors as are known in the art.

[0045] Referring now to FIG. **7**, in some embodiments of the invention, there is illustrated system **4000** installing

clamshell device **4050** about element **4008**. Body **4002** has been moved towards element **4008** to engage cam surfaces **4020** and **4022**, to rotate clamp **4004** about pivot **4012**, and to rotate clamp **4006** about pivot **4014**. Closing clamp **4004** and clamp **4006** forces engaging surface **4024** towards engaging surface **4026**. Between engaging surfaces **4024**, **4026** is tail **4054** of clamshell device **4050**. Tail **4054** is held together by connector **4052**. Suitable connectors **4052** include rivets, screws, bolts, adhesives, male-female connectors, heat welds, adhesives, and other connectors as are known in the art.

[0046] Referring now to FIG. **8**, in some embodiments of the invention, body **4002** has been moved away from element **4008**, leaving behind clamshell device **4050** that has been installed about element **4008**. Clamshell device **4050** includes tail portion **4054**, which is held together by connector **4052**, as body **4002** moves away from element **4008** in the direction of the arrow, clamp **4004** and clamp **4006** open, by pivoting about the pivots, due to the biasing force provided by spring **4010**. Clamp **4004** opens as far as stop **4016**, and clamp **4006** opens as far as stop **4018**.

[0047] Referring now to FIG. **9**, in some embodiments of the invention, system **4100** is shown for installing clamshell devices about an element. System **4100** includes clamp system **4102**, clamp system **4104**, and clamp system **4106**, which are releasably connected to rack **4108**. ROV **4110** is provided, which may release clamp system **4102**, **4104**, and/or **4106** from rack **4108**, to install a clamshell device about an element.

[0048] Referring now to FIG. **10**, in some embodiments, system **4200** is illustrated for installing a clamshell device about element **4220**. System **4200** includes rack **4208**, which may hold a plurality of clamp systems. Rack **4208** is connected by umbilical **4214** to subsurface buoyancy module **4216**, which may serve to isolate system **4200** from water surface heave. Buoyancy module **4216** is connected by umbilical **4212** to surface structure **4222**, which may be connected to element **4220**. ROV **4210** may or may not be connected to umbilical **4214**. In operation, ROV **4210** retrieves a clamp system from rack **4208**, and installs the a clamshell device connected to the clamp system about element **4220**, then deposits the used or empty clamp system back on rack **4208** and may retrieve another clamp system from rack system **4208** and install the a clamshell device connected to the clamp system about element **4220**. This process may be continued until all the desired apparatus have been installed about element **4220**, and/or until the capacity of rack **4208** is finished, at which time rack **4208** may be reloaded at surface structure **4222** or at another suitable location.

[0049] Although any clamshell device is believed to be suitable for use in the invention, in some embodiments of the invention, a clamshell device is utilized that includes a locking mechanism that will allow the system to lock the clamshell device around an element upon installation. The ends of the clamshell device may be outfitted with a mating locking mechanism that locks upon contact. Some examples of such locking mechanisms include male-female connectors, rivets, screws, adhesives, welds, and/or other connectors as are known in the art.

[0050] While the system has been described as being used in aquatic environments, that embodiment or another embodiment of the invention may also be used for installing clamshell devices on elongated structures in atmospheric environments with the use of an apparatus such as a crane.

[0051] While the illustrative embodiments of the invention have been described with particularity, it will be understood that various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the spirit and scope of the invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the examples and descriptions set forth herein but rather that the claims be construed as encompassing all the features of patentable novelty which reside in the invention, including all features which would be treated as equivalents thereof by those skilled in the art to which this invention pertains.

1. A clamp system for remotely installing a clamshell device around an element, the clamp system comprising:

a body; and

at least one set of clamps supported by the body, the set suitable for holding and releasing the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices,

wherein at least one clamp comprises a cam surface adapted to engage the element and close the clamp about the element.

2. The clamp system of claim 1, wherein the at least one set of clamps comprises a first clamp comprising a first cam surface, and a second clamp comprising a second cam surface.

3. The clamp system of claim 1, wherein the body has a top and a bottom, wherein the at least one set of clamps is comprised of a first set of clamps and a second set of clamps, wherein the first set of clamps is supported by the top of the body and the second set of clamps is supported by the bottom of the body.

4. The clamp system of claim 1, wherein there are at least two sets of clamps.

5. The clamp system of claim 1, wherein the at least one set of clamps holds the clamshell device.

6. The clamp system of claim 1, wherein the body has a taller first height and is collapsible to a shorter second height for holding shorter devices or for storage of the clamp system.

7. The clamp system of claim 1, wherein at least one clamp comprises at least one nipple, pin, screw, bolt, nail, adhesive, or other type of connector for anchoring the clamshell device to the set of clamps.

8. The clamp system of claim 7, further comprising a release adapted to release the at least one nipple, pin, screw, bolt, nail, adhesive, or other type of connector so the clamshell device is not anchored to the set of clamps.

9. The clamp system of claim 1, wherein a plurality of clamps comprises a cam surface.

10. The clamp system of claim 1, wherein each clamp comprises a cam surface.

11. The clamp system of claim 1, further comprising a spring or other biasing device to hold the at least one set of clamps in an open position.

12. The clamp system of claim 1, further comprising at least one stop to limit the opening of the at least one set of clamps.

13. The clamp system of claim 1, the body further comprising an ROV connection adapted to connect the body to an ROV.

14. The clamp system of claim 1, the clamshell device comprising a fairing.

15. The clamp system of claim 1, the clamp system is mounted to a rack with at least one other clamp system.

16. The clamp system of claim 1, wherein the clamp system is attached to an umbilical.

17. The clamp system of claim 1, wherein the clamp system is attached to an umbilical, the umbilical attached to a subsea buoyancy device, the subsea buoyancy device adapted to isolate the clamp system from surface heave.

18. A method of remotely installing a clamshell device having a longitudinal axis around an element, using a clamp system comprising at least one clamp with a cam surface, the method comprising:

positioning the clamp system adjacent to the element wherein the clamp system carries the clamshell device selected from the group consisting of vortex-induced vibration reduction devices and drag reduction devices;

moving the clamp system to position the clamshell device around the element;

moving the clamp system to engage the cam surface with the element to close the clamshell device around the element; and

securing the device in position around the element.

19. The method of claim 18, wherein the clamp system may be mounted on a rack with at least one other clamp system, the method further comprising:

repeating the positioning, moving, moving and securing with the at least one other clamp system.

20. The method of claim 18, wherein the clamshell device installed is selected from a fairing, a shroud, an ultra-smooth sleeve, and a strake.

21. The method of claim 18, wherein the clamshell device installed is selected from a flotation module and a collar.

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